BRUKER

AV

Service Manual

Version 001

BRUKER

The information in this manual may be altered without notice.

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Introduction 1

General *1.1*

This manual is intended to serve as a **single** reference guide to AVANCE AV spectrometers. It has been written primarily for service engineers, though some information may also prove useful to applications, sales and training personnel.

It is hoped that after reading this manual service engineers will be able to effectively troubleshoot an AVANCE AV type spectrometer. Little effort has been made to explain the internal workings of the various boards and units. With the use of SMD technology these boards are not intended to be repaired in the field. Instead the manual concentrates on describing the board functions and specifications as well as the relevant inputs and outputs.

If you have any corrections or comments with regard to improving this manual please contact

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Since there are now many engineers who already have a good knowledge of the AVANCE series this manual has included many sections designed to highlight the differences between the more recent AV series and the previous AVANCE series so that service personnel can build on previous knowledge. First a brief word on what differentiates an AVANCE AV from an AVANCE DRX.

Terminology: AVANCE DRX versus AVANCE AV series *1.2*

Units that are specific to AVANCE are:

AQX / AQR chassis

FCU0

TCU0 or TCU 1

ASU (Amplitude Setting Unit)

LOT (Local Oscillator Tune)

PTS or Schomandl frequency synthesizer.

The original "**AVANCE** Service Manual" available from Bruker CH (P/N Z31245, DWG-No. 915002) was published in 1996.

The above configuration will consistently be referred to as **AVANCE DRX** in this current manual.

Units that are specific to AV are

Introduction

Single AQS chassis

FCU3

TCU3

SGU

REF

ACBX

ACBS

PSM

System amplifiers can be internal or external.

The above configuration will consistently be referred to as **AV** in this manual.

With the exception of the AQS rack, each spectrometer unit has been described under a set of standard headings. Where there is no relevant information then this heading is either described as na (not applicable) or simply not included.

AQS Rack

2

Introduction   *2.1*

The AQS is designed to house slot-in type units in an integrated rack system. As a single rack the AQS replaces the AQX and AQR racks previously used in AVANCE DRX systems. Elements of the design philosophy have been to

- fit more units into a smaller space resulting in a more compact spectrometer.

- increase the number of signals going over the backplane

- isolate the digital section from the analog section.

When the total number of RF channels exceeds 4 (external amplifiers) or three (internal amplifiers and solids), then a second AQS rack is necessary. A second rack will enable up to 8 RF channels to be installed. The first AQS rack is called the Basic Rack.

To the front the AQS rack can be divided into two sections, a purely digital section to the left (aka VME bus) and an analog section to the right (aka user bus) see ***"AQS rack front view" on page 12***.

The digital section contains 8 slots which will house up to 8 digital VME units all of which have the same physical width

The analog section has also nominally 8 connectors though the number of units that can be installed will depend on their physical width.

The rear of the rack is primarily designed for power supplies, both digital, analog and specialized power units for internal amplifiers see ***Figure 2.2.***.The rear also houses the ACB and PSD boards.

Functions / Description   *2.2*

The principal functions of the AQS rack are to

1. provide power to the various units

2. provide bus interconnects in the form of VME bus and user bus sections.

3. physically house the various units in a single rack

One design feature was that the AQS rack system should be as compatible as possible with some older AQR and AQX type units such as the Router, RX22 and SADC etc. This has meant the inclusion of adapters in the analog section see ***"rear adapters" on page 22***.

AQS Rack

Figure 2.1.   AQS rack front view

AQS Type Label

Main Switch

Part Num. ECL
and Ser. Num. Label

AQS

Digital / VME Bus Part

analog / User Bus Part
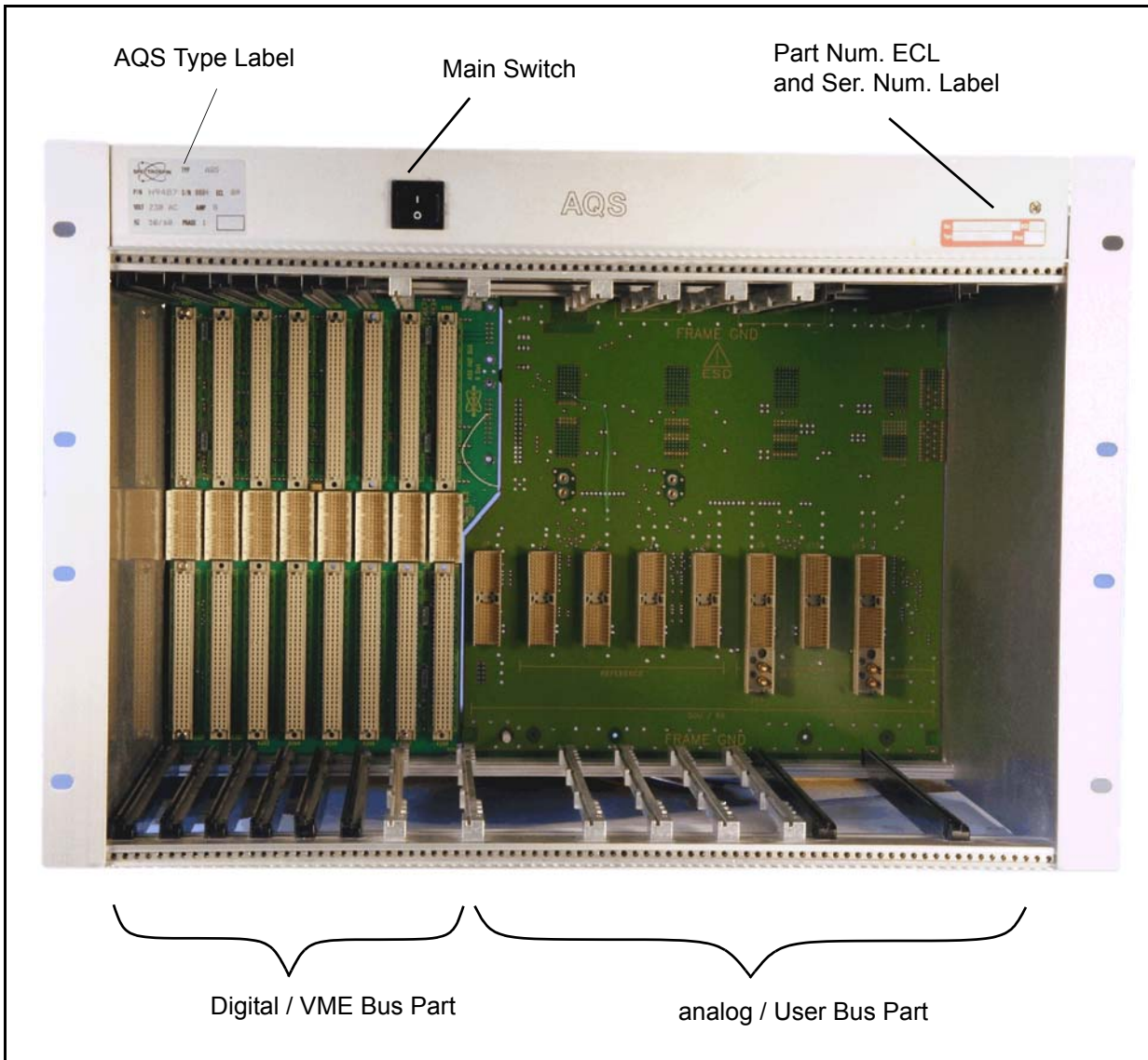
VME Section: 2.3

To the left is the purely digital section containing the CCU10, TCU3, FCU3s, GCU and RCU, in that order. This section is often referred to as the VME bus section though there are actually three bus connections which are discussed below. The digital units are all the same width and all occupy a single slot.

Note that the SADC or HADC/2 may occupy the rightmost physical slot of the VME bus but the actual electrical connection at the rear is made with the user bus.This is by means of special double rear adapters which also connect the RX22 to the user bus. (The adapter for the RX22 is required because it is physically shorter than more recent AQS units. When the RX-E is introduced an adapter for the Receiver will no longer be necessary.)

There are some physical ramifications of the new AQS rack. Instead of the previously used 30 pin connector in the middle position of each slot the VME section

backplane uses a 90 pin connector J0. Only devices with the proper 90 pin connector (TCU3, CCU10, FCU3) or devices without any middle connector in the middle position (RCU, GCU) can be inserted.

Figure 2.2.   Rear view of AQS rack showing power supplies

Power supply for first internal amp

Space for power supply for second internal amp

Digital power supply

Analogue power supplies

Transformer for analog power supplies
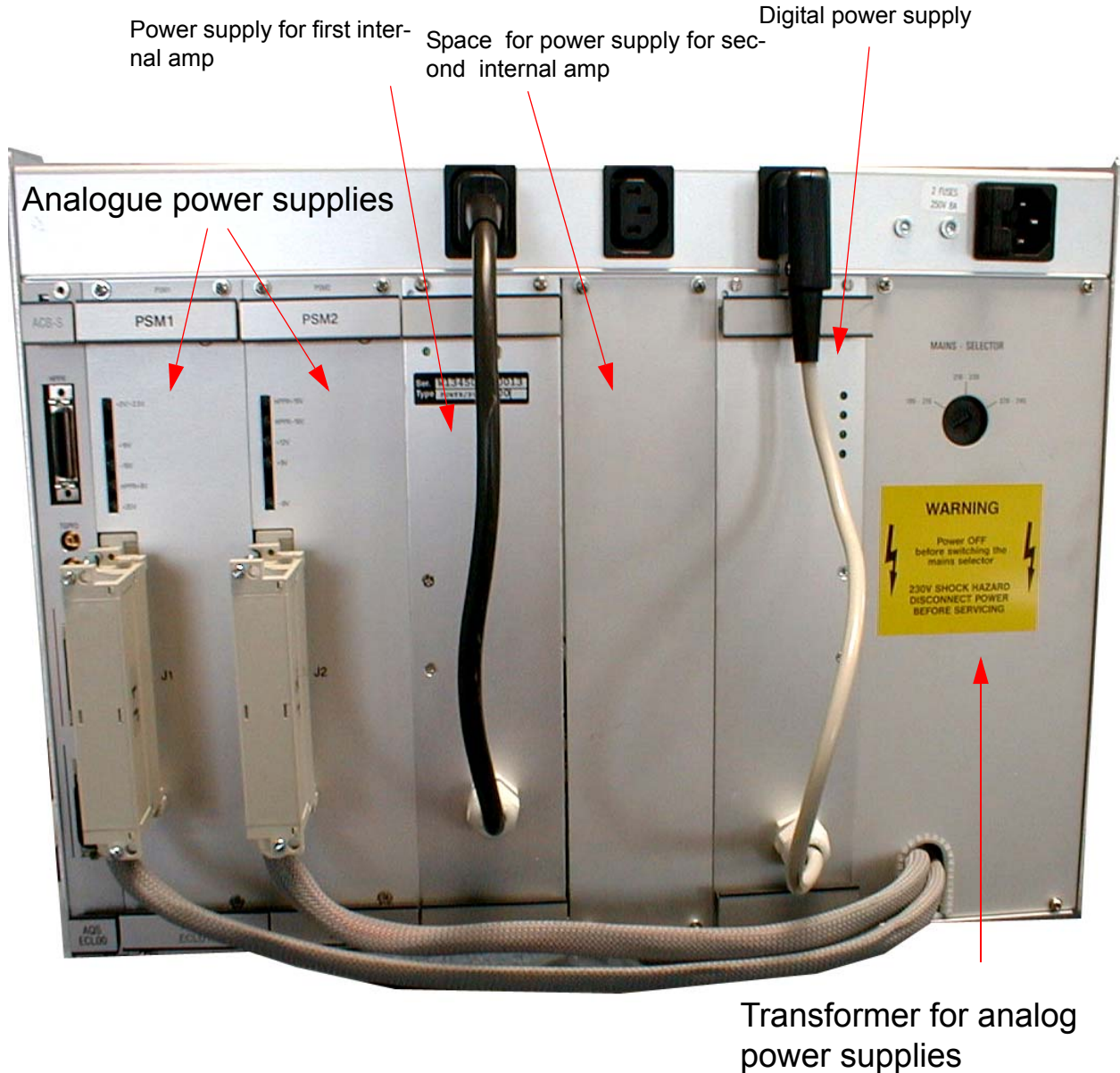
➪ *Warning: Previous AVANCE DRX digital units such as the GCU and RCU look identical from the front but will be damaged if used since the middle connector in the backplane has now 90 pins instead of 30 pins.The units are electronically compatible with both systems, but mechanically incompatible and under no circumstances should the previous AVANCE DRX units be used in the new AVANCE AV system.*

