



BSMS/2 Systems with ELCB

Technical Manual

Version 001



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P/N: Z108028

DWG-Nr.: Z4D10209-001

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Safety Instruction

1

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.

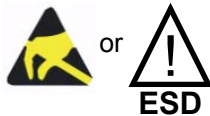


Figure 1.3. Electrostatic sensitive Device!

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 these 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

Based on the BSMS/2 mainframe that was introduced into market in 1998, there is now an enhanced BSMS/2 system available. The former Controller, Lock and Shim Boards (CPU/3, LCB, all variants of SCB7/13) are now replaced by a set of higher integrated boards (ELCB and SCB20), which provide better performance, higher resolution and increased stability. The Shim boards have been unified - a standard SCB20 provides now the necessary precision for all possible variants of connected Shim Systems.

The new ELCB software takes over the functions of the former CPU/3 and Lock firmware. It can be accessed over an ethernet link and provides a CORBA interface for TopSpin version 2.0 and higher. For TopSpin version 1.3 there is an additional RS232 interface providing the communication with the former SBSB protocol.

Note that the BSMS/2 chassis must have at least ECL 02.00 for supporting the new boards.

A new Web-based service tool is available, 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 ELCB based BSMS/2.

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.

Both, the VME and the user bus are controlled by the new ELCB. In addition to this board, there are typically a L-TX and L-RX board (Lock RF boards), one GAB or GAB/2 (gradient amplifier), one or two SCB20 (Shim Control), a 2H-TX (Deuterium transmitter) and a SLCB/2 (Sample and Level Control Board) plugged in a BSMS/2 rack at the front side.

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	195 .. 245	Vrms	Mains selector range
	Frequency	47 .. 63	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

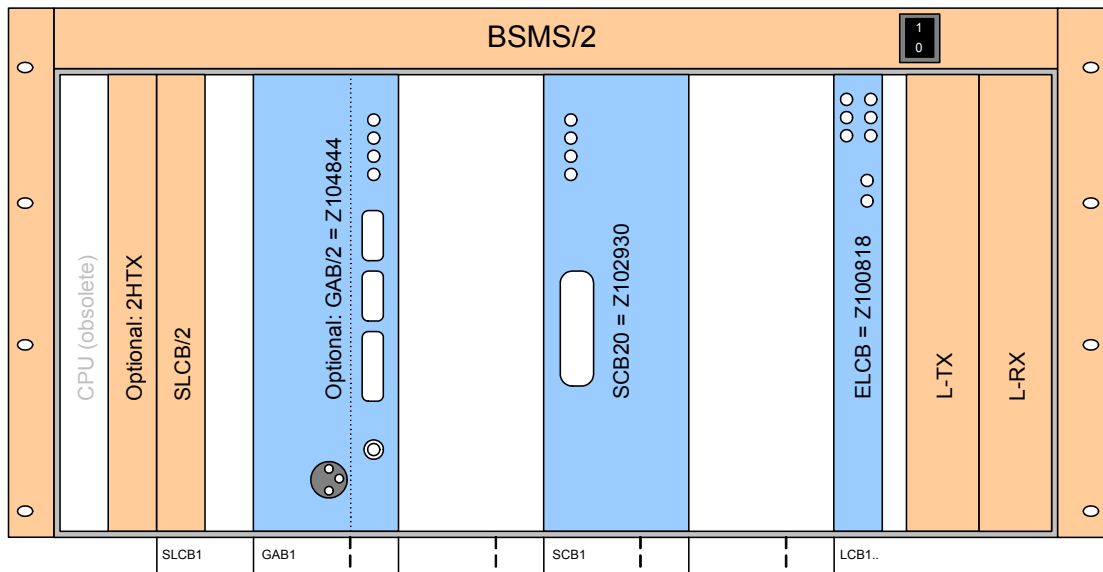
There are basically two standard configurations, described in the following sub chapters.

BOSS1 Configuration

2.3.1

The diagram below shows a typical BOSS1 configuration. The Gradient Amplifier (GAB/2 or GAB) and the 2HTX are optional - in Solids configuration there are no RF boards (L-TX and L-RX). The new SCB20 provides a 50 pin connector 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



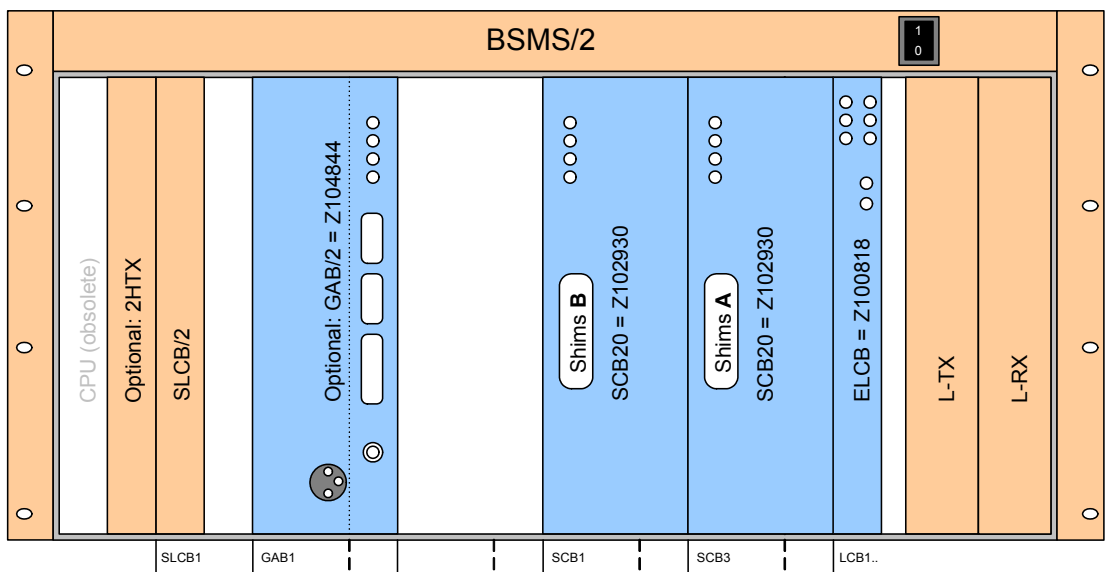
Important: Note the position of the SCB20 for BOSS1 systems!

Configuration for BOSS2, BOSS3 and BOSS-WB

2.3.2

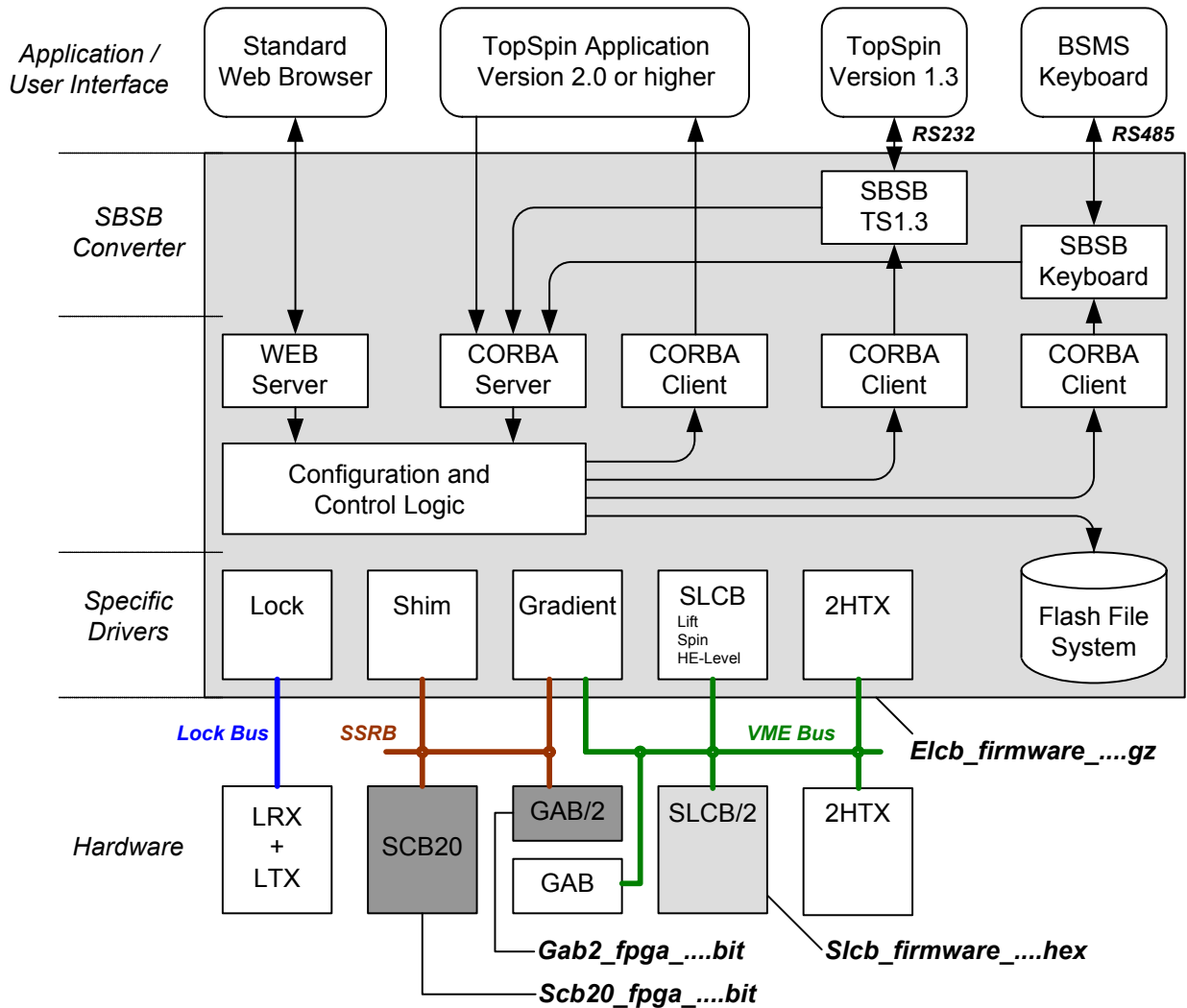
Non-BOSS1 Systems requiring more than 20 Shim currents need a second SCB20. Similar to the former BSMS/2 systems, the Shim cables „A“ and „B“ have to be connected from right to left.

Figure 2.2. Configuration for BOSS2, BOSS3 and BOSS-WB



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 2.3. System Architecture / Overview



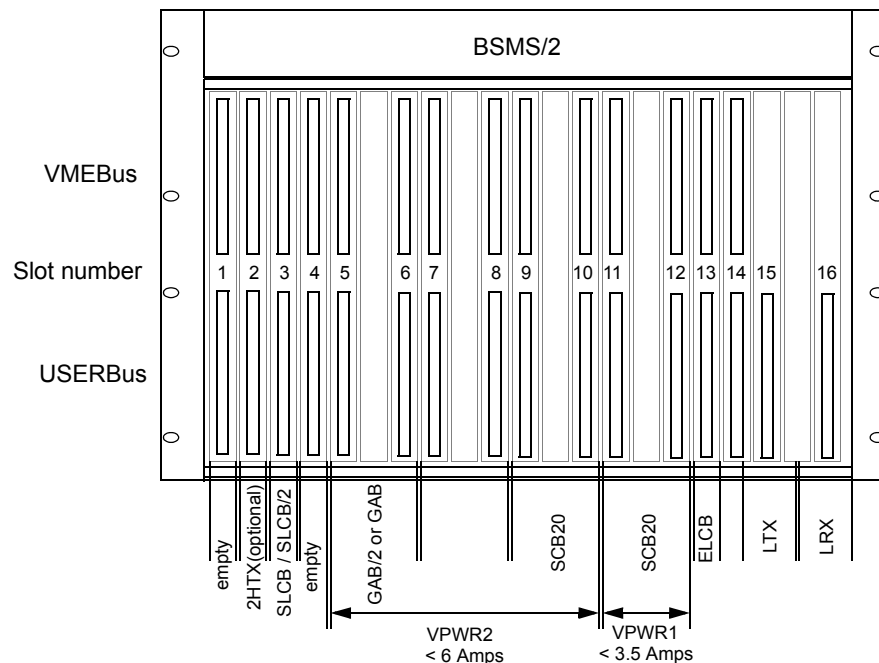
From the firmware perspective, there are two embedded applications - the ELCB firmware that controls the complete BSMS/2, and the SLCB/2 firmware for Lift, Spin and HE-Level control (this firmware has not been changed with the introduction of the new ELCB based BSMS/2 system).

Additionally there are two FPGA designs for each, the SCB20 and the GAB/2 which provide field upgrades of the hardware.

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 2.4. 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 and PSB2.

Note[4]: The pneumatic control board is plugged in the rightmost slot at the rear side.

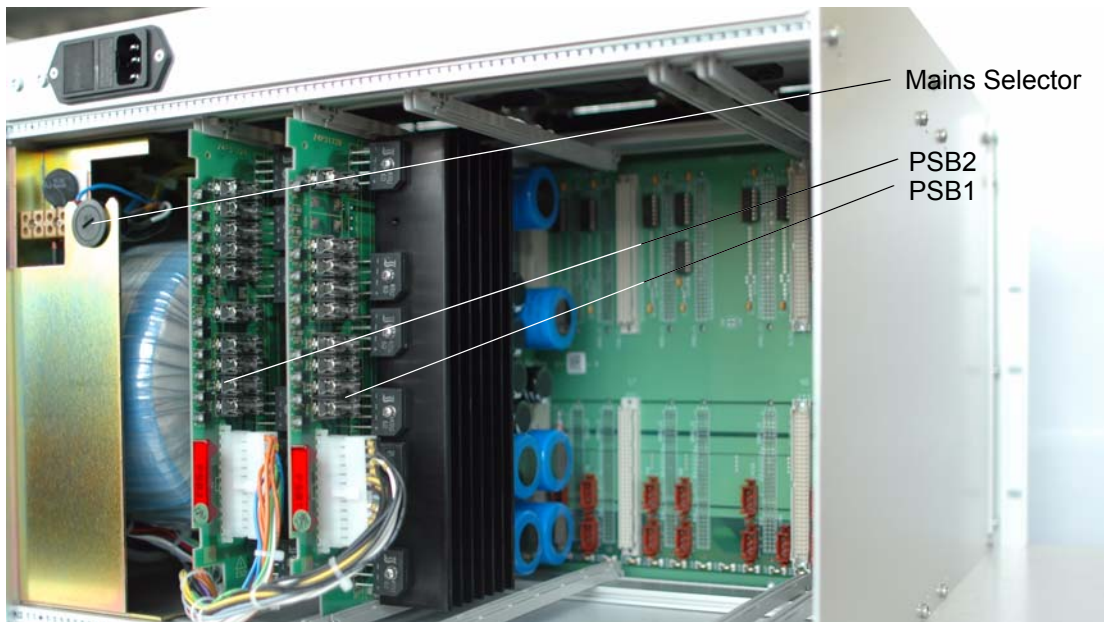
Note[5]: Slot 17 is foreseen for the probe temperature control.

