Bruker BioSpin

BSMS/2 Systems with ELCB

Technical Manual

Version 005

think forward

NMR Spectroscopy

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Terms and symbols 1.1

WARNING: Disregard of this may lead to personal injury.

NOTE: Hint for good operating practice.

Figure 1.1. High voltage!

Indicates dangerous voltage. Do not open cover with this label!

Figure 1.2. Dangerous device!

Instruction manual symbol. It is necessary for the user to refer to the manual prior to the use of marked items.

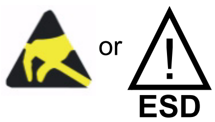


Figure 1.3. Electrostatic sensitive Device!

Observe precautions for handling.

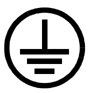


Figure 1.4. Protective ground (earth) terminal

Used to identify any terminal which is connected to the external protective conductor for protection against electrical shock in case of fault.

Disclaimer 1.2

The following general safety precautions must be observed during all phases of operation and service of the BSMS/2 system. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture and intended use of the BSMS/2 system.

BRUKER assumes no liability for the customer‘s failure to comply with theses requirements and is therefore not responsible or liable for any injury or damage that occurs as a consequence of non-approved manipulations on the BSMS/2 system.

Emergency 1.3

The mains switch on the BSMS/2 chassis front serves as an EMERGENCY OFF. It powers down the systems.

Personnel safety 1.4

Ground connection 1.4.1

WARNING: To minimize shock hazard the BSMS/2 chassis must be connected to an electrical ground.

The electronics cabinet is equipped with a three-conductor ac power cable. Do only use power cables approved by BRUKER or compliant with IEC safety standards.

Technically qualified personnel only 1.4.2

WARNING: Installation and servicing should only be done by BRUKER qualified personnel. Always disconnect power cable before servicing. Under certain conditions dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

NOTE: Operating personnel must not remove chassis covers except as described in this manual. Do not replace BSMS/2 units with mains switch turned on.

User interface, system messages, and manuals require a good understanding of the English language.

Electrical safety 1.4.3

The BSMS/2 systems's degree of protection against electrical hazard complies with IEC IP20, i.e. all electrical parts are protected against touching.

WARNING: All electrical connectors must be used as supplied by BRUKER. Do not substitute them by other types.

Lifting the BSMS/2 chassis 1.4.4

WARNING: At least two people are needed to insert and remove the BSMS/2 chassis from the electronics cabinet. A fully equipped BSMS/2 system can weight in excess of 50kg.

NOTE: Remove some or all of the BSMS/2 units from the chassis prior to handling to reduce weight.

Cleaning 1.4.5

WARNING: Always switch power off and disconnect the power cable before cleaning. Never power on until all surfaces are completely dry.

Clean the outside of the BSMS/2 chassis and units with a soft, lint-free cloth dampened in water. Do not use any detergent or other cleaning solvents.

BSMS/2 System with ELCB

2

Introduction 2.1

Since 1998 when the BSMS/2 mainframe was introduced into market several minor extensions and adaptations have taken place.

With the introduction of the **AVANCE II** NMR system in 2005, a major modernization has taken place by enabling the BSMS/2 to be operated via **ethernet TCP/IP** communication and WEB based control.

At this time several classic BSMS/2 boards have been modernized in order to replace the former up to 15 years old board like CPU/3, the LCB and the various SCB7 and SCB13 shim current boards. All these units have been replaced by higher integrated boards providing better performance, higher resolution and increased stability.

In 2010 the Variable Temperature System has been integrated into the BSMS/2. With this step the former family of BVT3000 and BVT3200 units and the former pneumatic units PNK3, PNK3S and PNK5 as well as the SLCB/2 and SLCB/3 boards were replaced by the new Sensor & Pneumatics Board (SPB) and the Variable Power Supply Board (VPSB).

Note that the BSMS/2 chassis must have **at least ECL 02.00** for supporting the all new boards available since 2005.

Subunits in the ELCB based BSMS 2.1.1

Shim

The **SCB20** (Shim Current Board) provides the required precision for all existing types of shim systems and can therefore replace any variant of former SCB7 and SCB13. Connectivity to the different Shim Systems is provided by a set of various adapters.

Lock

The **ELCB** (Ethernet based Lock Control Board) incorporates the lock functions like the lock control algorithm and the H0 current source. In addition this ELCB acts as communication gateway between the workstation and the various subunits inside of the BSMS/2. The BSMS/2 can now be directly accessed with a standard Internet browser via ethernet TCP/IP protocol or allows hardware independent communication with TopSpin 2.0 and higher by using a CORBA interface.

In late 2008 the new **L-TRX** board has started to replace the former L-TX, L-RX and partially the BSMS/2 2H-TX unit. This highest integrated RF unit provides a more digital integrated lock RF and includes all what is necessary to allow gradient shimming on 2H.

Gradient amplifier

With the introduction of the **AVANCE III** in 2007, the GAB has been replaced with a **GAB/2**, which provides AVANCE III compatible control (LVDS48) and has now built-in preemphasis capability as standard feature.

Variable temperature control, sample handling and level monitoring

Most recently in 2010 there has been made a higher integration of the pneumatic functions for sample handling (lift, spin), the variable temperature control (power supply and various sensor interfacing, gas flow controls) and fill level monitoring for the magnet (helium and nitrogen level). These functions are now provided by the new **SPB / SPB-E** and **VPSB** boards, which replace the former SLCB and PNK, the built in BVT3200 (with corresponding power supply) or any of the stand alone BVT3000 variants. With the introduction of these boards, the VME part of the BSMS has become obsolete.

In 2011 a new digital nitrogen level sensor has been introduced together with the ASCEND family of magnet systems.

Accessing the ELCB based BSMS — *2.1.2*

All subunits may be accessed by a Web-based service tool, making service handling much easier and comprehensive. The former BSMS Tool (console program using the RS232 connection) is obsolete and should no longer be used in connection with the ECLB based BSMS/2.

Note: The additional RS232 communication capability of the ELCB has been foreseen for intermediate control the ELCB with TopSpin 1.3. This is not anymore required since TopSpin 2.0 is available.

SaveConfig is no longer used, as the new ELCB has an automatic save configuration mechanism and stores all the parameters (e. g. for Lock, Shim, Lift, HE-Level measurement) within its nonvolatile memory (NVM). In order to be able to switch back to a known state, a saved configuration from the installation may be restored later on - this fail-safe configuration can be re-activated by any user.

All activities of the new BSMS/2 and the data exchange with the TopSpin application are logged by the ELCB software. This information is accessible by the service tool and, additionally, it is periodically transferred to the workstation in order to keep a detailed long term history for trouble shooting. It is configurable how detailed the activities are logged.

Technical Data *2.2*

Table 2.1. Technical Data of BSMS/2 Chassis

BSMS / 2 technical data				
General	Height	310	mm	Chassis dimensions
	Width	485	mm	
	Depth	482	mm	
	Weight	32	kg	Approx. weight with a typical configuration
Front Rack	Board Height	233.35	mm	
	Board Length	220	mm	
Back Rack	Board Height	233.35	mm	
	Board Length	220	mm	
AC	Input Voltage	187-223	Vrms	Mains selector range
		201-239	Vrms	
		212-253	Vrms	
	Frequency	50 / 60	Hz	
	Input Current	max. 4	Arms	

Environmental conditions:

The BSMS/2 mainframe is designed as a subunit in the electronics cabinet of the NMR Spectrometer. For the environmental conditions please refer to the site planning guide of the spectrometer system.

Configurations *2.3*

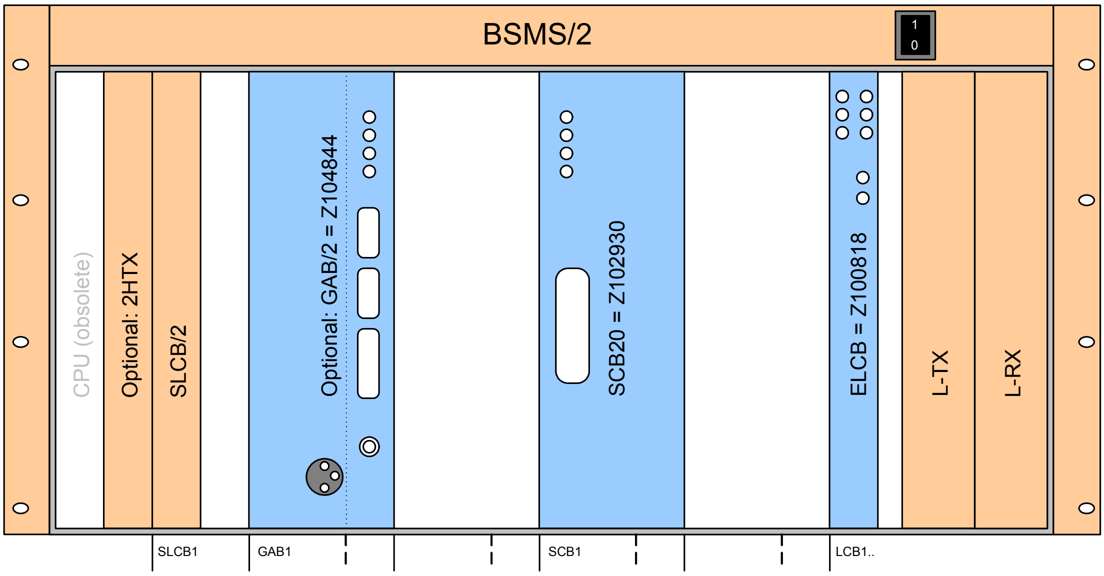
In the following sub chapters, there are the various standard configurations described in detail. The units are marked in a specific color, according to the date of introduction:

- orange: Units that existed before 2005
- blue: Units that were introduced 2005 with the ELCB
- green: L-TRX and the related power supply introduced in 2008
- pink: Units for variable temperature control, sample handling and magnet fill level monitoring with related power supply introduced in 2010

Configuration with LTX / LRX 2.3.1

The diagram below shows a typical AVANCE III - BOSS1 configuration. The Gradient Amplifier (GAB/2) and the 2HTX are optional, depending on the application. For specific applications (e. g. solids configuration) the RF boards (L-TX and L-RX) may be missing. The new SCB20 provides a 50 pin connecter compatible with „plug“ Shim systems. Older style Shim systems may also be connected by using an appropriate adapter (see also chapter SCB20).

Figure 2.1. BOSS1 configuration with LTX / LRX (front)

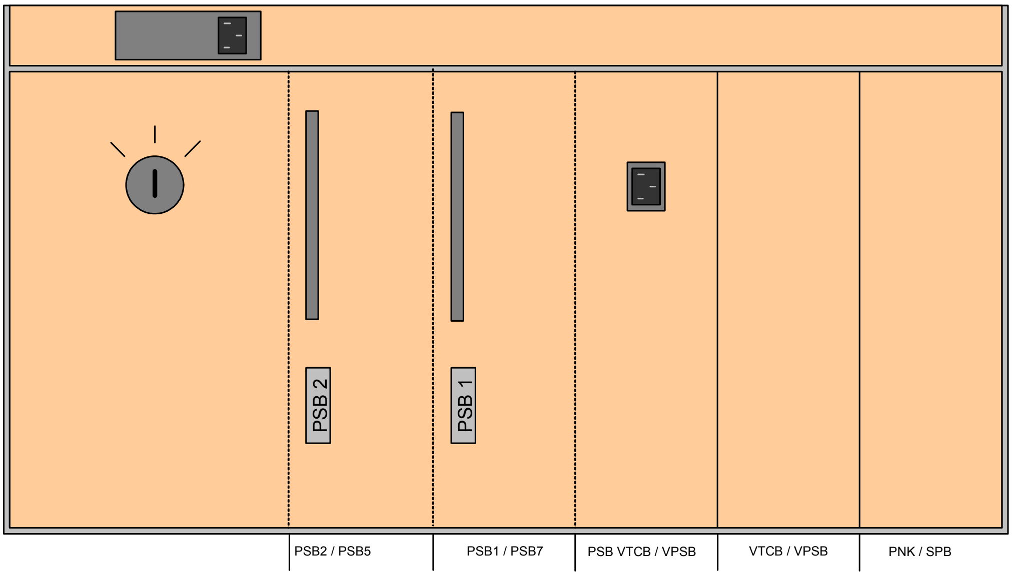


Important: Note the position of the SCB20 for BOSS1 systems!

Note: The GAB/2 can be controlled by both, the IPSO gradient controller in AVANCE III spectrometers (large LVDS interface) or by the former GCU/3 (small LVDS interface).

The power supplies at the rear side (PSB1 and PSB2) for the new boards in configuration with L-TX / L-RX are the same as for the former CPU based BSMS configurations.

Figure 2.2. Power supplies for any non-L-TRX configuration (rear side)



This power supply configuration has to be changed for configurations with L-TRX and for configurations with SPB / SPB-E:

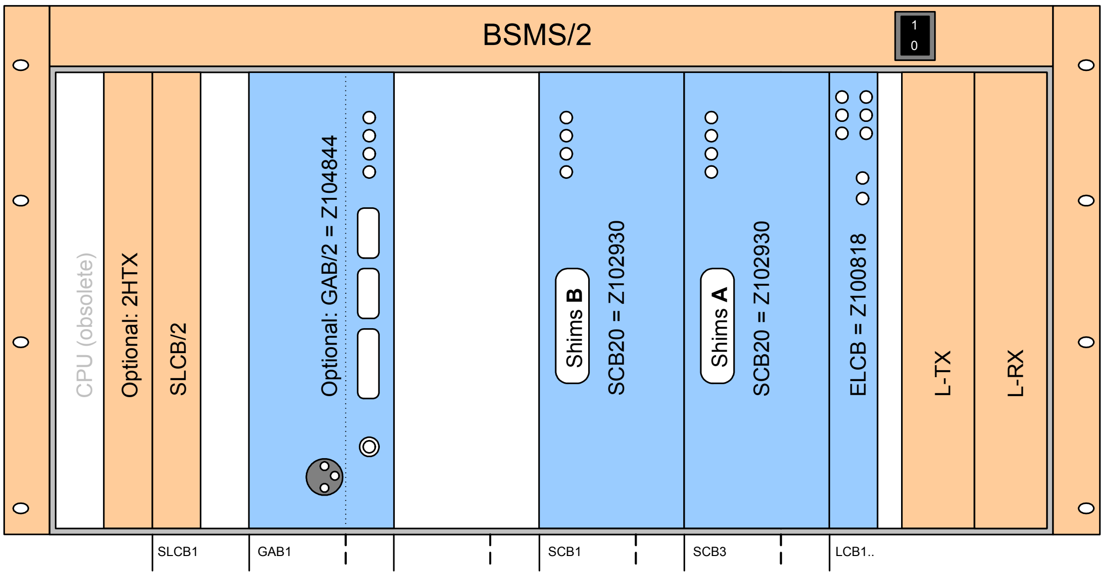
L-TRX: Replace PSB2 by a PSB5

SPB / SPB-E: Replace PSB1 by a PSB7

Configuration for non-BOSS1 with LTX / LRX 2.3.2

Non-BOSS1 Systems requiring more than 20 Shim currents need a second SCB20. Similar to the former BSMS/2 systems, the Shim cables „A“ and „B“ have to be connected from right to left.

Figure 2.3. Configuration for BOSS2, BOSS3 and BOSS-WB



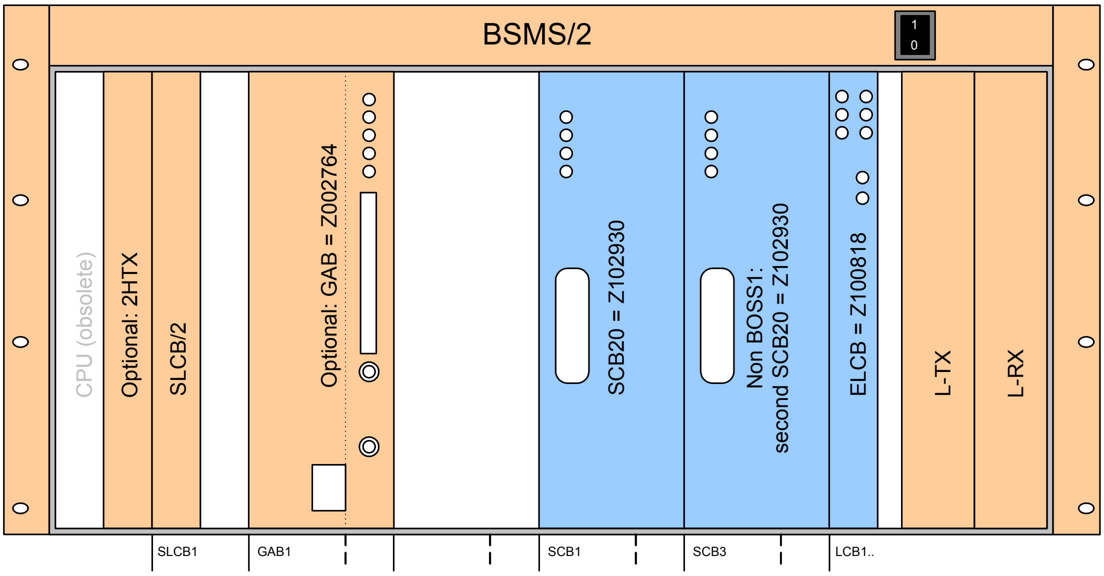
Configurations with GAB 2.3.3

ELCB based BSMS/2 can also run with the former GAB. The gradient controller is automatically detected by the driver software running on the ELCB.

Note: The former GAB provides only the large parallel interface for gradient pulse control. Make sure that your gradient controller is compatible (TCU / FCU / GCU systems).

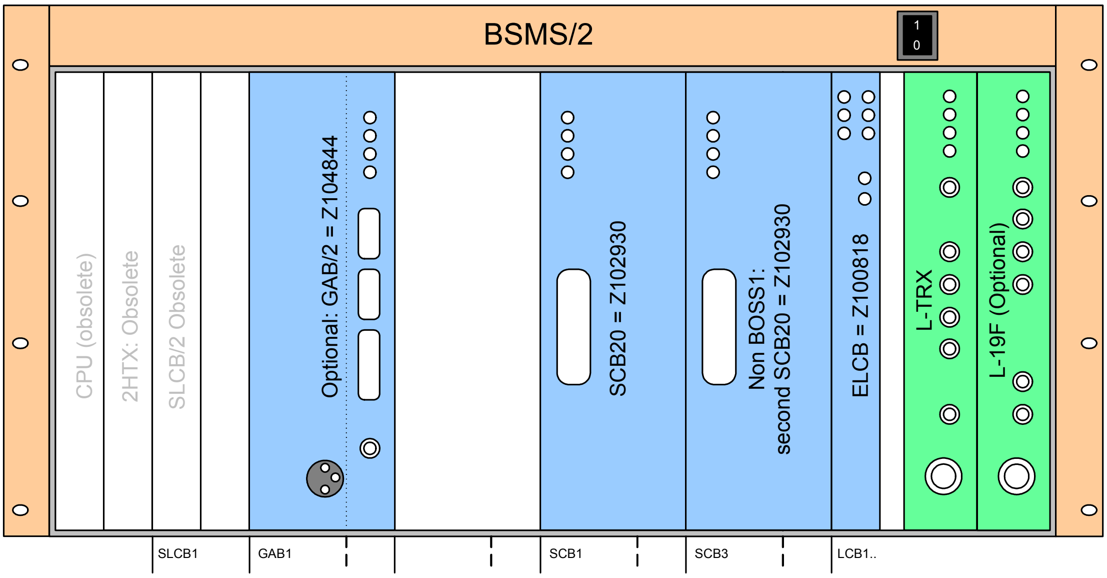
The example diagram below shows the variant for non-BOSS1 configurations. If a BOSS1 system is connected then the right hand SCB20 is not installed.

Figure 2.4. AVANCE II - configurations with GAB



Configurations with L-TRX *2.3.4*

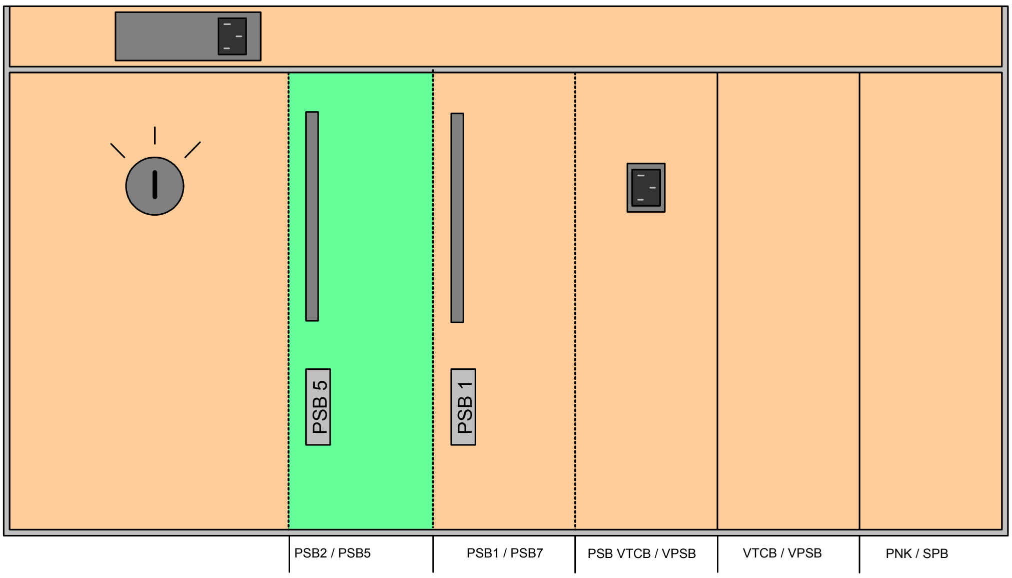
Figure 2.5. Configuration with L-TRX (example with GAB/2)



The new L-TRX is installed in the former LTX slot, and former LRX slot is covered by a blind plate 8TE (Z14118).

For gradient shimming, the L-TRX has a built in 5 Watt 2H amplifier, replacing the formerly used 2HTX.

Power supplies for L-TRX (rear side)



For operation of the L-TRX in a BSMS/2 chassis, the formerly used PSB2 has to be replaced by the new PSB5.

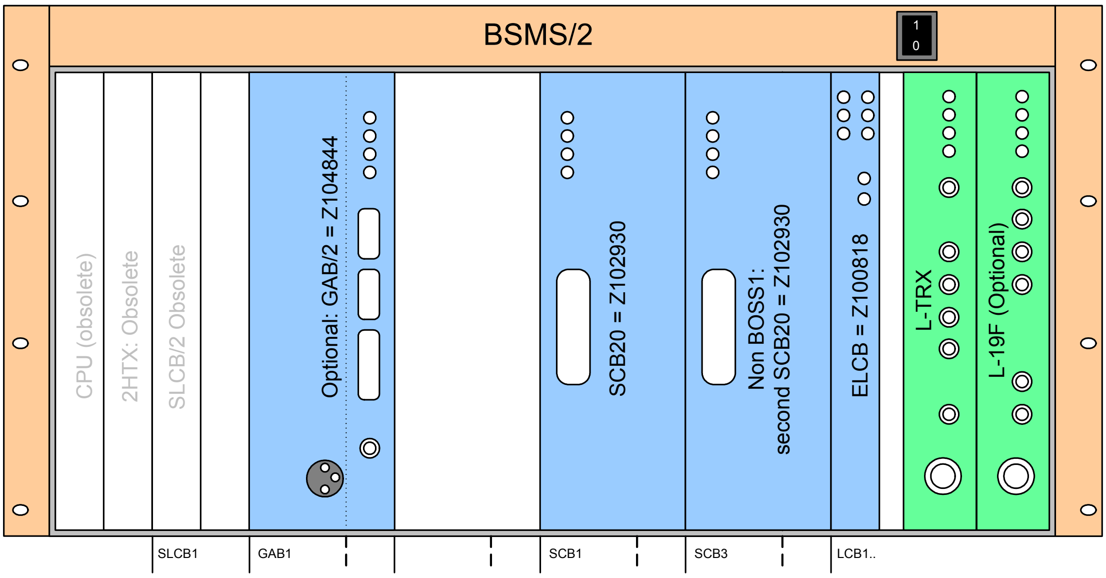
19F option for L-TRX

Requires the optional unit BSMS/2 19F Lock Transceiver 300 - 1000 MHz (Z120014).

Configurations with SPB(-E) and VPSB 2.3.5

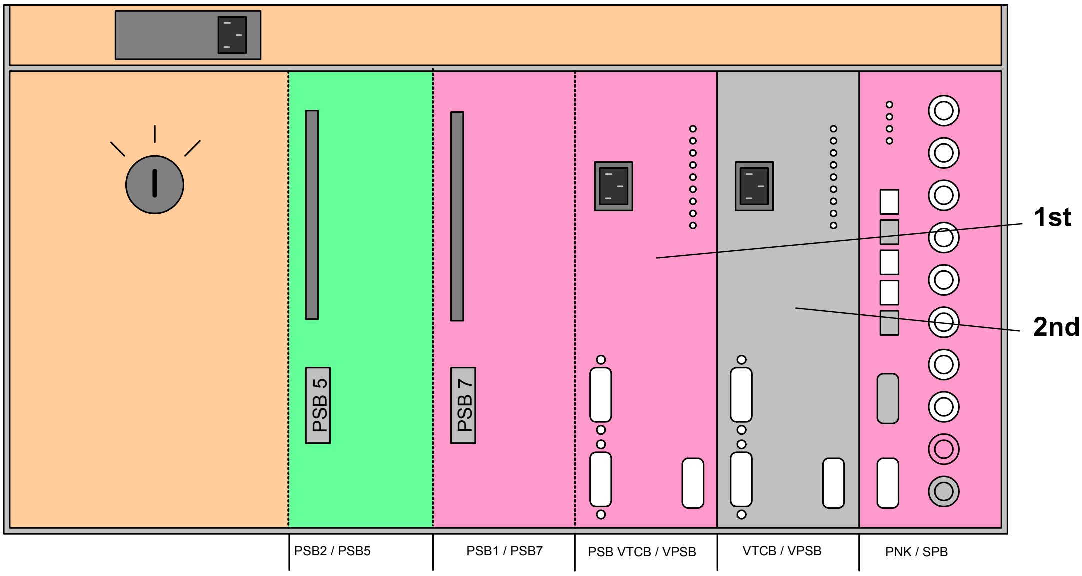
The SPB (or SPB-E) provides all functions of the former SLCB/2 (helium level supervision, BST sensors) and the corresponding PNK board (lift, sample rotation). These two boards are therefore no longer needed in new configurations.

Figure 2.6. Configuration with L-TRX and optional L-19F unit (example with GAB/2)



Both, the SPB(-E) and VPSB are plugged from the rear side. A second VPSB can be installed as an option (SPB-E required for connectivity).

Figure 2.7. SPB(-E), VPSB(´s) and power supply (rear side)



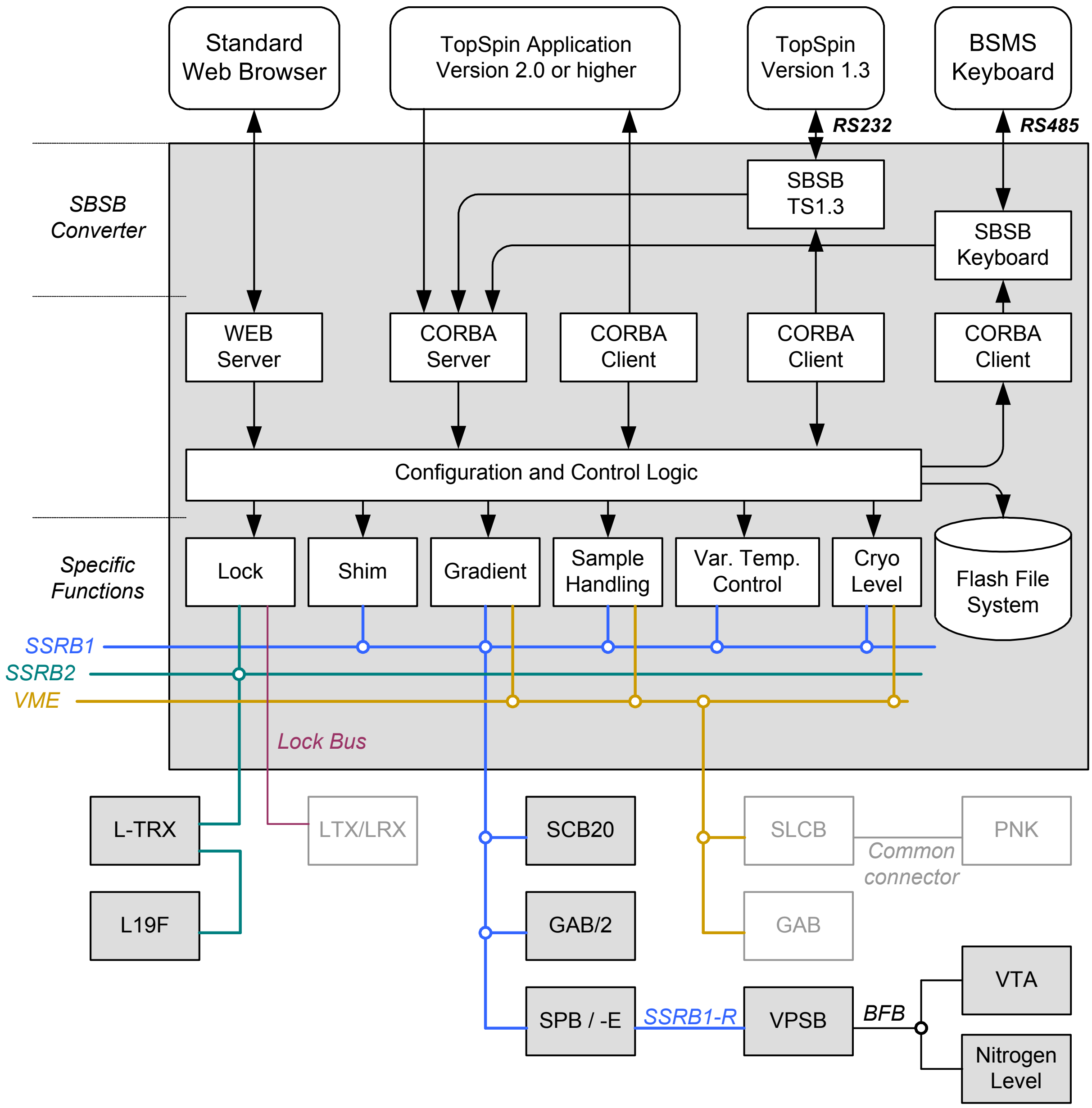
Note: The optional second VPSB is marked in gray color. If it is not installed then the empty slot has to be covered with a blind plate.

For operation of the SPB(-E) in a BSMS/2 chassis, the formerly used PSB1 has to be replaced by the new PSB7 and the SLCB/2 removed.

System Architecture / Overview *2.4*

The following diagram shows the functional system architecture from the User Interface (TopSpin and Keyboard, standard web browser for the service engineer) across the BSMS down to the specific hardware subsystems.

Figure 2.8. System Architecture / Overview



Firmware:

- BsmsCheckDownload.txt contains the information about all required firmware versions for all installed sub units in a BSMS

- ELCB firmware provides all functions for the ELCB (mainly lock control), and in addition the control logic and driver functions for all the installed sub units.
- FPGA-Design (field downloadable) is required for L-TRX, SCB20, GAB/2, SPB(-E), and VPSB
- Additional controller software is installed on the various VT-Adapters, BSCU type cooling units and digital nitrogen level sensors, which are also connected over the BFB (Bruker Field Bus[1]).
- There is no firmware required for LTX, LRX, 2H-TX, GAB and PNK

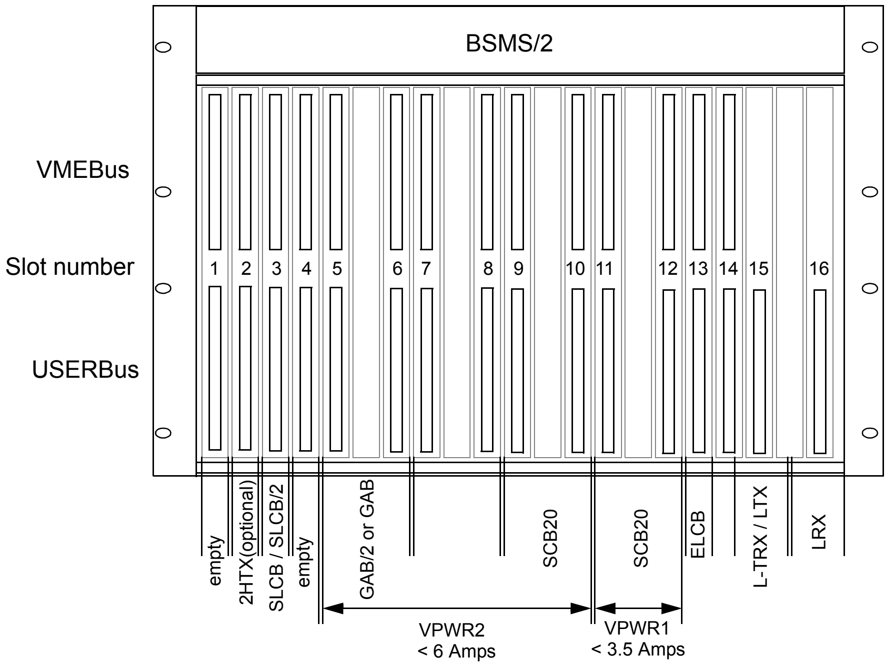
1. This peripheral bus has been introduced 2010 together with the BSVT system. Connectors can be found on BSMS/2 VPSB (see ***page 241***) and SPB-E boards (***page 216***)

BSMS/2 Rack 2.5

The back plane combines the VME bus and the user bus and provides access from the front and rear side.

There is an equally spaced raster for the connectors at the front side, however some positions are empty. Since some slots (user bus part) provide specific power supply voltages or control signals, the subsystem boards have to be plugged in a well defined order into the BSMS/2.

Figure 2.9. The BSMS/2 rack with the specific slots



Note[1]: The slot numbers (1 to 16) are encoded by 4 user bus lines, starting with a 0 for Slot 1 (GND / GND / GND / GND) and ending with 15 for Slot 16 (VCC / VCC / VCC / VCC).

Note[2]: There are two different power supplies in the BSMS/2. Both have - in addition to the general supply voltages for the subsystem - a symmetrical high power output (VPWR_P / VPWR_GND / VPWR_N). One (PSB1) provides at maximum 3.5 Amps for the GAB / SCB20 board in slot 11 / 12, the other (PSB2) supplies the remaining GAB / SCB20 boards (up to three boards in slot 5 to 10) with a maximum current of about 6 Amps (total for all boards).

Note[3]: At the rear side, there are the two additional „slots“ number 18 and 19 for the two power supplies. PSB1 is used in systems with SLCB / PNK, whereas PSB7 in systems with SPB(-E). PSB2 is used in systems with LTX / LRX, whereas PSB5 in systems with L-TRX.

Note[4]: The pneumatic control board is plugged in the right most slot at the rear side (PNK variant in connection with SLCB or SPB(-E) for temperature control).

Note[5]: Slot 17 is foreseen for the probe temperature control.

Figure 2.10. Front View of BSMS/2 Rack

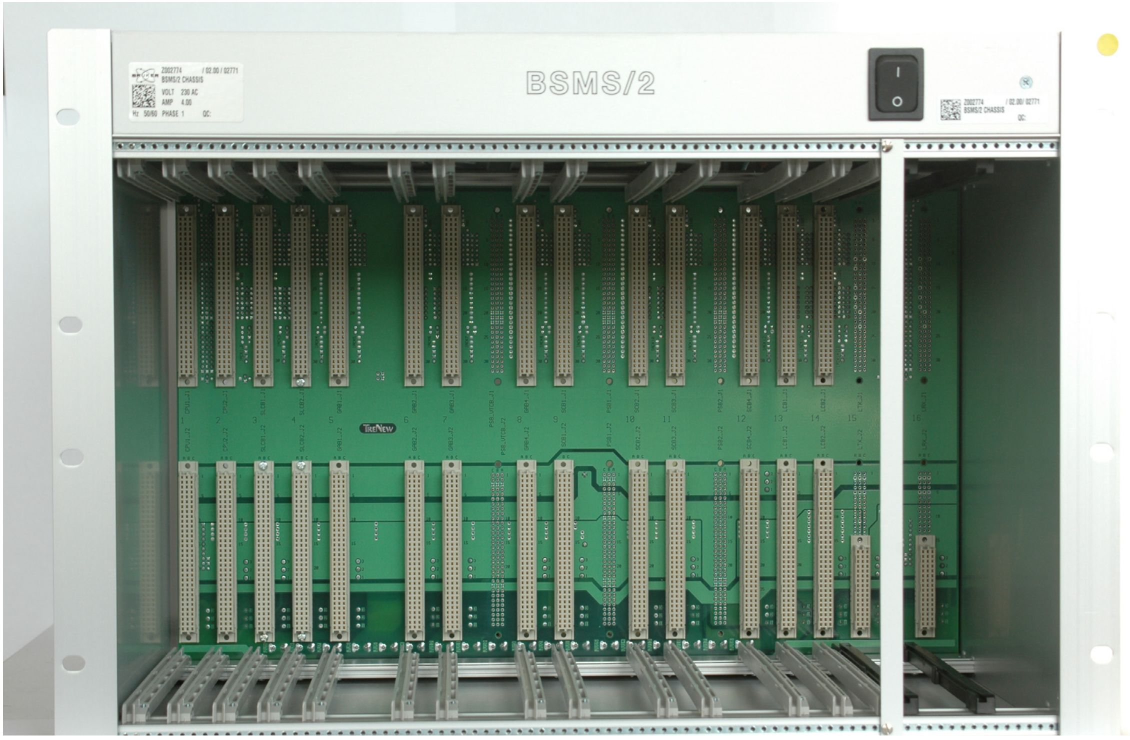
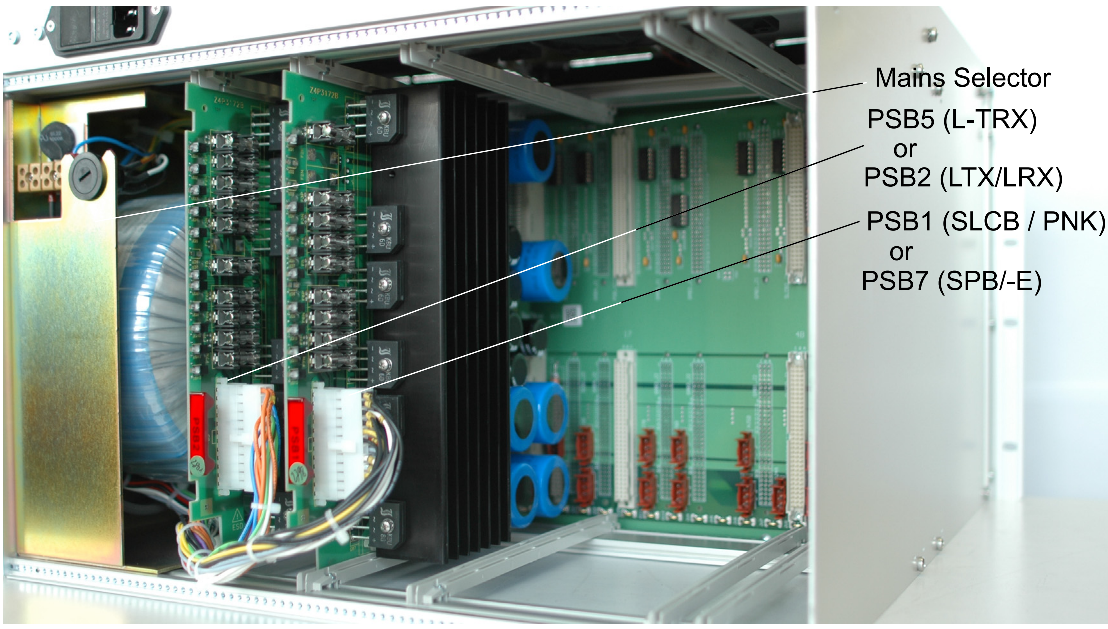


Figure 2.11. Rear View of BSMS/2 Rack



Service Web *2.6*

All operational functions for NMR application are provided by the CORBA interface, as described before. An additional set of operations is reserved for service engineers, e. g. for downloading new firmware, calibration and diagnostics. These functions are only available on the Service Web, which is the successor of the former BSMS tool. It is no longer necessary to use a specific client software for service access (any Web browser can be used), the new concept provides a graphical user interface and is therefore much easier and comprehensive.

IP Address of the BSMS/2 *2.6.1*

In typical TopSpin 1.3 configurations (no DHCP server in the spectrometer network) the BSMS/2 has the fixed IP address **149.236.99.20**.

If there is a DHCP server, which is installed with TopSpin 2.0 or later, then there is dynamically assigned an IP address to the BSMS/2. This IP address remains as long as there is no change of the hardware (ELCB / workstation). The dynamic IP address can be obtained by running TopSpin 2.0 or later and typing „ha“. After scanning of the spectrometer network, which takes several seconds, all connected IP devices are listed in a dialog (e. g. the BSMS).

In order to provide correct DHCP address assignment, it is necessary to start up the workstation before the BSMS/2 is switched on.

If it is not possible to reach the BSMS/2 by the Web browser (e. g. if a non TopSpin DHCP server has assigned an unknown IP address to the BSMS/2) then the BSMS/2 can be started with unplugged Ethernet cable, which forces the BSMS/2 to keep its fixed IP address. After booting, the Ethernet can be plugged and the BSMS/2 should be accessible at its fixed address.

Figure 2.12. BSMS/2 Main Service Page

1. Service Page: Access to the logging information and configuration of the logging. A service engineer can log in on this page (in order to get access to the extended functions / parameters).
2. Device Setup: Shows the hardware configuration (connected subsystems, hardware codes), the versions of the actually loaded firmware and the required firmware versions. This page provides also the links to the specific firmware download pages (see later on).
3. Calibration: Links to the different specific calibration routines that are necessary upon installation of a spectrometer (e. g. for Helium level measurement, air pressure for lift, and so on).
4. Variable temperature control (if SPB / -E is installed): Information, activation and configuration (setting of aimed temperatures, temperature and power limits, aimed VT gas flow, regulation settings, and so on).

5. He- and N2-level: Monitoring of cryo levels in the magnet. The N2 level monitoring requires a SLCB/3, VPSB or SPB-E.
6. Sample Handling: Commands and configuration of sample lift, sample rotation and sample mail (extended sample transport - related hardware needs to be installed for this feature).
7. Shim: Commands and configuration of Shim system (e. g. download of BOSS file) and diagnostic functions for trouble shooting.
8. Lock: Commands and configuration of NMR Lock (optional 19F lock if this feature is installed) and diagnostic functions / self tests for trouble shooting. This section provides also access to the lock RF board(s) LTX/LRX or L-TRX.
9. Gradient: Information and configuration of gradient amplifier if this board is installed (GAB or GAB/2).
10. 2H-TX control: 2H router address setting if 2H-TX is installed.
11. ELCB info: Detailed info about ELCB, including ethernet info and configuration.

Installation and preparation for use 2.7

The BSMS/2 mainframe must be installed at it‘s designated position in the electronics cabinet to ensure proper air ventilation for the cooling fans. The position may vary in different cabinet types and sizes.

The chassis must be secured with at least 4 screws in the cabinet. The power cable is included in the cabinet wiring.

Mains selection and fuses 2.7.1

Prior to the first power-up of the BSMS/2 mainframe, it must be ensured that the mains selection switch is in the correct position (see selector on the back side of the BSMS/2). Make sure that the mains cable is disconnected for adjusting the voltage selector.

In general, the mains voltage selection switch should be set to the matching range; however, if the mains power is weak, the next lower range should be chosen despite the greater power dissipation in the power supply modules.

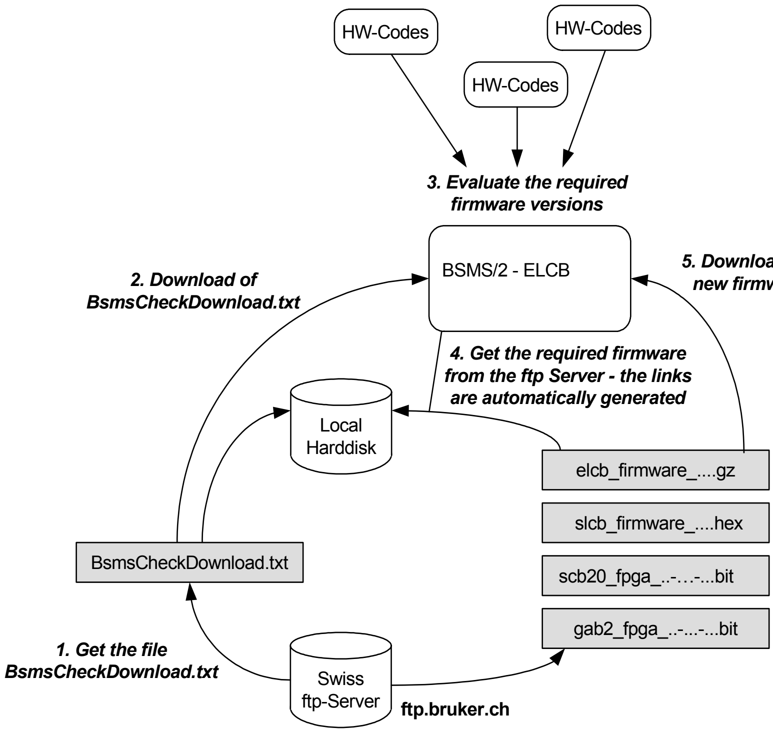
For example:

- 230 V stable mains power => choose the 212 - 253 VAC position
- 230 weak / unstable mains power => choose the 201 - 239 VAC position

The BSMS/2 is protected by two fuses as specified on the power supply nameplate. The fuses are located in a removable fuse holder next to the AC power connector (use 5 Amps time-lag fuse types).

Check / Download firmware 2.7.2

Figure 2.13. Principle of firmware upgrading

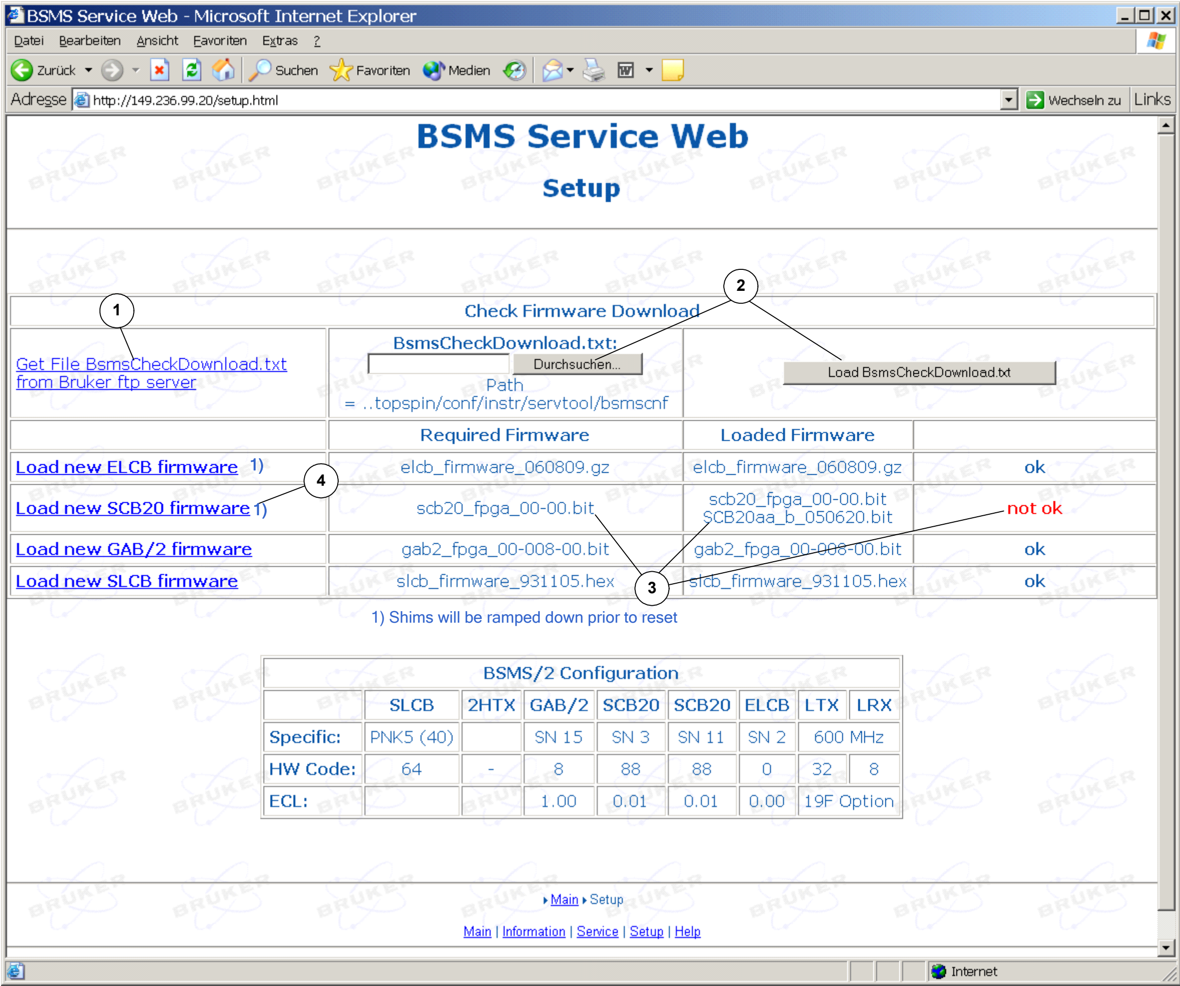


With every TopSpin installation there are also the necessary firmware files installed on the workstation. In addition, the latest firmware versions can be downloaded from the Swiss ftp server. The actual download to the hardware has to be performed by the customer or by a service engineer. This ensures that there is no accidental overwriting of currently loaded firmware versions.

1. One has to make sure that the file „BsmsCheckDownload.txt“ is up to date - if necessary, this file can be downloaded from the Swiss ftp server.
2. The file „BsmsCheckDownload.txt“ has to be transmitted to the BSMS/2.
3. According to the „BsmsCheckDownload.txt“ file and the hardware codes of the connected subsystems the required firmware versions are evaluated and displayed - outdated or incompatible versions are marked as „not ok“ and a related error message is issued.
4. Missing firmware files can be downloaded from the Swiss ftp server. When all the necessary files are available on the local hard disk, the outdated firmware components (marked as „not ok“) have to be installed on the corresponding BSMS/2 subsystems.

Note 1): When a new ELCB or SCB20 firmware is being loaded, the Shim currents are ramped down slowly before the hardware reset - in order to minimize eddy currents in the magnet. After restart (or after power up), the Shims are started up softly as well. The timing of the Shim ramp can be adjusted in the Shim Configuration submenu (Shim Soft Start/Shut Down Duration).

Figure 2.14. Setup of the BSMS/2 firmware



In addition to the firmware information, there is also the hardware configuration displayed on the „Setup“ screen: In our example, it is a 600 MHz configuration with two SCB20 providing maximum 40 Shims (BOSS2 / 3 / WB ..), GAB/2, SLCB with PNK5 and the 19F Lock Option installed. The new boards provide the BIS information, including Serial Number and the ECL.

Calibration and system configuration overview 2.7.3

The Web page „Main“ -> „Calibration“ provides the links to the individual necessary calibration / system configuration procedures.

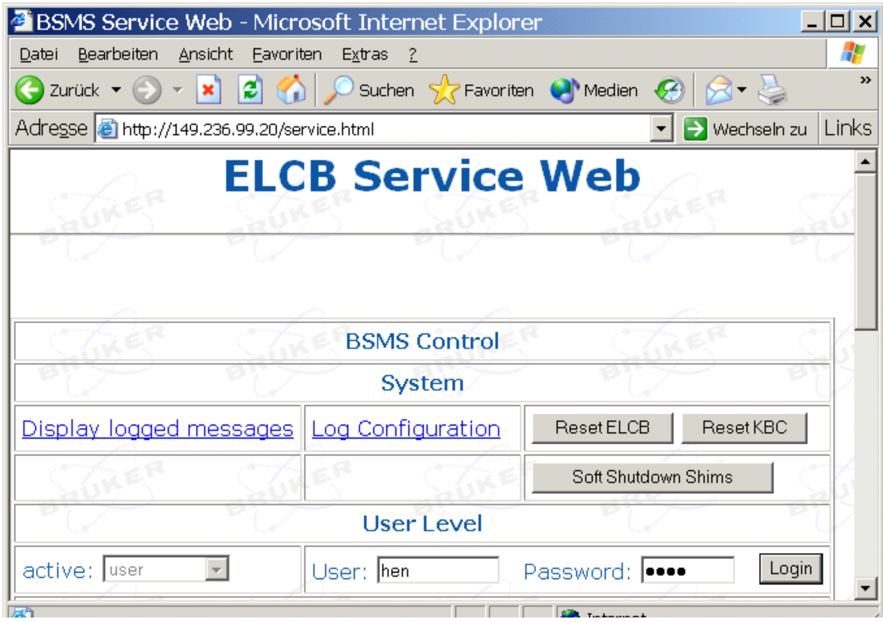
Figure 2.15. Calibration and System Configuration

Establishing the Service Engineer Access Level 2.7.4

Some of the calibration procedures can be done by the customer. However, there are critical settings such as the Helium Level Measurement Calibration, which needs to be executed by a service engineer. It is necessary to have the according access rights to manipulate these parameters.

The access rights for service engineers can be obtained on the Web page „Main“ -> „Service“ (user name and password required, see below) - they expire after one hour.

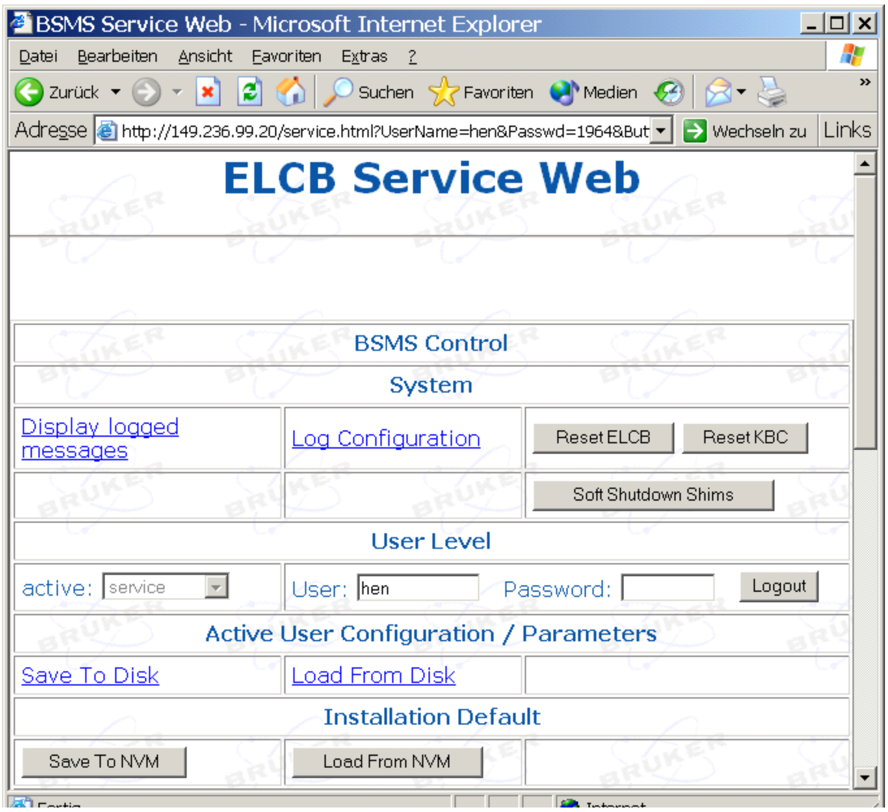
Figure 2.16. Log in as service engineer



Type in your user name (example „hen“) and the four digit service access code (last four digits of the BSMS keyboard password). Depress the button „Login“.

When you have successfully logged in, then there are additional buttons available (e. g. Installation Default: Button „Save To NVM“).

Figure 2.17. Service Page after successful service engineer registration



Lift and Spin Calibration 2.7.5

The procedures for Lift and Spin calibration are available on the corresponding Web pages. Basically, the procedures are similar to the former BSMS/2 calibrations (see also in the SLCB manual). However, the handling by the service tool has been improved and simplified - the necessary actions can be initiated by simply select the appropriate buttons, and each step of the calibration is listed / described on the Web page.

For systems with BSMS/2 SPB, the spin calibration (needle valve) is no longer necessary.

Helium Level Measurement Calibration 2.7.6

Similar to the former Helium Level Measurement Calibration (see also in the SLCB manual) there is an improved and simplified version provided by the Service Web. It is necessary to have service engineer access rights to perform this calibration. Each step of the calibration is listed / described on the Web page.

Auto Lock Calibration 2.7.7

The „Auto Lock“ feature is based on performing a simple 2H experiment on the solvent (see also in the former Lock manual). According to the peak frequency of the resulting FID either the H0 field (normal case) or the shift (optional) are adjusted.

The relation factor between frequency and H0 field is influenced by the Shim System (there are different factors for standard, wide bore and super wide bore magnets) and may additionally vary slightly between different exemplars. Therefore there is a calibration procedure provided for perfect adjustment of this factor. It is necessary to have a sample inserted (with any solvent of the specific nucleus). The calibration can be executed simply by depressing a button - the procedure takes about one minute. After a successful calibration, the Auto Lock is able to lock in even if the field has drifted very far away from the correct value.

Setup of the Pulse / Signal polarities 2.7.8

The polarities of the trigger signals (Lock Hold, TP-F0 for the Lock Transmitter path and the external synchronization signals for RCP shimming) can be set according to the connected hardware. It is necessary to have service engineer access rights to modify these values.

Final steps of an installation 2.7.9

Once the installation has been completed successfully, a backup of the resulting configuration can be saved on the nonvolatile memory (NVM). This fail-safe configuration can be re-activated later for switching back to a known state.

The sub-chapter „Installation Default“ on the Web page „Main“ -> „Service“ provides the button „Load from NVM“ for re-activation of these installation settings (available for all users).

The button „Save to NVM“ in the same sub-chapter is reserved for service engineers (login required) and provides storing a backup of the installation settings onto the nonvolatile memory.

Additionally, it is possible to transfer the complete BSMS/2 configuration to the workstation, where it can be stored as a text file - this function is available for all users, under the sub-chapter „Active User Configuration / Parameters“.

For logged in service engineers it is possible to retrieve a configuration from the workstation and re-activate its settings.

Replacing boards *2.8*

Important: Before removing an SLCB, PNK or SPB board, it is recommended to make sure that there is no sample remaining in the magnet!

If the ELCB is being replaced then the Shim values have to be stored by typing the TopSpin command „wsh“.

Then the Shims can be ramped down softly by depressing the button „Soft Shutdown Shims“ on the page „Main“ -> „Service“ (see also figure 2.11 and 2.12). When the ramp down of the Shims is complete, the message „Shims shut down. Switch BSMS Power Off“ appears, and the BSMS/2 can be switched off for the replacement of the boards.

When the BSMS/2 has booted with the new hardware, the page „Main“ -> „Setup“ has to be opened, and it has to be checked if the firmware versions of all connected subsystems are correct. It may be necessary to download the required version from the Swiss ftp server and to install the firmware on the according board.

If the ELCB is one of the new boards then the complete calibration procedure has to be performed after the firmware check (as described before).

Diagnostic and Trouble Shooting *2.9*

In case of a problem regarding the BSMS/2, check the following points:

- Are all power voltages ok? Check the LED's on each subsystem indicating if it is correctly powered. At the rear side of the BSMS/2 rack, there are two additional rows of LED's belonging to the power supplies, which have to be checked as well.
- Are all firmware components up to date? It may be necessary to load the current BsmsCheckDownload.txt file from the Swiss ftp server and do the checks as described before.

For further investigations, the BSMS/2 provides a detailed logging service. The latest information can be retrieved under the menu point „Main" -> „Service" -> „display logged messages". On the same Web Page, there is a button for resetting the buffer before running a specific command sequence.

Additionally, it is possible to activate periodical transfer of that logging information to the hard disk of the workstation. This feature is available in TopSpin (version 2.0 or higher) by typing the command „bsmsdisp" and selecting the Service Tab. There is a check box for enabling this transfer and a button for viewing the stored long term information.

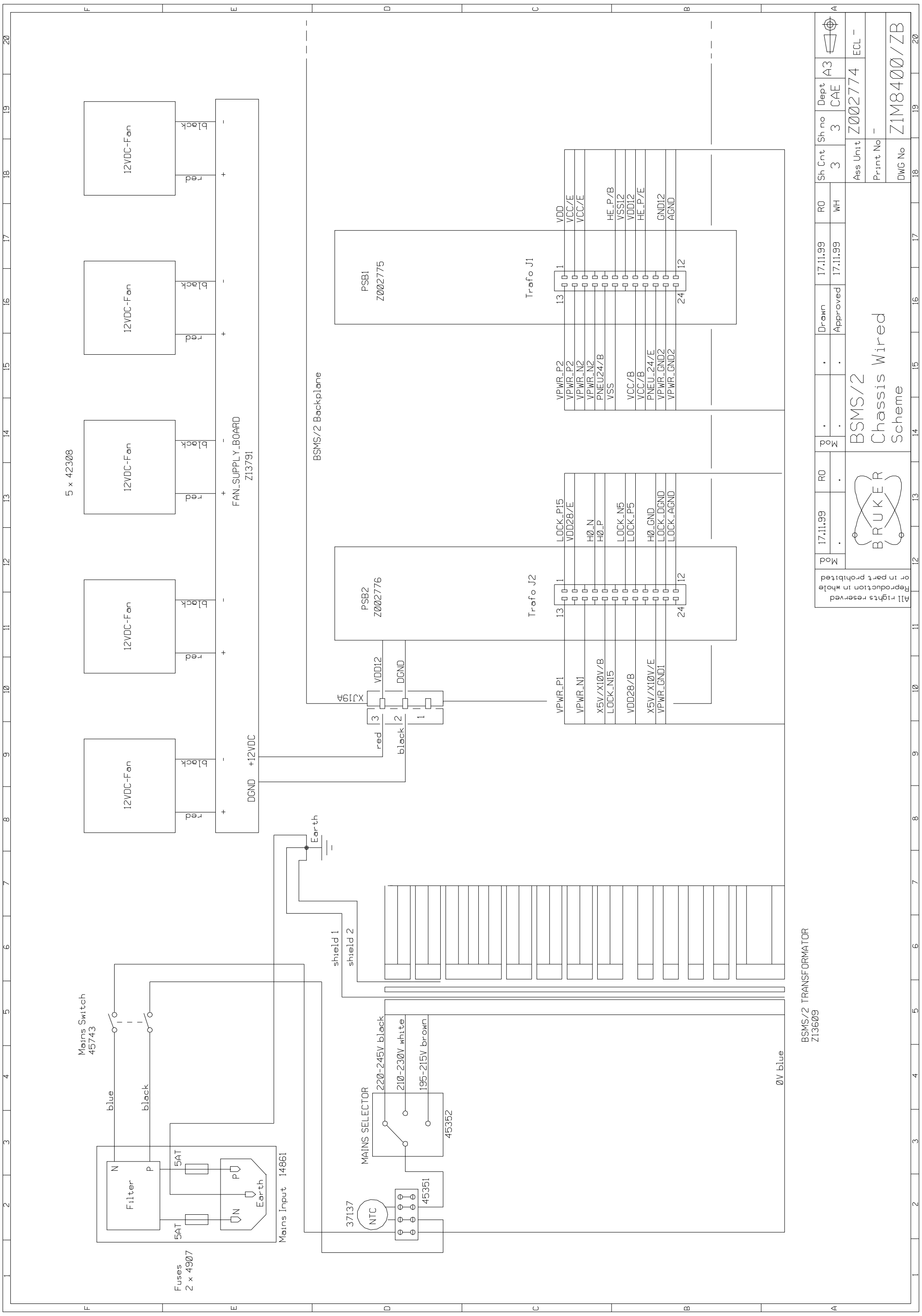
It may be necessary to configure the logging (how detailed some events are logged), which is provided under the menu point „Main" -> „Service" -> „Log Configuration".

There is a watchdog task running on the ELCB. If the application is blocked for a long time then the BSMS/2 is rebooted. The watchdog function, which is normally active, can be disabled on the service main page (service access is necessary).

After a restart, the logging of the session before - the post mortem log - is still available (depress „PostMortem" button on the page „display logged messages"), providing additional information.

AC / DC Wiring 2.10

Figure 2.18. AC / DC wiring and power supplies



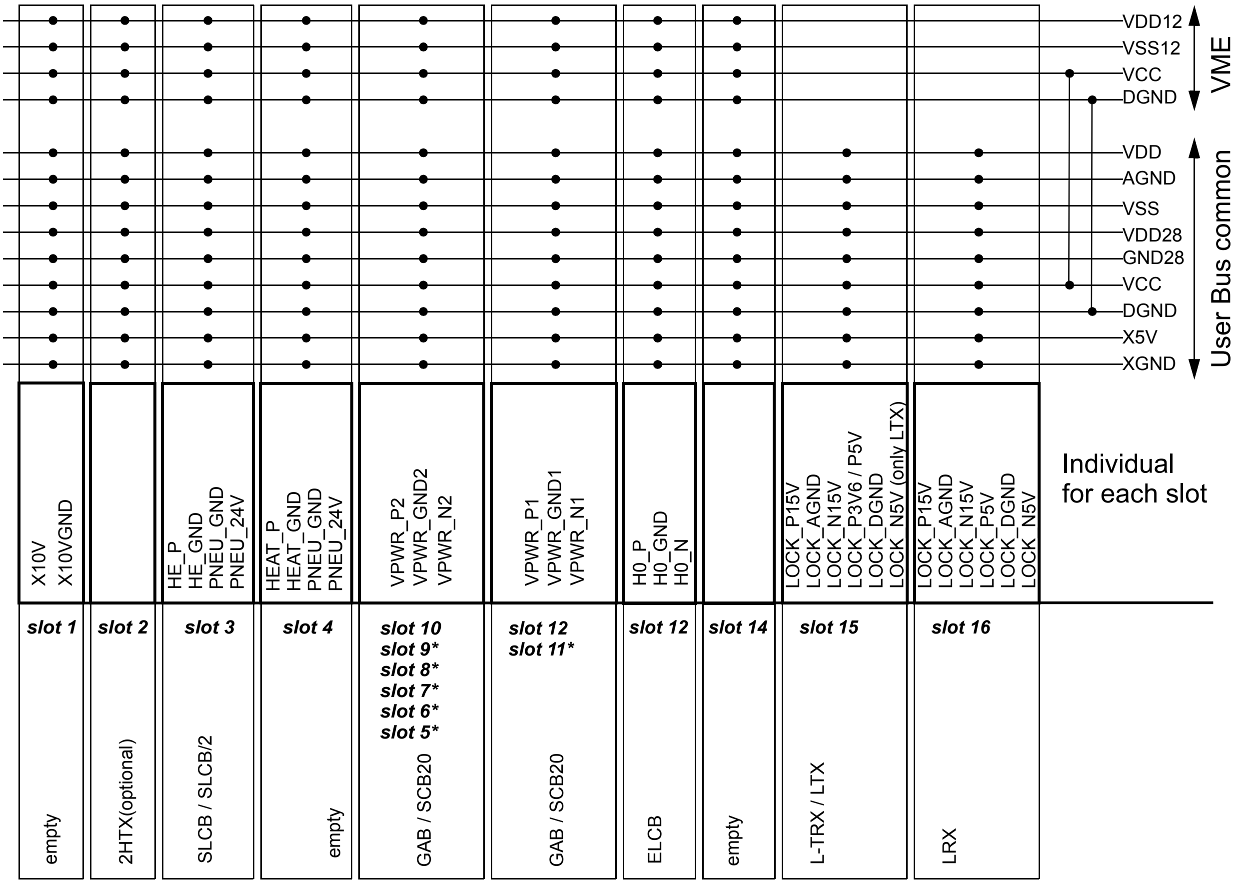
DC Power distribution *2.11*

The diagram below shows the DC power distribution for the different slots. All slots except 15 and 16 are connected with the VME bus (and therefore with the corresponding supply). There is a set of common supply voltages provided by the user bus (VDD / AGND / VSS ... XGND), which are assigned identically to the connector pins in the different slots (see also in the detailed user bus connector description).

Additionally, there are individual power supply voltages for some slots (e. g. X10V, X10VGND, ...) that are accessible via the user bus connector and by an extra power connector as well. It is therefore possible to configure the backplane by interconnecting extra power connectors of different slots (e. g. providing the voltages X10V and X10VGND of slot 1 also for the slot 2).

On the other hand, it is possible to disable certain individual power voltages by cutting the corresponding wire bridge (possible for VPWR_P2 / VPWR_GND2 / VPWR_N2 in slot 5 .. 9, VPWR_P1 / VPWR_GND1 / VPWR_N1 for slot 11). As a further option, the power pins cut from the original voltages can then be supplied externally / from another slot by the extra power connector.

Figure 2.19. Power distribution by BSMS/2 backplane



* The individual power supplies in these slots can be disabled by cutting the related wire

Note: There is a common neutral point for the different ground levels (AGND, DGND and GND28) which is joined by a 22 uH inductance with the frame ground.