No jumpers have to be set to connect daisy chain signals over free slots, however there should be no free slots between individual FCUs. CCU10 can only occupy slot1 as only in this slot can it route the RS485 signals to connector X3 (SBSB1, SBSB2)

Figure 2.3. Schematic of AQS front section
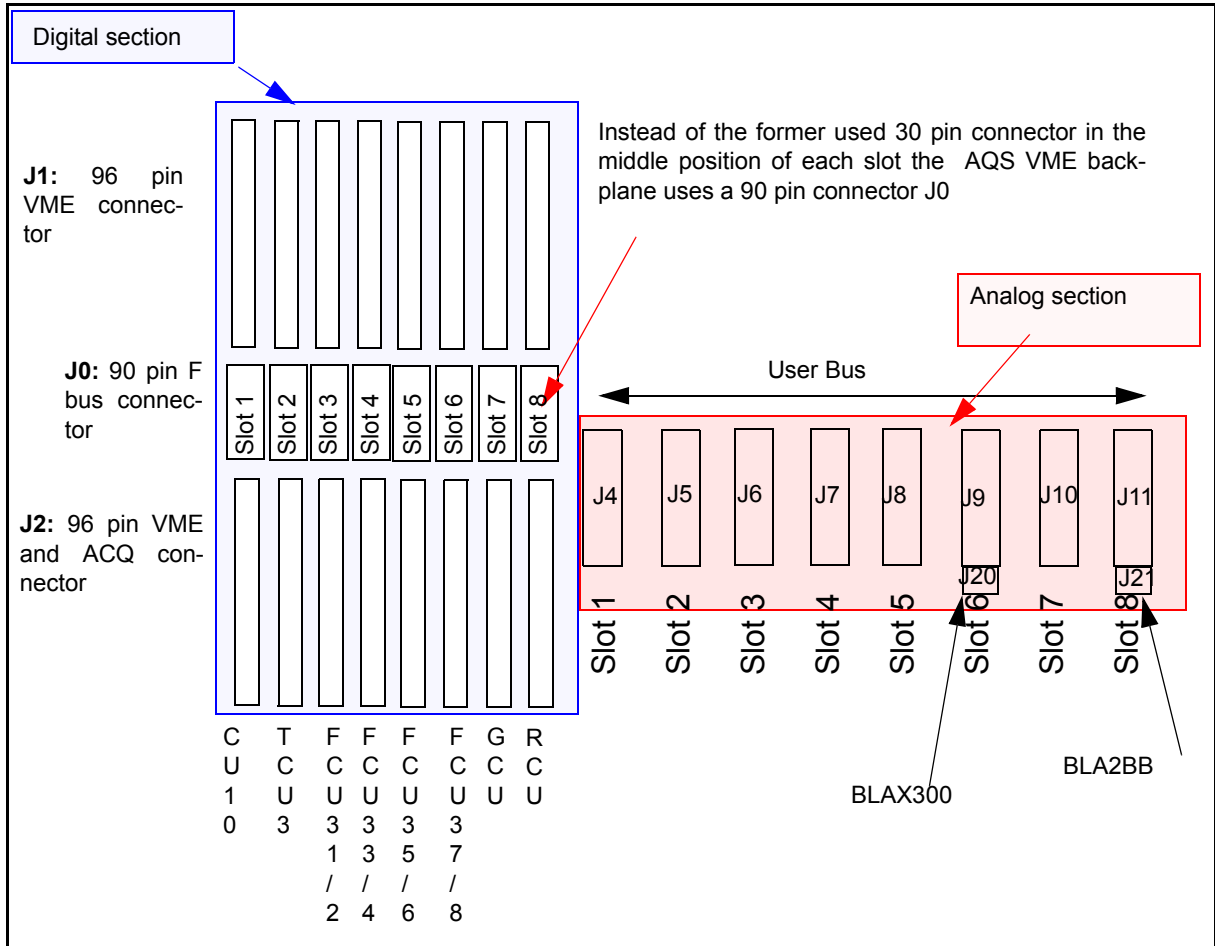
Table 2.1. VME type units compatible with AV systems

Unit	Compatible with AV series	Incompatible with AV series
CCU	CCU10	CCU09
TCU	TCU3	TCU0,1,2
FCU	FCU3	FCU0

Table 2.1.   VME type units compatible with AV systems

Unit	Compatible with AV series	Incompatible with AV series
GCU	90 pin rear middle connector or no middle rear connector	30 pin rear connector
RCU	90 pin rear middle connector or no middle rear connector	30 pin rear connector

Figure 2.4.   Schematic of VME , User buses and LVDS

(note that the board configuration is for illustration purposes only . e g. internal amps and Router would not be fitted in the same system.
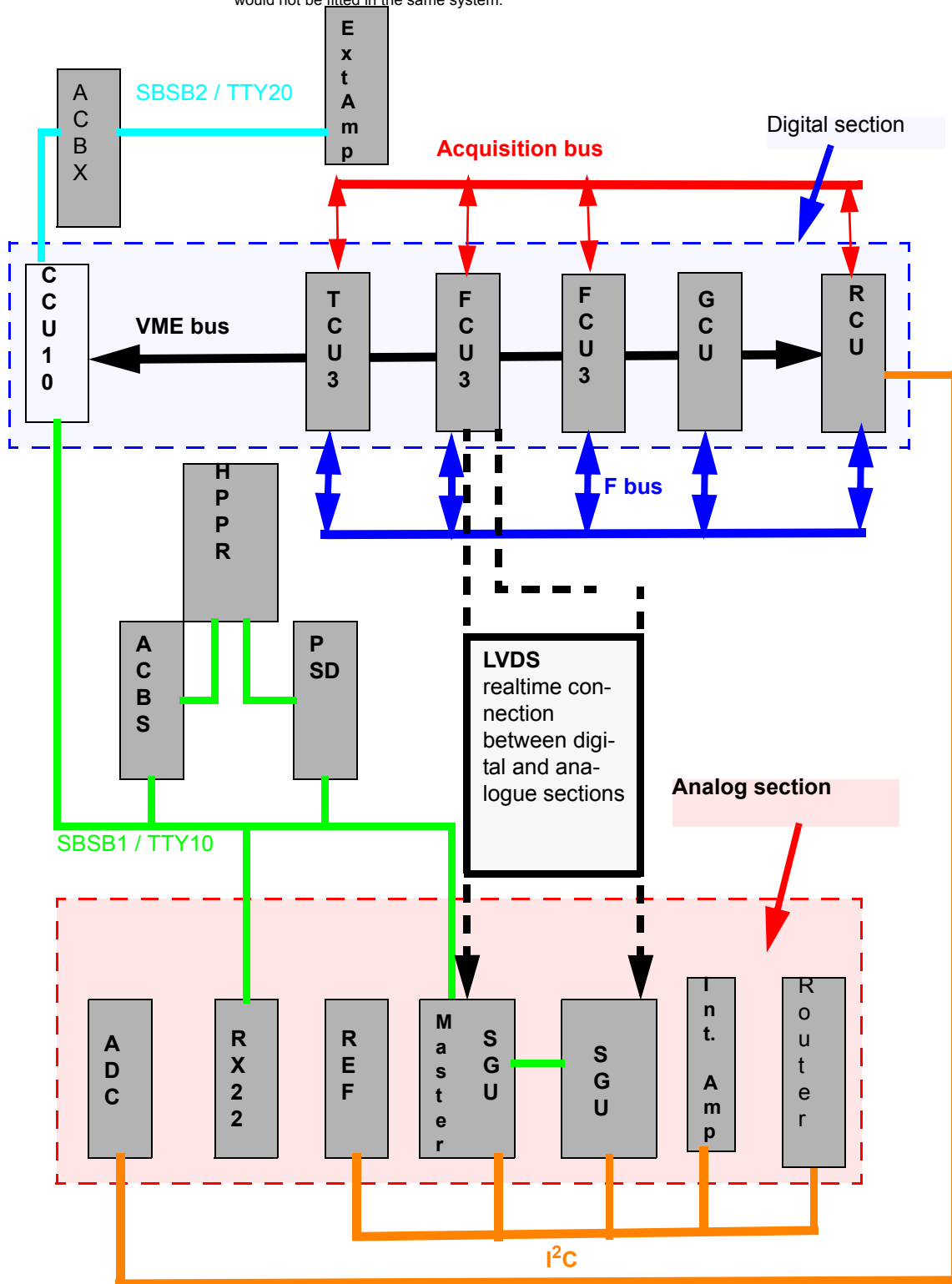
VME Bus: Connectors J1 and J2   *2.3.1*

The VME bus is a 32 bit bus used for general communication (non real-time) between all units in the digital section. The CCU10, TCU3 and RCU can all be master of this bus, the FCU3 and GCU are only ever slaves. Outside of acquisition the CCU10 is normally the master.

The CCU10 calculates all aspects of the required signals such as the phase, amplitudes, frequencies, time delays, shape etc. and transfers them to the FCU3 or GCU via the VME bus. This transfer is timing non-critical in that the acquisition will not commence until the information has been transferred. Once the data transfer is complete the TCU3 will take control of the timing via commands sent over the acquisition bus.

Apart from loading acquisition parameters the VME bus is also used for DMA (Direct Memory Access) by the RCU to store the digitized FID. Upon delivery of the RCUGO signal from the TCU3 the RCU can take control of the VME bus. In this way processed data may be transferred to the host workstation.

Acquisition Bus: Connectors J1 and J2   *2.3.2*

This is a unidirectional 16 bit bus used for real-time orders given by the TCU3 to other real-time orientated units such as the FCU3 or GCU. This ensures that the TCU3 controls the timing of the acquisition which becomes critical once the acquisition has started. The TCU3 is the one and only master of the bus with the FCU3 and GCU only ever as slave. The principal communication over this bus is the control of the FCU3 timing via a set of TCU3 instructions.

F Bus: 90pin J0 Middle Connector: *2.3.3*

The F bus is sometimes referred to (incorrectly) as the FIFO bus. The F bus joins slots 2 to 8 and is used primarily for real-time asynchrone communication between the TCU3 and the FCU3 or GCU. The TCU3 is the only master of this bus. The F bus typically carries instruction lists to the FCU3 where they are loaded. The transfer of these instructions to the SGU is achieved by means of the LVDS.