BSMS/2 System with ELCB

Figure 2.5. Front View of BSMS/2 Rack



Figure 2.6. 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

2.6.3

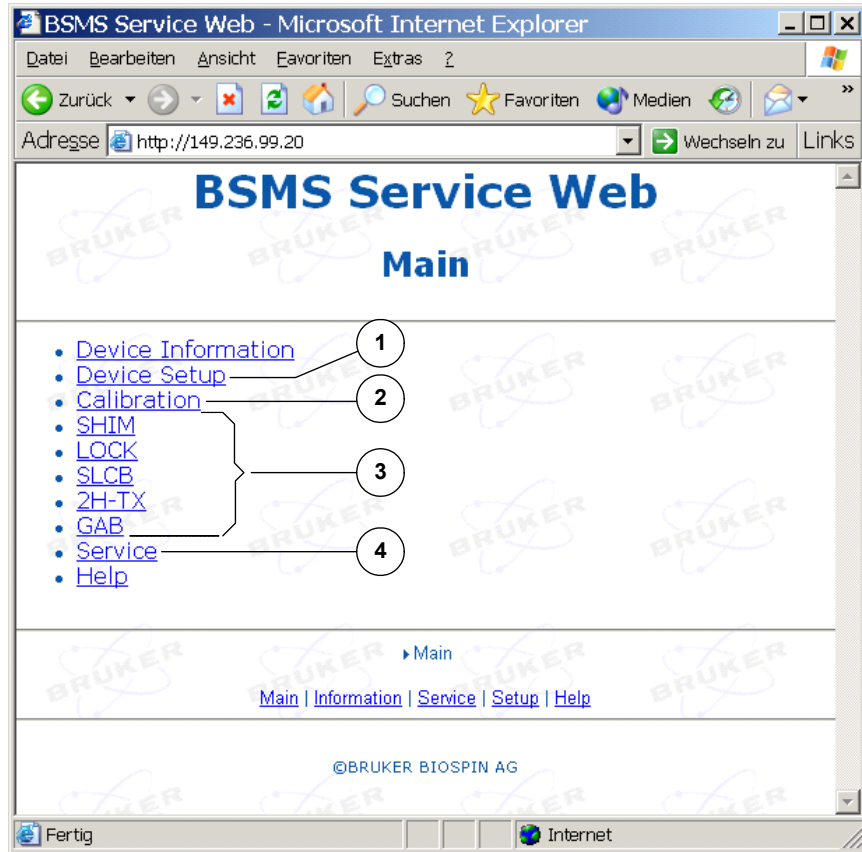
In typical TopSpin 1.3 configurations (no DHCP server in the spectrometer network) the BSMS/2 has the fixed IP address **149.236.99.20**.

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 2.7. BSMS/2 Main Service Page



1. 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).
2. Calibration: Links to the different specific calibration routines that are necessary upon installation of a spectrometer (e. g. for Helium level measurement, spin calibration, air pressure for lift, and so on).
3. Access to the specific subsystem functions - these functions are basically intended for diagnostic and troubleshooting.
4. 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 restricted functions / parameters).

Installation and preparation for use

2.7

The BSMS/2 mainframe must be installed at its 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

2.7.5

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:

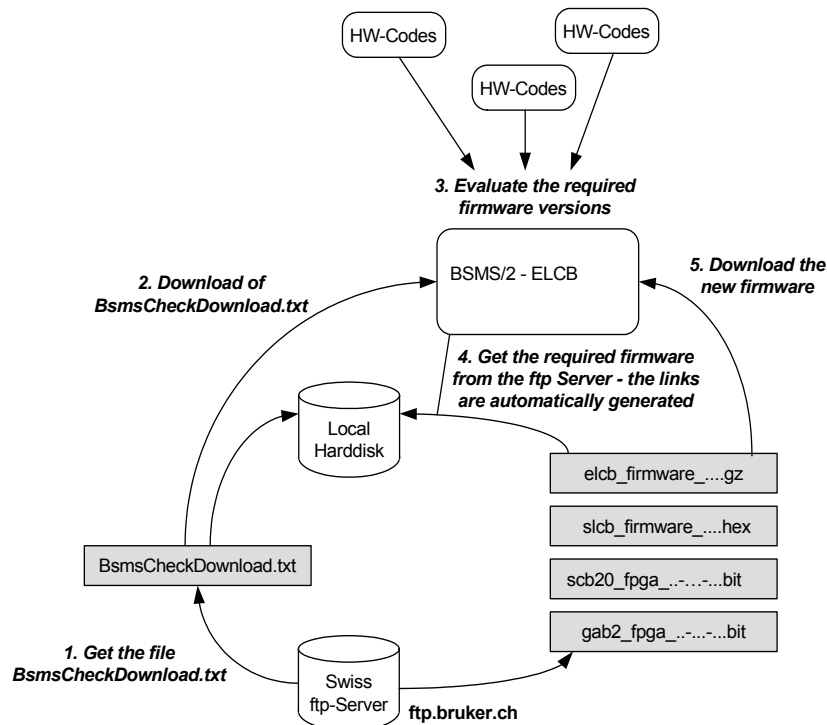
- 230 V stable mains power => choose the 220 - 245 VAC position
- 230 weak / unstable mains power => choose the 210 - 230 VAC position

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

2.7.6

Figure 2.8. 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 harddisk, 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 2.9. Setup of the BSMS/2 firmware

The screenshot shows the 'BSMS Service Web Setup' interface. It includes a 'Check Firmware Download' section with a table comparing required and loaded firmware. A 'BSMS/2 Configuration' table is also present at the bottom of the page.

Required Firmware		Loaded Firmware		
Load new ELCB firmware 1)	elcb_firmware_060809.gz	elcb_firmware_060809.gz		ok
Load new SCB20 firmware 1)	scb20_fpga_00-00.bit	scb20_fpga_00-00.bit SCB20aa_b_050620.bit		not ok
Load new GAB/2 firmware	gab2_fpga_00-008-00.bit	gab2_fpga_00-008-00.bit		ok
Load new SLCB firmware	slcb_firmware_931105.hex	slcb_firmware_931105.hex		ok

BSMS/2 Configuration								
	SLCB	2HTX	GAB/2	SCB20	SCB20	ELCB	LTX	LRX
Specific:	PNK5 (40)		SN 15	SN 3	SN 11	SN 2	600 MHz	
HW Code:	64	-	8	88	88	0	32	8
ECL:			1.00	0.01	0.01	0.00	19F Option	

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

2.7.7

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

Figure 2.10. Calibration and System Configuration



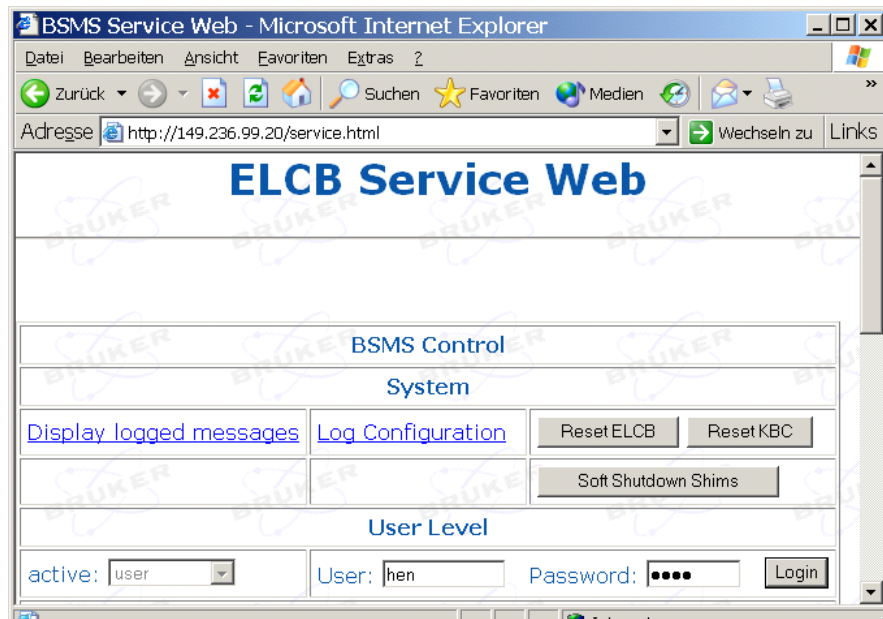
Establishing the Service Engineer Access Level

2.7.8

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.

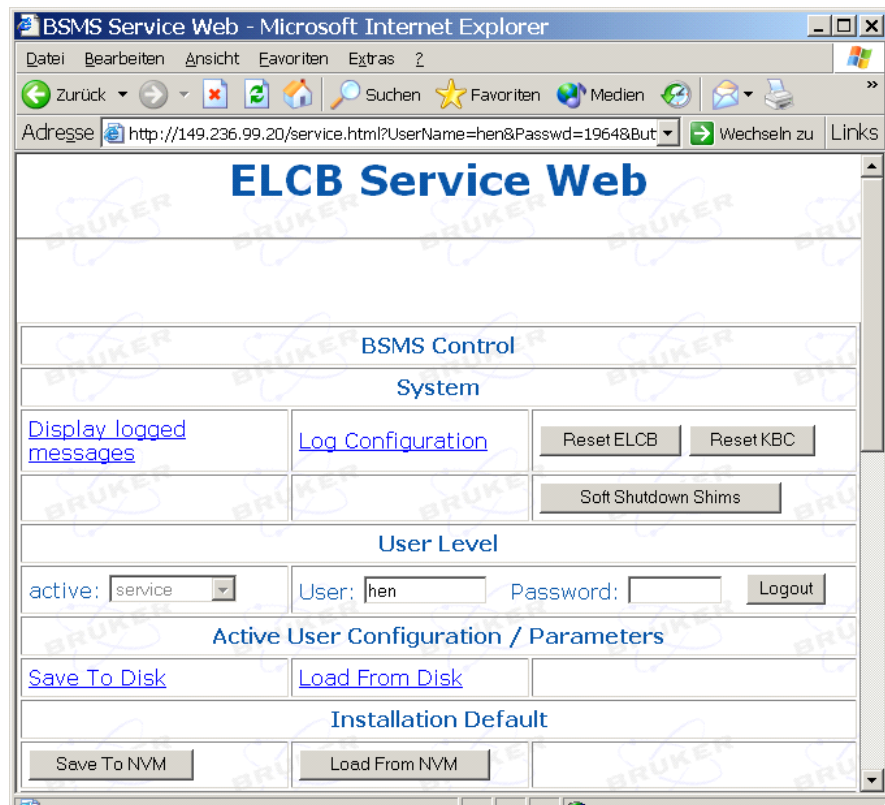
Figure 2.11. Log in as service engineer



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 2.12. Service Page after successful service engineer registration



Lift and Spin Calibration

2.7.9

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 depressing the appropriate buttons, and each step of the calibration is listed / described on the Web page.

Helium Level Measurement Calibration

2.7.10

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

2.7.11

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

2.7.12

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

2.7.13

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 or a PNK, 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 Shut-down 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).

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.

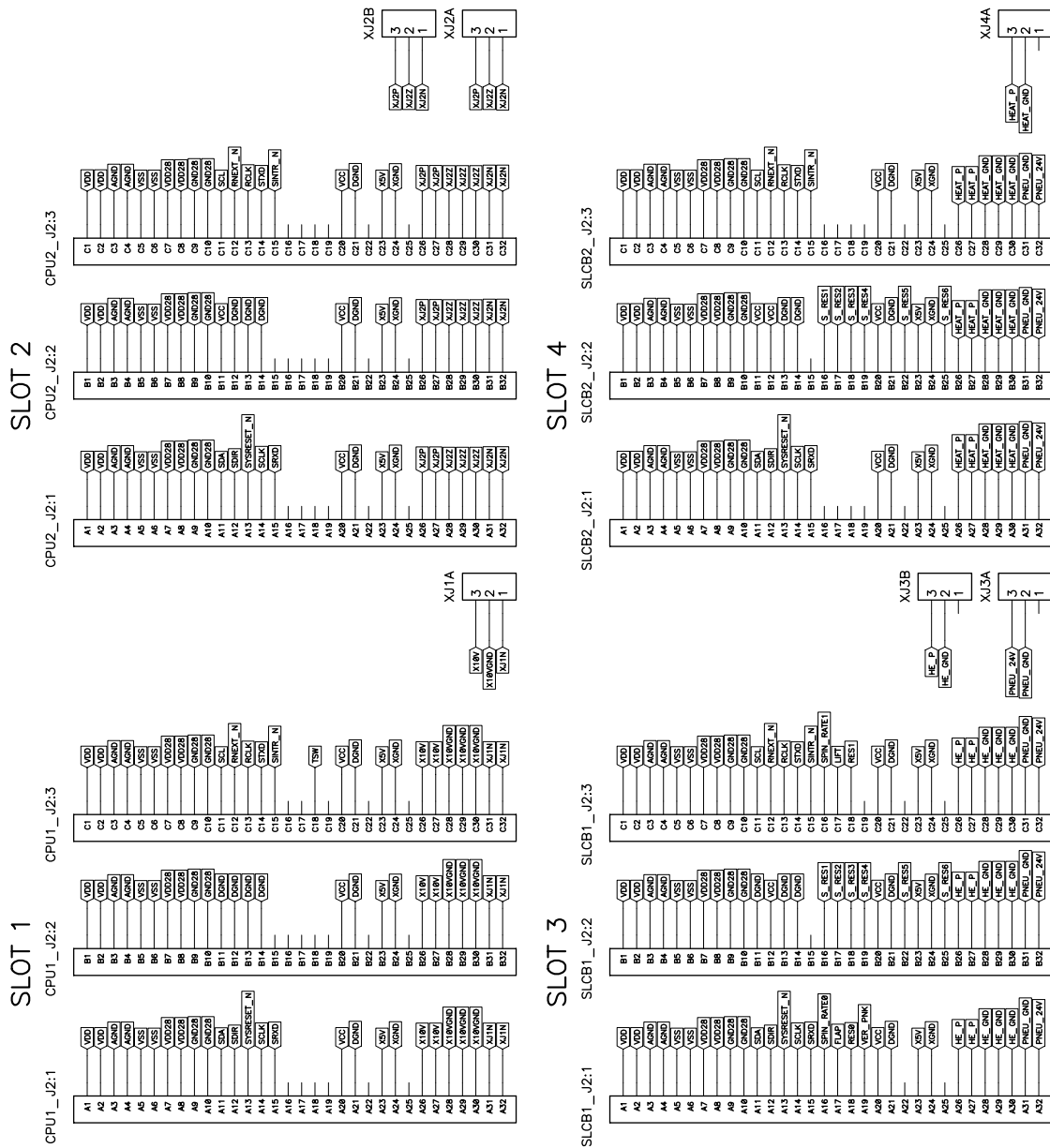
Additionally, it is possible to activate periodical transfer of that logging information to the hard disk of the workstation. This feature is available in TopSpin (version 2.0 or higher) by typing the command „bsmsdisp“ and selecting the Service Tab. There is a check box for enabling this transfer and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