Backplane 2.12

Figure 2.20. Backplane - Slot 1 to 4

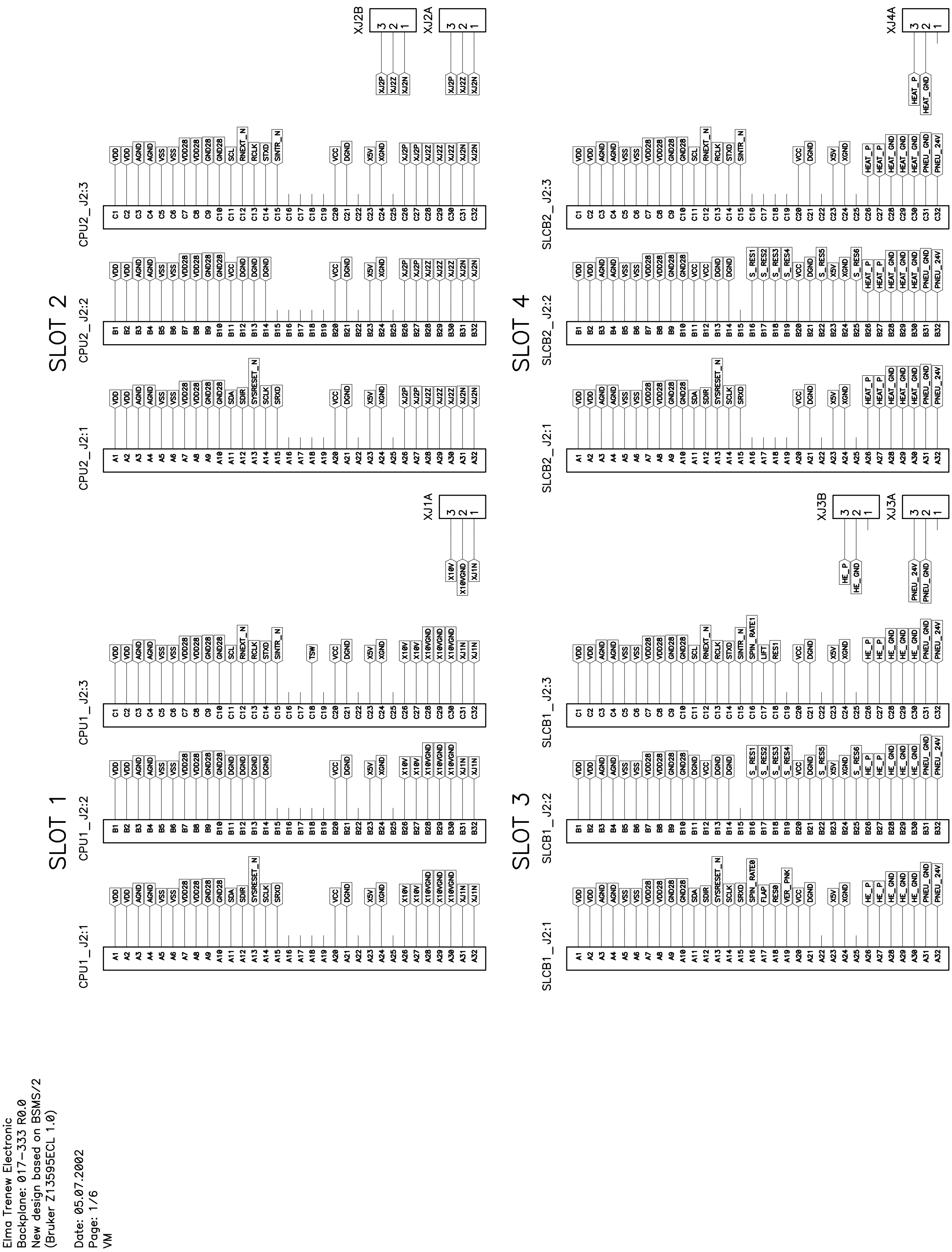


Figure 2.21. Backplane - Slot 5 to 8

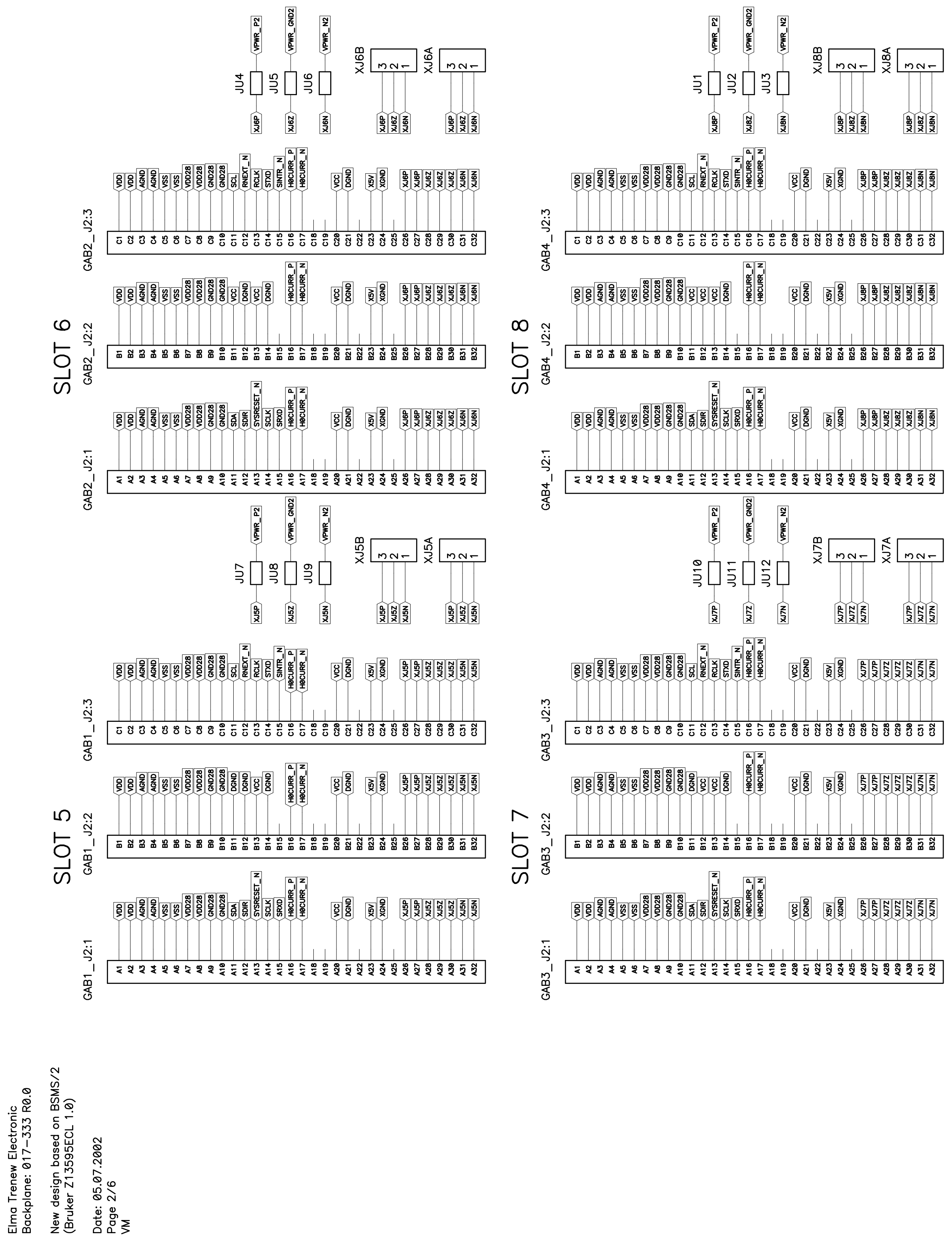


Figure 2.22. Backplane - Slot 9 and 10

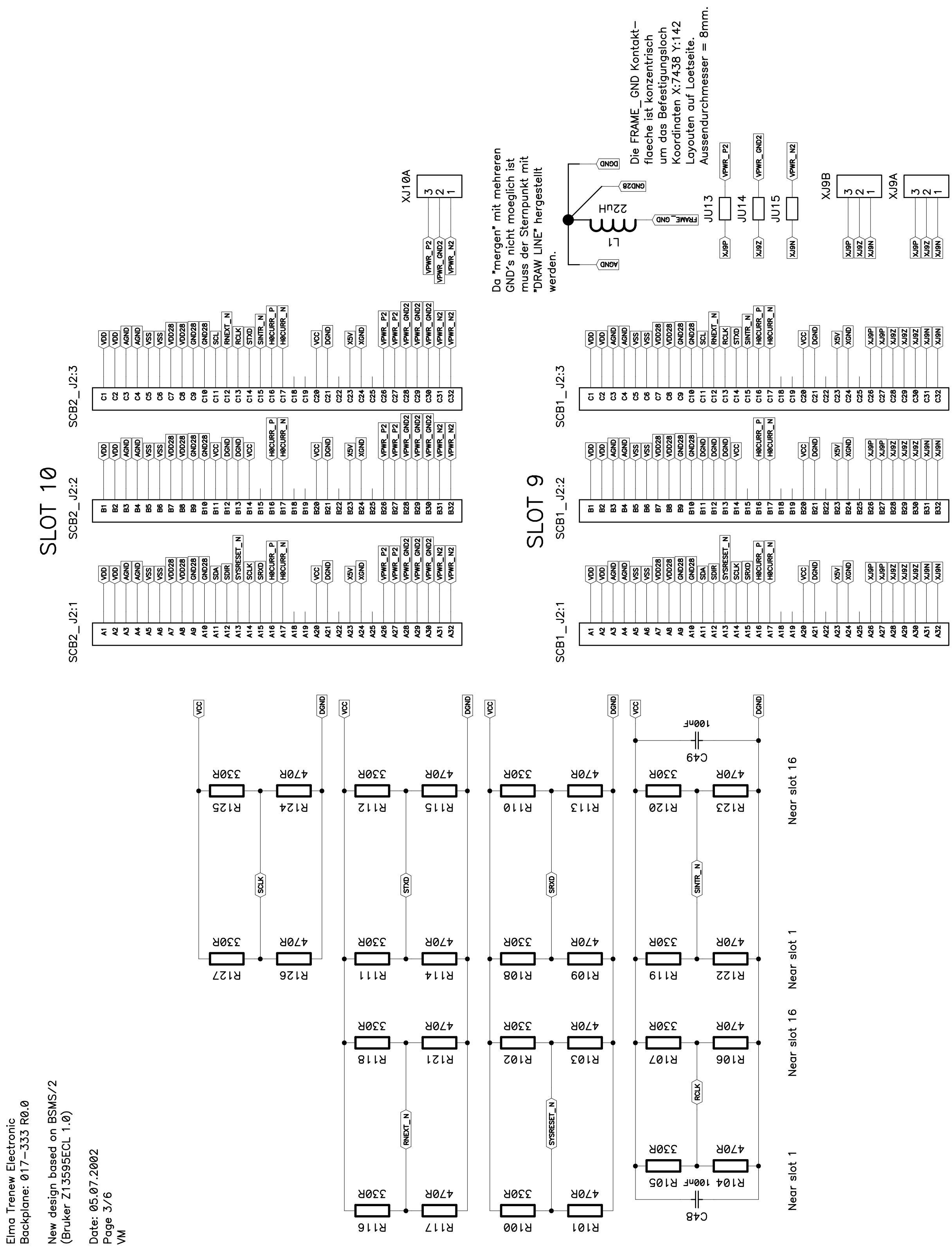


Figure 2.23. Backplane - Slot 11 to 14

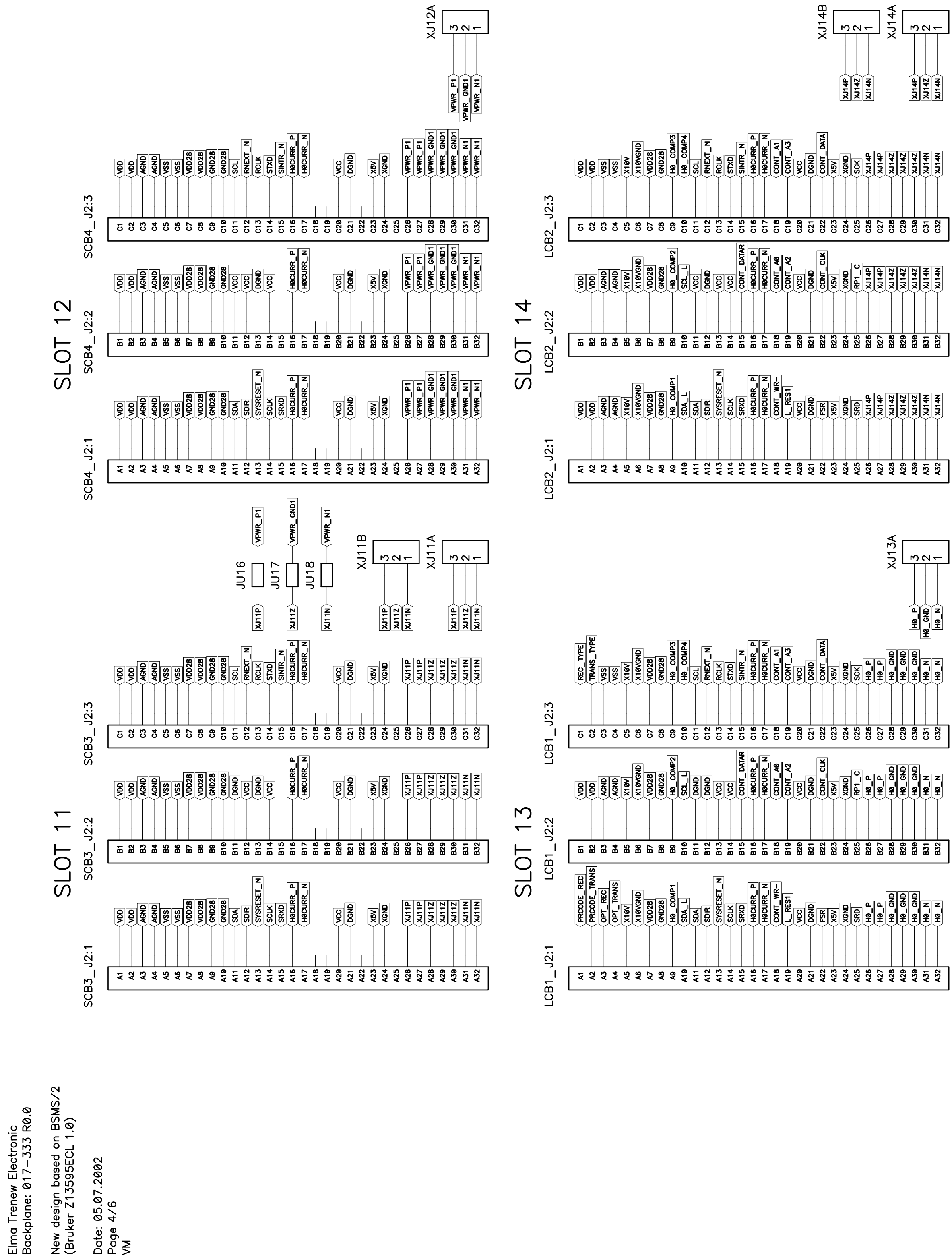


Figure 2.24. Backplane - Slot 15, 16 and 17

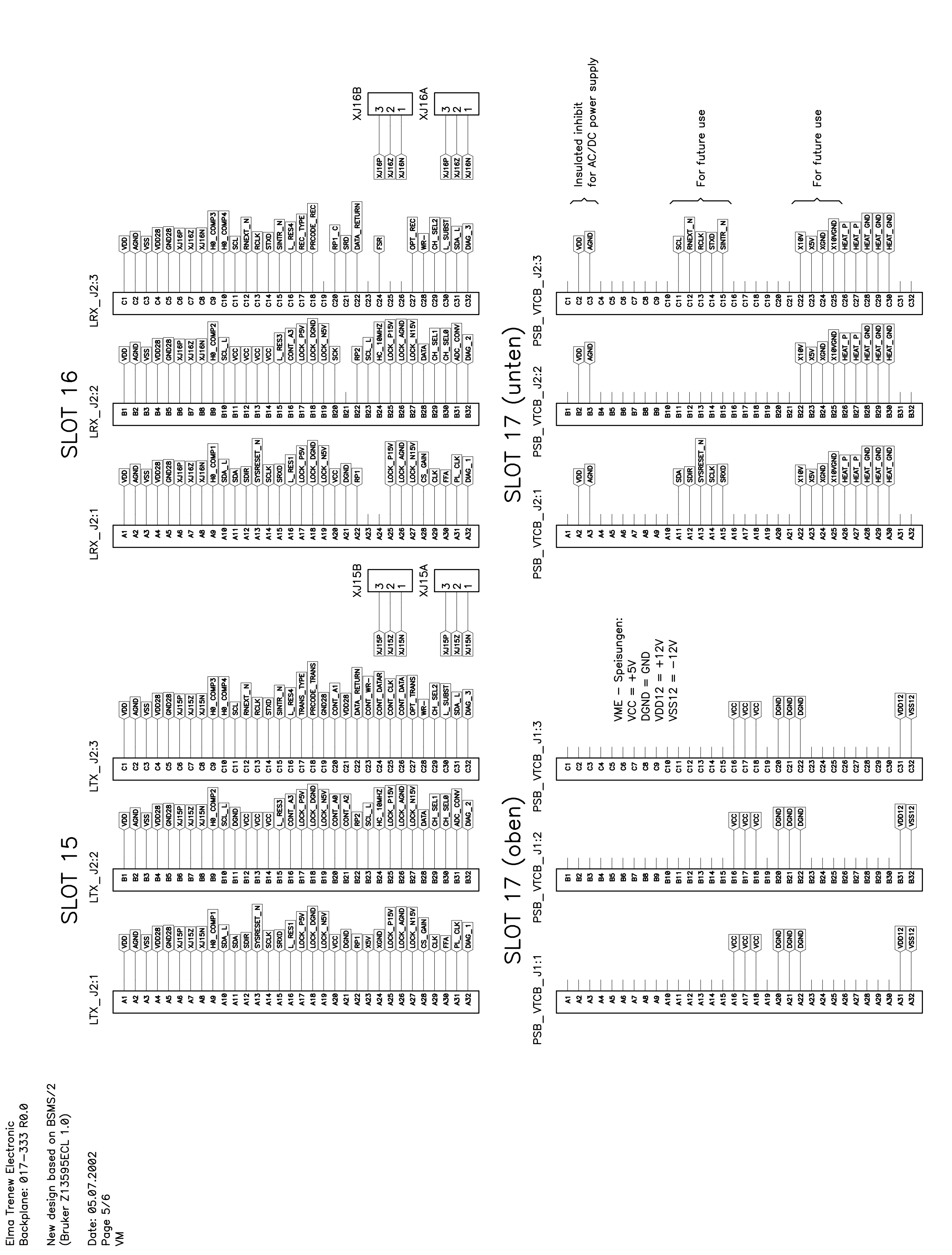
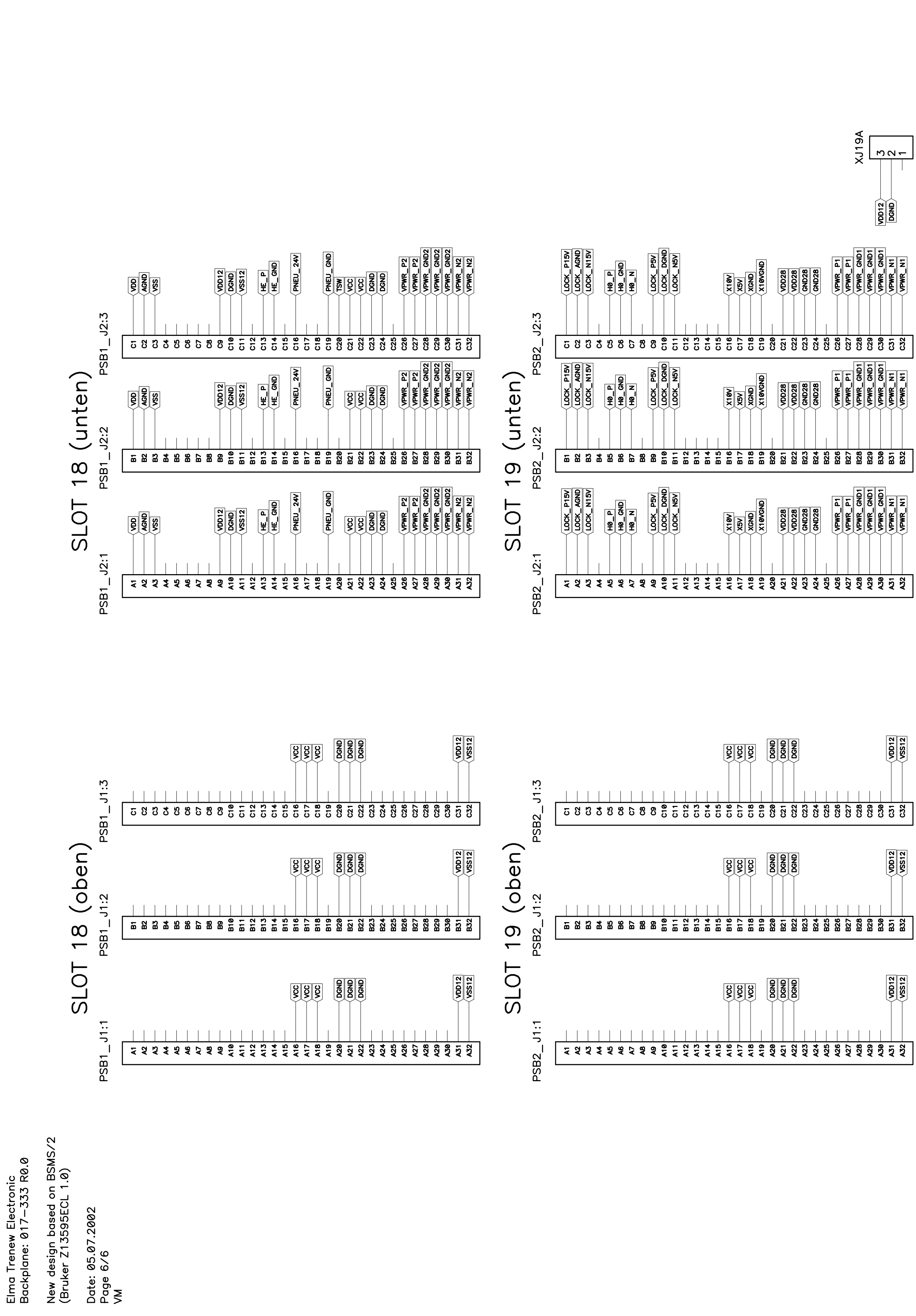


Figure 2.25. Backplane - Slot 18 and 19



Power Supplies *2.13*

There are two different Power supply boards that are plugged from the rear side into the backplane - PSB5 or PSB2 at the left side, PSB1 at the right side.

Behind each LED (indicating that the according voltage is available) there is the corresponding fuse (which can be exchanged without plugging out the PSB).

Table 2.2. PSB1 Electrical Characteristics (SLCB / PNK configurations)

Voltage Name (LED)	Reference	Voltage @ rated load	Current @ rated load	Voltage ripple	Fuse
VCC	DGND	5 +/- 0.1 V	5.0 A	20 mV	6.3 AT
VDD12	DGND	12 +/- 0.7 V	2.5 A	30 mV	3.15 AT
VSS12	DGND	-12 +/- 0.7 V	2.5 A	30 mV	3.15 AT
HE_P	HE_GND	35 .. 42 V	0.4 A	1 V	0.63 AT
PNEU_24V	PNEU_GND	21 .. 27 V	1.0 A	1.5 V	1.25 AT
VDD	AGND	15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VSS	AGND	-15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VPWR_P2[a]	VPWR_GND2	20 .. 25 V	6.0 A	1 V	8.0 AT
VPWR_N2[a]	VPWR_GND2	-20 .. -25 V	6.0 A	1 V	8.0 AT

Table 2.3. PSB2 Electrical Characteristics (LTX / LRX configurations)

Voltage Name (LED)	Reference	Voltage @ rated load	Current @ rated load	Volt. ripple	Fuse
VDD28	GND28	27.8 +/- 1.1 V	2.0 A	20 mV	2.5 AT
H0_P	H0_GND	29.5 +/- 1.8 V	0.5 A	20 mV	0.63 AT
H0_N	H0_GND	-29.5 +/- 1.8 V	0.5 A	20 mV	0.63 AT
LOCK_P5V	LOCK_DGND	5 +/- 0.25 V	1.0 A	20 mV	1.25 AT
LOCK_N5V	LOCK_DGND	5 +/- 0.25 V	1.0 A	20 mV	1.25 AT
X10V	X10VGND	8.5 .. 11.5 V	1.5 A	0.8 V	3.15 AT
X5V	XGND	5 +/- 0.3 V	1.0 A	20 mV	
LOCK_P15V	LOCK_AGND	15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
LOCK_N15V	LOCK_AGND	-15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VPWR_P1[a]	VPWR_GND1	20 .. 24 V	3.5 A	0.8 V	4.0 AT
VPWR_N1[a]	VPWR_GND1	-20 .. -24 V	3.5 A	0.8 V	4.0 AT

Table 2.4. PSB5 Electrical Characteristics (L-TRX configurations)

Voltage Name (LED)	Reference	Voltage @ rated load	Current @ rated load	Volt. ripple	Fuse
VDD28	GND28	27.8 +/- 1.1 V	2.0 A[c]	20 mV	4.0 AT
H0_P	H0_GND	29.5 +/- 1.8 V	0.5 A	20 mV	1.0 AT
H0_N	H0_GND	-29.5 +/- 1.8 V	0.5 A	20 mV	1.0 AT
LOCK_P3V6[b]	LOCK_DGND	3.6 +/- 0.1 V	2.0 A	20 mV	-
X10V	X10VGND	8.5 .. 11.5 V	1.5 A	0.8 V	4.0 AT
X5V	XGND	5 +/- 0.3 V	1.0 A	20 mV	
LOCK_P15V	LOCK_AGND	15 +/- 0.6 V	1.0 A	20 mV	2.0 AT
LOCK_N15V	LOCK_AGND	-15 +/- 0.6 V	1.0 A	20 mV	2.0 AT
VPWR_P1[a]	VPWR_GND1	20 .. 24 V	3.5 A	0.8 V	6.3 AT
VPWR_N1[a]	VPWR_GND1	-20 .. -24 V	3.5 A	0.8 V	6.3 AT

Table 2.5. PSB 7 Electrical Characteristics (BSVT configurations)

Voltage Name (LED)	Reference	Voltage @ rated load	Current @ rated load	Voltage ripple	Fuse
VCC	DGND	5 +/- 0.1 V	5.0 A	20 mV	6.3 AT
VDD12	DGND	12 +/- 0.7 V	2.5 A	30 mV	3.15 AT
VSS12	DGND	-12 +/- 0.7 V	2.5 A	30 mV	3.15 AT
HE_P	HE_GND	35 .. 42 V	0.4 A	1 V	0.63 AT
PNEU_24V	PNEU_GND	24 +/- 0.3 V	1.0 A	20mV	1.25 AT
VDD	AGND	15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VSS	AGND	-15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VPWR_P2[a]	VPWR_GND2	20 .. 25 V	6.0 A	1 V	8.0 AT
VPWR_N2[a]	VPWR_GND2	-20 .. -25 V	6.0 A	1 V	8.0 AT

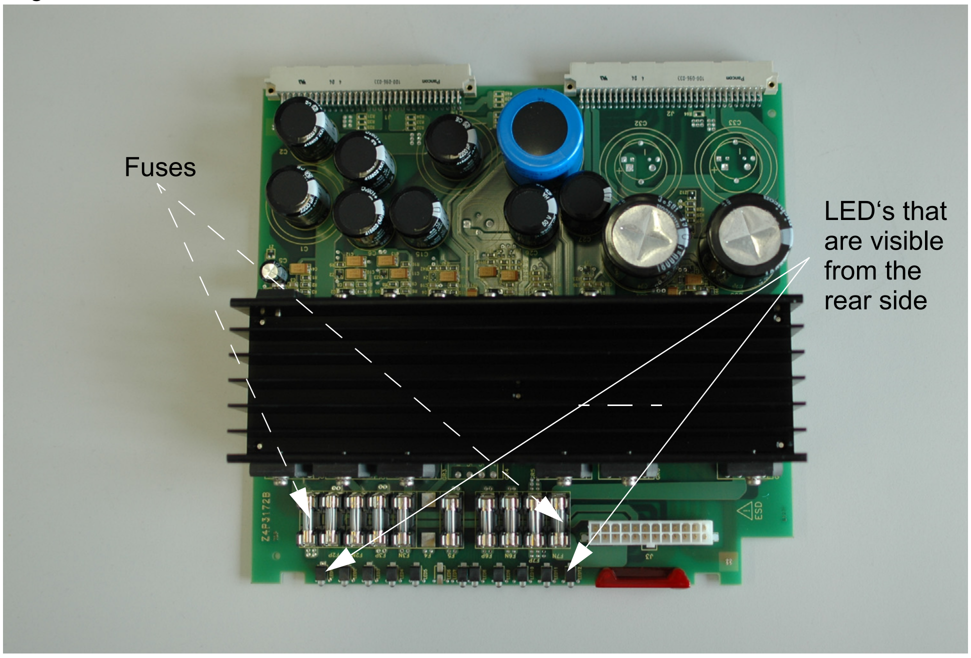
Note[a]: In contrast to the power supply naming, VPWR_P2 / GND2 / N2 belong to the power supply PSB1/PSB7 whereas PWR_P1 / GND1 / N1 belong to the power supply PSB2 or PSB5 respectively.

Note[b]: This voltage is generated by a DC/DC converter from VDD28.

Note[c]: In addition to this current, the supply current for the DC/DC converter (LOCK_P3V6) has to be considered as well.

Note: The shaded rows indicate that the referred voltages are non-regulated.

Figure 2.26. View of a PSB2 module

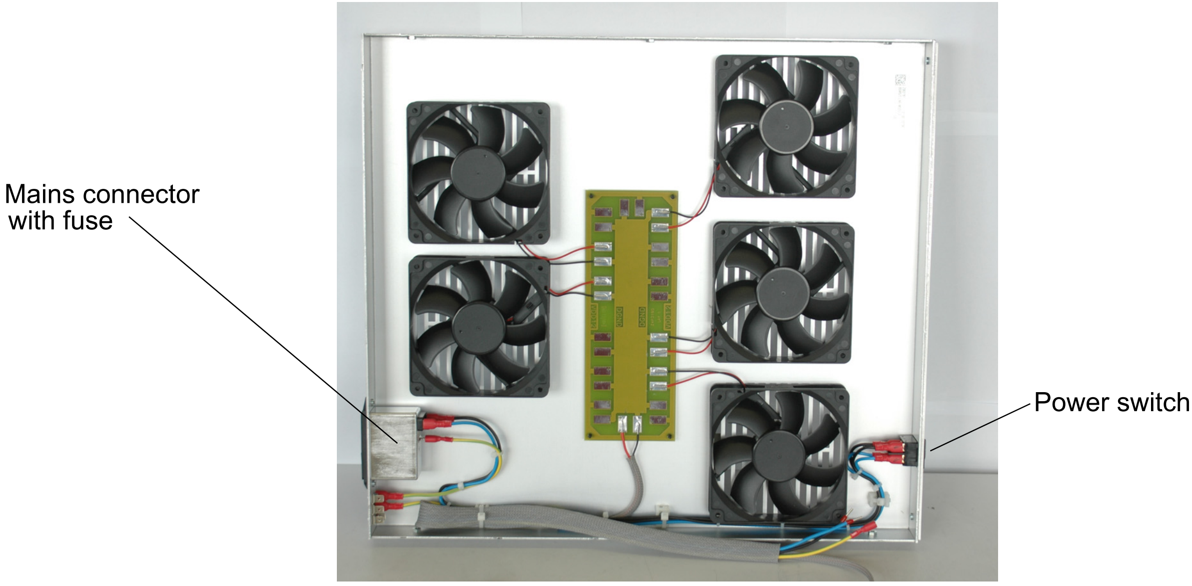


The PSB1, PSB5 and PSB7 are similar - they are based on the same printed circuit layout, but with different components on it.

Fans — *2.14*

On top of the BSMS/2, there is the fan tray, which can be lifted up when the according screws are removed. It contains also the mains connector, the fuses and the power switch.

Figure 2.27. Fan Tray



Fan Repair procedure — *2.14.1*

Warning: Before you remove a fan (e. g. a defect one), make sure that the mains cable is disconnected.

Figure 2.28. Fan Tray removal, step by step

1) Remove screws of the fan tray

2) Solder out the two wires connecting the fan to be removed

3) Cut the fan rubber fittings and remove the fan

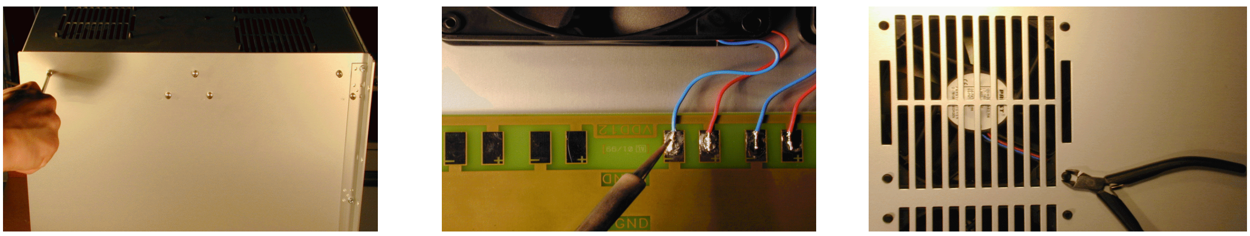
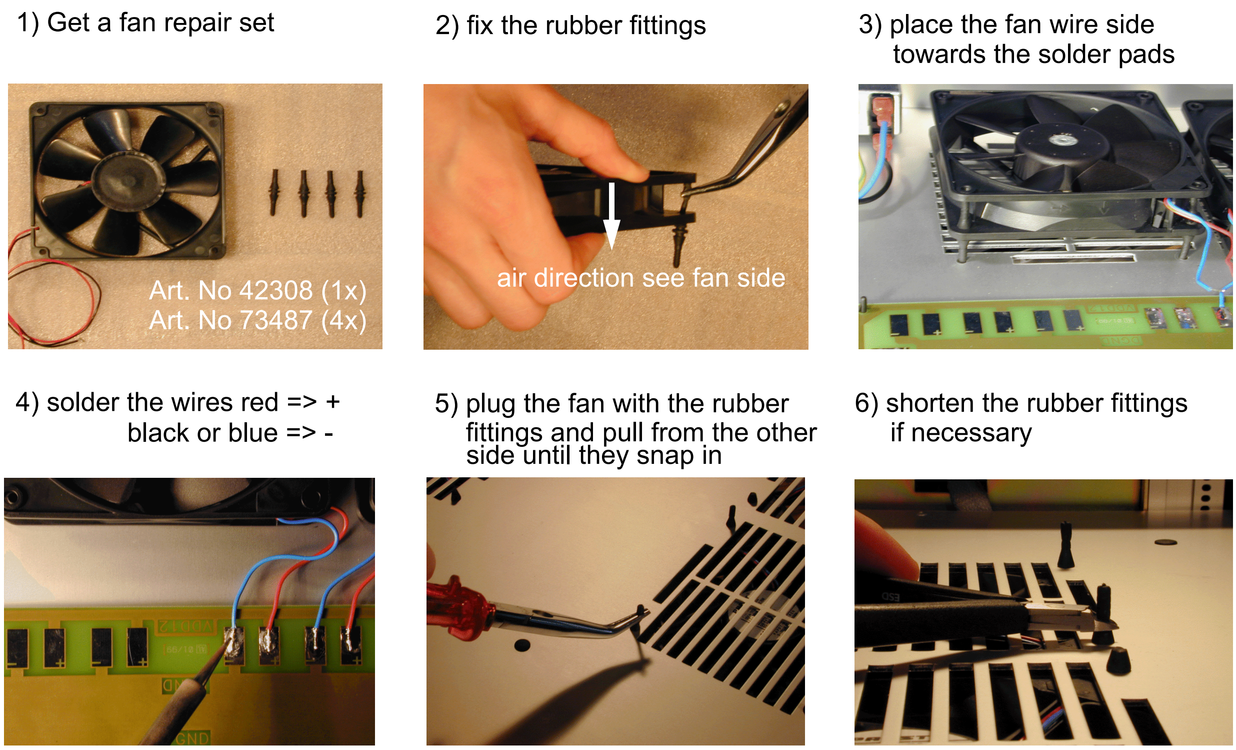


Figure 2.29. Fan Tray Reassembly, step by step



ELCB 3

Introduction 3.1

The Extended Lock Control Board (ELCB) combines two former boards, the CPU and the LCB. Therefore it provides two main functions - the Digital Lock (as it is described in the Deadalus Lock Manual) and the control of the complete BSMS/2, (e. g. Shim, Lift, Gradient Amplifier). The latter functions are described in the BSMS/2 mainframe and related subunit chapters.

All former Lock functions have been adapted to the new hardware platform. The analog design of the current source is basically the same as on the LCB, however some of the former components have been replaced by modern ones. Therefore, the electrical performance could be improved in parts.

Using the same algorithm for evaluation of the closed loop Lock regulation, the new ELCB is fully compatible with the LCB. It has the same or a better performance for NMR experiments. Both, the new L-TRX and all former L-RX / L-TX board versions (including the 19F options) are supported by the new ELCB.

Since the new DSP has a much higher performance, it provides faster handling of real time Lock Hold pulses, which now may range down to a length of 100 microseconds.

Additionally, it was possible to implement a more sophisticated method for locking in, which is now very reliable. While the Lock is sweeping, the „wiggles“ of the Lock signal are now analyzed. This provides a simple and fast lock in. The Auto-Lock functions have been optimized as well.

Lock Parameters and Technical Data 3.2

Table 3.1. Parameter and Technical Data

Parameter	Min	Factory Default	Max	Unit	Notes
Lock Field (H0)	-9999 -170	+5000	+9999 +170	Field Units mA	
Lock Regulator	-99 -1.70	0	+99 +1.70	Field Units mA	
Sweep Amplitude	0	100 4000 68.0	100 4000 68.0	Sweep Units Field Units mA	

Table 3.1. Parameter and Technical Data

Parameter	Min	Factory Default	Max	Unit	Notes
Sweep Rate	0.01	2.00	5.00	Hz	
Lock Phase	0.0	180.0	359.9	Degrees	1)
Lock Power	-50.0 -60.0 -60.0	0.0 0.0 0.0	+10.0 +0.0 +10.0	dB dB dB	2)
Lock RF Gain 2H Lock RF Gain 19F	75.0 55.0	120.0 120.0	155.0 135.0	dB dB	
Lock Shift	-200.0	0.0	200.0	ppm	
Lock Drift	-2000.0	0	2000.0	Field Units / 24 hours	3)
Current Noise			400	nA (pp)	4)
Current Source Bandwidth	600			Hz	5)
Lock Hold active	100			us	
Lock Hold inactive	100			us	
Lock Hold latency			100	us	

General Note: Any of the values listed above may change without notice.

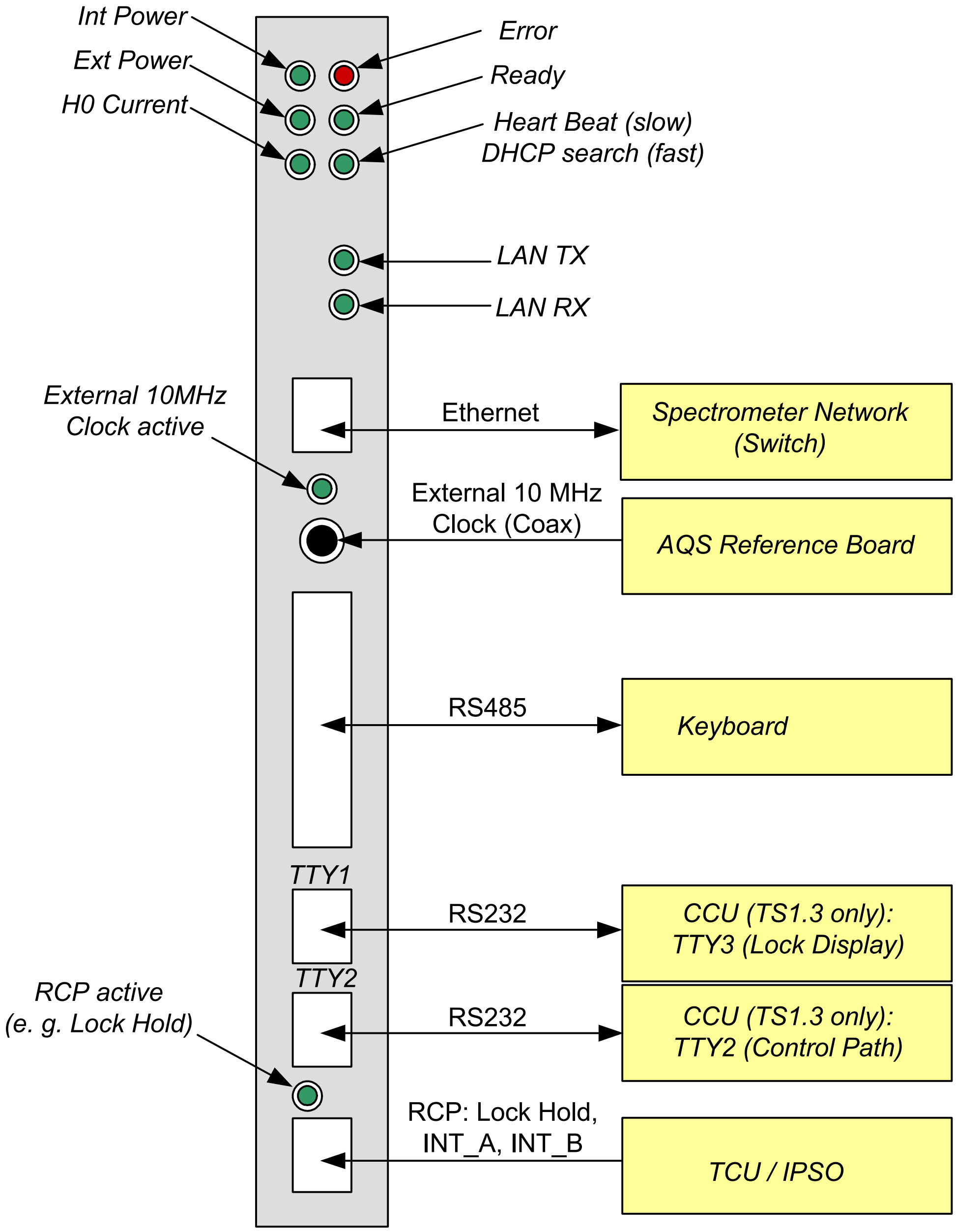
1. Values from -1000.0 to + 1000.0 degrees are accepted, however the actual phase is evaluated modulo 360 degrees.
2. The actual range depends on the hardware code and on the frequency: The first series of RF boards (HW code 0) had a range from -50 to +10 dB, the next following series (HW code 1 and higher) had a range from -60 to +0 dB. For frequencies of 600 MHz and above, this range has been extended (-60 dB to +10 dB) on the hardware versions 6 and higher.
3. This value is used for static drift compensation with manual evaluation / definition of the drift rate (called „Manual Drift Compensation“, e. g. in solids configuration). Static / manual drift compensation is active while the lock is not sweeping.
4. Maximum Noise between 0.01 Hz and 10 Hz
5. Minimum range of -3dB point

Configuration and wiring 3.3

The drawing below shows the front panel of an ELCB with the LED‘s and connectors. For TopSpin 2.0 at least the Ethernet, the 10 MHz reference clock and the RCP input have to be connected accordingly.

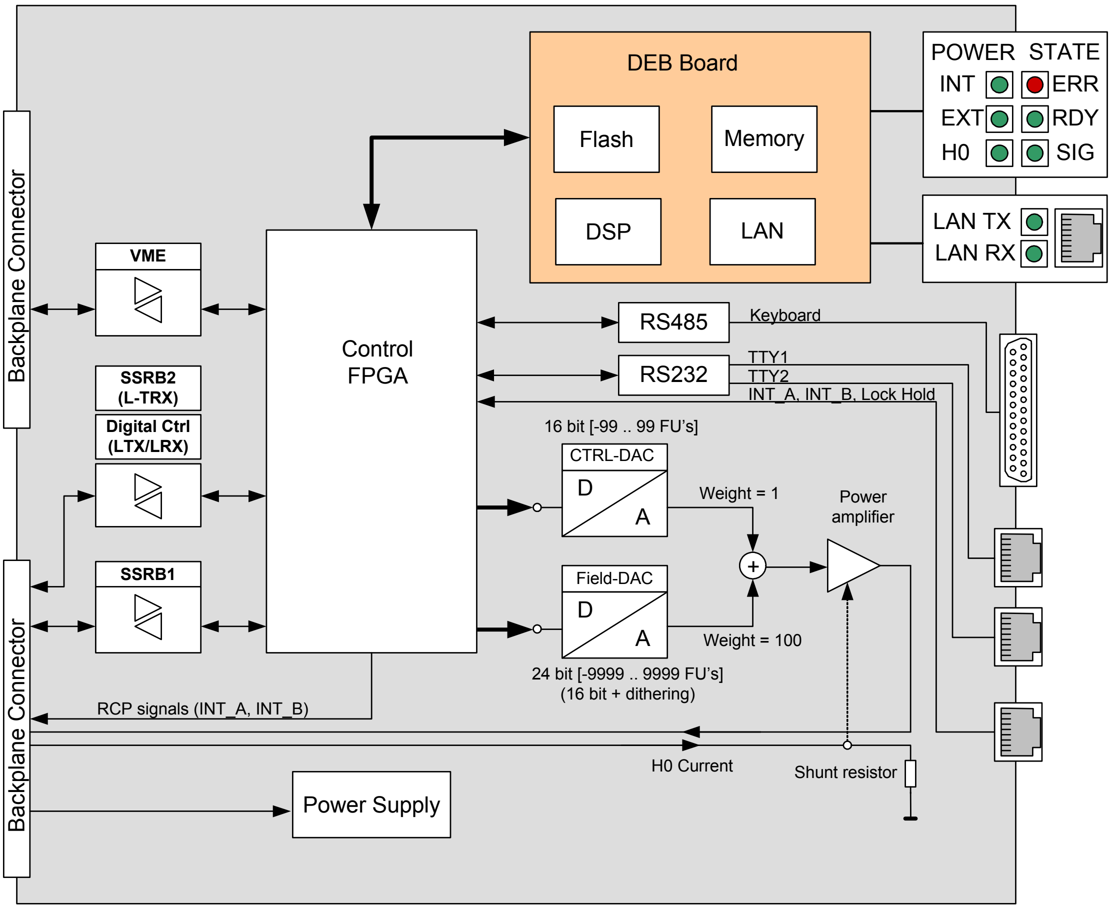
There is a dedicated connector for the optional Keyboard, and in a TopSpin 1.3 (or similar) configuration, the two TTY links have to be connected for communication with the former SBSB protocol and for sending the Lock Display data over RS232.

Figure 3.1. ELCB front panel with LED‘s and connectors



System Architecture / Overview 3.4

Figure 3.2. Functional system architecture



The processor board (DSP Ethernet Board DEB) is a separate board plugged onto the base board. It contains a TI signal processor with memory, Flash and the electronics that provides access to the ethernet.

A central control FPGA handles the access to the peripheral hardware - new BSMS/2 boards (e. g. SCB20, GAB/2, b, VPSB) communicate over SSRB, whereas the former SLCB/2 is controlled over the VME bus. There are three RJ45 connectors, two of them are TTY ports, which provide access for TopSpin 1.3 (and similar). Real time signals (INT_A and INT_B for RCP-Shimming, Lock Hold) are now connected with the ELCB. The 2H-TX - or alternatively the RCB - is no longer needed for this purpose, and real time signals that are routed to the 2H-TX have no effect in an ELCB based BSMS/2.

The Keyboard support, which has formerly been implemented in the CPU, is now provided by the ELCB (see also description in the overview chapter).

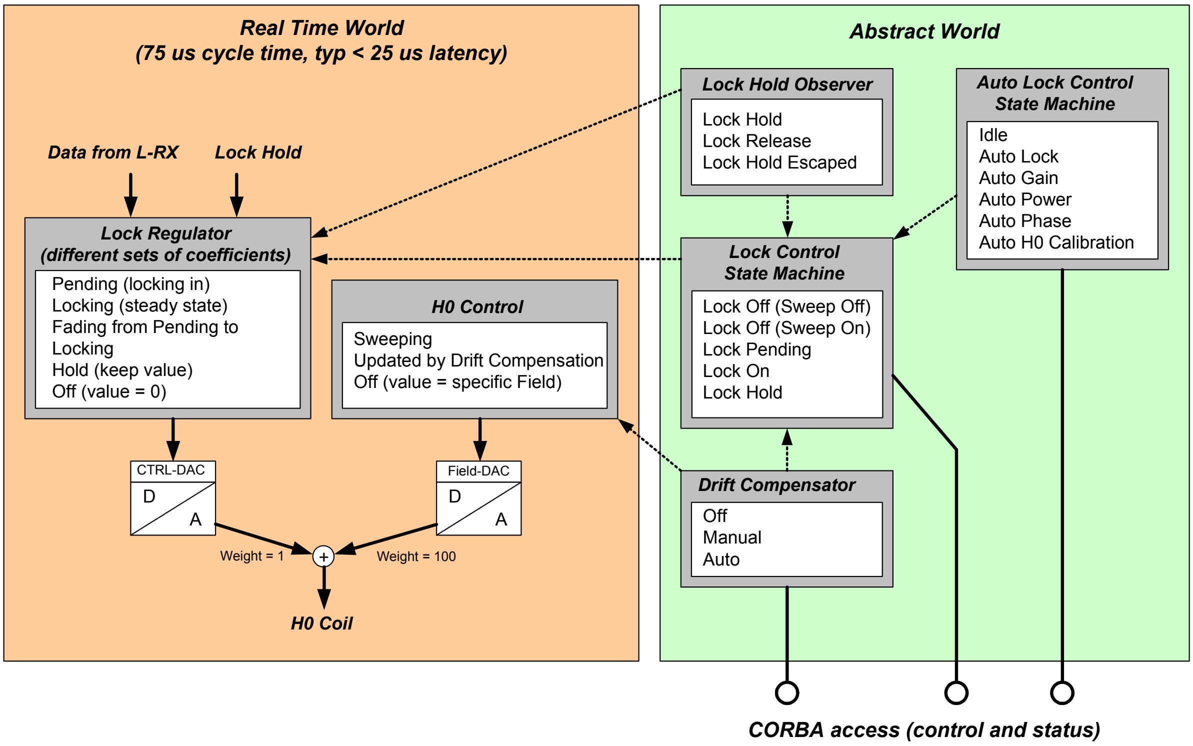
Protection 3.4.1

The power amplifier providing the Lock current for the H0 coil is protected against short circuits (limiting the output current) and over temperature.

Lock Software Architecture 3.4.2

Only the Lock relevant part of the software is described in the following sub chapters. The description of the overall architecture and the drivers for the other subsystems can be found in the related chapters.

Figure 3.3. Abstract control domain and real time domain



One part of the Lock software runs in „real time“ mode: An interrupt service routine is called every 75 microseconds. This routine reads the L-RX data and evaluates the corresponding Ctrl-DAC and Field-DAC values, which are applied by the Control FPGA to the hardware. The typical delay time from arrival of the L-RX data to the completion of the DAC write cycle is less than 25 micro seconds.

On the other hand, there is a more abstract part, modelling the Lock behavior and controlling higher level functions, e. g. locking in, selecting the appropriate set of Regulator Coefficients, compensating the drift and so on. This part of the software is connected with the CORBA interface - it handles requests from the TopSpin application and notifies about state changes (e. g. Lock Hold). It is non real time and may react with a delay of several milliseconds.

The Lock Hold signal affects directly the regulator, which guarantees extremely short reaction times. An external Lock Hold Observer examines every 20 milliseconds the Lock Hold state. If the regulator runs in Lock Hold mode or if a short Lock Hold pulse has been active in the mean time („Lock Hold Escaped“) then the Lock Hold Observer updates the Lock Control State Machine and notifies the registered clients - even the shortest Lock Hold pulses are indicated on the Keyboard (if connected) and in the TopSpin application.

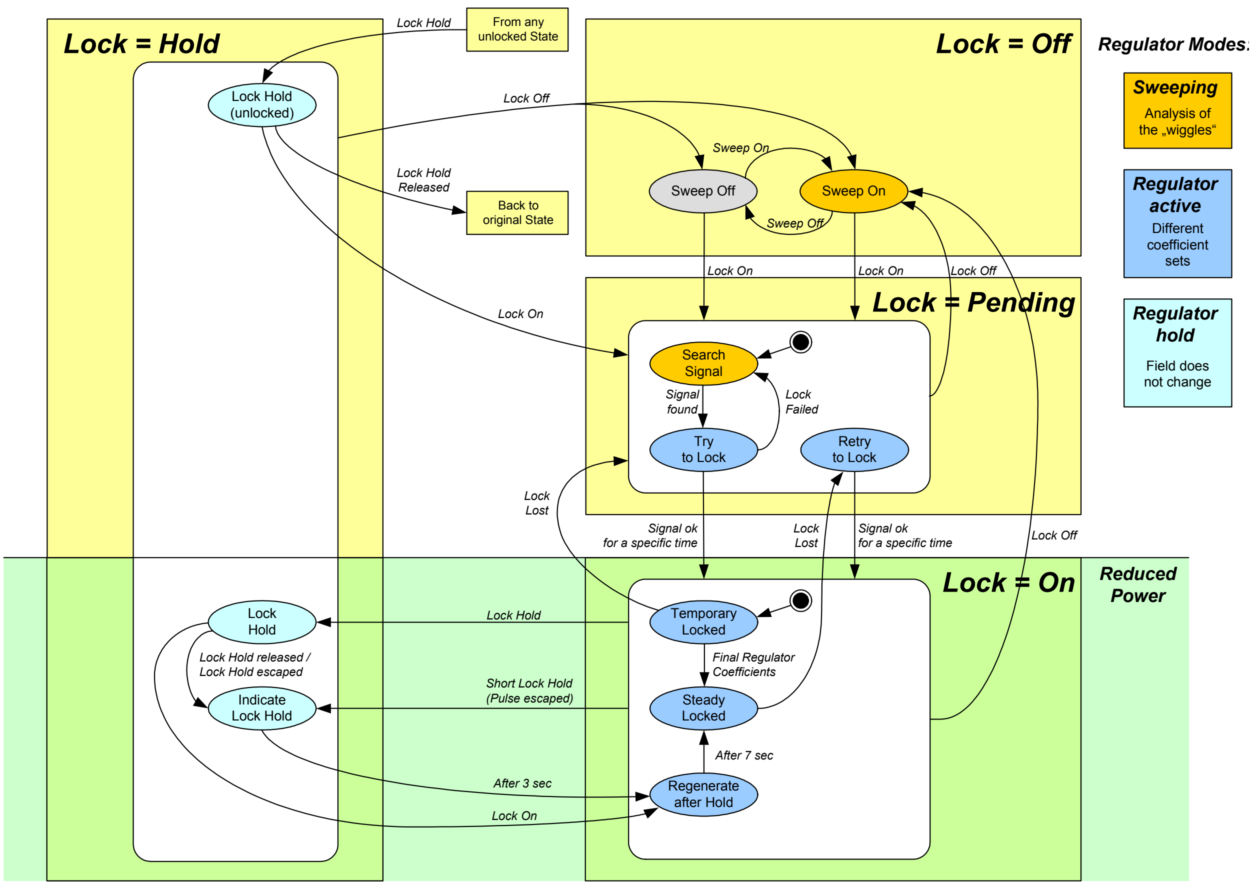
Lock Control State Machine 3.4.3

The Diagram below shows the Lock Control State Machine, which handles the requests from the CORBA or Web interface and controls the transitions between the different lock states. The lock in strategy has been improved compared to the former LCB. Nevertheless, the new procedure is fully compatible with the various TopSpin operations accessing the Lock (e. g. GradShim, TopShim).

While switched off, the Lock may be sweeping or not, depending on the parameter „Sweep“. When the Lock is switched on, then it starts by searching signal (while sweeping) and enables the Regulator as soon as the Lock Signal has fulfilled the necessary criterion. If the Lock In trial succeeds then the state machine steps through „Try To Lock“, „Temporary Locked“ and reaches in the end the state „Steady Locked“. When the lock signal gets lost in the mean time, the state machine steps back and restarts searching signal.

Lock Hold is normally issued by the Lock Hold Observer on detection of a Lock Hold pulse coming from the hardware. Alternatively, this signal can be set by the CORBA interface (intended for test purpose). The Lock Hold state can be left either by de-activating the Lock Hold signal or by switching the Lock on or off. The Lock Hold Pulse is intended to be activated when the Lock is locked in. However, the ELCB tolerates Lock Hold Pulses in any state - it returns to the original state when the Lock Hold pulse becomes inactive.

Figure 3.4. Lock state machine



Handling of high Gradient rates for Auto Shim and Drift Compensation 3.4.4

Auto Shim and Drift Compensation handles Gradient pulses at high rates similar to the LCB - if necessary, the Lock level is sampled at the optimum time.

The Auto Shim has been improved so that it is no longer necessary to adapt the Auto Shim interval to the pulse program (timing of the Gradient pulses). The ELCB guarantees now automatically the specified time interval between setting of a new Shim and the measurement of the resulting Lock level, regardless of the pulse program.

Automatic Drift compensation is hold by the Lock Hold pulse as well. However, drift compensation is evaluated every second and it is not affected by Gradient pulses shorter than 1 second.

Measurements provided for diagnostic 3.4.5

When the ELCB is started up, the following tests are performed:

H0 current measurement:

For detection of correct H0 coil connection, it is possible to measure the current that actually flows through the shunt resistor. If the H0 coil is not properly connected, an error message is issued by the TopSpin application / Keyboard.

RF board Tests (LTX / LRX):

The same set of RF board tests that were provided by the former LCB are now executed on power up by the ELCB. An additional test checks for correct connection of the 10 MHz reference signal at the L-TX board. In case of a failed test, an error message is issued by the TopSpin application / Keyboard.

It is possible to invoke these tests manually by the Service Web.

RF board Tests (L-TRX):

The new L-TRX provides a larger set of test functions, which are run automatically after power up and can be invoked manually by the Service Web for diagnostics (see also ***"Diagnostic Functions:" on page 129***).

History of Lock Regulator and Drift Compensator:

There is a history of the Lock Regulator and the Drift Compensator available on the ELCB (5 minutes with 1 entry per second, 5 hours with one entry per minute and 1 week with one entry per hour). The data is volatile and can be accessed by the Service Web.

Display / Download of the latest FFA:

While locking in initiated by Auto Lock, the Lock performs a simple 2H experiment (alternatively 19F). The resulting FID can be visualized (graph of the spectrum) and / or downloaded (as text) by the Service Web.

Calibration 3.4.6

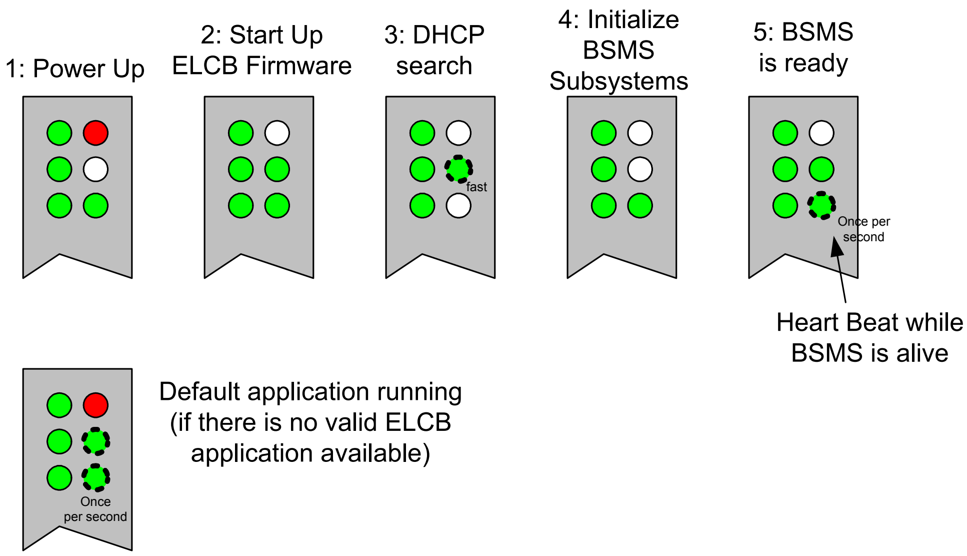
It is user selectable whether the Lock adjusts the Field (default) or the Shift (optional) for locking in by the Auto Lock procedure. The relation between the frequency and the field depends on the Shim System (different for standard bore, wide bore and super wide bore magnets), which is defined in the BOSS file. This value may deviate additionally between different individuals of the same type.

In the Service Web there is a „push button“ calibration of this relation. The calibration needs a sample containing a lock relevant solvent.

Front Panel - LED‘s during start up 3.4.7

The diagram below shows a typical behavior during start up. The „heart beat“ LED shows correct operation of the ELCB - if this LED does not blink any longer then the ELCB application has been blocked and needs to be restarted (if the watchdog is enabled, this is performed automatically).

Figure 3.5. LED‘s indicating different states during start up



Bus Interface 3.5

Since the ELCB is the new master of the BSMS/2, it controls both busses of the backplane, the VME (upper connector) and the User Bus (lower connector). In addition, the lower connector provides access to a local control bus to the LTX (for setting up the RF parameters) and to a local data bus from the LRX (for receiving the demodulated 2H data).

Table 3.2. User Bus Back Plane Connector

	A	B	C
1	LRX:HWCODE	+15V	LRX:TYPE
2	LTX:HWCODE	+15V	LTX:TYPE
3	LRX:OPTION	AGND	-15V
4	LTX:OPTION	AGND	-15V
5	X10V	X10V	X10V
6	X10VGND	X10VGND	X10VGND
7	24V	24V	24V
8	24VGND	24VGND	24VGND
9	COMPCURR_P	COMPCURR_P	-
10	LTRX-SSRB2: /SINTR other: /BP_RCP0	/BP_RCP1	-
11	GPIO1	SLOT_ID[0]	GPIO2
12	GPIO0	SLOT_ID[1]	/RNEXT
13	/SYS_RESET	SLOT_ID[2]	RCLK
14	SSRB1:SCLK	SLOT_ID[3]	SSRB1:STXD
15	SSRB1:SRXD	LTRX-SSRB2: SRXD LTX:CTRL_DATAR	SSRB1:/SINTR
16	H0+	H0+	H0+
17	H0-	H0-	H0-
18	LTX:/CTRL_WR	LTX:CTRL_A[0]	LTX:CTRL_A[1]
19	/BP_RCP2	LTX:CTRL_A[2]	LTX:CTRL_A[3]
20	5V	5V	5V
21	DGND	DGND	DGND
22	LRX:FSR	LTRX-SSRB2: SCLK LTX:CTRL_CLK	LTRX-SSRB2: STXD LTX:CTRL_DATA
23	X5V	X5V	X5V
24	X5VGND	X5VGND	X5VGND
25	LRX:SRD	LRX:RP1_C	LRX:SCK
26 / 27	H0_P	H0_P	H0_P
28 .. 30	PWGND	PWGND	PWGND
31 / 32	H0_N	H0_N	H0_N

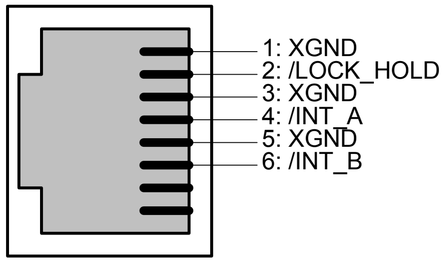
Note: The signals indicated with a gray pattern are not actually used - they are reserved for future extension.

Front connectors 3.5.2

Both TTY RJ45 connectors are wired according to the 9 pin RS232 standard connector layout, with identical enumeration of their 8 signals (e. g. pin 2 = Transmit Data, pin 3 = Receive Data). The 9th signal (Ring Indicator) is not used and left open.

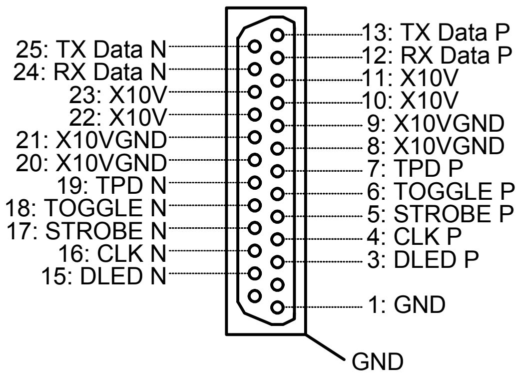
An additional RJ45 connector provides the RCP inputs, according to the figure below. The LED near the connector is active when a RCP signal is actually handled by the ELCB. Thus, this LED serves for checking if the RCP pulse signals are available and if they are handled as expected (e. g. if RCP handling is enabled for the specific signal). It is blinking e. g. during Gradient experiments (Lock Hold) or RCP shimming (INT_A).

Figure 3.6. RJ45 connector for real time control



The specific RS485 connector for the Keyboard has been moved from the former CPU to the ELCB. It is wired according to the figure below:

Figure 3.7. DSUB-25 connector for keyboard



Service Software 3.6

For service purpose, there is a Web access available (setup, calibration and diagnostic). Some of these Web functions are open for all users (e. g. clients), other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

Lock Service Web 3.6.1

The Submenu „Main“ -> „Lock“ provides access to all service functions in connection with the ELCB and the related RF boards (L-RX, L-TX).

Figure 3.8. Main window for NMR lock functions

Most of the functions under the menu point „Lock Parameters & Commands“ are normally handled by the TopSpin application over the CORBA interface. It is however possible to invoke all of these functions by the Service Web. Also the solvent specific parameters that are normally passed by the TopSpin application (e. g. Lock Power, Lock Phase, Lock Gain, Loop Gain, Loop Time, Loop Filter, ..) can be checked and / or defined there.

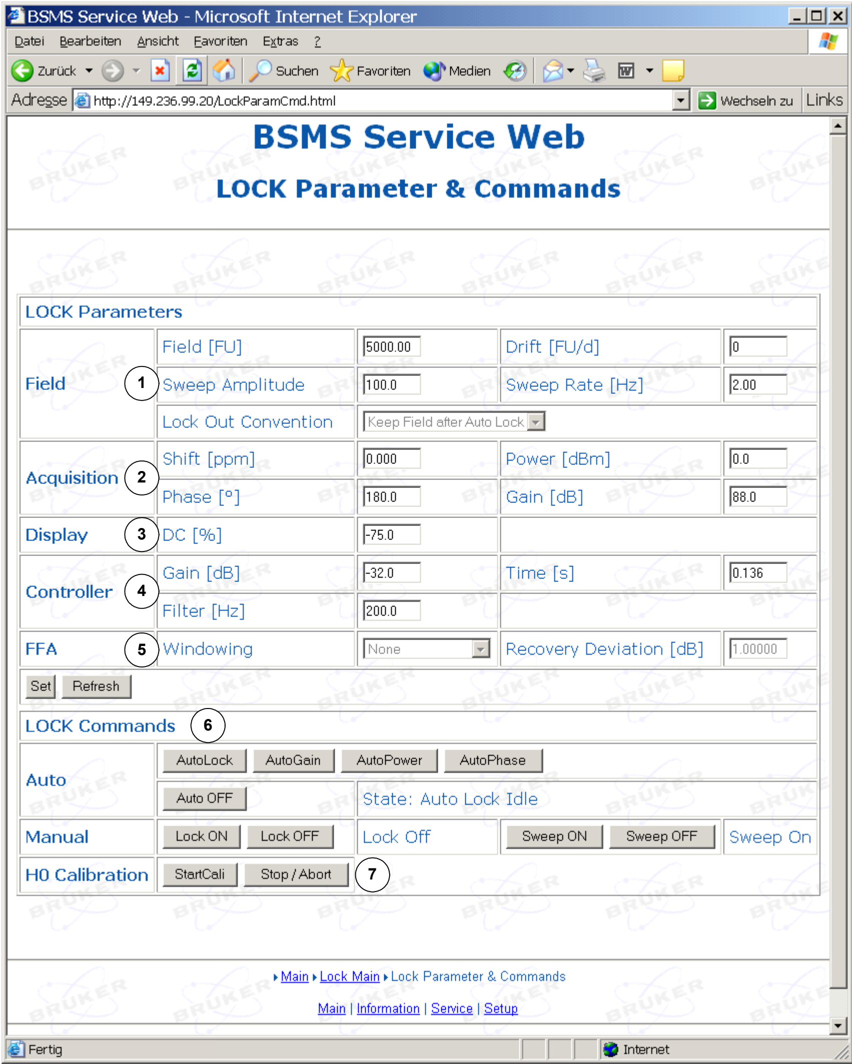
The point „Lock Configuration“ provides setup of the Lock relevant parameters at installation.

„Statistics“ displays information about Lock failures (in case that the Lock got lost), and „Diagnostics“ provides the sub-menu displaying of the 2H spectrum captured during the last Auto Lock trial, a sub-menu for configuration and trouble shooting of the RF boards (L-TX and L-RX) and a sub-menu containing the history of the Lock Regulator / Drift Compensator.

Lock Parameters and Commands 3.6.2

The following dialog provides - alternatively to the TopSpin application - the setup of nucleus specific parameters and invoking of Lock / Auto Lock functions.

Figure 3.9. Basic lock operations by Service Web

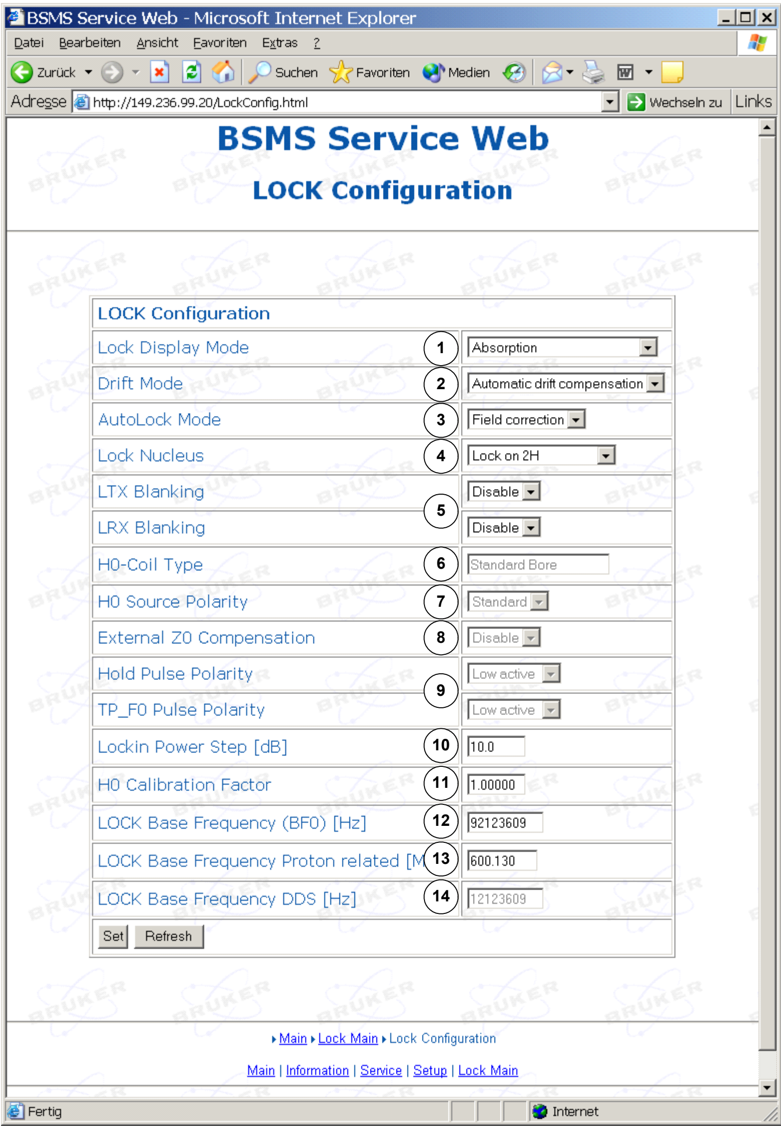


1. All Lock Field relevant parameters can be defined here. The specified Drift value (Field Units per 24 hours) is applied / compensated while manual Drift Compensation is active. It is possible to define the behavior for Locking out („Lock Out Convention"). When the default option is selected („Keep Field after Auto Lock") then the Field value of the „locked" state remains after „lock off" only if the „locked" state has been reached by the Auto Lock command (e. g. TopSpin Command „Lock" and definition of solvent). Alternatively it is possible to force resetting the Field to the value it had before it was „locked", or the Field value of the „locked" state can be kept always after „lock off".
2. This section provides the setup of the solvent specific RF board settings
3. It is possible to shift the Lock Line within the Lock Display window from top (+100%) to bottom (-100%).

4. The regulator can be configured / optimized by these three parameters. These parameters are in the EDLOCK table (solvent specific) and are evaluated alternatively by a TopSpin macro (e. g. LOCK.7).
5. There are two internal parameters for optimization of the Auto Lock procedure, which should not be changed.
6. All Lock commands provided by the Keyboard and / or the TopSpin application (bsms display started by command „BSMSDISP“) can be invoked in this section.
7. The only calibration that is needed in context with the Lock can be started here. There must be a sample in the magnet containing a solvent of the selected nucleus, and locking in must be basically possible.

Lock Configuration — *3.6.3*

Figure 3.10. Configuration of NMR lock



1. There are several options for the Lock Display (e. g. Absorption, which is the standard Lock level, Absorption Low Pass filtered, Dispersion, Regulator Output, ...). The display mode can be changed e. g. for trouble shooting.
2. The drift can be compensated automatically - it is compensated according to the continuously estimated remaining drift rate. Alternatively, it is possible to compensate the drift at a fixed rate that can be evaluated / entered manually. As a third option, the drift compensation can be switched off.
3. When locking in Auto Lock mode, either the Field (default) or the Shift (optional) can be adjusted for achieving the resonance condition.
4. If there is a 19F option installed at both RF boards (L-TX and L-RX), then the nucleus for Locking can be selected by the TopSpin command „LOCNUC“ and the desired nucleus „2H“ or „19F“. This option reflects that selection - switching between the two nuclei simply by setting this parameter would not work. It is necessary that the TopSpin application selects also the appropriate preamplifier setup.
5. Option for L-TX and L-RX blanking (enables RCP inputs on L-TX).
6. The H0 coil type defined in the BOSS file is displayed here. It can not be modified manually.
7. Polarity of the H0 current can be reversed here.
8. If there is an external B0 compensation connected (e. g. for micro imaging), then the H0 current can be routed accordingly - it is however necessary to have a specific ELCB supporting that feature. Alternatively, there are specific Shim adapters available, providing access for the B0 compensation (see also in the SCB20 chapter later on).
9. Setup of the pulse polarities.
10. The Lock In Power Step can be modified here - it is normally 10 dB. When locked in, the Lock Power is reduced by this value.
11. This factor is evaluated by the automatic H0 calibration. It can be set manually, e. g. for resetting the calibration (default = 1.0).
12. Base Frequency for Shift = 0 ppm, related to the currently selected nucleus (2H or 19F).
13. Base Frequency for Shift = 0 ppm, related to Proton.
14. Resulting DDS frequency (for testing / debugging).

Diagnostic and Trouble Shooting *3.6.4*

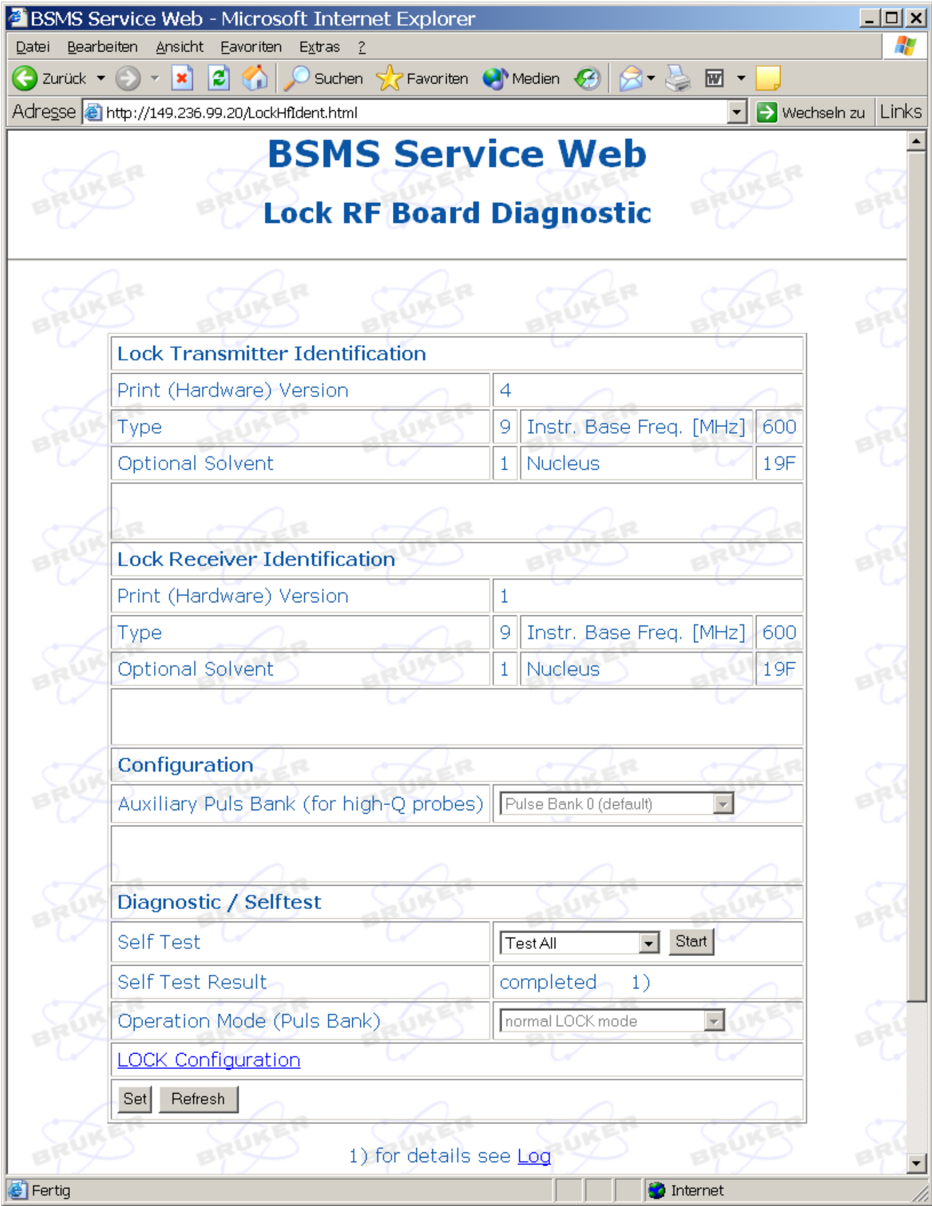
If there is a problem related to the Lock, the logging can be configured in the Service Menu for issuing detailed information about the Lock System. It has to be made sure, that the 2H path is correctly initialized by typing „ii“ in the TopSpin. Additionally, all RF board tests can be run on the Lock „RF Board Diagnostic“ menu.

Since the Lock needs almost the complete spectrometer for correct operation, it is sometimes difficult to find a Lock related error. If it can not lock in or if there are no „Lock wiggles“ available on the Lock display, there are many possible reasons - the Field could be completely out of range, the Shims could be erroneously set, there could be a problem on the 2H path / probe, some Cryo Shims or even the magnet could have quenched.

For checking the magnet (if the 2H FFA spectrum after a failed Auto Lock trial is completely flat), it is recommended to run a simple 1H experiment on a water sample with a very large bandwidth - if there is a peak at all, it will show up.

The diagram below shows the RF board Diagnostic page, indicating the types and version codes of the connected RF boards. In our example, there is a 19F option installed on both boards.

Figure 3.11. Lock RF boards - information and diagnostics



SCB20 4

Introduction 4.1

The SCB20 (Shim Control Board) is the enhanced and unified successor of the former SCB7 / 13 Shim Boards.

The new design is higher integrated so that one SCB20 can replace the combination of a SCB13 with a SCB7 (BOSS1 configuration), and two SCB20 can replace three SCB13 (for all other Shim Systems).

There is exactly one standard version of SCB20, which provides now the necessary performance and precision for all possible variants of connected Shim Systems.

Low level hardware functions are implemented directly on the SCB20, whereas higher level functions such as BOSS file handling, Auto Shim and RCB Shim are provided by the Software running on the ELCB.

It is now possible to store a complete BOSS file on the nonvolatile memory of the ELCB. For BOSS1 Shim Systems there is a predefined BOSS matrix, which does not need to be downloaded.

The formerly used BOSS files and the former Shim values are fully compatible. However the current sources of the new SCB20 have been unified - each current source provides a current ranging from -1 Ampere (-130‘000 current units) to +1 Ampere (+130‘000 current units). Since exchanging of Shim settings with the TopSpin application (command „rsh“ and „wsh“) is based on currents, it is not possible to transfer the former SCB7 / 13 Shim settings directly to the new SCB20 boards. It is however possible to enter manually all shims values (Z1, Z2, ...) that are also stored in the TopSpin shim files.

Technical Data *4.2*

Table 4.1. Electrical Characteristics

Parameter	Min	Typ	Max	Unit	Notes
Output Current (continuous)	-1.0		+1.0	Amp	
Current Value, Resolution and Step Size		20 2		Bit uA	
Maximum Offset		+/- 20		uA	
Gain Error			0.5	%	1)
Maximum Offset Drift		+/- 1		uA / ^{o}C	
Gain Drift		< 11		ppm / ^{o}C	
Tolerated range of connected Shim Coil resistance	0		15	Ohm	
Required power supply voltage |VCC| and |VEE|	20		26	Volt	
Sum of all shim currents (sum of absolute values)			6	Amp	2)
Small Step Response time (Transition from -100 to 100 mA)		20		ms	3)
Large Step Response time (Transition from -1 to 1 A)		160		ms	3)
Power Amplifier Temperature for Shut Down		165		^{o}C	
Current Limit (Power Amplifier)		3.5		Amp	
Current Limit (shunt) for Shut Down		1.2		Amp	

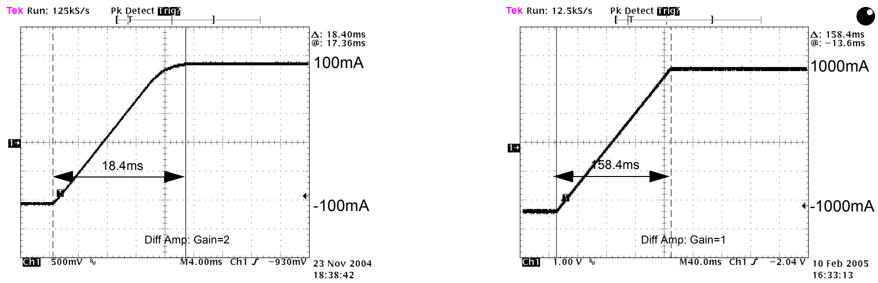
1. The SCB20 boards are calibrated in the factory in order to achieve this accuracy. The uncalibrated gain error is significantly higher.
2. The sum of all Shim currents (absolute values) of one SCB20 board must not exceed this value. Additionally, the constraints of the power supplies have to be taken into account (including the dissipation loss of the SCB20). Therefore, the maximum available current sum may be further reduced, according to the following limits:

   SCB20 in BSMS/2 Slot 10/11: **up to 2A for each, + and -**

   SCB20 in BSMS/2 Slot 4 .. 9: **up to 4 A for each, + and -**

3. Measured with a Z-Shim (Boss-2) and an additional Resistor of 2.7 Ohms (consideration of wiring and connectors). See the diagrams below:

Figure 4.1. Step Response with step size of 200mA (left) and 2.0A (right)



Configurations 4.3

There are basically two standard configurations - one SCB20 providing the necessary number of currents for BOSS1 and BSN-18, and two SCB20 covering all other types of Shim Systems. It may be necessary to use an adapter for connecting „non plug“ Shim Systems. The interconnection is described in detail in the following sub-chapters.

Configuration for a specific Shim System is done by loading a specific BOSS matrix. The corresponding files are delivered with the TopSpin installation, the latest versions can be downloaded from the Swiss ftp server.

BOSS1 Systems do not need a BOSS file - the predefined matrix is already available in the ELCB software. It were theoretically possible to override this matrix by a specific file, however there hasn‘t been any corresponding file defined so far.

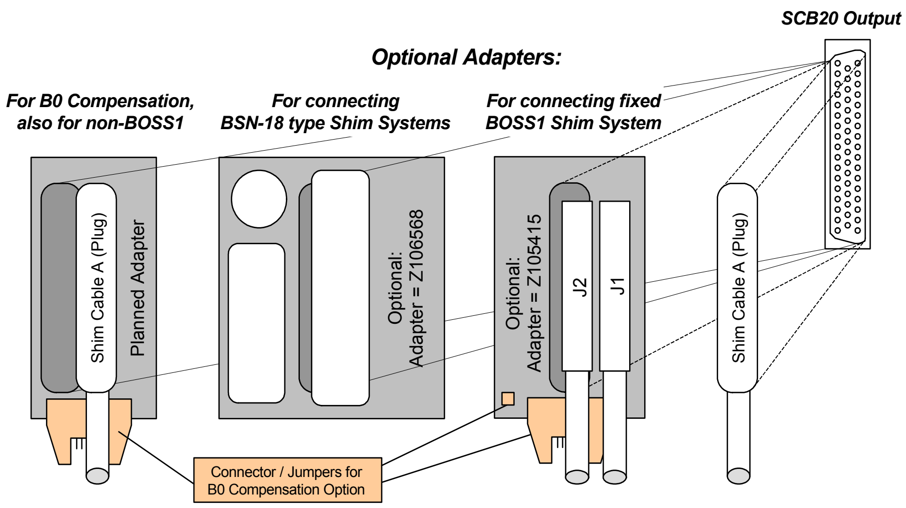
All other Shim Systems (BOSS2, BOSS3, Wide Bore) require the according BOSS data to be loaded once. This is normally handled by the TopSpin application (version 2.0 or higher) - or it has to be performed manually during the installation. The complete BOSS data remain then in the nonvolatile memory of the ELCB.