➪ *Note: The SGU has no direct connection with the VME, ACQ or F Bus. Therefore all frequency, phase, amplitude and shape information must be transferred via the LVDS. In this context the LVDS can be seen as the bridge between the purely digital section and the analog section. The only other connections between the digital and analog sections are the SBSB1 and SBSB2 buses which are connected to tty10 and tty20 of the CCU10 respectively (see "Schematic of VME , User buses and LVDS" on page 16*

Other signals that are transferred over the 90 pin J0 connection are

BBIS signals	(slot 1-8)
RS485 signals to X3 (tty10/tty20)	(slot 1 only)
Auto configuration signals	(slot 1-8)

Figure 2.5.   Simplified schematic of use of buses for acquisition
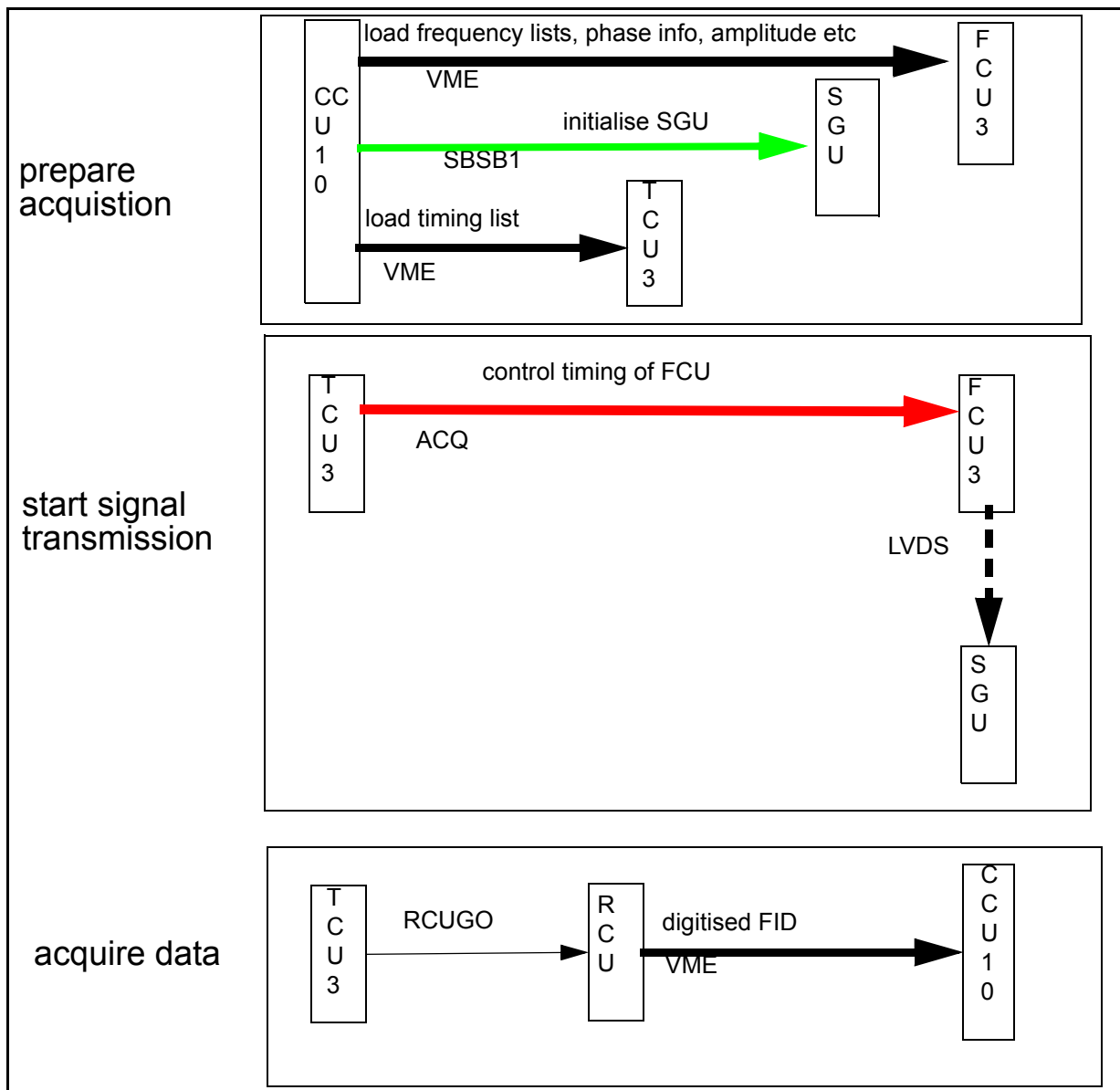
SGU reset signals	(slot 1-8)
JTAG	(slot 1-8)

User bus (analog) section: *2.4*

The user bus section of the AQS has been designed to be flexible in terms of which units it can accommodate. As a result there are various configurations depending on the number of racks, number of Routers, whether internal or external amplifiers are used etc. As a general rule starting from the left the board order is : (SADC + RX22), REF, bank of SGUs, internal amplifiers or Router(s).

Regarding the physical connections the following points need to be noted:

Due to the heavy duty connectors at J20 and J21 the AQS BLAX300 is fixed to connector J9 / J20 and the BLA2BB to J11/ J21 (see and **_"AQS rack front view" on page 12_**).

Due to its extra width when a BLAX300 is fixed to connector J9 / J20 then connector J10 is no longer available.

When two Routers are used a single adapter makes a connection with J10 and J11 (see **_"Sample configuration / 4 channels /single rack" on page 28_**).

The SADC and RX22 also use an adapter to make a single connection, usually at J4.

110 pin user Bus rear connectors J4 - J11:   2.4.1

The user bus is a catch all term used to describe several buses that run along the backplane. The buses include SBSB1, SBSB2, Intra rack bus and I^2C buses which are discussed below. To reduce traffic the **SGU master is rack master of the user bus** even though all SGUs are physically identical. One SGU which for a standard system is situated in **slot 3** in the AQS user bus (3rd from the left of the **occupied** slots J6 in **_"Schematic of AQS front section" on page 14_**) serves as the rack master. This reduces the needed communication to a minimum for the CCU10 and the various analog units. The user bus connects all the analog units and is made via a set of eight 110 pin connectors (J4-J11) at the rear. With only a few exceptions all signals along this bus are available to all the analog units.

Note that for systems with two AQS racks, the SGU master occupies slot 5 (J8), and for Solids systems slot 6 (J9). The **rack has to be configured** to make the position of the master SGU known (see **_"SGU Signal Generation Unit" on page 89_**).

SBSB1 / tty10 / RS485   2.4.2

The SBSB1 stands for Serial Bruker Spectrospin Bus One and the physical connection is made over the 110 pin rear connector . This is an RS485 type bus connection between the CCU10 and the SGU/RX22/HPPR. In the 'cf' routine the bus is assigned to the tty10 port of the CCU10. Through its connection with the master SGU this bus is the principal connection between the CCU10 (and hence the host workstation) and the various analog units in the user bus.

It is used for non timing critical communication. Typical uses might be

1. setting of RG value in the RX22

2. selecting the OBS module in the HPPR

3. establish what units are in the spectrometer during the cf routine

4. the loading of the various units from the edsp and eda menus

For a more detailed description of the various uses of the SBSB1 / tty10 see the chapter on the CCU10.

This is the connection between the CCU10 and the ACB-X and consequently the amplifiers. Typical uses might be

1. establishing the number and type of external amplifiers present in the cf routine

2. setting of amplifier parameters with the 'edacb' command

3. display of the amplifier forward and reflected outputs on the screen.

In the 'cf' routine the bus is assigned to the tty20 port of the CCU10.

Intra Rack Bus: *2.4.4*

Internal communication between SBSB devices (e.g. clearing power up errors etc.) is done via the so called Intra-Rack bus (serial asynchronous bus, TTL levels) with the rack master SGU as bus master.

I^2C Bus: *2.4.5*

Some of the previous generation units (Router, FADC, etc., and the BLA2BB) have limited capability regarding on-board intelligent processing power and as such have no SBSB capability. They do however have I^2C capability. These units are controlled by the CCU10 communicating with the maser SGU via the SBSB1 bus, the SGU master in turn converts this to a I^2C bus command which is then sent to the Router, FADC, BLA2BB etc.

Note: There are actually two I^2C buses in the user bus to allow for the possibility of controlling up to 16 devices. The second I^2C bus is only required for multiple rack systems.

Figure 2.6.   AQS Rack rear view

AC power connection to
Digital power supply
BLAX300 power supply
BLA2BB power supply
modules

Mains Connector and Fuses

Mains Selector

J3   J15   J13   J14   J12   J2
                                     J1
                                  J16

X3

WARNING

Power OFF
before switching the
mains selector

230V SHOCK HAZARD
DISCONNECT POWER
BEFORE SERVICING

J20   J21   J17

Digital Power Supply
Connector

J1   J2

Transformer

AC Cables for PSMs
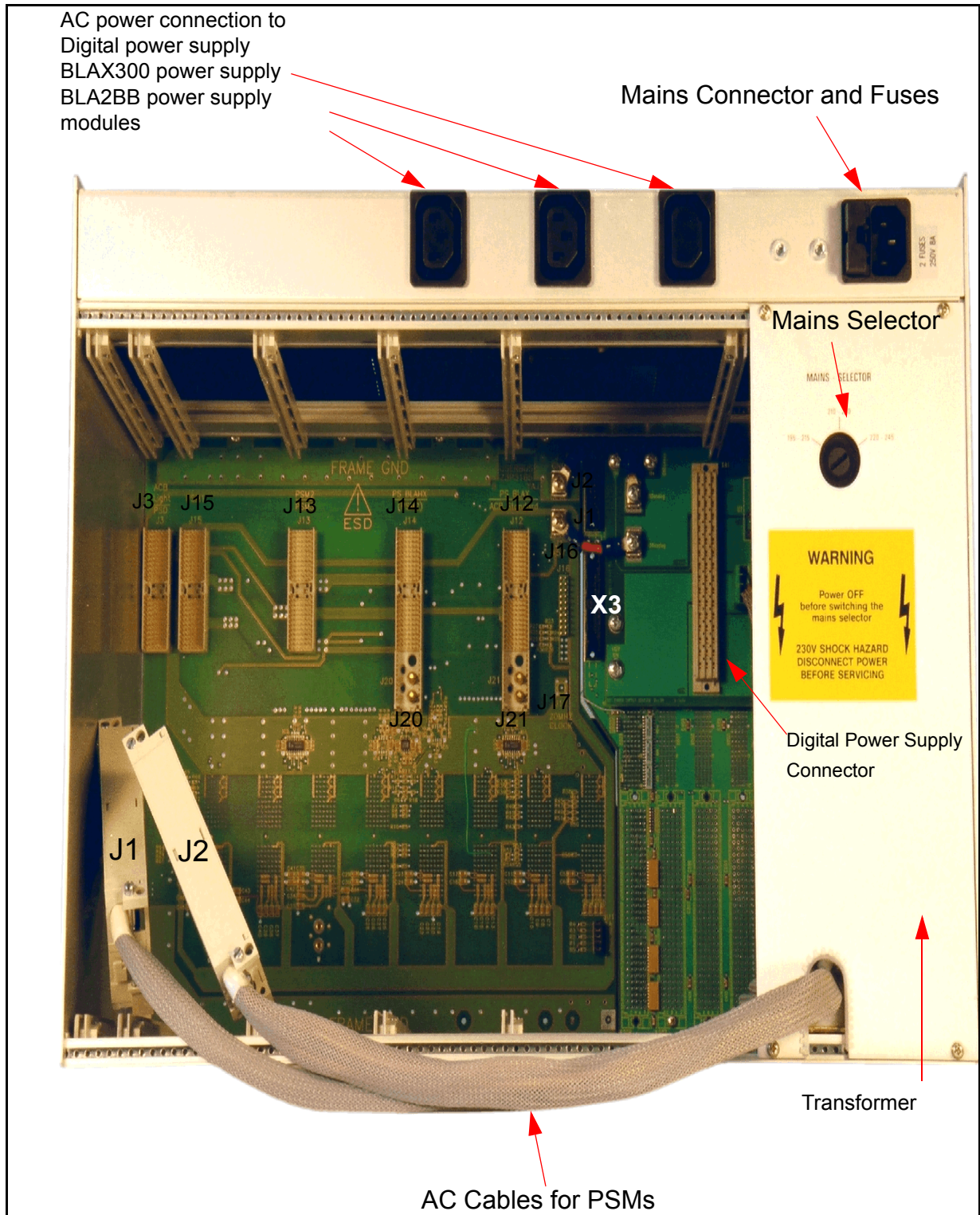
Table 2.2.   assignment of AQS Rear Connectors

Connector	Unit
J3	ACB-S PSD
J15	PSM1
J13	PSM2/3
J14	BLA2BB
J12	BLAX ACB-X
J1	+5V analog supply
J2	analog ground

Unit Configuration / Version / Jumpers 2.5

In order to make several previous generation units compatible with the new AQS rear adapters have to be fitted to make up for the difference in depth and in width.