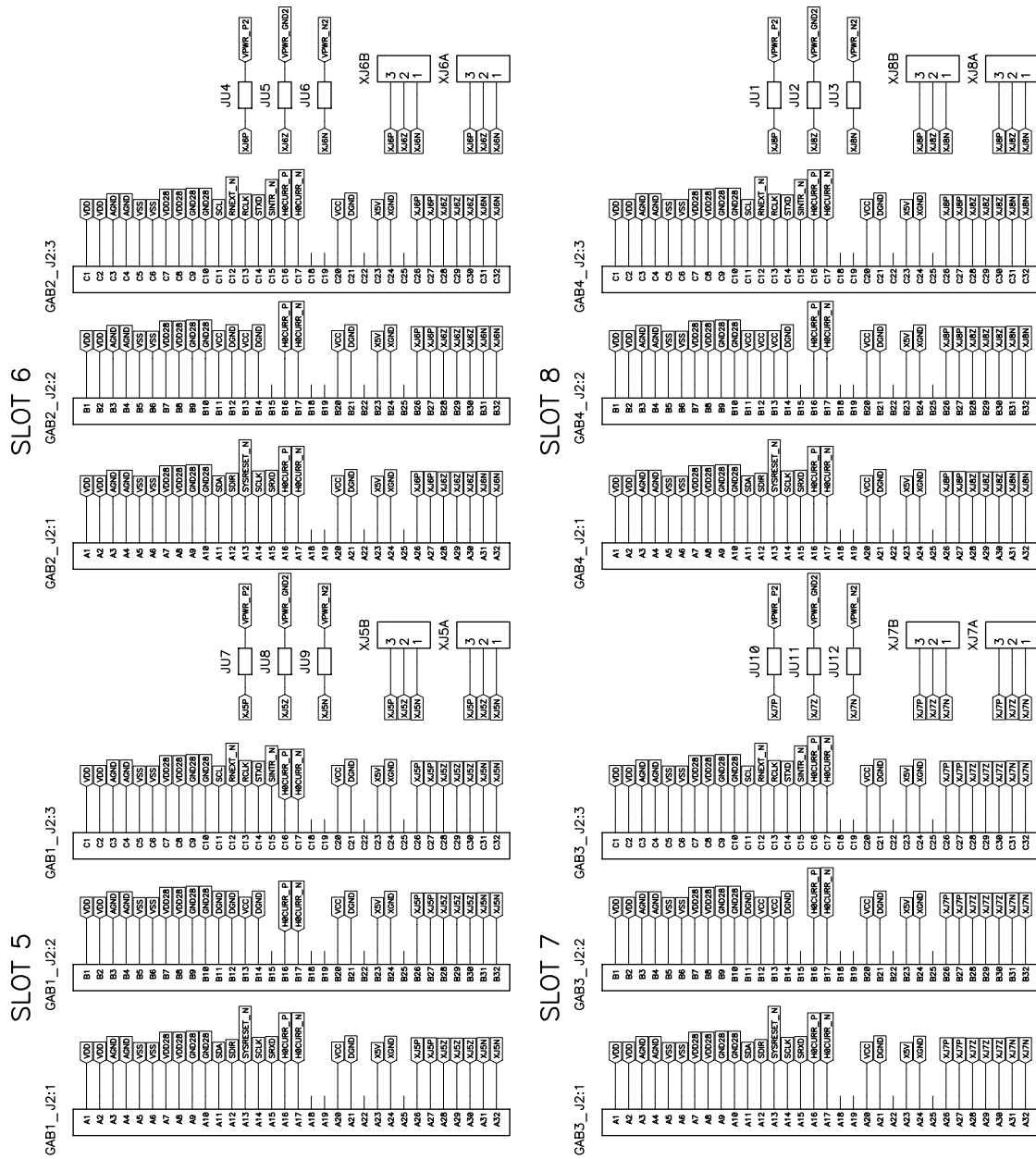
After a restart, the logging of the session before - the post mortem log - is still available (depress „PostMortem“ button on the page „display logged messages“), providing additional information.

Figure 2.15. Backplane - Slot 1 to 4



Elma Trenew Electronic
 Backplane: 017-333 R0.0
 New design based on BSMS/2
 (Bruker Z13595ECL.1.0)
 Date: 05.07.2002
 Page: 1/6
 VM

Figure 2.16. Backplane - Slot 5 to 8



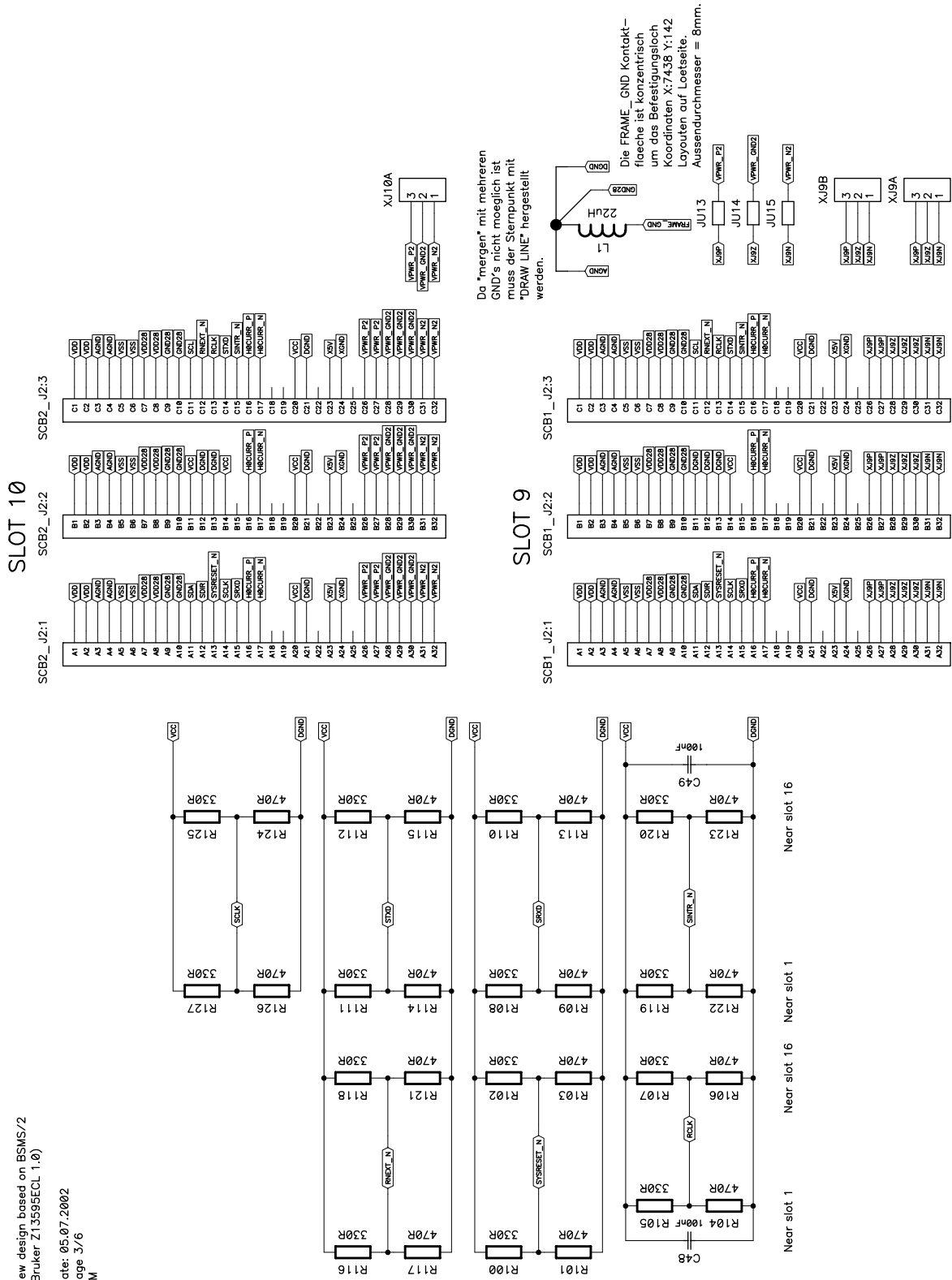
Elma Trenaw Electronic
 Backplane: 017-333 R0.0
 New design based on BSMS/2
 (Bruker Z13595ECL 1.0)

Date: 05.07.2002
 Page 2/6
 VM

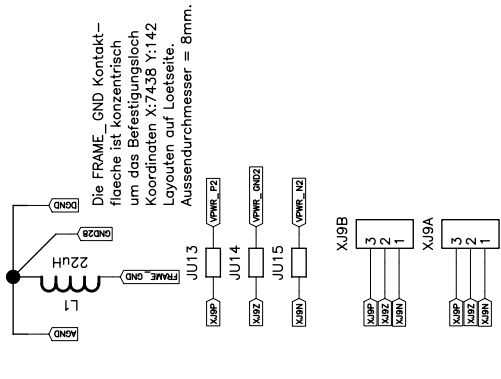
Figure 2.17. Backplane - Slot 9 and 10

Elma Trenew Electronic
 Backplane: 017-333 R0.0
 New design based on BSMS/2
 (Bruker Z13595ECL 1.0)

Date: 05.07.2002
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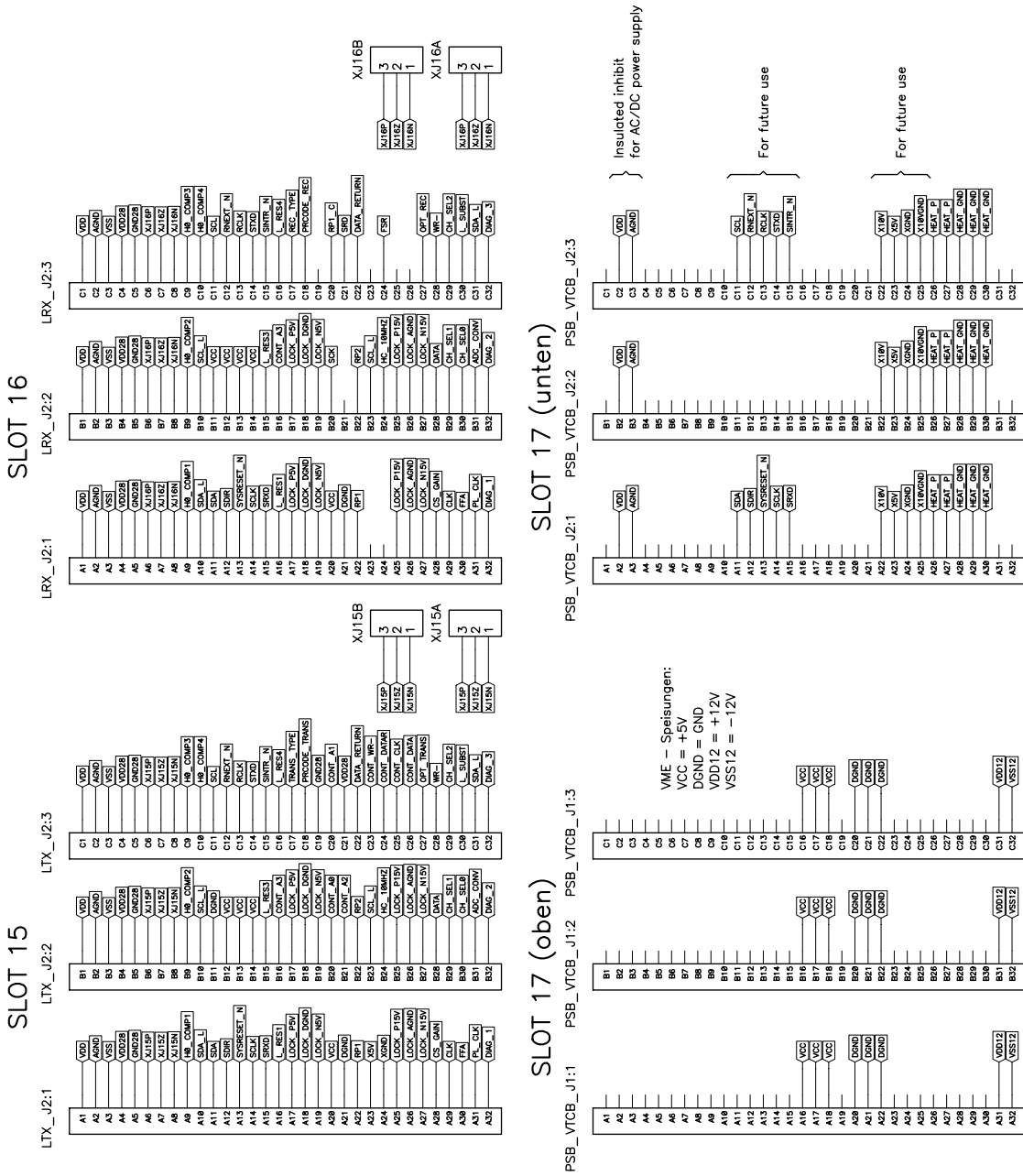


Da "mergen" mit mehreren GND's nicht möglich ist muss der Sternpunkt mit "DRAW LINE" hergestellt werden.