BOSS1 Configuration 4.3.1

One SCB20 is sufficient for any type of a BOSS1 Shim System. It is recommended to plug the SCB20 into slot 9 / 10 (position „SCB1“), since there is a stronger power supply behind. If there is a GAB or a GAB/2 in the same BSMS/2 rack, then this position is mandatory (due to a specific common ground connection) - an error message is issued if this condition is not fulfilled.

There is a set of different adapters providing connectivity with all types of Shim Systems delivered by Bruker.

Figure 4.2. Adapters for BOSS1 and BSN-18 type Shim Systems

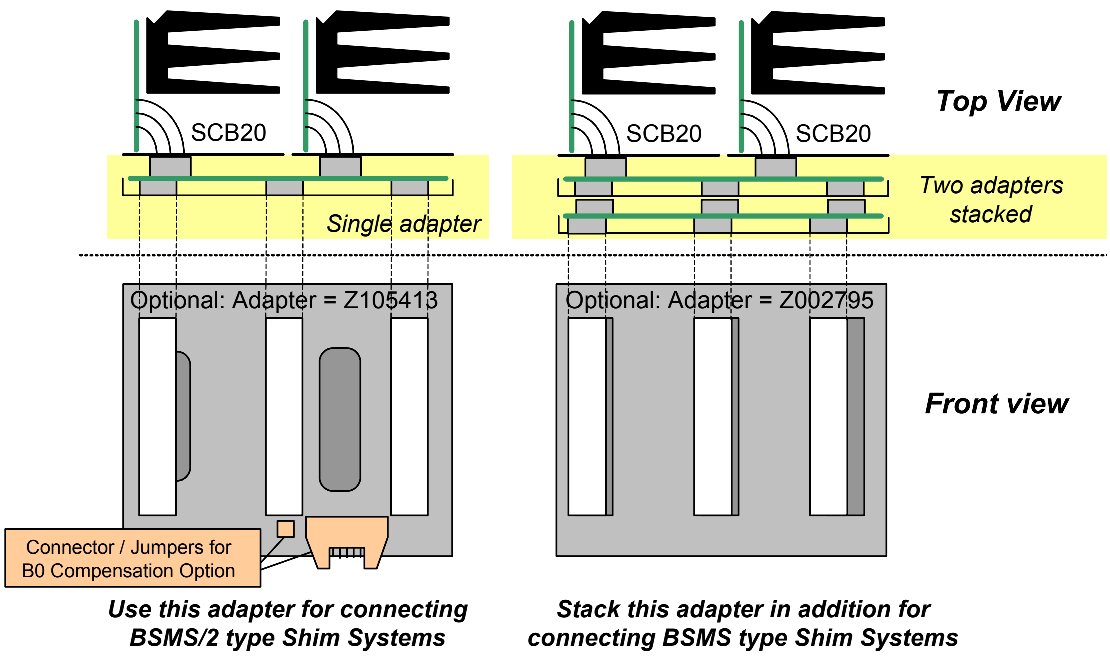


Configuration for BOSS2, 3 and WB 4.3.2

New „plug“ Shim Systems can be directly connected to the SCB20, using the according Shim cables. There are two types of former Shim Systems with fixed cables, the BSMS/2 types and the BSMS types. Both have the same type of connectors, however with a different space in between.

BSMS/2 type Shim Systems need a single adapter (Z105413). The fit for the older BSMS type Shim Systems is provided by an additional adapter (Z002795), which has to be stacked onto the BSMS/2 adapter (Z105413).

Figure 4.3. Adapter for BSMS/2 and Adapter stack for former BSMS



Overview of all shim adapters *4.3.3*

The following table gives an overview over the currently available Shim adapters. For each combination of electronics (Shim Boards SCB7, SCB13 or SCB20) and Shim System there is the required adapter (or set of adapters) indicated.

Note: The Shim Boards SCB7 and SCB13 are not used in BSMS/2 with ELCB and are listed for completeness only.

Table 4.2. Overview over all Shim adapters

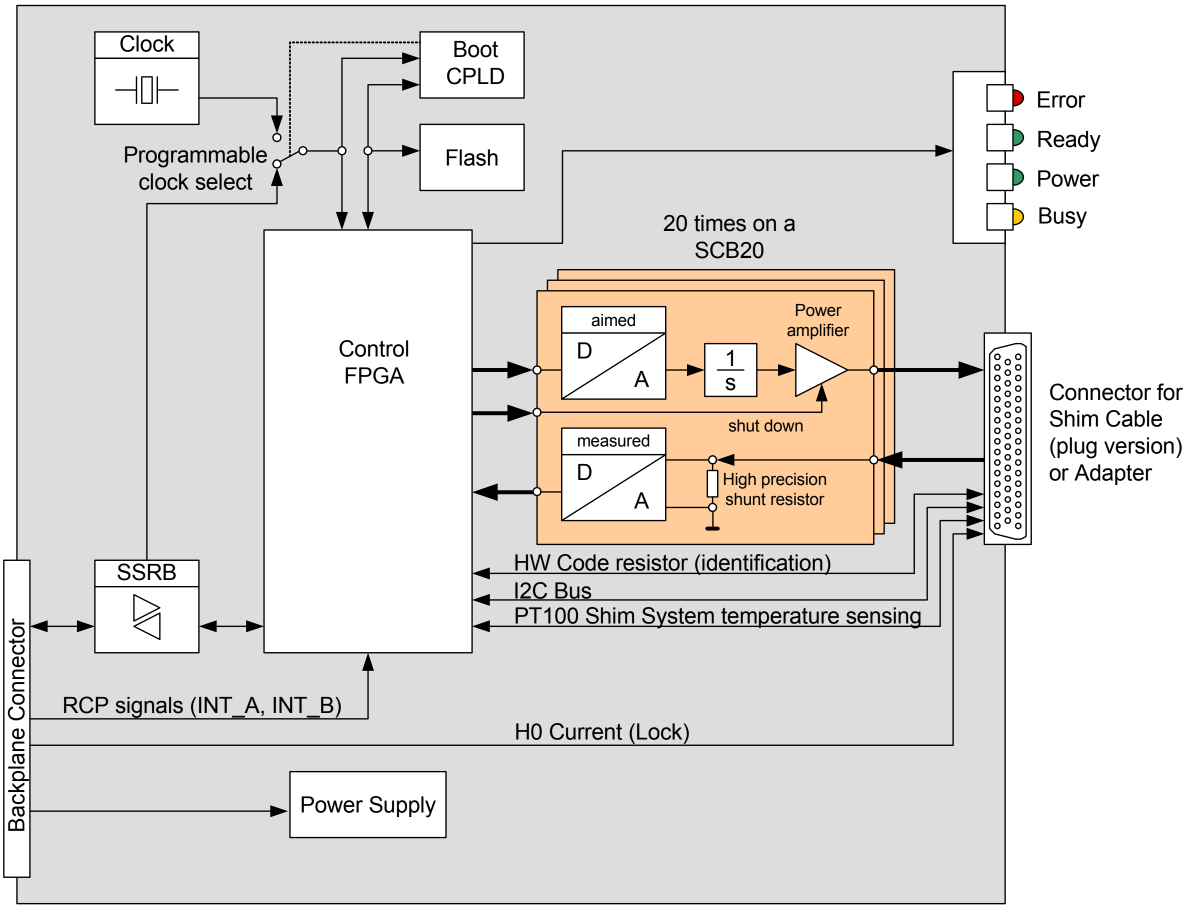
	Shim System						
	BSN-18	**BOSS1**	**BOSS1 „Plug“**	**BOSS2 „BSMS“**	**BOSS2 „BSMS/2“**	**BOSS2 & WB „Plug“**	**BOSS3**
BSMS „SCB13“	Z002734	-	Z003933 2)	-	Z002796	Z106194 2)	Z106194 2)
BSMS/2 „SCB13“	Z002734	-	Z003933 2)	Z002795	-	Z002844 2)	Z002844 2)
BSMS/2 „SCB20“	Z106568	Z105415 ***2)***	- ***1)***	Z105413 + Z002795 ***2)***	Z105413 ***2)***	- ***1)***	- ***1)***

1) Use the additional adapter Z108181 for connection of an external B0 compensation, see ***Figure 4.2.***

2) The adapter is ready for B0 compensation

System Architecture / Overview 4.4

Figure 4.4. Block Diagram of the SCB20 shim current board



The SCB20 is a SSRB slave and controlled by the ELCB, which is the BSMS/2 controller / coordinator. In addition to the SSRB and power supply, there are the synchronisation signals for RCP Shimming (INT_A, INT_B) that are provided by the IPSO (TCU in former consoles) and that are routed across the ELCB. Also the H0 current for Locking is provided by the ELCB - it is routed by the Shim cable to the Shim System, which contains also the H0 coil for the Lock.

In normal configuration the SCB20 uses a common 10MHz clock that is distributed by the ELCB (this clock is typically generated by the AQS reference board). It is possible to select alternatively a local oscillator.

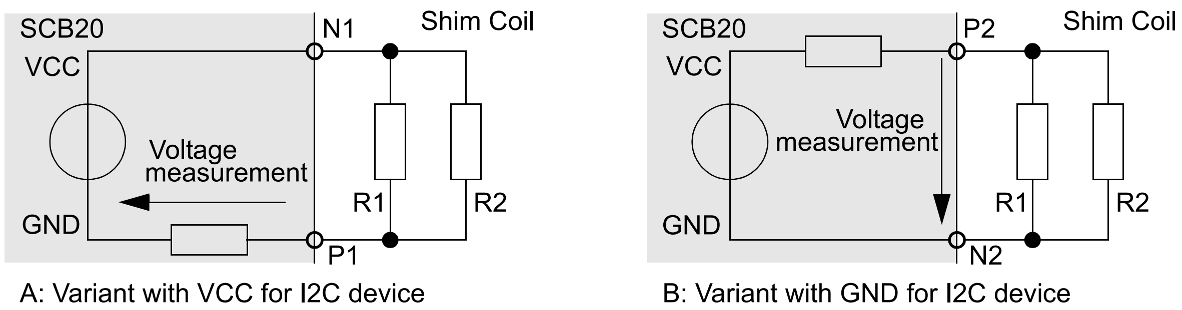
When the SCB20 is starting up, then the CPLD loads at first the current FPGA design from the flash. It is therefore possible to upgrade SCB20 boards in the field (e. g. for new features). The FPGA provides coordination / control of the hardware functions (e. g. controlling the current source regulator loops, protection and real-time functions). As soon as the FPGA is ready, the corresponding embedded software of the ELCB initializes the parameter settings (e. g. values of the Shim currents) and starts operation.

The yellow „Busy“ light flashes whenever there is interaction with the ELCB - there is a task running on the ELCB that periodically checks the connected SCB20 boards, which results in a regular flashing of the „Busy“ LED‘s.

Shim Coil identification 4.4.1

Each connected Shim System has a set of resistors built in that provide identification by measurement of the resistance values (hardware codes).

Figure 4.5. Interface for HW codes and I2C identification device



There are two ports for identification of the connected Shim System on each SCB20. BOSS1 style Shim Systems (one SCB20) may use therefore up to 2 resistor based hardware codes, non BOSS1 systems use actually 3 hardware codes - theoretically, up to 4 codes were possible.

The ports are implemented in two variants, so that the totally 4 wires (including Ground and power supply) can alternatively be used for I2C communication. New Shim systems may additionally contain a nonvolatile memory providing I2C access. This device will store in a first implementation the BIS, it is however an option for the future to store also the corresponding BOSS data in the Shim System.

Protection 4.4.2

The power amplifiers are protected against short circuits (limiting the output current) and over temperature. Additionally, the current sources are shut down if one of the measured currents exceeds the operating values or if the consistency check fails (e. g. if it is not possible to reach the aimed current value).

These two measures protect the SCB20 against short circuits and / or mismatched connections.

Measurements provided for diagnostic 4.4.3

In the following section, there is a list of possible diagnostic functions that can be invoked by SSRB commands. According to the results of the measurements the software running on the ELCB may notify the user about abnormal events.

Status / Errors

The SCB20 can perform the following checks:

- Power voltages ok
- Short circuits / disconnected lines at the current source output
- Current source status (operational or shut down)
- Heat sink over temperature

Output measurements

Both, the current and the voltage of each current source output can be retrieved over the SSRB. Additionally, the voltage after the integrator stage (U Int) can be measured for each channel. This feature provides additional information about the connected load and could potentially be used for identification.

Temperature measurement

There is a PT100 resistor built in the shim tube providing temperature measurement. It is therefore possible to read the shim tube temperature over the SSRB bus for diagnostic purpose. If the shim tube temperature exceeds a given limit then the current sources are shut down.

Calibration *4.4.4*

The precision of the actual current depends directly on the quality of the current measurement. In order to achieve the desired excellent performance, it is necessary to calibrate both, gain and offset. The initial calibration during production is however sufficient for the life cycle of the SCB20 board.

Gain Calibration

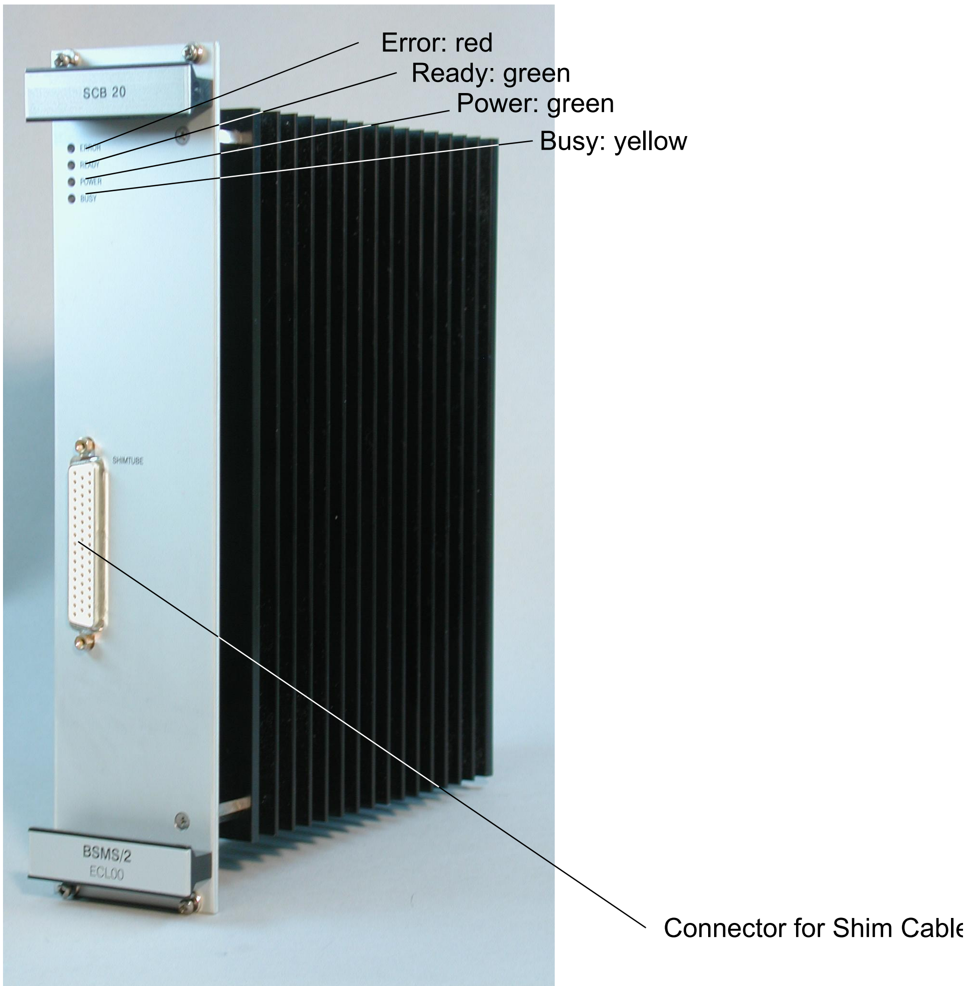
The gain deviation depends mainly from the shunt resistor value, the influences of the other components are relatively small.

Offset Calibration

Even if the offset is very small, there is also a factory calibration of the offset. Both, the Gain and Offset correction parameters are stored in the nonvolatile memory of the SCB20.

Front Panel - Connectors and LED's 4.4.5

Figure 4.6. The picture below shows a SCB20 shim current board



Error LED

This LED is active after Power ON. It turns off as soon as the SCB20 is initialized (e. g. FPGA design loaded from Flash) ***and*** the communication with the ELCB is established.

Later on, an active Error LED indicates that an error occurred (e. g. short circuit, over temperature, ...) ***and*** that in consequence the current sources have been shut down.

Ready LED

This LED is active as soon as the FPGA design is loaded and valid Shim values are activated (initially no current). It is turned off while the Shim settings are changed (flickering during Shimming).

Power LED

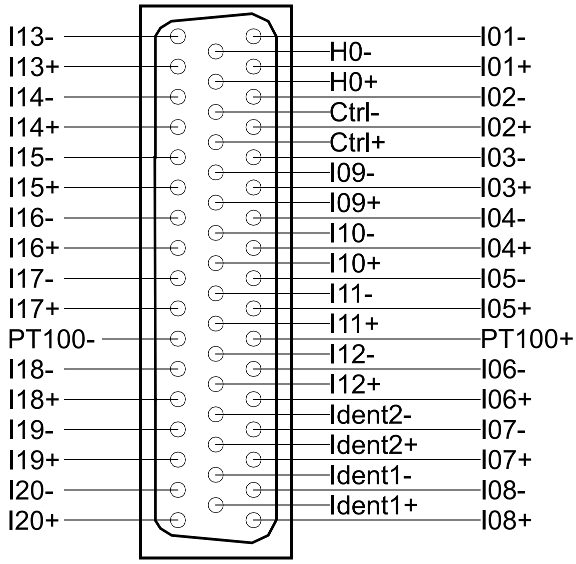
Indication that the SCB20 is correctly powered.

Busy LED

While the SCB20 is accessed by the ELCB (e. g. for setup, writing of new shim current values, ..) this LED is active. Since all connected SCB20 are checked by the ELCB software in regular intervals, this LED indicates in addition the „heart beat" of the Shim System.

Connector Pinout

Figure 4.7. Pinout of the 50 pin Shim connector



The SCB20 provides a 50 pin connector at the front panel for connecting the Shim system. There are the 20 current sources (I1 .. I20), the Lock current (H0), two identification connections (Ident1/2), a connection for the temperature measurement (PT100) and the spare signals (Ctrl), which could be used in the future for I2C communication.

Bus Interface 4.5

As mentioned already earlier in this document, the SCB20 is not actually connected with the VME bus (apart from the power and ground lines). The communication with the ELCB runs exclusively over the User Bus.

Backplane Connector (User Bus) 4.5.1

Table 4.3. User Bus Back Plane Connector

	A	B	C
1 / 2 (Note)	VDD_BPL	VDD_BPL	VDD_BPL
3 / 4 (Note)	AGND	AGND	AGND
5 / 6 (Note)	VEE_BPL	VEE_BPL	VEE_BPL
7 .. 10	-	-	-
11	-	Slot ID 0	-
12	-	Slot ID 1	/RNext
13	/SysReset	Slot ID 2	RCLK
14	SSRB:SCLK	Slot ID 3	SSRB:STXD
15	SSRB:SRXD	-	SSRB:/SINTR
16	H0+	H0+	H0+
17	H0-	H0-	H0-
18 / 19	-	-	-
20	VCC_BPL	VCC_BPL	VCC_BPL
21	DGND	DGND	DGND
22 .. 25	-	-	-
26 / 27	P_VPWR	P_VPWR	P_VPWR
28 .. 30	VPWRGND	VPWRGND	VPWRGND
31 / 31	N_VPWR	N_VPWR	N_VPWR

Note: The VDD_BPL, AGND and VEE_BPL could be connected by placing the according 0 Ohms resistors - in the actual design, these lines are ***not*** connected.

Service Software 4.6

All connected SCB20 boards in a BSMS system are controlled by the ELCB software - both, the specific low level drivers and the overall control logic is implemented there. The ELCB software provides the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration and diagnostic). Some of these Web functions are open for all users (e. g. clients), other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

Shim Service Web 4.6.1

The Submenu „Main“ -> „Shim“ provides access to all service functions in connection with the SCB20 boards

Figure 4.8. Main Menu for the Shim Subsystem

Under the menu point „Shim BOSS“ it is possible to check the available Shims for the currently loaded BOSS file and to modify the Shims, alternatively to the Keyboard or TopSpin Application („bsmsdisp“). This page is helpful for double checks with the Application.

Downloading of new BOSS files and setting up of specific parameters for the Shim functions (e. g. pulse polarity for RCB) can be done under „Shim Configuration“.

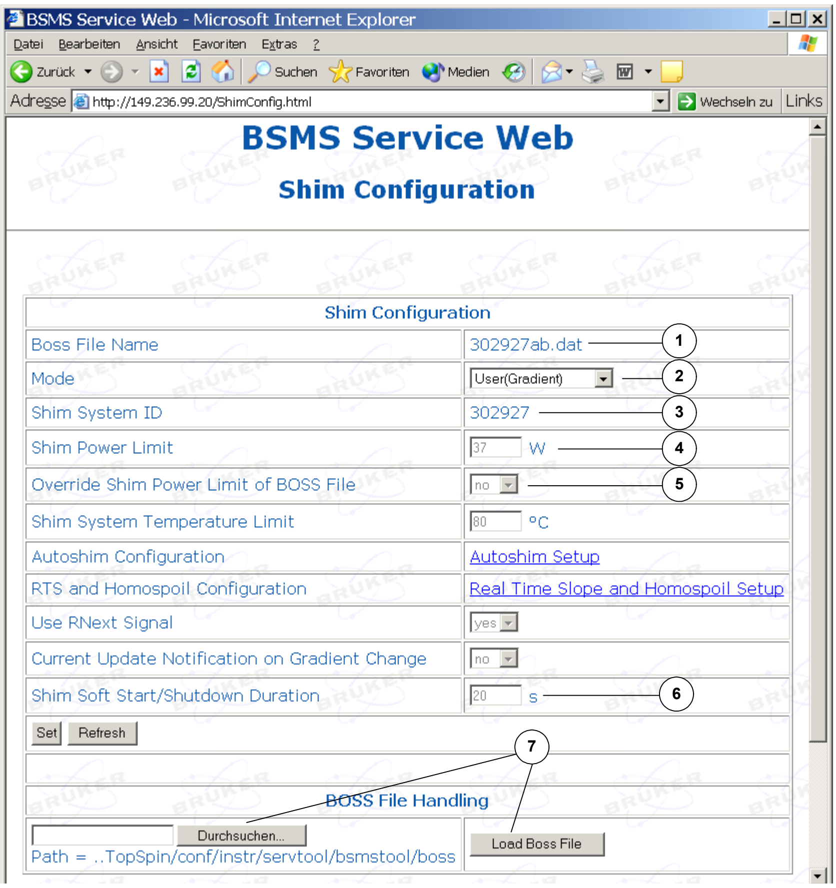
The example shows a BSMS/2 with two SCB20, therefore there are two according menu points for low level service functions, one for each board, providing diagnostic information in case of problems.

A further option for debugging the Shim functions is the „Shim Current Tool“, which provides access to all currents - it is possible to define the strength of the currents individually, and to read the resulting current measurements on the display.

There is additionally a „Shim Power Supply Information“, which displays information about the current consumption due to the currently defined Shim settings.

Setup the Shim functions *4.6.2*

Figure 4.9. Setup and Configuration of the Shim Subsystem

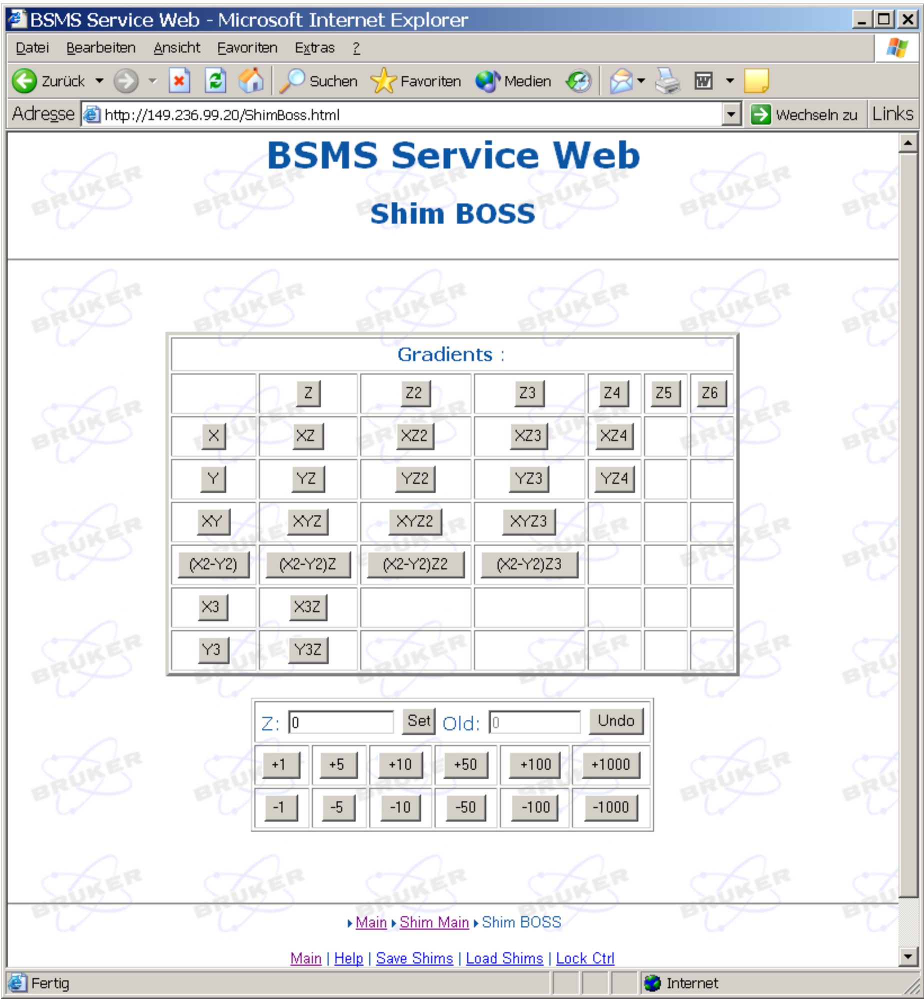


1. The currently loaded BOSS file name is displayed here. If the connected Shim System is a BOSS1 then the name of the predefined data set „BOSS1“ is displayed. If there is no valid BOSS data available for the connected Shim System, then this is indicated by „**No BOSS Matrix loaded!**“. The file names for non-BOSS1 Shim Systems start with the Shim System ID (see point 3), with two characters appended - the first character specifies the frequency range for BOSS3 and BOSS-WB systems - character ‚a‘ means no specific range. The second character indicates the version of the BOSS file (ascending for higher versions).
2. Some BOSS files provide more than one mode, which can be selected here. However, it is no longer necessary to differentiate between US and non-US systems, install mode and user mode. Typically, one mode is sufficient.
3. Here is the identification of the connected Shim System, which is based on 2 (BOSS1) or 3 hardware codes.

4. The maximum power dissipated in the Shim System - this value is defined in the BOSS file.
5. For specific situations it is possible to adapt / extend the „Shim Power Limit“. Setting this flag to „yes“ allows to override the value of the BOSS file by a user specific limit (service account necessary) -> the value can then be entered under point 4.
6. Time in seconds for softly starting up / shutting down the Shim Subsystem.
7. Normally the TopSpin application (version 2.0 or higher) makes sure that there is an appropriate BOSS file loaded - it can be however necessary to do this manually. This menu point provides selecting a specific BOSS file and loading it to the BSMS/2. The BOSS file is handled by the ELCB firmware - if the file is not valid (e. g. syntax errors, missing definitions), the Logging can be checked for details (kind of error, line number of the BOSS file where the error has been detected).

View and modify the Shims 4.6.3

Figure 4.10. View and manual modification of the Shims



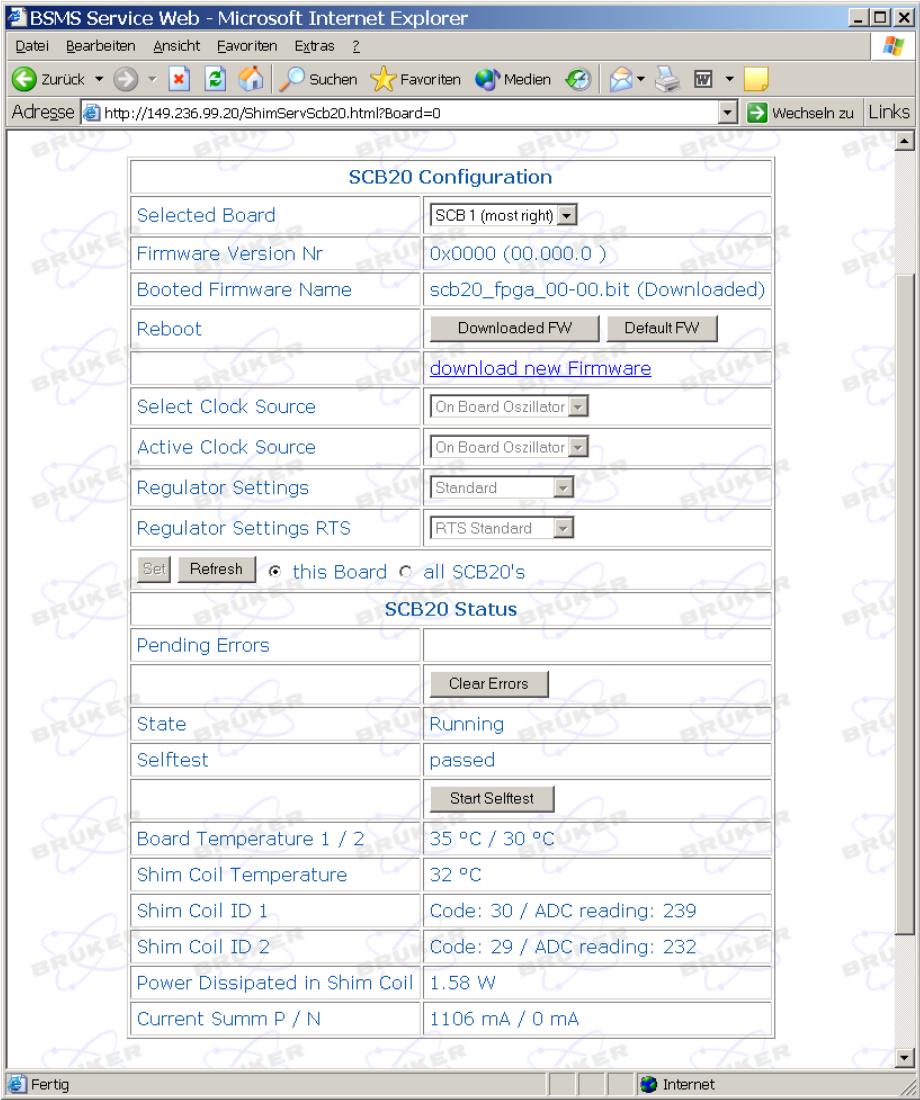
The example in the diagram above shows a Shim Subsystem configured for 28 available / accessible Shims. By the small panel at the bottom, the selected Shim („Z“ in our example) can be viewed or modified manually.

Depressing the link „Save Shims“ shows the complete Shim settings. It is possible to store these settings into a file. However, it is recommended to use the TopShim command „wsh“ for saving the Shim settings for later use by the TopSpin application in order to guarantee compatibility.

Diagnostic and Trouble Shooting *4.6.4*

The following diagram shows the specific service Web page for the Shim function. There is a separate Web page for each SCB20 board, indicating the hardware status and the configuration. Several operations are reserved for service engineers and need the login procedure with a correct password.

Figure 4.11. SCB20 diagnostic Web page



For the case that there is a problem regarding the Shim function (e. g. if there is an error message issued when the user wants to set or modify the value of a Shim), it is possible to run the built in self test on each SCB20 board in order to verify that the SCB20 boards are in a correct state.

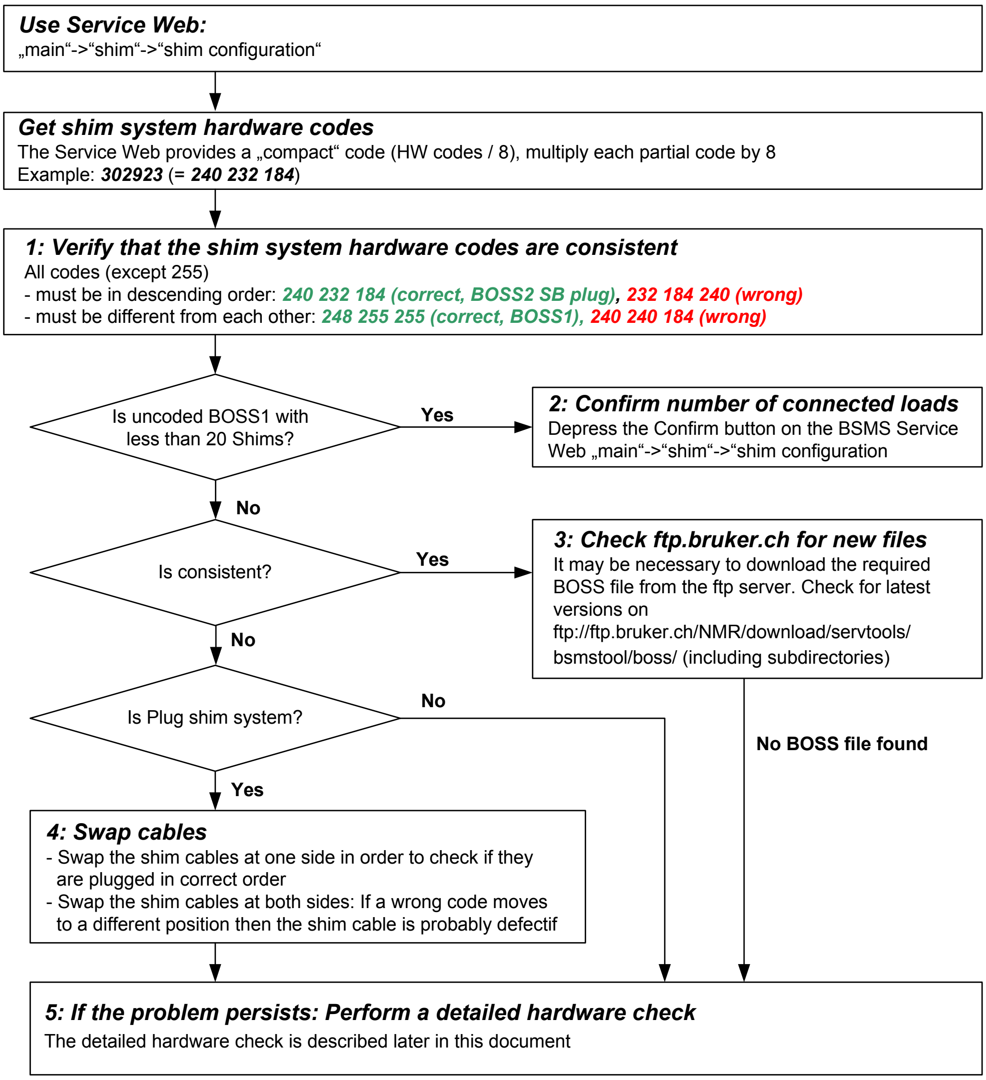
The power dissipation in the Shim Coil and the power consumption is displayed as additional information. In case of a failed attempt to set or modify a shim value, it is recommended to check if the power limit of the Shim Coil is reached or if the power supply is at its limit. It may be necessary to reset manually all currents to zero, which can be easily done by the „Shim Current Tool".

Additional information about the consumed power and remaining margin can be retrieved under „Main" -> „Shim" -> „Shim Power Supply Information".

No BOSS file for currently installed Shim System? 4.6.5

The procedure given here may be useful in case of an error message „Error: Shim: Cannot initialize Shim System .. with BOSS file ..." or if you can not find an appropriate BOSS matrix file for the Shim System type that is indicated by the BSMS Service Web.It may be necessary to apply the procedure iteratively.

Figure 4.12. Trouble shooting problems with Shim System and BOSS file



1. Verify that the Shim System hardware codes are consistent

The „compact“ Shim System code provided by ELCB based systems has to be extended by multiplying each part by 8 in order to get the actual hardware codes, according to the following examples:

- „302928“ -> 240, 232, 224 (BOSS2-SB NON US)
- „302923“ -> 240, 232, 184 (BOSS2-SB PLUG)
- ...

Note1: In case of a connected BOSS1 Shim System, the ELCB Service Web indicates explicitly „BOSS1“ as connected Shim System type and does not provide the corresponding hardware codes. In this case, there is no need to download a BOSS file - the predefined BOSS1 definitions are used.

For non-BOSS1 systems, verify the following points:

- Are codes 255 only followed by further codes 255?
- Are all codes except 255 different from each other?
- Apart from values of 255, are the values of the codes decreasing from left to right?

2. Uncoded BOSS1 Shim Systems with less than 20 Shims

The ELCB firmware checks if the number of connected loads corresponds with the number of Shim coils defined in the BOSS file. For BOSS1 systems, the ELCB assumes 20 loads. However, there are older, uncoded Shim Systems with less than 20 loads (e. g. only 17 Shim coils). After power up, the user is informed about that by an error message. On the BSMS Service Web there is a button for confirmation of the actual number of loads of the currently connected Shim System. Afterwards, the load check is executed accordingly.

3. Check ftp.bruker.ch for new BOSS files

New BOSS files are published on the following ftp location:

ftp://ftp.bruker.ch/NMR/download/servtools/bsmstool/boss/

Check this directory (and the sub-directories) for new BOSS files and installation guides / service information. It might be necessary to update your locally installed BOSS files.

4. Swap cables if you have a „plug“ type Shim System

The two Shim cables 'A' and 'B' could be connected in wrong order. Swapping the connectors at one side would eliminate the error. Make sure that the BSMS is switched off before swapping the cables!

In case of a defective Shim cable, swapping of the cables at both ends would move a wrong code to another position, e. g. from {<correct> <correct> <not correct>} to {<not correct> <correct> <correct>}.

5 Perform a detailed hardware check

Verify that the Shim cables are correctly connected, check for any mechanical damage (cables, bent connector pins) and red error LED's on the SCB20.

Analyze the BSMS logging (provided by the service Web) particularly the sequence during the start up period. TopSpin 2.0 or later provides periodical transfer of the logging information to the workstation (in TopSpin type "bsmsdisp", select tab "service", enable the periodical transfer). The resulting long term logging can be displayed in the same menu page.

Measure the resistance values that define the hardware codes using an Ohm meter (the values are in the range of 20-200 kOhm).

Pins for „non-plug“ Shim Systems (DIN connectors):

- V1: row 2, column B and D on SCB-R
- V2: row 2, column B and D on SCB-M
- V3: row 2, column B and D on SCB-L (may be missing)

Pins for „plug“ Shim Systems (DSUB50 connectors):

- V1: Pins 18 and 19 on connector A
- V2: Pins 20 and 21 on connector A
- V3: Pins 18 and 19 on connector B (may be missing)

For detachable cables do the measurement including and excluding the cables (connections are 1:1). If there is a significant measurable difference, the cable is defect.

Compare the measured resistance values to the values corresponding to your Shim System part number as found in the table below. (Remark: this table only contains Shim Systems needing a BOSS matrix). If one of the values is outside the range given in the table then the Shim System is damaged and needs to be replaced.

If all resistance values are in the range given in the table then compare the version codes in square brackets [xxx] to the ones returned by the BSMS.

If there is a difference in V1 or V2 then retry with a replaced right hand SCB20. If there is a difference in V3 then retry with a replaced left hand SCB20.

The following table lists all Shim Systems needing a BOSS matrix file. Acceptable ranges for resistance values are in kOhm, and the corresponding hardware codes are in square brackets.

Table 4.4. List of Shim Systems needing a BOSS matrix file.

Shim Coil	Part Number	V1 Res [code]	V2 Res [code]	V3 Res [code]
BOSS2 STD S1 BSMS BOSS2 STD S1 BSMS/2 BOSS2 STD S2 BSMS BOSS2 STD S2 BSMS/2 BOSS2 STD S3 BSMS BOSS2 STD S3 BSMS/2 BOSS2 STD S4 BSMS BOSS2 STD S4 BSMS/2 BOSS2 STD S5 BSMS BOSS2 STD S5 BSMS/2 BOSS2 STD S6 BSMS BOSS2 STD S6 BSMS/2	Z4114 Z6555 Z4115 Z6556 Z4116 Z6557 Z7888 Z6558 Z4800 Z6559 Z4676 Z6560	147 .. 153 kOhm [240]	94 .. 99 kOhm [232]	68..72 kOhm [224]
BOSS2 USA S1 BSMS BOSS2 USA S1 BSMS/2 BOSS2 USA S2 BSMS BOSS2 USA S2 BSMS/2 BOSS2 USA S3 BSMS BOSS2 USA S3 BSMS/2 BOSS2 USA S4 BSMS BOSS2 USA S4 BSMS/2 BOSS2 USA S5 BSMS BOSS2 USA S5 BSMS/2 BOSS2 USA S6 BSMS BOSS2 USA S6 BSMS/2	Z7874 Z44811 Z7875 Z44812 Z7876 Z44813 Z7889 Z44814 Z4810 Z44815 Z4678 Z44816	147…153 kOhm [240]	94…99 kOhm [232]	53…56 kOhm [216]
BOSS/W1 S2/BOSS2 BOSS/W2 S4/BOSS2 BOSS/W3 S5/BOSS2 BOSS/W4 S6/BOSS2 BOSS/W4 S7/BOSS2 BOSS/W6 S6/BOSS2	Z46428.A Z46428.B Z46428.C Z46428.D Z46428.E Z46428.F	147…153 kOhm [240]	147…153 kOhm [240]	42…45 kOhm [208]
BOSS/W1 S2/BOSS2 US BOSS/W2 S4/BOSS2 US BOSS/W3 S5/BOSS2 US BOSS/W4 S6/BOSS2 US BOSS/W4 S7/BOSS2 US	Z48379.A Z48379.B Z48379.C Z48379.D Z48379.E	147…153 kOhm [240]	94…99 kOhm [232]	34…37 kOhm [200]

Table 4.4. List of Shim Systems needing a BOSS matrix file.

Shim Coil	Part Number	V1 Res [code]	V2 Res [code]	V3 Res [code]
BOSS2 STD S1 PLUG BOSS2 STD S2 PLUG BOSS2 STD S3 PLUG BOSS2 STD S4 PLUG BOSS2 STD S5 PLUG BOSS2 STD S6 PLUG BOSS2 STD S7 PLUG BOSS2 STD S8 PLUG BOSS2 STD S9 PLUG BOSS2 STD SA PLUG	Z49732.1 Z49732.2 Z49732.3 Z49732.4 Z49732.5 Z49732.6 Z49732.7 Z49732.8 Z49732.9 Z49732.A	147…153 kOhm [240]	94…99 kOhm [232]	25…27 kOhm [184]
BOSS3 STD S4 PLUG BOSS3 STD S5 PLUG BOSS3 STD S6 PLUG BOSS3 STD S7 PLUG BOSS3 STD S8 PLUG BOSS3 STD S9 PLUG BOSS3 STD SA PLUG BOSS3 STD SC PLUG	Z73436.4 Z73436.5 Z73436.6 Z73436.7 Z73436.8 Z73436.9 Z73436.A Z73436.C	94…99 kOhm [232]	53…56 kOhm [216]	21…23 kOhm [176]
BOSS2/W1 ECL00 BOSS2/W2 ECL00 BOSS2/W3 ECL00 BOSS2/W4 ECL00 BOSS2/W5 ECL00 BOSS2/W6 ECL00	Z46435.A Z46435.B Z46435.C Z46435.D Z46435.E Z46435.F	53…56 kOhm [216]	42…45 kOhm [208]	29…31 kOhm [192]
BOSS2/W1 ECL01 BOSS2/W2 ECL01 BOSS2/W3 ECL01 BOSS2/W4 ECL01 BOSS2/W5 ECL01 BOSS2/W6 ECL01	Z46435.A Z46435.B Z46435.C Z46435.D Z46435.E Z46435.F	53…56 kOhm [216]	42…45 kOhm [208]	25…27 kOhm [184]

GAB/2 5

Introduction 5.1

The GAB/2 is the successor of the GAB gradient amplifier. It supports all its NMR gradient functions and is compatible with both, the former AVII and the new IPSO based AVANCE spectrometers.

For compensation of eddy current effects on the Z1 field in connection with Gradient pulses, there has been a preemphasis built into the new GAB/2. The preemphasis current is based on three different exponential functions, each with a separate amplitude and time constant. These six parameters can be configured by the CORBA interface of the ELCB.

When it is used in a former AVII, real time gradient data are sent by the GCU/3 over a 28 bit LVDS link. In spectrometers of the new generation, the IPSO uses the 48 bit LVDS link for real time gradient control. According to the connected gradient controller, the GAB/2 selects automatically the appropriate LVDS input. Shaped gradient pulses can be transmitted with a time resolution of up to one sample per microsecond.

For future applications it is possible to connect the GAB/2 with any other device issuing the required real time gradient data. It is however necessary that the connected device fulfills the LVDS interface specifications, which are given in detail later in this document.

Both, the former GAB and the new GAB/2 can be used in a ELCB based BSMS/2. The new GAB/2 provides improved diagnostic functions and automatic offset calibration, which are both implemented in the specific GAB/2 driver. This driver is part of the BSMS software running on the ELCB.

In order to reduce distortions to a minimum, there is an improved, shielded connector for the Gradient cable to the probe head.

Technical Data 5.2

Table 5.1. Electrical Characteristics (typical values)

Parameter	Min	Typ	Max	Unit	Notes
Peak Current	-10.0		+10.0	Amp	1)
Peak Voltage	-33		33	Volts	
Fall Time (90 - 10%)			10	us	2)

Table 5.1. Electrical Characteristics (typical values)

Parameter	Min	Typ	Max	Unit	Notes
Fall Time (residual current smaller than 10 uA)			80	us	2)
Amplitude Resolution for full range -10A to +10A	16	20 3)		bit	
Residual current when there is no Gradient active	-10.0		+10.0	uA	
Preemphasis time constants	0.02		20	ms	

Notes concerning the Electrical Characteristics:

1. The peak current is provided during maximum 50 ms in a time frame of 1 sec.
2. Fall Time measurements with a load of 30uH / 1Ohm.
3. Typical resolution of 20 bit with preemphasis

Configurations 5.3

Figure 5.1. GAB/2 in an AVII spectrometer

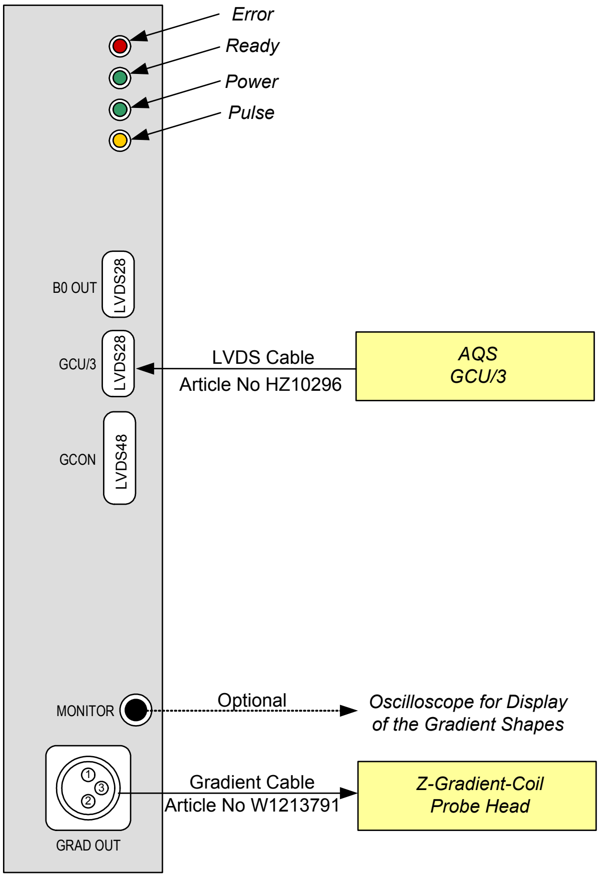
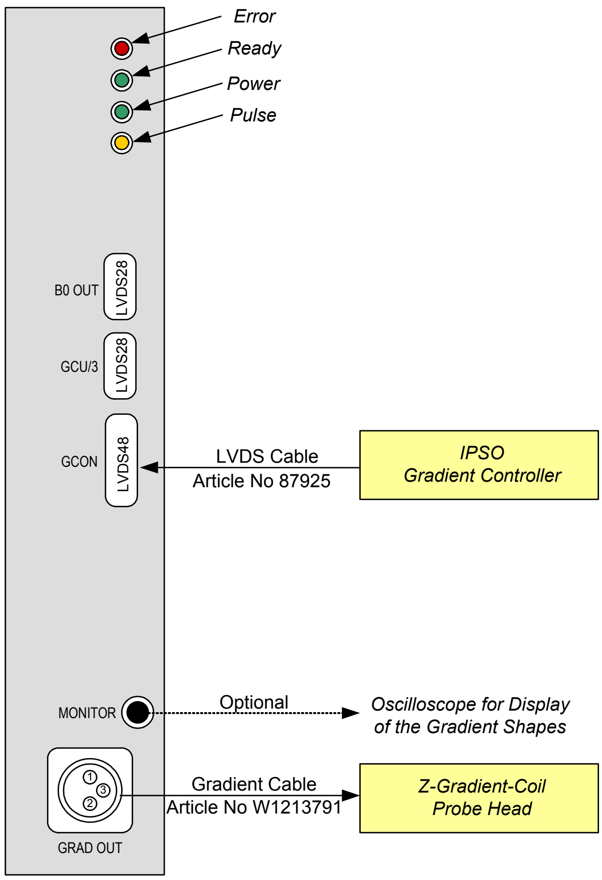


Figure 5.2. GAB/2 in an AVANCE spectrometer with IPSO

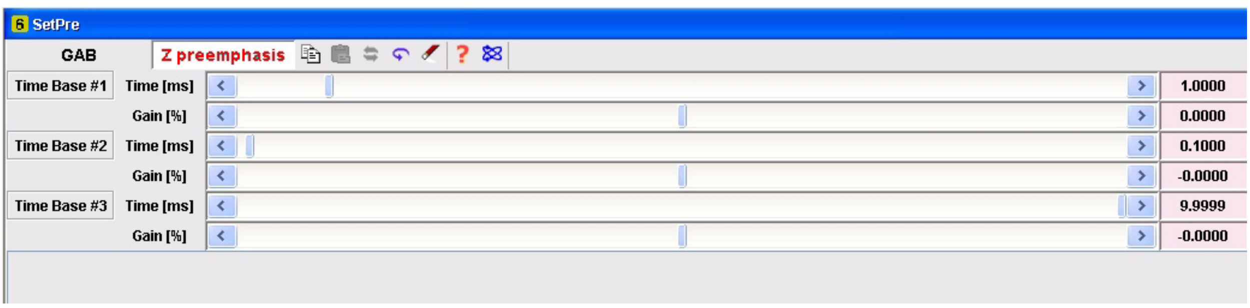


Preemphasis 5.3.1

The GAB/2 provides three preemphasis terms (exponential functions), each with selectable gain and time constant. Typing „setpre“ in TopSpin (command line) opens a window for definition of the preemphasis parameters.

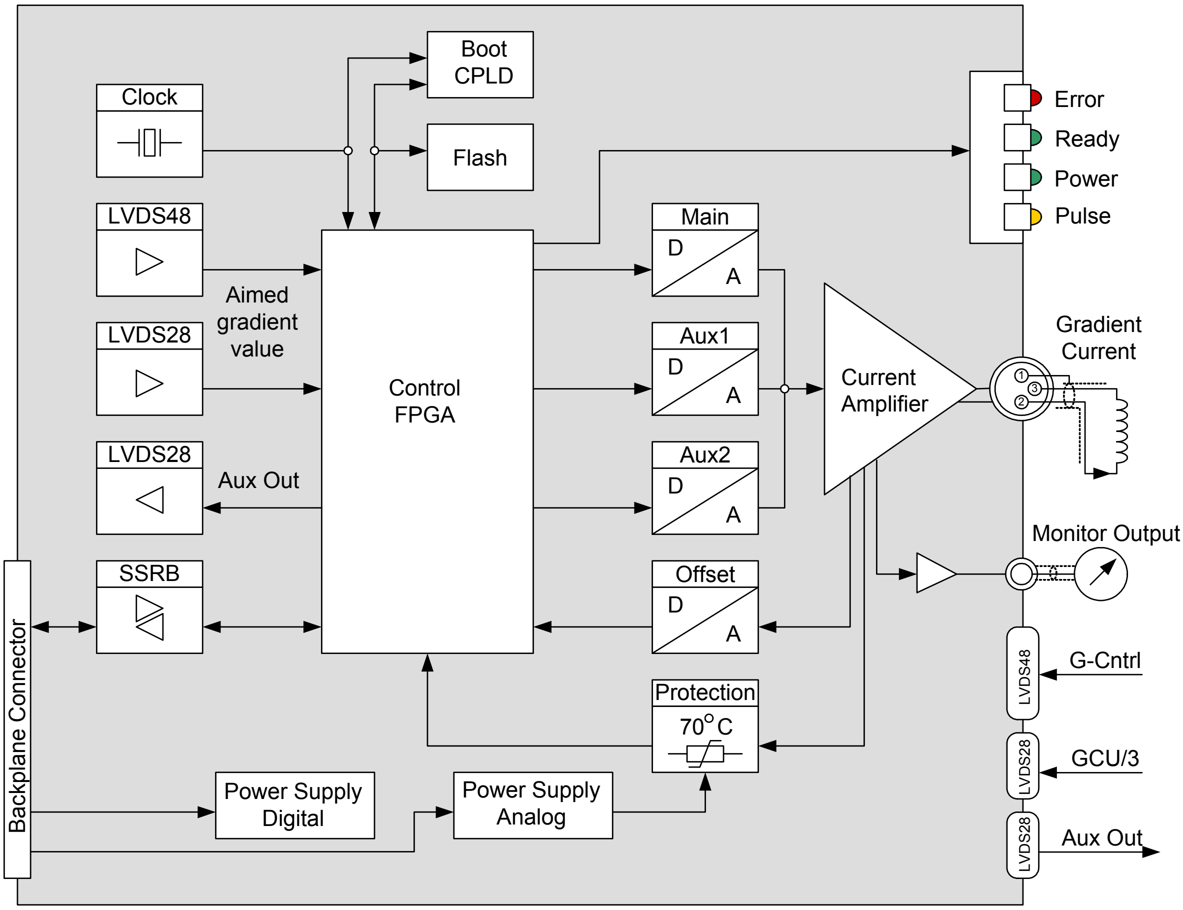
Note: The time constants by „setpre“ are defined in milliseconds, whereas the BSMS service web provides time constant setting in seconds.

Figure 5.3. TopSpin window for preemphasis settings



System Architecture / Overview 5.4

Figure 5.4. Block Diagram of the GAB/2 Gradient Amplifier board



After power up, the design file stored in the Flash is downloaded to the FPGA. During this period, all four LED‘s are on.

Then the GAB/2 is ready to be configured by the ELCB. The corresponding GAB driver in the ELCB software is responsible for setting up the hardware for correct operation. The ELCB communicates over the SSRB (Synchronous Serial Rack Bus on the back plane) with the GAB/2. In addition, the error handling and service access (e. g. diagnostic functions) is part of the ELCB software.

The characteristics of the desired Gradient pulses for a specific NMR application is controlled just in time by real time commands transmitted over a LVDS link. Either the Gradient Controller of the IPSO or the AQS GCU/3 generates the necessary data, according to the pulse program that is running in the TopSpin application.

In compliance with the incoming LVDS data, there are the desired analog current pulses generated. The current amplifier provides the aimed current regardless of the connected load - e. g. varying resistance of the cable, or changing characteristics of the coil with temperature have no effect on the resulting current.

Protection 5.4.1

Both, the high power Gradient Connector and the Monitor Output are protected against short circuits and erroneously connected cables. The output current is limited (high side current measurement) and the temperature of the electronics is supervised. In case of overtemperature or overcurrent, the GAB/2 is switched off, and an error message is sent to the TopSpin application and the BSMS Keyboard.

Status LED‘s on the front panel 5.4.2

POWER LED

This LED indicates the state of all internal power supplies. It is active when all power supply voltages are within the specified range.

READY LED

This LED is switched on while the GAB/2 is on / ready for issuing Gradient pulses.

ERROR LED

After power up, this LED stays active until the GAB/2 has been completely initialized by the ELCB software. If the GAB/2 could not be accessed over the SSRB then this LED remains on.

In case of a error on the GAB/2, this LED is switched on until the error is handled by the ELCB software - an error message is sent then to the TopSpin application and the BSMS Keyboard. Therefore, the ERROR LED only flashes for a short time in case of an error.

PULSE LED

When the GAB/2 is in operation mode, the pulse LED is active as long as there is actually a Gradient current available at the Gradient connector. In any other state, this LED indicates that new data are arriving at the LVDS input.

At power up, the PULSE LED indicates an uninitialized FPGA. This LED remains active if it was not possible to load a valid FPGA file from the Flash.

Measurements provided for diagnostic 5.4.3

Monitor Output

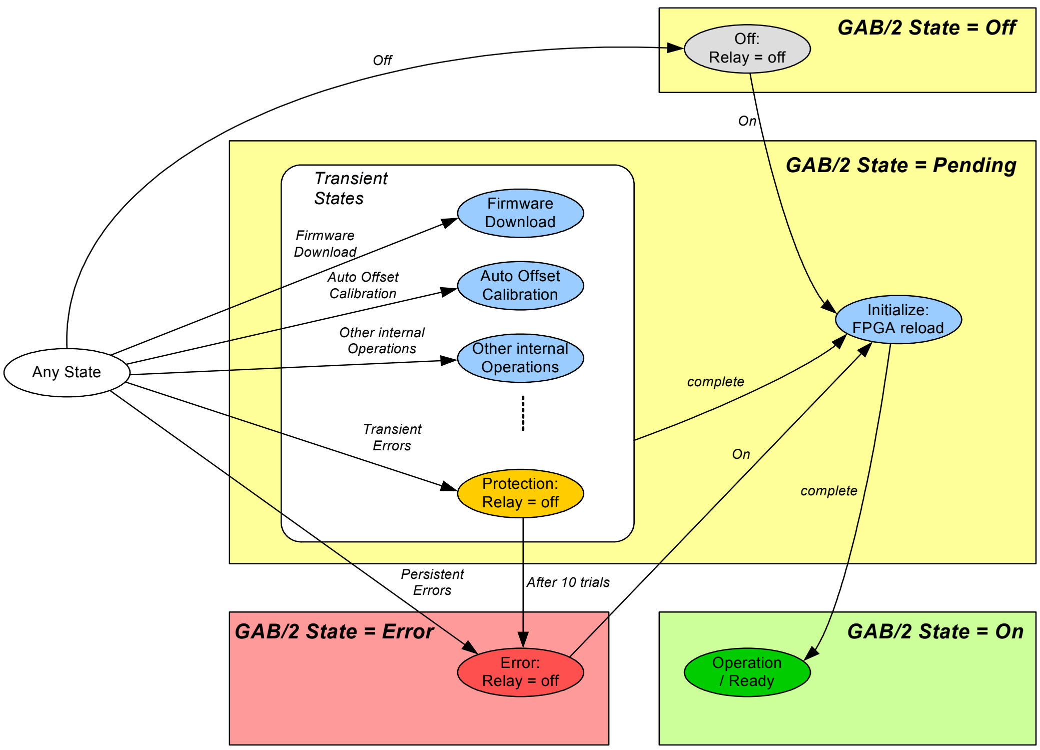
The monitor output reflects the Gradient current provided by the Gradient current connector. This output is intended for diagnostic purpose. It can be useful for debugging the hardware or software (pulse programs). The relation is 1 Volt (monitor voltage) per 1 Ampères (Gradient current).

Logging of LVDS link

For diagnostic purpose, the GAB/2 hardware provides recording of the LVDS link data - incoming requests for specific Gradient currents are logged (aimed value and time stamp in a raster of 10 ns). So it can be checked if the real time Gradient commands correspond exactly with the Gradient defined by the pulse program in TopSpin. This feature is accessible over the Service Web - the logging buffer can be reset before running an experiment, and the resulting information is displayed afterwards.

GAB/2 Control State Machine *5.4.4*

Figure 5.5. The GAB/2 Control State Machine



After Power Up of the BSMS/2, the GAB/2 Control State Machine steps through the necessary steps for getting operational. First, the FPGA design is reloaded from the Flash, and after correct setup of the hardware - if no error occurs - the final state „Operation“ is reached. In this state the GAB/2 is ready for handling the incoming requests over LVDS.

It is possible to switch off the GAB/2 or to start some specific operations (e. g. Firmware Download or Automatic Offset Calibration) when the GAB/2 is in any state. After completion of a specific operation, the GAB/2 is re-initialized. In the end - on successful Initialization - the GAB/2 is ready / operational again.

There is a set of non severe errors (e. g. parity bit errors on 48 bit LVDS link, temporary interruption of the selected LVDS link). If such an error occurs then the GAB/2 steps into a „Protection“ state - any existing Gradient current is reset (the relay is switched off). After a time-out the GAB/2 tries to re-initialize and reach the „Operate“ state again.

In case of a severe error (e. g. break down of the supply voltage) the GAB/2 steps into the Error state. It remains in this state until the client (e. g. TopSpin application) re-initializes the GAB/2. Both, the severe and non-severe errors, are reported to the client (TopSpin application / BSMS Keyboard).

Front Panel - Connectors *5.4.5*

The Gradient current connector is shown in detail in the block diagram (figure 5.3). Current flowing in the indicated direction induces a positive Z-Gradient. The Monitor Output is a simple coaxial connector, e. g. for directly connecting a scope.

Figure 5.6. LVDS 48 interface used in AVANCE spectrometers with IPSO

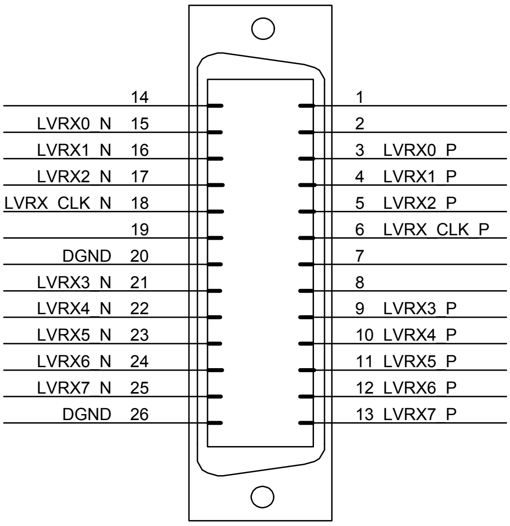
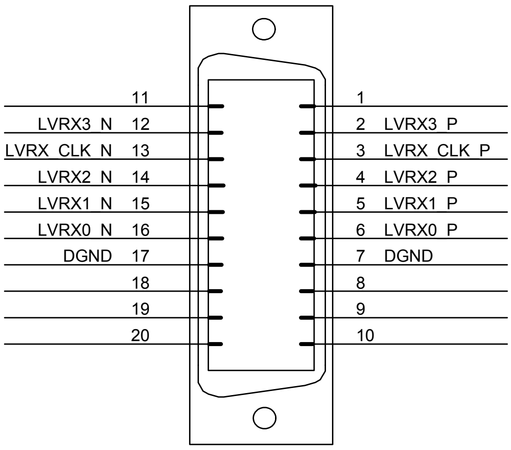


Figure 5.7. LVDS 28 interface used in AVII spectrometers



Bus Interface 5.5

As mentioned already earlier in this document, the GAB/2 is not actually connected with the VME bus (apart from the power and ground lines). The communication with the ELCB runs exclusively over the User Bus.

Backplane Connector (User Bus) 5.5.1

Table 5.2. User Bus Back Plane Connector

	A	B	C
1 .. 10	-	-	-
11	-	Slot ID 0	-
12	-	Slot ID 1	-
13	/SysReset	Slot ID 2	RCLK
14	SSRB:SCLK	Slot ID 3	SSRB:STXD
15	SSRB:SRXD	-	SSRB:/SINTR
16 .. 19	-	-	-
20	VCC_BPL	VCC_BPL	VCC_BPL
21	DGND	DGND	DGND
22 .. 25	-	-	-
26 / 27	P_VPWR	P_VPWR	P_VPWR
28 .. 30	VPWRGND	VPWRGND	VPWRGND
31 / 31	N_VPWR	N_VPWR	N_VPWR

LVDS Interface Specification *5.6*

Both LVDS interconnections provide data multiplexing - one LVDS signal pair represents 6 or 7 physical signals at the client side. This can be realized by a LVDS transmission rate 7 times higher than the data rate at the client side.

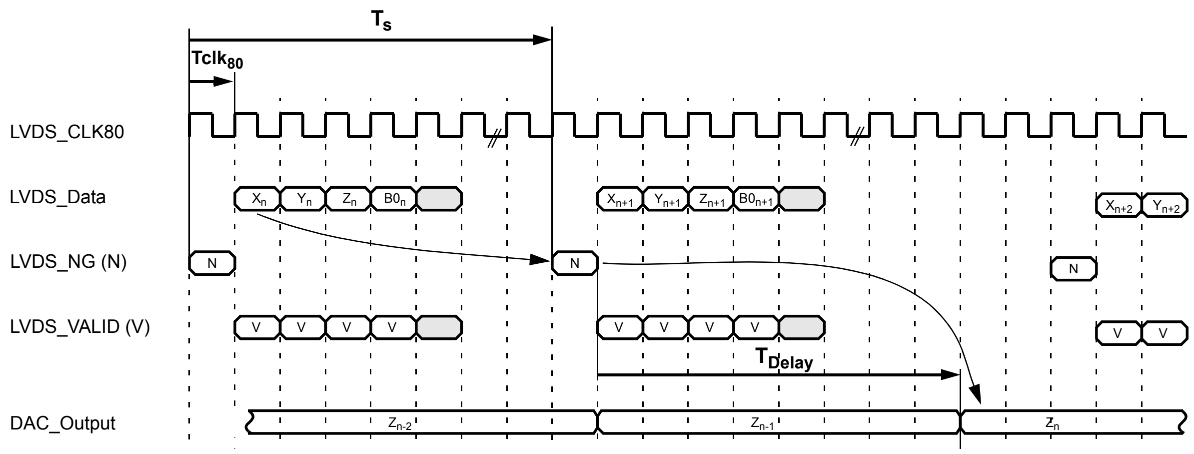
The actual protocol for transmission of Gradient commands is based on the physical signals at the client side that are listed in the table below

Note: The LVDS-28 link provides only 16 bit Gradient data, whereas the LVDS-48 link transmits 20 bit Gradient data.

Table 5.3. LVDS signals (client side)

LVDS-28		LVDS-48	
4 data pairs @ 140 MHz / 28 bit @ 20 MHz		8 data pairs @ 560 MHz / 48 bit @ 80 MHz	
		1	Next Go (NG)
		2	Valid
		3	Last
1 .. 16	Data [0] .. Data [15] ***+100% = 0x7FFF*** ***- 100% = 0x8000***	4 .. 17	Not used
17 .. 20	Not used	18 .. 37	Data [0] .. Data [19] ***+100% = 0x7FFFF*** ***- 100% = 0x80000***
21 .. 26	Address [0] .. Address [5]	38 .. 43	Address [0] .. Address [5]
27	Valid (BSTR)	44 .. 47	Address [6] .. Address [9]
28	Next Go (NXGO)	48	Parity bit (PAR)

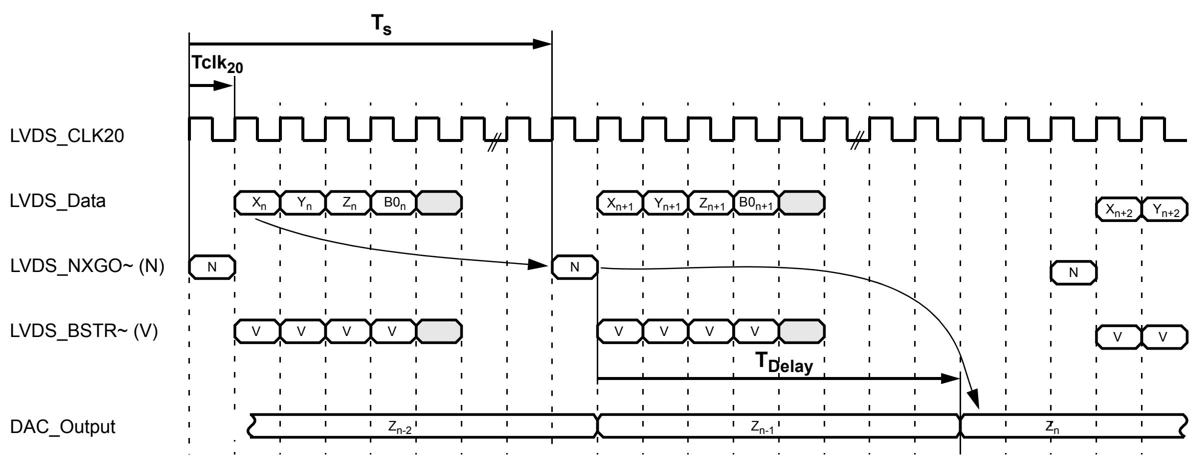
Figure 5.8. Timing for the communication over the 48 bit LVDS link



Between two subsequent commands, there must be a time span (T_s) of at least one microsecond.

Valid Gradient data can be sent in any order between two activation commands (Next Go = NG). If there is a Z component marked with the Valid flag, then it is loaded into the GAB/2. With the next activation command, the data are transferred into the DAC and become active one microsecond (T_{Delay}) after the activation command.

Figure 5.9. Timing for the communication over the 28 bit LVDS link



The 28 bit LVDS link is based on 20 MHz - in contrast with the 80 MHz based 48 bit LVDS link. The protocol however is the same - between two subsequent commands, there must be a time span (T_s) of at least one microsecond.

Due to the slower clock rate, the duration of a Gradient command is 50 ns ($Tclk_{20}$). There are the same rules for transmission of Gradient data as for the 48 bit LVDS, and the delay between the activation command and the corresponding DAC output is also 1 microsecond (T_{Delay}).

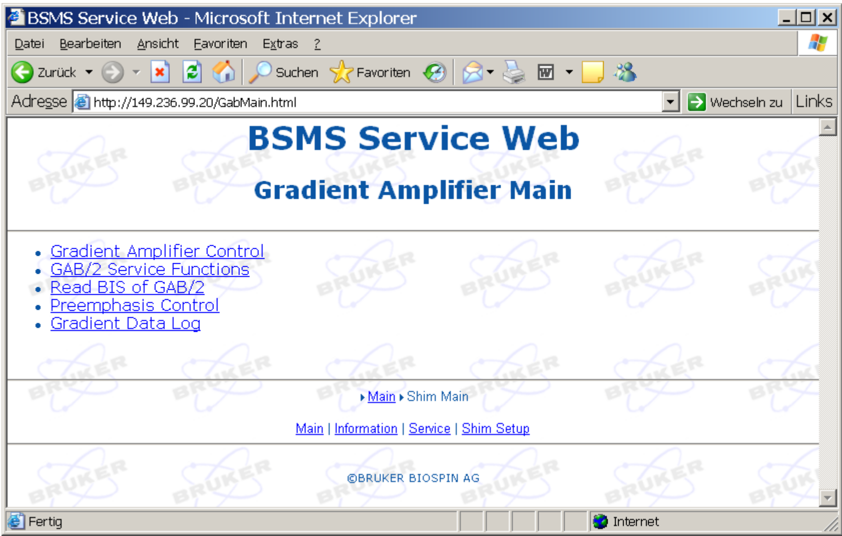
Web Interface 5.7

Both, the specific low level drivers and the overall control logic for the GAB/2 are implemented in the ELCB software. It provides setup and configuration for the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration and diagnostic). Some of these Web functions are open for all users (e. g. clients), other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

GAB/2 Service Web 5.7.1

The Submenu „Main“ -> „GAB“ provides access to all service functions for a connected GAB or GAB/2 board. Depending on the connected board (GAB or GAB/2) there is a different set of commands available - the GAB provides a subset of all these commands.

Figure 5.10. Main Menu for the GAB/2 Subsystem



On top of the GAB/2 menu there is the link to the Gradient Amplifier Control sub page. This page provides an overview over

- the connected board (GAB or GAB/2)
- its type (e. g. Z-Gradient Amplifier present)
- operating state (e. g. „operate“). If the GAB/2 is in state „off“, „protection“ or „error“ then the current source is disconnected by a relay.

The GAB/2 service functions provide detailed information for diagnostics and a push button offset calibration (see also ***"Offset Re-Calibration in the field" on page 100***).

There are further links for BIS reading, preemphasis parameter setting and logging of the real time gradient signals on the LVDS interface.

Offset Re-Calibration in the field 5.7.2

During production, the GAB/2 is calibrated for minimum residual offset. This calibration is normally sufficient for a long time period and a wide temperature range. However, it may happen in rare circumstances that the dynamic offset compensator reaches its limitations. This is reported by an error message sent to the TopSpin application and the BSMS Keyboard.

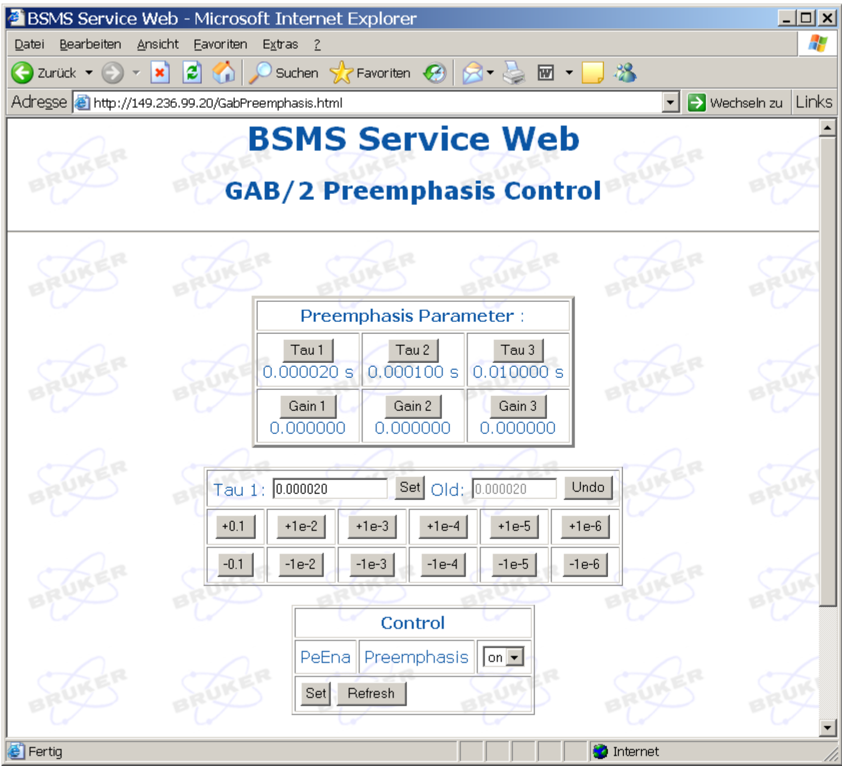
It is then necessary to go to the page „main“ -> „GAB“ -> „GAB/2 Service Functions“ and invoke the offset calibration again by depressing the button „Calibrate“ in the row „Offset Calibration“.

The other parameters on the GAB/2 Service Page are intended for diagnostic purpose. Service engineer access rights are necessary for modification - it is however not recommended to change these parameters under normal circumstances.

Preemphasis setting by Service Web 5.7.3

Normally, the preemphasis parameters are defined by the „setpre“ feature provided by TopSpin (see also ***"Preemphasis" on page 91***). Alternatively, the gains and time constants can be set also by the Service Web.