Figure 2.7.   rear adapters

ADAPTER ADC + RX22/FTLP-4M

ADAPTER ROUTER DUAL

ADAPTER ROUTER / RX22-BB
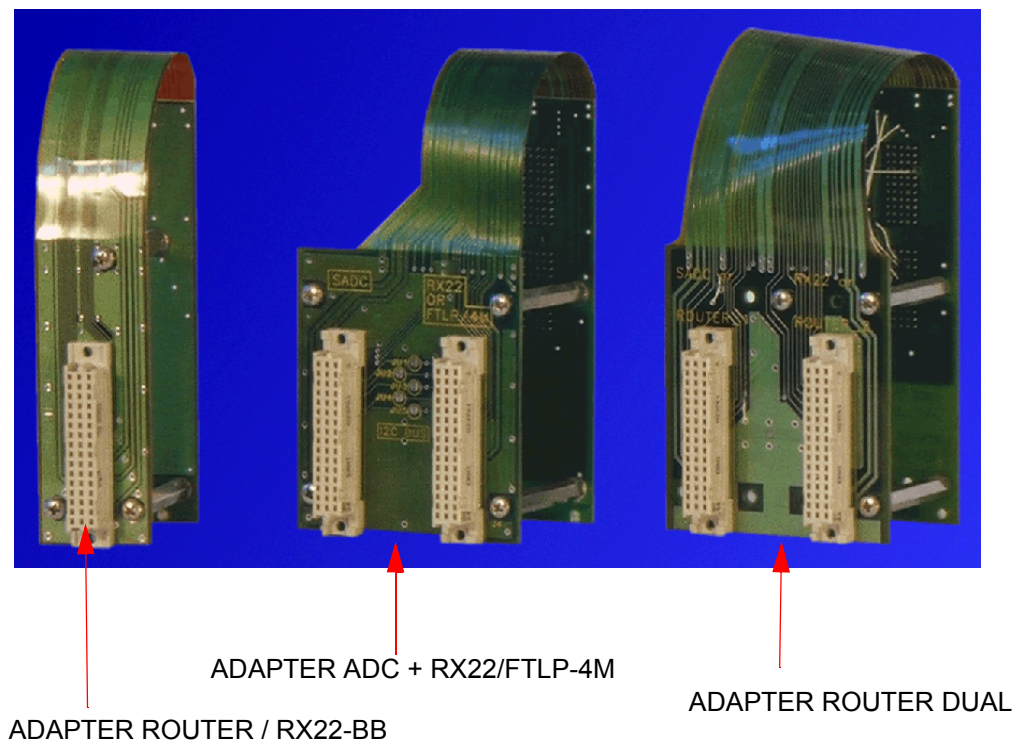
Figure 2.8.   View of AQS ADAPTER ADC + RX22/FTLP-4M mounted
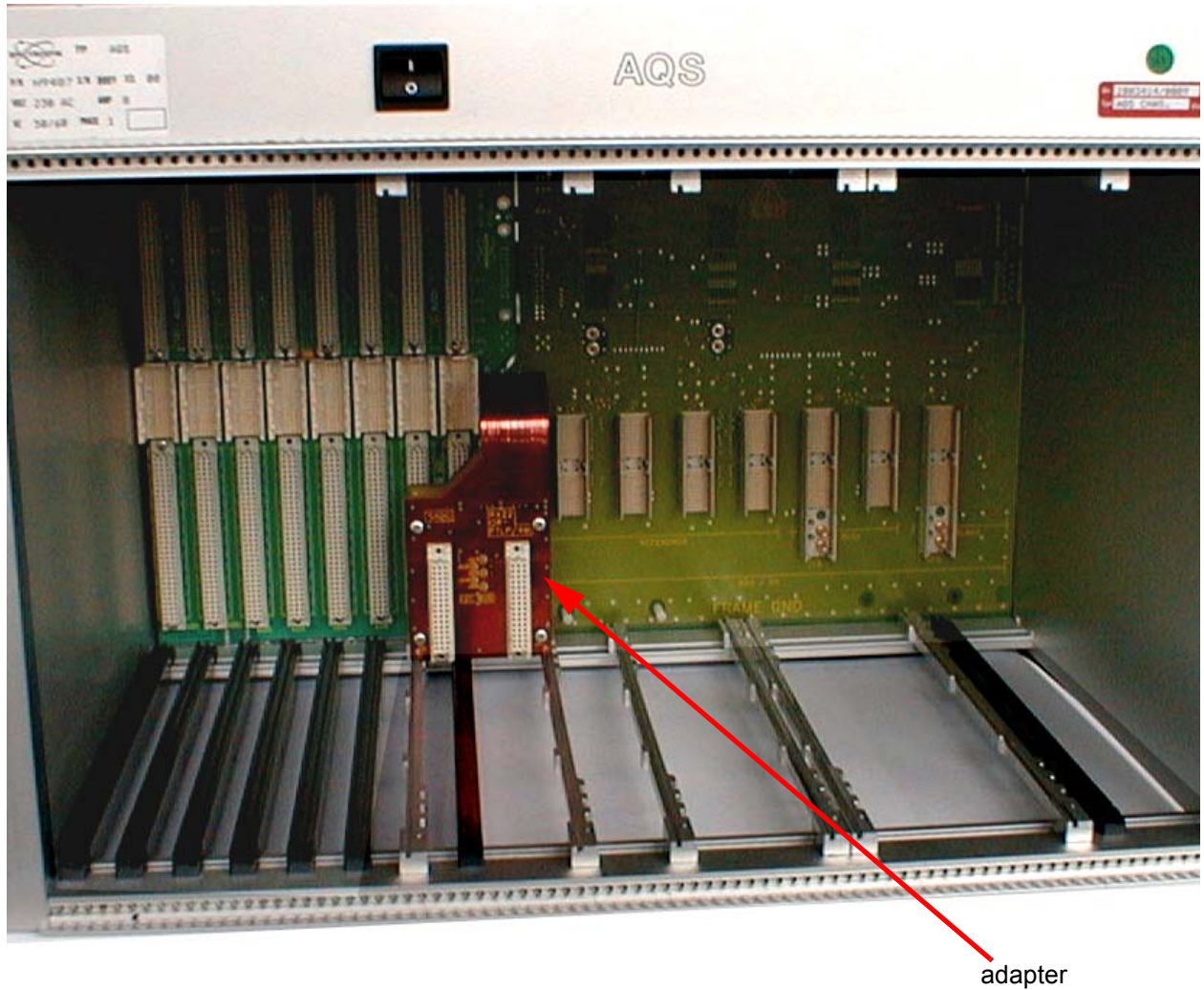
adapter

Table 2.3.   Adapter connectors

P/N	Title	Use
Z003575	AQS ADAPTER ROUTER / RX22-BB	Used for a single Router or a single RX22
Z003348	AQS ADAPTER ADC + RX22/FTLP-4M	Used for ADC plus RX22 or ADC plus FLTP-4m
Z003349	AQS ADAPTER ROUTER DUAL	Used for two Routers

General points regarding VME units 2.6

When considering the points listed below it may be helpful to refer to either **_"Sample configuration / internal amps / single rack" on page 26_** or **_"Sample configuration / 4 channels /single rack" on page 28_**

Note that the physical FCU unit is referred to as FCU3. Each physical unit has two Frequncy Control channels. As more than one FCU3 is normally present the FCU channels are numbered FCU3 (1/2/3/4/5/6) etc.

- The order of units from the left is CCU10, TCU3, FCU3s, GCU and RCU

- All these units are compatible with the slide rails. No adjustment is necessary.

- No rear adapters are necessary.

- If no GCU is fitted then the RCU is shifted one slot to the left and slot 6 is free

- If the system has only two channels, slot 4 is vacant.

- If the system has three channels then slot 4 is occupied though FCU3(4) of FCU3(3/4) is redundant.

- To upgrade from two to three or four channels the only change to the VME section is to simply add FCU3(3) to slot 4 and reconfigure.

- Every system has one and only one of each VME unit except for the FCU3. Each FCU3(3) corresponds to a pair of RF channels.

- All units to the left of and including the RCU are connected to the VME bus.

- An extender board VME_1 Extender Board P/N H9476 is available which allows on-board measurements to be made.

General points regarding analog user bus units 2.7

- The number of channels and the number of SGUs is the same

- The order of units from left is (SADC+RX22), REF, SGU1-4 Internal amplifiers or Routers. The Routers are only required for external amplifiers and require adapters.

- Up to three channels require a single Router, four or more require two Routers.

- SADC (HADC/2) and RX22 need adaptors at rear and the rail position is non standard.

- Any vacant slots should be between the rightmost SGU and the internal amplifiers/ Router

- All units to the right of and including the SADC (HADC/2) are connected to the user bus.

Standard Single Rack Configuration with internal amplifiers 2.7.1

Note that in this configuration the max number of RF channels is three. This is compatible with the three channels that are available with the internal amplifiers. The BLA2BB provides 2 channels and the (optional) AQS BLAX300 provides a single third channel .The three channel configuration is shown on **_page 26_**

All units to the left of and including the RCU are connected to the VME bus. All units to the right of and including the SADC (HADC/2) are connected to the user bus.

If only the BLA2BB is fitted then two SGUs and one FCU3 will suffice as there are only two amplifier channels. This will leave VME slot 4 and user slots 5,6,and 7 unoccupied.

Figure 2.9.   Sample configuration / internal amps / single rack

Standard Single Rack Configuration with external amplifiers: 2/3/4 Channel   *2.7.2*
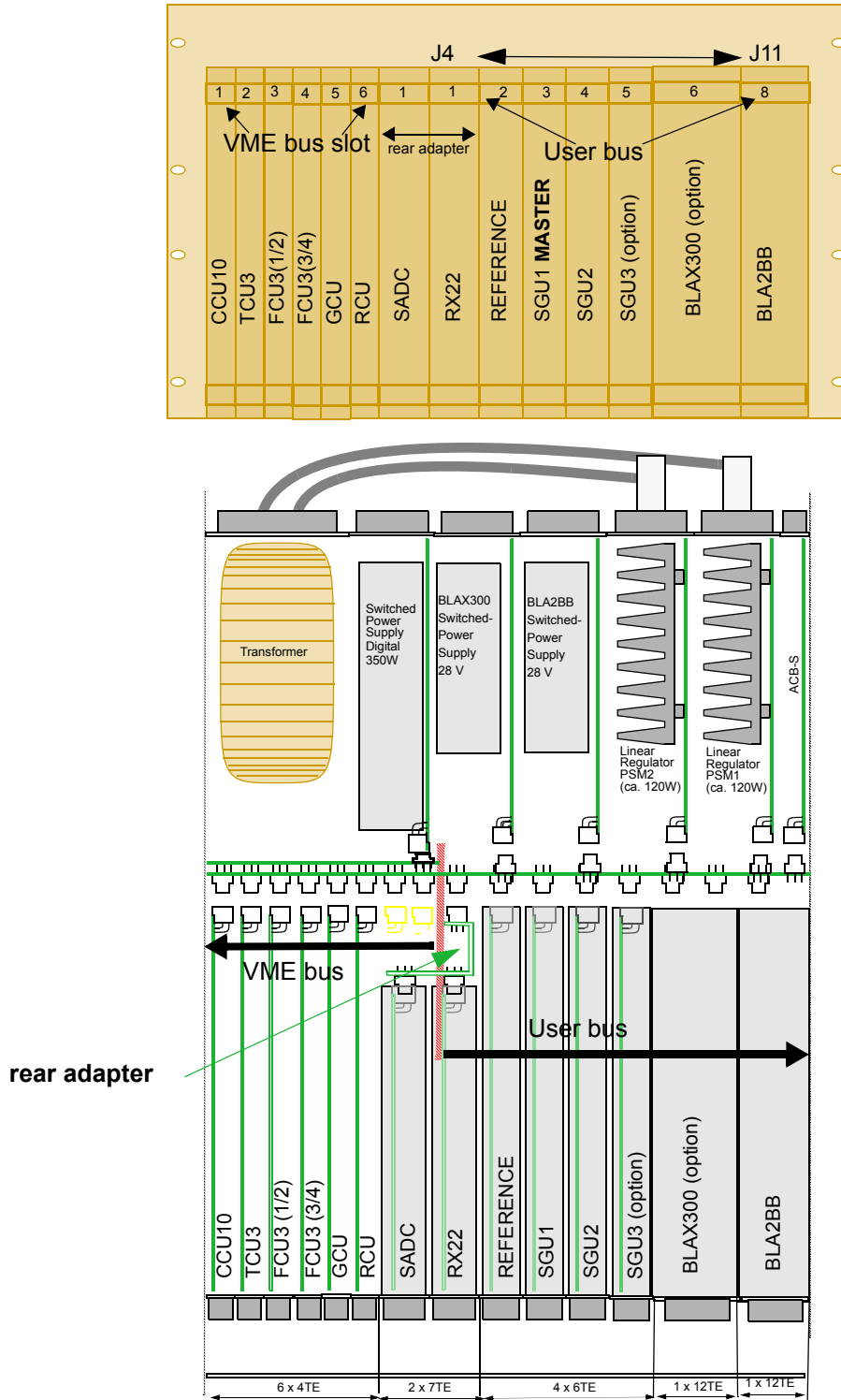
A single AQS rack can accommodate up to 4 RF channels if external amplifiers are used. This configuration is shown on .