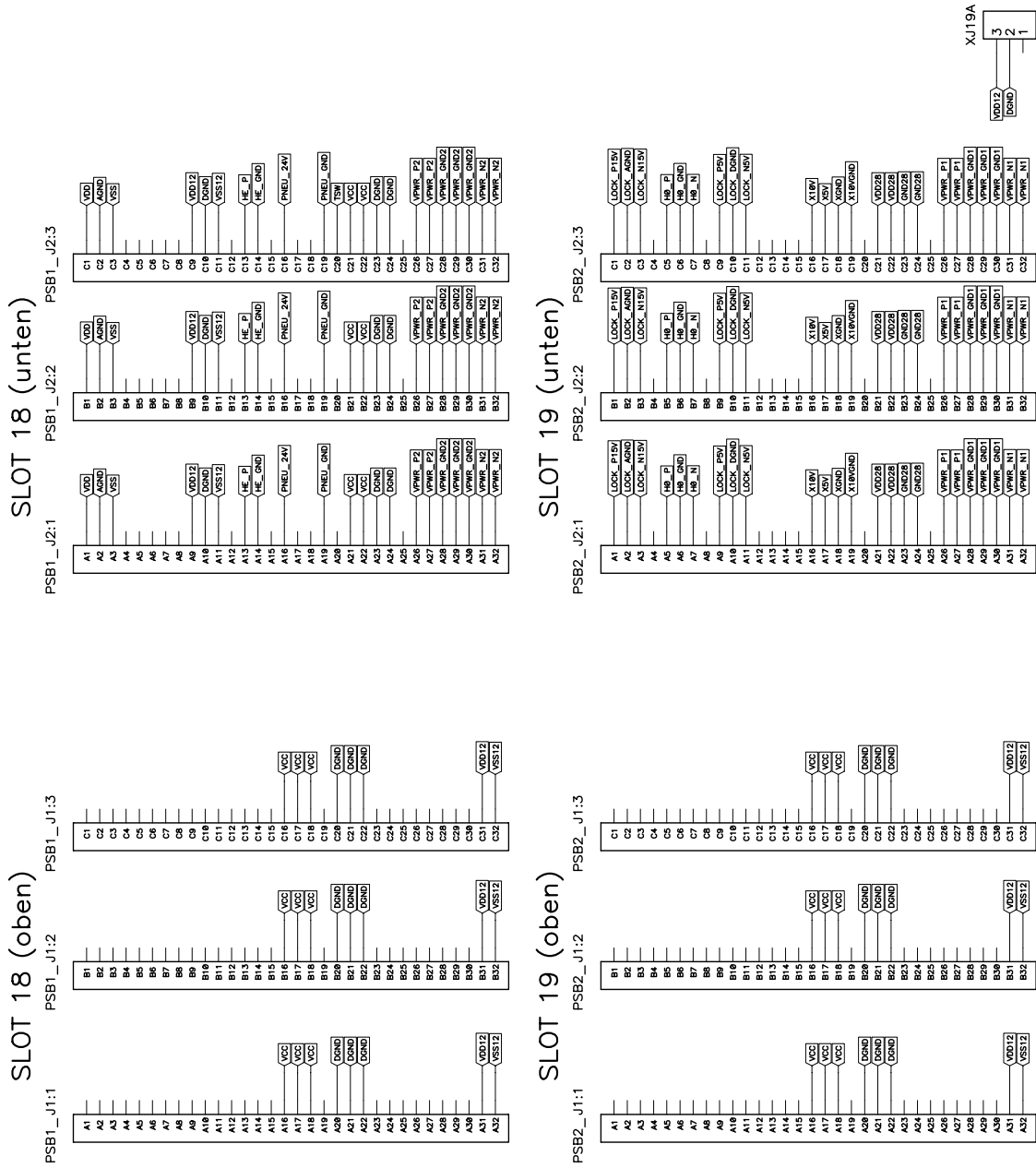
Die FRAME_GND Kontaktfläche ist konzentrisch um das Befestigungsloch mit den Koordinaten X:7.438 Y:1.42 Layouten auf Lotseite. Aussendurchmesser = 8mm.

Figure 2.19. Backplane - Slot 15, 16 and 17



Elma Trenew Electronic
 Backplane: 017-333 R0.0
 New design based on BSMS/2
 (Bruker Z1559SECL 1.0)
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Figure 2.20. Backplane - Slot 18 and 19



Elma Trenew Electronic
 Backplane: 017-333 R0.0
 New design based on BSMS/2
 (Bruker Z13595ECL 1.0)
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There are two different Power supply boards that are plugged from the rear side into the backplane - 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 (wich can be exchanged without plugging out the PSB).

Table 2.2. PSB1 Electrical Characteristics

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*	VPWR_GND2	20 .. 25 V	6.0 A	1 V	8.0 AT
VPWR_N2*	VPWR_GND2	-20 .. -25 V	6.0 A	1 V	8.0 AT

Note[*]: The naming may be a bit confusing - nevertheless, VPWR_P2 / VPWR_GND2 / VPWR_N2 belong to the power supply PSB1.

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

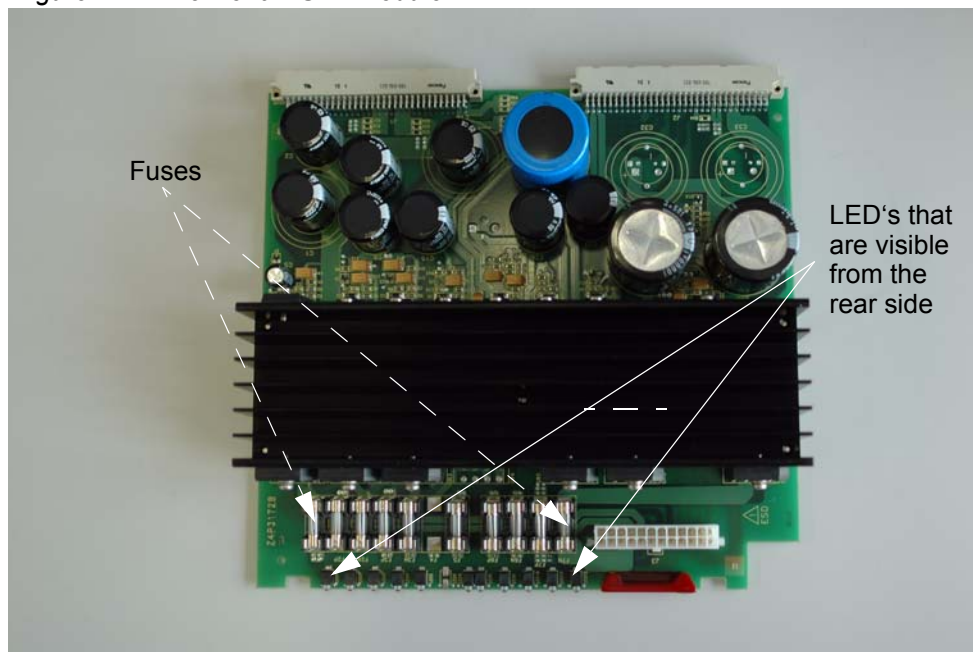
Table 2.3. PSB2 Electrical Characteristics

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

Table 2.3. PSB2 Electrical Characteristics

Voltage Name (LED)	Reference	Voltage @ rated load	Current @ rated load	Volt. ripple	Fuse
LOCK_N15V	LOCK_AGND	-15 +/- 0.6 V	1.0 A	20 mV	1.25 AT
VPWR_P1*	VPWR_GND1	20 .. 24 V	3.5 A	0.8 V	4.0 AT
VPWR_N1*	VPWR_GND1	-20 .. -24 V	3.5 A	0.8 V	4.0 AT

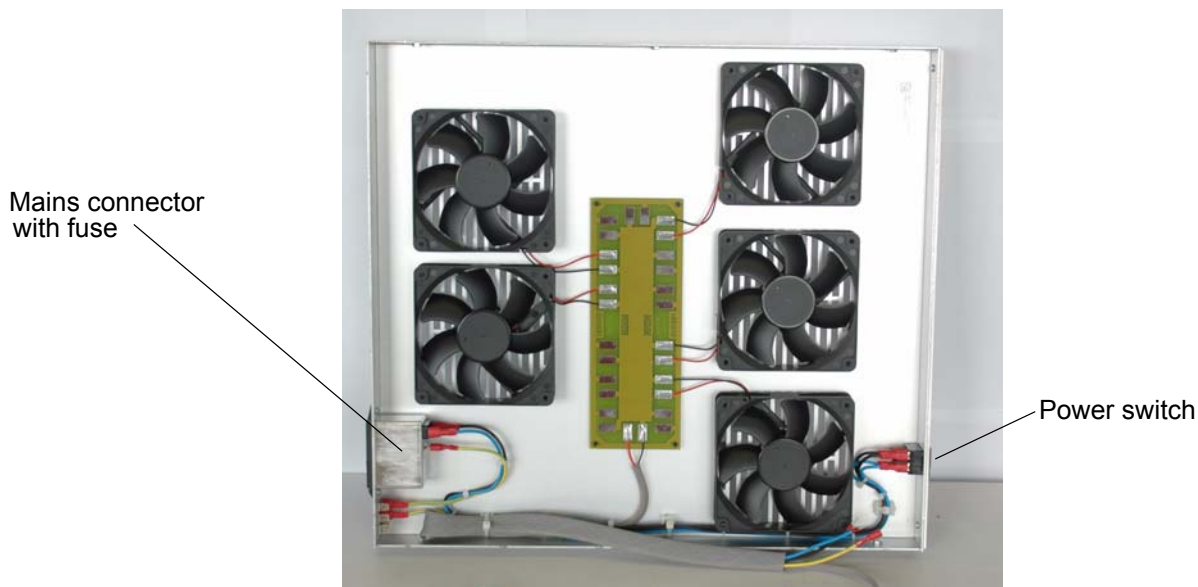
Figure 2.21. View of a PSB2 module



The PSB1 is similar - it is based on the same printed circuit layout, but with different components on it.

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 2.22. Fan Tray



Fan Repair procedure

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

Figure 2.23. 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 2.24. Fan Tray Reassembly, step by step

1) Get a fan repair set



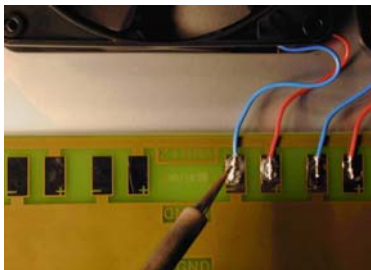
2) fix the rubber fittings



3) place the fan wire side towards the solderpads



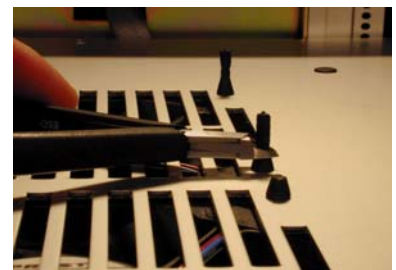
4) solder the wires red => +
black or blue => -



5) plug the fan with the rubber fittings and pull from the other side until they snap in



6) shorten the rubber fittings if necessary



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. All 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 analysed. This provides a simple and fast lock in. The Auto-Lock functions have been optimized as well.

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	
Sweep Rate	0.01	2.00	5.00	Hz	

Table 3.1. Parameter and Technical Data

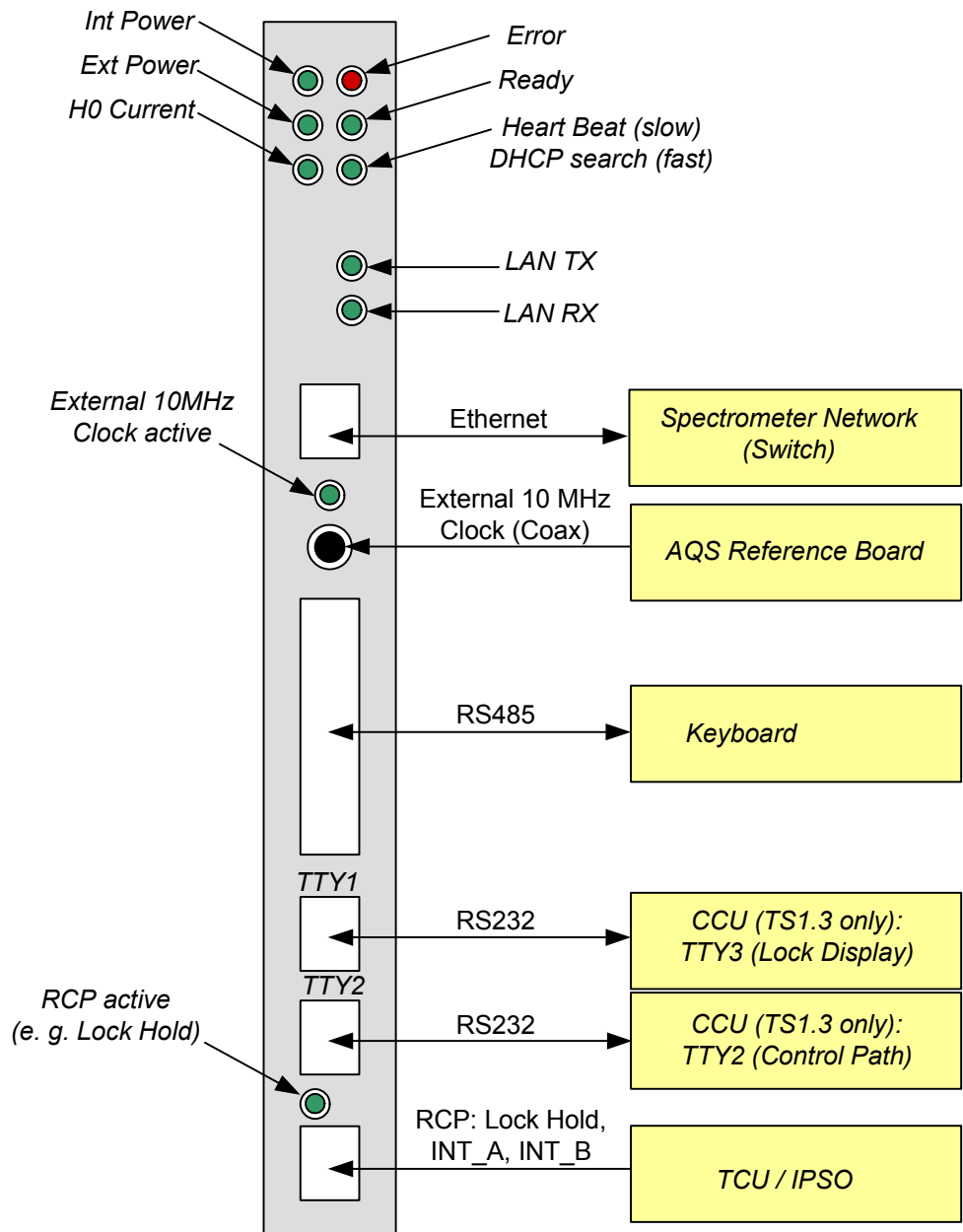
Parameter	Min	Factory Default	Max	Unit	Notes
Lock Phase	0.0	180.0	359.9	Degrees	1)
Lock Power	-50.0 -60.0 -60.0	0.0 0.0 0.0	+10.0 +0.0 +10.0	dB dB dB	2)
Lock RF Gain 2H Lock RF Gain 19F	75.0 55.0	120.0 120.0	155.0 135.0	dB dB	
Lock Shift	-200.0	0.0	200.0	ppm	
Lock Drift	-2000.0	0	2000.0	Field Units / 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.