Figure 5.11. Preemphasis settings

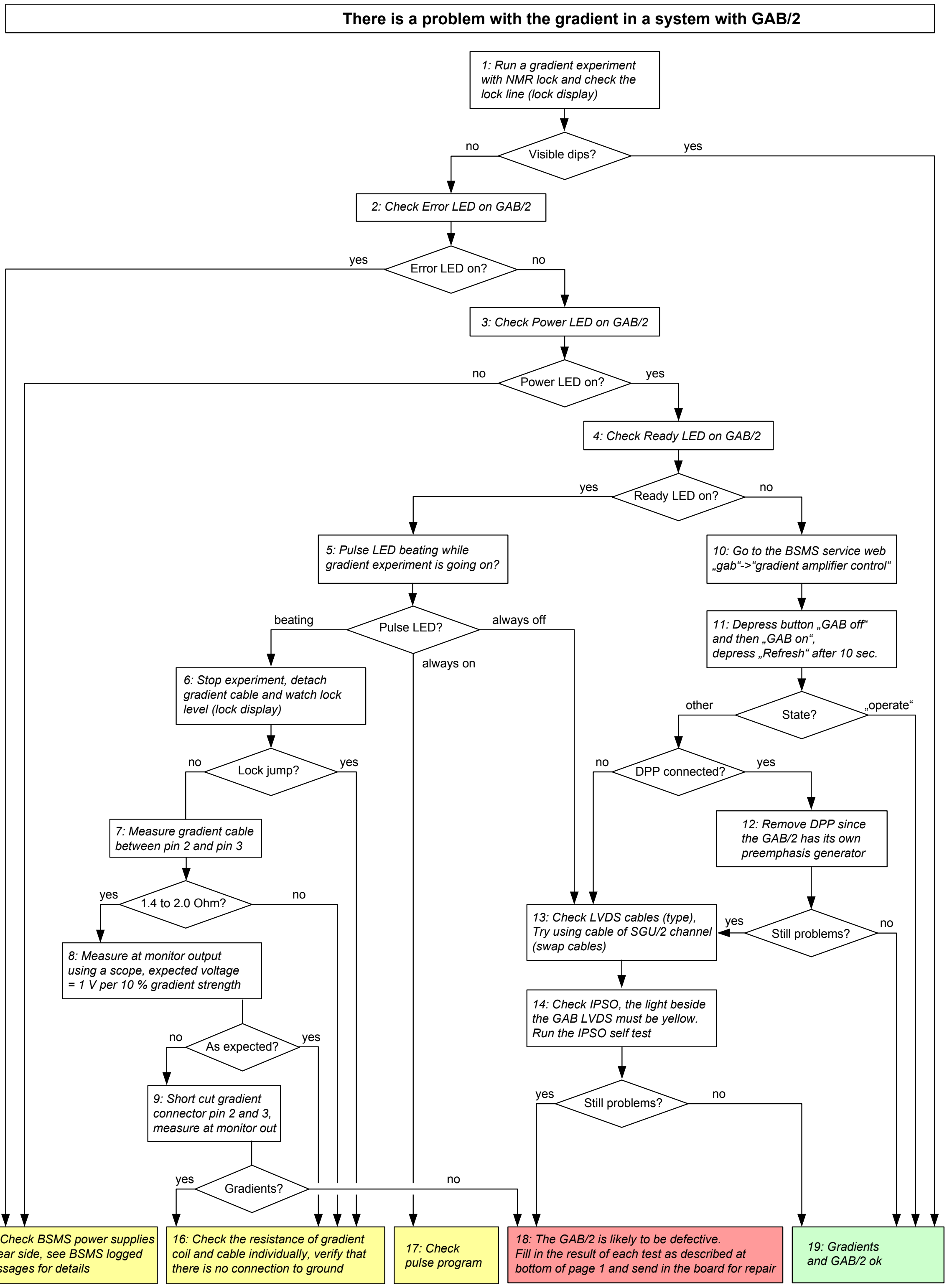


Note: The time constants (Tau1 .. Tau3) are defined in seconds.

Trouble Shooting 5.7.4

The following flow chart describes the suggested trouble shooting procedure in case of gradient problems.

Figure 5.12. Trouble shooting procedure for GAB/2



Some of the necessary checks are described in detail below. It depends on the preceding test results, which check actually has to be performed next. Typically, not all checks have to be executed.

1. Run a gradient experiment

In the ATP you may run a profile experiment (gzp) and check if the resulting profile has the expected shape.

You can execute a Bruker standard experiment (e. g. gradient COSY) on a nucleus other than your lock nucleus (typically 2H for lock) with activated NMR lock. You should be able to see the deep dips in the lock level (check the lock display) while the gradient is active.

6. Check for unintended / faulty ground connection

In case of a faulty connection between one of the gradient wires and the ground potential there is typically a current flowing. This current has an influence on the Z1-Shim and disappears as soon as the gradient connector is unplugged. A perfect shim with the influence of that current would get significantly worse without, and the lock level would drop accordingly.

7. Measure gradient cable between pin 2 and 3

Unplug the gradient cable and measure at GAB/2 side. Since the resistance of the gradient (cable and coil) is very low, the measurement has to be made very carefully (at best differential measurement).

8. Connect an oscilloscope to the monitor output

The monitor output on the GAB/2 provides a voltage that represents the current actually provided by the GAB/2 current source. 1 Volt represents 1 Ampère current, which is a gradient strength of 10%. If the voltage at the monitor is only a few millivolts and very noisy, there is probably no gradient load connected. In this case, the gradient cable and the coil resistor have to be measured by a Ohm meter (see point 16).

9. Suspicion of open gradient load

Detach the gradient cable and connect pin 2 and 3 of the gradient connector e. g. by a bent paper clip. Restart your gradient experiment afterwards and check the monitor output.

10. Use the BSMS Service Web to get the GAB/2 state

In TopSpin (version 2.0 or later) type "ha" to get access to the Service Web. In former TopSpin versions (1.3) or XWinNMR, use a standard Web browser and select the address 149.236.99.20.

11. Restart the GAB/2 on the corresponding service web page.

Perform the indicated command sequence. Wait about 10 seconds before depressing the "refresh" button. If you have no success, you may try several times.

12. If there is a DPP

The GAB/2 can operate without DPP and has its own preemphasis generator. The DPP is therefore not necessary and should be removed. Some versions of the DPP did not provide a parity bit, which would cause communication errors.

13. Check the LVDS cables

Verify that only the certified LVDS cables are used, if you are not sure about the required type, contact your Service support. You might try with a cable from a SGU/2 channel.

15. If the GAB/2 is in error state

Normally, the cause for a GAB/2 error is reported to TopSpin by an error message. One possible cause could be a missing power supply voltage. It is helpful to check also the logging provided by the BSMS Service Web (page "service"->"display logged messages"). There might be a hint why the GAB/2 is in error state.

Long term BSMS logging can be enabled on the "bsmsdisp" provided by TopSpin. The enable check box is on the service page (password required), and the logging can be viewed on the same page.

L-TRX / L-19F 6

Introduction 6.1

The BSMS/2 LOCK TRANSCEIVER (L-TRX) and the **optional** BSMS/2 LOCK TRANSCEIVER 19F (L-19F) are new designed and incorporate the following units:

- former BSMS LOCK TRANSMITTER (L-TX)
- former BSMS LOCK RECEICER (L-RX)
- actively gated 5W pulsed power amplifier for 2H gradient shimming purposes
- former BSMS L-TX OPTION 19F
- former BSMS L-RX OPTION 19F

In addition, the L-TRX / L-19F have several new features:

- enhanced digital transmitter and receiver
- power amplifier with active quiescent current control
- field-upgradable by firmware
- fast SSRB interface to ELCB
- real-time pulses also accessible via backplane connector
- on board over temperature protection
- extended internal diagnostics
- BIS hardware identification system
- milled housing with narrow form factor and optimized cooling fins
- dedicated up- and down converter unit for fluorine lock (L-19F)

As with the former lock system there is one L-TRX unit per system frequency. The L-19F unit is one single 19F unit for 300 MHz to 1000 MHz system frequency.

Figure 6.1. L-TRX Block Diagram

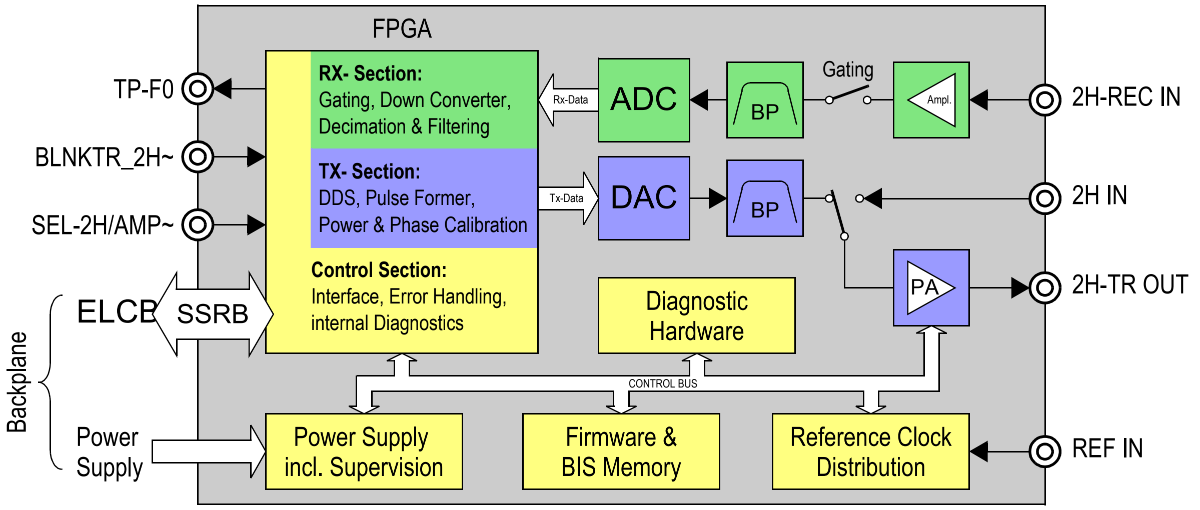


Figure 6.2. L-19F Block Diagram

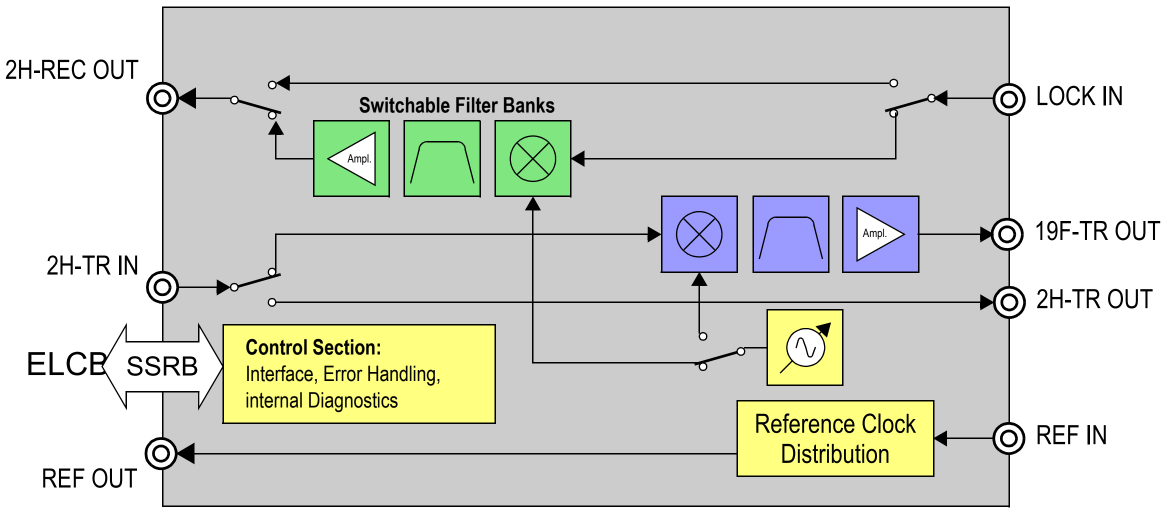


Figure 6.3. Block Diagram L-TRX unit

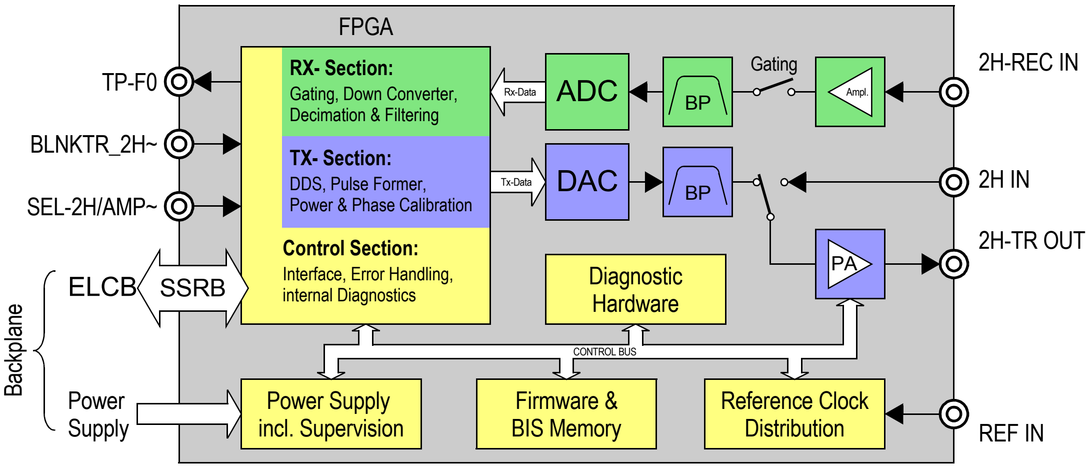
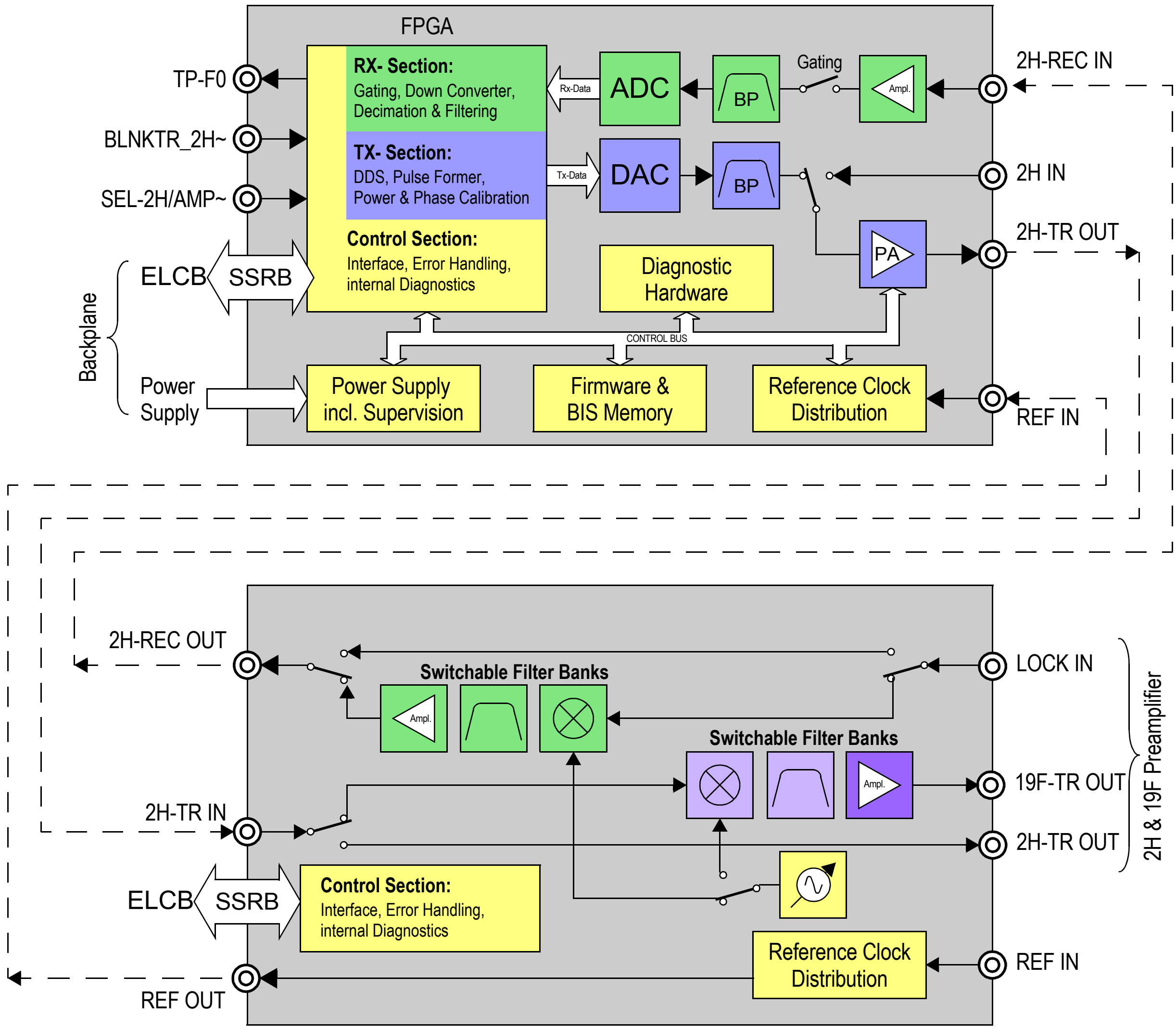


*Figure 6.4. Block Diagram with **optional** L-19F unit*



Function Description 6.2.1

The architecture of the L-TRX / L-19F units is significantly different to the design of the former L-TX and L-RX units. The individual signal processing and amplifier control stages are as much as possible shifted into the digital domain.

Signal processing:

The transmitter consist of a direct digital synthesizer. The output power range is fully implemented with D/A-converters, which eliminates the need of real-time controlled analog attenuators.

The receiver consists of a mostly direct digital system. The receiver gain is mainly implemented in the digital section.

Deuterium power amplifier with active quiescent current control:

The operating point of the on-board 5W power amplifier for 2H gradient shimming is matched to the different operating modes in order to reduce power dissipation. The individual quiescent current values are stored in the calibration data memory of each unit. In ‚2H Lock‘ mode the quiescent current is actively regulated.

Gradient shimming:

Together with the L-19F unit, the on-board 5W power amplifier should not be used for gradient shimming on 2H. In spectrometer configurations with the L-19F unit a high power 2H amplifier is anyway mandatory for 2H observe experiments. In this configuration the same high power 2H amplifier is used for gradient shimming.

The L-TRX / L-19F units do not support gradient shimming on 19F.

Reference clock:

The L-TRX / L-19F units use the same reference frequency mixture produced by the AQS REFERENCE board as the AQS SGU. The former 10 MHz system clock is not required anymore.

SSRB communication interface with ELCB:

The L-TRX / L-19F units use a dedicated SSRB (Synchronous Serial Rack Bus) interface for control and data transfer to the ELCB.

Real-time pulses via backplane:

The L-TRX is able to receive and transmit real-time control pulses via backplane to reduce external wiring. This feature is currently only used in the NanoBay console (BLNKTR_2H~). Other pulses and/or consoles may follow in the future.

2H-TR power amplifier output connector:

The output connector is a N-type instead of SMA to avoid the risk of unintentional wrong wiring. E.g. low power rf-boards could be permanently damaged if wrongfully connected to the 5W power output of the L-TRX.

Product firmware:

The L-TRX / L-19F firmware packages are field-upgradable via ELCB. The factory configuration is stored on-board in a write protected memory section. The user can always reload the factory firmware.

Fluorine lock:

The former fluorine lock option piggy modules have been integrated into a dedicated deuterium to fluorine up and down converter unit (L-19F). While locking on a deuterated solvent, the L-19F unit is bypassed. Whereas the L-19F unit translates the deuterium lock signal into the fluorine lock signal, while locking on samples containing fluorine as lock solvent.

Protection *6.2.2*

Power Supply and Reference Clock Supervision:

All power supply voltages and the necessary reference clocks are internally monitored. In case of a failure the ‚PWR/CLK‘ LED (L-TRX) or the ‚PWR‘ LED (L-19F) are deactivated and an appropriate error message is generated (if still possible).

Over-Temperature Protection (L-TRX only):

The power amplifier and board temperature are monitored on-board. The ELCB can access the relevant sensors and act accordingly.

If the temperature reaches the limit of safe operation, the power amplifier is switched off immediately without intervention of the ELCB. The L-TRX enters the ERROR state. An error message is sent to TopSpin and displayed on the BSMS keyboard. See ***"Over Temperature Error:" on page 131***

After regaining normal temperature conditions, the L-TRX reverts to the operating mode prior to the error.

Over-Current Protection (L-TRX only):

If the power amplifier drain current exceeds the limit of safe operation, it is switched off and the L-TRX enters the ERROR state. An error message is sent to TopSpin and displayed on the BSMS keyboard. See ***"Over Current Error:" on page 132***

Internal Diagnostics *6.2.3*

The L-TRX has extensive internal diagnostic functions which can be accessed via the service web. See ***"Diagnostic Functions:" on page 129***.

Many of the diagnostics are performed automatically during power-up and assessed by the ELCB. If a failure occurs, an appropriate error message is generated.

Due to the low complexity of the L-19F unit, the unit does not have any dedicated diagnostic functions.

Technical Data BSMS/2 Lock Transceiver 6.2.4

Transmitter (TX):

Output power for gradient shimming @ +4 dBm input power	min. 5W
Conditions: pulsed power only, max. pulse length = 1s, max. duty-cycle = 10 %, all independent of actual output power	
Output power for Lock operation:	
FFA Mode (250us pulse)	typ. 28dBm
Lock Mode (Lock pulse)	-60...+20dBm
Output power resolution	typ. 0.1dB
Frequency resolution	≤ 14mHz
Phase resolution	≤ 0.1°(deg)
Phase range	0..360 endless°(deg)
Frequency range	f_{2H} ± 1MHz
Load mismatch:	
no damage	infiniteVSWR
for on board diagnostics	≤ 3.6VSWR
Confamp (except for Z109887 and Z109888 with ECL< 2)	Supported

Receiver (RX):

Gain range	80dB
Gain resolution	0.1dB

Technical Data BSMS/2 19F Lock Transceiver 300-1000 6.2.5

Transmitter (TX, 19F lock operation):

Output power for Lock operation:	
FFA Mode (250us pulse)	typ. +10dBm
Lock Mode (Lock pulse)	-60...+10dBm
Output power resolution	See **6.2.4**
Frequency resolution	See **6.2.4**
Phase resolution	See **6.2.4**
Phase range	See **6.2.4**
Frequency range	f_{19F} ± 1MHz
Load mismatch	See **6.2.4**
Confamp	N/A

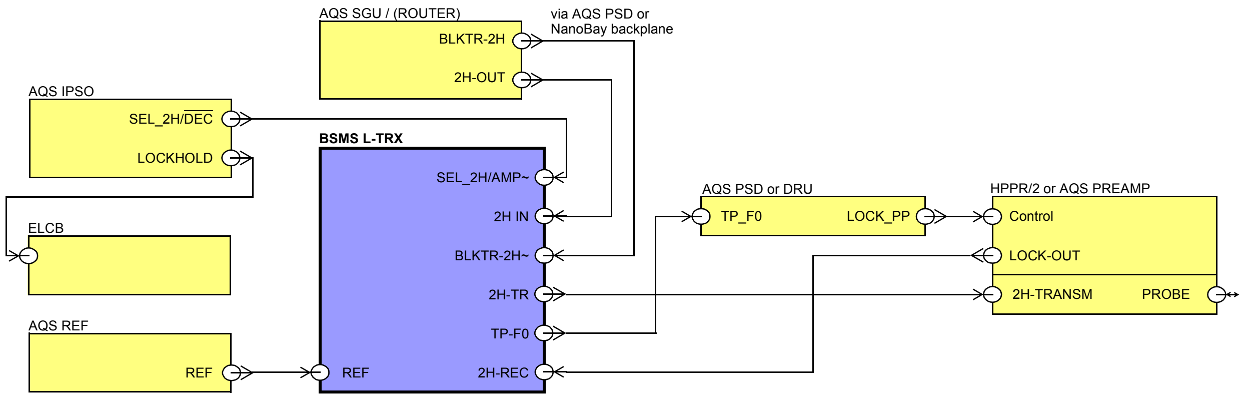
Receiver (RX, 19F lock operation):

Gain range	60dB
Gain resolution	See **6.2.4**

2H Lock with L-TRX internal Power Amplifier 6.2.6

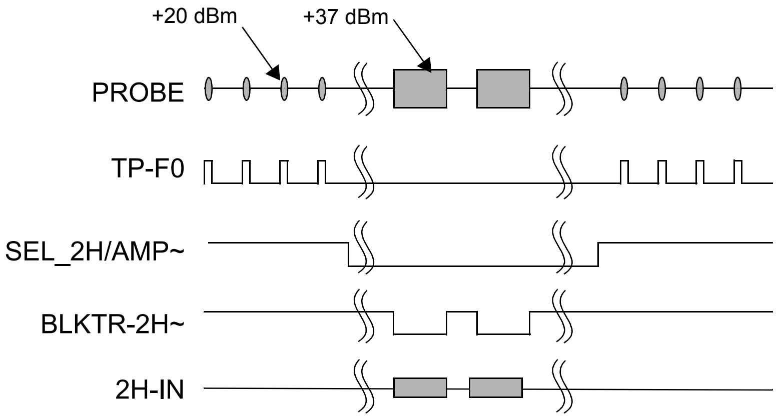
Minimal system for 2H lock using internal power amplifier for gradient shimming only (no 2H Observe or Decoupling capability). Set ‚2H-TX Control‘ Router Address according to your configuration. (see **"2H-TX Control (Router Address):" on page 124**)

Figure 6.5. 2H Lock system with L-TRX internal power amplifier for gradient shimming



Interrupt of ‚Lock 2H‘ operation with SEL_2H/AMP~ signal in real-time.

Figure 6.6. Timing diagram of ‚Lock 2H‘ operation with interrupts for gradient shimming



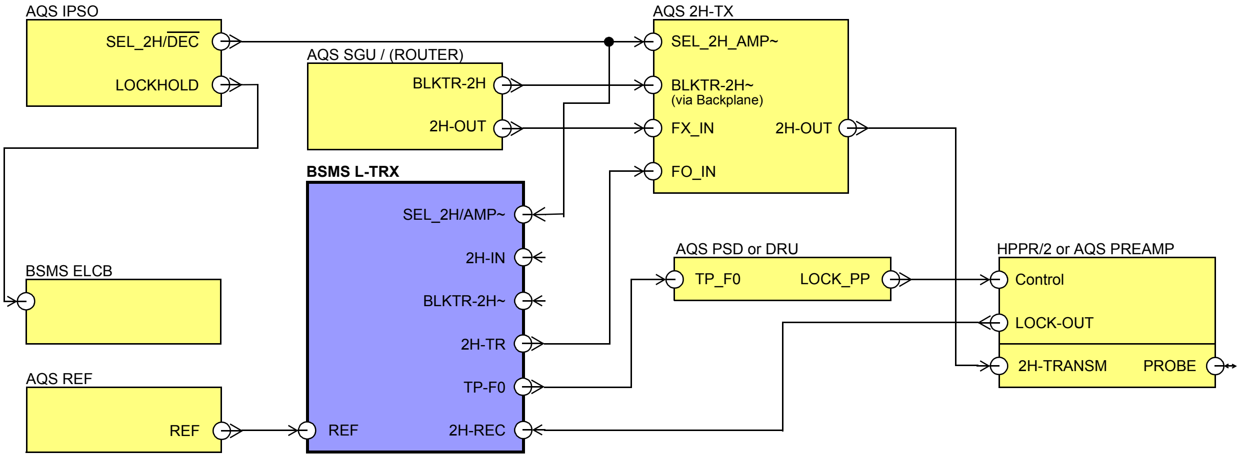
Lock 2H → 2H Gradient Shimming → Lock 2H

2H Lock with additional, external 2H Power Amplifier 6.2.7

A more powerful external amplifier can be used for 2H gradient shimming, 2H Observe and 2H Decoupling. Set ‚2H-TX Control‘ Router Address to ‚255‘. (see ***"2H-TX Control (Router Address):" on page 124***).

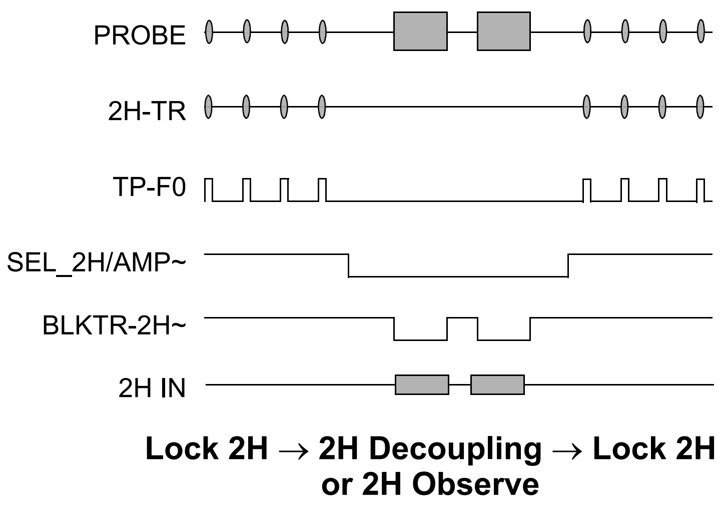
In order to mute the lock stimulus in real-time during 2H-Observer and 2H-Decoupling experiments, the signal ‚SEL_2H/DEC‘ must be connected to the AQS 2H-TX and the L-TRX unit. For further details on the wiring see ***Figure 6.13.***.

Figure 6.7. 2H Lock system with additional, external 2H power amplifier



Interrupt of ‚Lock 2H‘ operation with SEL_2H/AMP~ signal in real-time.

Figure 6.8. Timing diagram of ‚Lock 2H‘ operation with interrupts for 2H Decoupling or 2H Observe

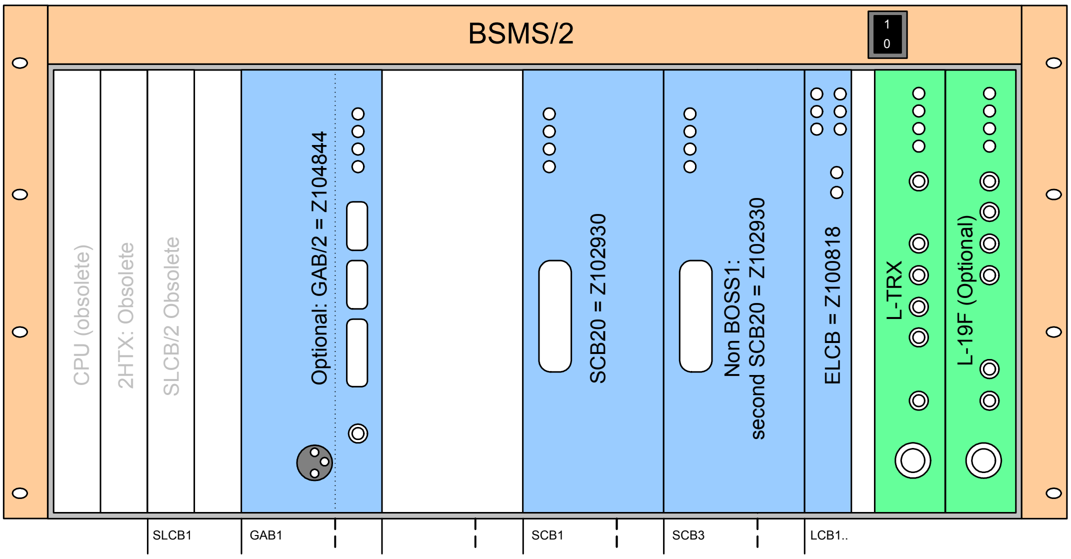


AVANCE III MicroBay/OneBay/TwoBay Configurations 6.3

The BSMS/2 CHASSIS (Z002774, ECL $\geq$ 02) is compatible to both generations of lock systems. Only a power supply board must be replaced.

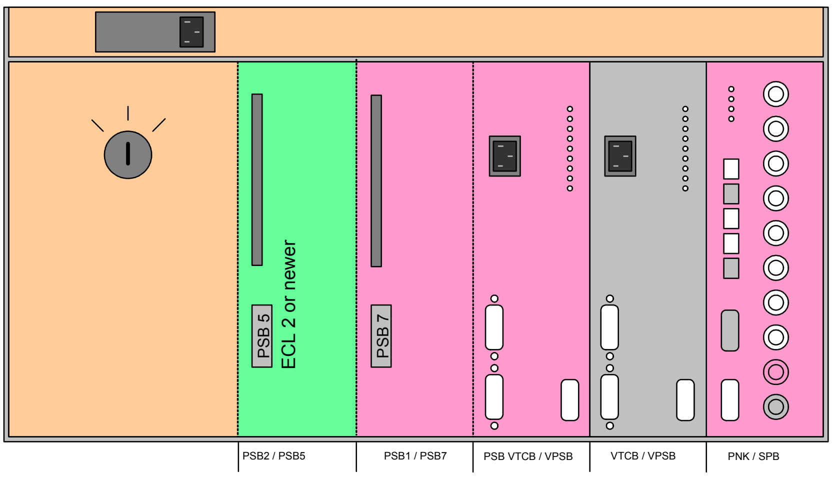
Installation 6.3.1

Figure 6.9. L-TRX and L-19F slots in BSMS/2 chassis (Front View)



- Install the L-TRX unit in the L-TX slot
- Install the L-19F unit in the L-RX slot
- If L-19F is not installed, cover the L-19F slot with a blind plate (Z14118, 8TE)
- If L-19F is installed, cover the remaining openings with two blind plates (Z123939, 1TE, in parts list of L-19F included)

Figure 6.10. PSB5 slot in BSMS/2 chassis (Rear View)



230V SHOCK HAZARD
Disconnect power before servicing!

- Remove the cover plate over the power supply boards
- Replace PSB2 with PSB5 (Z111143)
- Replace the cover plate

Settings 6.3.2

2H-TX Control (Router Address):

Enable or disable the internal power amplifier for gradient shimming. See **"2H-TX Control (Router Address):" on page 124**.

If no AQS 2H-TX is present, enable the internal power amplifier for gradient shimming:

- Set router address according to the BLNKTR~ pulse used:
  Nanobay 3 Channel = ‚7‘
  MicroBay 2 Channel = ‚**7**‘
  MicroBay 3 Channel = ‚**7**‘
  OneBay/TwoBay ext. BLA = ‚**7**‘

If an AQS 2H-TX is present, disable the internal power amplifier:

- Set router address to ‚**255**‘.

With this setting the internal power amplifier is only used for ‚2H Lock‘ operation.

Wiring 6.3.3

The following figures describe the wiring of the L-TRX with the CABLE SET L-TRX UPGRADE (H14042, blue).

Figure 6.11. Wiring AVANCE III MicroBay with AQS Preamplifier (H14034 and H14013)

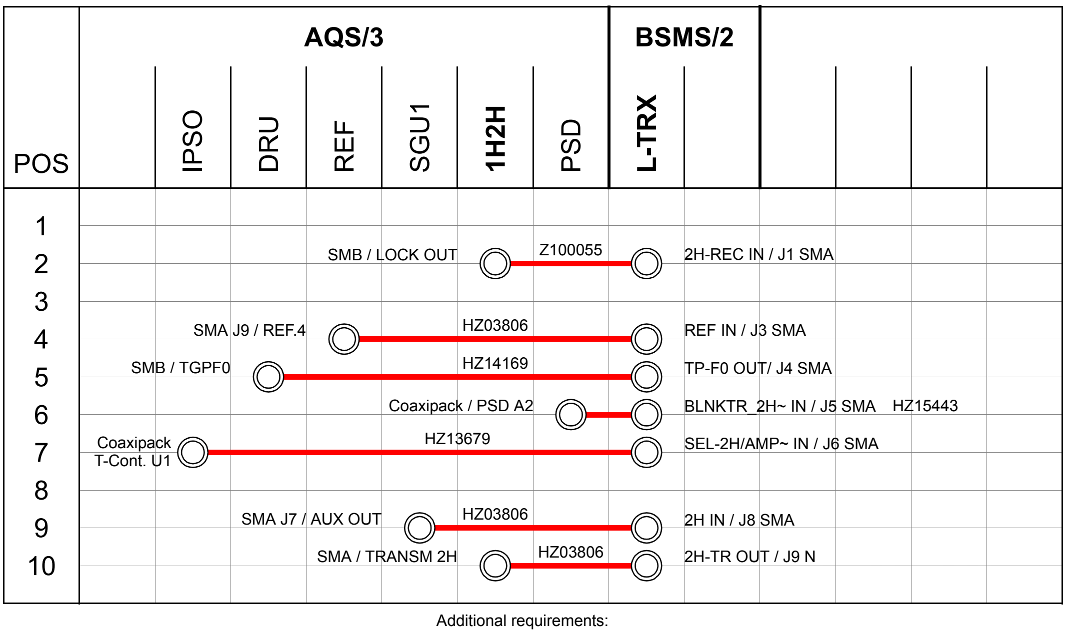


Figure 6.12. Wiring AVANCE III MicroBay, One & TwoBay with HPPR/2 Preamplifier and no external 2H Amplifier (H14010 and H14013)

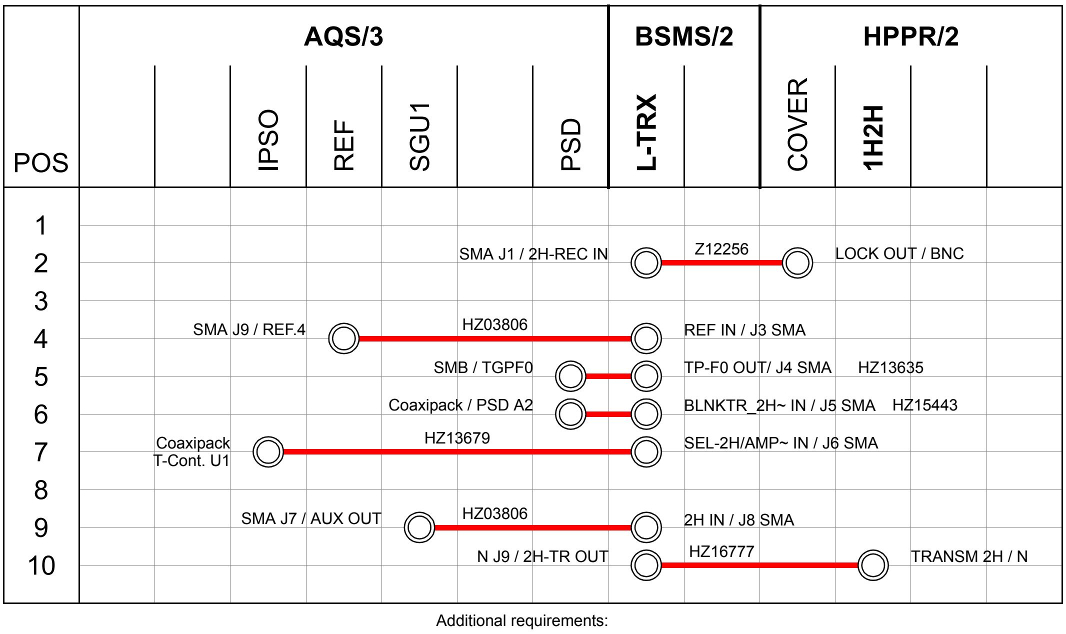


Figure 6.13. Wiring AVANCE III One & TwoBay with AQS 2H-TX (H14010, H14020 and H14014)

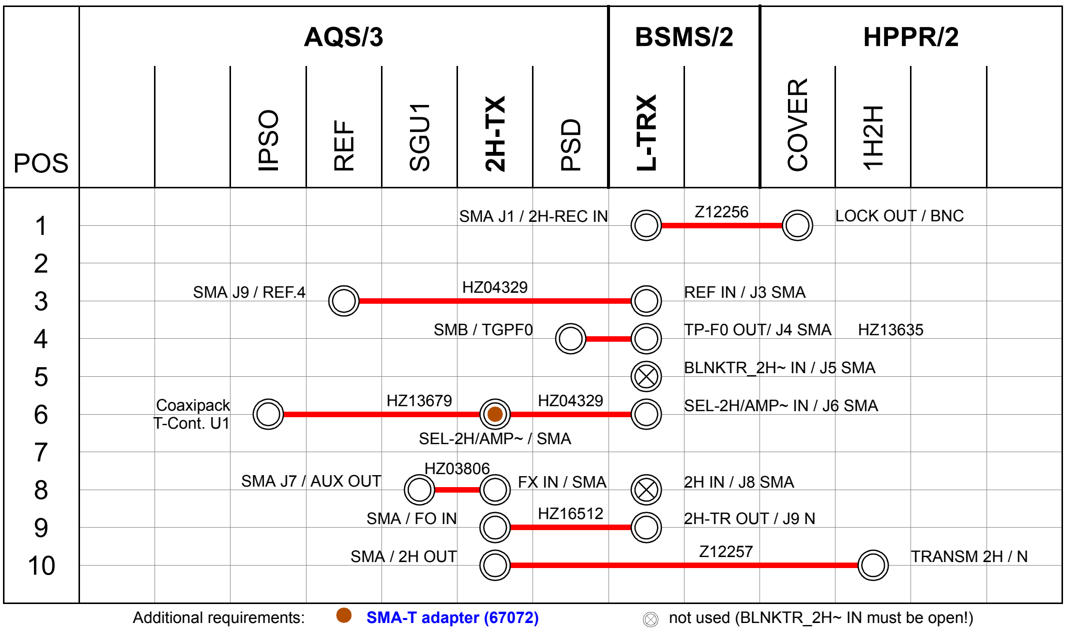
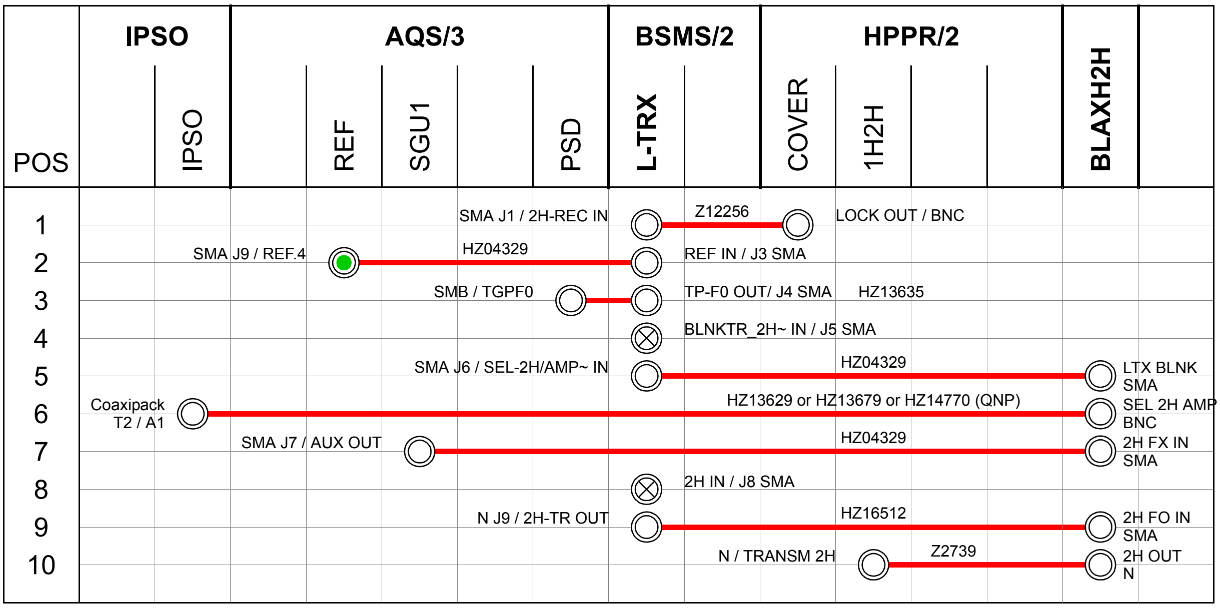
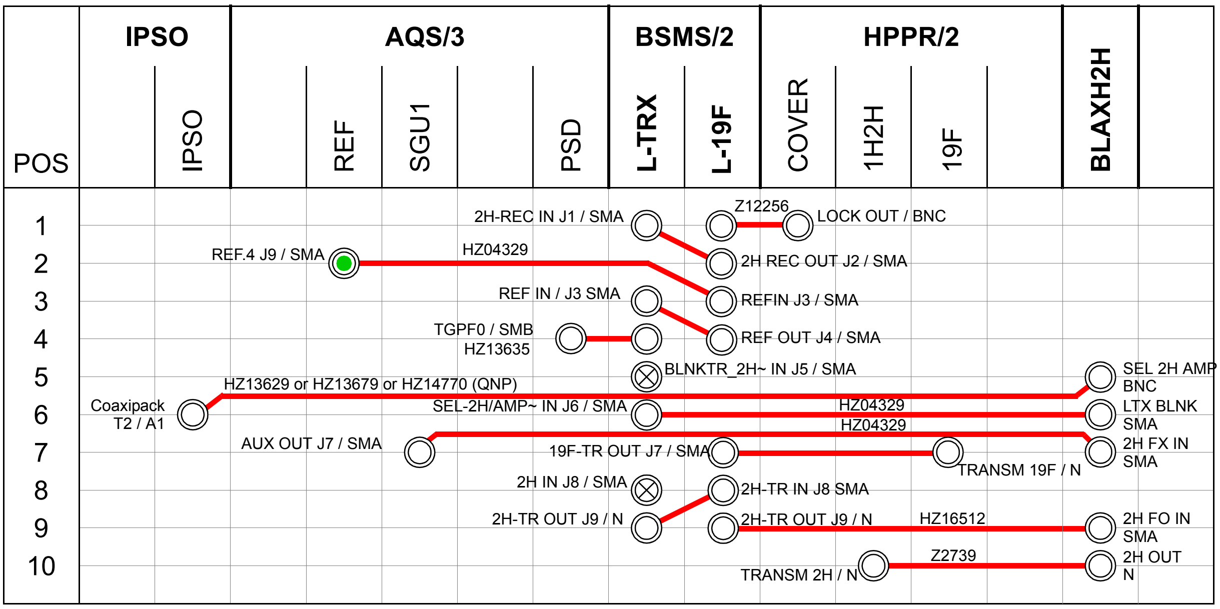


Figure 6.14. Wiring AVANCE III One & TwoBay with BLAXH2H (H14008, H14010 and one of H14014 or H14015 or H14016)



Additional requirements: ● REF/2: Splitter (Z102000) or 6dB attenuator (45999) ⊗ not used (BLNKTR_2H~ IN must be open!)

Figure 6.15. Wiring AVANCE III One & TwoBay with L-19F and BLAXH2H (H14008, H14010, Z125188 and one of H14014 or H14015 or H14016)



Additional requirements: ● REF/2: Splitter (Z102000) or 6dB attenuator (45999) ⊗ not used (BLNKTR_2H~ IN must be open!)

Table 6.1. Wiring BLNKTR_2H~ (AQS PSD to 2H Amplifier) [a]

BLNKTR	MicroBay 2 Channel	MicroBay 3 Channel	One & TwoBay
BLNKTR(1)~	AQS BLA2BB X (via AQS backplane)	AQS BLA2BB X (via AQS backplane)	External BLA 1-6 (Cable HZ10148)
BLNKTR(2)~	AQS BLA2BB H (via AQS backplane)	AQS BLA2BB H (via AQS backplane)	
BLNKTR(3)~		AQS BLAX300 (via AQS backplane)	
BLNKTR(4)~			
BLNKTR(5)~			
BLNKTR(6)~			
BLNKTR(7)~	L-TRX (Cable HZ15443)	L-TRX (Cable HZ15443)	L-TRX (Cable HZ15443)
BLNKTR(8)~			

a. AQS 2H-TX: blanking pulse via AQS backplane

Front Panel - Connectors and LED's 6.4

BSMS/2 Lock Transceiver 6.4.1

Figure 6.16. View BSMS/2 LOCK TRANSCEIVER 300

ERROR
READY
PWR/CLK
INACTIVE

2H-REC IN	(J1)
REF IN	(J3)
TP-F0 OUT	(J4)
BLNKTR-2H~ IN	(J5)
SEL-2H/AMP~ IN	(J6)
2H IN	(J8)
2H-TR OUT	(J9)

LED ‚ERROR' (red):

All errors detected by the L-TRX are displayed with the ‚ERROR' LED. In addition interrupt requests activate the LED for at least 250 ms. If the ELCB does not process the interrupt immediately, the LED stays active. In diagnostic mode the LED beats with approx. 2 Hz. During the Error state only a minimal set of diagnostic functions is available.

LED ‚READY' (green):

The ‚READY' LED is active if the L-TRX is successfully initialized and ready for ELCB commands. If the LED stays dark, the L-TRX FPGA initialization has failed. If an error is detected, the LED is deactivated. In addition any communication deactivates the LED for at least 250 ms.

LED ‚PWR/CLK' (green):

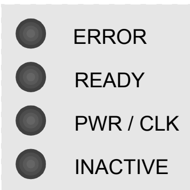
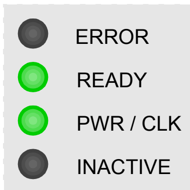
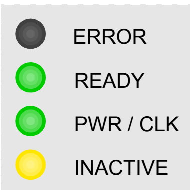
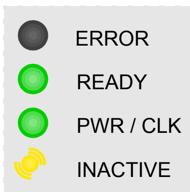
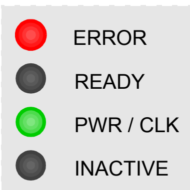
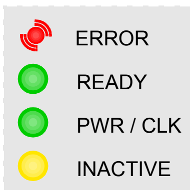
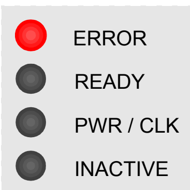
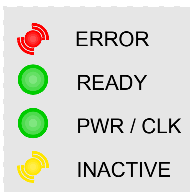
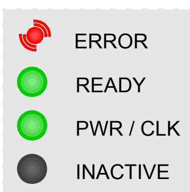
In case of a power supply failure or missing reference clock the ‚PWR/CLK' LED is deactivated. The L-TRX enters the ERROR state.

LED ‚INACTIVE' (yellow):

During normal operation the ‚INACTIVE' LED displays the L-TRX Lock signal generation status. The LED is continuously on when no Lock mode is active or beats with approx. 2 Hz if the signal generation is suppressed with the SEL_2H/AMP~ input.

In diagnostic mode the LED displays the transmitter (power amplifier) status. If the transmitter is switched off, the LED is active. During pulsed operation the LED beats with approx. 2 Hz. In CW signal generation mode the LED is deactivated.

Table 6.2. L-TRX Status LED's in different operating modes

LED Status	Operating Mode	LED Status	Operating Mode
	Power OFF: The L-TRX is switched off.		‚Lock 2H': Normal operating mode. Pulsed Lock signal generated.
	‚Idle': No 2H stimulus signal, no RF-signal generated.		‚Lock 2H' and ‚Mute 2H': L-TRX in normal Lock mode with temporary signal suppression due to active external SEL_2H/ AMP~ signal. The LED beats with approx. 2 Hz.
	‚Error': Error in L-TRX detected but neither power supply failure nor missing reference clock. (e.g. over temperature in power amplifier)		‚Diagnostic': Power amplifier not active respectively no output signal generated. The ‚ERROR' LED beats with approx. 2 Hz.
	‚Error': Error in L-TRX power supply or missing reference clock.		‚Diagnostic': Pulsed output signal generated. Both ‚ERROR' and ‚INACTIVE' LED beat with approx. 2 Hz.
			‚Diagnostic': CW output signal generated. The ‚ERROR' LED beats with approx. 2 Hz.

2H-REC IN (J1, SMA):

2H receiver input from 2H preamplifier (HPPR/2, AQS 1H2H, LOCK-OUT)

- Maximum input power with no damage: +0 dBm

REF IN (J3, SMA):

Reference clock input from AQS REFERENCE board or L-19F REF OUT (J3)

- Nominal input power @ 160 MHz: -0.5 ±0.5 dBm
- Nominal input power @ 320 MHz: -3.5 ±0.5 dBm

TP-F0 OUT (J4, SMA):

Transmitter pulse output to HPPR preamplifier (via AQS DRU or PSD board)

- 5V TTL output, no damage with 50 Ω load
  (pulse polarity see ***"Lock Configuration:" on page 125***)

BLNKTR-2H~ IN (J5, SMA):

Power amplifier blanking pulse from AQS SGU (via NanoBay backplane or AQS PSD board)

- 5V TTL input
  (high (+5V) = power amplifier blanked, low (0V) = power amplifier gated)

SEL-2H/AMP~(J6, SMA):

Power amplifier control signal from IPSO unit (SEL_2H/$\overline{\text{DEC}}$, AQS or 19“ unit)

- 5V TTL input
  (high (+5V) = 2H Lock, low (0V) = 2H amplifier selected for gradient shimming, 2H Lock muted)

2H IN (J8, SMA):

Power amplifier input RF-signal from AQS SGU (direct or via AQS ROUTER)

- Maximum input power with no damage: +10 dBm

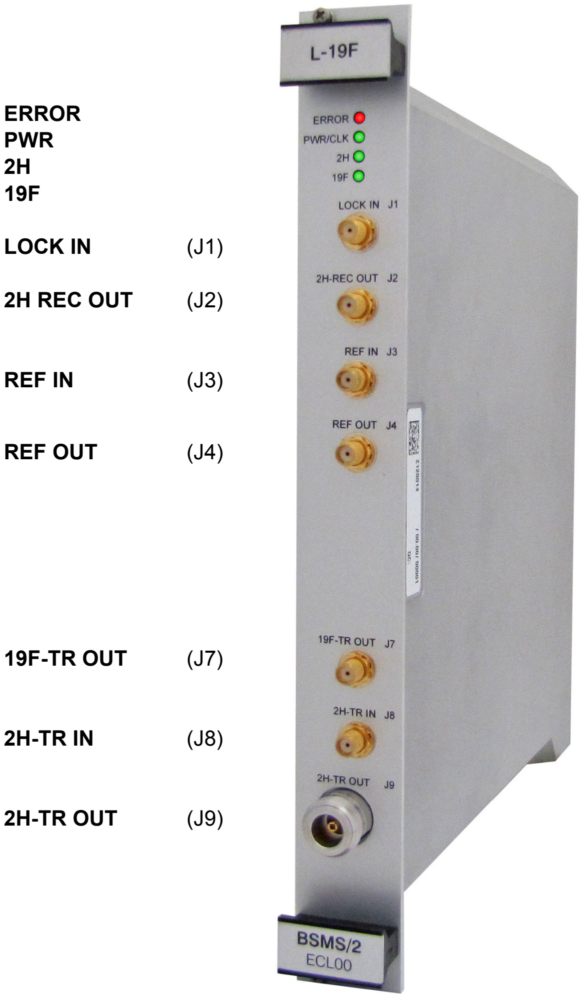
2H-TR OUT (J9, N):

2H RF-output to HPPR preamplifier (2H TRANSM), AQS 2H-TX (FX-IN) or L-19F unit (2H-TR IN) depending on configuration

- Transmitter output specification see ***"Transmitter (TX):" on page 110***

BSMS/2 19F Lock Transceiver 300-1000 6.4.1

Figure 6.17. View BSMS/2 19F LOCK TRANSCEIVER 300-1000



LED ‚ERROR‘ (red):

All errors detected by the L-19F unit are displayed with the ‚ERROR‘ LED.

LED ‚PWR‘ (green):

In case of a power supply failure the ‚PWR‘ LED is deactivated. The L-19F unit enters the ERROR state.

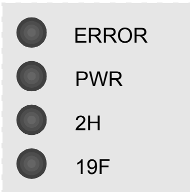
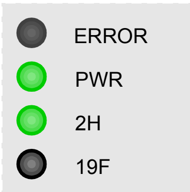
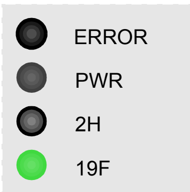
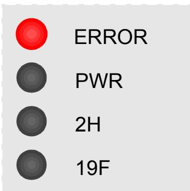
LED ‚2H‘ (green):

If the L-TRX & L-19F units are configured to lock on a deuterated solvent, the ‚2H‘ LED is activated. The deuterium signal is bypassed by the L-19F unit.

LED ‚19F‘ (green):

If the L-TRX & L-19F units are configured to lock on a solvent with fluorine, the ‚19F‘ LED is activated. The L-19F unit translates the L-TRX deuterium lock signal to fluorine lock signal.

Table 6.3. L-19F Status LED‘s in different operating modes

LED Status	Operating Mode
	Power OFF: The L-19F unit is switched off.
	‚2H‘: L-TRX and L-19F are configured for deuterium lock.
	‚19F‘: L-TRX and L-19F are configured for fluorine lock.
	‚Error‘: Error in L-19F power supply. At least one power supply voltage is out of range.

LOCK IN (J1, SMA):

Receiver input from HPPR/2 or AQS 1H2H preamplifier (LOCK-OUT)

- Maximum input power with no damage: +0 dBm

2H REC OUT (J2, SMA):

Receiver output to L-TRX 2H-REC IN J1

REF IN (J3, SMA):

Reference clock input from AQS REFERENCE board

- Nominal input power @ 160 MHz: -0.5 ±0.5 dBm
- Nominal input power @ 320 MHz: -3.5 ±0.5 dBm

REF OUT (J4, SMA):

Reference clock output to L-TRX REF IN J3

19F-TR OUT (J7, SMA):

19F RF-output to HPPR/2 19F preamplifier (19F TRANSM)

- 19F Transmitter output specification see ***"Transmitter (TX, 19F lock operation):" on page 110***

2H-TR-IN (J8, SMA):

Deuterium lock signal from L-TRX 2H-TR OUT J9

- Maximum input power with no damage: +37 dBm (2H operation)
- Maximum input power with no damage: +10 dBm (19F operation)

2H-TR OUT (J9, N):

2H RF-output to any high power amplifier (FX-IN)

- Transmitter output specification see ***"Transmitter (TX, 19F lock operation):" on page 110***

Web Interface 6.5

The configuration, service and diagnostic functions of the L-TRX can be accessed via the ELCB service web.

For more information on the Lock configuration setup please refer to ***"Service Software" on page 62***.

Service Web 6.5.1

2H-TX Control (Router Address):

Enable or disable the L-TRX internal power amplifier for gradient shimming.

Figure 6.18. 2H-TX Control

If no external 2H power amplifier is present, enable the internal power amplifier for gradient shimming.

Table 6.4. 2H-TX Control: Router Address

AV III Configuration		Router Address
NanoBay		**3**
MicroBay	2 Channel	**7**
MicroBay	3 Channel	**7**
OneBay / TwoBay	ext. BLA	**7**

If an external 2H power amplifier (e.g. AQS 2H-TX, BLAXH2H) is present, disable the internal power amplifier:

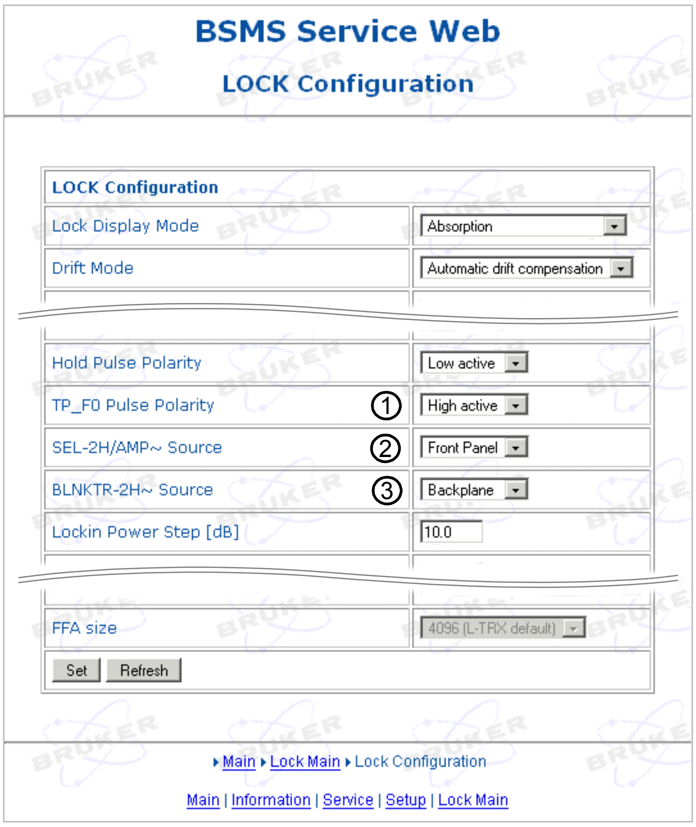
- All configurations: set router address to ‚**255**‘.

With this setting the internal power amplifier is only used for ‚2H Lock‘ operation.

Lock Configuration:

Configuration settings for external pulses. For other settings please refer to ***"Lock Configuration" on page 65***.

Figure 6.19. Lock Configuration



1. TP_F0 pulse polarity: select ‚High active‘ (standard) or ‚Low active‘

   ‚High active‘ = all configurations

   ‚Low active‘ = currently not used

2. SEL-2H/AMP~ pulse source: select ‚Front Panel‘ (standard) or ‚Backplane‘

   ‚Front Panel‘ = all configurations

   ‚Backplane‘ = currently not available

3. BLNKTR-2H~ pulse source: select ‚Front Panel‘ (standard) or ‚Backplane‘

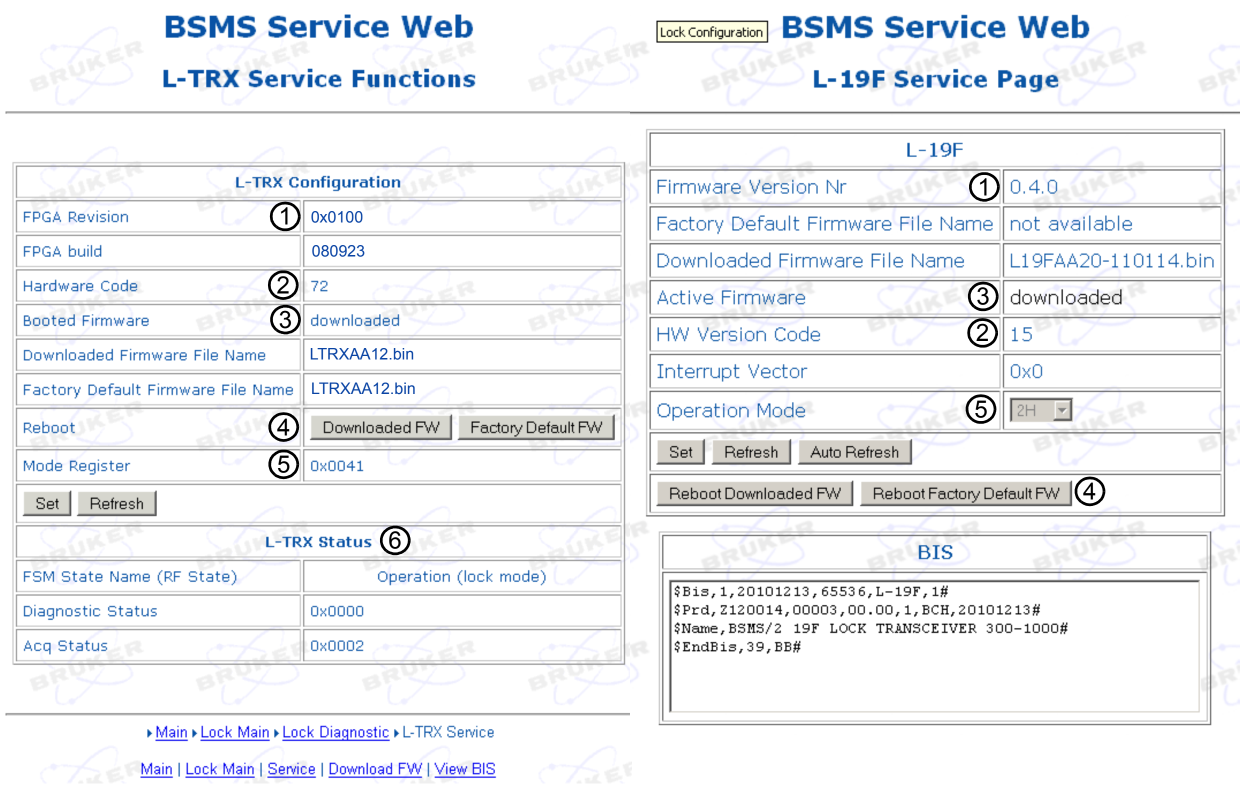
   ‚Front Panel‘ = MicroBay / OneBay configuration with internal power amplifier used for gradient shimming

   ‚Backplane‘ = NanoBay-E console ECL ≥ 02

Service Functions:

Most information on this page are for service use only.

Figure 6.20. Service Functions

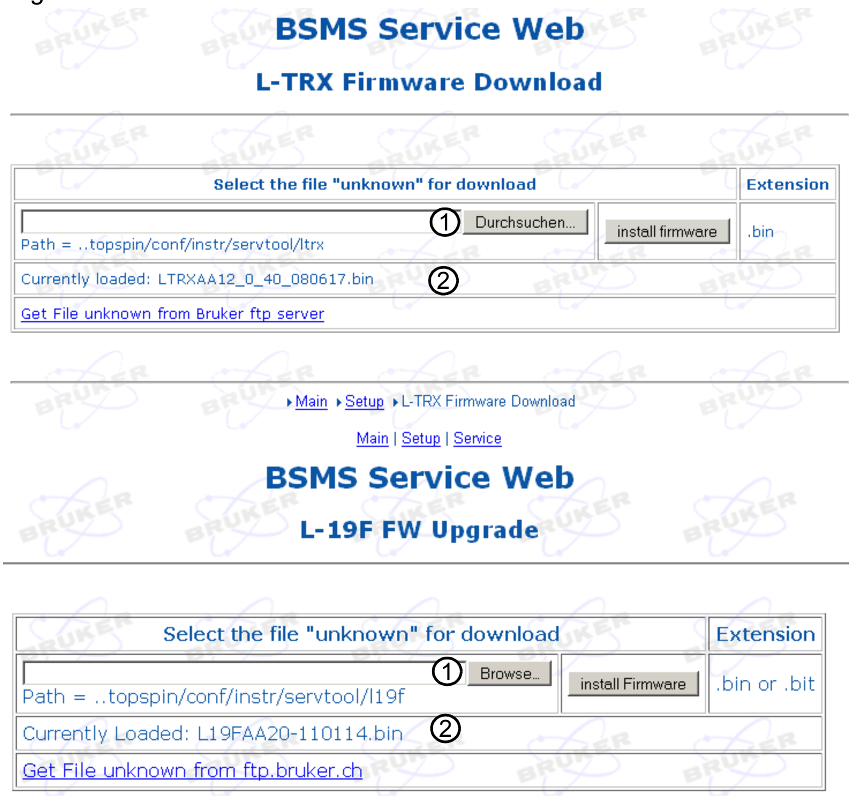


1. FPGA revision and build date (yymmdd)
2. Hardware code = used by ELCB to identify Lock system
3. Firmware status and file name (download and factory default)
4. Reboot buttons: use ‚Factory Default FW‘ to revert to factory firmware
5. Mode register status
6. L-TRX status information

Firmware Upgrade/Download:

A new firmware release can be downloaded from the Bruker ftp-server. The factory firmware is retained in a write protected memory section.
To revert to the factory firmware see ***"Service Functions:" on page 126***.

Figure 6.21. Firmware Download



1. Path and filename for firmware download (file-type = .bin)
2. Current firmware filename

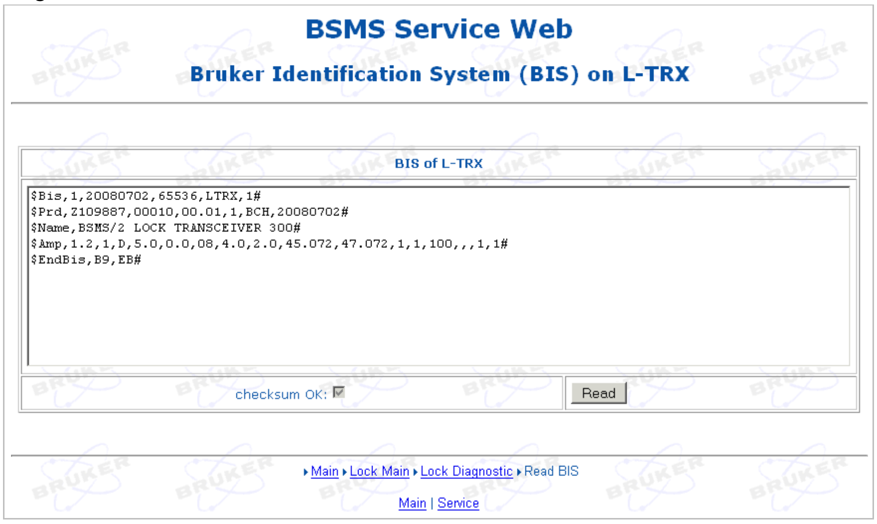
A firmware download will take up to 5 minutes.

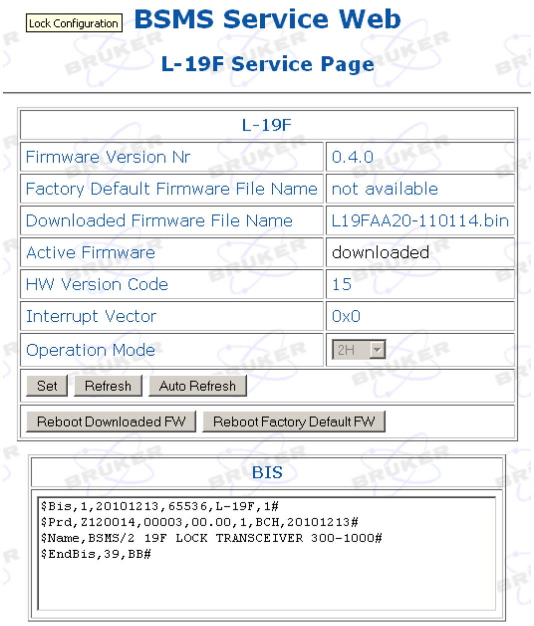
Before upgrading the L-TRX software read the corresponding release note carefully. Different system frequencies and hardware revisions might require different software versions.

BIS Information:

The BIS memory is write protected. The information can only be altered at the factory.

Figure 6.22. View BIS

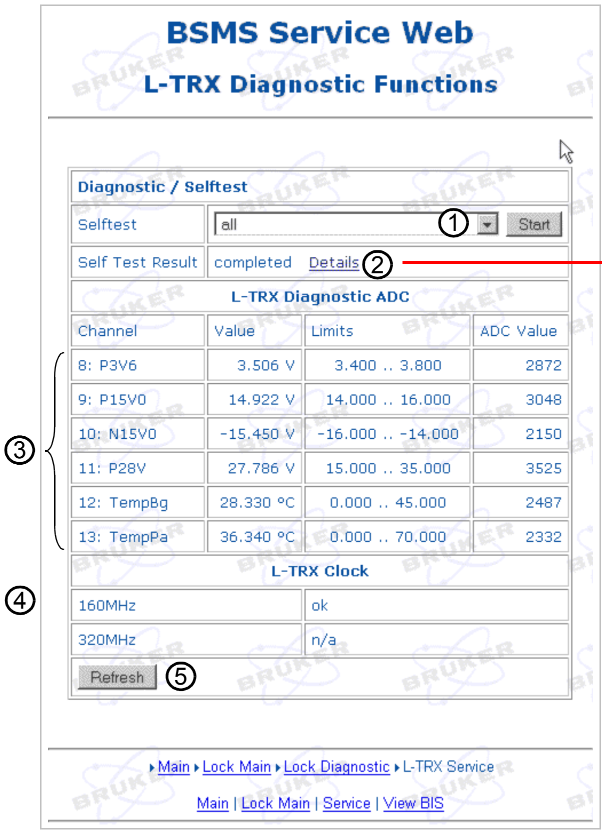




Diagnostic Functions:

The numbers and types of the diagnostic functions, measurements and selftests may vary, depending on hardware level (ECL) and/or firmware release.

Figure 6.23. L-TRX Diagnostic Functions



Selftest result log

```
V1;
U_P3V6_Selftest; 3.507; passed;
U_P15V0_Selftest; 14.859; passed;
U_N15V0_Selftest; -15.399; passed;
U_P28V_Selftest; 27.904; passed;
TempBg_Selftest; 29.2; passed;
TempPa_Selftest; 38.4; passed;
ErrorCount_AdcLvdsIf_Selftest;    0; passed;
DCOffset_ADC_Selftest_10dBm_LSB24; 3857.50; passed;
PeakPower_ADC_Selftest_10dBm; -7.24; passed;
2ndHarm_ADC_Selftest_10dBm; -48.44; passed;
Spours_ADC_Selftest_10dBm; -89.27; passed;
Spours_0bin_ADC_Selftest_10dBm; -70.68; passed;
DCOffset_ADC_Selftest_DDSoff; 4045.50; passed;
InBandNoisePower_ADC_Selftest_DDSOff; -66.30; passed;
OutBandNoisePower_ADC_Selftest_DDSOff; -74.29; passed;
Spours_ADC_Selftest_DDSoff; -91.71; passed;
Level_CW_DEC_Selftest_10dBm; -1.6135; passed;
Phase_CW_DEC_Selftest_10dBm; -0.429; passed;
NoisePower_CW_DEC_Selftest_10dBm; -74.9196; passed;
NoiseP_CW_DEC_Selft_10dBm_LPF_BW; -74.9353; passed;
Spours_64bin_CW_DEC_Selftest_10dBm; -102.85; passed;
Spours_0bin_CW_DEC_Selftest_10dBm; -82.03; passed;
Spours_8bin_CW_DEC_Selftest_10dBm; -92.98; passed;
Level_Lock20dBm_Selftest; -2.5370; passed;
Phase_Lock20dBm_Selftest; 0.4312; passed;
RP1Position_Lock20dBm_Selftest;  3; passed;
NoisePower_Lock20dBm_Selftest; -79.4044; passed;
Level_Lock28dBm_Selftest; -2.3397; passed;
Phase_Lock28dBm_Selftest; 0.3903; passed;
RP1Position_Lock28dBm_Selftest;  1; passed;
NoisePower_Lock28dBm_Selftest; -72.6619; passed;
```

1. Select selftest to be executed
2. Selftest result summary, use ‚Details‘ to read the complete selftest result log.
3. Diagnostic ADC measurements
4. Reference clock status
5. Refresh (update) measurements

Table 6.5. Summary of Diagnostic Selftests and ADC Functions

	Name	Description	Precondition
Selftest	ADC interface	Tests LVDS interface between receiver ADC and the signal processing unit. This test does not verify the electrical performance of the ADC.	Reference clock present and power supplies within specification
	Power supply	Voltage measurement with diagnostic ADC	none

Table 6.5. Summary of Diagnostic Selftests and ADC Functions

	Name	Description	Precondition
Selftest	Reference frequency	RF-signal detector, minimal power level only	none
	Temperature	Temperature measurement with sensors and diagnostic ADC	none
	CW-ADC diagnostic	Verification of transmitter and receiver signal path (internal loop). Measurement bandwidth is 80 MHz, CW stimulus internally generated with +10 dBm and -Inf dBm power level.	L-TRX does not report any error and the load mismatch at output J9 2H-TR OUT is within specification (see section ***6.2.4***)
	CW-ADC diagnostic DDS off		
	Pulse diagnostic	Verification of transmitter pulse shape with own receiver (internal loop).	
	CW-decimated diagnostic	Verification of transmitter and receiver signal path (internal loop). Measurement bandwidth is 3.3 kHz (lowpass filter), CW measurement signal with +10 dBm power level.	
	Lock mode diagnostic	Verification of transmitter and receiver signal path (internal loop). Measurement bandwidth is 330 Hz (bandpass filter), pulsed stimulus signal with +20 dBm and +28 dBm power.	
	Lock mode diagnostic, FFA power		
	ext. pulse power diagnostic	Measures output power in 2H amplifier operation. Actual output power level at J9 2H-TR OUT depends on input level at J8 2H-IN.	Apply RF pulse (pulse length 1ms to 100 ms, up to 4 dBm) to J8 2H-IN, with appropriate blanking signal at input J5 BLNKTR-2H~
	ext. RX input power CW diagnostic	Measures receiver input power level in CW operation (lowpass filter, BW=3.3 kHz). Power level is scaled to dBFS.	Terminate J1 2H-REC IN to measure receiver noise. Connect any signal source with frequency of f_{2H} to measure signal strength.
	ext. RX input power gated diagnostic	Measures receiver input power level in pulsed operation with phase alternating gating (bandpass filter, BW=330 Hz). Power level is scaled to dBFS.	
Diagnostic ADC	Power supply input voltages	Voltage measurement with diagnostic ADC	none
	Board and power amplifier temperature	Temperature measurement with sensors and diagnostic ADC	none

No ‚2H Lock‘ during Firmware Download:

During a firmware download all other functions are temporarily suspended.

- Do not attempt to initiate ‚2H Lock‘ mode, select amplifier for gradient shimming or any diagnostic mode during download.

Firmware Download takes too long:

If the firmware download takes much longer than 5 minutes, the service web message log configuration may be amiss.

- Check service web ‚Service‘ → ‚Log Configuration‘ that the setting for ‚Log Specific Info: SSRB communication to slave units‘ is set to ‚Off (default)‘

Without this setting all communication to the L-TRX is logged in detail, which extends the download time indefinitely.

Missing Reference Clock:

The reference clock is vital to most operations of the L-TRX. The clock is generated by the AQS REFERENCE board. SSRB communication with the ELCB is possible without reference clock.

In case of a missing reference clock the ‚PWR/CLK‘ LED is deactivated.

- Check the clock wiring and the AQS REFERENCE board for correct operation.

Over Temperature Error:

In case of power amplifier or board over temperature all operations are temporarily suspended and the L-TRX enters the ERROR state. An error message is sent to TopSpin and displayed on the BSMS keyboard. When the over temperature condition is past, the L-TRX reverts to the operating mode prior to the error.

Error message examples:

- L-TRX interrupt: ‚L-TRX Amplifier overtemperature error occurred‘
- ELCB periodic monitoring:
  ‚L-TRX Temperature 'TempPA' out of range. Value: 76°C Limits: 0 / 75‘

In case of an error do as follows:

- Check that no 2H Observe or Decouple experiment is running with the internal power amplifier. The internal power amplifier can only be used for gradient shimming.
- Check that the maximum duty cycle and pulse length specifications are not violated. See ***"Technical Data BSMS/2 Lock Transceiver" on page 110***.

Over Current Error:

If the power amplifier drain current exceeds the limit of safe operation, it is switched off and the L-TRX enters the ERROR state. An error message is sent to TopSpin and displayed on the BSMS keyboard.