All units to the left of and including the RCU are connected to the VME bus. All units to the right of and including the SADC (HADC/2) are connected to the user bus.

Note that the rear adapter for the two Routers makes physical contact with J11 and hence both Routers are effectively connected to user slot 8. Note also that the SADC + RX22 rear adapter effectively means that although two physical slots are occupied the electrical connection at the rear is made at the single connector J4 of user bus slot1.

Figure 2.10. Sample configuration / 4 channels /single rack
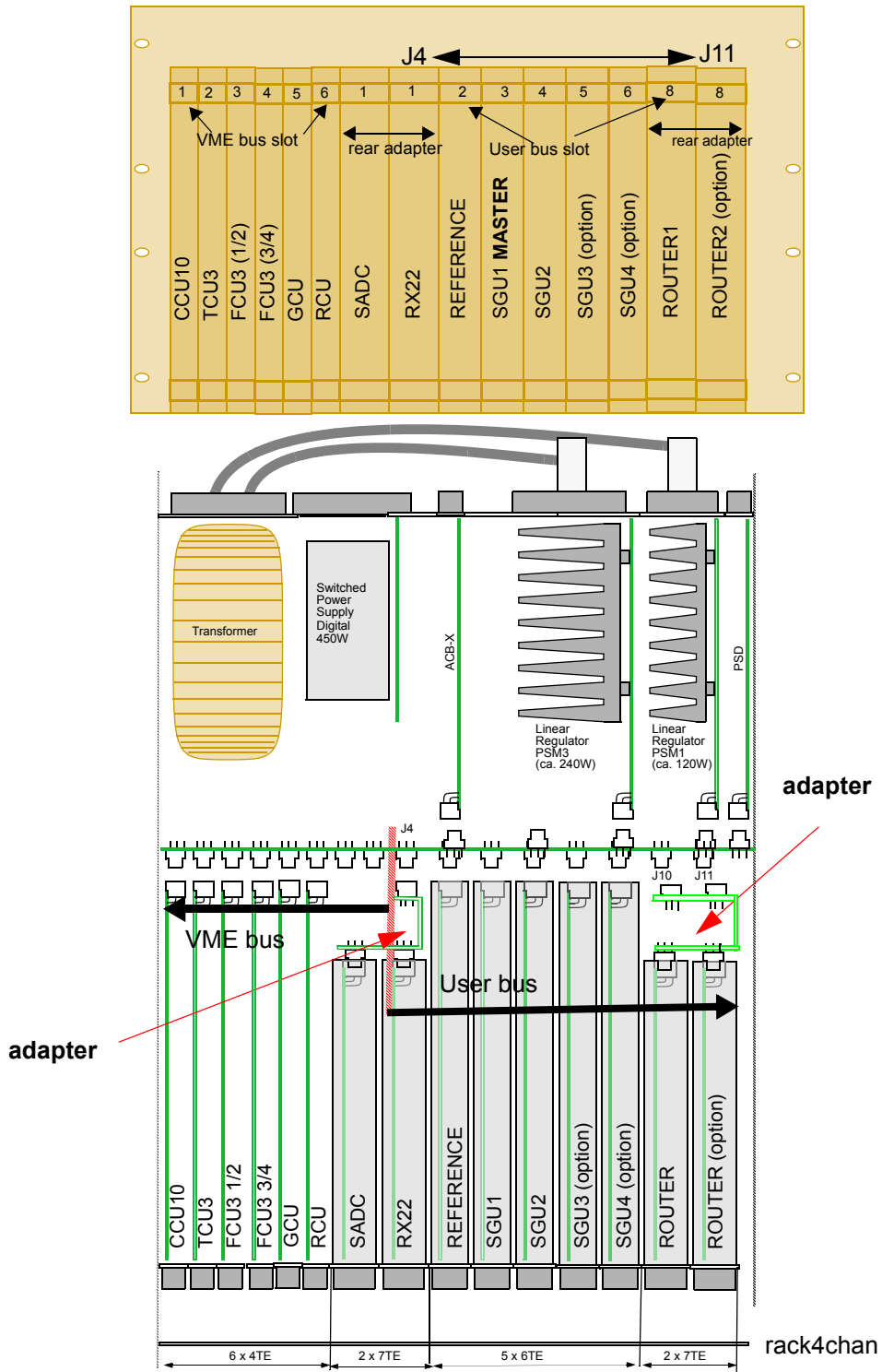
Figure 2.11. A sample configuration / 6 channels / two racks - part 1
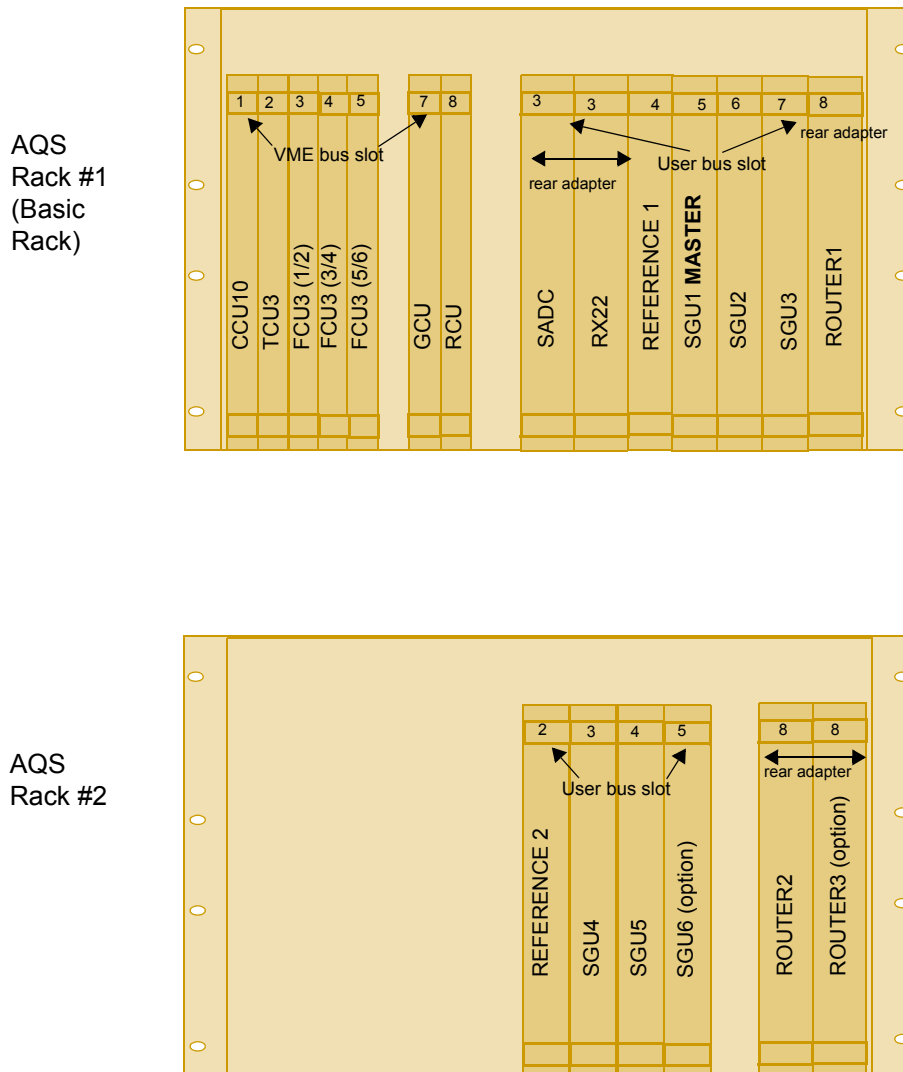
Rack address setting   *2.8*

Every slot on the AQS user Bus backplane is hardware coded, so that every unit can be addressed via its specific slot address. To minimize traffic most communication with the analog boards take place via the **master SGU**. Although all SGUs are physically identical only one can be master. The physical position of the master SGU is fixed using the rack address. Essentially the rack address makes the position of the SGU master known to the software as well as whether the rack is the basic rack or the extension rack in a two rack system. The master SGU is always located in the **Basic Rack** (AQS Rack #1). The rack address is set with jumpers on the rear side of the AQS backplane. In as much as is possible the

AQS Rack

SGU master slot allocation has been standardized. Regardless of the number of channels MicroBay and OneBay have the same coding.

Figure 2.12. A sample configuration / 6 channels / two racks - part 2
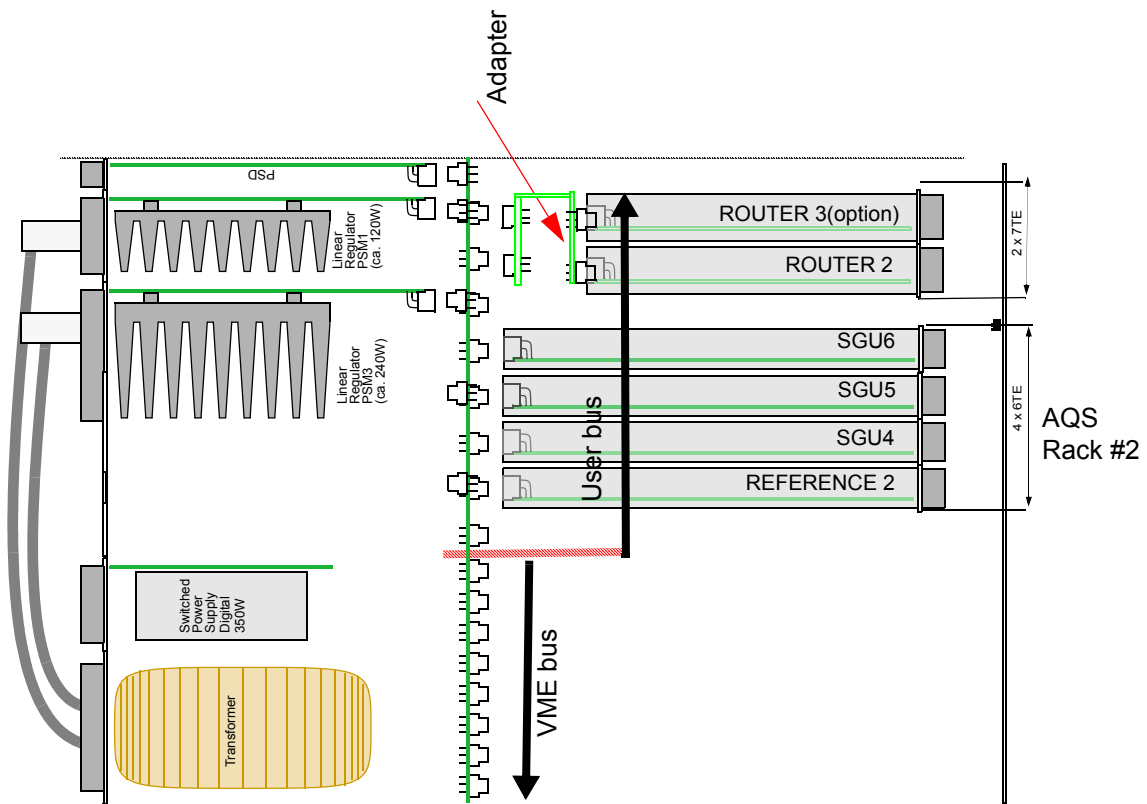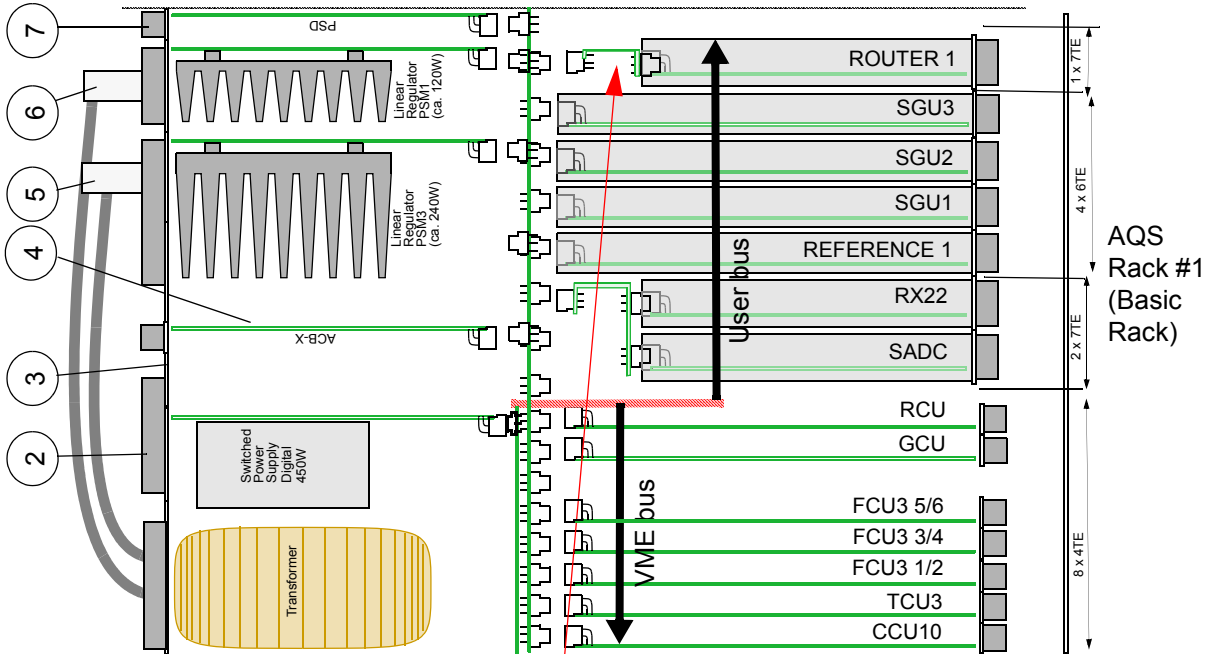
Table 2.4.   AQS rack address jumper coding