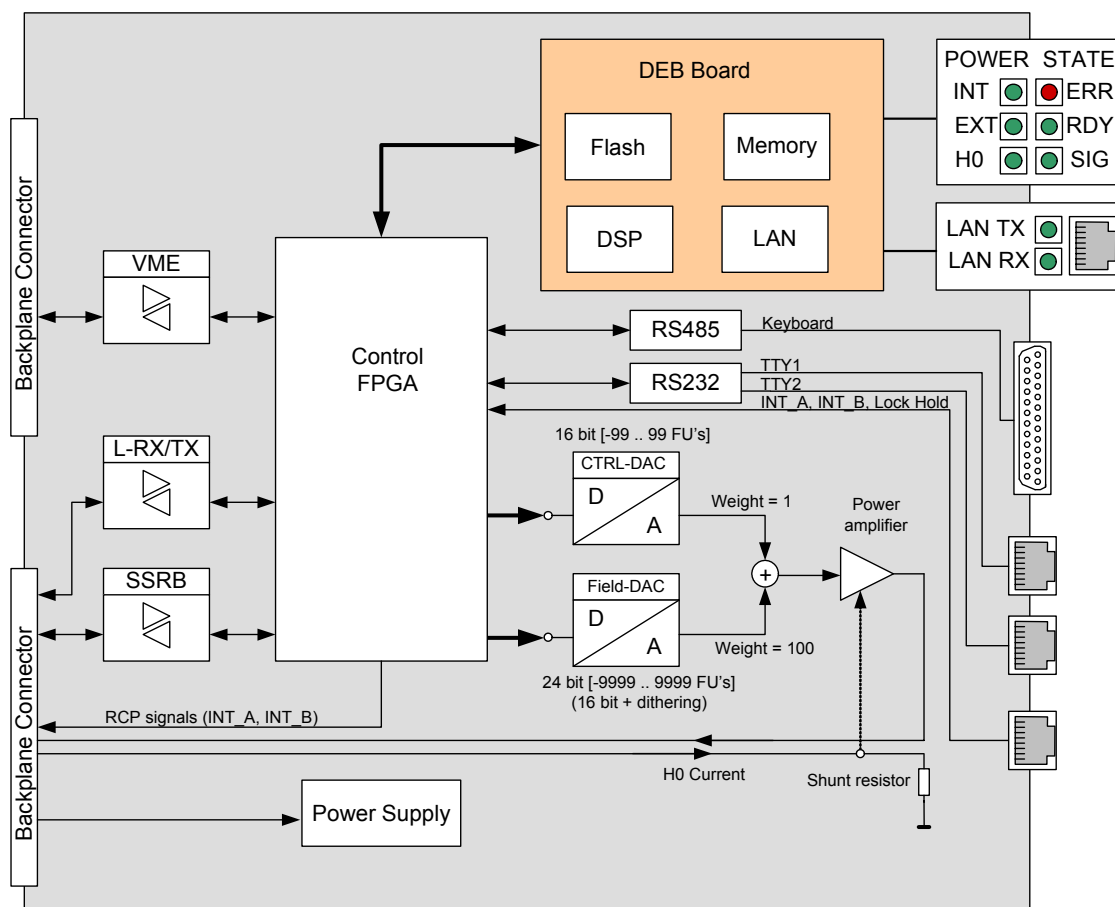
1. Values from -1000.0 to + 1000.0 degrees are accepted, however the actual phase is evaluated modulo 360 degrees.
2. The actual range depends on the hardware code and on the frequency: The first series of RF boards (HW code 0) had a range from -50 to +10 dB, the next following series (HW code 1 and 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

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.



The following diagram shows the functional system architecture of an ELCB:



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 and GAB/2) communicate over SSRB, whereas the 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.

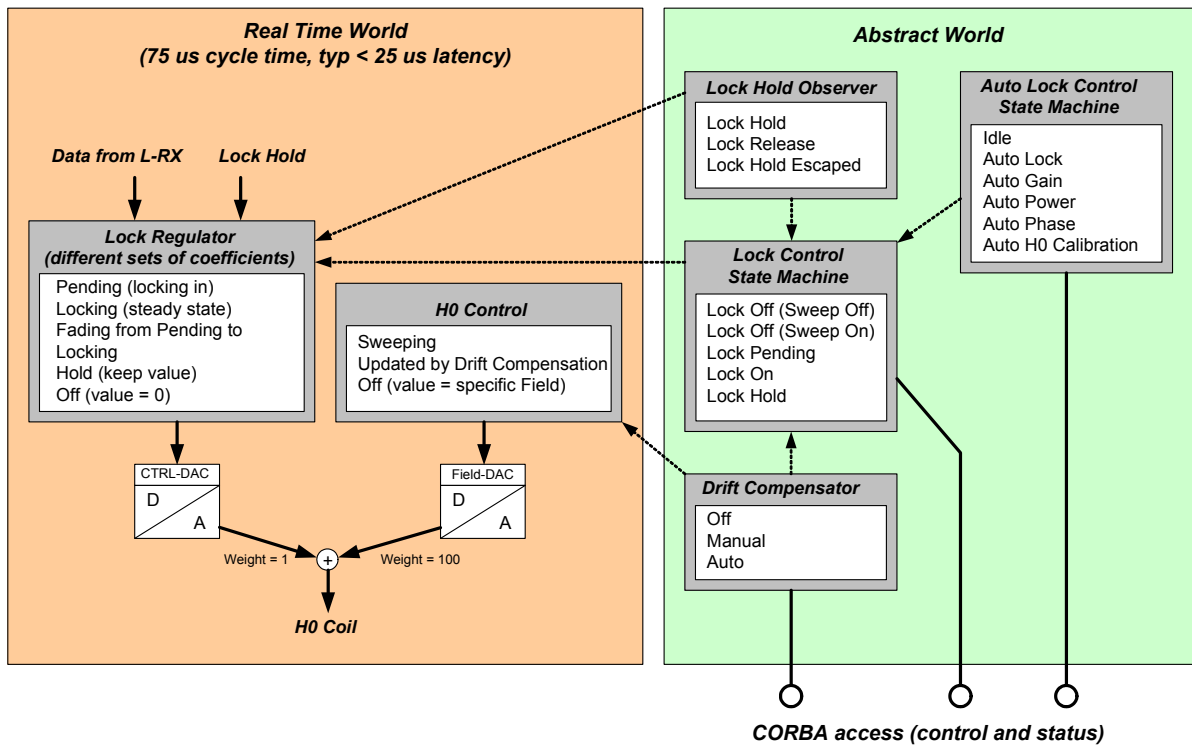
The Keyboard support, which has formerly been implemented in the CPU, is now provided by the ELCB (see also description in the overview chapter).

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.

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 sub-systems can be found in the related chapters.



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 behaviour 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.

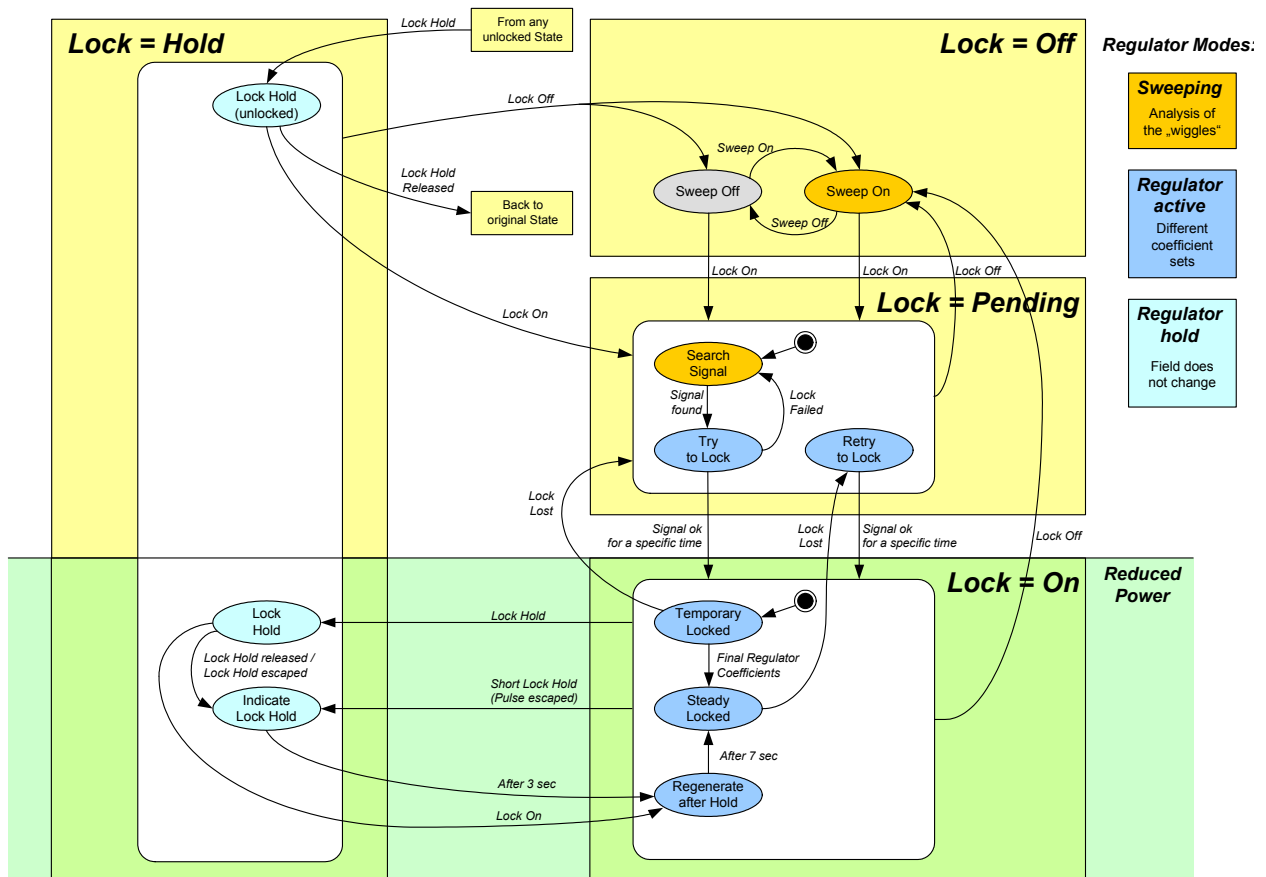
The Diagram below shows the Lock Control State Machine, which handles the requests from the CORBA or Web interface and controls the transitions between the different lock states.

In comparison with the former LCB, the procedure of locking in has been optimized and is now very reliable. 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.



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 (L-RX / L-TX):

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.

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.

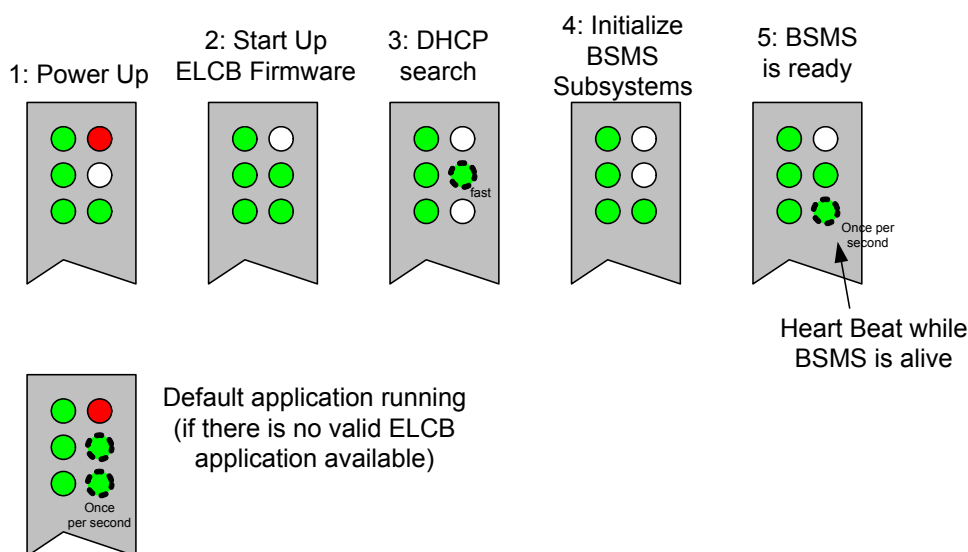
Display / Download of the latest FFA:

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.

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.

The diagram below shows a typical behaviour 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).



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).

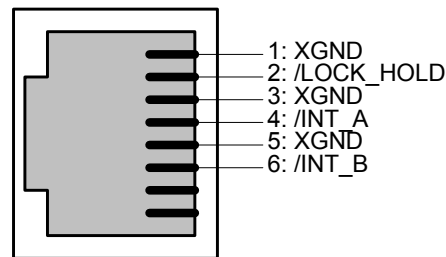
Table 3.2. User Bus Back Plane Connector

	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	/BP_RCP0	/BP_RCP1	-
11	GPIO1	SLOT_ID[0]	GPIO2
12	GPIO0	SLOT_ID[1]	/RNEXT
13	/SYS_RESET	SLOT_ID[2]	RCLK
14	SSRB:SCLK	SLOT_ID[3]	SSRB:STXD
15	SSRB:SRXD	LTX:CTRL_DATAR	SSRB:/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	LTX:CTRL_CLK	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

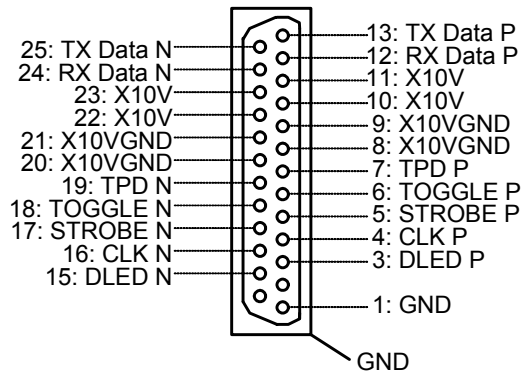
Note: The signals indicated with a gray pattern are not actually used - they are reserved for future extension.

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).



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:



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).

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



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.