1. Reboot L-TRX to clear error state
2. The 2H-TR output (J9) of the L-TRX must be connected to a load (max. mismatch see ***"Technical Data BSMS/2 Lock Transceiver" on page 110***). Check wiring and load (i.e. 2H Amplifier). To avoid this error, try to improve the matching of the 2H coil of your probe.
3. Repeat your experiment
4. If the error remains it is a hardware failure. Replace the L-TRX and/or contact a Bruker service representative.

Duty Cycle Error and Pulse Length Error:

If the power amplifier is operated over its specification[1] in terms of maximal duty cycle or the maximal pulse length, the L-TRX board issues an error and deactivates the power amplifier stage. The power amplifier is reactivated after the blanking signal has been deasserted and the measured duty cycle is within specification.

The BSMS system will report an error with the following message : ‚L-TRX 2H Amplifier: RF Pulse Length or Duty Cycle violation! Please check your Pulse Program.‘

Power Supply Error P3V6:

Early versions of the power supply Z111143 (BSMS/2 POWER SUPPLY BOARD 5) were not capable of providing both units L-TRX and L-19F with enough current. If this error occurs please check if a new version (ECL ≥ 2) has been installed.

L-TRX specific Error Messages — *6.5.3*

Table 6.6. L-TRX Error Messages

Error	Description / Measures
L-TRX Power Supply error occurred	External or internal power supply failure. • check power supply board status • check power supply diagnostic • check the version of PSB5 is at least ECL 2 If the power supply input voltages are within their limits, a hardware failure has occurred. Replace the L-TRX and/or contact a Bruker service representative.
L-TRX 160MHz clock missing or L-TRX 320MHz clock missing	see ***"Missing Reference Clock:" on page 131***

1. see ***"Technical Data BSMS/2 Lock Transceiver" on page 110*** or BIS of L-TRX board in figure ***"View BIS" on page 128***

Table 6.6. L-TRX Error Messages

Error	Description / Measures
L-TRX Amplifier: overcurrent error occurred	see ***"Over Current Error:" on page 132***
L-TRX Amplifier: bias current regulator underflow error occurred	A hardware failure has occurred. Replace the L-TRX and/or contact a Bruker service representative.
L-TRX Error: Signal 'BLKTR-2H' was activated without selecting 'SEL_2H/DEC'	• check wiring (if external power amplifier is used, the BLNKTR-2H~ input must be left open) • check experiment setup (pulse program)
L-TRX FPGA DCM (PLL) lock error occurred	Reference clock synchronization failure • restart BSMS (power off/on) • check reference clock (REF_IN J2) from AQS REFERENCE board If the error remains a hardware failure has occurred. Replace the L-TRX and/or contact a Bruker service representative.

System Requirements 6.6

The L-TRX / L-19F can replace the former L-TX/L-RX system in all configurations with ELCB. Constraints and minimal requirements are listed below.

Power Supply 6.6.1

The L-TRX requires in both BSMS/2 and NanoBay configurations a designated power supply board.

Table 6.7. Power supply boards for different Lock systems

Chassis	**L-TRX / L-19F**	**L-TX / L-RX**
BSMS/2	BSMS/2 PSB 5 (Z111143, ECL 2 or newer)	BSMS/2 PSB 2 (Z002776)
NanoBay	INES PSB 6 (Z111144)	INES PSB 3 (Z103142)

Lock Control Board 6.6.2

BSMS/2 ELCB (Z100818):

- Hardware requirement: ECL06 or newer
- Firmware requirement: Releases spring 2011 and onwards support both generations of lock systems. Software components and interfaces are set up accordingly.

BSMS LCB (Z002720):

The L-TRX and the L-19F units are not compatible to the LCB board. Please contact your sales representative for an upgrade of your console.

TopSpin Software 6.6.3

Minimal requirement: TS2.1pl5, TS3 and onwards

Related Units and Accessories 6.6.4

AQS REFERENCE Board:

The L-TRX / L-19F units are compatible to all versions. If four or five TX channels (AQS SGU) are present in the console a REF/2 board (Z104236) with an AQS BB SPLITTER 2-WAY (Z102000) or 6 dB attenuator (45999) at connector J8/REF.3 or J9/REF.4 must be used.

AQS 2H-TX Amplifier board (Z103550, Z103551):

The L-TRX is compatible to all versions. Only the frequency range has to be matched.

BSMS/2 2H-TX Amplifier board (Z002793, Z002794):

This configuration is not officially supported. When detected, the BSMS subsystem will report an error message.

Note: The BSMS 2H-TX is no longer supported because it has only 20W and there are two other more powerful 2H amplifiers available.

The new L-TRX has an integrated 2H amplifier to enable 2H gradient shimming without an additional, external 2H-TX. When requiring more power for very short 2H pulses and high power 2H decoupling experiments it is recommended to use the existing high power 2H amplifiers (e.g. AQS 2H-TX, BLAHX2H) with 80W and more.

2H Preamplifiers:

The L-TRX is compatible to all HPPR/2 style 2H preamplifier modules (AQS 1H2H, HPPR/2 1H2H, HPPR/2 2H). Only the 2H frequency has to be matched.

19F Preamplifiers:

The L-19F is compatible to all HPPR/2 19F modules.

RT and Cryo Probes:

The L-TRX / L-19F units are compatible to all probes with the appropriate 2H or 19F frequency.

Ordering Information 6.7

Table 6.8. L-TRX Unit Numbers

Part No.	Unit
Z109886	BSMS/2 LOCK TRANSCEIVER 200
Z123938	BSMS/2 LOCK TRANSCEIVER 250
Z109887	BSMS/2 LOCK TRANSCEIVER 300
Z109888	BSMS/2 LOCK TRANSCEIVER 400

Table 6.8. L-TRX Unit Numbers

Part No.	Unit
Z109889	BSMS/2 LOCK TRANSCEIVER 500
Z109890	BSMS/2 LOCK TRANSCEIVER 600
Z109891	BSMS/2 LOCK TRANSCEIVER 700
Z109892	BSMS/2 LOCK TRANSCEIVER 750
Z109893	BSMS/2 LOCK TRANSCEIVER 800
Z109894	BSMS/2 LOCK TRANSCEIVER 850
Z109895	BSMS/2 LOCK TRANSCEIVER 900
Z109896	BSMS/2 LOCK TRANSCEIVER 950
Z109897	BSMS/2 LOCK TRANSCEIVER 1000

Table 6.9. L-19F Unit Numbers

Part No.	Unit
Z120014	BSMS/2 19F LOCK TRANSCEIVER 300-1000

SLCB/2 & SLCB/3 7

Introduction 7.1

The SLCB (Sample & Level Control Board) was introduced 1992 and has been enhanced for the BSMS/2 system with ELCB.

This chapter describes the SLCB/2 and SLCB/3 boards as a subsystem of the BSMS/2 with ELCB (Bruker Smart Magnet control System) which handles the sample control, helium (He) level measurement, and (optional) *analog* nitrogen (N2) level measurement systems. All functions of the sample and level subsystem of the BSMS/2 are accessible via the BSMS panel within Topspin, the BSMS/2 Service Web or the BSMS keyboard.

There are two versions available, the SLCB/2 and the SLCB/3.

In this chapter the abbreviation SLCB stands for the boards SLCB/2 and SLCB/3. The former version Z002707 BSMS SLCB SAMPLE+LEVEL CONTROL BOARD, used for earlier BSMS systems, is not described here.

The SLCB is a smart controller board which is inserted into slot 3 of the BSMS/2 chassis (front side) as described in chapter ***"Configurations" on page 19***. It has the following functions:

1. Sample lift control.
2. Sample rotation control (spin).
3. Helium (He) level measurement.
4. Nitrogen (N2) level measurement (SLCB/3 only).

All functions are controlled by a microprocessor. The application software runs on a real time operating system and can be downloaded via the BSMS/2 Service Web.

For sample lift and sample rotation, the SLCB must be combined with a pneumatic module. The pneumatic module is plugged into the rear side of the BSMS/2.

The shim upper section model type BST is automatically recognized by the BSMS/2.

Configurations 7.2

Basically there are two configurations available - one for standard systems and another one for systems with an additional input for the ***"Nitrogen Level Sensor"*** (analog mode only).

Table 7.1. SLCB variants

Bruker Part Number	Name	Purpose
Z100322	BSMS/2 SLCB/2 SAMPLE+LEVEL CTRL BD	- standard
Z108145	BSMS/2 SLCB/3 SAMPLE+LEVEL CTRL BD	- analog N2 level sensor interface (e.g. required for BSNL option)

Technical Data 7.3

The boards differ in the number of interfaces and additional software regulated gas flows:

Table 7.2. SLCB/2 vs. SLCB/3

	SLCB/2	SLCB/3
Helium level sensor (HELIUM LEVEL)	included	included
BST sensor interface (SAMPLE CONTROL)	included	included
BACS interface (SAMPLE CHANGER)	included	included
Analog liquid nitrogen level sensor interface (NITROGEN LEVEL)	n/a	included

He level measurement

Parameter		**Details**	**Min**	**Typ**	**Max**	**Unit**
Helium measurement system	range[a]		**0**		**100**	%
	resolution[b]			1		%
	accuracy[c]		**-4**		+4	%
Helium measurement source voltage	range		29.0		31.0	V
Helium measurement current	range		40		150	mA
	resolution			1		mA
	accuracy		**-5**		**+5**	%
	default			110		mA

He level measurement

Parameter		Details	Min	Typ	Max	Unit
	de-ice current			200		mA
	auto switch-off time				**30**	s

a. valid for calibrated system only

b. valid for calibrated system only

c. for a He-level in the range of 20%...100%

N2 level measurement (SLCB/3 only)

Parameter		Details	Min	Typ	Max	Unit
N2 measurement system	range		**0**		**100**	%
	resolution		**-1**		**+1**	%
	accuracy		**-3**		+3	%
N2 voltage measurement	maximum input range[a]		-8.0		0	V_{DC}
	resolution			10		mV
	accuracy		**-5**		**+5**	%FS
Sensor supply	output voltage positive		9.75	10	10.25	V
	output voltage negative		- 9.75	- 10.0	- 10.25	V
	supply current				50	mA

a. analog sensor has to be calibrated for 0V .. -5V (=> 100% .. 0%), new digital sensors are factory calibrated

BST signal interface

Parameter		Details	Min	Typ	Max	Unit
Sample Rotation signal analog[a]	range		**0**		**5**	V
SAMPLE_UPS signal digital	high level input voltage		**2.6**		5	V
	low level input voltage		**0**		**2.4**	V
Light barrier supply	output voltage		**4.75**		5.25	V
	sink resistance[b]		**95**		**105**	Ohm

a. when using signal for sample down detection, calibration is necessary

b. allows to connect LED directly without additional series resistor

Sample changer interface

Parameter		Details	Min	Typ	Max	Unit
Power source (S_5VP, input)	input voltage		4.5	5	5.5	V
	supply current		50			mA
SIGSH, SIGSH~	source				**4**	mA
(output current)	sink		**-4**			mA

Environment

Parameter		Details	Min	Typ	Max	Unit
Operating temperature (ambient)[a]			15	25	35	°C
Relative humidity	non-condensing		**10**		**95**	%
Storage condition	non-condensing		**5**		**50**	°C

a. where specifications are met

System Architecture / Overview 7.4

The SLCB is a VME slave and controlled by the ELCB, which is the BSMS/2 controller / coordinator.

Figure 7.1. Block diagram of the SLCB/2

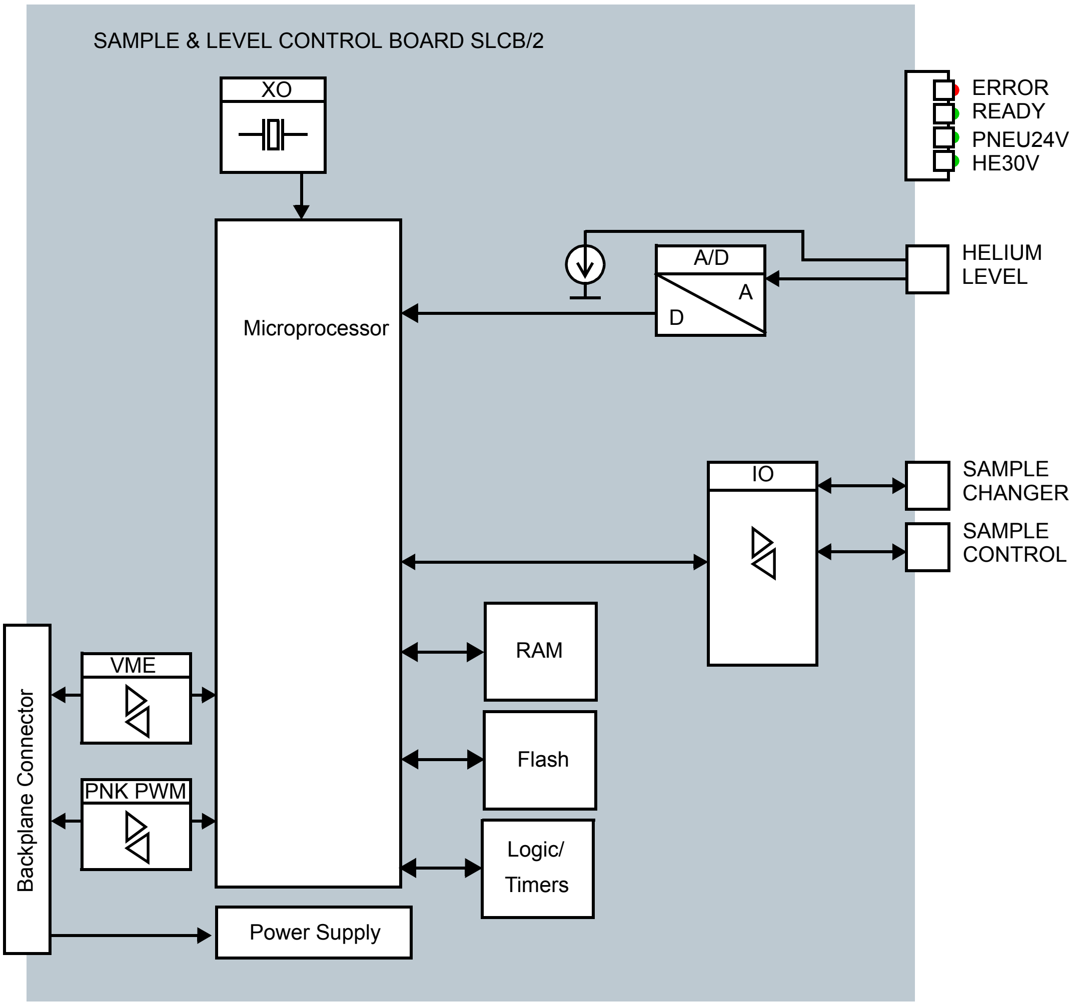
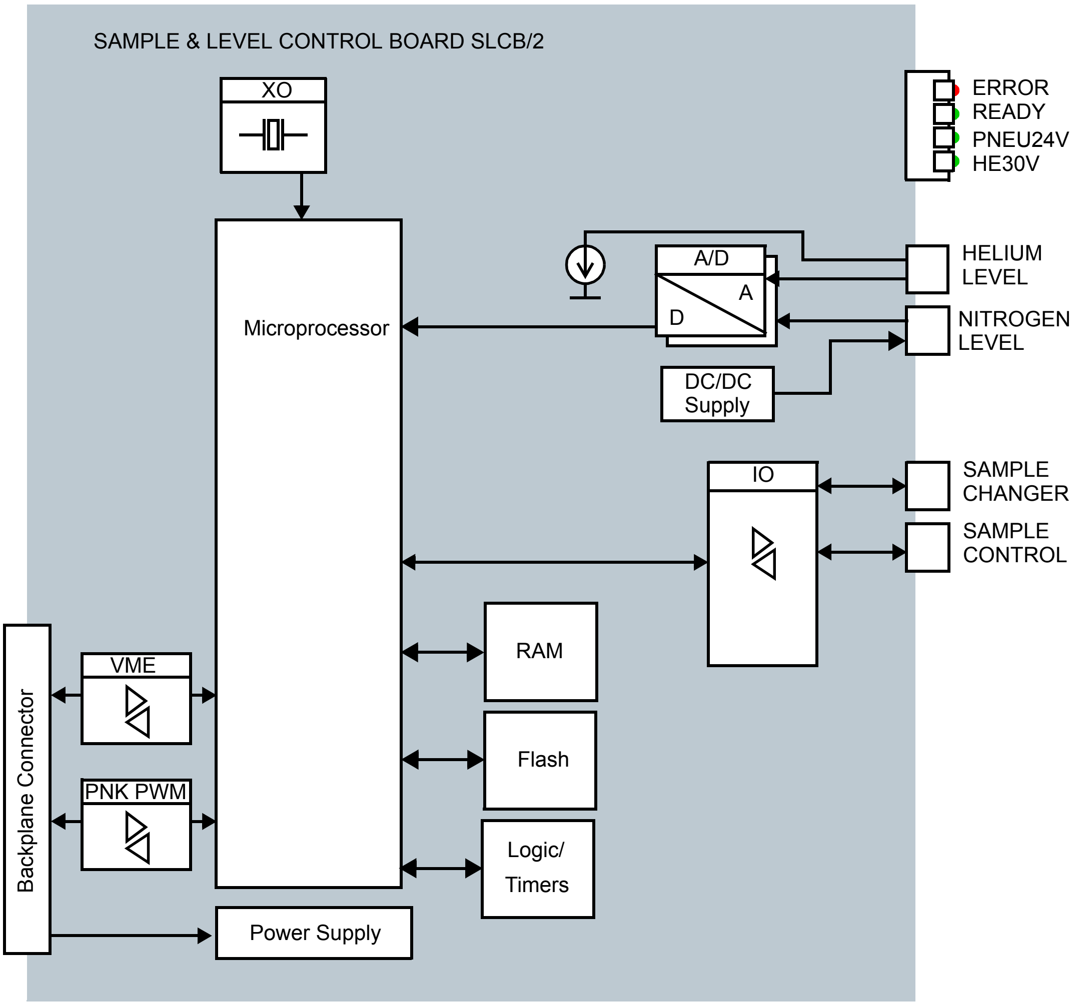


Figure 7.2. Block diagram of the SLCB/3



Front Panel - Connectors and LED's *7.4.1*

Figure 7.3. The picture below shows a SLCB/2

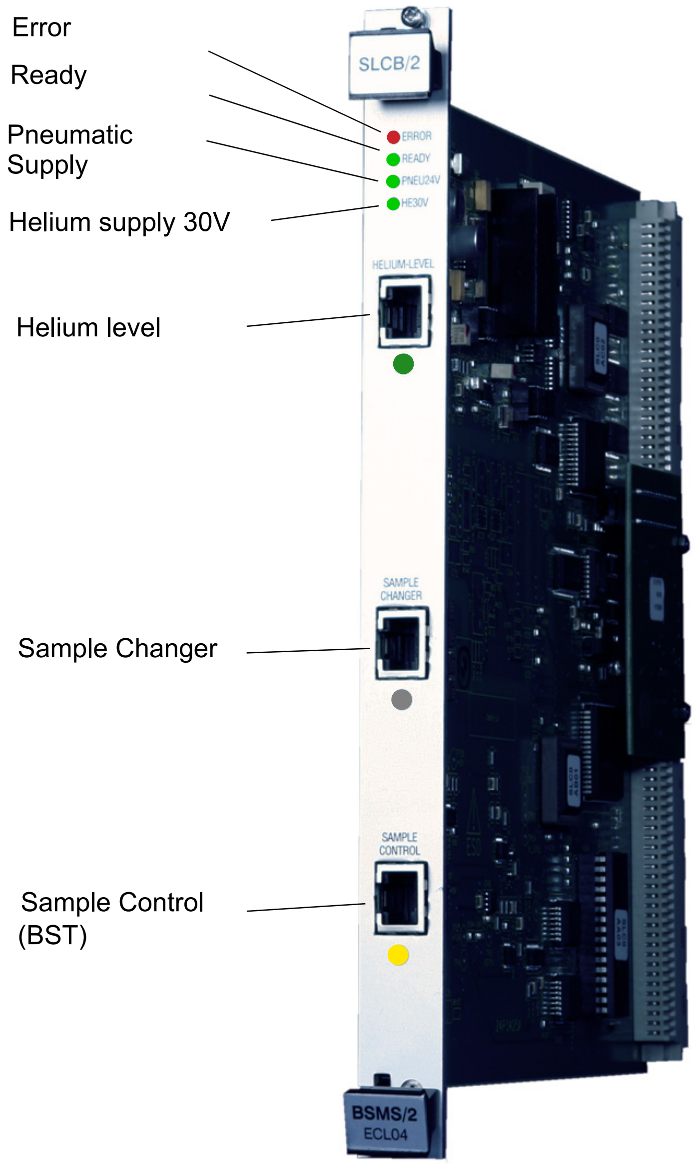
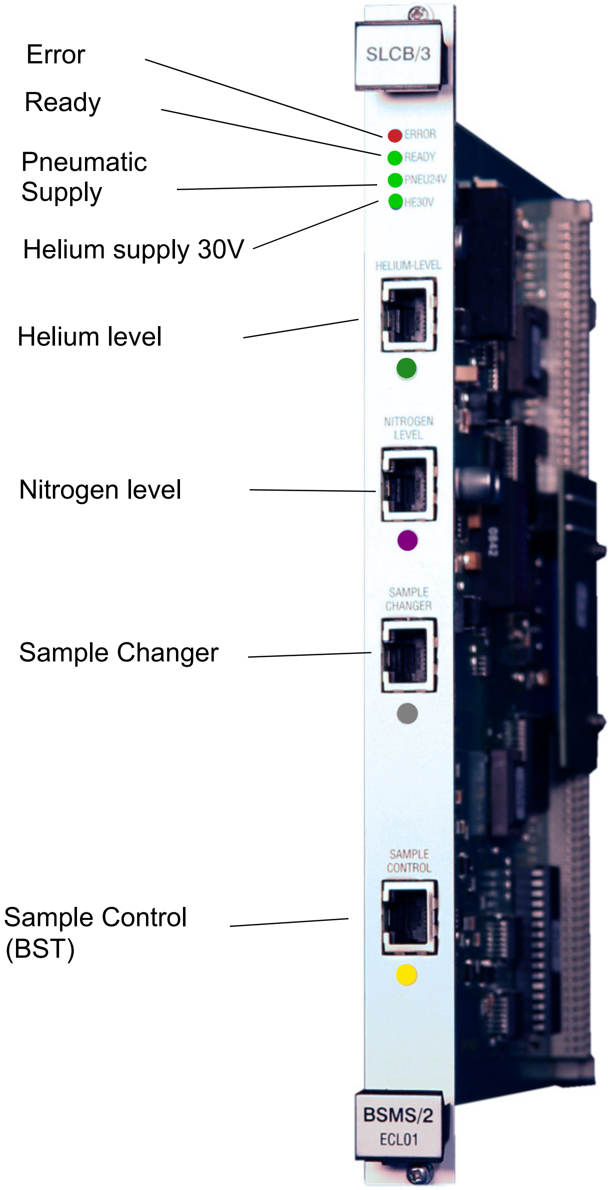


Figure 7.4. The picture below shows a SLCB/3



Error LED

This LED is active after Power ON. It turns off as soon as the SLCB is initialized and the communication with the ELCB is established.

Later on, an active Error LED indicates that an error occurred (e. g. short circuit,...).

Ready LED

This LED is active as soon as the firmware is loaded and the board is running.

PNEU24V LED

Indication that the galvanically isolated power supply for the pneumatics is available.

HE30V LED

Indication that the galvanically isolated power supply for the helium level measurement is available.

Connectors

Table 7.3. Connectors

Label	Description	Note
HELIUM LEVEL	Connector for helium level sensor	
NITROGEN LEVEL	Connector for N-level sensor	SLCB/3 only
SAMPLE CHANGER	External sample lift control, currently used by the BACS sample changer.	
SAMPLE CONTROL	Signals from BST (upper light barrier, sample down sensor and tube version)	

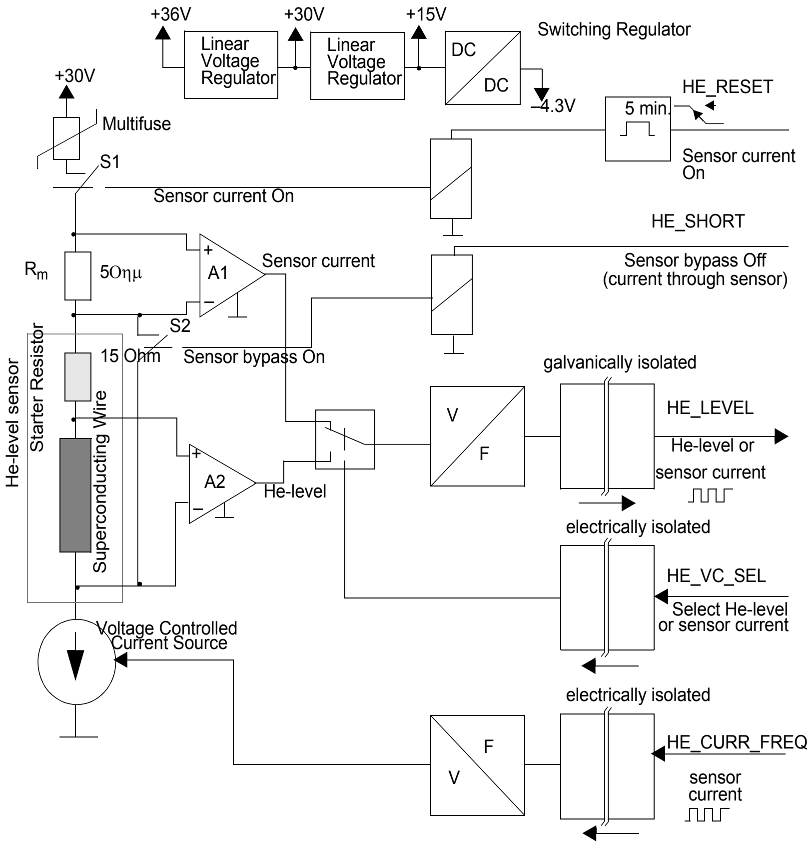
Not all connectors are protected against short-circuiting. Ensure correct wiring.

Function description *7.5*

Liquid helium level measurement *7.5.1*

For monitoring the He-level, a He-level sensor is inserted into the top of the helium dewar. The he-level sensor is a wire that is superconducting in liquid helium. Together with the starter resistor the total resistance at 100% fill level is about 150 Ohms.The resistance is measured using a current source and instrumentation amplifiers. The voltage resulting from the saturation resistance gives an indication of the actual He-level in the dewar.

Figure 7.5. Block diagram Helium level measurement



The He-level sensor is galvanically isolated from the BSMS electronics. The frequency modulated control and measuring signals are transmitted by optocouplers.

The He-level sensor current is produced by a controllable current source. The applied current is measured via a shunt resistor and the differential amplifier A1 as a function test. The voltage across the sensor is measured by the differential amplifier A_2.

To avoid damaging the magnet or evaporating too much helium through warming, the length of time the current is applied is limited. The supply of power is restricted to a maximum period of 30 seconds by the switch S1. As a further safety measure, the S2 switch short-circuits the He-level sensor in between measurements to provide a current bypass.

Timing diagram

Figure 7.6. He-Level Measurement Timing Diagram

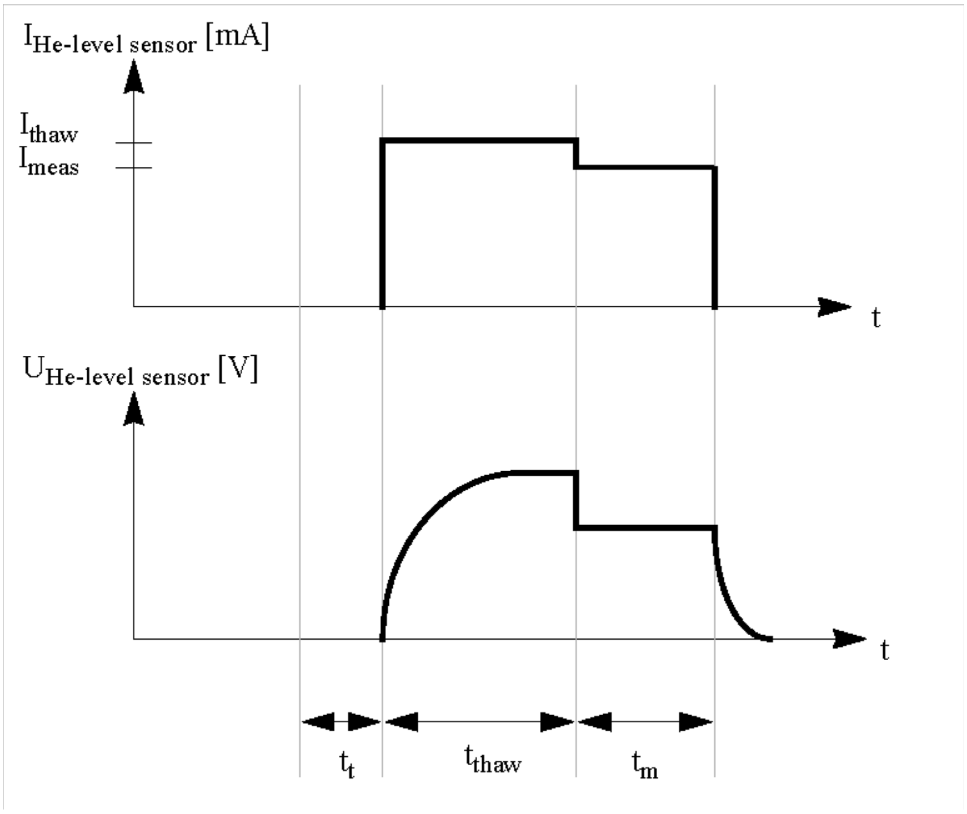


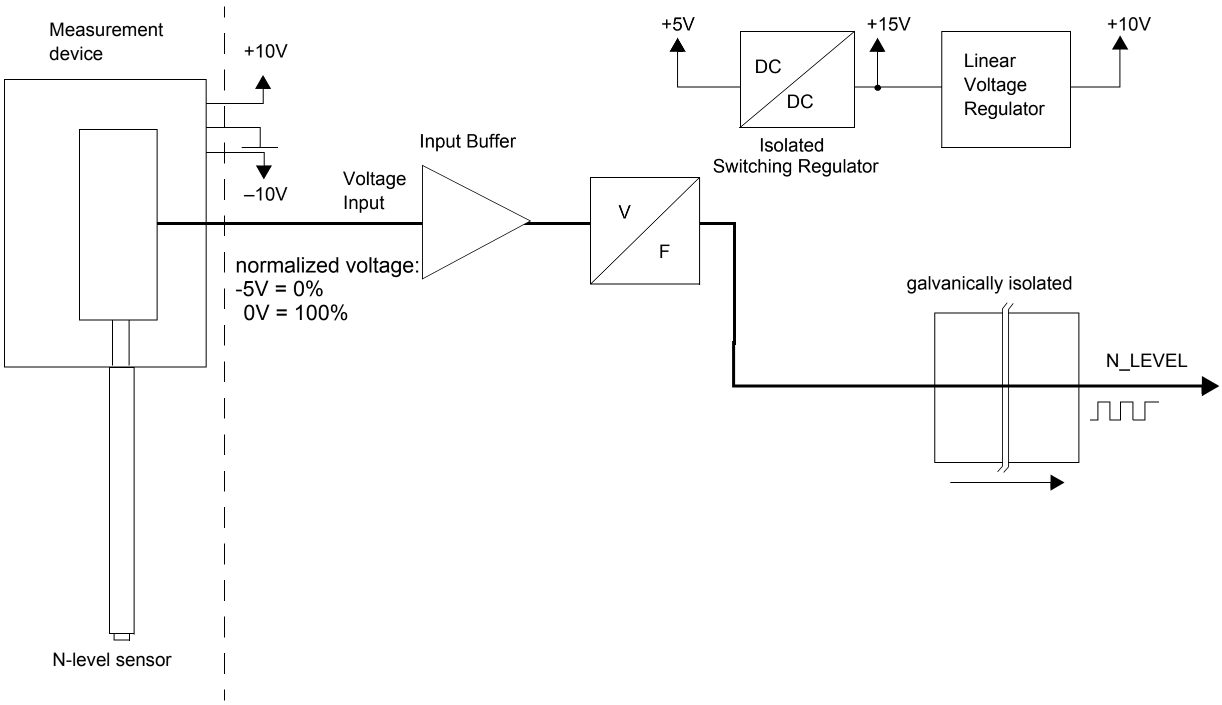
Tabelle 7.4. Definitions

Time	Description
t_t	Duration of He-measurement system test. This precedes every He-level measurement.
t_{thaw}	Duration of sensor thaw. The thawing current (I_{thaw}) places the He-level sensor in a resistive state. As soon as the measuring current has established a stable value, thawing is halted. It can be assumed that the part of the sensor that is not immersed in the liquid helium has become resistive.
t_m	Duration of He-level measurement. To avoid unnecessary turbulence, a small sensor current (Imeas) is used to conduct the measurement itself.
I_{meas}	Current during measurement (default: 110 mA)
I_{thaw}	Current during sensor thaw. This has a value of I_{meas} x MeasThawfactor. MeasThawfactor has a default value of 1.05, and can be changed from the BSMS/2 Service Web with service access privilege.

Liquid nitrogen level measurement (SLCB/3 only) 7.5.2

Nitrogen level measurements are performed by a sensor that is encircled by a cylindrical conductor. The sensor and surrounding conductor form a capacitor. The presence of liquid nitrogen between the sensor and conductor changes the capacitance, and this is measured. The capacitance is then converted by the sensor electronics into a proportional voltage which is interpreted by the SLCB to provide the reading.

Figure 7.7. Analog nitrogen level measurement block diagram



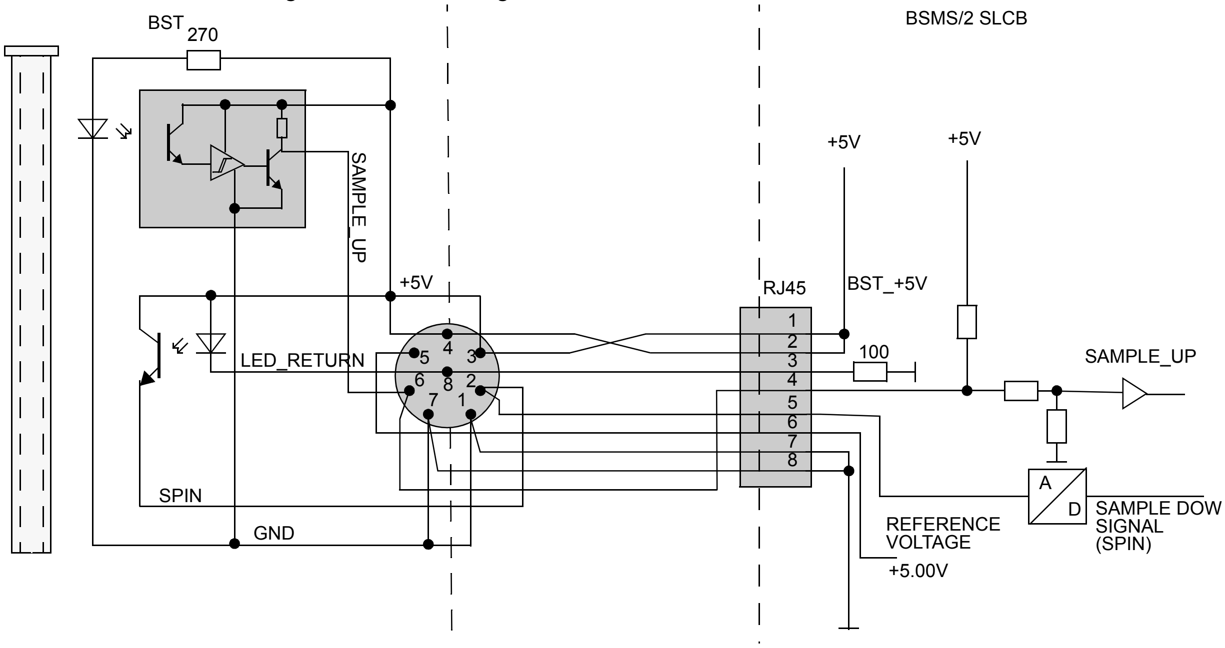
The measurement circuit on the SLCB board is separated galvanically from the other electronics.

The interface of the SLCB/3 is fully compatible with all models of Bruker **"Nitrogen Level Sensor"**.

Sample Down and Sample Up detection 7.5.3

The SLCB provides the electrical interface for standard Bruker Shim Upper part (BST)

Figure 7.8. BST Signals



The circuits in the BST are not short-circuit proof. Damaged and used up cables may damage the infrared diodes inside the shim upper part (BST). Check connectors and cables when exchange the BST or the SLCB.

Version of the Shim Upper Part 7.5.4

The shim upper part version can be read by the SLCB.

Sample Changer Interface 7.5.5

The sample changer has its own pneumatic controller. The shim upper part (BST) is equipped with a light switch to detect whether there is a sample present for pickup. This information is then passed to the sample changer via the sample changer interface of the BSMS.

Table 7.5. Pin assignment Sample Changer RJ45

Pin	Signal (Connector)	Function	Specification
1	SampleUp	positive active (CMOS-high) when sample is up	CMOS, IOut max. +/-4mA
2	SampleUp	negative active (CMOS-low), when sample is up	CMOS, IOut max. +/-4mA

Table 7.5. Pin assignment Sample Changer RJ45

Pin	Signal (Connector)	Function	Specification
3			
4			
5			
6			
7	S_5VP	+5V from sample changer	+/- 5%, IL max. 30mA
8	S_GND	ground potential from sample changer	

reserved / do not connect

Remarks:

- all signals from SLCB are galvanically isolated
- SampleUp / SampleUp represent the state of the upper light barrier directly
- outputs are complementary, broken lines can be detected

The measurement circuit on the SLCB board is galvanically isolated from the other electronics.

Calibration 7.5.6

The ELCB has full control over the SLCB hardware and provides methods for setting up the sample lift, helium level measurements and nitrogen level measurement (SLCB/3 only).

SLCB calibration is stored in the non-volatile memory of the ELCB.

Spin calibration

Spinning rate calibration is necessary in conjunction with the pneumatic module.

Setup of sample lift parameters

Depending on cryostat bore size and height and NMR spinner type a different amount of gas is necessary for lifting the sample. Setup of the lift parameters is described on the according service web page in detail.

Helium level sensor calibration

Sensor characteristic depends on cryostat size and sensor model. Setup up of the sensor is described on the according service web page in detail.

Nitrogen level sensor calibration

The digital ***"Nitrogen Level Sensor"*** is factory calibrated. There are no settings stored on the SLCB. Former analog sensors have to be calibrated itself. For detailed information consult the Magnet System Service Manual SB/WB/SWB ZTKS0177 / Z31977.

Bus Interface 7.6

The SLCB is connected to the VME bus where the communication with the ELCB is running.

Table 7.6. User Bus Back Plane Connector (DIN41612)

Pin	A	B	C
1	VDD_BPL	VDD_BPL	VDD_BPL
2	VDD_BPL	VDD_BPL	VDD_BPL
3	AGND	AGND	AGND
4	AGND	AGND	AGND
5	VEE_BPL	VEE_BPL	VEE_BPL
6	VEE_BPL	VEE_BPL	VEE_BPL
7	24V_POWER	24V_POWER	24V_POWER
8	24V_POWER	24V_POWER	24V_POWER
9	GND_POWER	GND_POWER	GND_POWER
10	GND_POWER	GND_POWER	GND_POWER
11	-		-
12	-		
13			RCLK
16	SPIN_RATE0		SPIN_RATE1
17	FLAP		LIFT
18	RES0		RES1
19	VER_PNEU_MODULE		
20	VCC_BPL	VCC_BPL	VCC_BPL
21	DGND	DGND	DGND
22			
23	X_5V	X_5V	X_5V
24	X_GND	X_GND	X_GND
25			
26	HE_+30V	HE_+30V	HE_+30V
27	HE_+30V	HE_+30V	HE_+30V
28	HE_GND	HE_GND	HE_GND
29	HE_GND	HE_GND	HE_GND
30	HE_GND	HE_GND	HE_GND
31	GND_PNEU	GND_PNEU	GND_PNEU
32	24V_PNEU	24V_PNEU	24V_PNEU

Table 7.7. VME Bus Back Plane Connector (DIN41612)

Pin	A	B	C
1	DV(0)		
2	DV(1)		
3	DV(2)		
4	DV(3)	BG0IN~	
5	DV(4)	BG0OUT~	
6	DV(5)	BG1IN~	
7	DV(6)	BG1OUT~	
8	DV(7)	BG2IN~	
9	DGND	BG2OUT~	DGND
10	SYSCLK	BG3IN~	SYSFAIL~
11	DGND	BG3OUT~	BERR~
12	DS1~		SYSRES~
13	DS0~		LWORD~
14	WRITE~		AM(5)
15	DGND		AV(23)
16	DTACK~	AM(0)	AV(22)
17	DGND	AM(1)	AV(21)
18	AS~	AM(2)	AV(20)
19	DGND	AM(3)	AV(19)
20	IACK~	DGND	AV(18)
21	IACK_IN~		AV(17)
22	IACK_OUT~		AV(16)
23	AM(4)	DGND	
24	AV(7)		
25	AV(6)		
26	AV(5)		
27	AV(4)		AV(11)
28	AV(3)		AV(10)
29	AV(2)		AV(9)
30	AV(1)		AV(8)
31	VSS12		+12V
32	VCC	VCC	VCC

Service 7.7

A connected SLCB in a BSMS/2 system is controlled by the ELCB. The ELCB software provides the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration and diagnostic). Some of these Web functions are open to all users, other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

System requirements 7.8

All SLCB/2 and SLCB/3 boards are compatible with BSMS/2 systems with ELCB. Typically, BSMS/2 with ELCB have been delivered with ECL02 of Z002774 BSMS/2 CHASSIS WIRED.

Ordering information 7.9

See ***"SLCB variants" on page 138***

PNK Modules 8

Introduction 8.1

Delivered BSMS/2 systems until 2010 have integrated all pneumatic sub-systems and associated driver electronics integrated in one module, called PNK.

This module is located on the rear side in the right most slot (as seen from rear) and comes in three variants:

Table 8.1. PNK variants

Bruker Part Number	Name	Purpose
Z003139	BSMS/2 PNK3 PNEUMATIC SB	This is the standard module with one spin valve and two lift valves
Z003828	BSMS/2 PNK3S PNEUMATIC SB	This is a standard version with an additional emergency lift feature, intended for the Cryo Probe Sample Safety option
Z003140	BSMS/2 PNK5 PNEUMATIC WB	This is the “wide bore” module with two spin valves and three lift valves, accounting for the increased air consumption

Technical Data *8.2*

The boards differ in the number of interfaces and additional software regulated gas flows:

Sample lift

Parameter		Details	Min	Typ	Max	Unit
Input pressure	range		4		6	bar
	stability	@0..150l/min	**-0.5**		**0.5**	bar
Air flow	PNK3, PNK3S (standard bore)		**100**			l/min
	PNK5 (wide bore)		**150**			l/min

Sample Rotation

Parameter		Details	Min	Typ	Max	Unit
Input pressure	range		4		6	bar
	stability		**-0.5**		**0.5**	bar
Max. air flow @ 5bar supply	PNK3, PNK3S (standard bore)			**15**	50	l/min
	PNK5 (wide bore)			**25**	100	l/min
Rotation rate	range set point		**7**		**50**	Hz
	range measurement		**0**		**100**	Hz
	setting resolution		**1**			Hz

Environment

Parameter		Details	Min	Typ	Max	Unit
Operating temperature (ambient)[a]			15	25	35	°C
Relative humidity	non-condensing		**10**		**95**	%
Storage condition	non-condensing		**5**		**50**	°C

a. where specifications are met

Figure 8.1. Block diagram of the PNK3 module

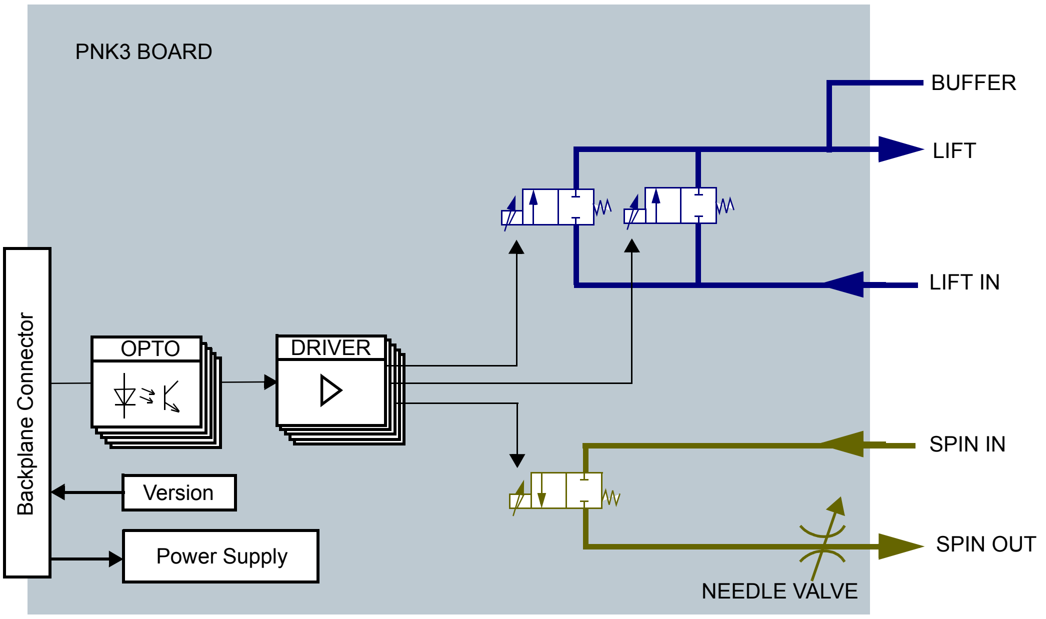


Figure 8.2. Block diagram of the PNK3S module

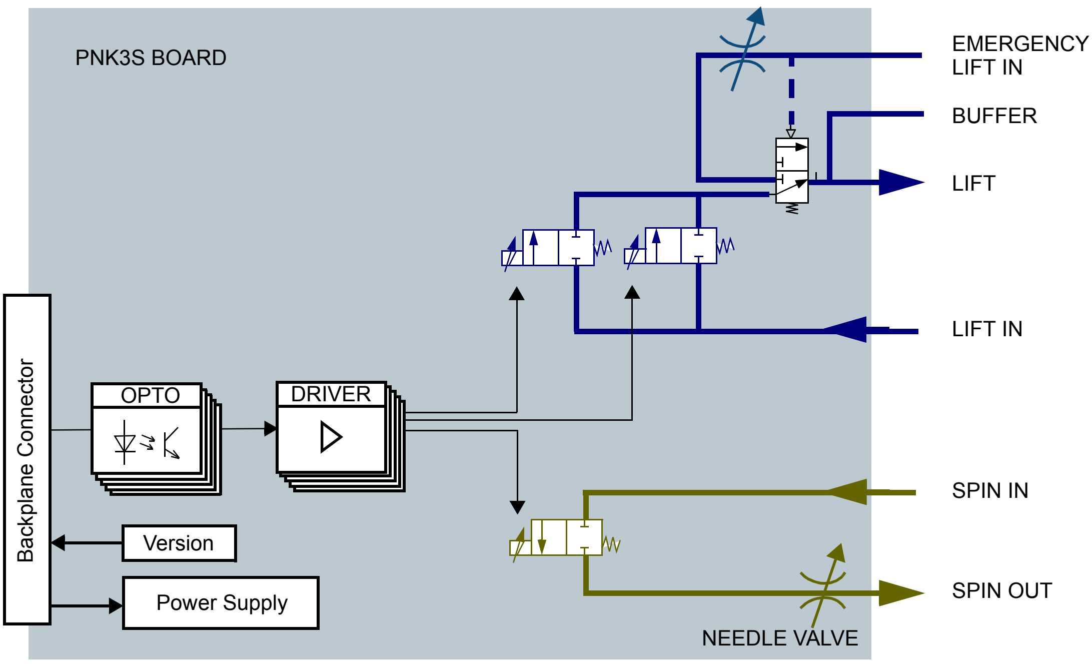
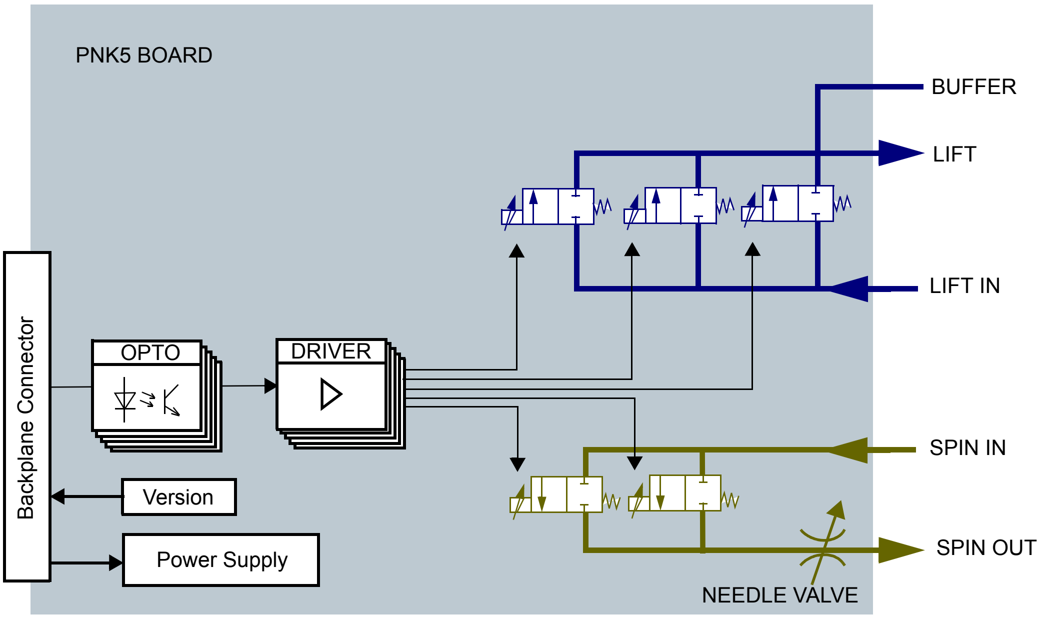


Figure 8.3. Block diagram of the PNK5 module



The PNK is controlled by the BSMS/2 SLCB by two PWM (Pulse Width Modulation) signals. These signals are galvanically isolated and then fed to two groups of switching drivers. There is one driver per valve solenoid.

All valves in one group (1,2 or 3 valves, depending on group and PNK type) are connected in parallel.

A screwdriver operated needle valve at the spin output greatly improves the PWM linearity by presenting a flow dependant exhaust pressure to the PWM valve. Furthermore, the needle valve adapts the PWM range to the spin airflow range when calibrated properly.

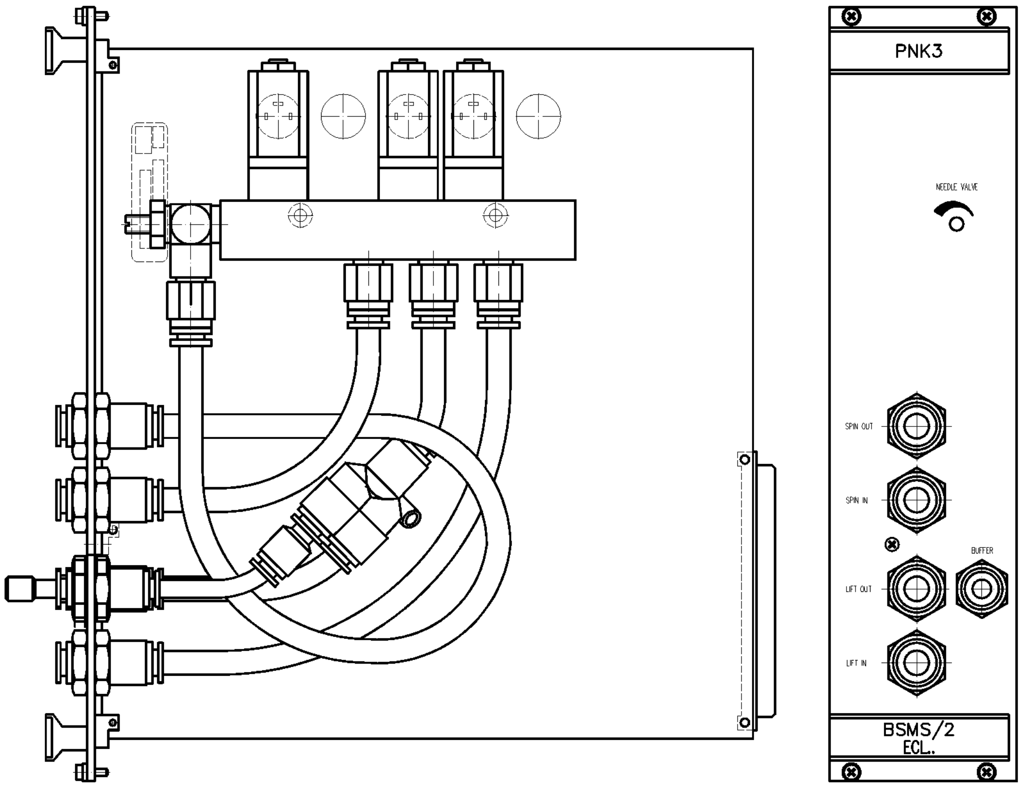
General Installation Hints 8.4

In BSMS/2 systems with ELCB and Service Web, calibration and parameter setup for spin and lift is straightforward and described in detail on the corresponding BSMS/2 Service Web page.

Never supply the console with non-filtered gas. Gas supply filter 88437 must be installed!

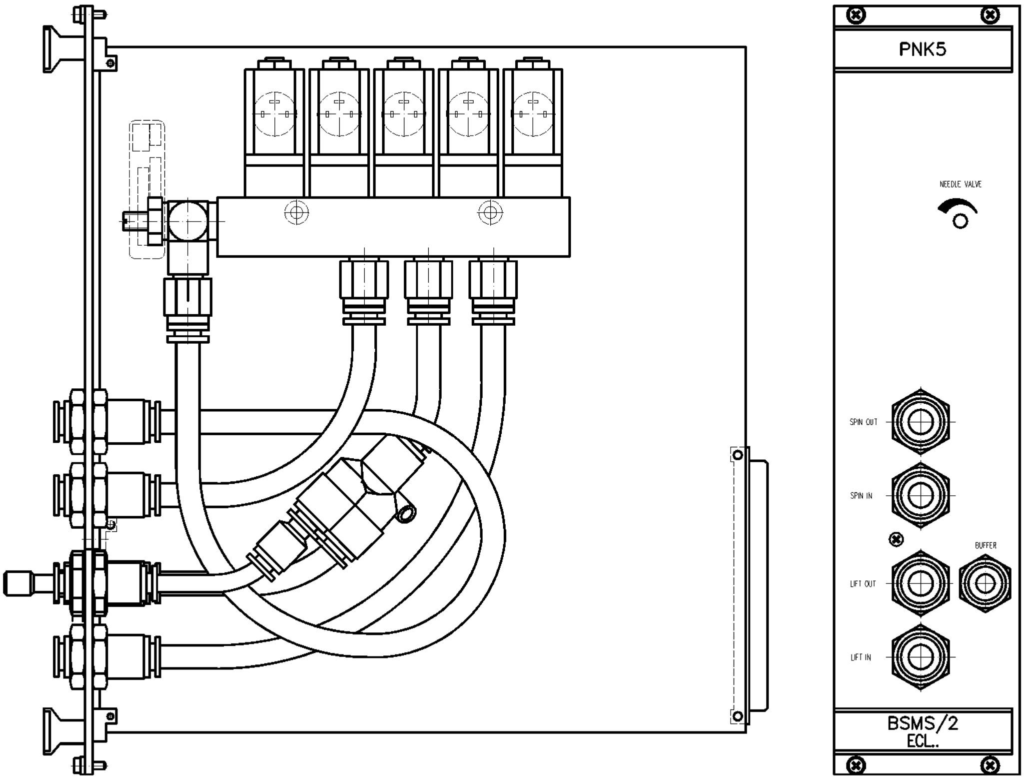
Module Drawings *8.5*

Figure 8.4. PNK3 Drawing



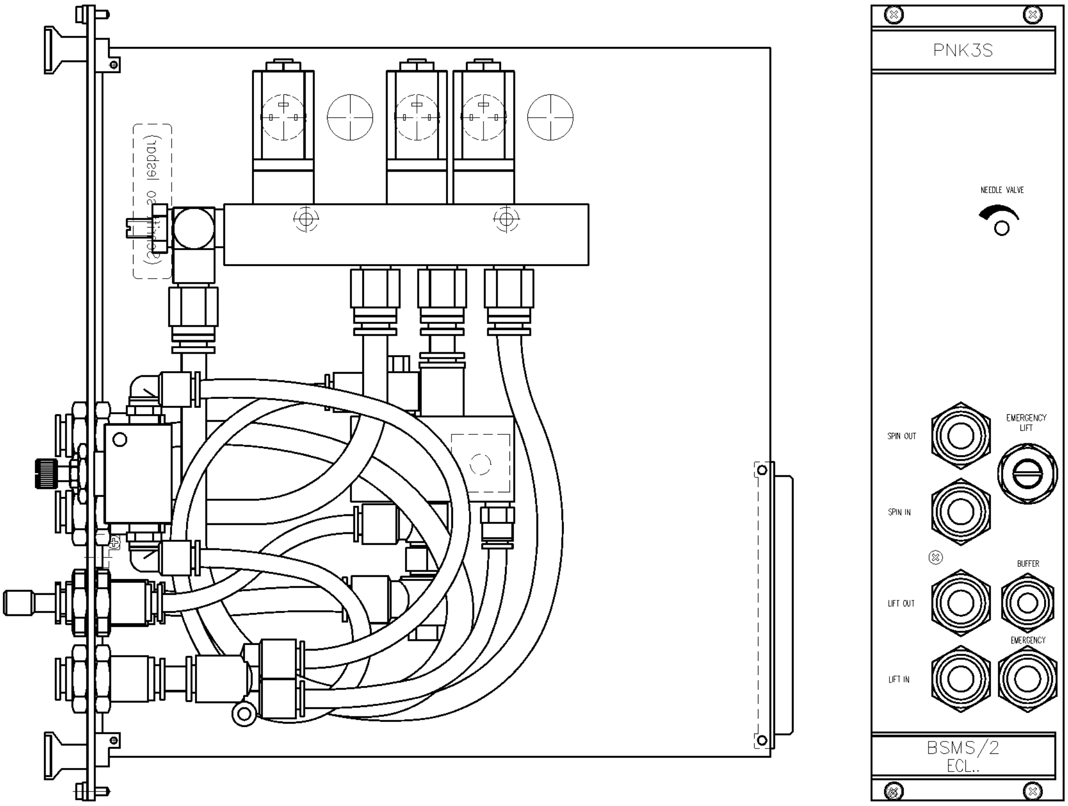
Note the valve block carrying three valves only.

Figure 8.5. PNK5 Drawing



Note the valve block carrying five valves.

Figure 8.6. PNK3S Drawing

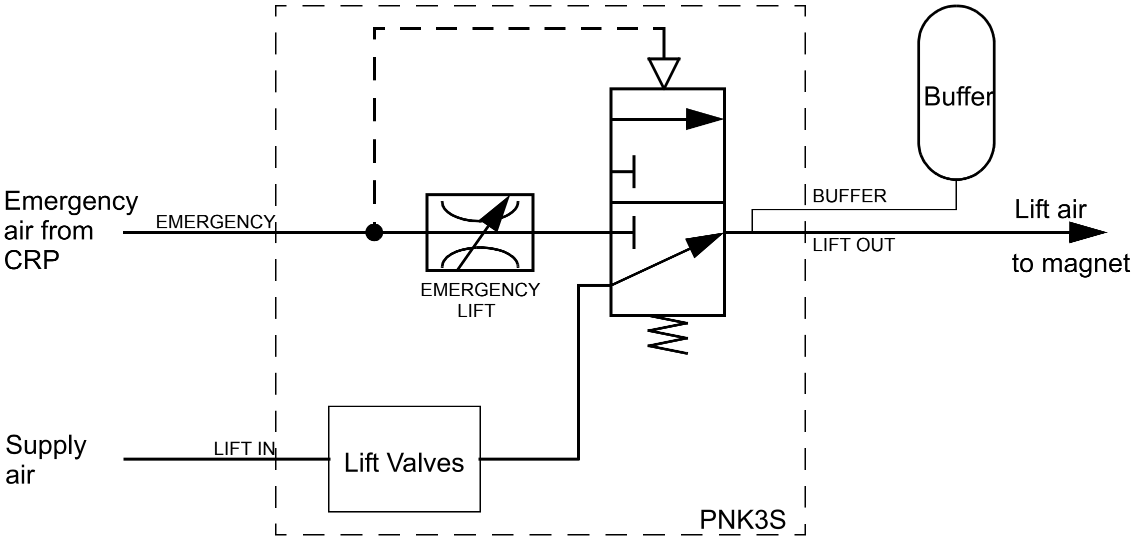


Note the manual valve (marked “EMERGENCY LIFT“) and the emergency lift inlet (marked “EMERGENCY“).

PNK3S Description 8.6

Emergency Lift Functional Description 8.6.1

Figure 8.7. Block Diagram Emergency Lift



During normal operation, the lift air from the lift valves is passed through to the lift air outlet and the buffer. The pneumatic switch over valve is held in this position by a spring. In case of an emergency sample eject, the CRP delivers lift air to the inlet marked “EMERGENCY“. This air is throttled by the EMERGENCY LIFT valve, allowing the valve operating pressure to build up and finally switch over the valve.

Now the emergency lift air is passed through to the lift air outlet and the buffer. The normal lift air is held off and the sample protected from jumping out of the magnet because of double lift air.

That same throttle valve is used to adjust the emergency lift airflow to a value that comfortably suspends the sample in its up position without catapulting it out of the magnet.

The buffer smooths the instantaneous switch over and eventual switchback and sample landing.

WARNING:
The standard buffer must be present and working. A missing or plugged buffer can result in sample and/or probehead damage due to the instantaneous switching of the emergency lift.

In contrast, the normal lift is slowly ramped up and down and a missing buffer would only be remarked in case of a power failure during a “lift up” period.

PNK3S additional Installation Hints 8.6.2

When exchanging an existing PNK3 with a new PNK3S, the spin and lift must be re-calibrated (as with any PNK exchange) and the emergency lift airflow must be adjusted.

1. replace the old PNK3 with the new PNK3S
2. check the buffer connection
3. start BSMS/2 Service Web, go to Sampling Handling -> Sample Rotation
4. follow the instructions
5. close the EMERGENCY LIFT valve (turn clockwise)
6. access the Cryo Controller (CRCO) with UniTool and switch on emergency lift
7. adjust the valve until the sample floats in the upper position
8. check adjustment by switching on and off with UniTool

The sample must not land too hard or jump too far out of the magnet. If you cannot find a satisfactory valve position, check the following:

- Is the buffer connected and not plugged?
- Are shim system and probehead mounted ok (air leakage)?
- Is the sample temperature stub unconnected and exhausting lift air?
- Is the Cryo Platform air supply pressure below specification?
- Is the emergency lift hose running from CRP to console bent or squeezed?
- Does the Cryo Platform deliver lift air? Use a short piece of hose to open the self closing hose plug at the Cryo Platform.
- Disconnect the LIFT OUT and connect an air supply to EMERGENCY lift in. The air supply must switch over the pneumatic valve and exhaust at LIFT OUT. Try to change the airflow with the manual valve.

Front Panel - Connectors 8.6.3

Figure 8.8. The picture below shows a PNK3

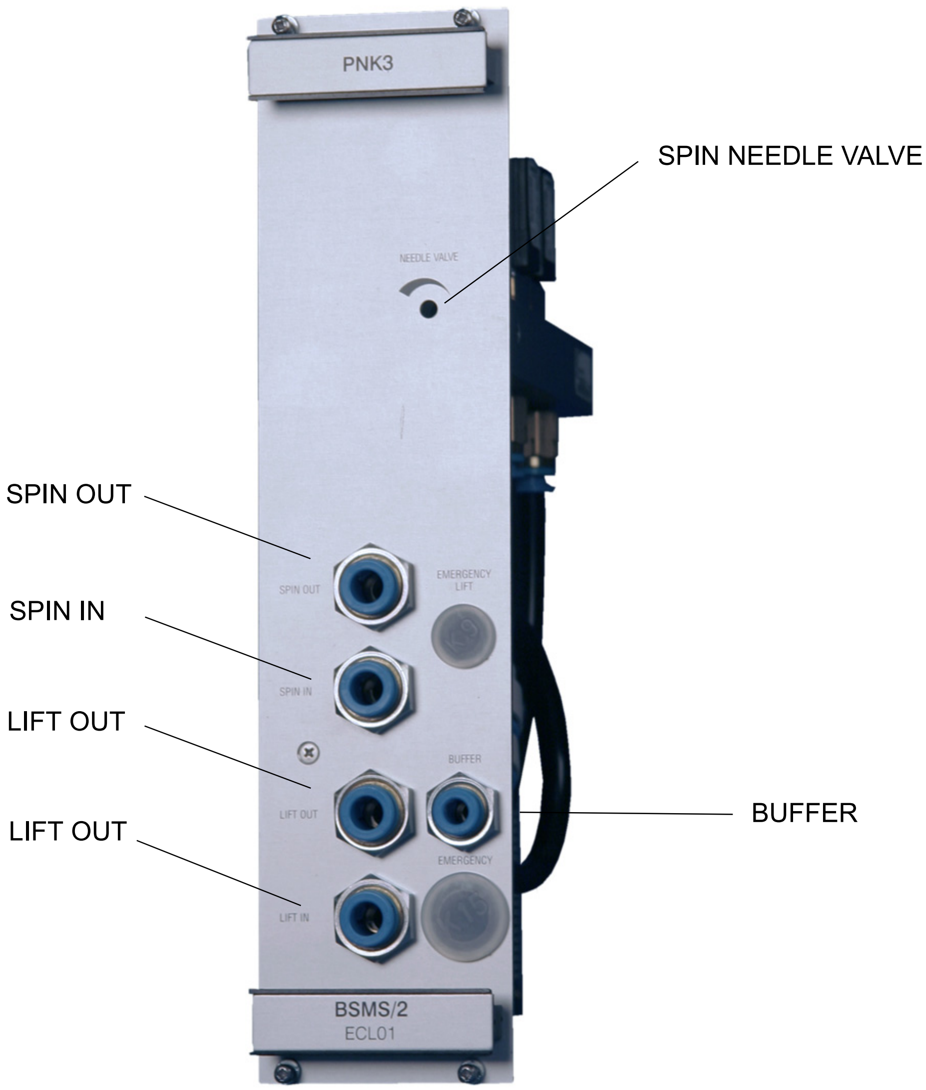


Figure 8.9. The picture below shows a PNK3S

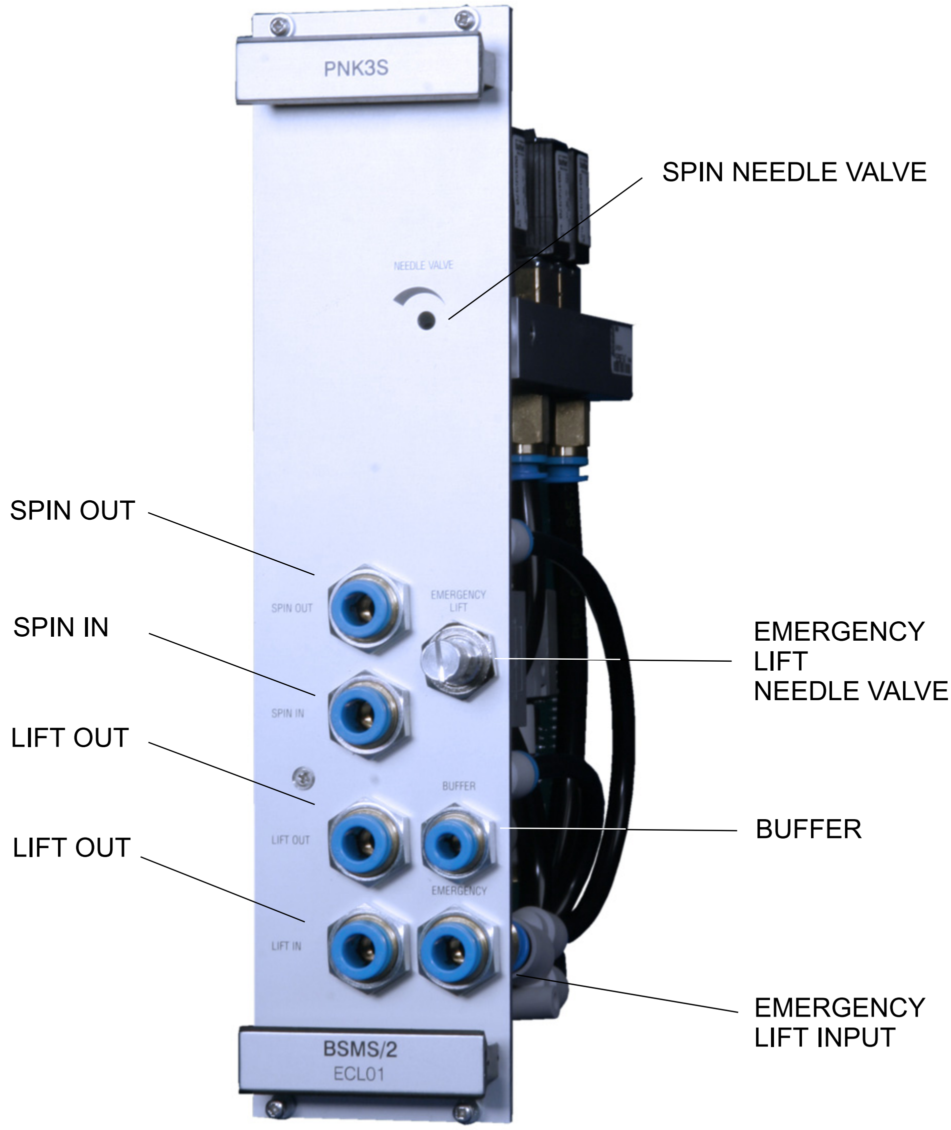
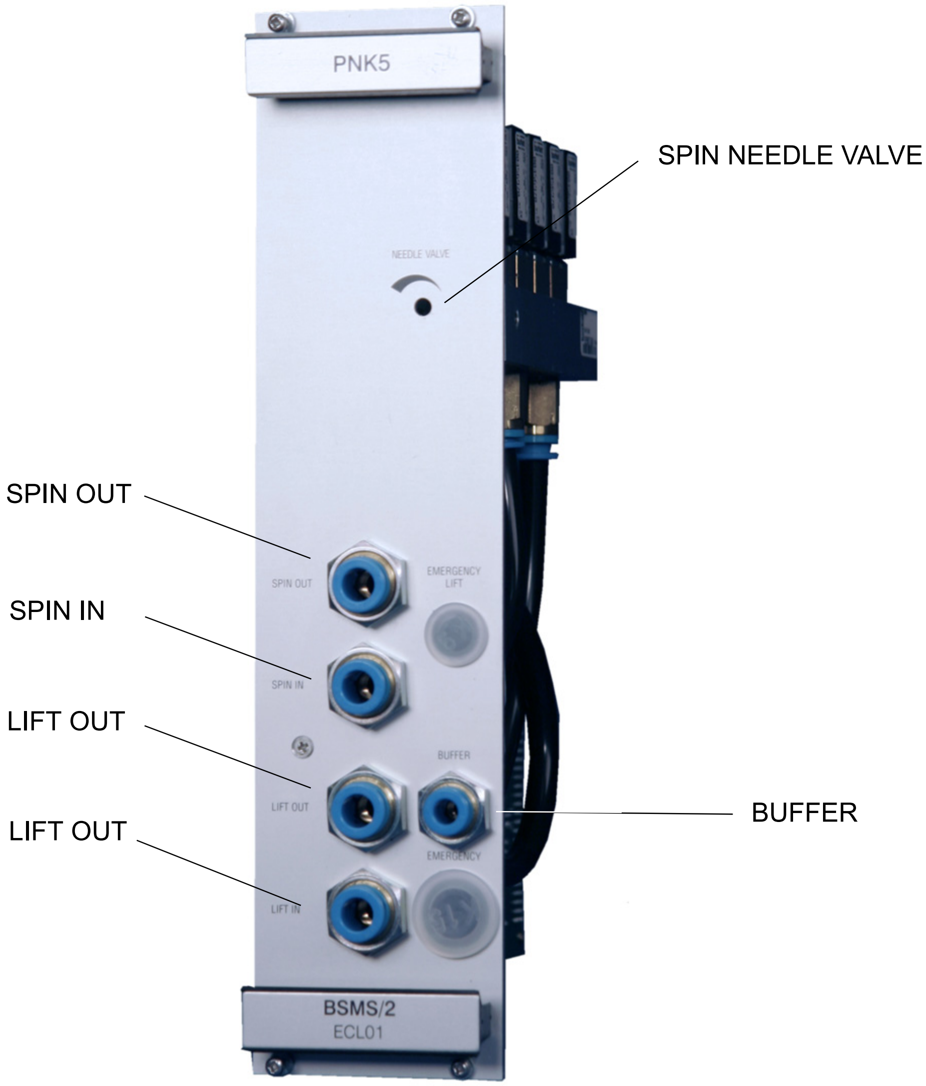


Figure 8.10. The picture below shows a PNK5



Bus Interface *8.7*

The PNK boards are directly coupled to the SLCB/2 or SLCB/3.

Table 8.2. User Bus Back Plane Connector (DIN41612 R)

Pin	A	B	C
32			
31			
30			
29			
28			
27			
26			
25			
24			
23			
22			
21			
20			
19			
18			
17	SPIN_RATE0		SPIN_RATE1
16	FLAP		LIFT1
15	RES0		RES1
14	VER_PNK		
13	VCC_BPL	VCC_BPL	VCC_BPL
12	DGND	DGND	DGND
11			
10			
9			
8			
7			
6			
5			
4			
3			
2	GND_PNEU	GND_PNEU	GND_PNEU
1	24V_PNEU	24V_PNEU	24V_PNEU

Service 8.8

A connected PNK in a BSMS/2 system is controlled by the SLCB and ELCB software - the specific low level drivers and the overall control logic are implemented there. The ELCB software provides the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration). Some of these Web functions are open to all users, other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

Sample Handling Service Web 8.8.1

Via the Sample Handling Service Page lift and spin can be calibrated or parameterized. Please read the instructions on these pages carefully.

Figure 8.11. Sample Handling Service Page

Diagnostic and Trouble Shooting 8.8.2

Sample rotation (SPIN) not running

- Check air hoses and console gas pressure
- Check needle valve
- Lift the sample and insert again

Gas flow variations

- Check supply pressure
- Check the gas pressure after console pressure regulator, pressure must be higher than 4 bar and stable.

As long as the console pressure is within the specified range of 4-6 bar the console pressure regulator is within a useful operating point. Gas supply pressure must be at minimum 1 bar **higher** than set with the pressure regulator of the console (head room for proper pressure regulation).

System requirements *8.9*

Never supply the console with non-filtered gas. Gas supply filter 88437 must be installed!

Ordering information *8.10*

See ***"PNK variants" on page 155***.

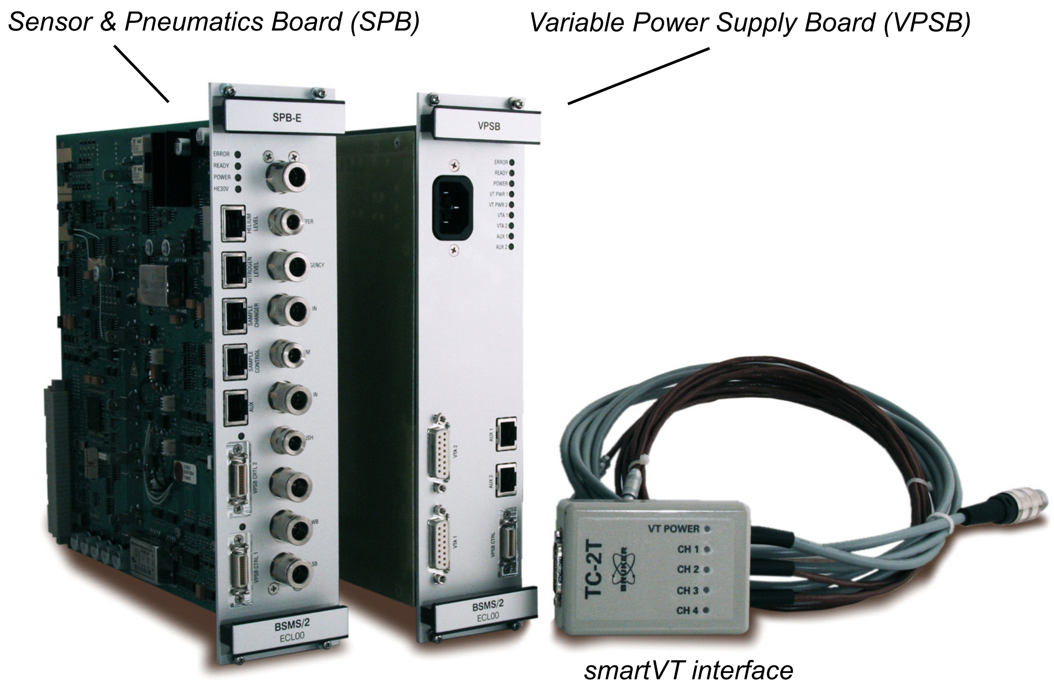
BSVT Introduction & Configurations

9

Introduction 9.1

Since mid 2010 a new and higher integrated VT system is provided for all NMR applications. The so called BSVT (Bruker Smart Variable Temperature System) replaces all former standalone BVT3000 (Standard, MAS, BEST) and BSMS integrated BVT3200 variants. By using a modular BSMS/2 integrated concept all BVT variants and also former pneumatic units like PNK3, PNK3S and PNK5 as well as the SLCB/2 and SLCB/3 boards are replaced by the new *Sensor & Pneumatics Board* (SPB) and the *Variable Power Supply Board* (VPSB). The adaptation of the various probes and temperature control accessory interfaces is realized with *smartVT interfaces (also named VTAdapters).* This digital interface has also been introduced for other new digital sensors (e.g. digital liquid nitrogen level sensor).