System	SGU Master slot	Basic Rack Address	Extension Rack Address	System Description
Micro bay	3	0X1F	na	2/3 channel AV
One Bay	3	0X1F	na	2/3 channel AV
One Bay	3	0X1F	na	4 channel AV (ext amplifiers)
Two Bay	3	0X1F	na	up to 4 channel AV (ext amplifiers
Two Bay	5	0X1C	0X1E	5/6/7 channel AV
Two Bay Solids	5	0X1D	na	2/3 channel AV
Two Bay Solids	6	0X1B	0X1E	up to 6 channel AV

Units that need adjustment to rails or adapters.   *2.8.1*

Note that this only applies to analog boards and is is due to the different physical widths of units. Previous generation boards such as the SADC/HADC/2, RX22 and Router have widths of 7TE whereas the newer units such as the REF, SGU are only 6 TE wide. The system will of course be shipped with the slide rails in the correct position but this may need to be changed if an upgrade is being carried out. Refer to diagrams for the widths of the various boards (figures 2.9-2.12).

Switching on and off.   *2.9*

The AQS should always be switched off at the mains before any units are re-moved or inserted etc. Before switching off the AQS the CCU10 should first be **shut down**. This can be done using the ' init 5' command. The shut down can be observed using the Hyperterminal icon

Differences from previous versions.   *2.9.1*

The AQS is a completely new development specifically for the AV series. Its fore-runners were the dual rack systems the AQR and the AQX used in AVANCE DRX series.

Part Numbers and Cables   *2.10*

The rack part number is Z003414.

Power Supply / Fuses   *2.11*

The mains connection as well as the rack fuses can be seen in ***"AQS Rack rear view" on page 21***. The power supplied by the AQS rack shall be discussed in three sections, analog power supplies (user bus units), digital power supplies (VME units) and dedicated power supplies (BLAX300 and BLA2BB).

analog power supplies to the user bus   *2.11.1*

The 8 slots of the user bus are powered by power supply modules (PSMs). The rear connectors J4 to J11 are shown in ***"Schematic of AQS front section" on page 14*** . Each slot receives the identical dc voltages via the 110 pin back plane connector though many of the analog units do not use all of the voltages available at the rear connector. ***"Analog Voltage Supplies from the AQS Backplane" on page 33*** is a quick reference table of the various pins and the corresponding voltage delivered by the PSM at these pins. The table also shows which of these voltages are actually used (applicable) by the various units . In reality it is very difficult to test these voltages without an extension unit for the various analog units. However many of the units have front panel power voltage LED displays which are discussed in the relevant chapters on the different units.

Table 2.5.   Analog Voltage Supplies from the AQS Backplane

a = applicable na = not applicable

PIN	Signal	RX22	SADC	REF	HADC/2	SGU	Router	FTLP/4M	RXC
A21-25	P5V	na	na	a	na	a	na	na	a
B21	P35V	na	na	na	na	a	na	na	a
B23-25	P19V	a	a	a	a	a	a	a	a
C20	P2V	na	na	na	na	a	na	na	na
C21	P9V	a	a	a	a	a	a	a	a
C22	N9V	na	na	a	na	a	a	a	a
C23-25	N19V	a	a	na	a	a	a	a	a
D20	N2.5V	na	na	na	na	a	na	na	na
D21	P9V	a	a	a	a	a	a	a	a
D22	N9V	na	na	a	na	a	a	a	a
E21	P9V	a	a	a	a	a	a	a	a
E22	N9V	na	na	a	na	a	a	a	a
E23-25	P12V	na	na	a	na	a	na	na	a
A15-18 B15-18 C15-18 D15-18 E15-18	GND all grounds are connected	a	a	a	a	a	a	a	a

Three versions of the of PSM (PSM1, PSM2 and PSM3) are available, of which only two are ever required in a single rack. They are located at the rear of the AQS see ***"Rear view of AQS rack showing power supplies" on page 13***. PSM1 is used in all configurations in conjunction with either PSM2 or PSM3. The voltages delivered by PSM2 and PSM3 are identical, the only difference is the current (and hence the power) that can be supplied.

Table 2.6.   power supply modules

UNIT	Power	P/N	Usage	Rear Connector
PSM1	120W	Z003402	all configura-tions	J15

Table 2.6.   power supply modules

UNIT	Power	P/N	Usage	Rear Connector
PSM2	120W	Z003403	used for configurations with internal amplifiers	J13
PSM3	240W	Z003404	used for configurations with external amplifiers	J13

PSM3 will deliver twice as much power as PSM2.

PSM3 is used when external amplifiers are fitted. When internal amplifiers are used then PSM2 will suffice because of the additional dedicated power supplies for the internal amplifiers.

PSM1 and PSM2 are fully exchangeable. Although PSM3 is wider (24Te) than PSM1 and PSM2 (both 12 TE) no adjustment to the slide rails is required when replacing a PSM2 with a PSM3.

Description: *2.11.2*

Each PSM receive ac voltages directly from a transformer located at the rear of the rack. The ac voltages are then rectified and stabilized on-board the PSM and connected to the user bus backplane. Connector J1 carries the ac voltages for PSM1 while J2 carries the ac voltages for either PSM2 or PSM3 see ***"Transformer wiring" on page 35***. The transformer can be adjusted to accept line voltages of either 203, 218 or 230V by means of the mains selector switch. see ***"AQS Rack rear view" on page 21***.

The color coding of the transformer mains wiring is as follows:

Yellow /green :earth or ground.

Blue: neutral

Brown/white/black: 203/218/230V respectively.

Front panel display   *2.11.3*

Each PSM has a front panel LED display to indicate the voltage levels.

PSM1 delivers: 2V / -2.5V, 19V, -19V, 9V(for HPPR), 35V

PSM2 and PSM3 delivers 19V, -19V (HPPR) ,12V, 9V,-9V.

Figure 2.13. Transformer wiring

windings-No.:	voltage-/current	Power (VA)	name
1	20V/2,8A	56	HPPR_P19 GND_HPPR19
2	20V/2,8A	56	HPPR_N19
3	12,5V/7,5A	93.8	HPPR_P9 GND_HPPR_P9
4	32V/0,4A	12,8	P35 GND_P35
5	20V/12A	240	P19 GND_P19
6	20V/4,8A	96	N19 GND_N19
7	14,5V/13,8A	200,1	P12 GND_P12
8	11,5V/13,8A	158,7	P9 GND_P9
9	12V/7,5A	90	N9 GND_N9

230V
218V
203V
50/60Hz
Thermo-Switch ~110C°
0
Shield

Steckerbelegung (Pin assignment)

Stecker (connector) Pin-No.	J1 Signal-name	Code	Farbe (Color)	J2 Signal-name	Code	Farbe (Color)
4	P35 / E	.	1 weiss	N9 / E	.	violett
6	HPPR_P9 / E	.	grau	.	.	.
8	P35 / B	.	1 weiss	N9 / B	.	violett
10	HPPR_P9 / B	.	grau	.	.	.
12	.	.	.	.	.	.
14	N19 / E	.	gelb	P9 / E	.	orange
16	P19 / E	.	weiss	P12 / E	.	rot
18	.	.	.	.	.	.
20	N19 / B	.	gelb	P9 / B	.	orange
22	P19 / B	.	weiss	P12 / B	.	rot
24	.	.	.	.	.	.
26	.	.	.	.	.	.
28	.	.	.	HPPR_N19	.	grün
30	.	.	.	GND_HPPR19	.	schwarz
32	.	.	.	HPPR_P19	.	grün

/B -> Begin der Wicklung (coil begin)
/E -> Ende der Wicklung (coil end)

ws   sw
br
bl
Schirm (shield)
gegn

Primär-Anschlüsse

Farbe (color)	Spannung (voltage)
gelb/grün (yellow/green)	shield
blau (blue)	0V
braun (brown)	203V
weiss (white)	218V
schwarz (black)	230V

J1/J2 connectors to PSM1/2/3
Can measure ac voltages here.

Pin 32
Pin 32
J1
J2
Pin 4

PSM Fuses: *2.11.4*

Each PSM has a set of fuses which are easily accessible. Powering off and removing the unit from thee rack will reveal the fuses, details of which are in the tables below.

note that on PSM1 fuses F1 and F2 are not mounted and on PSM2 /PSM3 fuse F5 is not mounted.

note: the 'T' denotes that the fuses are antisurge

Table 2.7.   Fuses PSM1

PHY LOC	P/N	VALUE
F3	2259	8AT
F4	2256	3.15AT
F5	4907	5AT
F6	2246	0.315AT

Table 2.8.   Fuses PSM2

PHY LOC	P/N	VALUE
F1	2254	2AT
F2	2254	2AT
F3	2259	8AT
F4	2258	6.3AT
F6	2257	4AT

Table 2.9.   Fuses PSM3

PHY LOC	P/N	VALUE
F1	2254	2AT
F2	2254	2AT
F3	2259	8AT
F4	2259	8AT
F6	4907	5AT

Figure 2.14. PSM1 component layout

Figure 2.15. PSM1

Fuses
F3 - F6

connector from transformer
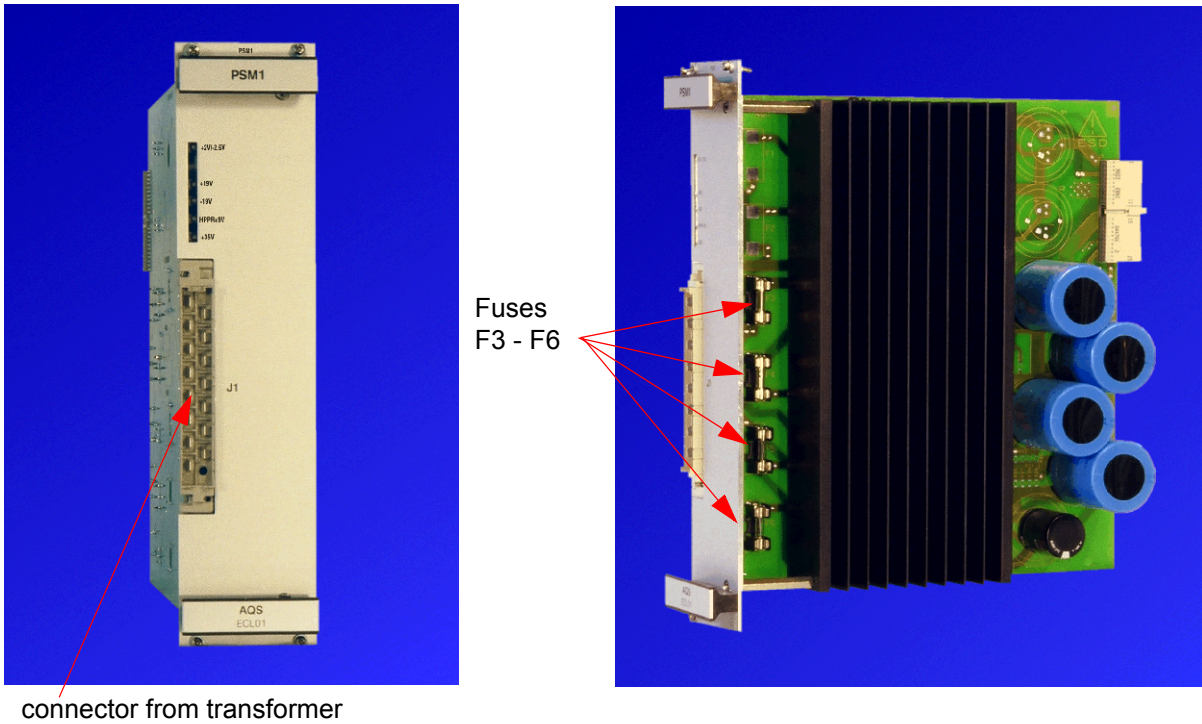
Apart from the fuses on the individual modules the AQS transformer has a temperature sensitive switch which will cut power outputs if the temperature exceeds 110°C.