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

BSMS Service Web
LOCK Parameter & Commands

LOCK Parameters

Field	Field [FU]	5000.00	Drift [FU/d]	0
	Sweep Amplitude	100.0	Sweep Rate [Hz]	2.00
Lock Out Convention		Keep Field after Auto Lock		
Acquisition	Shift [ppm]	0.000	Power [dBm]	0.0
	Phase [°]	180.0	Gain [dB]	88.0
Display	DC [%]	-75.0		
Controller	Gain [dB]	-32.0	Time [s]	0.136
	Filter [Hz]	200.0		
FFA	Windowing	None	Recovery Deviation [dB]	1.00000

Set Refresh

LOCK Commands

AutoLock AutoGain AutoPower AutoPhase

Auto OFF State: Auto Lock Idle

Manual Lock ON Lock OFF Lock Off Sweep ON Sweep OFF Sweep On

H0 Calibration StartCali Stop / Abort

[Main](#) | [Lock Main](#) | Lock Parameter & Commands
[Main](#) | [Information](#) | [Service](#) | [Setup](#)

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 behaviour 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

3.6.12

LOCK Configuration		
Lock Display Mode	1	Absorption
Drift Mode	2	Automatic drift compensation
AutoLock Mode	3	Field correction
Lock Nucleus	4	Lock on 2H
LTX Blanking	5	Disable
LRX Blanking	5	Disable
H0-Coil Type	6	Standard Bore
H0 Source Polarity	7	Standard
External Z0 Compensation	8	Disable
Hold Pulse Polarity	9	Low active
TP_F0 Pulse Polarity	9	Low active
Lockin Power Step [dB]	10	10.0
H0 Calibration Factor	11	1.00000
LOCK Base Frequency (BF0) [Hz]	12	92123609
LOCK Base Frequency Proton related [MHz]	13	600.130
LOCK Base Frequency DDS [Hz]	14	12123609

[Main](#) | [Lock Main](#) | [Lock Configuration](#)
[Main](#) | [Information](#) | [Service](#) | [Setup](#) | [Lock Main](#)

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 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

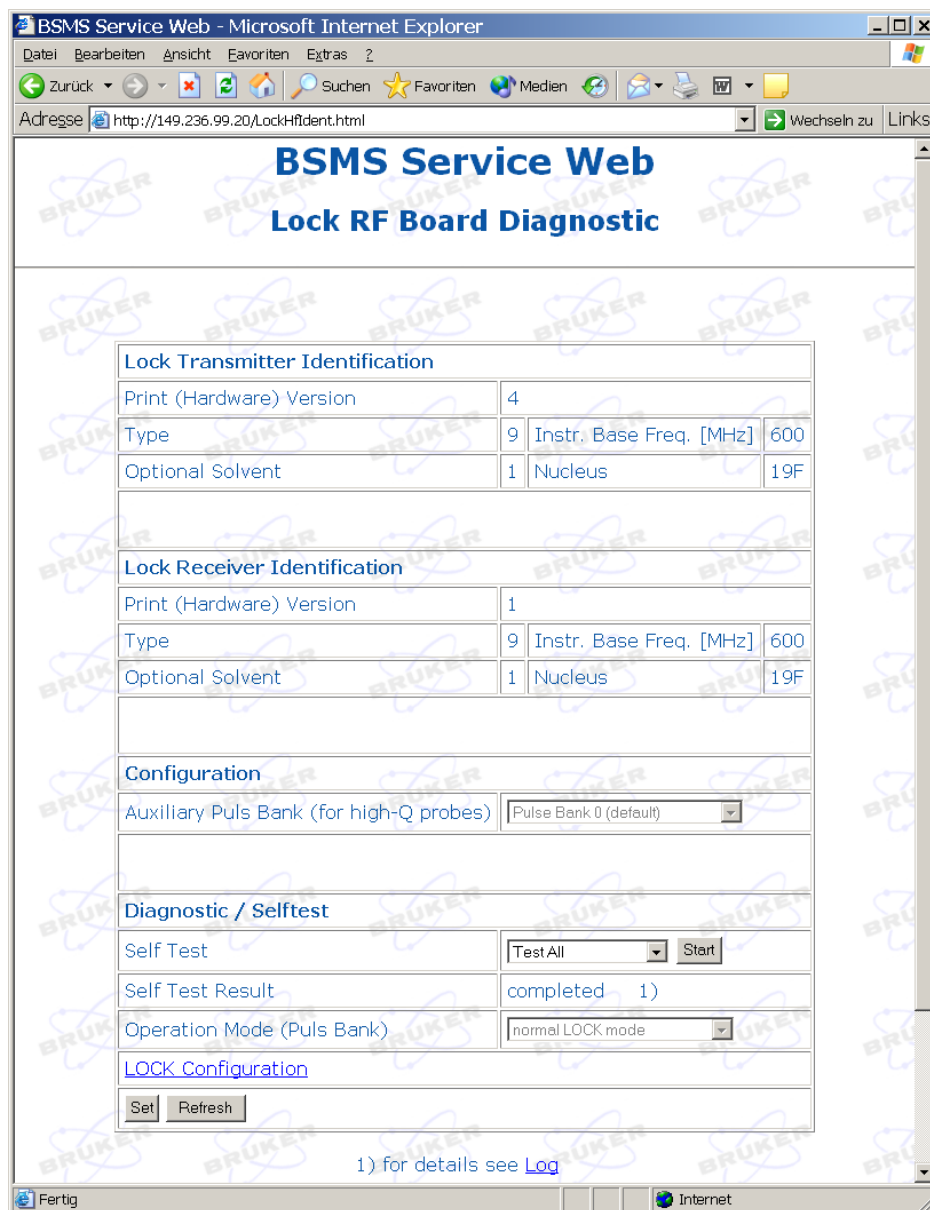
3.6.13

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 / probehead, 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.



The SCB20 (Shim Control Board) is the improved 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 Ampère (-130'000 current units) to +1 Ampère (+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.

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 / °C	
Gain Drift		< 11		ppm / °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		°C	
Current Limit (Power Amplifier)		3.5		Amp	
Current Limit (shunt) for Shut Down		1.2		Amp	

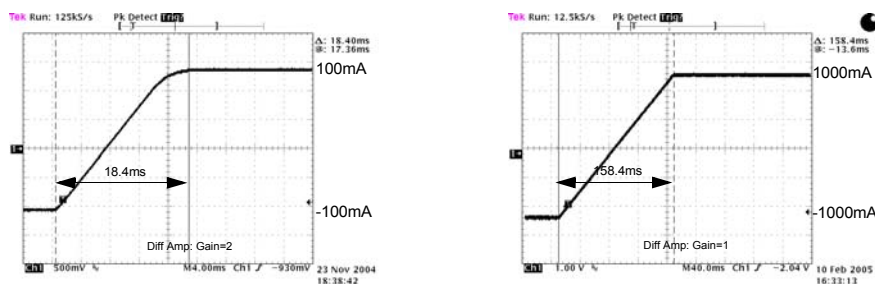
1. The SCB20 boards are calibrated in the factory in order to achieve this accuracy. The uncalibrated gain error is significantly higher.
2. The sum of all Shim currents (absolute values) of one SCB20 board must not exceed this value. Additionally, the constraints of the power supplies have to be taken 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.

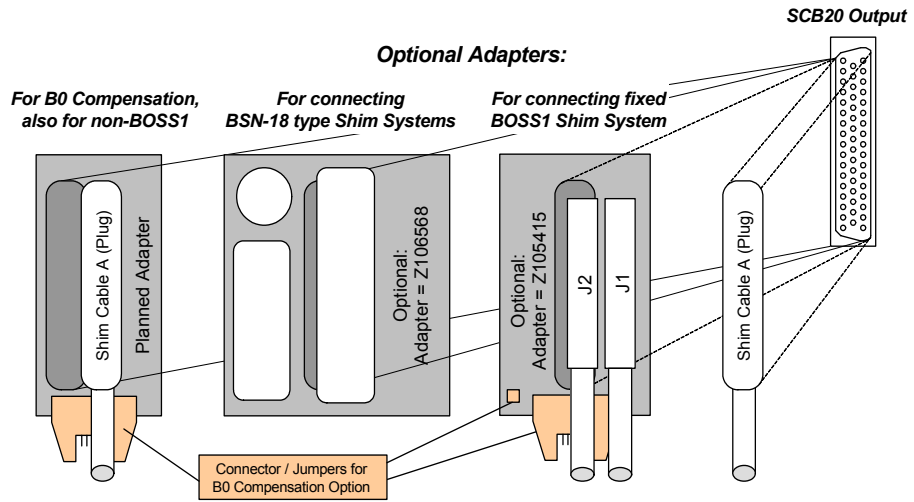
BOSS1 Configuration

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

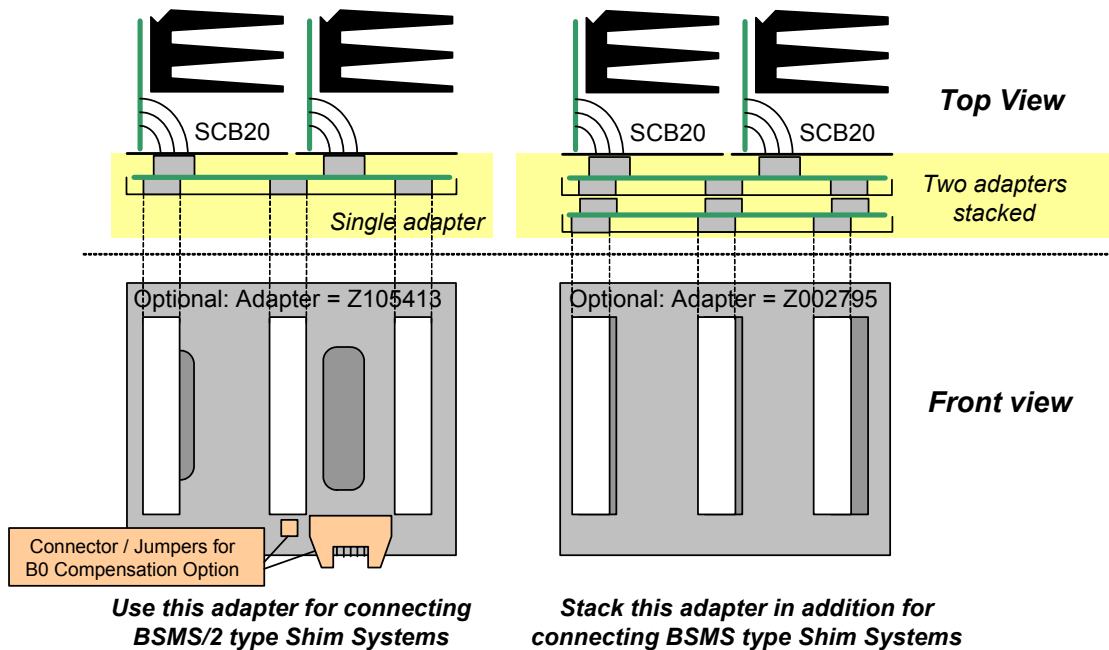
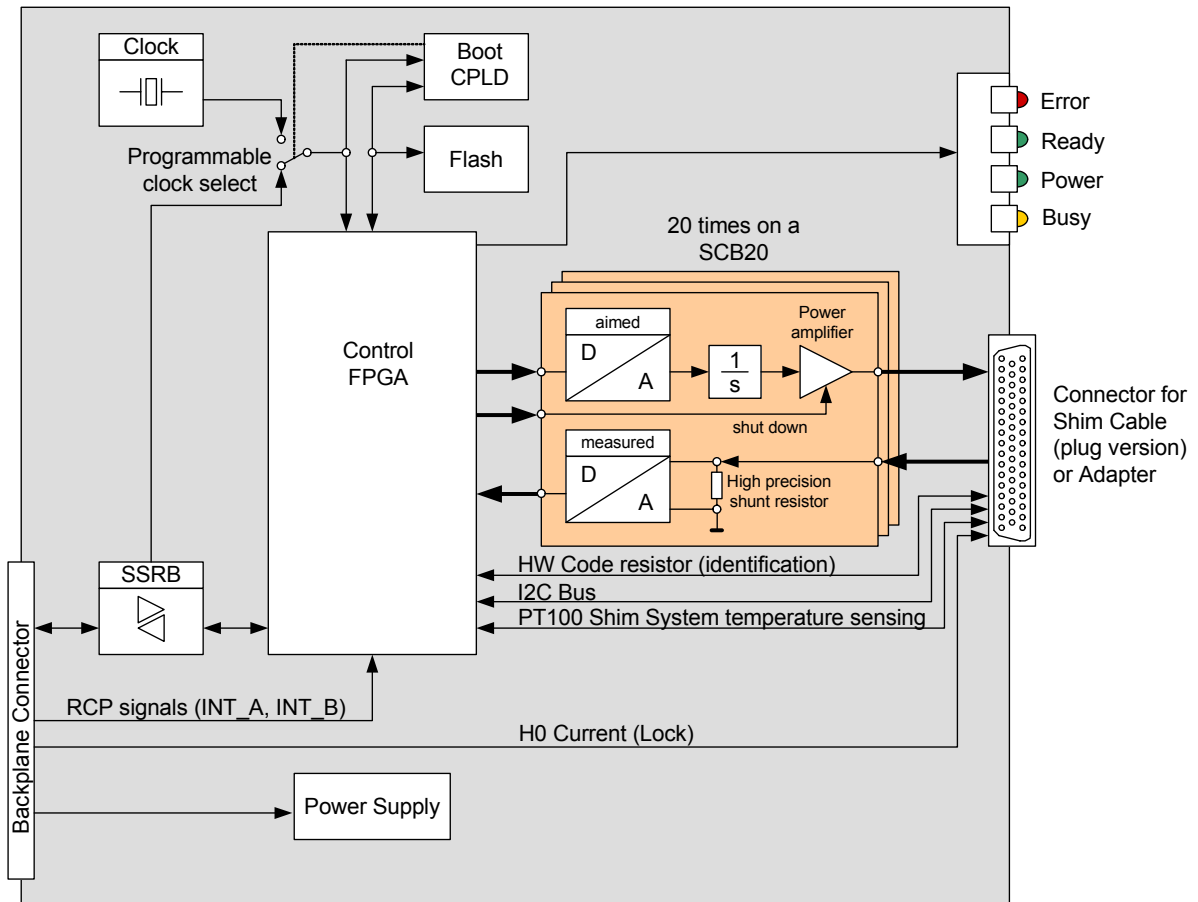


Figure 4.4. Block Diagram of the SCB20 shim current board



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.

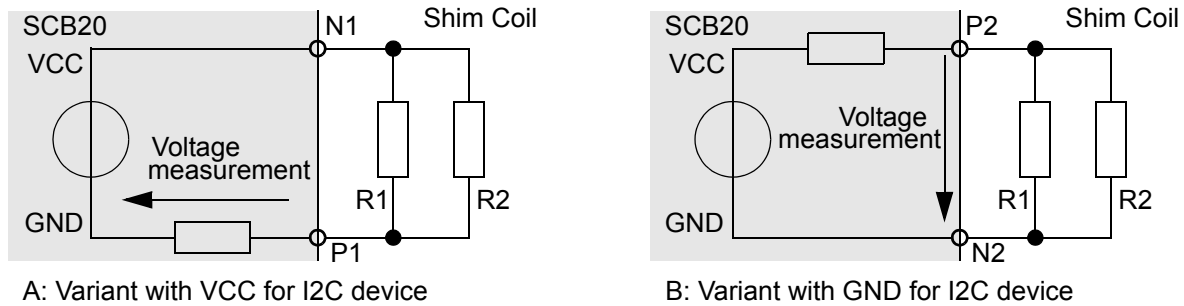
In normal configuration the SCB20 uses a common 10MHz clock that is distributed by the ELCB (this clock is typically generated by the AQS reference board). It is possible to select alternatively a local oscillator.

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.

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

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

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

4.4.6

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.