Figure 9.1. typical BSVT components



BSVT Hardware 9.2

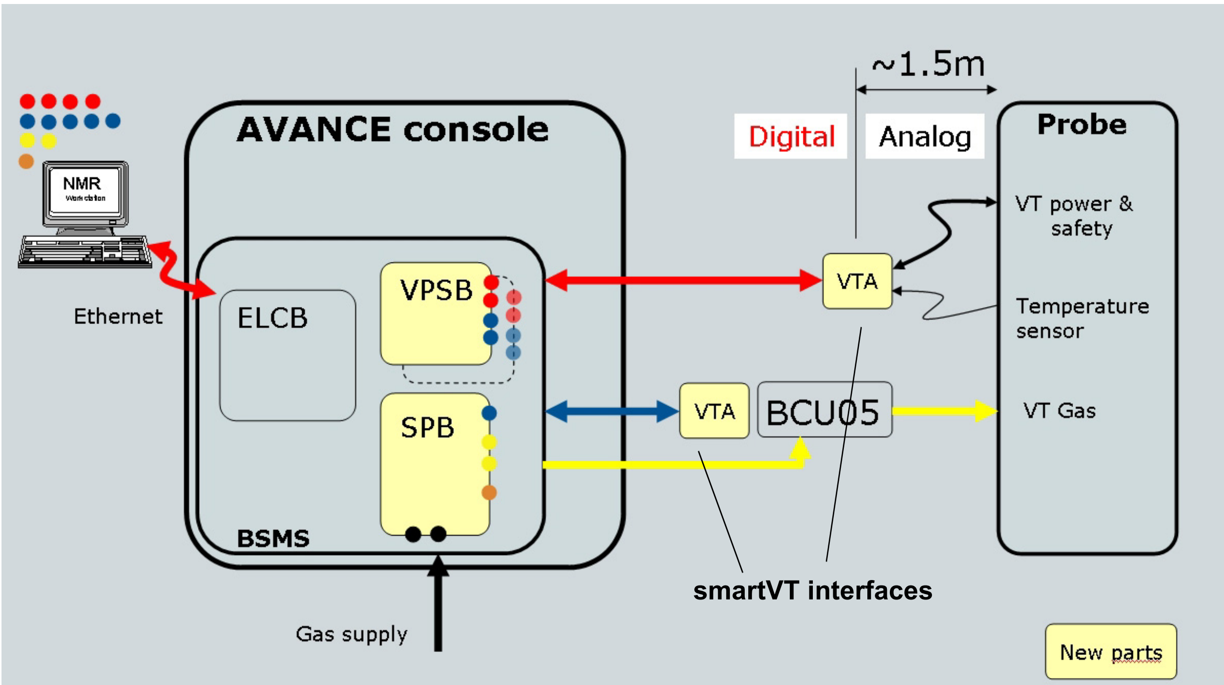
The new VT system consists of the following hardware:

- Sensor & Pneumatics Board (SPB or SPB-E) *always required*
- Variable Power Supply Boards (VPSB) *only required for VT option*
- VT Interfaces (several styles) *only required for VT option* [1]

For existing probes and existing VT accessories the corresponding VT interfaces have to be ordered separately. When ordering new probes and VT accessories the VT interfaces are included.

These new units are controlled by the BSMS/2 ELCB and are therefore fully integrated into the well known Ethernet^{TM} based communication concept including the web-based service access.

Figure 9.2. BSVT – Open / Digital VT architecture



1. Mainly for interfacing existing VT accessories and NMR probes (important to check with console exchanges to have appropriate VT adapter!)

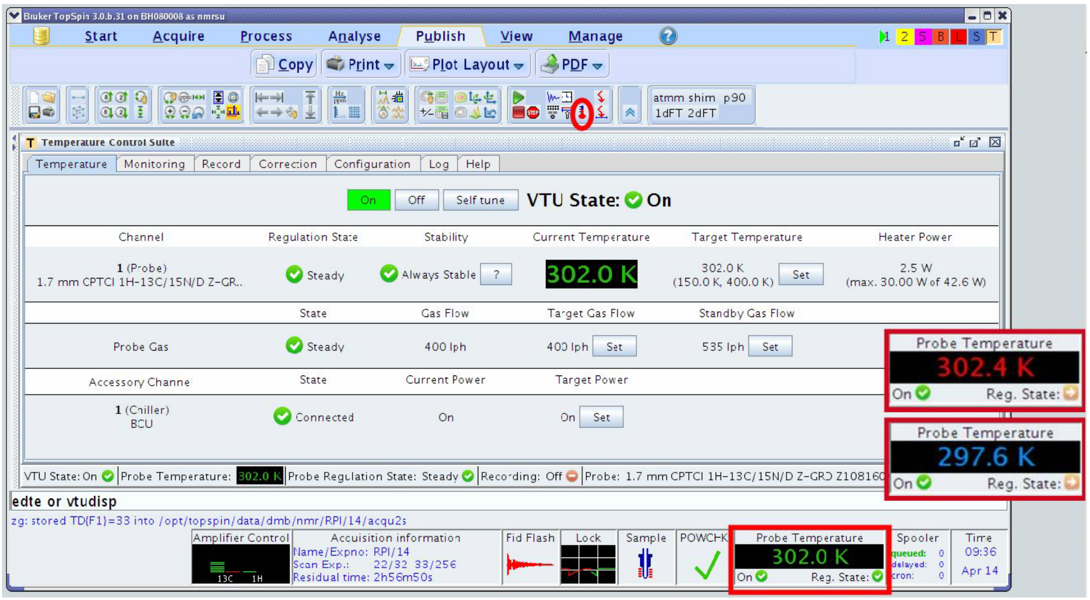
BSVT Software and Features 9.3

The new BSVT is fully supported with TopSpin 3.0 or later by using an attractive and modern VT panel for easy user control, monitoring, configuration and other VT specific operation.

- Full Client/Server architecture via ELCB (Ethernet™)
- Modern Topspin Control with JAVA operated GUI
- VT accessories (e.g. LN2 Exchanger, Booster, BCU-05) are fully supported
- Optimum performance is provided with basic configuration (no BTO-2000 required)
- Built-in gas flow control and supervision
- Expandable in future due to modular concept (e.g. easy upgrade for FlowNMR probe)
- Up to 4 heater channels and total 9 temperature sensors channels supported
- Plug & play operation
- Integrated flush gas and shim cooling connections
- No console interaction anymore during normal use (e.g. sensor style change)

The TopSpin compliant software architecture enables a seamless integration and provides a convenient user interface with common GUI elements. The new plug & play feature makes the system to behave very smart.

Figure 9.3. Example of the VT panel within Topspin3.0



BSVT Specifications 9.4

General

- Multi channel intelligent Ethernet™ based VT architecture (PnP)
- Up to 2 heater channels (additional 2 channels possible)
- Up to 2 sensor / cooling channels (additional 3 channels possible)
- Software controlled shim cooling and flush gas operation (SPB-E version)

VT control electronics

- Temperature setting resolution of 0.1°C (Topspin)
- BTO-2000 equivalent temperature stability
- Applicable temperature range (without cooling option, dew point <4°C):

  - Min. regulated temperature approx. +30°C with 25°C input gas temperature

  - Max. temperature depending on probe (>400°C with optional BVTB-3500)

Full electronic VT gas control

- VT gas flow up to 2000 l/h (min. 4 bar of dry air or N2 gas) with SPB

  3000 l/h with SPB-E
- Fine VT gas flow steps
- Extended monitoring and logging capabilities
- VT flow meter with approx. +/-5% precision
- VT gas pressure meter with approx. +/-5% precision

Other

- Minimum Topspin 3.0 required
- Additional VT interfaces might be required for software control of existing probes and accessories

Not supported probe interfaces

Table 9.1. Not supported external probe interfaces (discontinued products)

Part number	Description
W1100255	THERMOCOUPLE HR 500WB
W1100407	THERMOCOUPLE HR 600MHZ
W1100401	THERMOCOUPLE HR 200-500MHZ
W1100884	THERMOCOUPLE HR 750MHZ
W1100024	HEATER SC FOR HP CXP/MSL
W1100316	HEATER SC ALL HR HEAD
W1100399	HEATER SC ALL HR HEAD

Basic BSMS/2 BSVT configuration 9.5

Note: The *basic* BSMS/2 BSVT configuration includes sample transport and rotation and cryostat helium level measurement but does **not include a VT system**

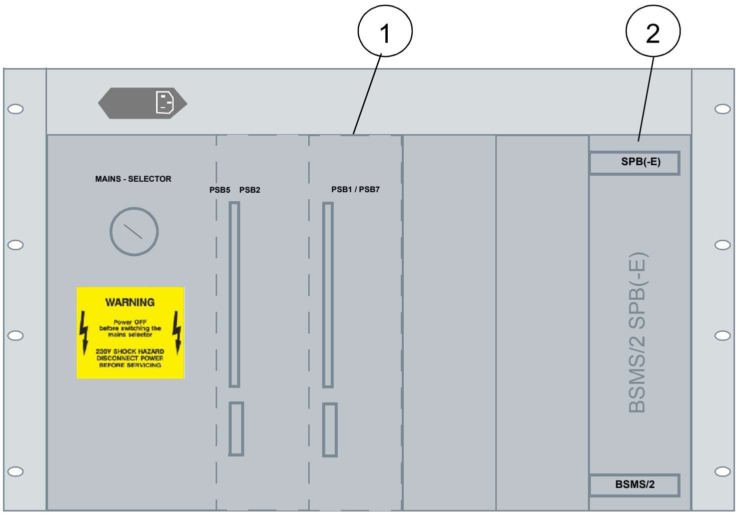
Table 9.2. Minimal requirements for all configurations

Part name	Part Number	ECL
BSMS/2 CHASSIS WIRED	Z002774	>= 02.00
BSMS/2 ELCB EXTENDED LOCK CTRL BOARD	Z100818	>= 05.00
PNM AIR FILTER SYSTEM AVANCE CABINET	88437	-

Table 9.3. Required boards depending on magnet system

	1 Power Supply		2 Sensors & Pneumatics	
Magnet System Bore	**PSB1 Z002775**	**PSB7 Z117631**	**SPB Z115191**	**SPB-E Z115192**
SB	✗	✓	✓	✓
WB			✗	✓

Figure 9.4. Minimal BSMS/2 configuration (without VT system)



BSMS/2 (rear view)

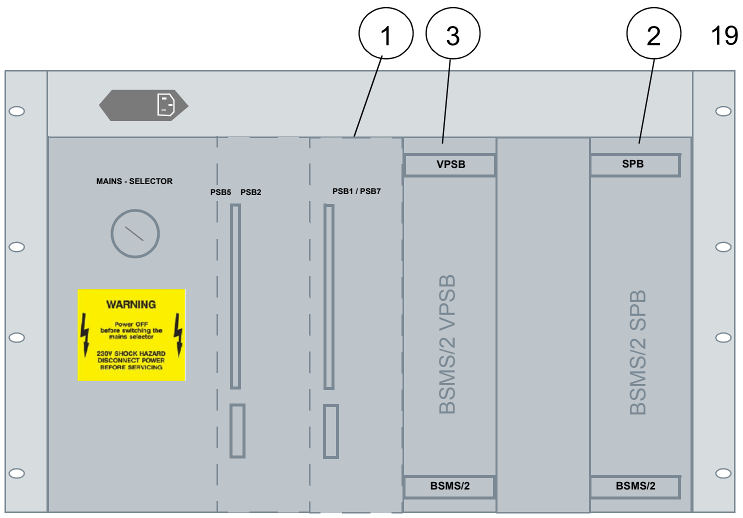
Basic BSMS/2 BSVT configuration with VT system option 9.6

Table 9.4. Required boards for basic BSVT configuration with VT system option

	1 Power Supply		2 Pneumatics & Sensors		3 Variable Power Supply
Magnet Bore	**PSB1 Z002775**	**PSB7 Z117631**	**SPB Z115191**	**SPB-E Z115192**	**VPSB Z115193**
SB	✗	✓	✓	✓	✓
WB	✗	✓	✗	✓	✓

The basic VT system option includes a *smart VT interface* for 2 thermocouple type T sensors (Z119237 BSMS/2 VTA TC-2T) (see also **9.9**)

Figure 9.5. Typical BSMS/2 configuration with VT system



BSMS/2 (rear view)

Note: When upgrading an already installed system from BVT3000, BVT3200 or BVT3200A to BSVT, then a different rear panel is necessary (Z117207).

Support for Nitrogen Level Sensor 9.7

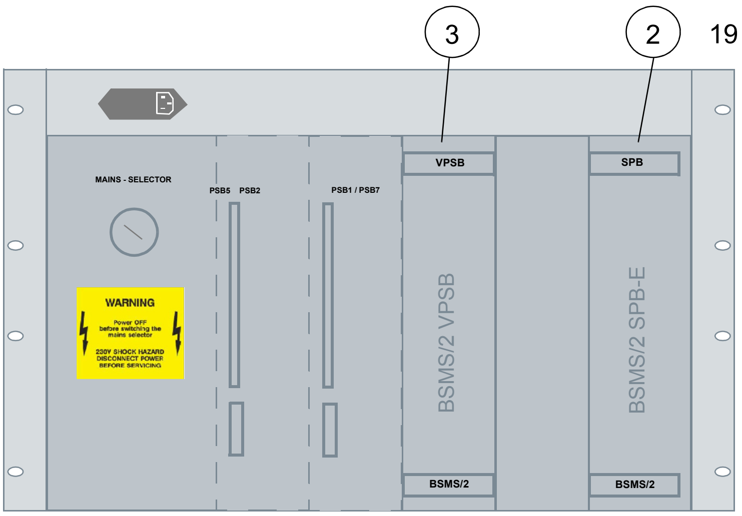
In former BSMS/2 systems the only unit that supported nitrogen level sensors was the SLCB/3. With introduction of the BSVT, interfaces changed and the new peripheral bus BFB (Bruker Field Bus) was introduced for connecting external digital sensors (see ***"System Architecture / Overview" on page 26***).

For detailed information on nitrogen level sensor and required cables see ***"Nitrogen Level Sensor" on page 261***.

Table 9.5. Support for Nitrogen Level Sensor

	3	2	
	VPSB Z115193	**SPB Z115191**	**SPB-E Z115192**
Digital sensor	✓	✗	✓
Analog sensor	✗	✗	✓

Figure 9.6. BSMS/2 units that support nitrogen level sensors



BSMS/2 (rear view)

Required cable sets for VT options 9.8

These cable sets can be used for BSMS/2 and NanoBay configurations

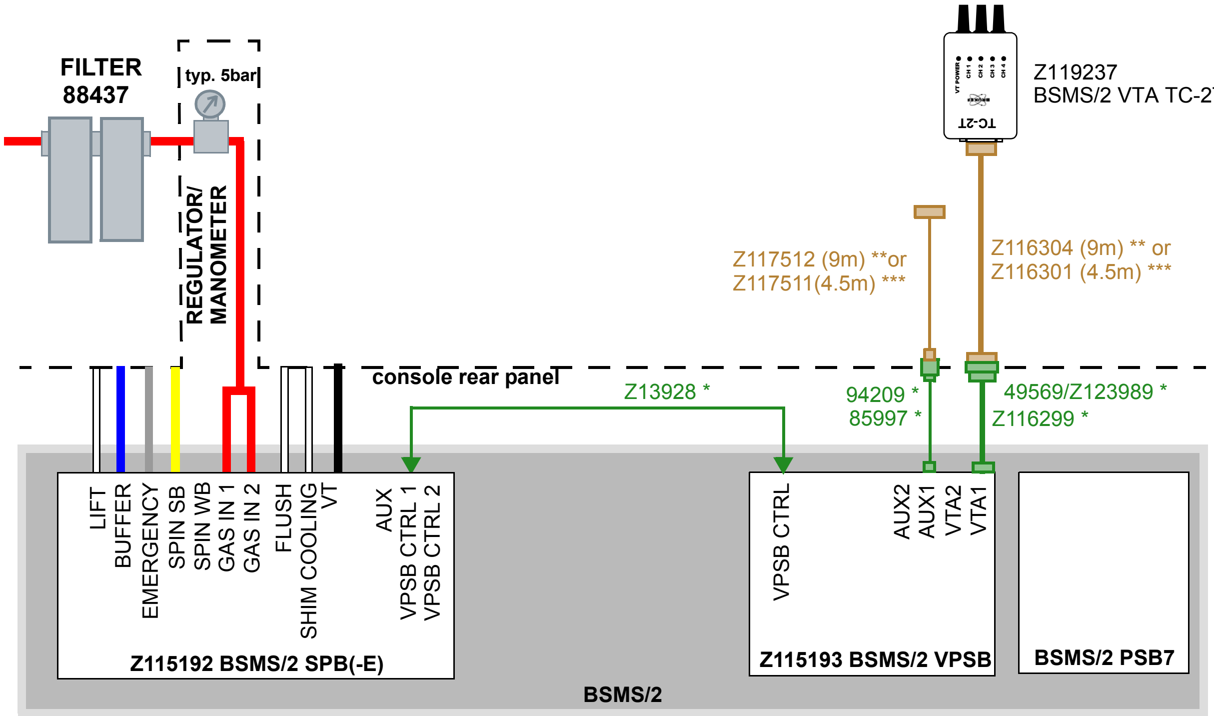
Table 9.6. Required cable set

Cable Set	Z119851 CABLE SET BSVT BASIC	Z119852 CABLE SET BSVT 9M HEATER	Z119853 CABLE SET BSVT 4.5M HEATER	Z119854 CABLE SET BSVT AUXILIARY HEATER (standard length 9m)	Z117512 CABLE RD 8P 9.0M BSMS/2 AUX VTA
1 probe heater and 1 cooling option	X	X			X[a]
2nd heater channel				X[b]	

a. only required for BVTB3500 booster operation

b. required for **LN2 evaporator** or **LN2 heat exchanger** operation or other additional heater channels

Figure 9.7. Basic BSMS/2 configuration with VT system option



* included in Z119851 CABLE SET BSVT BASIC

**included in Z119852 CABLE SET BSVT 9M HEATER

***included in Z119853 CABLE SET BSVT 4.5M HEATER

BSVT probe adaptation *9.9*

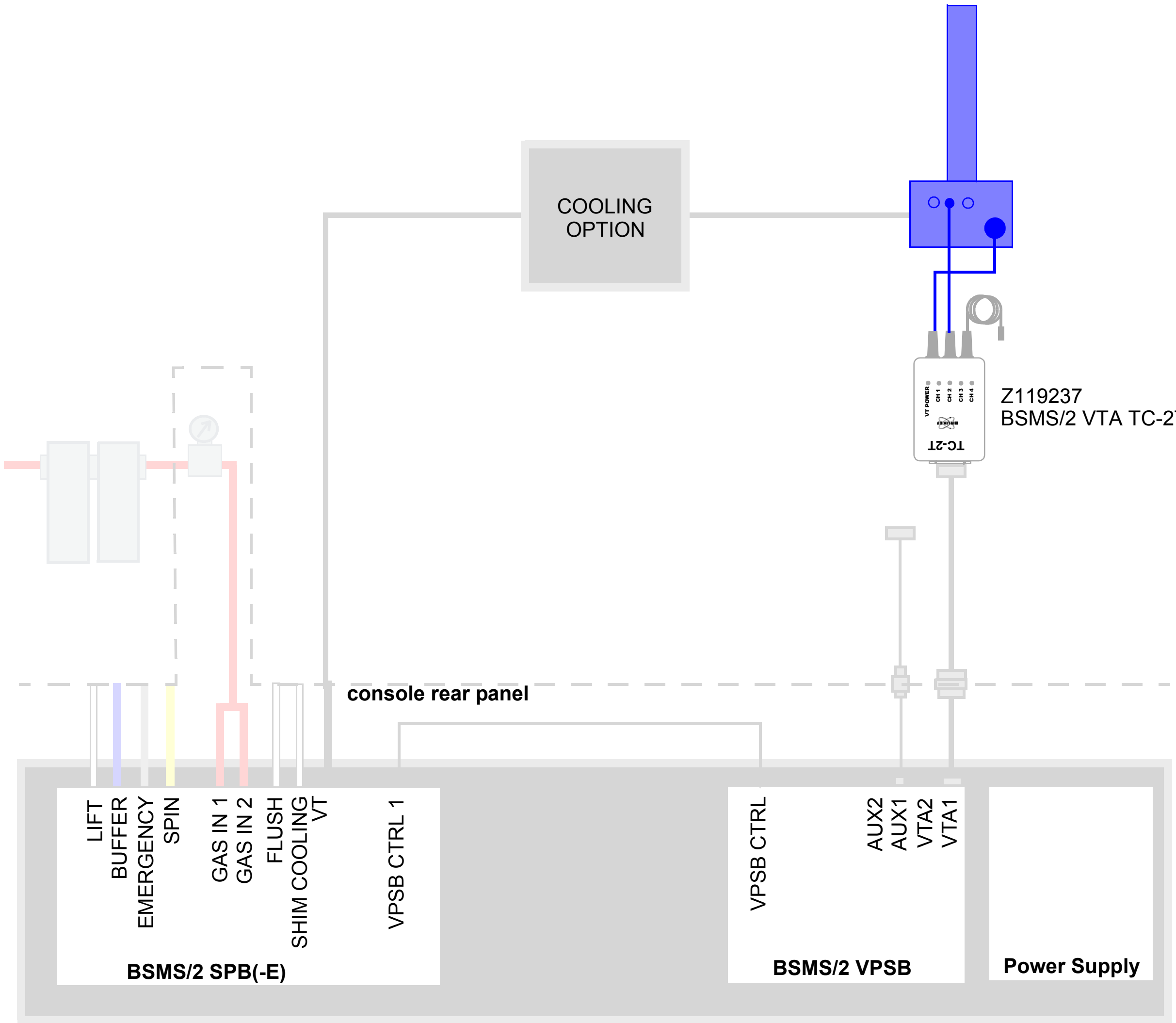
The whole variety of probe temperature sensor interfaces and VT accessories can be adapted with *smart VT interfaces* (BSMS/2 VTA).

For the different probe or VT accessory interfaces dedicated smart VT interfaces are available, for details see the following pages.

By default, delivered systems with VT option includes one smart VT interface for up to 2 thermocouple type T sensors.

HR RT probes (thermocouple type T) 9.9.1

Figure 9.8. Standard HR RT probe with thermocouple T

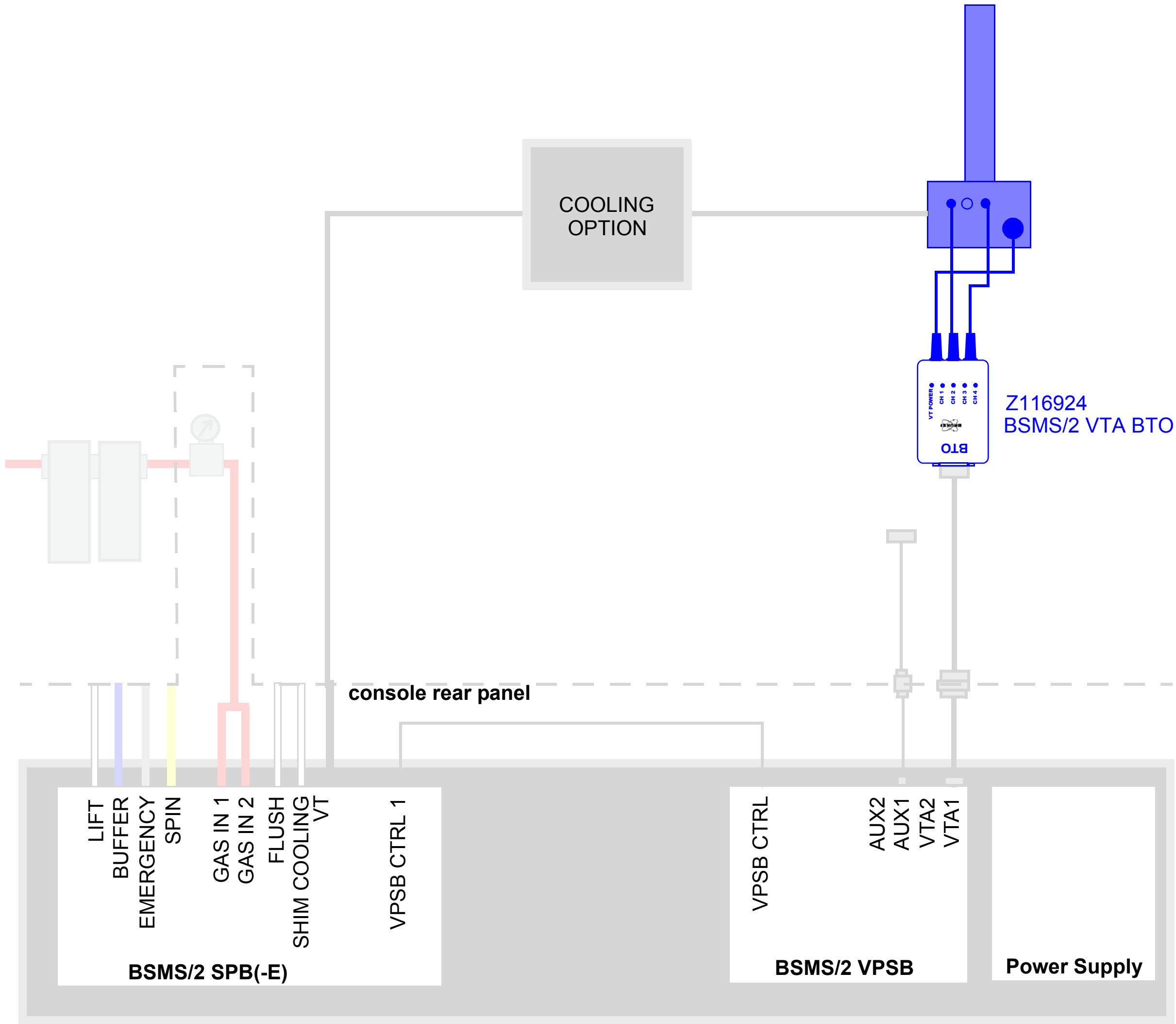


RT probes are typically operated with a VTA TC-2T. One of the sensor cables is not connected. It does not matter which sensor cable is connected as the connected sensor is recognized automatically. [1]

1. RT probes can also be operated with single Z116922 VTA TC-T. This variant is obsolete.

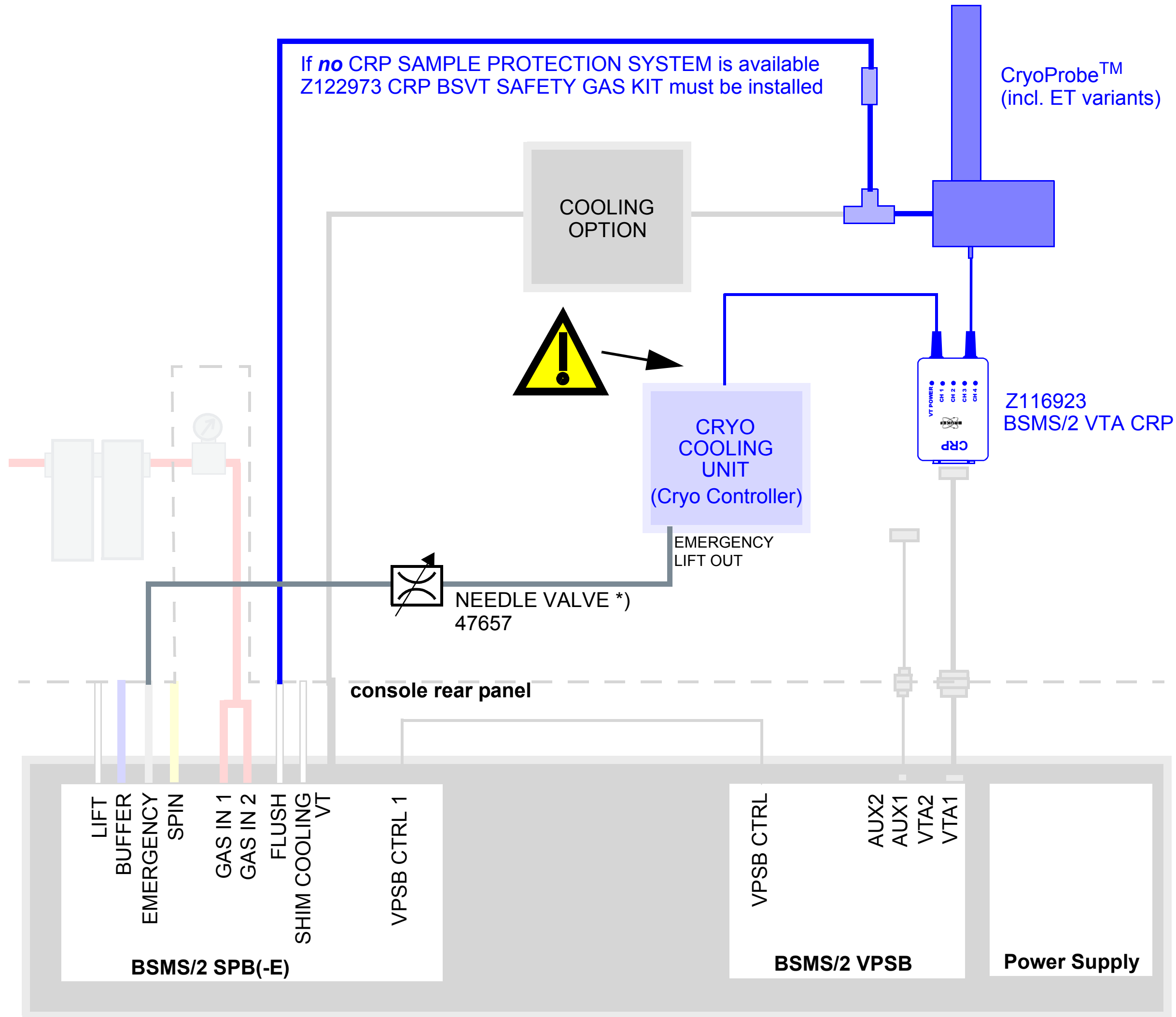
HR RT probes (BTO2000) *9.9.2*

Figure 9.9. HR RT probes (BTO2000)



CryoProbe probes 9.9.3

Figure 9.10. CryoProbe



*) part of Z109739 CRP SAMPLE PROTECTION SYSTEM 2 NEW

The BVT connector at the Cryo Controller has 24V on the male pins. Do not plug in the VTA connector while the Cryo Controller is on; there is risk of short-circuiting.

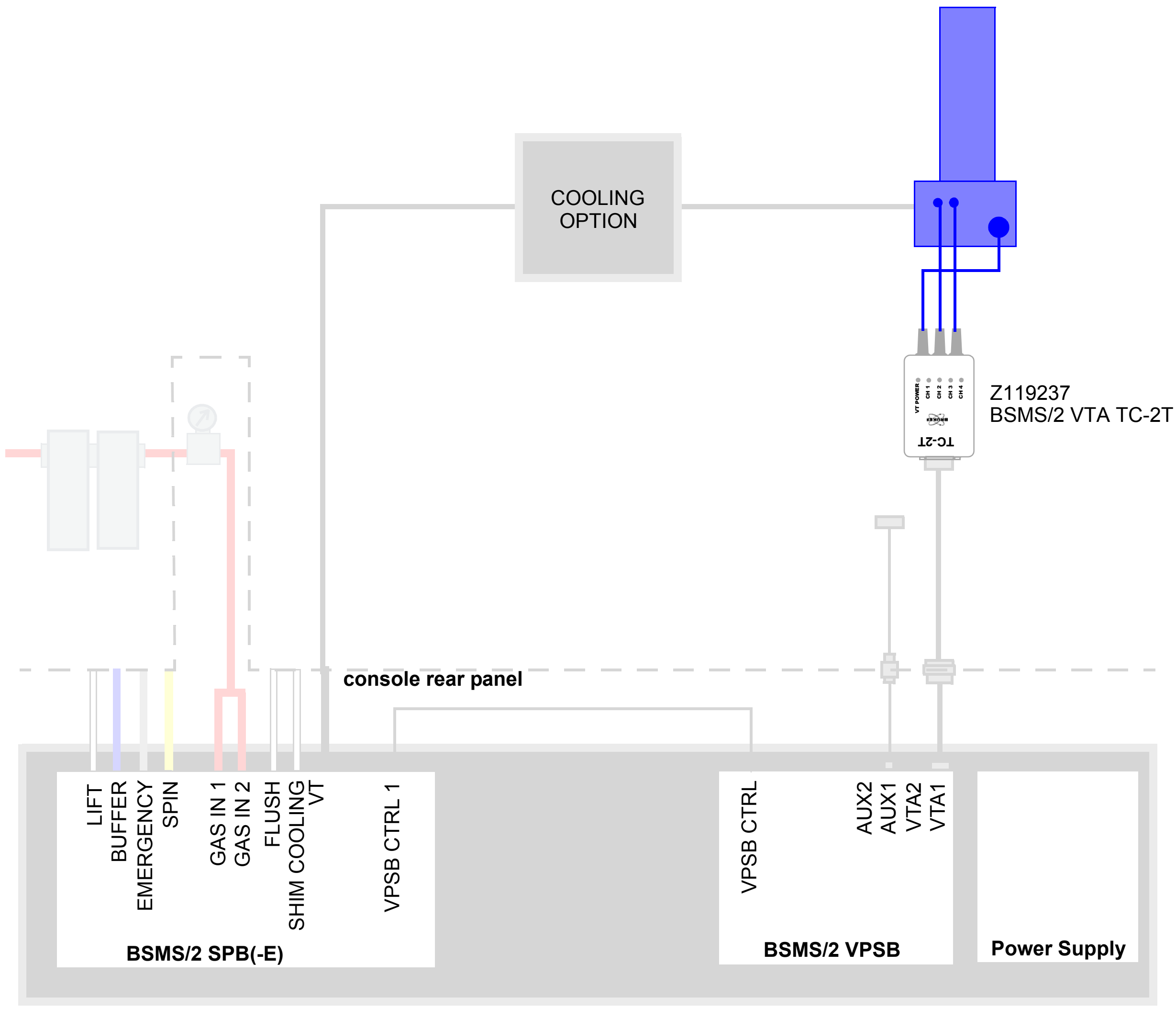
When operating a RT probe, the Z116923 BSMS/2 VTA CRP must not be disconnected from the Cryo Platform.

With BSVT the VT adapter box Z13874 is obsolete and must not be connected to the system.

Solids probes (2 thermocouple type T) 9.9.4

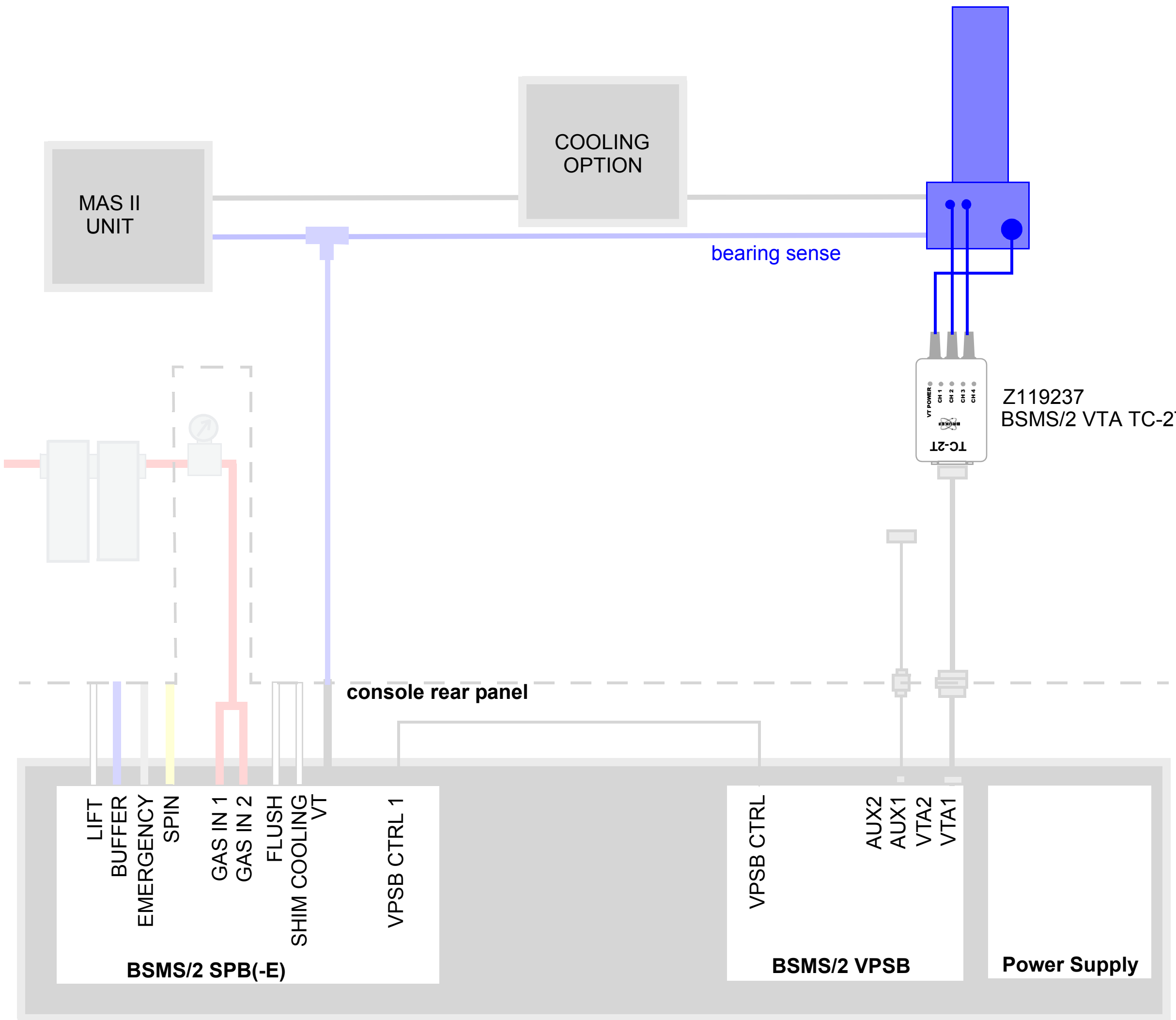
Solids probes DVT (thermocouple type T)

Figure 9.11. Solids probehead DVT with 2 thermocouple T



Solids probes VTN/WVT (thermocouple type T)

Figure 9.12. Solids probehead VTN/WVT with 2 thermocouple T

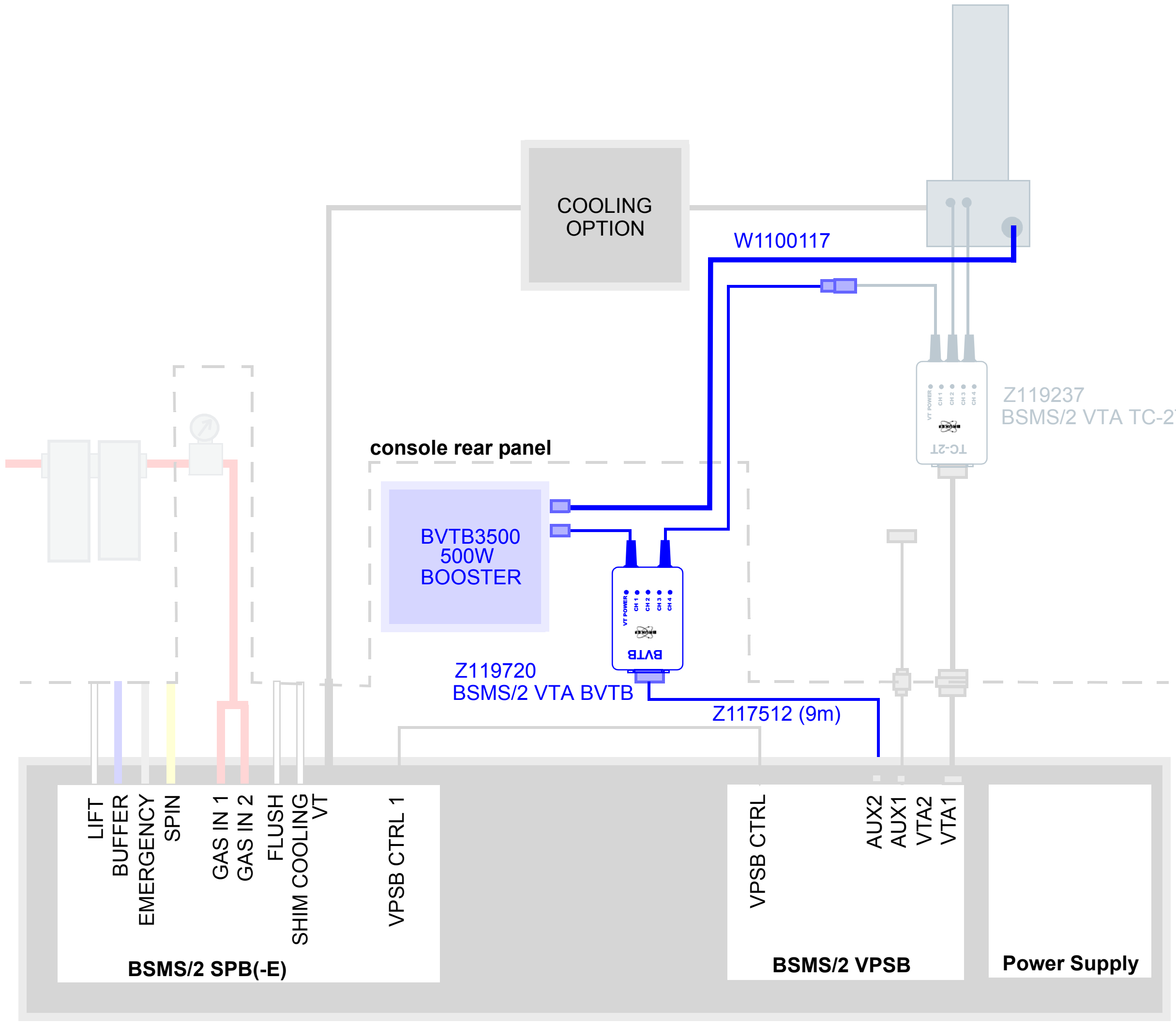


SPB(-E) must be configured for „external VT gas“
(BSMS Service Web)

BSVT and heater accessory (power booster) 9.10

BVTB3500 Booster

Figure 9.13. Power booster and solids probehead



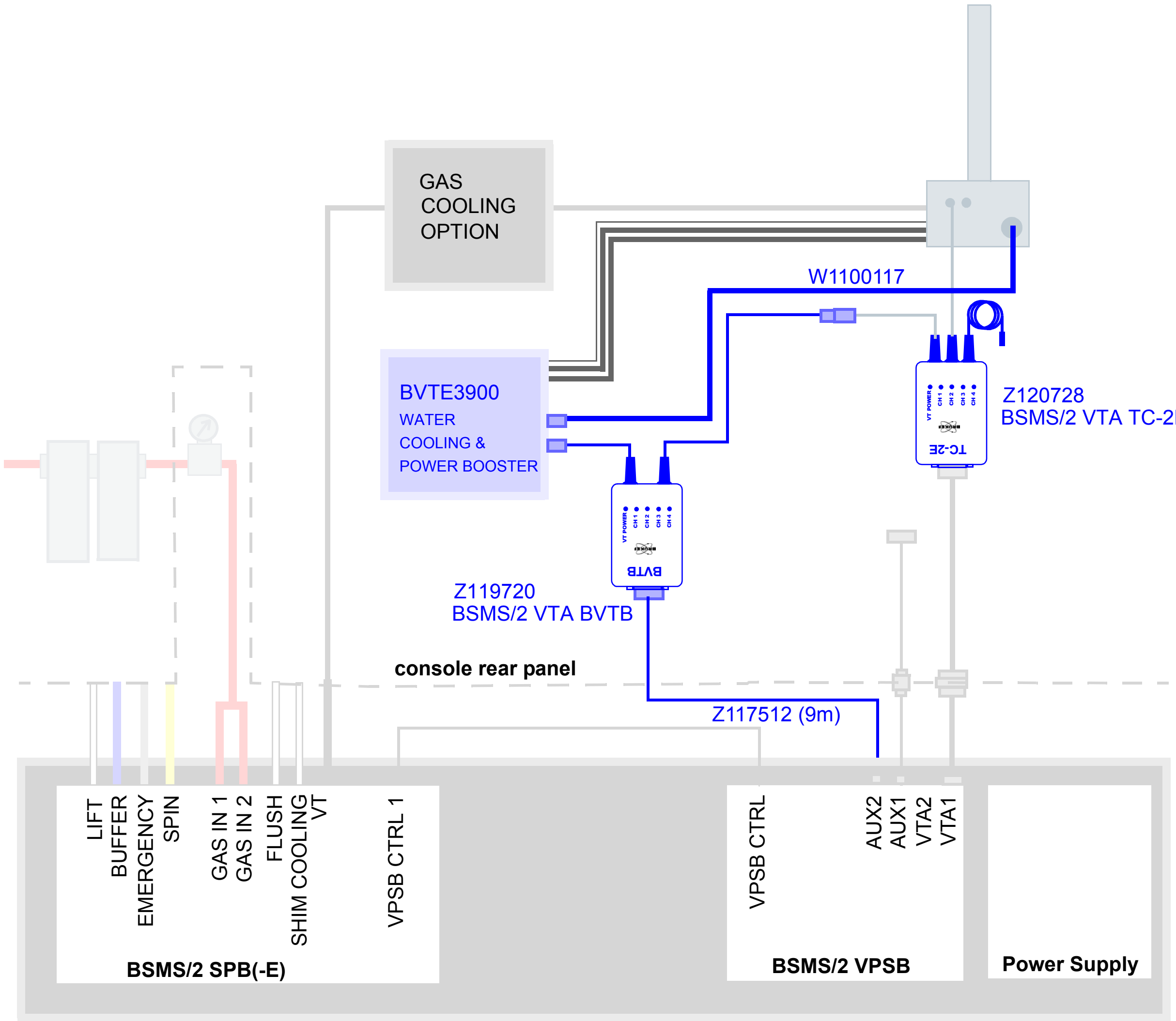
The power booster will also work with other probehead adaptation like VTA TC-T or VTA BTO etc.

BSVT and HT accessory (high temperature) *9.11*

BVTE3900

The BVTE3900 (P/N W1208962) is a cooling system for high temperature NMR.

Figure 9.14. BVTE3900 and BSVT

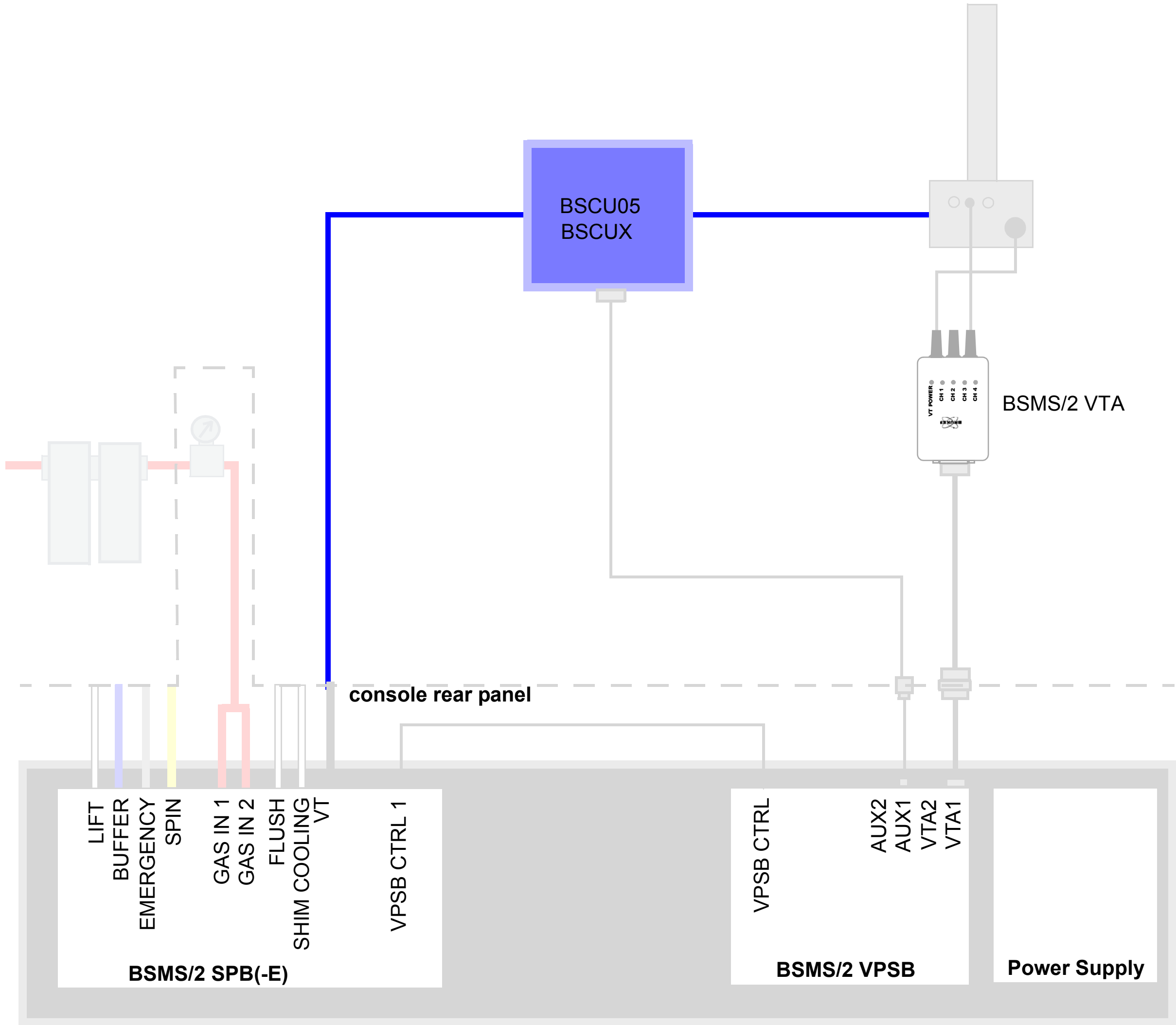


BSVT and VT gas cooling accessory adaptation 9.12

BSCU05 / BSCUX COOLING UNIT 9.12.1

Connection of BSCU05 and BSCUX is identical and straightforward.

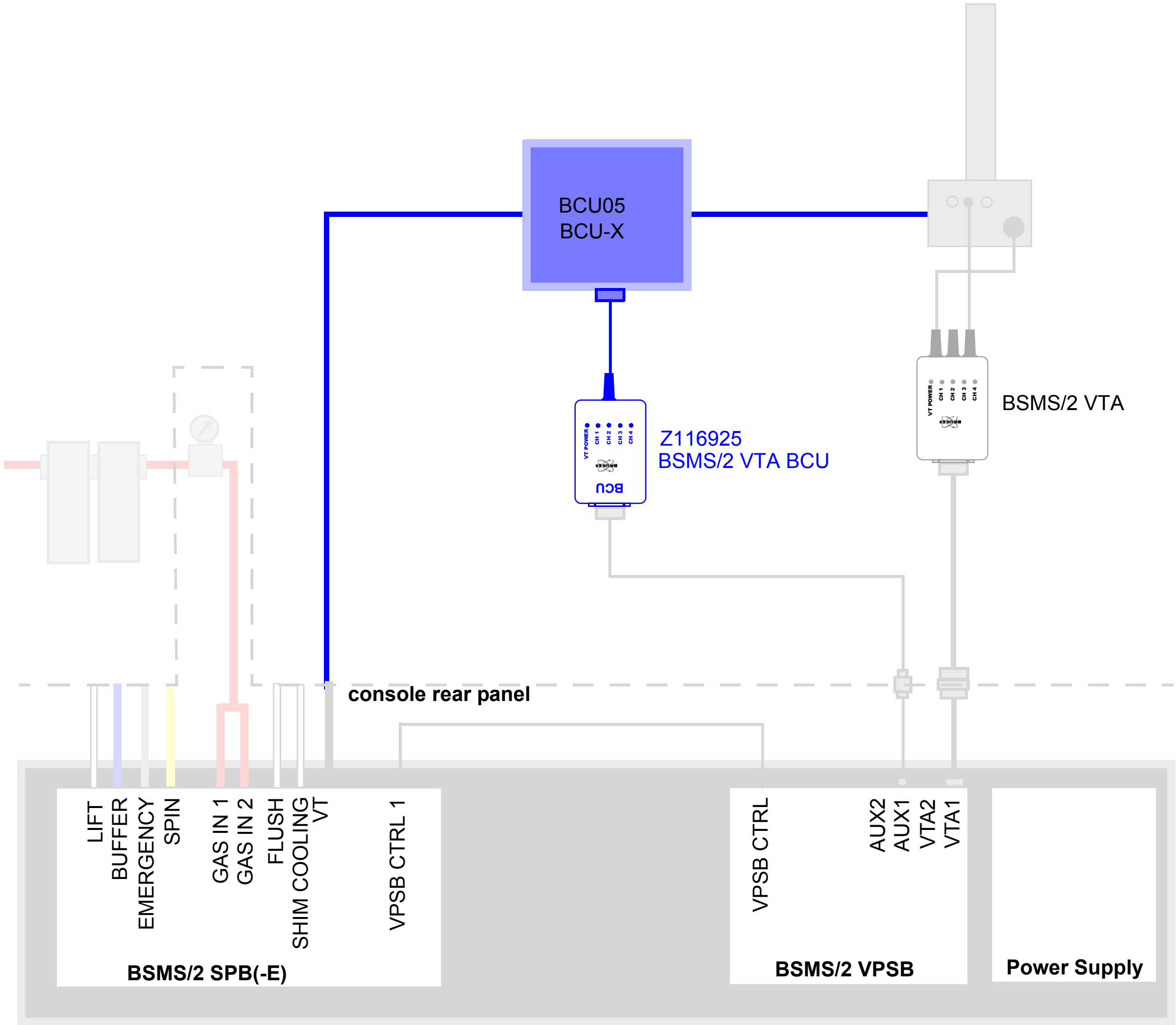
Figure 9.15. BSCU05 or BSCUX COOLING UNIT



BCU05 / BCU-X COOLING UNIT *9.12.2*

Connection of BCU05 and BCU-X is identical using a Z116925 BSMS/2 VTA BCU.

Figure 9.16. BCU05 or BCU-X COOLING UNIT

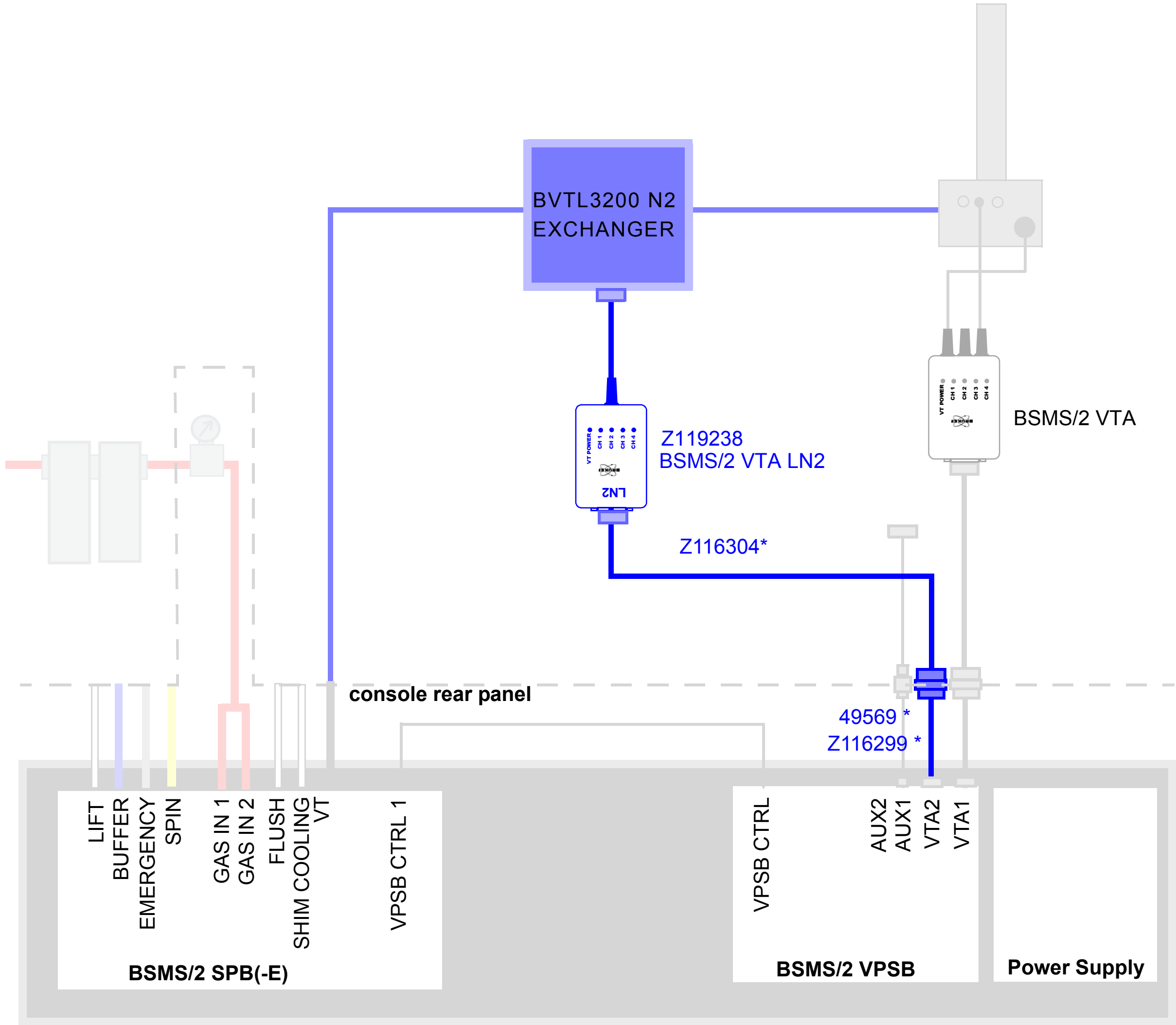


Do not feed the heater power cable from the VTA thru the BSC-X. Connect the heater cable directly to the probe.

BVTL3200 N2 EXCHANGER 9.12.3

BVTL3200 N2 EXCHANGER is adapted to the BSMS/2 BSVT system using a Z119238 BSMS/2 VTA LN2.

Figure 9.17. BVTL3200 N2 EXCHANGER

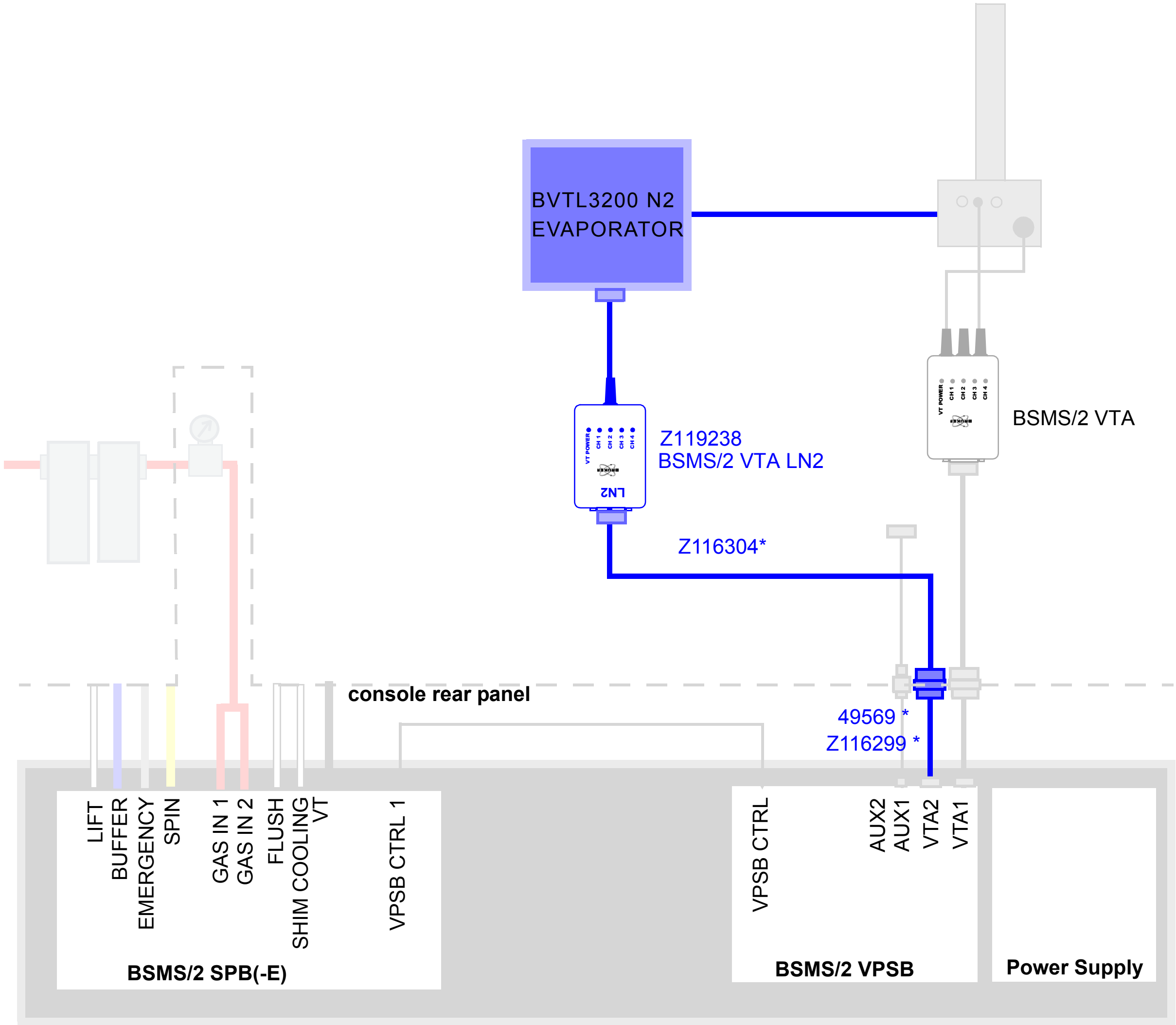


* part of Z119854 CABLE SET BSVT AUXILIARY HEATER

BVTL3200 N2 EVAPORATOR 9.12.4

BVTL3200 N2 EVAPORATOR is adapted to the BSMS/2 BSVT system using a Z119238 BSMS/2 VTA LN2.

Figure 9.18. BVTL3200 N2 EVAPORATOR

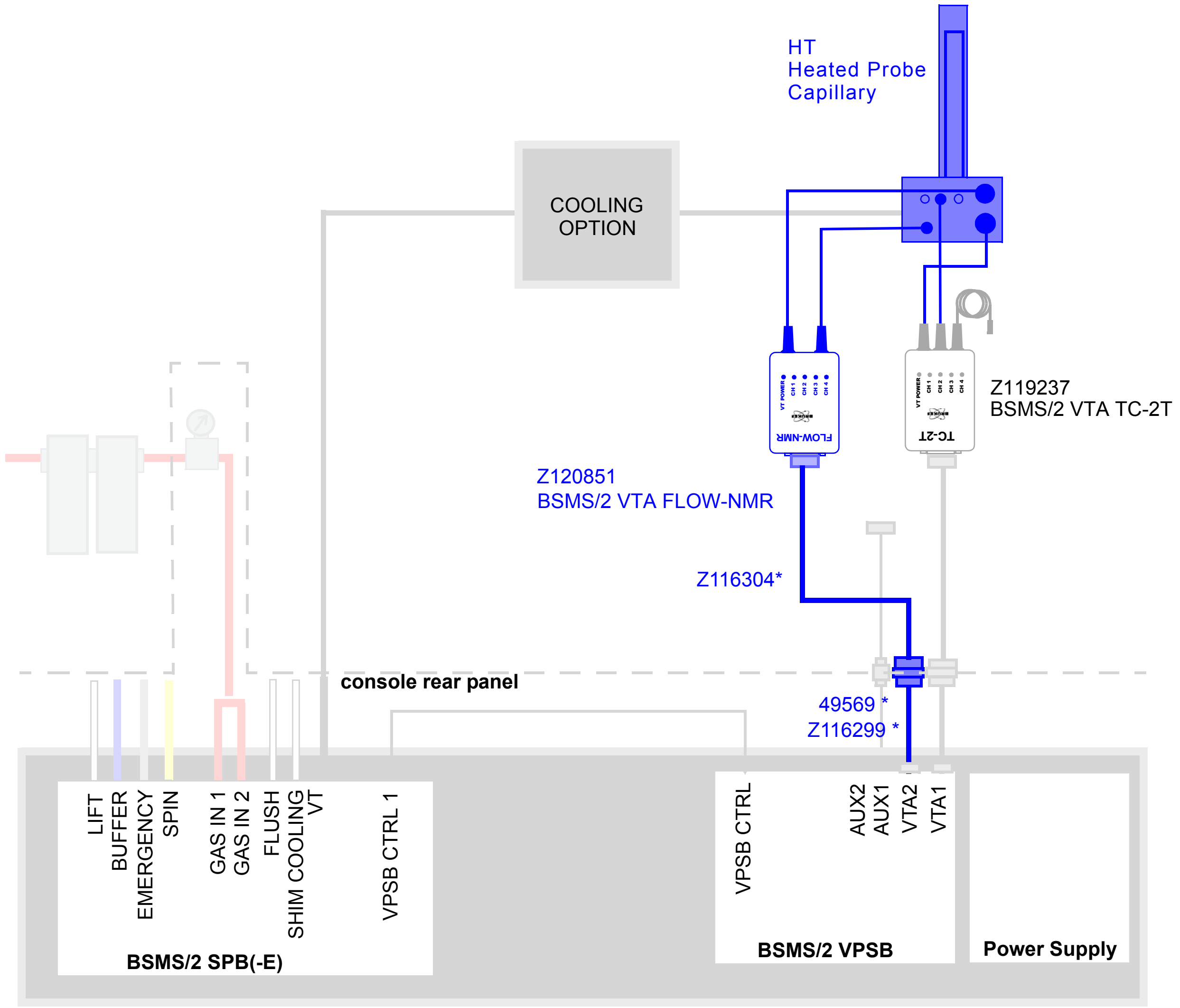


BSVT and FlowProbe adaptation (FLOW-NMR) 9.13

For Flow-NMR there exist several variants. The following configurations shows typical applications.

FlowProbe with HT Heated Probe Capillary

Figure 9.19. FlowProbe with HT Heated Probe Capillary

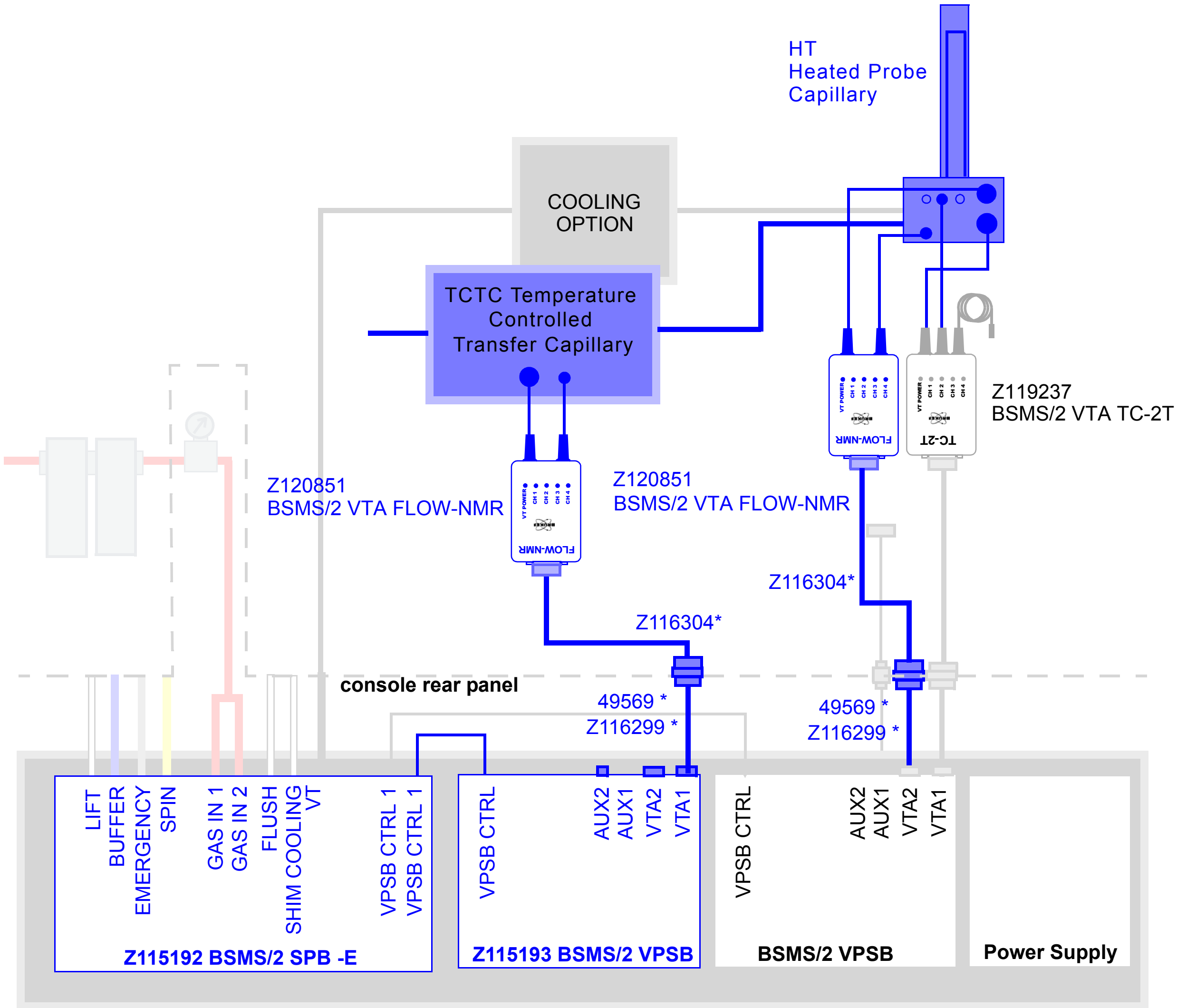


* part of Z119854 CABLE SET BSVT AUXILIARY HEATER

FlowProbes with BTO2000 require a Z116924 BSMS/2 VTA BTO

FlowProbe with TCTC Temperature Controlled Transfer Capillary

Figure 9.20. FlowProbe with TCTC Temperature Controlled Transfer Capillary

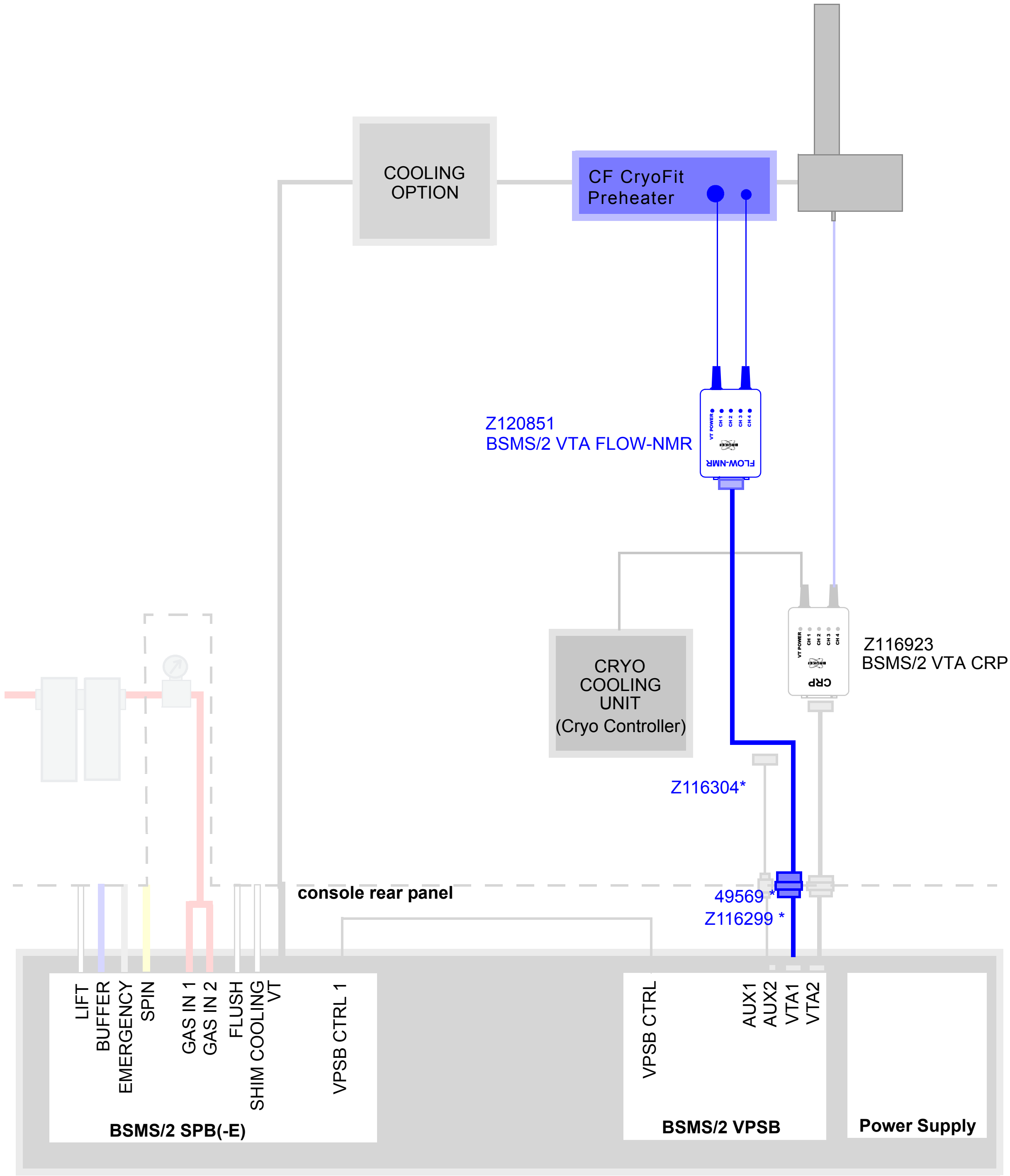


* part of Z119854 CABLE SET BSVT AUXILIARY HEATER

FlowProbes with BTO2000 require a Z116924 BSMS/2 VTA BTO

CryoProbe with CryoFit Preheater

Figure 9.21. CryoProbe with CryoFit Preheater



* part of Z119854 CABLE SET BSVT AUXILIARY HEATER

BSVT Concept 10

Plug and Play concept 10.1

The BSVT variable temperature control system is designed for usage with all existing and new types of BRUKER probes, chillers, pre-heaters (e. g. for flow NMR) and other accessories. Different types and numbers of temperature sensors can be connected to the appropriate VT adapters, which provide the matching cables and connectors. All VT adapters can be connected to the BSVT units in the console, either via a standard accessory cable (communication and VT adapter power supply) or via a standard heater cable (providing in addition the variable power).

After power up of the BSVT system, the VT adapters **connected to the cable** coming from the console are powered up and identified. The collectivity of the **connected adapters** (with corresponding probe, chiller, or accessory device) and the VT gas supplies (VT gas, flush gas, Shim cooling / drying) **are considered as an entity**, which is called BSVT configuration. The various options for BSVT configurations are described in chapter ***"BSVT Introduction & Configurations" on page 171***. It is possible to add or remove VT adapters, a probe or a chiller at any time even during operation.

The system can detect a new adapter only when it is connected or disconnected to or from a cable coming from the console. Connecting or disconnecting accessories to or from the adapter (e.g. N2 evaporator) will not lead to a configuration change.

After a BSVT configuration change, the new devices are recognized automatically and integrated into the system with minimal user interaction.

To enable and display a changed BSVT configuration, the temperature control has to be turned off and on again within the Topspin vtudisp/edte.