Digital power supplies   *2.11.5*

The various VME units have several voltages provided by the digital power supply available to them over the backplane .There are two versions of the digital power supplies the difference being the power rating. The unit has a fixed location at the rear of the AQS rack. The unit primarily supplies the VME (digital) units of which there is a max of 8. The unit also supplies 5V to the analog units via the connector J1 see ***"AQS Rack rear view" on page 21***.

Table 2.10.   Digital power supplies

Item	Configuration	P/N
POWER SUPPLY DIGITAL 350W	up to and including 4 RF channels	H9489
POWER SUPPLY DIGITAL 450W	greater than 5 RF channels	H9520

Although the two supplies are different physical widths no adjustment is necessary to the slide rails when upgrading from 350W to 450W.

Fuses

Do not attempt to unscrew the unit and replace fuses in the field (in contrast to the PSMs). If the digital power supply is faulty then it should be exchanged.

LED display:

Four front panel LEDS monitor the four power supplies details of which are in the table below. The actual voltage level is monitored so if the level drops, the LED will go out as opposed to shining with less intensity.

Table 2.11.   DIgital power supplies

Voltage / current	Function
+5V / 36A	powers the digital units (i.e. the VME/ACQ/F bus)
+5V / 10A	powers the analog units (i.e user bus)
+12V /8A	powers the rack cooling fans as well as powering the RS232 and RS485 links from the CCU10
-12V/ 2A	powers the CCU10 rs232

Overview of power supply usage by various VME units   2.11.6

As mentioned above the various VME units have several voltages available to them over the backplane. Each of these voltages can be measured on the units using an extender board. The table below summarizes the Test Points of the VME Extender Board and which voltages are actually required by the respective units.

Note: Ensure that the **extender board** has either a 90 pin rear centre connector or no rear centre connector.

Table 2.12.   Summary of power supply usage by the various VME units

Test Point on ext. board	Voltage	CCU10	TCU3	FCU3	GCU3	RCU
TP1	+12V	required	not required	not required	not required	required
TP2	-12V	required	not required	not required	not required	required
TP3	+5V	required	required	required	required	required
TP5/TP6	Dig Ground	required	required	required	required	required

Note 1: The VME units also require 3.3V. They have an on-board power regulator which converts the +5V received from the backplane to 3.3V.

note 2: TP4 on current unit versions will not display a 3.3V signal. This test point is designed for future developments when the 3.3V may be delivered directly over the backplane as opposed to down conversion from the 5V.

Dedicated power supplies for internal amplifiers. *2.11.7*

The BLA2BB and the AQS BLAX300 have identical power supplies used to power the corresponding linear amplifiers. This means that they can be exchanged in the field if it is suspected that one of them is malfunctioning.

The power supplies provide power rated at 28V/15A. All other voltages (+5V, +9V, -9V, +12V) are supplied by PSM2 over the backplane . Note that the +12V is only required for the BLA2BB minirouter.

Communications Control Unit CCU10

<div style="text-align:right; font-size:3em;">**3**</div>

Introduction   *3.1*

A modern digital spectrometer contains a large number of individual units that need to interface with each other in a precisely controlled and synchronous matter. This requires well defined communication between the various units and is best achieved by using a single unit to control the data exchange. As the name suggests the Communications Control Unit is the main link through which communication between the various units within the AQS as well as the host workstation take place. With the exception of BIS information the CCU10 performs no on-board data manipulation or computation. It merely transmits data between the various units as opposed to processing this data.

The CCU10 needs to combine a series of data transmission architectures to remain compatible with older units as well as the newest developments see . For this reason it needs to be able to use the RS232 protocol as well as the more recent RS485. The RS232 communication is implemented using external cables while the two RS485 connectors go over the X3 connector to the backplane.

The CCU10 is a VME type unit located at the extreme left of the AQS. The principal data exchange with other similar digital units within the AQS is achieved via a VME bus along the AQS backplane.

An ethernet link is the main connection with the spectrometer workstation be it a PC or an O2 from Silicon Graphics.

Functions / Description   *3.2*

The functions of the CCU10 are listed below:

1. Communication with the TCU, FCUs GCU and RCU via the VME bus which runs along the backplane. For more details see .

2. Ethernet link to the workstation. This link is effectively the means by which the commands entered at the operator desk are transmitted to the CCU10 and hence to the various AQS units. The physical link is achieved by means of the cable entering the CCU10 front panel via the RJ45 connector.

3. RS232 link with external units such as the temperature unit, pneumatic unit etc.

Figure 3.1.   Principal communication links of CCU10 in schematic form.
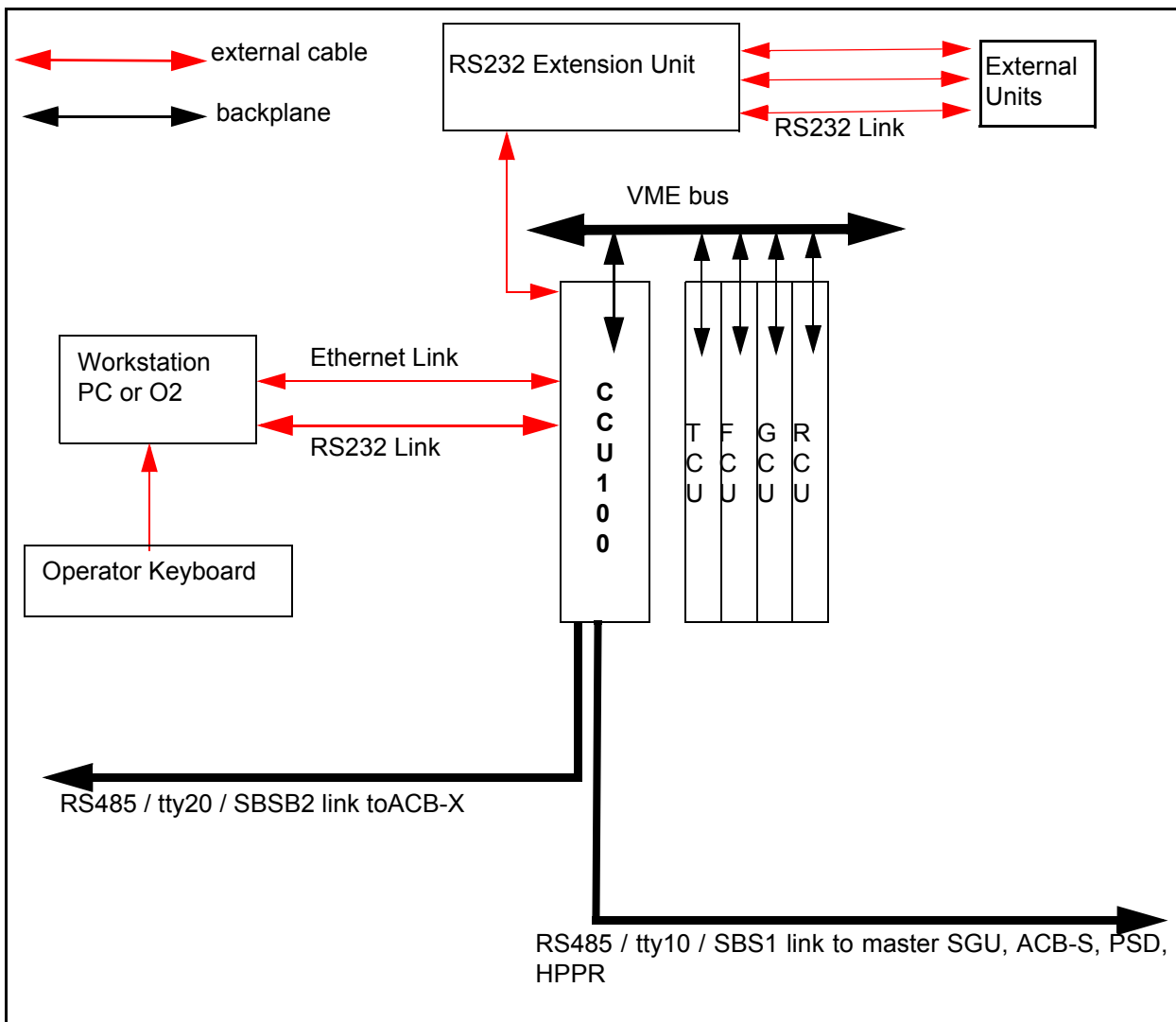
4. Communication with other digital VME units via the 90 pin middle rear connector JO at the rear of the unit. For more details see **"F Bus: 90pin J0 Middle Connector:" on page 17**.

5. Communication with various analog units via the tty10 and tty20 RS485 type links. The various units are the SGU master, ACB-S, PSD, HPPR (tty10/SBSB1) and the ACB-X (tty20/SBSB2).

Typical uses of the tty10 and tty20 links *3.2.1*

The best way to understand the role of the CCU10 is to look at some of the examples of the data communications. The list below is by no means exhaustive and is merely included as examples of the tty communication with the various units.

tty10 - SGU:

Number and type of SGUs installed during the 'cf'routine.

Which physical SGU is the 'observe' SGU.

Which output (main or auxiliary) is to be used

Whether DQD is to be used (for 'observe' SGU only)

Whether the SGU is in wobble mode

Frequency information regarding the value of the OBS and LO frequency.

tty10 - RX22:

RG setting

Diagnostic tool (RX22)

tty10 - Internal amplifiers:

Number and type of amplifiers installed during the 'cf' routine.

tty10 - Router:

Number and type of routers installed during the 'cf' routine.

Router switching control (RSEL bits)

tty10 - FADC:

Quadrature detection Mode (qf, qsim, qseq, DQD)

tty10-HPPR:

Number and type of modules installed during the 'cf' routine.

Selection of the OBS module

Selection of the Lock module

PICS (Probehead Information and Control System)

tty20- ACB-X:

Setting of amplifier parameters using the 'edacb' command

Display of FORW transmitted power

Board Configuration / Version *3.3*

Each spectrometer has one communications unit only and for AV systems this must be CCU10. This is a newly developed unit and the previous CU09 is not compatible with the AV series. The CCU10 position is fixed at the extreme left slot of the AQS.

Differences from previous versions. *3.3.1*

The CCU10 is based on the CU09 hardware is very similar to it in most respects. The principal differences are:

1. CCU10 has been fitted with a 90 pin middle rear connection replacing the 30 pin socket used in CU09. It can therefore not be used in older AQX systems.

2. CCU10 no longer has the tty10 and tty20 RS485 ports available on the RS232 Extension Unit. Consequently unlike CU09 the RS485 signals are not available on the front panel connectors ST8 and ST9.

Front Panel Wiring / Display *3.4*

RJ45 Hub. ST4:

This is the ethernet link to the workstation if a network is used.

RJ45 FETH. ST5:

This is the ethernet link to the workstation be it either a PC running on Windows NT or a Silicon Graphics O2.