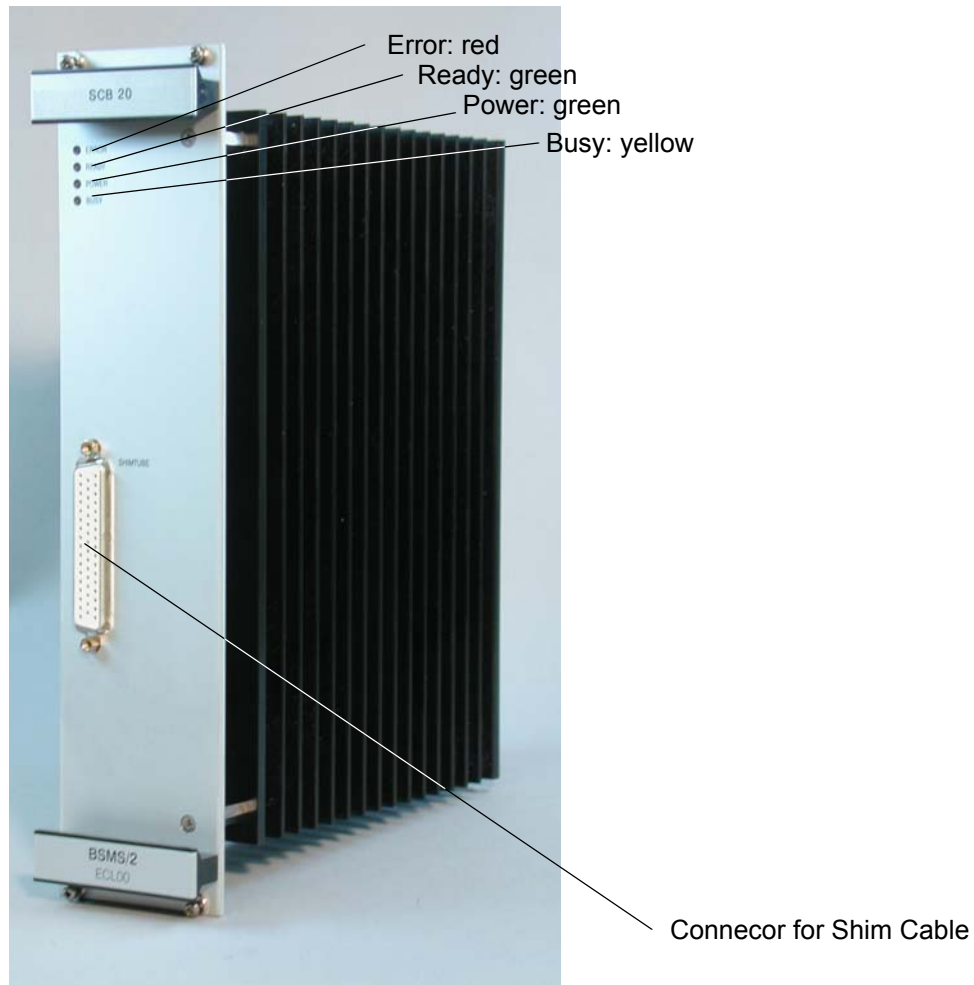
Gain Calibration

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.

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

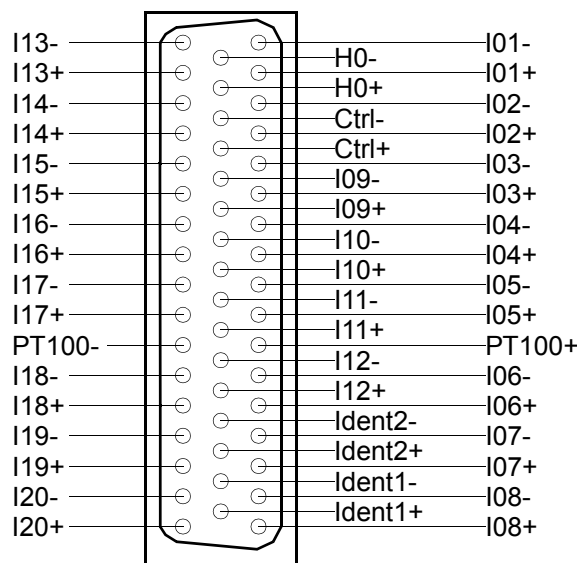
Indication that the SCB20 is correctly powered.

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.

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.

Table 4.2. 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.

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).

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

4.6.10

Figure 4.9. Setup and Configuration of the Shim Subsystem

Shim Configuration	
Boss File Name	302927ab.dat 1
Mode	User(Gradient) 2
Shim System ID	302927 3
Shim Power Limit	37 W 4
Override Shim Power Limit of BOSS File	no 5
Shim System Temperature Limit	80 °C
Autoshim Configuration	Autoshim Setup
RTS and Homospoil Configuration	Real Time Slope and Homospoil Setup
Use RNext Signal	yes
Current Update Notification on Gradient Change	no
Shim Soft Start/Shutdown Duration	20 s 6
<input type="button" value="Set"/> <input type="button" value="Refresh"/>	
BOSS File Handling	
<input type="text" value="Path = ..TopSpin/conf/instr/servtool/bsmstool/boss"/> <input type="button" value="Durchsuchen..."/> <input type="button" value="Load Boss File"/>	

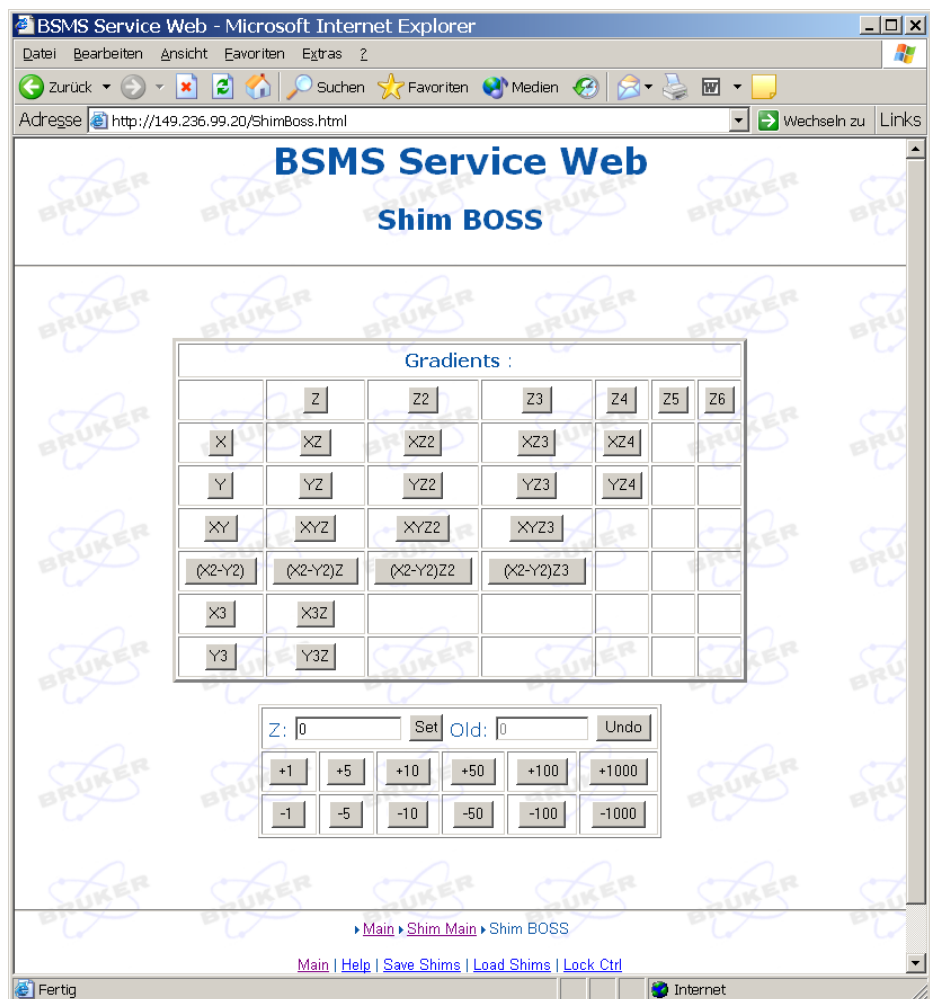
1. The currently loaded BOSS file name is displayed here. If the connected Shim System is a BOSS1 then the name of the predefined data set „BOSS1“ is displayed. If there is no valid BOSS data available for the connected Shim System, then this is indicated by „**No BOSS Matrix loaded!**“. The file names 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

4.6.11

Figure 4.10. View and manual modification of the Shims

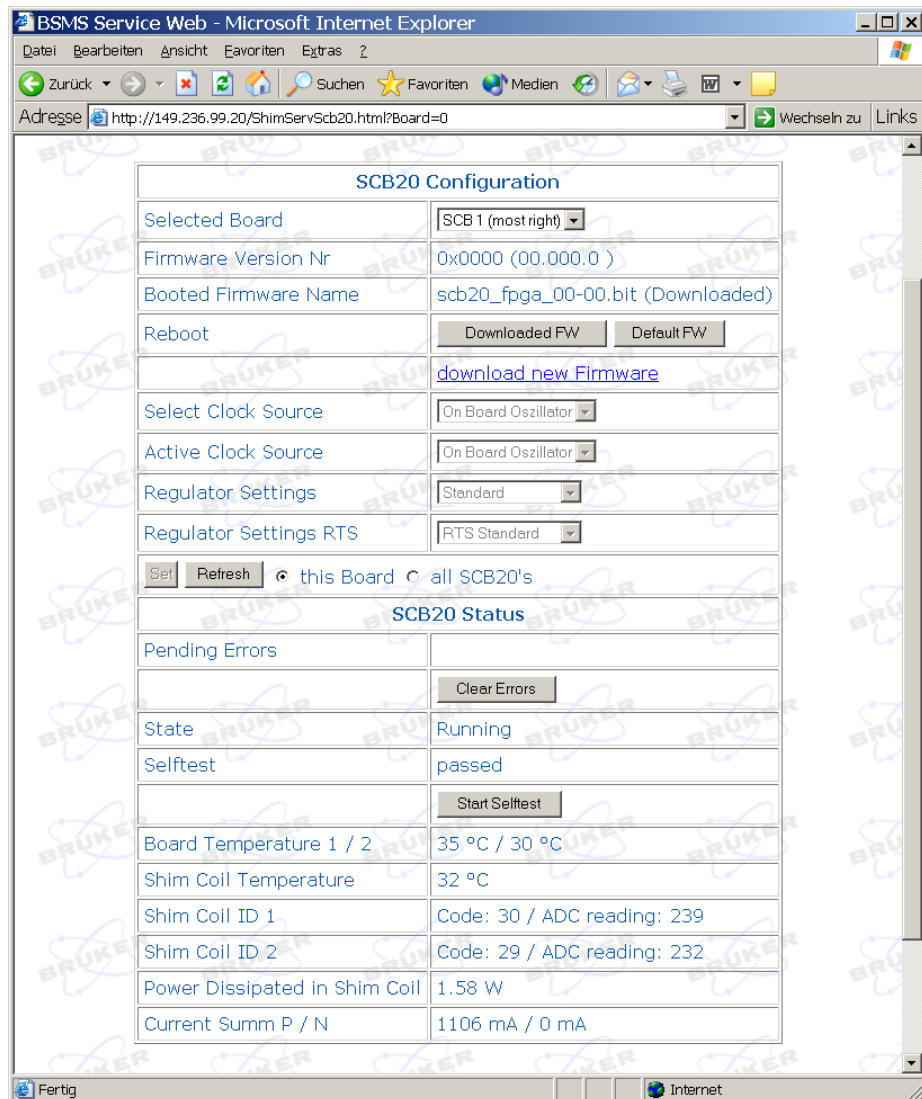


The example in the diagram above shows a Shim Subsystem configured for 28 available / accessible Shims. By the small panel at the bottom, the selected Shim („Z“ in our example) can be viewed or modified manually.

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.

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“.

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.

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)
Fall Time (residual current smaller than 10 uA)			80	us	2)

Table 5.1. Electrical Characteristics (typical values)

Parameter	Min	Typ	Max	Unit	Notes
Amplitude Resolution for full range -10A to +10A		20		bit	
Residual current when there is no Gradient active	-10.0		+10.0	uA	

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 / 10hm.