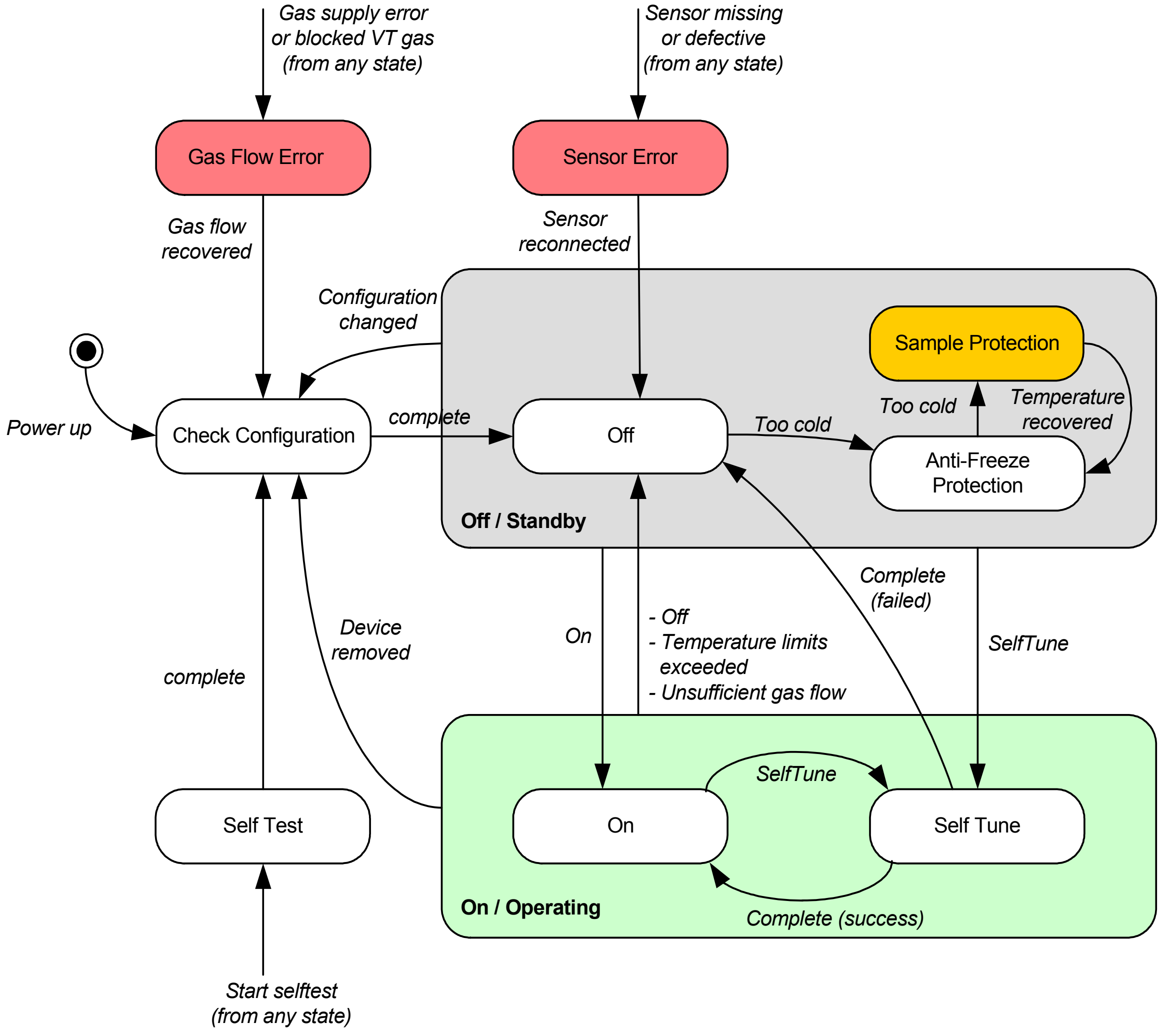
When a device involved in temperature regulation is removed then the temperature control is switched off. Adding further devices has no effect on a running temperature control process.

Control logic of the BSVT 10.2

There is a common control logic for the complete BSVT configuration. Rather than setting the gas flow or switching on or off a specific heater, the BSVT is switched on or off as a whole.

In addition to the base states (on / off) there are additional states for system calibration / tuning (self tune), system identification (self test), exceptional situations (anti freeze protection, sample protection), errors (gas flow error, sensor error), and a check configuration state (when a device has been added or removed).

Figure 10.1. BSVT states



State Off / Standby 10.2.1

This state is active when the BSVT is switched off. In general, the thermal energy of the system is kept as steady as possible (sub state **„off“**):

- Heater(s) = off
- Chiller = off

- Gas flow = standby gas flow (between 0 and maximum)

Nevertheless, it is possible that the system looses energy (e. g. chilling by active CryoProbe), and the temperature drops below the minimum allowed temperature. In this case, a minimum heating is activated, and the control logic goes into the sub state **„anti freeze protection“**:

- Heater(s) = on, regulating for temperature next to room temperature
- Chiller = off
- Gas flow = operating gas flow (between minimum and maximum)

If the measured temperature stays below the minimum temperature even if the antifreeze heating is active then the sample is lifted for protection (sub state **„sample protection“**). As soon as the temperatures are in range again, the sample is transported to its original location.

State On / Operating — *10.2.2*

This state is active when the BSVT is switched on. All devices of the BSVT configuration are active:

- Heater(s) = regulating for required target temperature(s)
- Chiller = according to user settings
- Gas flow = operating gas flow (between minimum and maximum)

The PID controller parameters can be optimized by a **„self tune“** operation. If the global self tune procedure is activated then all active channels are tuned in parallel. As soon as the self tune of a channel is complete, the according channel is starting operational temperature regulation.

Self tuning can be started from both states - off / standby and on / operating. If it fails in the end then the BSVT is switched off unless the self tuning has been started from on / operation and the measured temperatures have been close to the aimed values.

It is possible to add further devices to the BSVT configuration while the temperature control is on / operating. The added devices stay inoperable (no active temperature regulation) and provide only temperature measurement. As soon as the BSVT is switched off, the pending changes are handled, and the BSVT configuration is updated.

However, if devices that are involved in temperature regulation are removed during operation then the BSVT stops its activity.

State Sensor Error — *10.2.3*

If the connection to a sensor involved in temperature regulation gets lost then the BSVT goes into the sensor error state. However, if only one sensor of a double sensor adapter (e. g. TC-2T) is used, then the according channel runs in single sensor mode, and the unconnected sensor is not considered.

State Gas Flow Error 10.2.4

There are two possible types of gas flow errors - either the VT gas flow is blocked somewhere between the SPB and probe (VT gas tube, chiller, etc) or in the probe itself or the gas supply is too weak or out of order. In both cases, the BSVT goes into the gas flow error state. The gas flow status indicates the exact error type (blocked or missing). As soon as the VT gas flow has recovered (e. g. interrupted gas supply has been re-established and the required standby gas flow has been reached), the BSVT control goes back to the off state. There is a maximum gas pressure that can be adjusted in the service web - the VT gas flow regulation guarantees that this maximum pressure is never exceeded even if the VT gas is blocked somewhere.

State Self Test 10.2.5

If there is a problem - e. g. the BSVT refuses to go into operation or some connected devices do not behave as expected - it is recommended to run a self test. The self test can be started on the service web and may last some seconds (it may be useful to check the state until the self test is complete). In the end, there is a short self test report available, providing information about all connected devices and their status (e. g. missing sensor connections, missing gas flow, and so on).

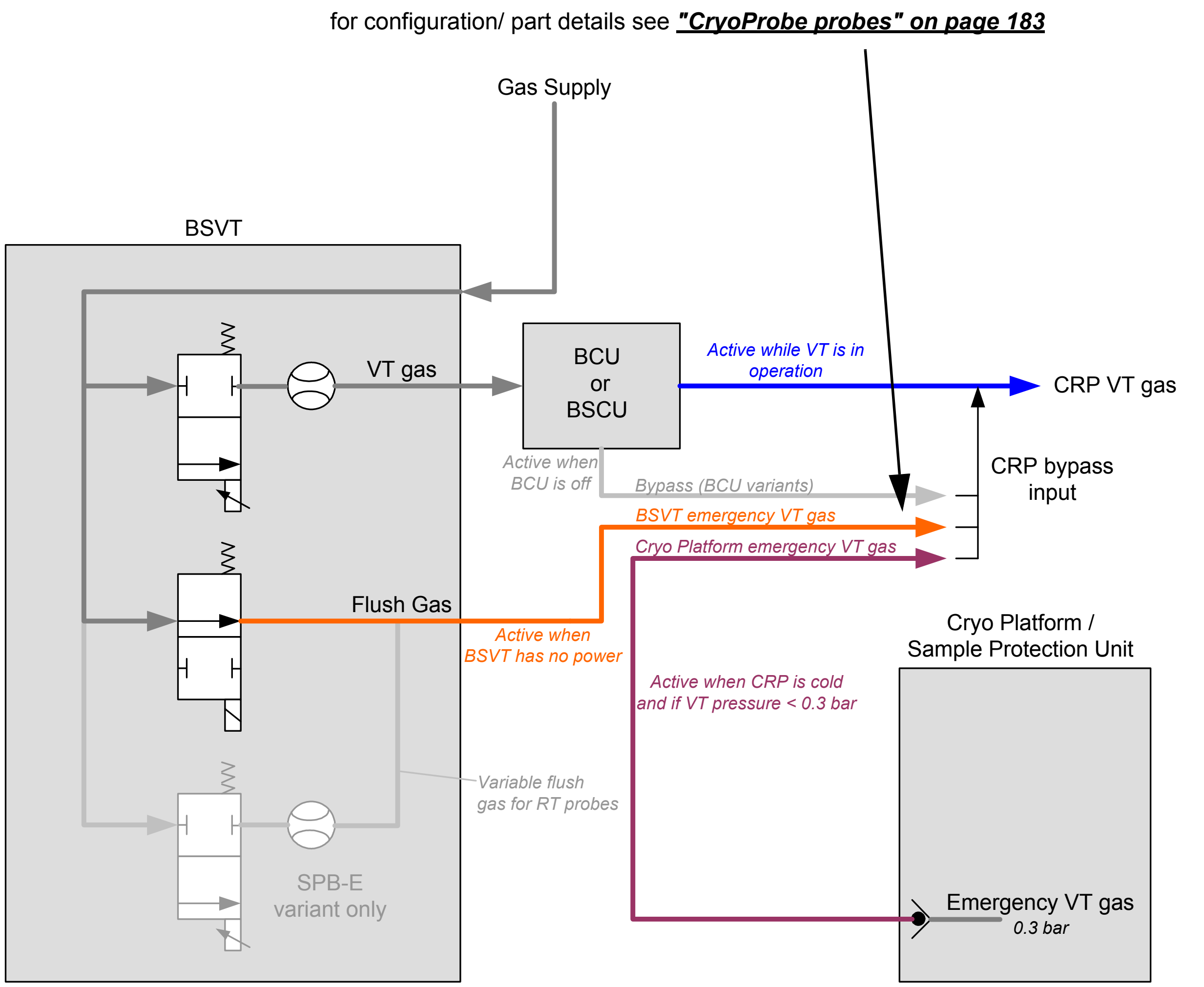
Specific configurations 10.3

In the following subsections there are a few specific configurations described.

BSVT with CryoProbes 10.3.1

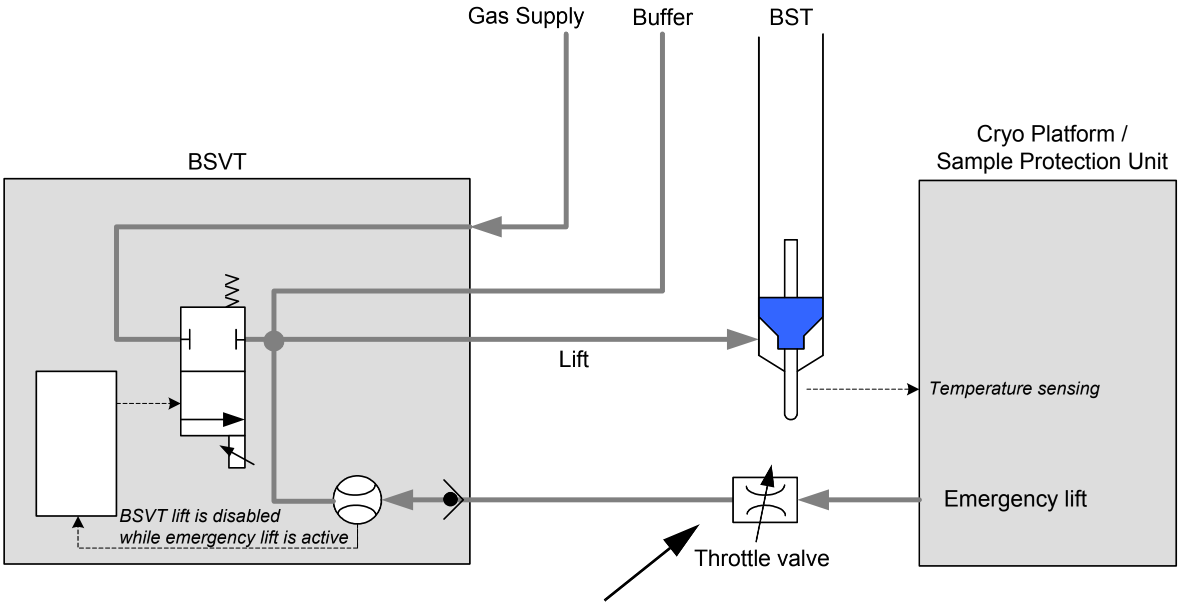
CryoProbes in cold state cool down the sample if there is no active VT operation. In this configuration, the auxiliary gas of the BSVT (which is designed for flushing of the RF section of room temperature probes), is used as a safety gas flow in order to prevent from sample freezing, in case the BSMS/2 BSVT system was powered down.

Figure 10.2. VT emergency gas flow



If a CRP Sample Safety Option is installed then the Cryo Platform initiates a sample ejection in case of insufficient temperature. This operation is detected by the BSVT, and in case of safety lift initiated by the Cryo Platform, the BSVT disables its own lift function.

Figure 10.3. Gas flow diagram for emergency lift

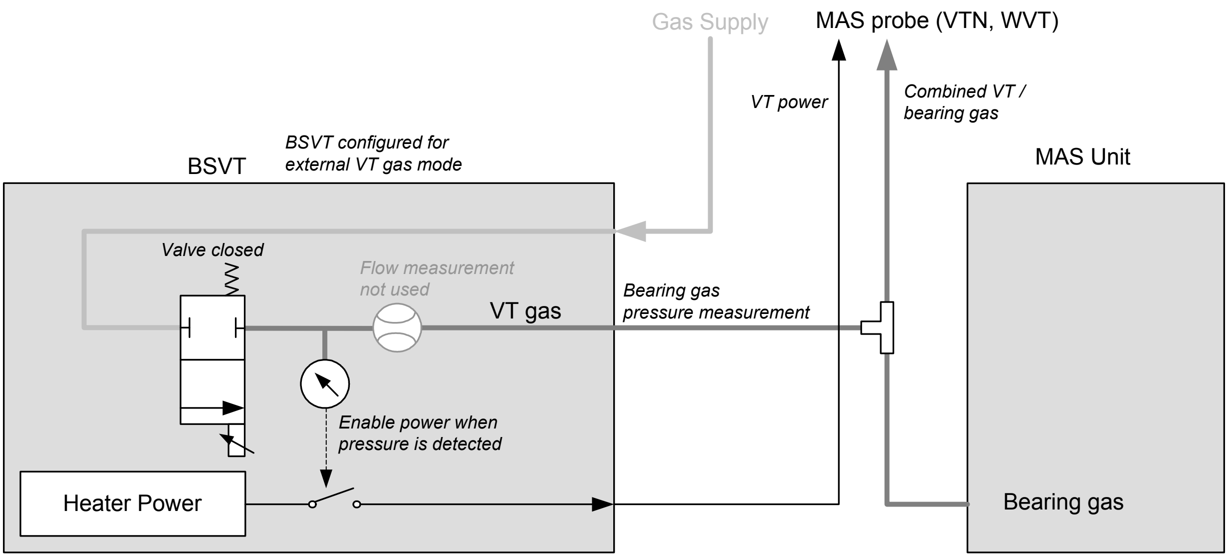


for configuration/ part details see **"CryoProbe probes" on page 183**

MAS probes with tempered bearing gas (VTN / WVT) 10.3.2

Some MAS probes have no specific VT gas channel - instead they use the MAS bearing gas for temperature regulation. In these cases, the BSVT can be configured for „external VT gas supply“, where the probe heating is enabled as long as there is enough pressure on the bearing gas detected. The VT gas valve in the BSVT unit is closed in this operation mode.

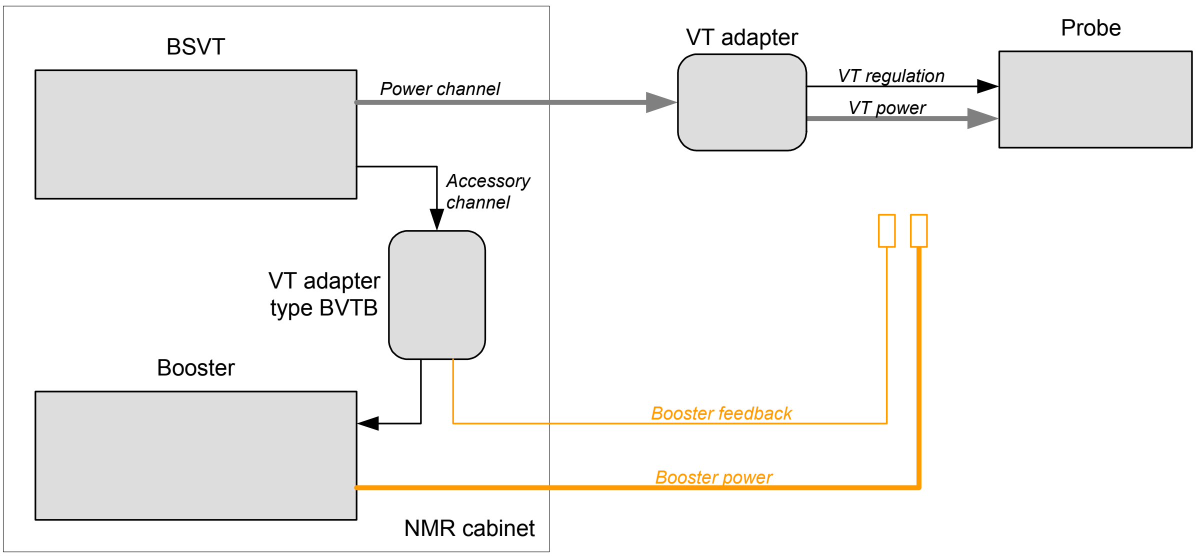
Figure 10.4. External VT gas supply (e. g. MAS bearing gas)



BSVT with booster *10.3.3*

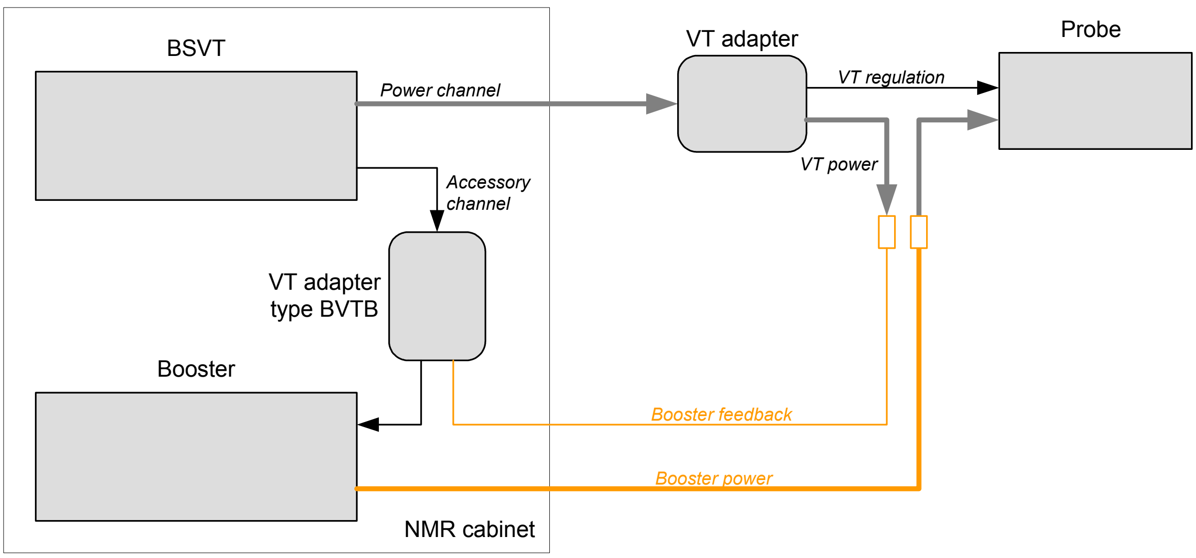
For very high temperature applications it may be necessary to use a booster (BVTB3500 500W booster). This booster is normally installed inside the NMR cabinet and connected via the appropriate VT adapter (VTA BVTB) to an accessory VT channel. If the installed booster is not used then the probe is connected to the VT power channel as indicated in the BSVT configuration chapter.

Figure 10.5. Booster installed, but normal probe operation



By connecting the booster cables accordingly, the user can activate booster operation. The BSVT is configured automatically without any further user intervention.

Figure 10.6. Booster in operation



Frequently asked questions *10.4*

- What is the difference between a **power channel** and an **accessory channel**?
  A power channel provides - in contrast to an accessory channel - a variable power, which can be controlled (VT power). The basic BSVT configuration provides 2 power channels and 2 accessory channels. BSVT configurations can be extended up to 4 power channels and 5 accessory channels.
  Both channel types have the 15 pin D-Sub connecter at the user side, but the accessory channel is connected to the back panel of the NMR cabinet by a smaller RJ45 connecter. The width of the power channel cable is quite higher than that of an accessory channel.
- What happens if a **probe** is connected to an **accessory channel**?
  A probe can be connected via the appropriate VT adapter to any channel. However, if the channel does not provide VT power then the VT temperature of the probe cannot be controlled and stabilized. Nevertheless, the temperature measurements are transferred in regular intervals to the BSVT unit and displayed within the Topspin GUI.
- What could be the reason for **inoperable** devices?
  It can happen that a power device connected to a power channel can not be operated and is marked as inoperable in the Topspin GUI. Either a heater or sensor cable between VT adapter and heating device (e. g. probe) is not connected. Or the device (VT adapter) has been added while the BSVT was in operation. In that case, the BSVT stays in operation mode (as long as there is no device removed that was involved in temperature regulation) - the new devices are integrated into the BSVT temperature control as soon as the temperature regulation is switched off next time.
- When the **target strength** (= cooling power) of the **cooling unit** is set, nothing happens, and the actual strength remains unchanged - why could this happen?
  BSVT operation is required for activation of a connected cooling unit. As soon as the BSVT is „on“, the actual cooling strength changes to the required value defined by the target strength parameter. In addition, the rotary knob of the new BSCU cooling units must be set to „**remote**“ position. Otherwise, the settings of the Topspin software are ignored and the locally set strength (by rotary knob position) is considered for operation.
  Note: The BCU-X requires a minimum VT gas pressure and gas flow before it becomes active. If there is no gas flow (or no gas supply) then a connected BCU-X cannot be detected by the VT adapter.
- Which channel is the **probe channel**?
  Probe channel identification is set to „auto“ by default (This setting can be defined on the BSMS service Web under the menu „VT configuration“).
  Normally, there is a single heater device in the BSVT configuration, and the mapping is therefore evident. Configurations for flow NMR applications can be handled automatically as well - additional heaters are connected via specific VT adapters, and the remaining active channel can therefore be considered as the probe channel. In applications with several VT adapters of the same type (e. g. specific MAS configurations with separate heaters for VT, bearing and rotation) it may be necessary to give an explicit definition of the probe channel.
- How is the **VT power** represented in the new BSVT?
  Inside the BSVT the VT power is represented in Watt (absolute power). However, the user can select alternatively a relative representation for the GUI (percent). In that case the reference power is the highest possible power that

can be achieved with the connected probe and the maximum voltage (48 Volt) of the VT power supply. Example:
- Cryo Probe heater with 48 Ohms: Imax = 1 A, Pmax = 48 Watt (= 100%)

- Has the **maximum VT power** setting an influence on the **Self Tune**?
  The Self Tune is no longer affected by the maximum VT power (as long as it is high enough), since the required power for Self Tune is evaluated in the beginning of the tuning automatically. If the power limit is set too low then the Self Tune aborts with a corresponding error message (similar case if the chilling is not sufficient to reach the target temperature). The temperature control process is not stopped in case of too restrictive power limitation (or insufficient chilling) - it is simply indicated in the regulator status that the heater power limitation is too strict or that the chilling is not sufficient.

- Do I still need the **cable Z13874** with **VT power attenuator** (with heat spreader) for **CryoProbes**?
  For operation of the former Variable Temperature control systems (e. g. BVT3000, BVT3200) with CryoProbes, it was necessary to insert a power attenuator between the BVT and the heater of the probe. The user could select between „low“ = 10%, „high“ = 50% and „ET“ = 100% resulting VT power at the probe. With the new BSVT, **this attenuator is no longer used**, since the VT power is provided by the BSVT in high resolution down to smallest values and therefore also appropriate for direct operation with CryoProbes. Problems with overheated attenuators or full power values varying with the selected power range at the attenuator are eliminated with the BSVT.

- When I power on the BSMS/2 chassis, all **LEDs on the VPSB board are off**. Is the board defect?
  The VPSB has no connection to the BSMS/2 backplane. It is powered from the mains and controlled completely via the cable from the SPB board (port is labeled VPSB CTRL). The power stages on the VPSB itself and the front panel LEDs are switched on, as soon as the ELCB has enabled the signals on this control port. This may take some time. If the LEDs were still remain OFF check the cable connection, correct working SPB (ERROR LED off on SPB) and verify that the latest ELCB firmware is loaded.

SPB 11

Introduction 11.1

The SPB (Sensor & Pneumatic Board) is the enhanced and higher integrated replacement of the former SLCB[1] (Sample & Level Control Board) and the PNK board family (PNK3, PNK3S, PNK5).

There are two versions of the SPB available: The basic version is used for Standard Bore systems whereas the extended version supports wide bore NMR magnets and additional features like the liquid nitrogen level sensor interface or control outputs for more than one VPSB.

Low level hardware functions (e.g. sample sensor interfaces, safety circuits) are implemented directly on the SPB, whereas higher level functions such as helium level calibration and measurement, sample transport control (lift), sample rotation regulation (spin) or pneumatic valve control for VT gases are provided by the software running on the ELCB.

The SPB pneumatics now include the gas flows for the variable temperature system (VT). Integrated mass flow and pressure sensors provide accurate gas flow setting.

The new electronics are fully compatible to the well known sensors for helium or nitrogen measurements or the sample detection electronics.

The SPB has additional interfaces for connecting up to 2 Variable Power Supply Boards (used by the VT system to control the probe temperature) and novel digital accessory sensors.

Configurations 11.2

Basically there are two variants - one for standard bore systems and another one for wide bore systems or systems with optional accessory (temperature or nitrogen level sensors).

1. SLCB/2 or SLCB/3 with interface for liquid nitrogen level sensor (analog mode only)

Table 11.1. SPB variants

Bruker Part Number	Name	Purpose
Z115191	BSMS/2 SPB SENSOR & PNEUMATIC BD	- Standard bore systems - CryoProbe systems - fixed gas flow for probe flushing - fixed gas flow for shim cooling
Z115192	BSMS/2 SPB-E SENSOR & PNEUMATIC BD	- Wide bore systems - *regulated* gas flow for probe flushing - *regulated* gas flow for shim cooling - support for all nitrogen level sensors (e.g.for systems with BSNL option installed before 2011)

Digital Nitrogen Level Sensors introduced in 2011 do not require a SPB-E anymore. The digital sensors are connected typically to AUX ports on the VPSB. However, the SPB-E support both analog and digital nitrogen level sensors. For details see ***"Nitrogen Level Sensor" on page 261***.

The boards differ in the number of interfaces and additional software regulated gas flows:

Table 11.2. Overview SPB vs. SPB-E

	SPB	SPB-E	Unit
Gas Flow VT	0..2000	0..3000	l/h
Gas Flow Probe Flush	300 (fixed)	0..600	l/h
Gas Flow Shim Cooling	1800 (fixed)	0..3000	l/h
Gas Flow Spin SB	0..720	0..720	l/h
Gas Flow Spin WB	n/a	0..1440	l/h
Gas Flow Sample Lift	0..6000	0..9000	l/h
Helium level sensor (HELIUM LEVEL)	included		
BST sensor interface (SAMPLE CONTROL)	included[a]		
BACS interface (SAMPLE CHANGER)	included	included	
Analog and digital liquid nitrogen level sensor interface (NITROGEN LEVEL)	n/a	included	
Maximum active temperature control channels (VPSB CTRL) [b]	2	4	
Auxiliary digital sensor interface (AUX)	n/a	1	

a. Old style shim upper parts (SOT72) using Z12084 CABLE ADAPT BSMS/SOT72 can be connected to a SPB(-E) ECL02.03 and newer. Because these shim upper parts do not include a sample up light barrier, reduced functionality (sample lift speed, display) will result.

b. Variant SPB has 1 VPSB CTRL interface to control 1 Z115193 VPSB (dual heater power supply), variant SPB-E has 2 VPSB CTRL interface to control 2 Z115193 VPSB for total 4 heater channels

He level measurement

Parameter		Details	Min	Typ	Max	Unit
Helium measurement system	range[a]		**0**		**100**	%
	resolution[b]			1		%
	accuracy[c]		**-4**		+4	%
Helium measurement source voltage	range		29.0		31.0	V
Helium measurement current	range		40		150	mA
	resolution			1		mA
	accuracy		**-2**		**+2**	%
	default			110		mA

He level measurement

Parameter		Details	Min	Typ	Max	Unit
	de-ice current			200		mA
	auto switch-off time				**30**	s
Helium measurement input voltage	differential input voltage		**0**		**+30**	VDC
	measurement accuracy		**-2**		**+2**	%FS

a. valid for calibrated system only

b. valid for calibrated system only

c. for a He-level in the range of 20%...100%

***Analog* N2 level measurement interface (SPB-E version only)**

Parameter		Details	Min	Typ	Max	Unit
N2 measurement system	range		**0**		**100**	%
	resolution		**-1**		**+1**	%
	accuracy		**-3**		+3	%
N2 voltage measurement	maximum input range[a]		0		-8.0	V_{DC}
	resolution			10		mV
	accuracy		**-2**		**+2**	%FS
Sensor supply	output voltage positive		9.75	10	10.25	V
	output voltage negative		- 9.75	- 10.0	- 10.25	V
	supply current				50	mA

a. sensor has to be calibrated for 0V .. -5V (=> 100% .. 0%)

BST signal interface

Parameter		Details	Min	Typ	Max	Unit
Sample Rotation signal analog[a]	range		**0**		**5**	V
SAMPLE_UPS signal digital	high level input voltage		**2.6**		5	V
	low level input voltage		**0**		**2.4**	V
Light barrier supply	output voltage		**4.75**		5.25	V
	sink resistance[b]		**95**		**105**	Ohm

a. when using signal for sample down detection, calibration is necessary

b. allows to connect LED directly without additional series resistor

Sample lift

Parameter		Details	Min	Typ	Max	Unit
Input pressure	range		4		6	bar
	stability	@0..150l/min	**-0.5**		**0.5**	bar
Gas flow	standard bore		**100**			l/min
	wide bore		**150**			l/min

Sample Rotation

Parameter		Details	Min	Typ	Max	Unit
Input pressure	range		4		6	bar
	stability		**-0.5**		**0.5**	bar
Max. air flow @ 5bar supply	standard bore			**15**		l/min
	wide bore			**25**		l/min
Rotation rate	range set point		**7**		**50**	Hz
	range measurement		**0**		**100**	Hz
	setting resolution		**1**			Hz

Sample changer interface

Parameter		Details	Min	Typ	Max	Unit
Power source (S_5VP, input)	input voltage		4.5	5	5.5	V
	supply current		50			mA
SIGSH, SIGSH~	source				**4**	mA
(output current)	sink		**-4**			mA

Auxiliary gas specifications (SPB version)

Parameter (@ input pressure 5bar)		Details	Min	Typ	Max	Unit
Flush gas flow	range [a]	ECL02 ECL01 ECL01	**270**	300	**330**	l/h
		ECL03	**500**	600	**700**	l/h
	accuracy		**-10**		**10**	%FS
	gas outlet			6		mm
Shim gas flow	range[b]		**1600**	1800	**2000**	l/h
	accuracy		**-10**		**10**	%
	gas outlet			8		mm

Auxiliary gas specifications (SPB version)

Parameter (@ input pressure 5bar)		Details	Min	Typ	Max	Unit
Gas supply	N2 or dry air		**4**		**6**	bar
Gas inlet				8		mm

a. factory setting

b. factory setting

Auxiliary gas specifications (SPB-E version)

Parameter (@ input pressure 5bar)		Details	Min	Typ	Max	Unit
Flush gas flow	range [a]		**0**	300	**600**	l/h
	accuracy		**-10**		**10**	%FS
	gas outlet			6		mm
Shim cooling gas flow	range[b]		**0**	1800	**3600**	l/h
	accuracy		**-10**		**10**	%FS
	gas outlet			6		mm
Gas supply	N2 or dry air		**4**		**6**	bar
Gas inlet				8		mm

a. adjustable by software

b. adjustable by software

VT gas specifications

Parameter		Details	Min	Typ	Max	Unit
Probe gas flow	range set point (standard variant)	SPB	**0**		**33**	l/min
	range set point	SPB-E	**0**		**50**	l/min
	resolution set point			1		l/min
	accuracy		**-5**		**5**	%FS
	temperature stability	[a]		0.5	**1**	%/°C
Gas supply	N2 or dry air		**4**		**6**	bar
Gas inlet				8		mm

a. flow is regulated, specification valid for constant gas supply pressure

Environment

Parameter		Details	Min	Typ	Max	Unit
Operating temperature (ambient)[a]			15	25	35	°C
Relative humidity	non-condensing		**10**		**95**	%
Storage condition	non-condensing		**5**		**50**	°C

a. where specifications are met

Figure 11.1. Block diagram of the SPB

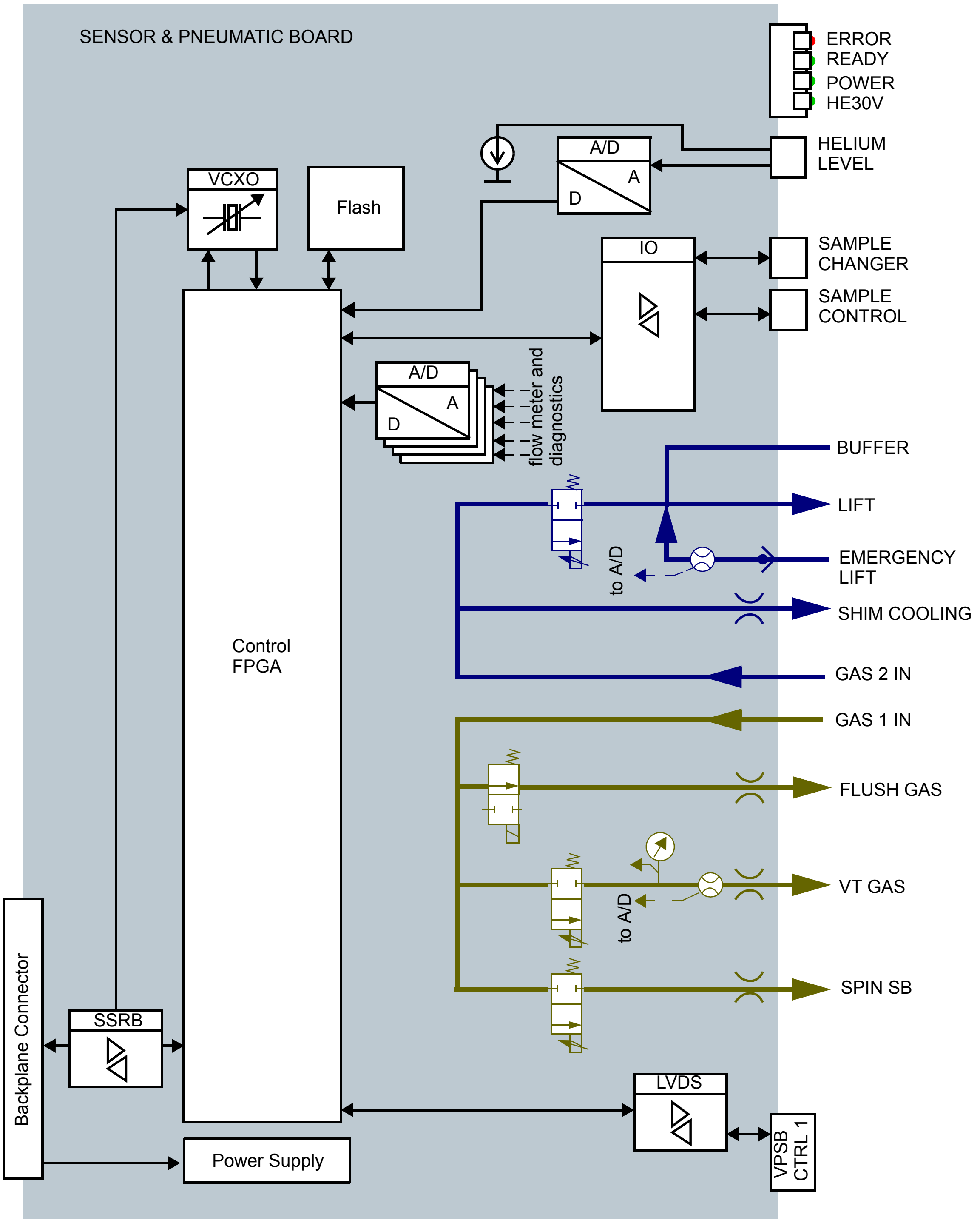
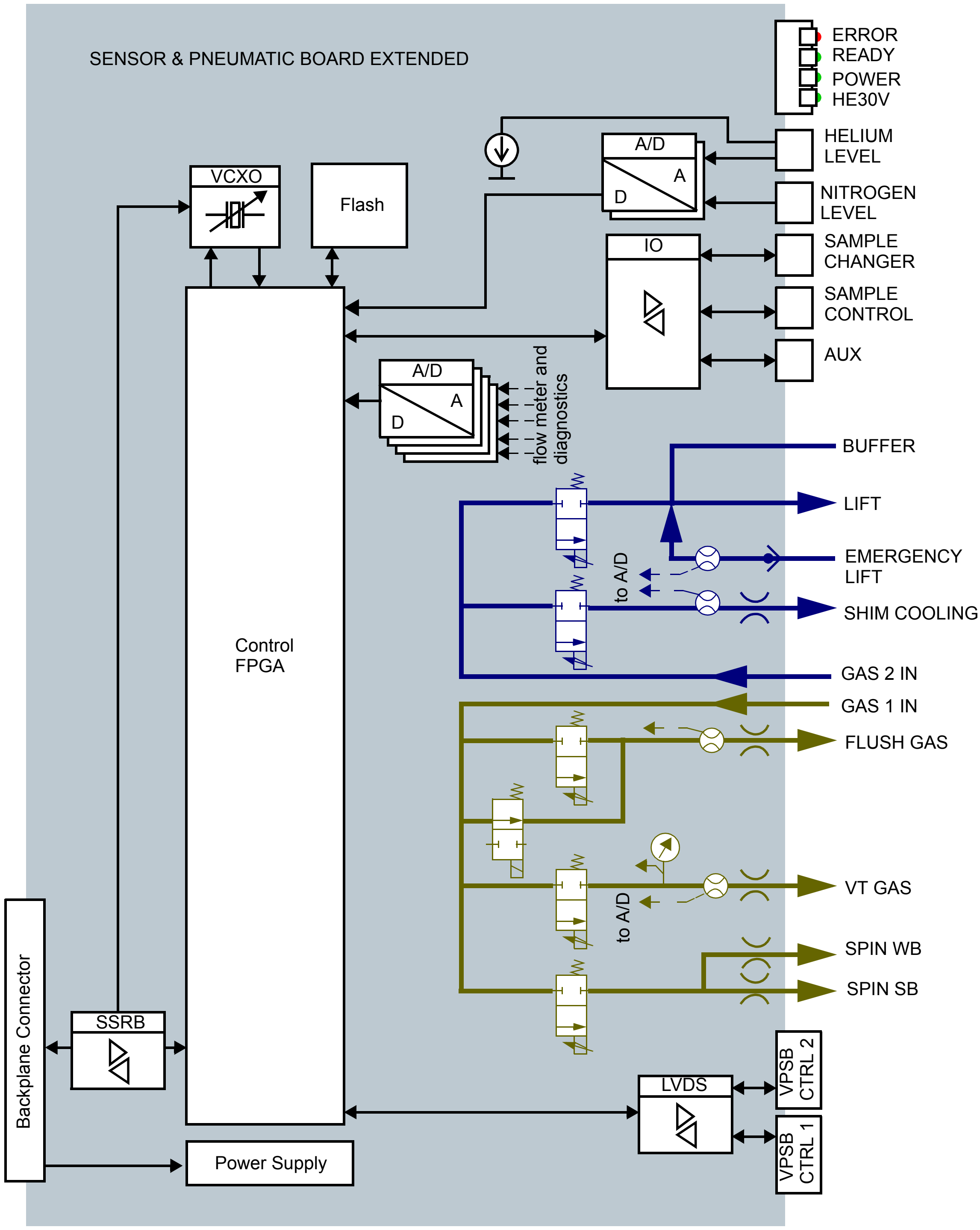


Figure 11.2. Block diagram of the SPB-E



The SPB(-E) is controlled by the ELCB, which is the BSMS/2 controller / coordinator. The ELCB and the SPB(-E) are connected via the BSMS/2 backplane SSRB (Synchronous Serial Rack Bus).

In normal configuration the SPB(-E) uses a common 10MHz clock that is distributed by the ELCB (this clock is typically generated by the AQS reference board) for oscillator synchronisation. If not available the system is running with the on-board crystal frequency.

When the SPB(-E) is starting up, the FPGA first tries to load the design (field bit stream) from the flash memory. If not available it loads a fully functional backup bit stream called factory bit stream whose primary purpose is to get the system up to a point where a valid bit stream can be loaded to the flash memory.

During startup the ELCB checks the SPB(-E) bit stream version.

Protection 11.4.1

All external interfaces are protected against short circuits (limiting the output current or with current measurement and power switches).

Measurements provided for diagnostics 11.4.2

The on-board diagnostics supervises essential board functions like power supply and clock synchronisation. A watchdog mechanism checks for valid connection to the ELCB. In case of a failure the board will reset and put electronics and valves into a safe state.

The software running on the ELCB may notify the user about abnormal events.

Status / Errors

The SPB(-E) can perform the following checks:

- Power supply voltages
- Short circuits / disconnected lines at sensor interface connectors and connection to VPSB (variable power supply board)
- Helium level measurement current source status (operational, correct current, broken sensor)
- Valve block temperature
- Emergency lift air status (used in CryoProbe systems)

Gas flow and pressure measurements

The gas flow channels for VT and probe flush gas are equipped with flow sensors. These are used for gas flow regulation and for diagnostic purposes. A pressure sensor checks VT gas pressure.

Temperature measurement

There is a PT1000 resistor built into the valve block providing temperature measurement.

Sample down detection circuit

The sample down signal is continuously measured using a fast sampling A/D converter. This feature provides superior adoption of the reflection sensor to different NMR spinners.

Calibration *11.4.3*

There are no calibration settings to store on the SPB. The ELCB has full control over the SPB hardware and provides methods for setting up the sample lift, helium level measurements and nitrogen level measurement (SPB-E only). Spin calibration known from former systems is no longer necessary.

Sample lift calibration

Depending on the cryostat bore size and height and the NMR spinner type a different amount of gas is necessary for lifting the sample. The setup of the lift parameters is described on the according service web page in detail.

Helium level sensor calibration

Sensor characteristic depends on cryostat size and sensor model. Setup up of the sensor is described on the according service web page in detail.

Nitrogen level sensor calibration

The digital ***"Nitrogen Level Sensor"*** is factory calibrated. Former analog sensors had to be calibrated itself by adjusting trimmers. For detailed information consult the Magnet System Service Manual SB/WB/SWB ZTKS0177 / Z31977.

Front Panel - Connectors and LED's *11.4.4*

Figure 11.3. Front view of a SPB

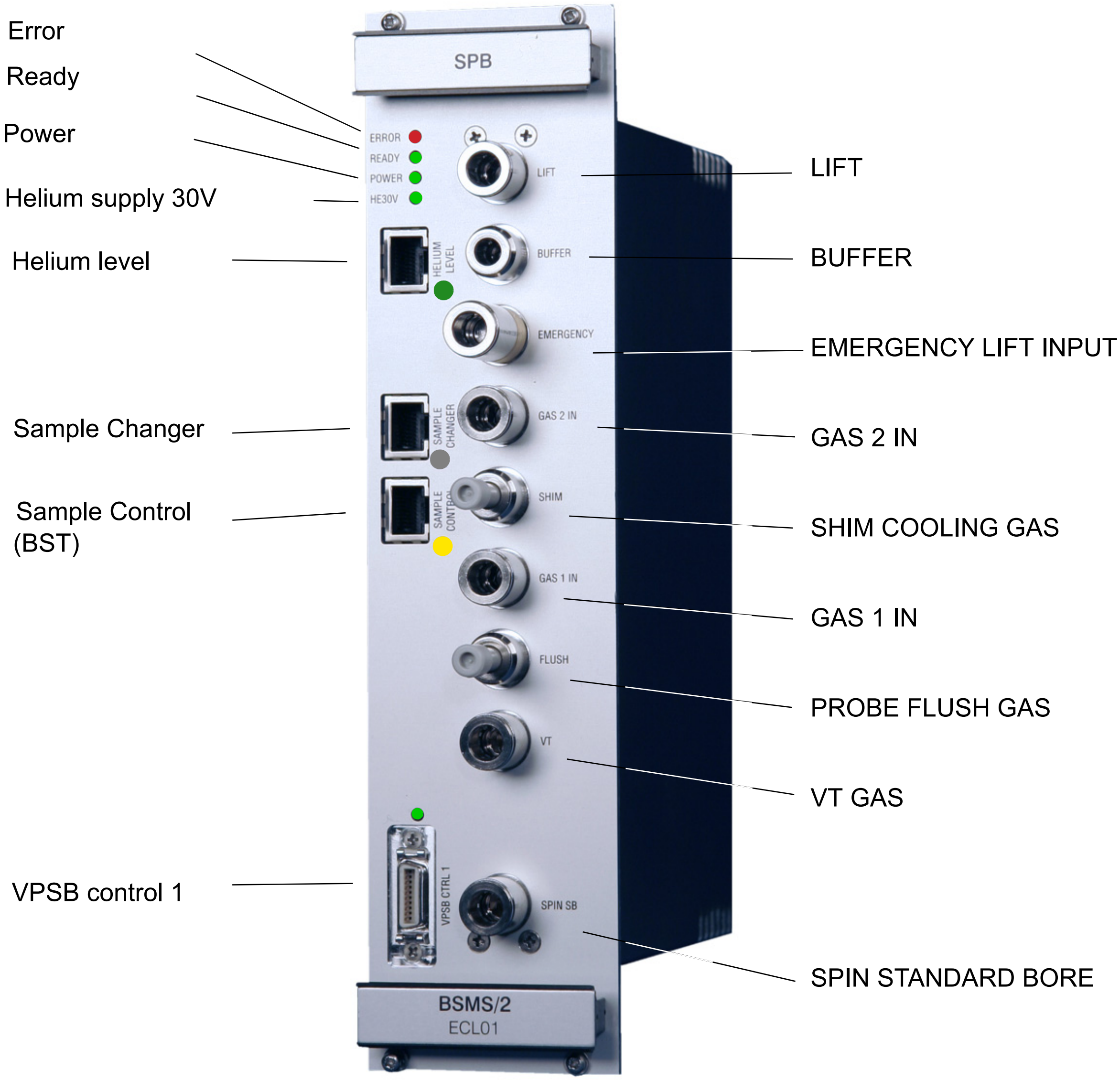
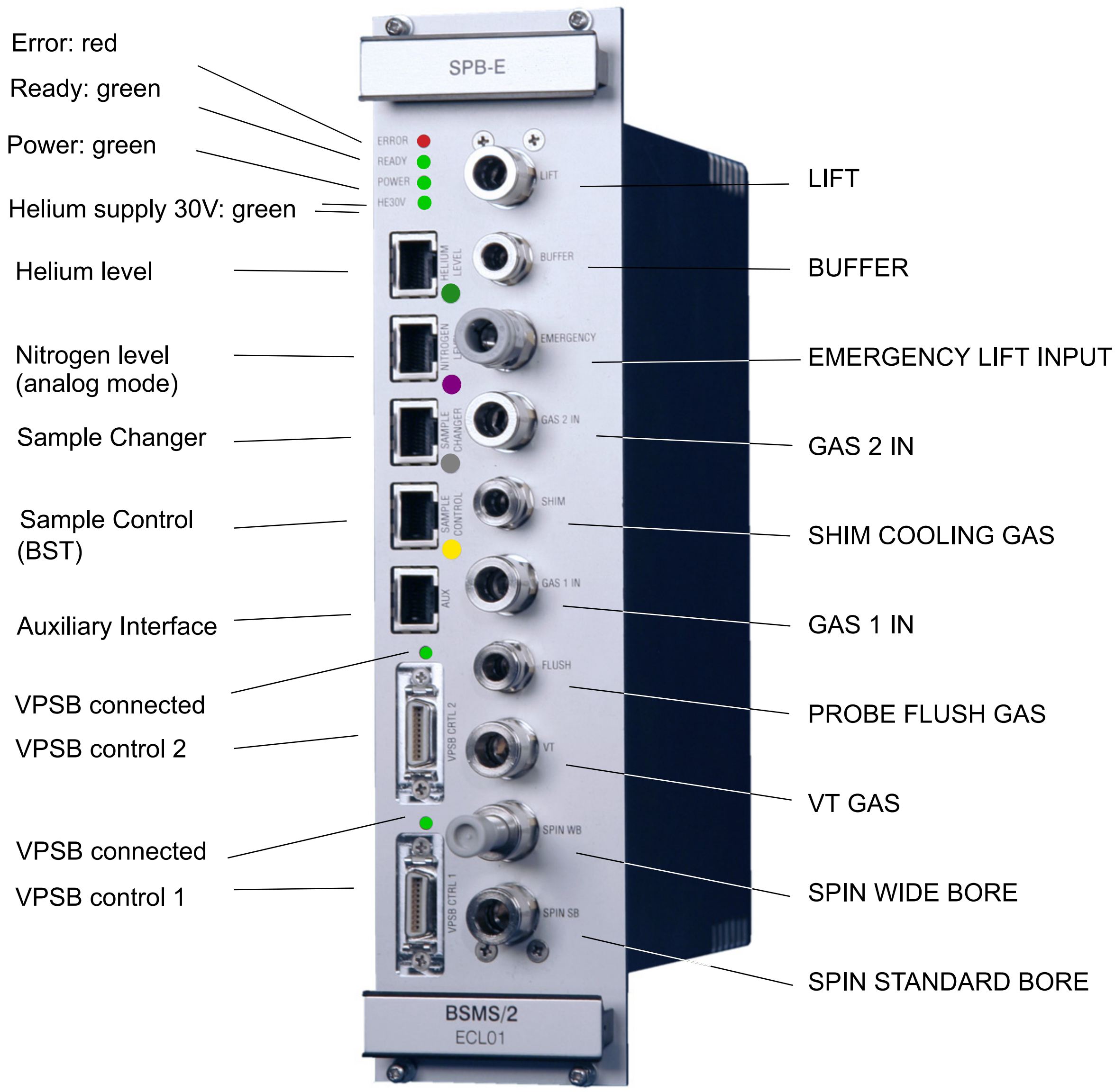


Figure 11.4. Front view of a SPB-E



Error LED

This LED is active after Power ON. It turns off as soon as the SPB is initialized (e. g. FPGA design loaded from Flash Memory) and the communication with the ELCB is established.

Later on, an active Error LED indicates that an error occurred (e. g. short circuit, watchdog event,...) and that in consequence all valves and connected sensors are switched off.

Ready LED

This LED is active as soon as the FPGA design is loaded and valve and sensor interfaces are active.

Power LED

Indication that the SPB is correctly powered.

HE30V LED

Indication that the galvanically isolated power supply for the helium level measurement is available.

VPSB connected LED

Whenever a VPSB is connected and initialized correctly, the LED above the connectors labeled VPSB CTRL will be switched on. This can used for diagnostic purpose.

Connectors

Table 11.3. Connectors

Label	Description	Note
HELIUM LEVEL	Connector for helium level sensor	
NITROGEN LEVEL	Connector for analog nitrogen level sensor	SPB-E only
SAMPLE CHANGER	External sample lift control, currently used by the BACS sample changer.	
SAMPLE CONTROL	Signals from BST (upper light barrier, sample down sensor and tube version)	
AUX	Auxiliary bus connector for BSMS/2 VT adapters, digital nitrogen level sensor or future use of other accessories	SPB-E only
VPSB CTRL 2	Control signals for BSMS/2 Variable Power Supply Board (VPSB) Digital signalling is with LVDS at 10MBit/s	SPB-E only
VPSB CTRL 1	Control signals for BSMS/2 Variable Power Supply Board (VPSB) Digital signalling is with LVDS at 10MBit/s	

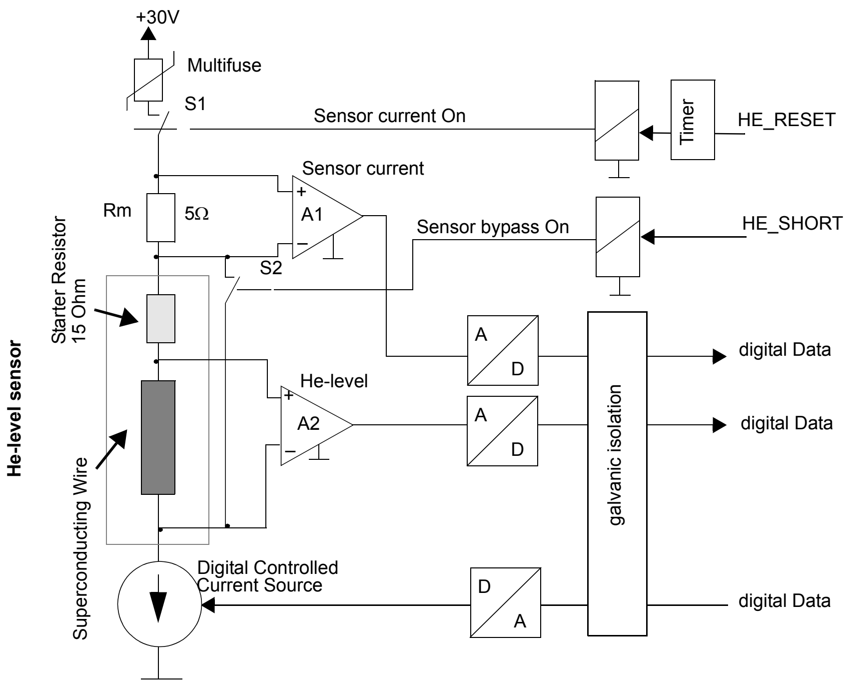
Connectors are protected against short-circuiting. Nevertheless, ensure correct wiring.

Function description 11.5

Liquid helium level measurement 11.5.1

For monitoring the He-level, a He-level sensor is inserted into the top of the helium dewar. This He-level sensor is a superconducting sensor through which electrical current is caused to flow. When warm, the sensor has a resistance of about 100 Ohms. The voltage resulting from the saturation resistance gives an indication of the actual He-level in the dewar.

Figure 11.5. Helium level measurement principle



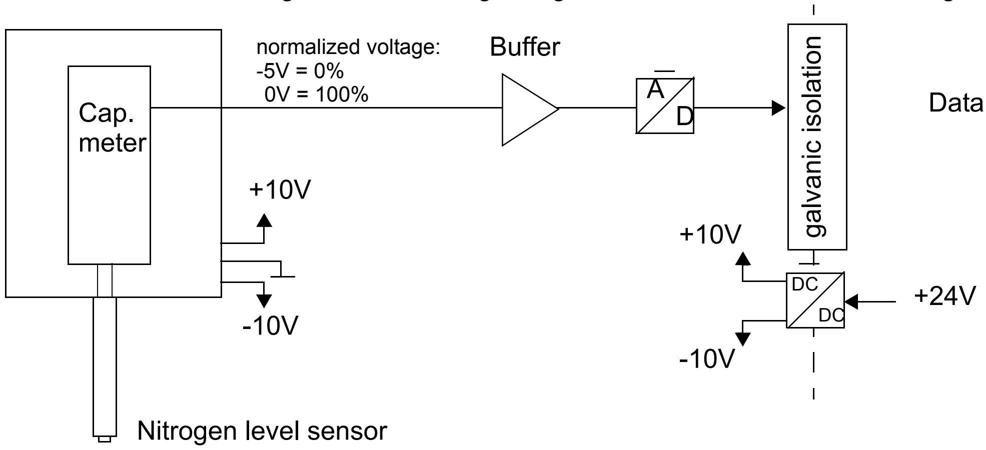
The He-level sensor is galvanically isolated from the BSMS/2 electronics. Measured signals are amplified and sampled. All control and data lines are galvanically isolated. The He-level sensor current is produced by a digital controlled current source. The applied current is measured via a shunt resistor and the differential amplifier A1 as a function test. The voltage across the sensor is measured by the differential amplifier.

To avoid damaging the magnet or evaporating too much helium through warming, the length of time the current is applied is limited. The supply of power is restricted to a maximum period of 30 seconds by the switch S1. As a further safety measure, the S2 switch short-circuits the He-level sensor in between measurements to provide a current bypass.

Analog liquid nitrogen level measurement (SPB-E only) *11.5.2*

Nitrogen level measurements are performed by a sensor that is encircled by a cylindrical conductor. The sensor and surrounding conductor form a capacitor. The presence of liquid nitrogen between the sensor and conductor changes the capacitance, and this is measured and converted by the sensor electronics into a proportional voltage which is interpreted by the SPB-E to provide the reading.

Figure 11.6. Analog nitrogen level measurement block diagram



The measurement circuit on the SPB-E board is separated galvanically from the other electronics.

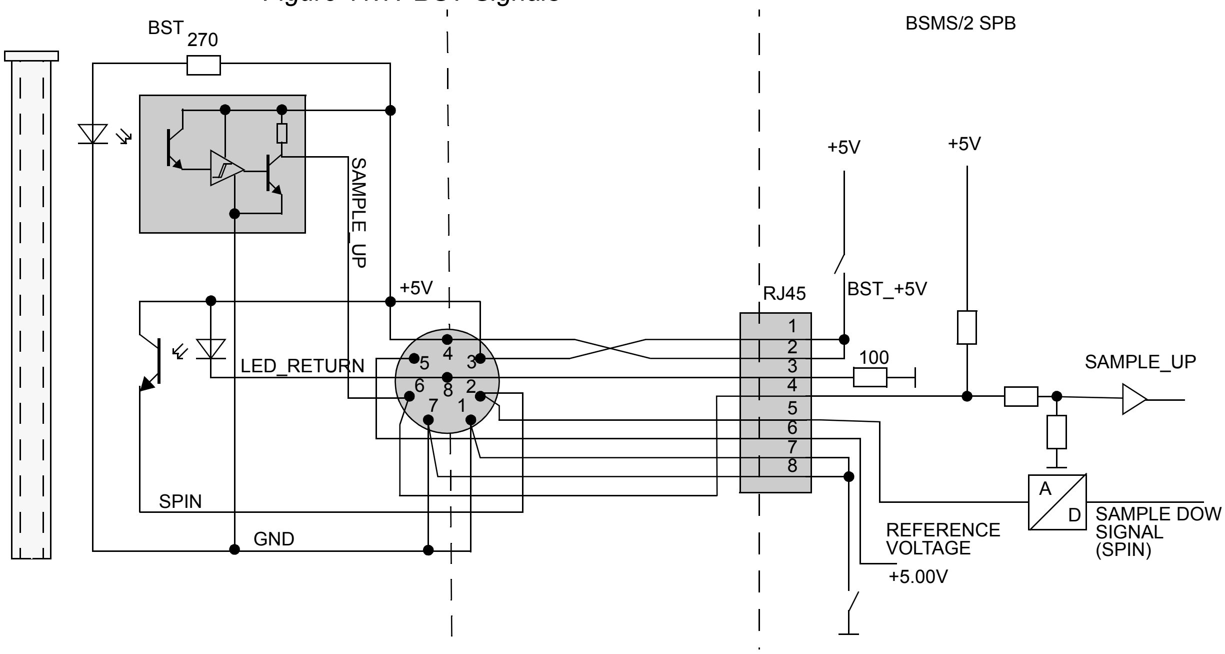
The interface of the SPB-E is fully compatible with all models of Bruker ***"Nitrogen Level Sensor"***.

It is recommended to use the digital nitrogen level sensor and connect it to the AUX port of the SPB-E or the BSMS/2 VPSB. For details see ***"Nitrogen Level Sensor" on page 261***.

Sample down and sample up detection *11.5.3*

The interface for standard Bruker Shim Upper part (BST) is backward compatible to the former SLCB circuit. An improved signal processing for the sample down detection allows reliable detection of the various spinners. Sensor supplies are short circuit proof and wiring detection allows improved system diagnostic.

Figure 11.7. BST Signals



Version of the shim upper part 11.5.4

The shim upper part version can be read by the SPB.

Old style shim upper parts (SOT72) using Z12084 CABLE ADAPT BSMS/SOT72 can be connected to a SPB(-E) ECL02.03 and newer. Because these shim upper parts do not include a sample up light barrier, reduced functionality (sample lift speed, display) will result.

Sample Changer Interface 11.5.5

The sample changer has its own pneumatic controller. The shim upper part (BST) is equipped with a light switch to detect whether there is a sample present for pickup. This information is then passed to the sample changer via the sample changer interface of the BSMS.

Table 11.4. Pin assignment Sample Changer RJ45

Pin	Signal (Connector)	Function	Specification
1	SampleUp	positive active (CMOS-high) when sample is up	CMOS, IOut max. +/-4mA
2	SampleUp	negative active (CMOS-low), when sample is up	CMOS, IOut max. +/-4mA

Table 11.4. Pin assignment Sample Changer RJ45

Pin	Signal (Connector)	Function	Specification
3			
4			
5			
6			
7	S_5VP	+5V from sample changer	+/- 5%, IL max. 30mA
8	S_GND	ground potential from sample changer	

reserved / do not connect

Remarks:

- all signals from SPB are galvanically isolated
- SampleUp / SampleUp represent the state of the upper light barrier directly
- outputs are complementary, broken lines can be detected

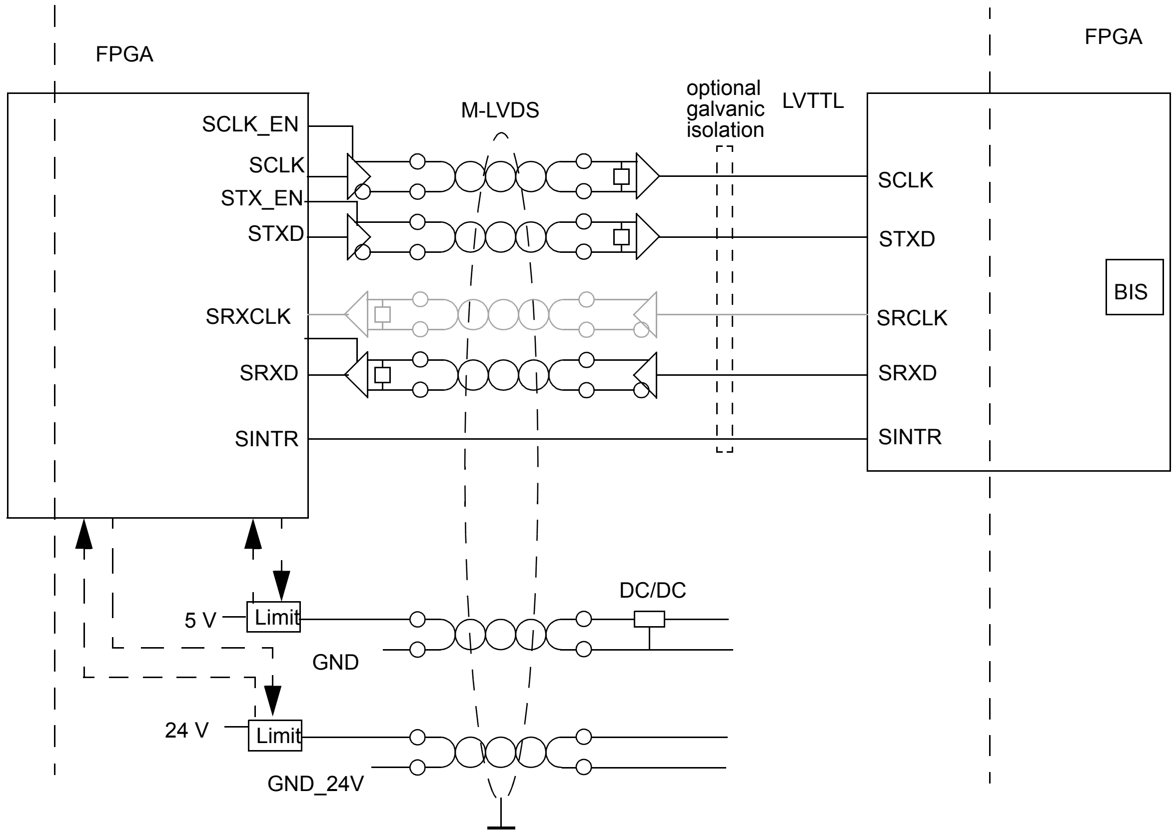
The measurement circuit on the SPB board is galvanically isolated from the other electronics.

Control output for BSMS/2 Variable Power Supply Board 11.5.6

The SPB provides 1 (SPB) or 2 (SPB-E) interfaces for connecting BSMS/2 VARIABLE POWER SUPPLY BOARDS (VPSB). These boards do not have any connections to the BSMS/2 backplane and all control signals are carried over this interface.

On the interface connector some supply and detection signals and a high speed LVDS-based digital interface are wired. The LVDS-based interface carries the Synchronous Serial Rack Bus signals from the ELCB and BSMS/2 backplane over the cable connection to the control FPGA on the VPSB. The interface is hot-plug capable, has automatic connect/disconnect detection and power supply signals are short-circuit proof.

Figure 11.8. Overview of point-to-point full duplex VPSB CTRL interface

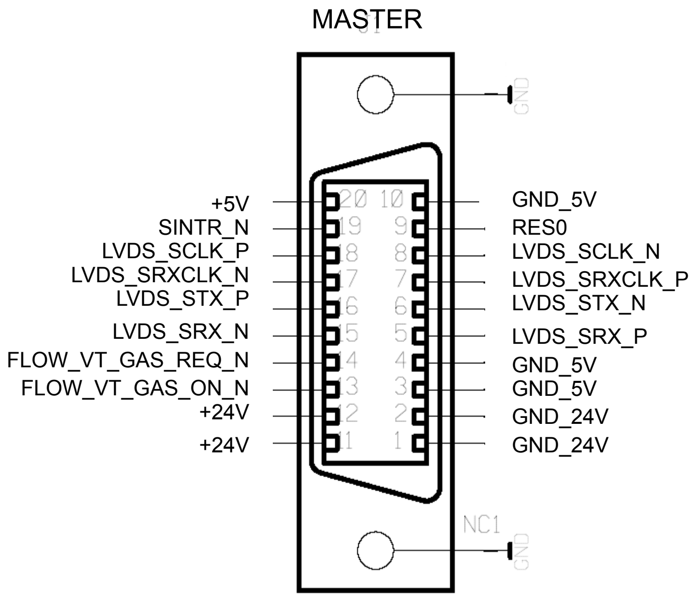


up to 20m shielded twisted-pair
AWG 28
max. 0.44 Ohm/m (loop impedance)

Table 11.5. Pin assignment VPSB CTRL (master interface)

Pin	Signal	Pin	Signal
1	GND_24V	11	+24V
2	GND_24V	11	+24V
3	GND_5V	13	FLOW_VT_GAS_ ON_N
4	GND_5V	14	FLOW_VT_GAS_ REQ_N
5	LVDS_SRX_ P	15	LVDS_SRX_N
6	LVDS_STX_ N	16	LVDS_STX_P
7	LVDS_SRXC LK_P	17	LVDS_SRXCLK_ N
8	LVDS_SCLK _N	18	LVDS_SCLK_P
9	RES0	19	SINTR_N
10	GND_5V	20	+5V

Figure 11.9. Pinning VPSB CTRL



Auxiliary Bus connector (VT accessory, SPB-E) 11.5.7

With introduction of the Bruker Sample & Variable Temperature System (BSVT) a new generation of sensor interface adaptors are available. These adapters convert sensor signals into a digital data-stream. These sensors are typically connected to the BSMS/2 VARIABLE POWER SUPPLY BOARDS (VPSB).

The SPB-E variant is equipped with one supplementary auxiliary bus interface connector.

The interface is hot-plug capable, has automatic connect/disconnect detection and power supply signals are short-circuit proof.

Figure 11.10.Overview Auxiliary Bus Connector (SPB-E) only

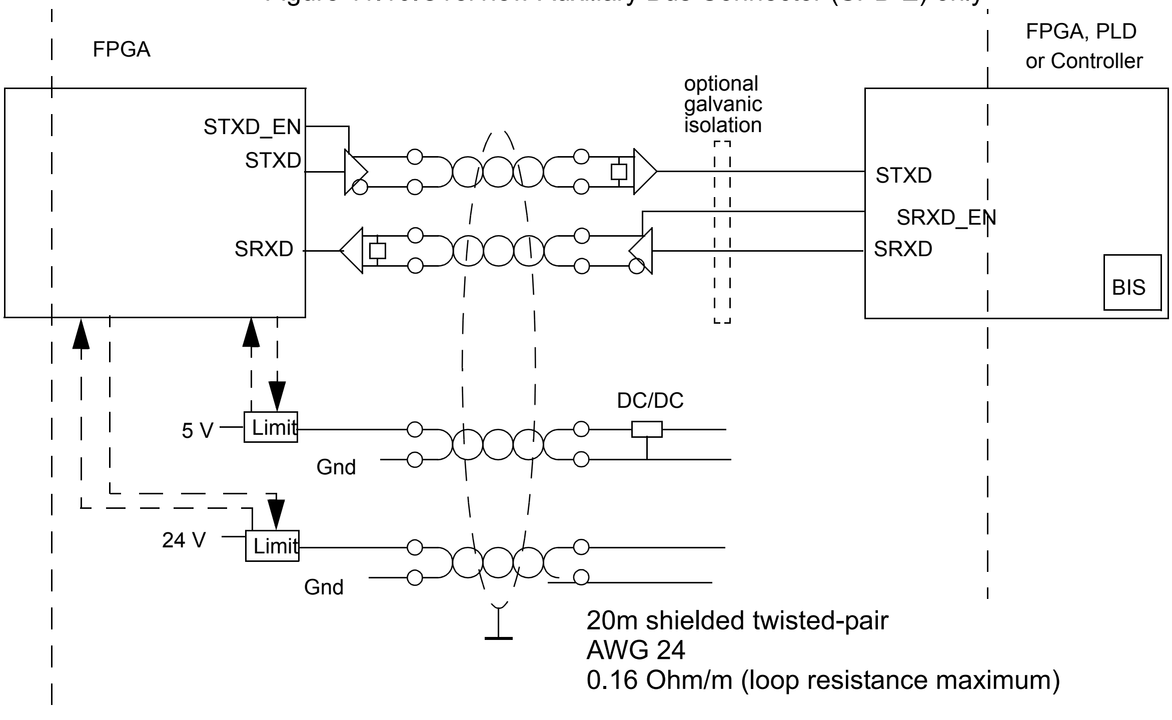


Table 11.6. Pin assignment of AUX connector RJ45

Pin	Signal
1	TX+
2	TX-
3	RX+
4	24V
5	GND_24V
6	RX-
7	5V
8	GND_5V

Pneumatics *11.5.8*

For detailed technical specifications please see ***"Technical Data" on page 207*** .

Never supply the console with non-filtered gas. A gas supply filter 88437 must be installed!

The SPB contains all valves, valve drivers, and pneumatic connectors necessary to control

- sample lift
- sample spinner (sample rotation)
- VT gas
- probe flush gas
- shim system cooling gas
- emergency lift detection

and replaces the former BSMS/2 PNK3, PNK3S and PNK5 boards.

The valve drivers are galvanically isolated and the module is controlled by the ELCB which also saves the calibration values.

To provide usage of different gases for sample transport/shim cooling and delicate probe head gases (VT, spin, flush gas), these two functional groups have separate gas inputs.

For reasons of sample safety it is necessary to connect a buffer to the lift system.

With the exception of the lift system and emergency lift gas for the CryoProbe sample safety option, there are no further calibration procedures necessary. In particular spin calibration is not necessary.

Controlled gas flow

The VT gas flow on the SPB(-E) is controlled using the integrated mass flow meter a solenoid control valve. Flow variations (within physical limits, some minimal quality of gas supply must be guaranteed) of the gas supply are eliminated and as a result stable conditions for the temperature regulation are provided.

The gas flow meter is factory-calibrated and the compensation values stored on the on-board non-volatile flash memory.

Table 11.7. Controlled gas flows

Regulated Gas flow channel	SPB	SPB-E
VT	yes	yes
Probe flush gas	no (fixed flow)	yes
Shim Cooling gas	no (fixed flow)	yes

The mass flow controller can not compensate for poor gas supply or insufficient input gas pressure. The new gas flow regulation ensure stable gas flow as long as site planning specifications for pressurized gas are met.

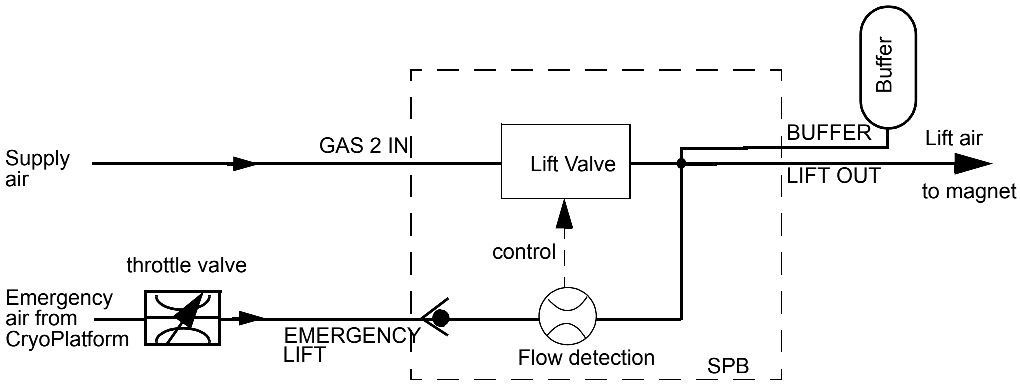
CryoPlatform emergency lift detection

For the CryoProbe Systems there is a Sample Safety Option available. This option runs independently from the NMR console and guarantees sample tempering (in case of a power failure) and emergency sample lift (in case of vacuum breakdown).

This additional emergency lift air must NOT be fed directly into the emergency lift input as with the legacy PNK3S. Instead the emergency lift air must be carried through an external throttle valve.

As before the amount of emergency lift air flow must be adjusted with this external throttle valve. Please see CryoProbe installation manual for details and some notes in ***"BSVT with CryoProbes" on page 198***.

Figure 11.11.Block diagram emergency lift detection



Bus Interface *11.6*

As mentioned earlier in this document, the SPB is not connected to the VME bus. The communication with the ELCB runs exclusively over the User Bus.

Table 11.8. User Bus Back Plane Connector (DIN41612 R)

Pin	A	B	C
32	VDD_BPL	VDD_BPL	VDD_BPL
31	VDD_BPL	VDD_BPL	VDD_BPL
30	AGND	AGND	AGND
29	AGND	AGND	AGND
28	VEE_BPL	VEE_BPL	VEE_BPL
27	VEE_BPL	VEE_BPL	VEE_BPL
26	24V_POWER	24V_POWER	24V_POWER
25	24V_POWER	24V_POWER	24V_POWER
24	GND_POWER	GND_POWER	GND_POWER
23	GND_POWER	GND_POWER	GND_POWER
22	-	Slot ID 0	-
21	-	Slot ID 1	/RNext
20	/SysReset	Slot ID 2	RCLK
19	SSRB:SCLK	Slot ID 3	SSRB:STXD
18	SSRB:SRXD	-	SSRB:/SINTR
14			
13	VCC_BPL	VCC_BPL	VCC_BPL
12	DGND	DGND	DGND
11			
10			
9			
8			
7	HE_+30V	HE_+30V	HE_+30V
6	HE_+30V	HE_+30V	HE_+30V
5	HE_GND	HE_GND	HE_GND
4	HE_GND	HE_GND	HE_GND
3	HE_GND	HE_GND	HE_GND
2	GND_PNEU	GND_PNEU	GND_PNEU
1	24V_PNEU	24V_PNEU	24V_PNEU

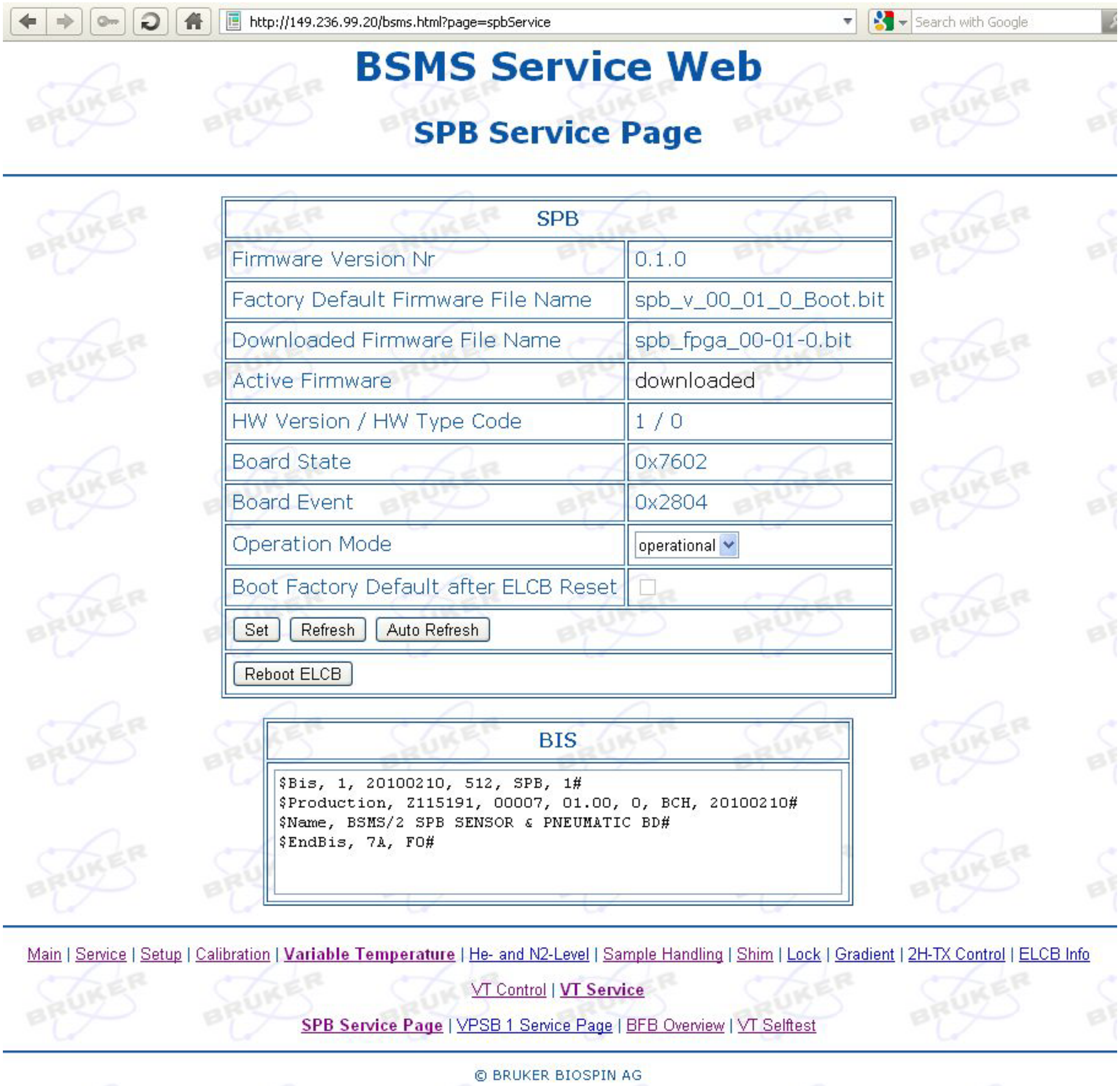
Service 11.7

A connected SPB in a BSMS system is controlled by the ELCB software - both, the specific low level drivers and the overall control logic is implemented there. The ELCB software provides the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration and diagnostic). Some of these Web functions are open to all users, other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

SPB Service Web 11.7.1

The SPB Service Page contains information about the board itself. Functions controlled by the ELCB are described in the corresponding chapters.

Figure 11.12.SPB Service Page



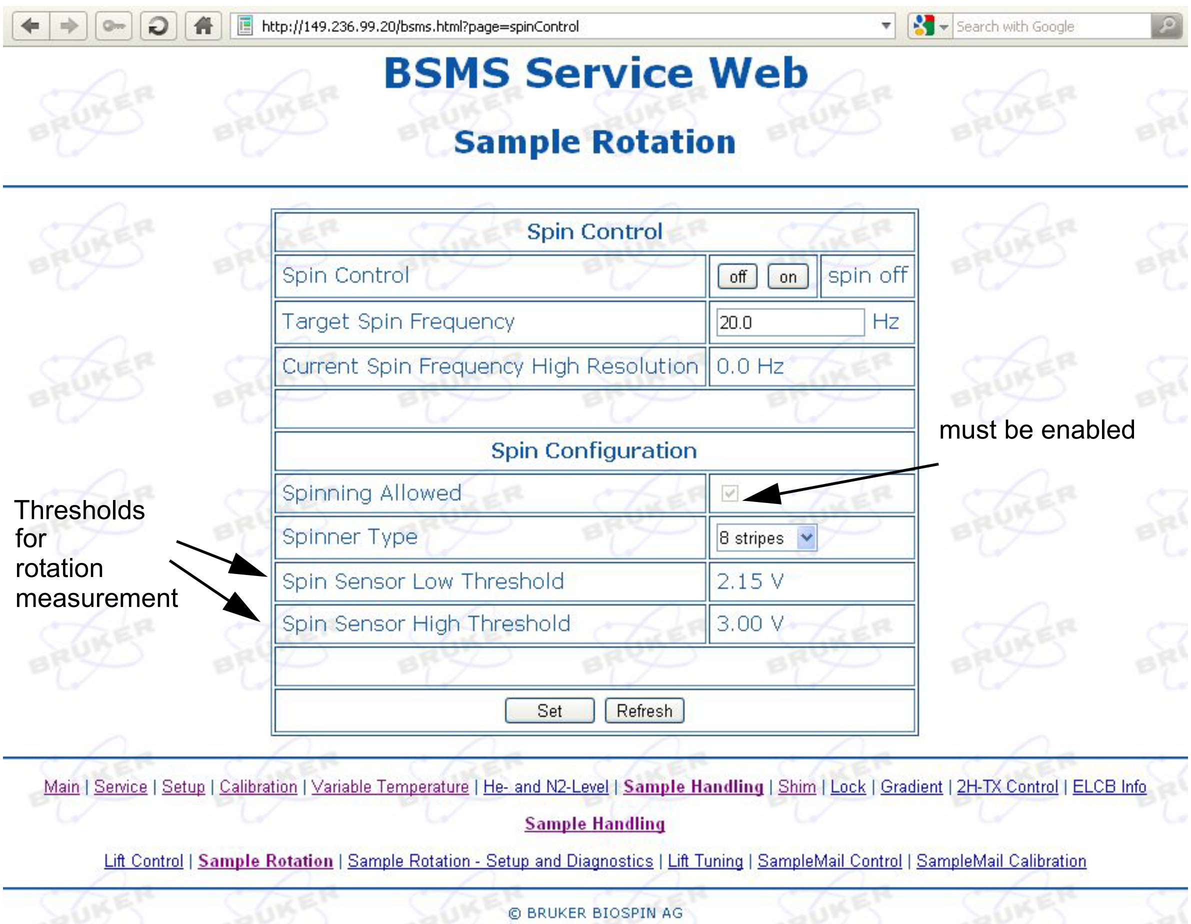
During normal operation all important signals and supplies are supervised. In case of a fatal hardware failure the board will go to a safe state (e.g. closes all valves). This is realized with a board watchdog mechanism. Board level trouble shooting must be done in the factory.

In case of failures, always check the LEDs on the SPB front panel and the LEDs on the BSMS/2 Power Supply Boards:

- red LED ERROR must be off
- green LED's READY, POWER and HE30V must be on
- if a VPSB is connected, the green LED above the VPSB CTRL connector must be on

Sample rotation (SPIN) not running

- Check air hoses and console gas pressure
- Lift the sample and insert again
- Check the sample down sensor signal threshold levels



Gas flow variations

- Check supply pressure

- Check the gas pressure after console the pressure regulator, pressure must be higher than 4 bar and stable.

As long as the console pressure is within the specified range of 4-6 bar the flow can be stabilized. The gas supply pressure must be at minimum 1 bar **higher** than set with the pressure regulator of the console (margin for proper pressure regulation).

System requirements *11.8*

See ***"Minimal requirements for all configurations" on page 175***.

Ordering information *11.9*

See ***"Basic BSMS/2 BSVT configuration" on page 175***.

VPSB 12

Introduction 12.1

The VPSB (Variable Power Supply Board) is a new development for the Temperature Control System.

Today‘s and future applications need flexible, scalable, highly integrated, precision power sources as heater power supplies. The VPSB integrates two independent variable power sources in one 12TE 19“ unit.

Precise temperature regulation for NMR samples over a wide range of VT gas flows and temperatures demands a very stable power source that can regulate heater power down to true zero watts and which is controllable with fine resolution. On the other hand new high temperature NMR experiments demand increased heater power.

Thanks to a novel architecture and modern integrated analogue and digital technology it is possible to integrate these characteristics into one compact unit.

Low level hardware functions (e.g. safety circuits, A/D and D/A converter control) are implemented directly on the VPSB, whereas higher level functions such as output power control and read-out of the power monitoring are done by software running on the ELCB.

A two-stage watchdog system and a smart probe heater impedance meter circuit ensure safe operation in case of serious malfunction.

The VPSB has interfaces for connecting new digital accessory sensors (temperature, digital level sensors).

Configurations 12.2

There is only one board variant available.

One VPSB has two power outputs that allow to set-up two controlled temperature channels. If more than 2 regulated temperature channels are required, then a second VPSB board can easily be added to the BSMS/2. There is only a mains cord and a control cable to connect. A requirement for operation with two VPSB is the presence of a SPB-E (Z115192).

Technical Data 12.3

Technical data, environment and norms 12.3.1

Parameter		Details	Min	Typ	Max	Unit
Input voltage	range		**85**		**264**	VAC
	frequency		**47**		**63**	Hz
Ambient operating temperature			**15**		**45**	**°C**
Safety	EN 61010-1					
Protection degree	IP20					
Approval	CB (EN60950)[a]					

a. including national deviations for Canada and the USA

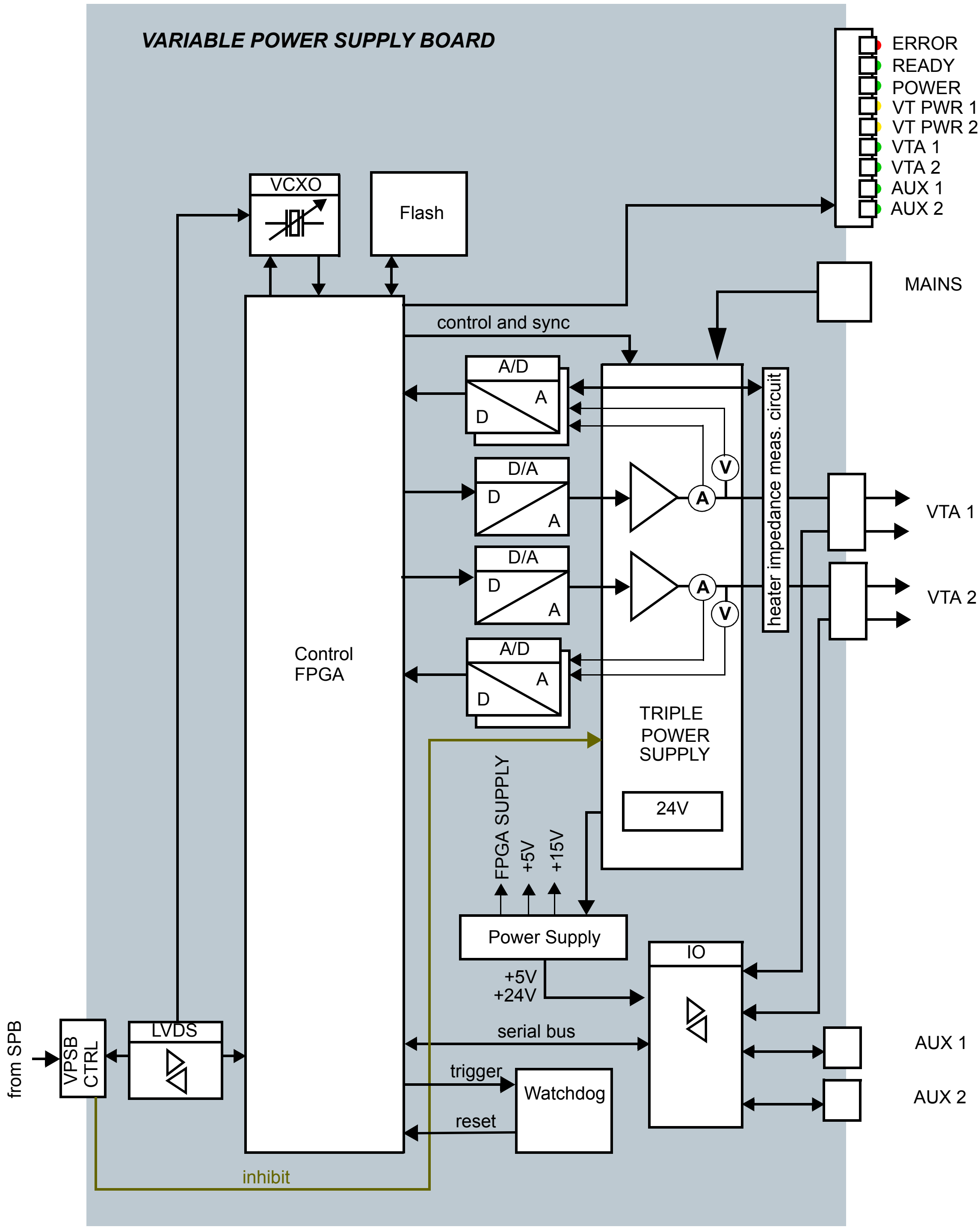
Electrical specification 12.3.2

Both power outputs have the same specification:

Variable Supplies Specification

Parameter		**Details**	**Min**	**Typ**	**Max**	**Unit**
Output power			**0**		**210**	W
Output voltage	range		**0**		**48**	VDC
Output current			**0**		**7**	A
Settling time	10..100% load				**10**	ms
Ripple & Noise		30MHz BW			**50**	mVpp
Hold-up time			**>10**			ms
Short circuit protection	constant current					

Figure 12.1. Block diagram of the VPSB



Control FPGA 12.4.1

The control FPGA receives commands (e.g. desired heater power) from the ELCB via the SPB LVDS (Low Voltage Differential Signaling) link. The link is an extended Synchronous Serial Rack Bus (SSRB). The FPGA drives the Digital-to-Analog and Analog-to-Digital converters that control the power stages of the variable power supplies.

Triple power supply and output power control 12.4.2

The heart of the VPSB is a 450W triple power supply with wide-range input. It can control the two main outputs down to true Zero with full resolution. The third supply delivers fixed +24V for external devices and on-board circuits.

The output of a VPSB channel is enabled whenever a temperature regulator is operating.

The effective heater power depends on the load resistance, which varies with probe type and heater temperature. Therefore the output current and voltage are measured with high resolution A/D-converters and the true output power is computed for the control process and diagnostics.

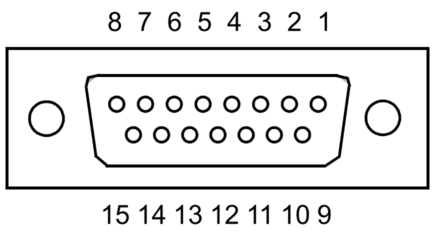
Before the output power is enabled the load resistance is measured by dedicated electronics. If the measured load changes during high power operation (broken lines, contact problems, material faults) the ELCB software will respond.

The two power stages can be enabled independently.

The registers for output power commands are self-clearing. A control instance must therefore update the output parameters at regular intervals, otherwise the outputs are reset by a watchdog circuitry for safety reasons.

Output power connector *12.4.3*

Figure 12.2. D-Sub15 female, pin assignment (VTA 1, VTA 2)



:

Table 12.1. D-Sub15 female, pin assignment

DSub Pin	Signal
1	Heater Power +
2	Heater Power +
3	Heater Power -
4	BFB_TX-
5	BFB_24V
6	BFB_RX-
7	BFB_5V
8	BFB_GND_5V
9	Heater Power +
10	Heater Power -
11	Heater Power -
12	BFB_TX+
13	BFB_RX+
14	BFB_GND_24V
15	reserve

Auxiliary bus connector (VT accessory) *12.4.4*

Together with the Bruker Sample & Variable Temperature System (BSVT) a new generation of sensor interface adaptors (VTA) are introduced. These adapters convert the sensor signals into a digital data stream and usually are connected to the BSMS/2 VARIABLE POWER SUPPLY BOARDS (VPSB).

The interface is hot-pluggable, has an automatic connect/disconnect detection and the power supplies are short-circuit-proof.

Figure 12.3. Overview Auxiliary Bus Connector

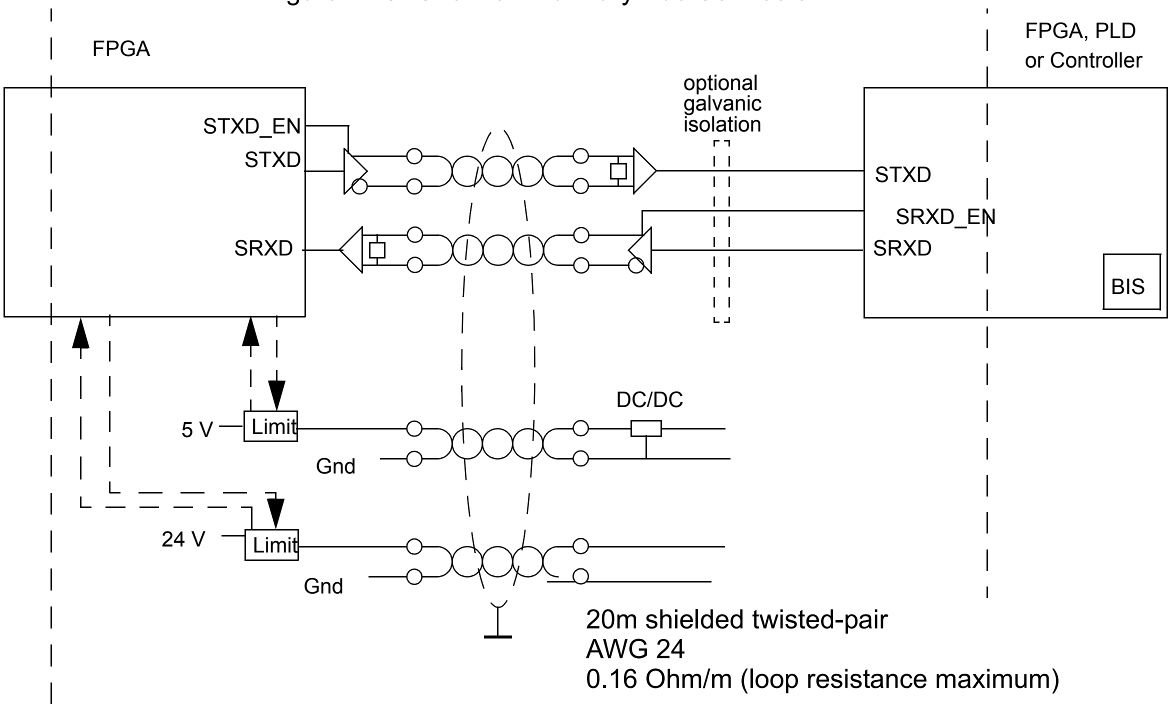


Table 12.2. Auxiliary Connector RJ45, pin assignment

Pin	Signal
1	TX+
2	TX-
3	RX+
4	24V
5	GND_24V
6	RX-
7	5V
8	GND_5V

Protection *12.4.5*

All external interfaces are protected against short circuits (limiting the output current or with current measurement and power switches).

The power stages are protected against over-heating.

Measurements provided for diagnostic *12.4.6*

The on-board diagnostics supervise essential board functions like power supply and clock synchronisation. A two-stage watchdog mechanism checks for valid connection to the ELCB and for valid power commands. In case of a failure the board will reset and switch off the power stages.

The software running on the ELCB may notify the user about abnormal events.

Status / Errors

The VPSB can perform the following checks:

- Power voltages ok
- Short circuits / disconnected lines at heater or sensor interface connectors

All connectors are equipped with current-shunt monitors. These measurements allow detection of connected adapters and over-current conditions.

Calibration *12.4.7*

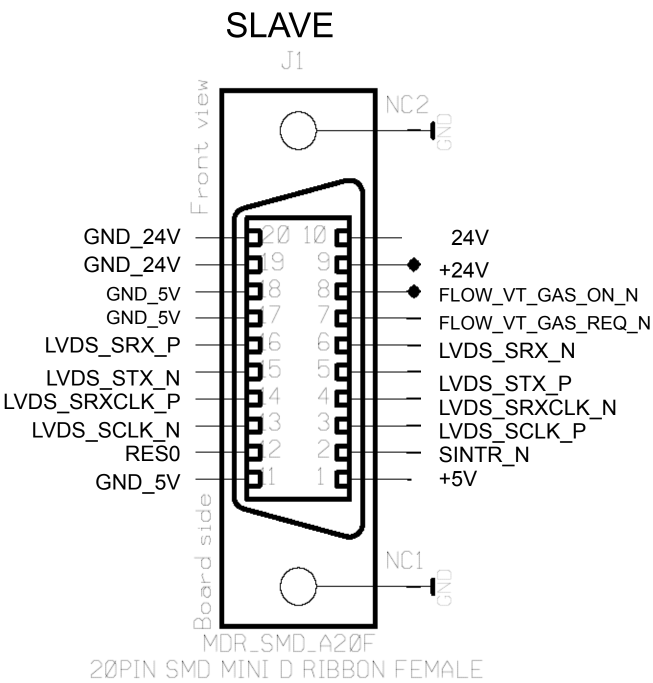
There are no calibration settings to store on the VPSB.

Though inserted in one of the BSMS/2 rack slots, the VPSB has no connection to the backplane. The communication with the ELCB exclusively runs over the VPSB CTRL cable from the SPB board.

Table 12.3. Pin assignment VPSB CTRL (slave interface)

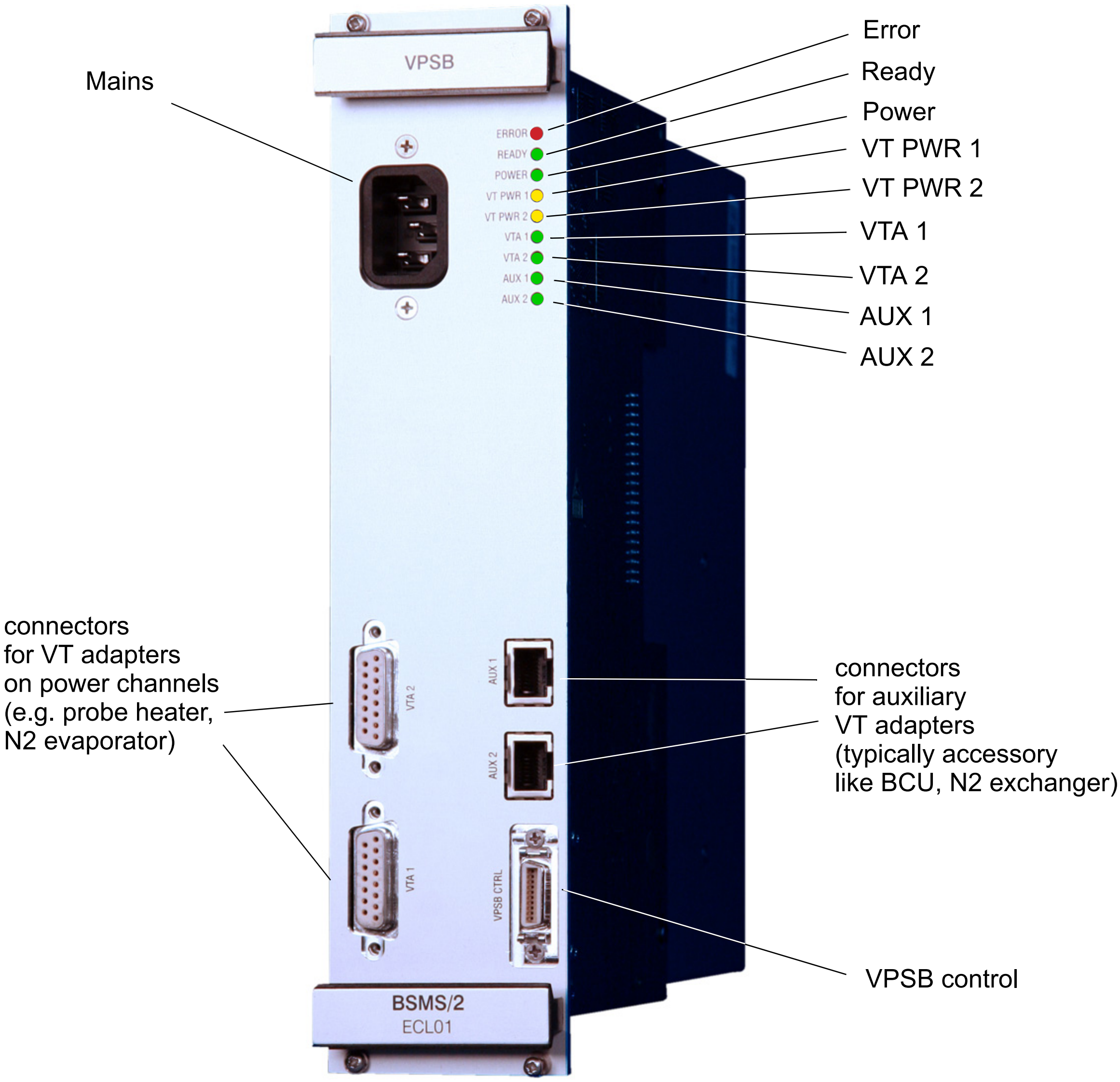
Pin	Signal	Pin	Signal
20	GND_24V	10	+24V
19	GND_24V	9	+24V
18	GND_5V	8	FLOW_VT_GAS_ON_N
17	GND_5V	7	FLOW_VT_GAS_REQ_N
16	LVDS_SRX_P	6	LVDS_SRX_N
15	LVDS_STX_N	5	LVDS_STX_P
14	LVDS_SRXCLK_P	4	LVDS_SRXCLK_N
13	LVDS_SCLK_N	3	LVDS_SCLK_P
12	RES0	2	SINTR_N
11	GND_5V	1	+5V

Figure 12.4. Slave pinning VPSB CTRL



Front Panel - Connectors and LED's 12.4.9

Figure 12.5. Front view of a VPSB



Error LED

This LED is lit after power ON. It turns off as soon as the VPSB is initialized (i.e. the FPGA has loaded its configuration from the flash memory ***and*** the communication with the ELCB is established).

Later on, the Error LED indicates is lit when an error has occurred (e. g. short circuit, watchdog event,...) ***and*** that in consequence the connected VTAs and the power outputs are switched off.

Ready LED

This LED is lit as soon as the FPGA design is loaded and the sensor interfaces are active

Power LED

Indication that the VPSB is correctly powered

VT PWR 1

This LED is lit whenever the output power on the connector VTA1 is enabled

VT PWR 2

This LED is lit whenever the output power on the connector VTA2 is enabled

VTA 1 LED

Whenever a VTA is connected to the connector labeled *VTA 1* **and** initialized correctly, the LED will be switched on

VTA 2 LED

Whenever a VTA or BSCU is connected to the connector labeled *VTA 2* **and** initialized correctly, the LED will be switched on

AUX 1 LED

Whenever a VTA is connected to the connector labeled *AUX 1* **and** initialized correctly, the LED will be switched on

AUX 2 LED

Whenever a VTA or BSCU is connected to the connector labeled *AUX 2* **and** initialized correctly, the LED will be switched on

Connectors

Table 12.4. VPSB front panel connectors

Label	Description	Note
VTA 1	for VTA adapters that are used for power channels (e.g. probe heater)	VTA 1 will be mapped to regulator channel 1 in Topspin[a]
VTA 2		VTA 2 will be mapped to regulator channel 2 in Topspin
AUX 1	for VTA adapters that do not require heater power (e.g. BCU control, N2 exchanger)	AUX 1 will be mapped to auxiliary channel 1 in Topspin[b]
AUX 2		AUX 2 will be mapped to auxiliary channel 2 in Topspin
MAINS	Mains power	

a. if a 2nd VPSB is in use then its VTA 1 will be mapped to regulator channel 3 and VTA 2 to regulator channel 4 respectively

b. if a 2nd VPSB is in use then the device at AUX 1 will be mapped to auxiliary channel 3 and AUX 2 to auxiliary channel 4 respectively

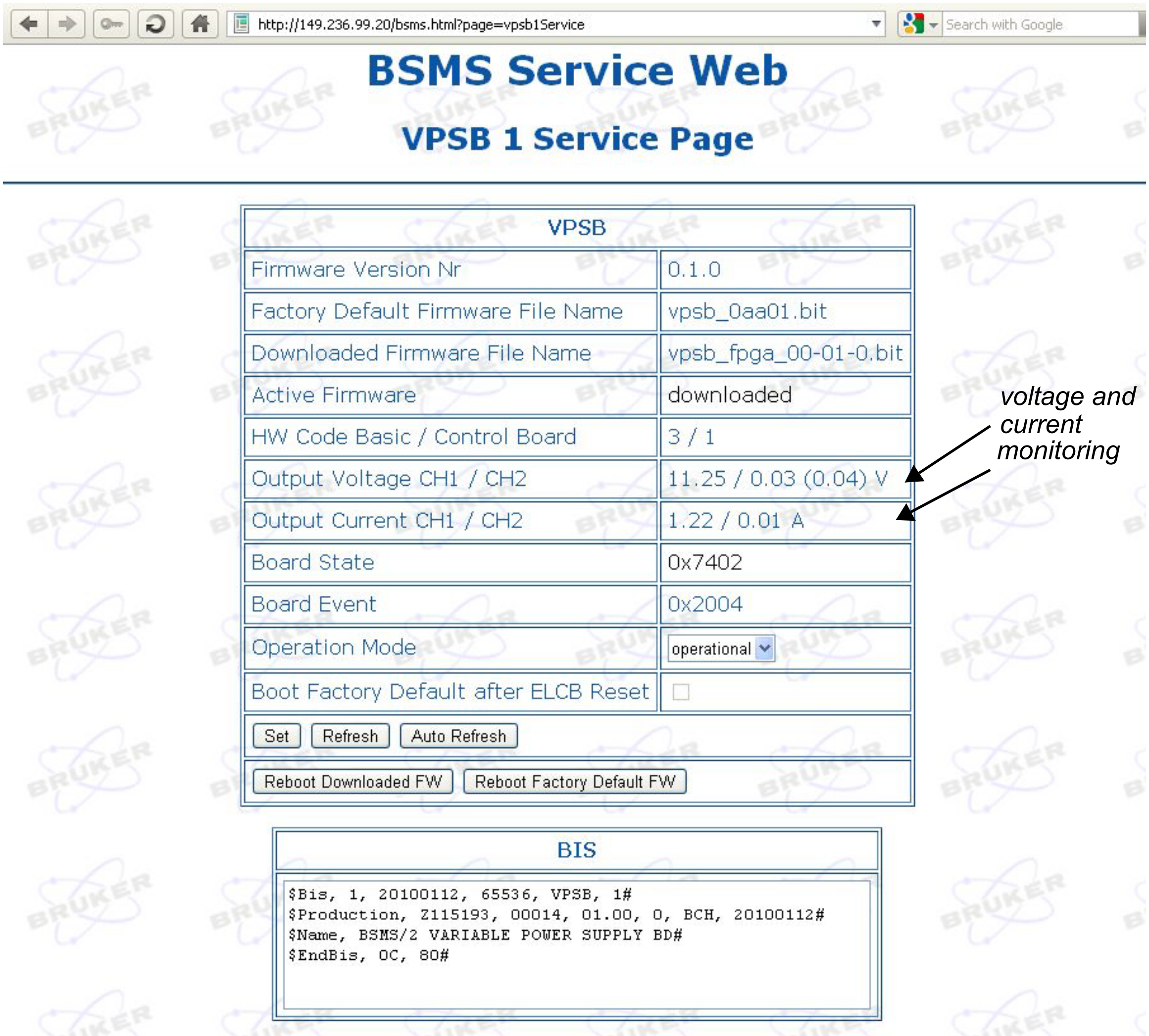
Service 12.5

A connected VPSB in a BSMS system is controlled by the ELCB software - both, the specific low level drivers and the overall control logic is implemented there. The ELCB software provides the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, calibration and diagnostic). Some of these Web functions are open to all users (e. g. clients), other functions are reserved for service engineers - it is necessary to log in and enter the required password before these functions can be accessed (description in the BSMS/2 Service Web chapter).

VPSB Service Web 12.5.1

The VPSB Service Page contains information about the board itself. Functions controlled by the ELCB are described in the corresponding chapters.

Figure 12.6. VPSB Service Page



Diagnostic and Trouble Shooting 12.5.2

During normal operation all important signals and supplies are supervised. In case of a fatal hardware failure the board will go to a safe state (e.g. shut down f the power conversion stages). This is implemented with a board watchdog system. Board level trouble shooting must be done in the factory.

In case of failures, always check the LEDs on the VPSB front panel and the connection to the SPB

- red ERROR LED must be off
- green READY LED and POWER LED must be on
- if a VTA is connected, the corresponding green LED must be on
- if the output on a channel is on (e.g. during temperature regulation) the corresponding yellow LED (VT PWR 1 or VT PWR 2) must be on. If not, check cables, connectors and firmware on connected devices.

There are no fuses that could be replaced at customer site.

System requirements 12.6

See ***"Minimal requirements for all configurations" on page 175***.

Ordering information 12.7

See ***"Basic BSMS/2 BSVT configuration" on page 175***.

VTA 13

Introduction 13.1

VTA is the abbreviation for **V**ariable **T**emperature System **A**dapter.

For application specific needs a wide variety of temperature sensors and heater interfaces must be supported. Some NMR probes need standard thermocouple sensors type-T, others need PT100 thermistors, some need two sensors etc.

In order to obtain precise and accurate temperature measurement the analog sensor signal cannot be carried over long distances or have many connector contacts between sensor and electronics.

Many NMR users want to work with different NMR probes and therefore must change the sensor adaptation conveniently.

For every temperature sensor and heater adaptation variant or other accessory device a tailored VTA is available but only *one type* of cable connection is needed for probe to console adaptation. This cable carries wires for digital signals, low-voltage power supply and the heater power.

The VT Adapters for probe head temperature control

- adapt the specific sensor, convert the sensor signal to a digital temperature reading and transmit this value to the BSMS/2 ELCB.
- measure the environmental temperature, use this value to compensate the room temperature dependencies of the specific sensor and transmit the room temperature value to the BSMS for further elimination of room temperature artefacts.

Heater power and heater safety sensor signals are fed through the VTA for three reasons:

- the heater power and the corresponding regulation sensor are bundled, thus preventing erroneous usage of a spare sensor for regulation
- the heater over-temperature sensor can be evaluated
- the heater current can be filtered close to the probe, suppressing RF noise picked up by the long cable running from the console to the magnet

To connect other temperature accessories like chillers, heat exchangers, nitrogen level measurement, pressure measurement etc. there are dedicated VTAs available. These accessory adapters are connected through a thinner cable that carries digital signals and low-voltage power supply only.

Configurations 13.2

The various applications and related VTA variants are presented in the following chapters:

- *"BSVT probe adaptation" on page 180*
- *"BSVT and heater accessory (power booster)" on page 186*
- *"BSVT and VT gas cooling accessory adaptation" on page 188*
- *"BSVT and FlowProbe adaptation (FLOW-NMR)" on page 192*

Table 13.1. List of available VTAs

Bruker Part Number	Name	Marking	Typical usage [Power or Auxiliary][a]	Typical usage Connected devices
Z119237	BSMS/2 VTA TC-2T	TC-2T	POWER	RT, Solids and Flow-probes VTN/WVT/DVT
Z116924	BSMS/2 VTA BTO	BTO	POWER	RT probes with BTO2000
Z116923	BSMS/2 VTA CRP	CRP	POWER	CryoProbe
Z120851	BSMS/2 VTA FLOW-NMR	FLOW-NMR	POWER	Flow NMR Capillary Heater
Z119237	BSMS/2 VTA TC-2E	TC-2E	POWER	probes for solids, high temperature
Z119238	BSMS/2 VTA LN2	LN2	POWER	N2 Evaporator N2 heat exchanger
Z116925	BSMS/2 VTA BCU	BCU	AUX	BCU-05, BCU-X
Z119720	BSMS/2 VTA BVTB	BVTB	AUX	BVTB3500 Power Booster
Z119239	BSMS/2 VTA AUX-2P	AUX-2P	AUX	-
Z116922	BSMS/2 VTA TC-T	TC-T	POWER	RT probes

a. POWER means that this application needs heater power and therefore must be connected through a cable that contains heater power wires to an output of the VARIABLE POWER SUPPLY BOARD (VPSB)

VTA TC-T

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-270**		**400**	°C
Thermocouple type T	Accuracy			**+/- 0.5**		°C
	Number of channels			**1**		
	Connector type[a]			**A**		
Heater	Connector type			**H**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
Thermocouple type K	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA BTO

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-270**		**400**	°C
Thermocouple type T	Accuracy	without sensor		**+/- 0.5**		°C
	Number of channels			**1**		
	Connector type[a]			**C**		
BTO2000 Supply	Voltage			**24**		V
	Current				**500**	mA
	Connector type			**D**		
Heater	Connector type			**H**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
Thermocouple type K	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA CRP

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-200**		**+850**	°C
PT100	Accuracy	without sensor		**+/- 0.25**		°C
	Number of channels			**1**		
	Connector type[a]			**M/N**		
Heater	Connector type			**M/N**		
	Maximum voltage				**50**	V
	Maximum current				**2.5**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
PT100	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA TC-2T

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-270**		**400**	°C
Thermocouple type T	Accuracy	without sensor		**+/- 0.5**		°C
	Number of channels			**2**		
	Connector type[a]			**A**		
Heater	Connector type			**H**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
Thermocouple type K	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA FLOW-NMR

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-200**		**350**	°C
Thermocouple type T	Accuracy	without sensor		**+/- 0.5**		°C

VTA FLOW-NMR

Parameter		Details	Min	Typ	Max	Unit
	Type			**1**		
	Number of channels			**1**		
	Connector type[a]			**A**		
Heater	Connector type			**J**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
PT100	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA TC-2E

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-200**		**+1000**	°C
Thermocouple type E	Accuracy	without sensor		**+/- 1**		°C
	Number of channels			**2**		
	Connector type[a]			**B**		
Heater	Connector type			**H**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Safety temperature measurement	Range		**-200**		**+850**	°C
Thermocouple type K	Resolution			**0.1**		
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA LN2

Parameter		Details	Min	Typ	Max	Unit
Level measurement	Range		**0**		**500**	Ohm
Resistive PT100 type	Resolution			**0.1**		Ohm
	Accuracy			**+/- 1**		Ohm
	Stability					°C/°C
	Connector type[a]			**J**		
Heater	Connector type			**J**		

VTA LN2

Parameter		Details	Min	Typ	Max	Unit
	Maximum voltage				50	V
	Maximum current				7	A
Safety temperature measurement	Range		-200		+850	°C
Resistive PT100 type	Resolution			0.1		°C
Measurement update rate				1		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA BCU

Parameter		Details	Min	Typ	Max	Unit
Control signal output	Max. voltage			5		V
	Max. current				50	mA
	Connector type[a]			K		

a. connector types: see ***"VTA cable connectors" on page 252***

VTA BVTB

Parameter		Details	Min	Typ	Max	Unit
BVTB control signal	Connector type[a]			L		
	Control voltage[b]		0		+10	V
Safety temperature measurement	Range		-200		+600	°C
(amplified voltage from BVTB3500)	Resolution			0.1		°C
Measurement update rate				1		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***
b. 0..+10V (refers to 0..500W), accuracy is defined from driving VPSB

VTA AUX-2P

Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		-260		850	°C
	Number of channels			2		
	Connector type[a]			C		
Measurement update rate				1		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

VTA MAG-RS

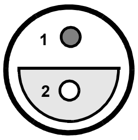
Parameter		Details	Min	Typ	Max	Unit
Temperature measurement	Range		**-260**		**850**	°C
	Number of channels			**2**		
	Connector type[a]			**O**		
Heater	Connector type			**P**		
	Maximum voltage				**50**	V
	Maximum current				**7**	A
Measurement update rate				**1**		s^{-1}

a. connector types: see ***"VTA cable connectors" on page 252***

Figure 13.1. VTA cable connectors

front view on cable connectors (mating side)

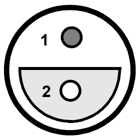
A



Thermocouple T

1 (Cu) Thermocouple +
2 (CuNi) Thermocouple -
3 (Cu) GND (Shield)

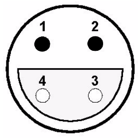
B



Thermocouple E

1 (NiCr) Thermocouple +
2 (CuNi) Thermocouple -
3 (Cu) GND (Shield)

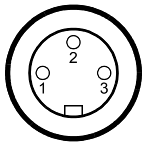
C



PT100
or
BTO2000

1 current +
2 PT100 / BTO T+
3 PT100 / BTO T-
4 current -

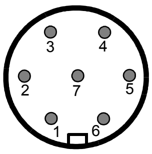
D



BTO2000
Power Supply

1 BTO XGND
2 BTO +24V
3 BTO GND

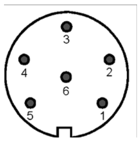
H



HEATER

1 heater -
2 heater -
3 safety thermocouple -
4 safety thermocouple +
5 heater +
6 heater +
7 GND (Shield)

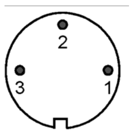
J



N2

1 N2 heater +, power output
2 level sensor +,
level detection input (0 - 2,5 V)
3 evaporator detection,
evaporator detected if grounded
4 AGND
5 N2 heater - ,
6 exchanger detection, exchanger
detected if grounded

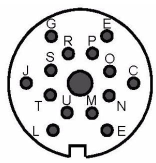
K



BCU05

1 heater on (output) turns on
the BCU05 when high (> 2,4 V)
2 DGND
3 nc not connected

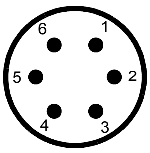
L



BVTB3500

A +5V (VCC)
C NC
E GND_BTO (isol.)
G +15 v_BTO (isol.)
J NC
L DGND
M sda
N scl
O power control
P PNEU_GND,HEAT_GND
R PNEU_GND,HEAT_GND
S thermocouple
T b_relay
U b_connected

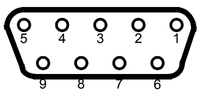
M



CRP LEMO 6

1 heater +
2 safety sensor PT100 T+
3 safety sensor PT100 T-
4 sample sensor PT100 T+
5 sample sensor PT100 T-
6 heater -

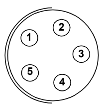
N



CryoPlatform (CRCO)

1 sample sensor PT100 T+
(incl. excitation)
2 Relay contact 1 (GPI 1)
3 -
4 XGND
5 -
6 sample sensor PT100 T-
(incl. excitation)
7 Relay contact 2 (GND/GPI1)
8 -
9 X24V (+24..31V) from
CryoController

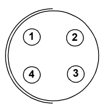
O



Magnet RS (Heater)

1 safety sensor PT100 T+
2 safety sensor PT100 T-
3 heater -
4 heater +
5 -

P



Magnet RS (Sensor)

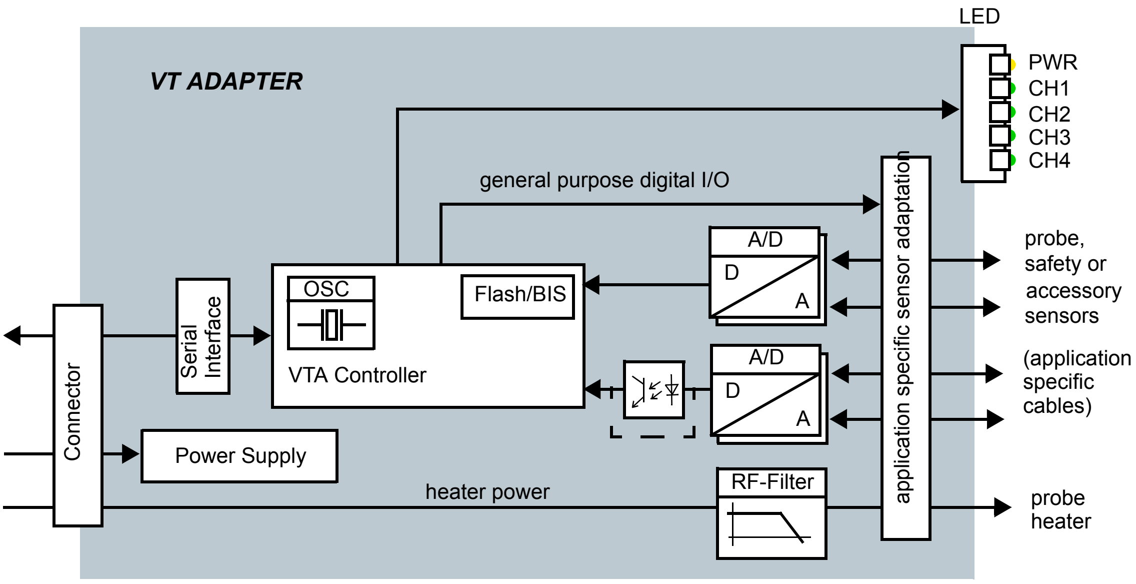
1 ssensor excitation +
2 sensor signal +
3 sensor signal -
4 sensor excitation -
5 -

System Architecture / Overview 13.4

The primary function of the VTA is to adapt the various sensors and signals of probehead and chiller devices to the common interface of the BSMS/2 integrated VT system.

Inside the VTA a common basic infrastructure for configuration, communication and board identification (BIS) is available. Depending on the specific function these are complemented by the appropriate number of ADC channels, galvanic isolation or sensor excitation signals. Some VTA (e.g. for connecting a BCU) are equipped with solid-state switches.

Figure 13.2. Block diagram of the VT Adapter



Thermocouple adaptation (VTA TC-T, TC-2T, TC-2E)

The thermocouple signal from the probehead is fed into the VTA where the cold-junction compensation and signal conversion is done. Simultaneous measurements of sensor temperature and cold-junction temperature leads to precise results. The heater current is fed through the VTA for RF filtering before entering the probehead. A dedicated ADC channel is used for measuring the safety temperature sensor that is mounted on the heater to prevent overheating. Broken, ground-shorted or disconnected sensor lines are detected for safety and diagnostic reasons.

Mainly for Solids NMR and high temperature applications there are VTA variants with two thermocouple connectors.

VTAs with two sensor inputs are fully operable with only one sensor connected. The open sensor line will be ignored and the VTA behaves like a single sensor type.

BTO2000 adaptation (VTA BTO)

The cold-junction compensated signal from the BTO2000 is fed into the VTA where the signal conversion is done. The VTA BTO provides the power supply for the thermal oven and electronics of the BTO2000. Apart from that the device provides the same functionality as the TC-2T variant.

CryoProbe adaptation (VTA CRP)

In contrast to the room temperature probes the CryoProbes use PT100 sensors for both regulator and safety temperature measurement. Their heater impedance is higher than that of a room temperature probe.

Furthermore, the analog signal from the safety sensor has to be wired to the CryoPlatform which also delivers the bias current. This ‘lending-out’ of the safety sensor establishes a redundant system for sample temperature monitoring. To prevent ground coupling, the signals between the BSMS/2 and the CryoPlatform are galvanically isolated. If the CryoPlatform is switched off, the VTA is unable to measure the safety sensor and thus inhibits sample heating.

Care must be taken when connecting the CryoPlatform: The male connector on the CryoPlatform side exposes a voltage of about 29V on a pin. It is almost impossible to plug the VTA cable without shorting this pin to frame ground which can damage the CRCO and the VTA. **Always switch off the CryoPlatform when connecting the VTA CRP to its rear panel! The VTA can be left connected to CryoPlatform and must not be disconnected when operating a RT probe.**

BCU-05 and BCU-X adaptation (VTA BCU)

To integrate the legacy “BCU” gas chillers into the new temperature system an adaptor VTA is needed. It detects the presence of such a chiller and enables remote operation.

The VTA BCU can be used for BCU05 or BCU-X (BCU-Extreme) type of cooling units and can be connected to an auxiliary control port.

New B**S**CU-05 and B**S**CU-X do not need a VTA BCU adapter. They come with an embedded VTA-style interface and should be connected to an auxiliary control port.

Adaptation of low temperature options (VTA LN2)

For sample temperature control far below room temperature two devices are available: the LN_2 Heat Exchanger and the LN_2 Evaporator.

The VTA LN2 adapts both of these and detects the type of the connected device. It monitors the level and safety sensors and continuously sends these values to the BSMS/2 ELCB where they are evaluated.

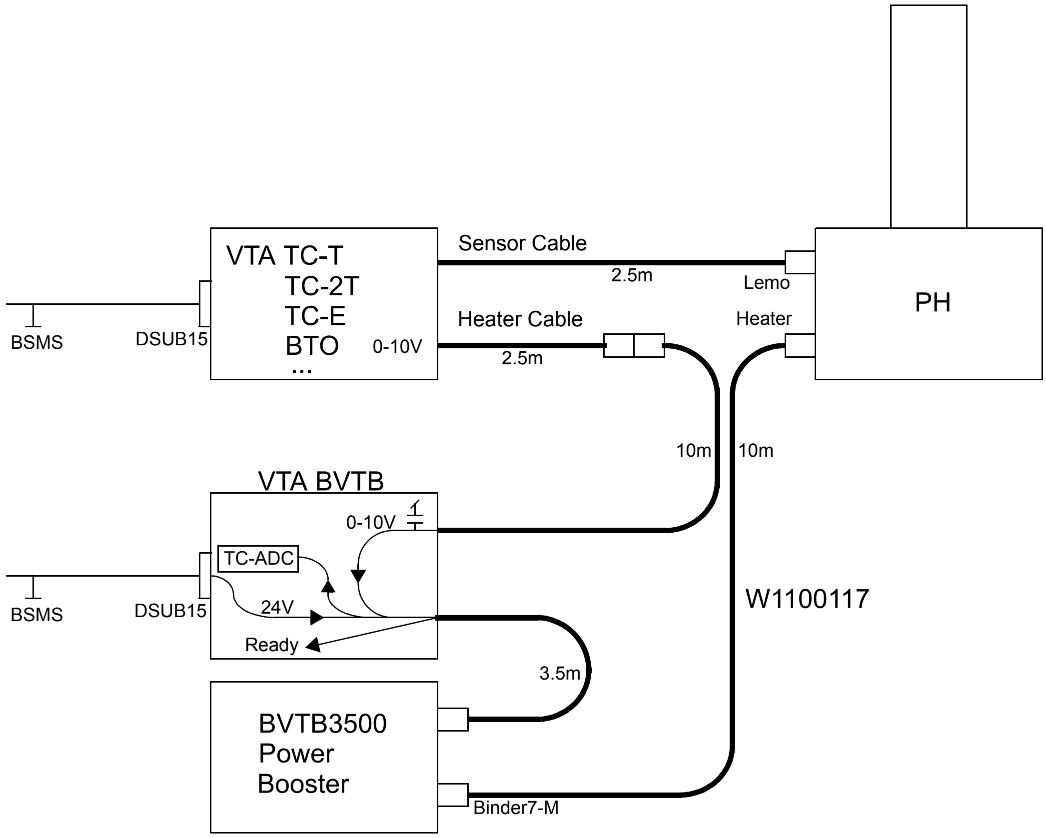
For LN_2 Heat Exchanger and LN_2 Evaporator operation heater power is required. The heater power is fed through the VTA and the heater safety sensor is monitored for safe operation. For that an additional heater cable is necessary (Z116301 CABLE RD 15P 4.5M 1:1 BSMS/2 VPSB-VTA or Z116304 CABLE RD 15P 9M 1:1 BSMS/2 VPSB-VTA).

BVTB3500 Power Booster adaptation

The BVTB3500 Power Booster is controlled by an external 0-10V signal that corresponds to an output power of 0-500W and an on/off control signal. The BVTB3500 itself provides a signal when the unit is powered on and makes the heater safety thermocouple signal available.

The VTA BVTB is connected between the output of the standard probe heater and the BVTB3500 control connector. By monitoring the heater control signal and safety thermocouple sensor the VTA is able to supervise the booster operation and provide safe operation.

Figure 13.3. Wiring diagram BSVT and BVTB3500



Protection 13.4.1

All external interfaces are protected against short circuits (either by limiting the output current or by current monitoring and shut down).

Measurements provided for diagnostic 13.4.2

The on-board diagnostics supervise essential board functions like power supply and ADC state. In case of a failure the board will reset and reboot.

The software running on the ELCB may notify the user about abnormal events.

Status / Errors

The VTA can perform the following checks:

- communication and functionality of the ADCs

- power voltages
- shorted or disconnected lines at sensor interface connectors

Calibration 13.4.3

There are no calibration settings to store on the VTA.

Connectors and LED's 13.4.4

Figure 13.4. The picture below shows two typical VT adapter

LED's CH1/2/3/4 and VT POWER

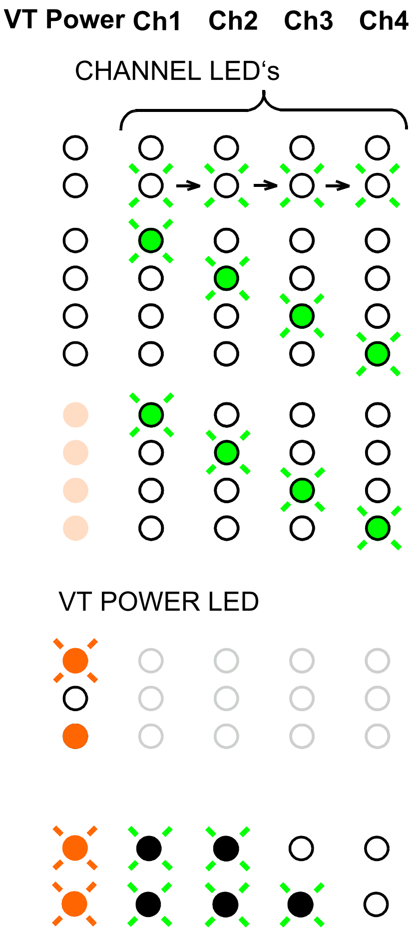
The LEDs on the VT adapters indicate the status of the adapters (connected, initialized). The indicated channel number (CH1, CH2, CH3, CH4) corresponds to the number which is displayed in the BSMS Service Web or on the *vtudisp* in Topspin.

VT adapters can be connected or disconnected at any time. The temperature control will go to **OFF state** if disconnected

In general, the

- green LED indicates the channel number and state
- amber LED indicates the heater status (power on, standby, on state)

Figure 13.5. LED Code on VT adapters



dark	off, not powered
all blinking	ready, but not initialized (2Hz, 250ms)
‚heartbeat'	Sensor Channel 1
‚heartbeat'	Sensor Channel 2
‚heartbeat'	Sensor Channel 3
‚heartbeat'	Sensor Channel 4
‚heartbeat'	active Heater/Sensor Channel 1
‚heartbeat'	active Heater/Sensor Channel 2
‚heartbeat'	active Heater/Sensor Channel 3
‚heartbeat'	active Heater/Sensor Channel 4
POWER blinking	Heater standby / off (2Hz, 250ms)
POWER dark	no heater available
POWER steady	heater on / regulator on
blinking	Internal failure (no signal)
blinking	Internal failure (no BIS)

Heartbeat frequency:
Power channel: long ON time, short OFF time
Auxiliary channel: short ON time, long OFF time

Bus Interface

VT Adapters are connected to the VPSB or SPB-E. These boards provide the necessary power supply and data interface signals.

Figure 13.6. D-Sub 15 male, pin assignment

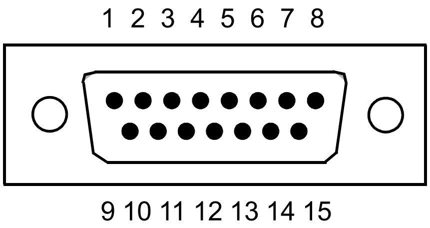


Table 13.2. D-Sub 15 male, pin assignment

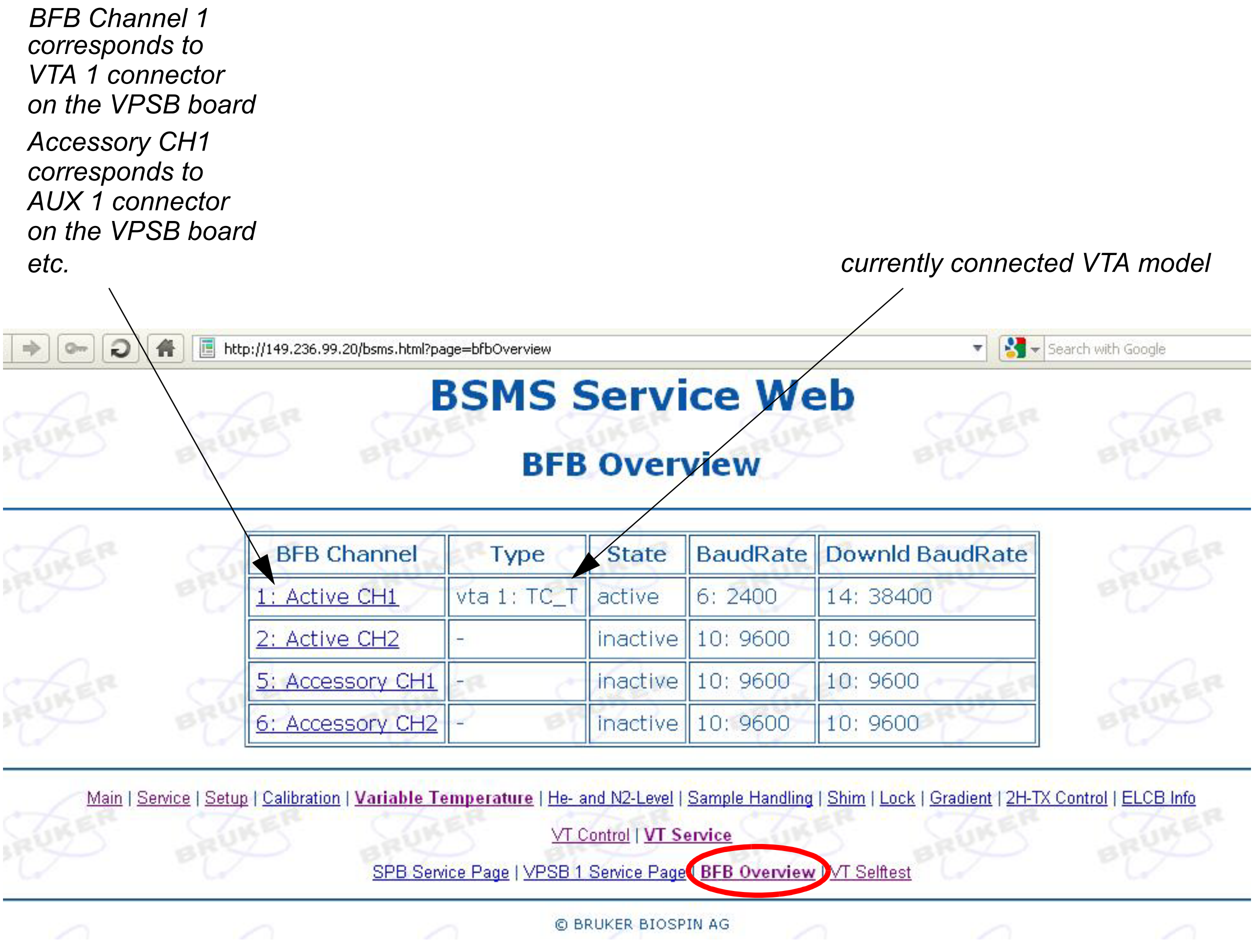
DSub Pin	Signal
1	Heater Power +
2	Heater Power +
3	Heater Power -
4	BFB_TX-
5	BFB_24V
6	BFB_RX-
7	BFB_5V
8	BFB_GND_5V
9	Heater Power +
10	Heater Power -
11	Heater Power -
12	BFB_TX+
13	BFB_RX+
14	BFB_GND_24V
15	reserved for production testing

Service 13.5

VTA Service Web 13.5.1

There is no particular web site for each connected VTA, but there is a common page listing all VTA or other devices connected to one of the peripheral bus (BFB) connectors:

Figure 13.7. Overview of VTAs connected to the BFB peripheral bus



BFB Channel	Type	State	BaudRate	Downld BaudRate
1: Active CH1	vta 1: TC_T	active	6: 2400	14: 38400
2: Active CH2	-	inactive	10: 9600	10: 9600
5: Accessory CH1	-	inactive	10: 9600	10: 9600
6: Accessory CH2	-	inactive	10: 9600	10: 9600

Diagnostic and Trouble Shooting 13.5.2

The device state is displayed using the 5 LED. See ***"LED Code on VT adapters" on page 257*** for detailed description.

In addition, on-board diagnosis data or failure events are sent to the ELCB immediately and displayed within Topspin GUI or Logfile.

System requirements 13.6

See ***"Minimal requirements for all configurations" on page 175***.

Ordering information 13.7

See ***"Basic BSMS/2 BSVT configuration" on page 175***.

Nitrogen Level Sensor 14

Introduction 14.1

For the ASCEND family of NMR magnet systems a new digital liquid nitrogen sensor has been developed and introduced in 2010.

The new sensor is compatible with all AVANCE spectrometers with BSMS/2 BSVT electronics (VPSB, SPB-E). For former BSMS/2 systems without BSVT, a Z108145 SLCB/3 board is necessary.

Due to its digital concept this sensor avoids effects of analogue technology and provides a user friendly plug and play operation as well as a direct on-board LED N2 level indication. It allows measuring the level of the liquid nitrogen within the corresponding cryostat of the magnet system at any time and as many times as wanted. Together with MICS software the Nitrogen level measurement allows monitoring the Nitrogen level over longer time periods and gives an estimate for the next refill date.

For easy use the sensor electronics has a built-in connector detection and automatically provides

- a digital reading of the absolute fill level in percent or
- an analog voltage between 0 and -5V (100% to 0% fill level)

on the same connector and is therefore fully compatible with all Bruker fill level measurement units.

Configurations and installation 14.2

For every size of cryostat an individual nitrogen level sensor length is necessary. The electronics itself does not change.

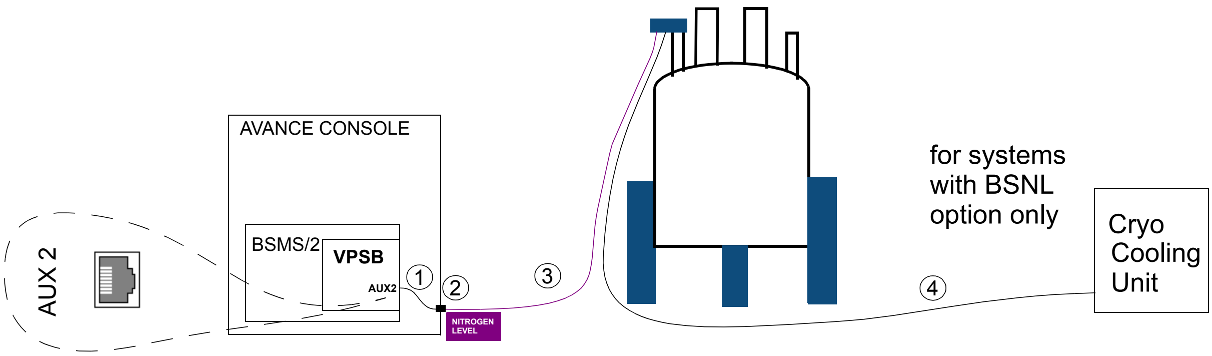
On system level there are two configurations depending on AVANCE spectrometer generation (digital or analog mode).

Installation 14.2.1

For detailed information on **sensor installation** consult the Magnet System Service Manual SB/WB/SWB ZTKS0177 / Z31977 and the wiring on ***page 262***.

Digital configuration (BSMS/2 with BSVT) 14.2.2

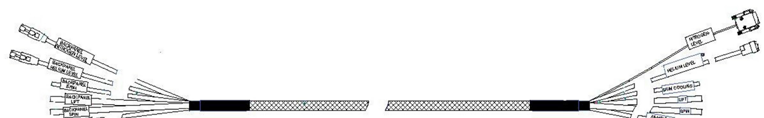
Figure 14.1. Digital configuration



① 88670 CABLE RD 4X2P2000 RJ45 CAT 5E VIOLET
② 94209 ST BU 8-8 RJ45 MOD JACK COUPLER CAT 5E
③ HZ14769 CABLE RD 8P 9000 DSUB 9P-RJ45
or
HZ16931 CABLE 9.0 MT BSMS/BSVT-MAGNET
HZ16932 CABLE 5.0 MT BSMS/BSVT-MAGNET

(① ② ③: **H14037 CABLE SET NITROGEN SENSOR**)

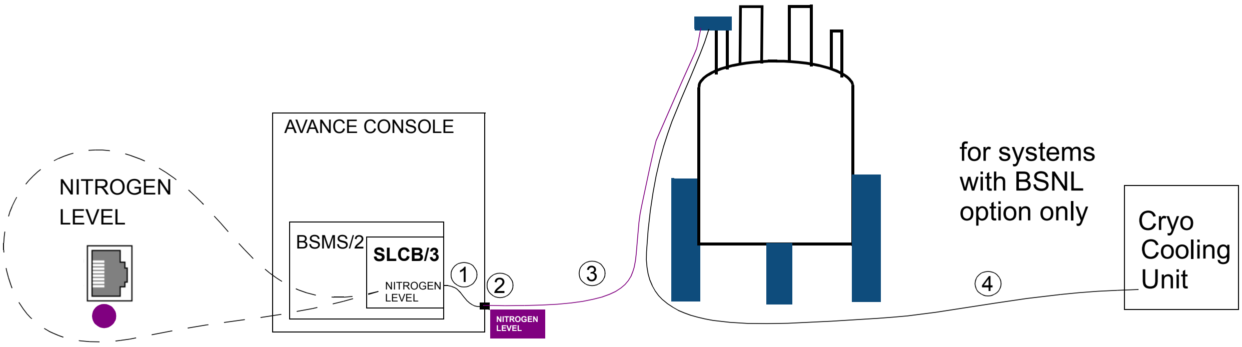
④ Z106877 CABLE 6M CU N2 LEVEL
Z109207 CABLE 8M CU N2 LEVEL
Z109208 CABLE 12M CU N2 LEVEL



HZ16931 and HZ16932 are combined cable sets between console and magnet

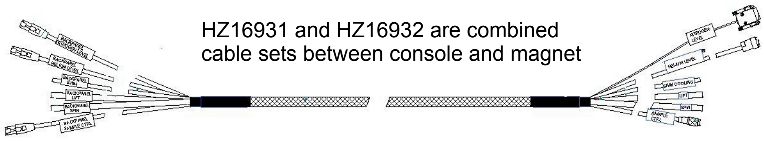
Analog configuration (BSMS/2 with SLCB/3) *14.2.3*

Figure 14.2. Analog configuration



1. 88670 CABLE RD 4X2P2000 RJ45 CAT 5E VIOLET
2. 94209 ST BU 8-8 RJ45 MOD JACK COUPLER CAT 5E
3. HZ14769 CABLE RD 8P 9000 DSUB 9P-RJ45
   or
   HZ16931 CABLE 9.0 MT BSMS/BSVT-MAGNET
   HZ16932 CABLE 5.0 MT BSMS/BSVT-MAGNET
4. Z106877 CABLE 6M CU N2 LEVEL
   Z109207 CABLE 8M CU N2 LEVEL
   Z109208 CABLE 12M CU N2 LEVEL

(1)–(3): **H14037 CABLE SET NITROGEN SENSOR**



Z115192 BSMS/2 SPB-E does also support the analog mode. When a SPB-E is available it is recommended to use the digital mode and use the AUX connector (improved precision and diagnostic).

Protection *14.2.4*

All external interfaces are protected against short circuits (either by limiting the output current or by current monitoring and shut down).

Measurements provided for diagnostic 14.2.5

The on-board diagnostics supervise essential board functions like power supply and ADC state. In case of a failure the board will reset and reboot.

The software running on the ELCB may notify the user about abnormal events.

Status / Errors

The LN2 sensor can perform the following checks:

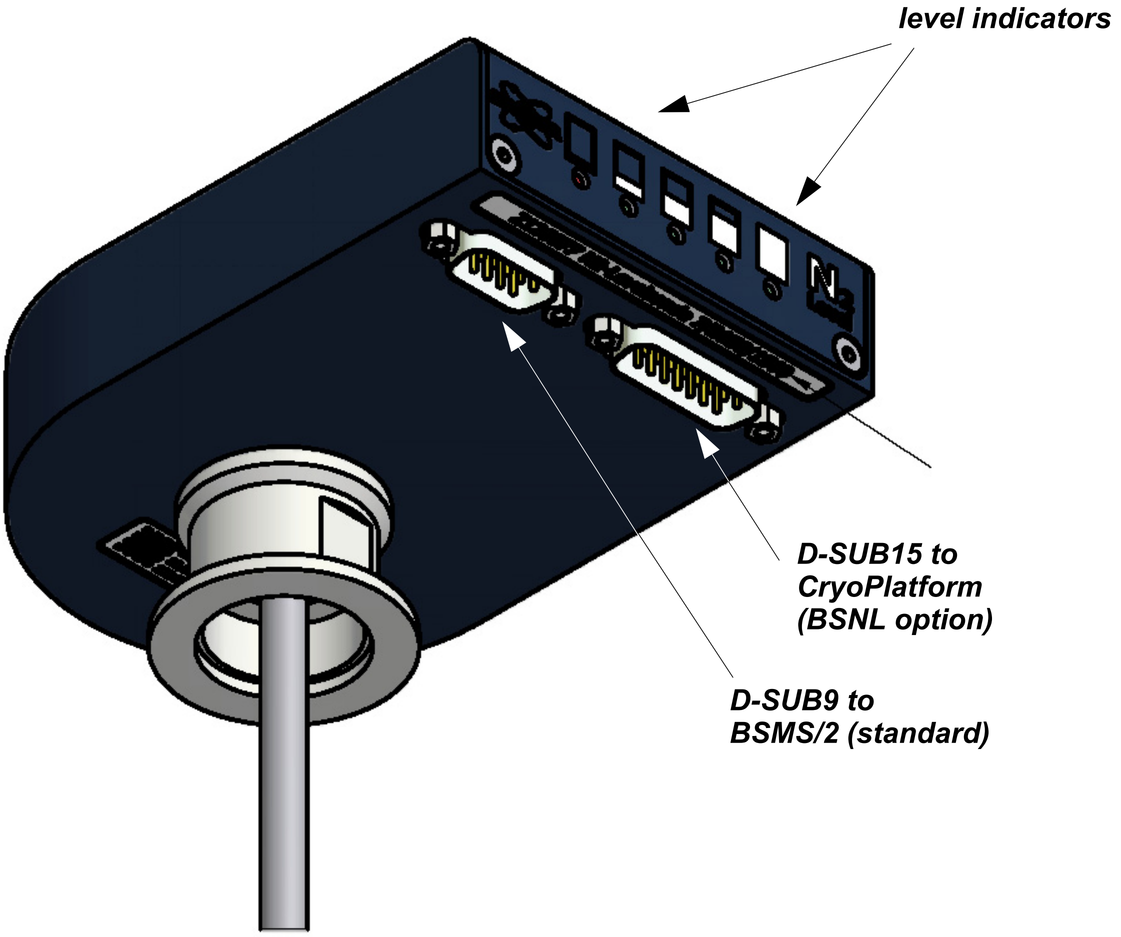
- communication and functionality of the ADCs
- power voltages
- shorted or disconnected lines at sensor interface connectors

Calibration 14.2.6

Factory calibration is stored on the board (no field calibration necessary).

Connectors and LED's 14.2.7

Figure 14.3. The picture below shows a nitrogen level sensor



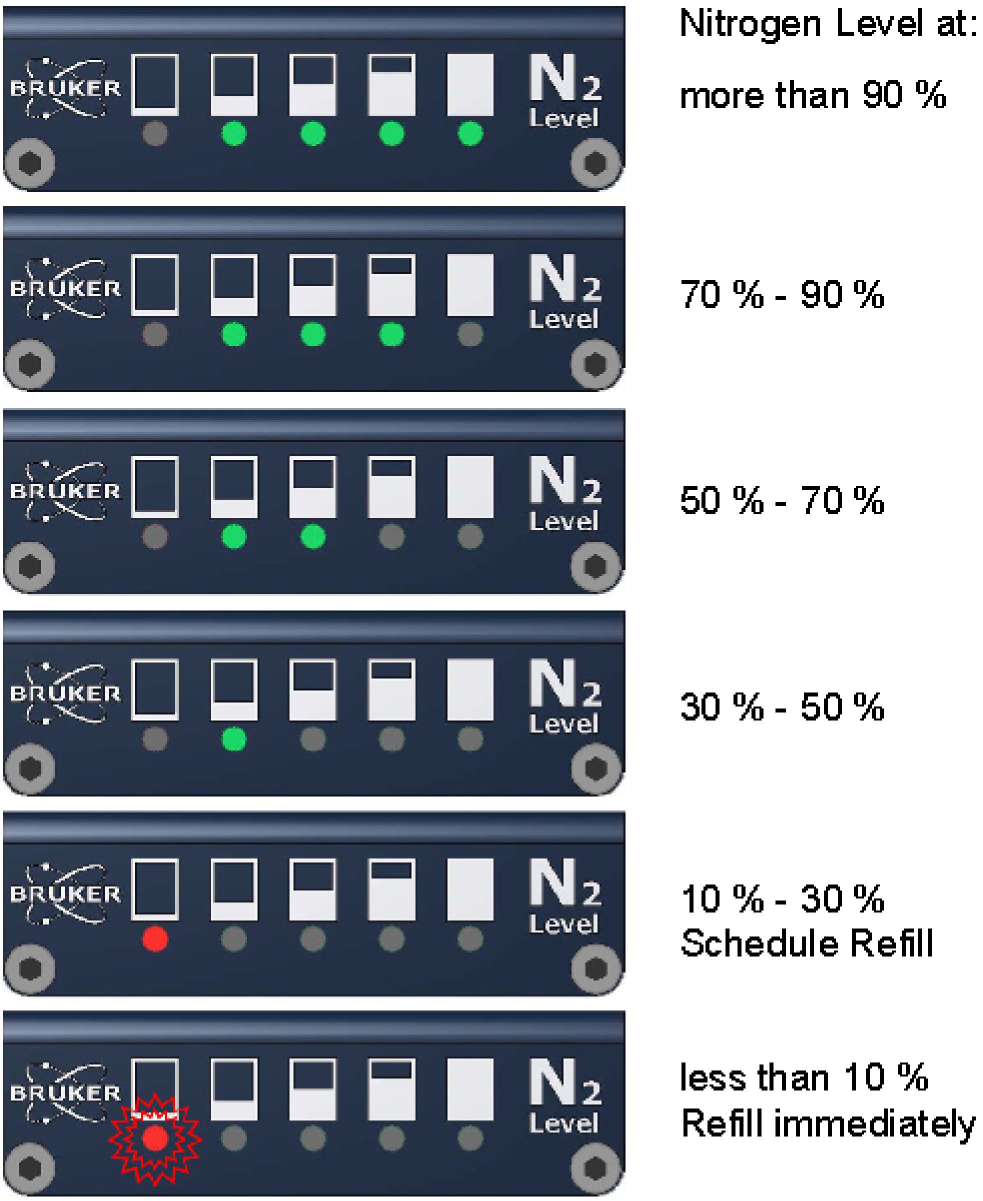
LED's

Like the VT adapters the LN2 sensor can be connected or disconnected at any time.

In general, the

- green LED's indicates the current nitrogen level
- red LED indicate an error or low nitrogen level

Figure 14.4. LED Code on N2 level sensor



Interface

The N2 level sensor is connected to the BSMS/2 BSVT electronics (back panel RJ45 connector labeled NITROGEN LEVEL) and to the CryoPlatform if a BSNL option is installed (Bruker Smart Nitrogen Liquefier). These units provide the necessary power supply and data interface signals.

Figure 14.5. D-Sub 9 male, pin assignment

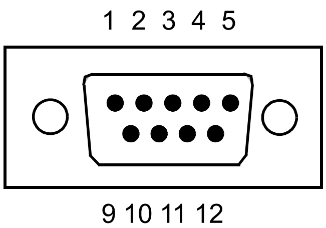


Table 14.1. D-Sub 9 male, pin assignment

DSub Pin	Digital Systems (BSVT)	Analog systems (SLCB/3)
1	BFB TX+	+10V
2	BFB RX-	-10V
3	BFB RX +	NC
4	reserved	NC
5	NC	NC
6	BFB RX-	analog output (-5V..0V)
7	BFB 5V	GND
8	GND	GND
9	reserved	NC

Figure 14.6. D-Sub 15 male, pin assignment

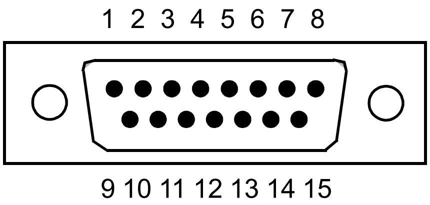


Table 14.2. D-Sub 15 male, pin assignment

DSub Pin	Signal
1	sensor excitation + (input)
2	sensor excitation - (input)
3	sensor signal - (sense output)
4	sensor signal + (sense output)
5	NC
6	NC
7	NC
8	detection +
9	NC
10	NC
11	NC
12	NC
13	NC
14	detection -
15	NC

Service *14.3*

This new digital nitrogen level sensor does not need any calibration in the field, the product is factory calibrated.

Service Web *14.3.1*

There is an ELCB service web page available for the nitrogen level measurement.

Diagnostic and Trouble Shooting *14.3.2*

The device state is displayed using the 5 LED. See ***"LED‘s" on page 265*** for detailed description.

In addition, on-board diagnosis data or failure events are sent to the ELCB immediately and displayed within Topspin GUI or logfile.

System requirements *14.4*

See ***"Configurations and installation" on page 261*** and ***"Support for Nitrogen Level Sensor" on page 177***

Ordering information *14.5*

Part numbers of the sensor depend on magnet size and height. Please consult the magnet documentation for an appropriate model and contact the sales department

magnetics@bruker.ch

Part numbers of cables in case of an upgrade can be found in ***"Digital configuration" on page 262*** and ***"Analog configuration" on page 263*** respectively.

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