Configurations

Figure 5.1. GAB/2 in an AVII spectrometer

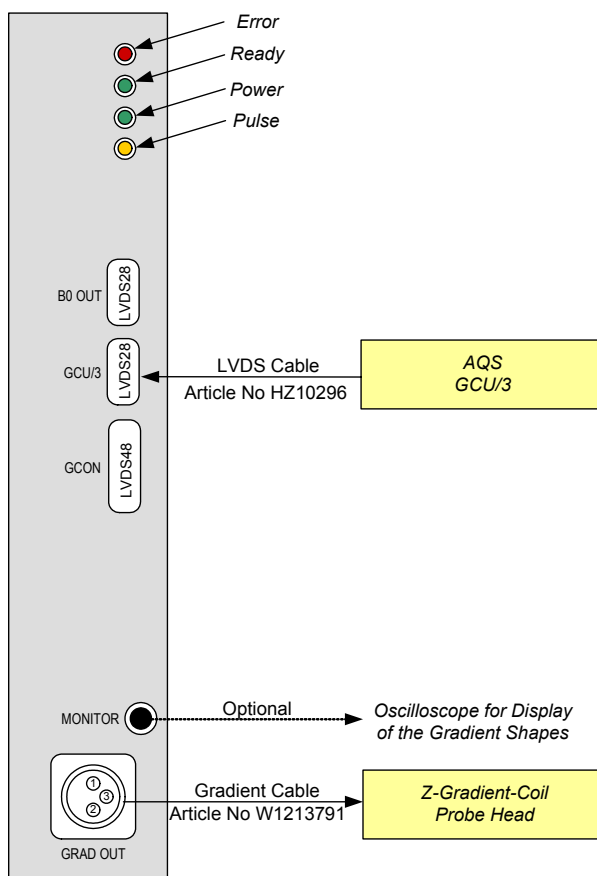


Figure 5.2. GAB/2 in an AVANCE spectrometer with IPSO

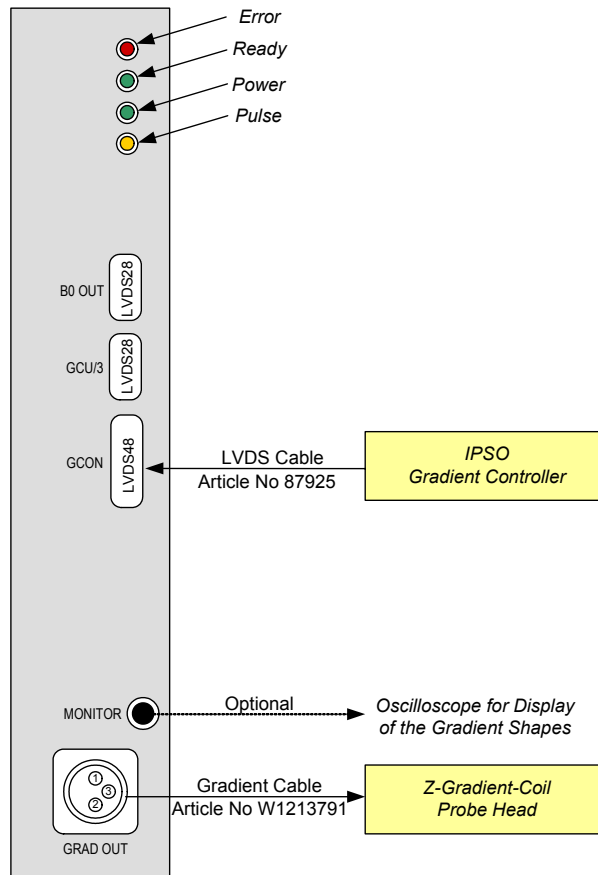
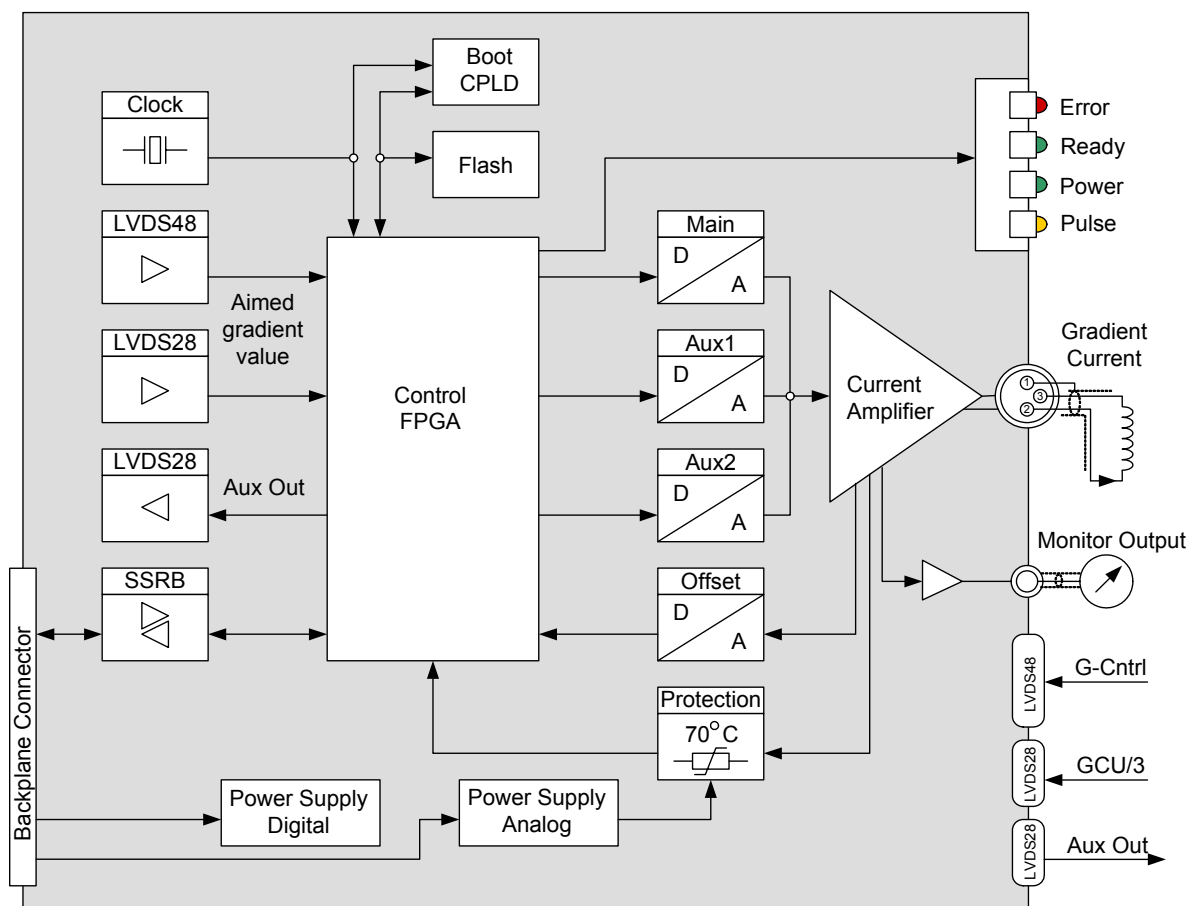


Figure 5.3. Block Diagram of the GAB/2 Gradient Amplifier board



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.

Protection5.4.1

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 panel5.4.2

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 diagnostic5.4.3

Monitor Output

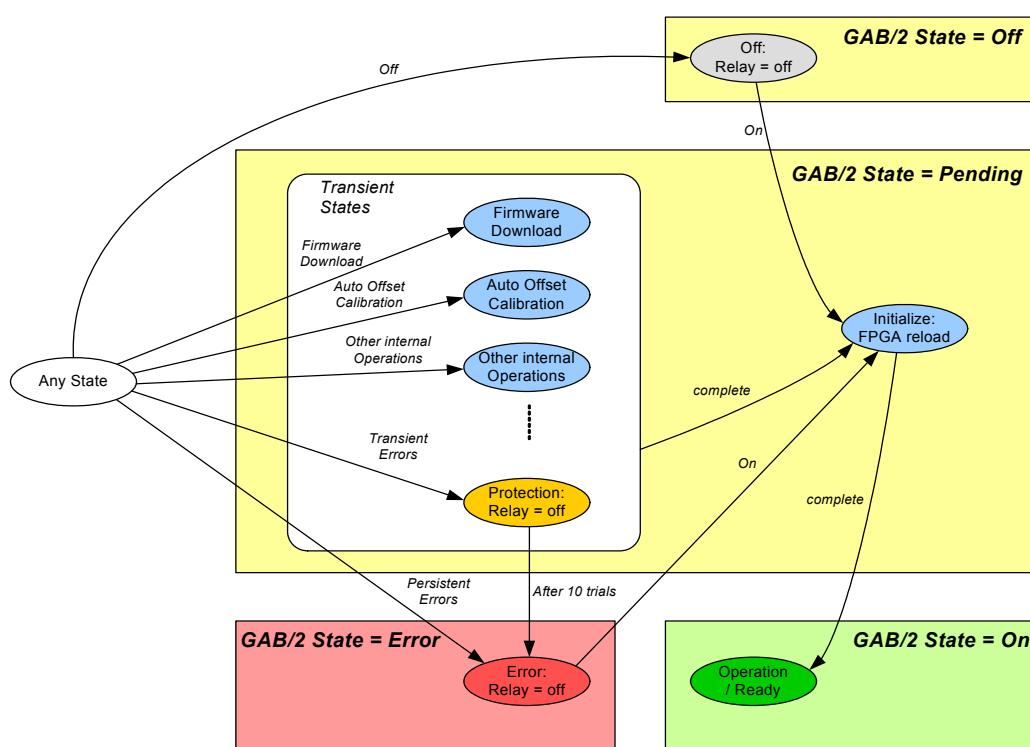
The monitor output reflects the Gradient current provided by the Gradient current connector. This output is intended for diagnostic purpose. It can be useful for debugging the hardware or software (pulse programs). The relation is 1 Volt (monitor voltage) per 1 Ampères (Gradient current).

Logging of LVDS link

For diagnostic purpose, the GAB/2 hardware provides recocording of the LVDS link data - incoming requests for specific Gradient currents are logged (aimed val-

ue 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.

Figure 5.4. 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 timeout 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 applica-

tion) 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 diagram 4.2 - 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 5.5. LVDS 48 interface used in AVANCE spectrometers with IPSO

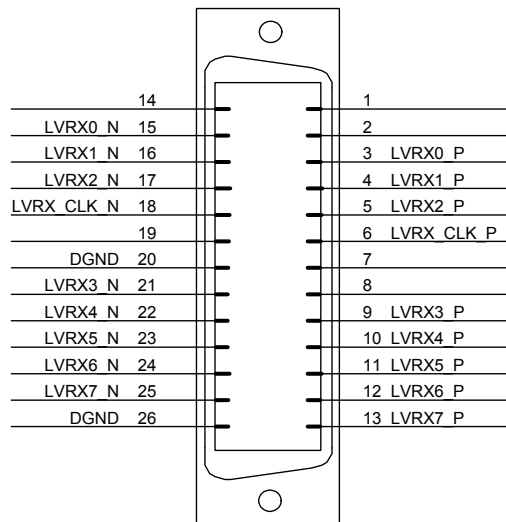
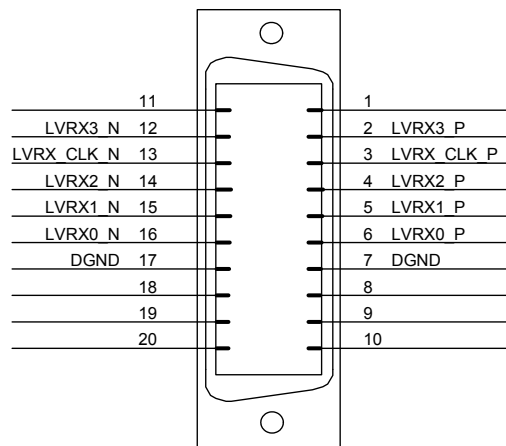


Figure 5.6. LVDS 28 interface used in AVII spectrometers



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.

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

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.

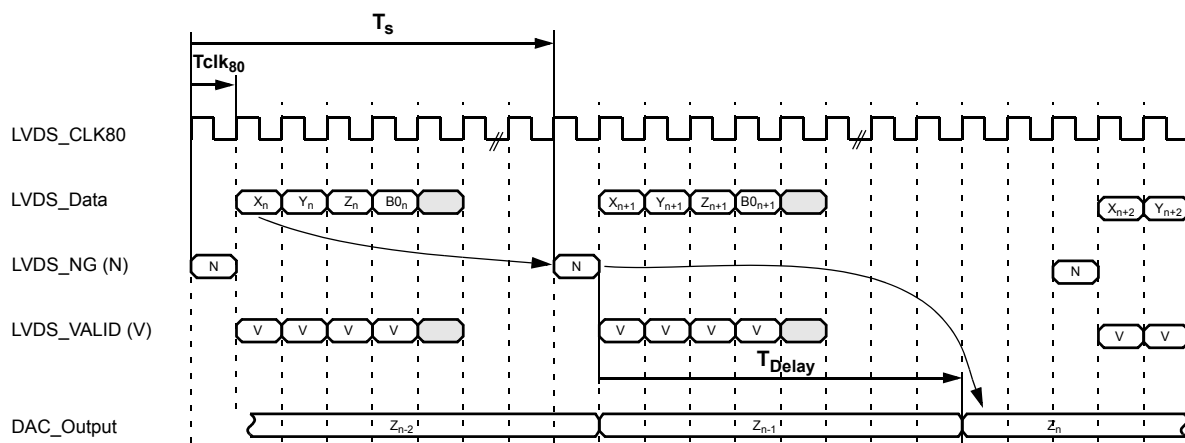
The actual protocol for transmission of Gradient commands is based on the physical signals at the client side that are listed in the table below

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)

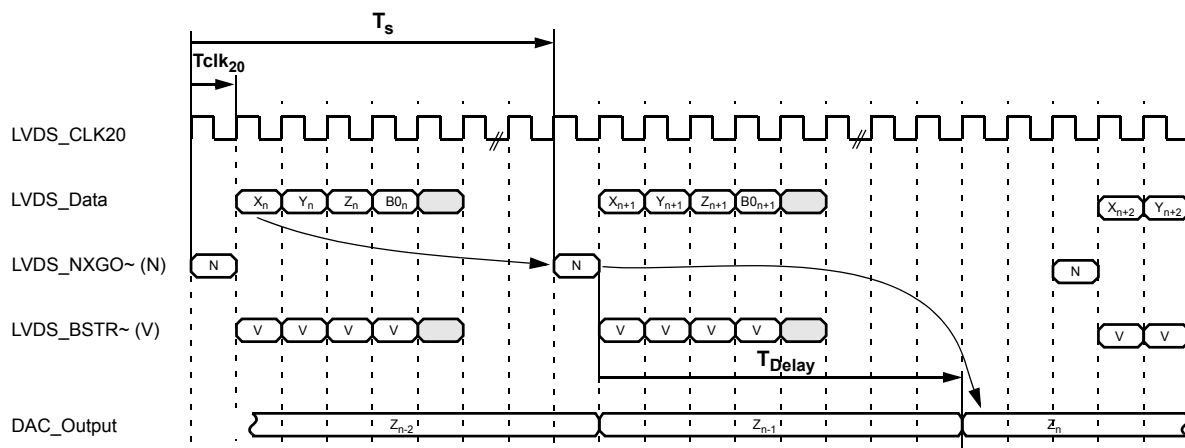
Figure 5.7. Timing for the communication over the 48 bit LVDS link



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 5.8. 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 ($T_{clk_{20}}$). 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

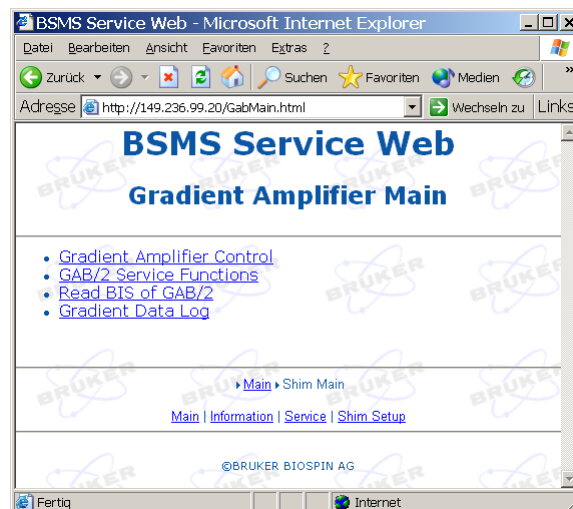
Both, the specific low level drivers and the overall control logic for the GAB/2 are implemented in the ELCB software. It provides setup and configuration for the operational functions for the NMR application by a CORBA interface. In addition there is a Web access available for service purpose (setup, 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 5.9. 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.

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 Top-Spin 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.

It may happen that the user wants to run a Gradient experiment and there is no effect on the NMR (e. g. no dips in the Lock level). Then the Gradient path can be checked step by step:

- Check if the GAB/2 is operational - the „Ready“ and the „Power“ LED must be active and the state displayed on the Service Web must be „operate“. In case that the GAB/2 is in „error“ state (e. g. due to a erroneous Gradient pulse that has exhausted the power supply), it can be switched on again as described in the state diagram (Figure 5.4).
- Verify that there are actually Gradient pulses issued by the Gradient control electronics (IPSO or GCU/3) - during an active Gradient, the „Pulse“ LED must be active. If the LED is not pulsing accordingly, then either the GAB/2 is not operational (see point above) or there are no commands arriving at the LVDS input.
- Gradient commands transmitted over the LVDS link can be logged on the Service Web page „main“->“GAB“->“Gradient Data Log“. The recorded info can be analyzed for checking if the correct Gradient shape data have been transmitted.
- A scope can be connected to the monitor output, which provides display of the Gradient shapes as a voltage curve (1 Volt at the monitor output refers to 1 Ampères Gradient current). The monitor output represents the actual current flowing through the Gradient coil (which must therefore be connected for correct measurements).
- If all points above are ok and there is nevertheless no visible effect of a Gradient then the correct interconnection with the probe head should be verified - the Gradient cable may be interrupted or the current wire may have an accidental contact with frame ground.

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