Note: Only one of the two ethernet connections can be used

Console tty00 ST7:

This is an alternative (to the ethernet) link to the workstation. Note that this RS 232 link is not actually necessary since all the information goes over the much faster ethernet link. However it is particularly useful if the ethernet link crashes.

tty01-tty05 ST8:

This consists of 5 individual RS232 links. To allow for space the RS232 ports are physically located on the RS232 Extension Unit and joined to the CCU10 via a 50 pin SCSI cable. The connection is one to one.

tty06-tty09 ST9:

This is another 4 individual RS232 links which as described above are linked to the RS232 Extension Unit via a SCSI cable.

Reset button:

see sec. *3.6.2*

Front Panel link LEDS *3.4.1*

The LEDs labelled 'link' on the front panel are an indication of the status of the ethernet link

LED1: Indicates transmission of data.

LED2: Indicates receiving of data.

LED3: Indicates ethernet link is good.

LED4: Indicates data collision has occurred.

.

Figure 3.3. LINK LED Front Panel Display

L
I
N | 4 | 3 | 2 | 1 |
K
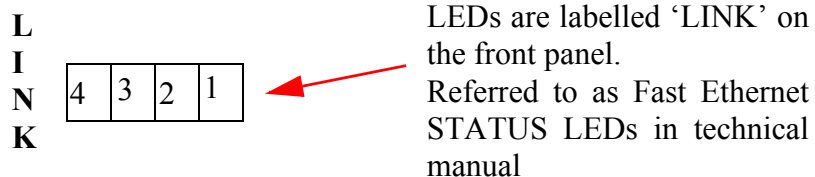
LEDs are labelled 'LINK' on the front panel.
Referred to as Fast Ethernet STATUS LEDs in technical manual

LED3 should be permanently lit once the CCU10 has booted. If you remove the ethernet cable temporarily, this LED will go out.

Figure 3.2.   CCU10 front panel

ST4 — RJ45 Ethernet connection to hub

ST5 — RJ45 Ethernet connection to workstation

Ethernet link status LEDs

Activity LEDs

reset button

ST7 — console tty0 to workstation

ST8 — tty01 - tty05 to RS232 extension unit

ST9 — tty06-tty09 to RS232 extension unit
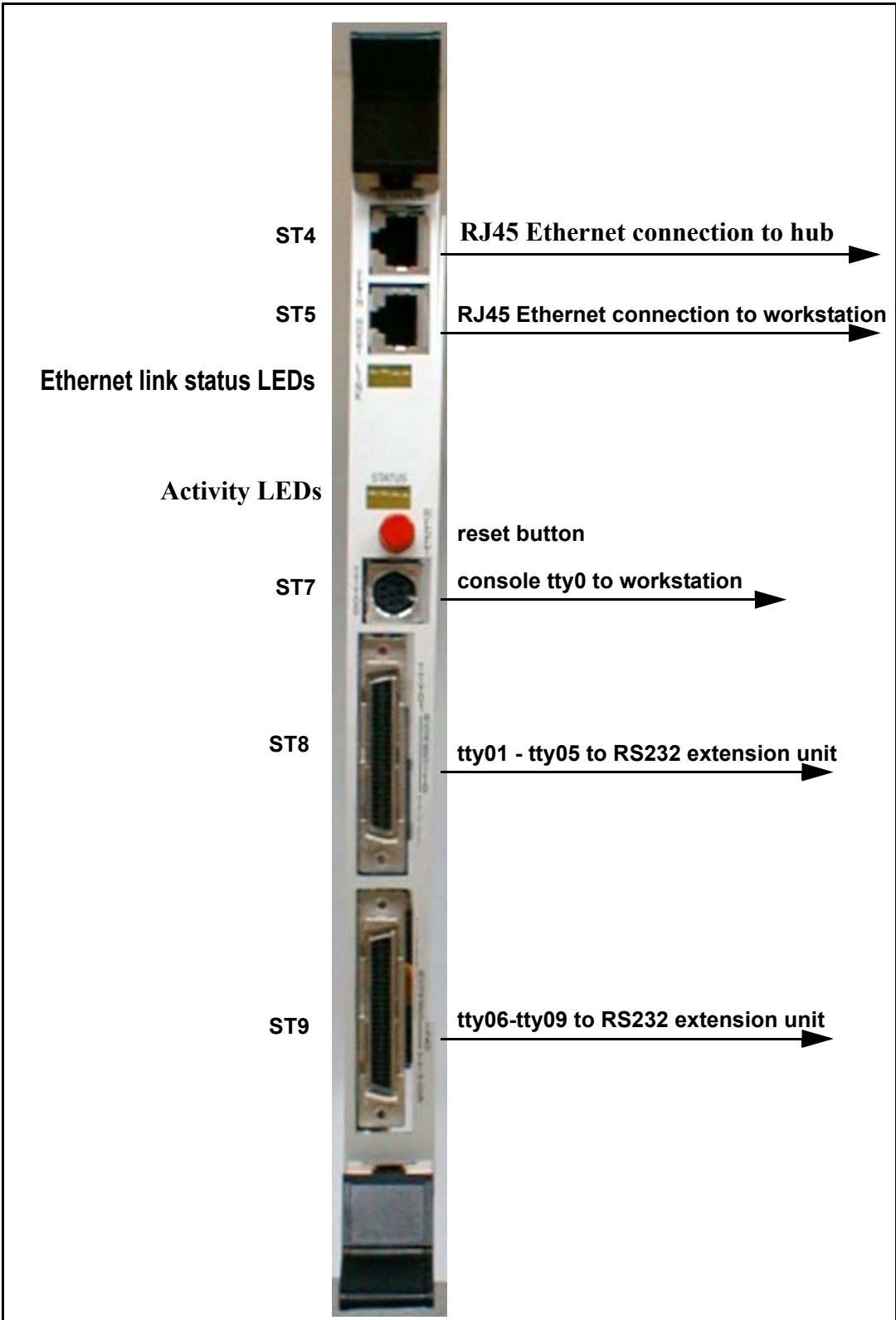
As data is transferred between the host workstation and the CCU10 LEDs 1 and 2 will blink. Note that LED4 lighting would indicate a problem.

Front Panel status LEDS   *3.4.2*

Figure 3.4.   Status LEDs

STATUS

| 4 | 3 | 2 | 1 |

LEDs are labelled 'STATUS' on the front panel.
Referred to as ACTIVITY LEDs in technical manual
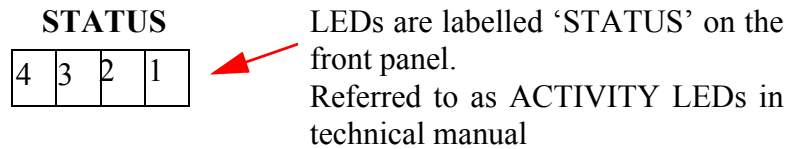
Although these LEDs do follow a test procedure during booting the pattern is too fast to follow. At the end of the booting the leftmost LED (LED4) should remain permanently lit signifying that all tests have been passed.

Connection of tty00:   *3.4.3*

This connection will depend on whether the host workstation is an O2 or a PC.

If it is an O2 the connection should be made to the COM2 port at the rear.

If it is a PC the connection should be made to the Serial B port.

On previous CUs this connection was RS232 SubD type, however to save space it is now round.

Part Numbers and Cables   *3.5*

CCU10 : H9503

RS232 Extension Unit : H9508

Table 3.1.   Cable part numbers

From	To	P/N
PC Host workstation	CCU10 / tty00	HZ04112
O2 Host workstation	CCU10 / tty00	HZ04161
Host workstation (either PC or O2)	CCU10FETH	83025 (5m) 83026 (10m)
Extension unit	CCU10 tty1-5 tty6-9	73104

Troubleshooting / Unit replacement / Tips 'n' Tricks   3.6

Exchange of the RCU can be carried out as follows:

1. Use 'init 5' to boot down the CCU10

2. Switch off the AQS

3. Remove the unit and replace

4. Switch on the AQS

5. Observe the booting up using the Hyperterminal icon

6. The message 'system is ready' will signify that the booting is complete.

7. Reconfigure the new RCU3 using the 'cf' routine.

Logging onto 'spect'   3.6.1

After rebooting the CCU10 it is customary to 'log onto spect'. This is physically logging onto the CCU10 and is usually done with the RS232 connection to tty00. The window interface is called up by clicking on the CCU Hyperterminal icon of the host workstation graphics monitor.

Note that you can also use ' telnet spect' to access via the ethernet link.

Reset   3.6.2

If the CCU10 hangs then it may be necessary to initiate a reset. A reset can be effected in three ways:

1. by pressing the red button on the front panel

2. by switching the AQS off and on at the mains

3. by activating a software reset with commands such a 'init 5'.

The effect of the reset is to put the various VME bus units into a defined state. The re-booting after a reset can be most easily observed by clicking on the CCU Hypertermina licon.

Exchange of the CCU10 can be carried out as follows:

1. Shut down the CCU10 with the ' init 5' command and switch off the AQS.

2. Remove the unit and replace

3. Switch on the AQS

4. Observe the booting up using the Hyperterminal icon

5. The message 'system is ready' will signify that the booting is complete.

6. Check the the rs232 link is OK by logging onto spect.

7. Check that the ethernet link is OK by ensuring that the link LED is lit or by using the 'telnet spect' command

Note that you can also 'log onto spect' over the ethernet connection using the 'telnet spect' command.

Communications Control Unit CCU10

Diagnostic Tests *3.7*

There is no specific diagnostic test for the CCU10. If the system boots then this is every indication that the CCU10 is functioning.

Note: The CCU10 is the successor of the older SIB unit. In the u/systest directory there is an SIB test. Do not attempt to run this test as it will crash the system.

Software *3.8*

In the 'cf' routine

tty10 is reserved for the RX22

tty20 is reserved for the ACB.

Both of these are RS485 links that are transmitted over the backplane.

Full duplex mode is not supported by the software.

Specifications *3.9*

10 RS232 Channels

2 RS485 Channels

The CCU10 on-board chip operating frequency is 100 MHZ , though the effective transmission frequency drops to 50 or 25 MHz depending on the bus used to communicate with other on-board components.

The ethernet link operates at 100Mbits/s half duplex.

Half duplex means that data transmission is allowed in one direction only at any given time. Full duplex (which is data transmission in both directions during any given time interval) is not supported. The 100Mbits/s transmission rate can of course only be attained if it can be matched at the ethernet card in the O2 or PC.

Although the CCU10 hardware manual refers to the possibility of having 16,32 or 64Mbyte of DRAM, all units to date have been fitted with 64Mbyte as standard.

Power Supply and Fuses *3.10*

The digital power supply provides the CCU10 with the required voltage levels via the backplane and the power requirements are listed below. You will need the VME_1 Extender Board P/N H9476 to check the voltages

Table 3.2.   CCU10 power requirements

Voltage	Current	Extender Board Test Point
+12V	0.3A	TP1
-12V	0.1A	TP2
+ 5V (digital)	5.3 A	TP3

The unit has only one fuse which protects the 12V RS485 supply and is relatively easy to exchange in the field.

Fuse: Multifuse 0.9A 60 V P/N. 22329

The fuse is located physically beside the tty06-tty09 front panel connection and is component U79.

Timing Control Unit TCU3

4

The TCU3 is a single slot-in unit located in the AQS rack. It replaces TCU0 and TCU1 (the TCU2 was not introduced) and is the first TCU version compatible with the new AV series. A single TCU3 is designed to provide all the required timing signals for a spectrometer with up to 8 RF channels.

As a general overview the TCU3 can be thought of as

- controlling the timing of events on various other VME units via signals transmitted along the AQS backplane

- providing a set of precisely timed outputs from the front panel which are available to drive other spectrometer units .

Very generally the performance of the TCU3 can be viewed in terms of how precisely it can control the timing of various events (timing resolution) as well as how many events it can control (number of outputs). Needless to say synchronization requires that all other relevant various units are clocked with a common signal which is a 20MHz signal originating on the REF. unit.

Although most of the TCU3 signals are generated automatically by the software it is possible to explicitly program the TCU3 to deliver specific outputs (see*"TCU3 control via explicit pulse programming." on page 58*).

As will be seen the TCU3 has been designed with future developments and extra options in mind. As a result many of the front panel outputs are currently not connected in the standard configuration. Only the top few outputs of T2 (T2 A,B,C) are normally connected and connector T1 is used only for solids.

There is effectively little of no distinction between the front panel outputs and backplane signals. Where possible signals are transmitted along the backplane to the various units. However units such as external amplifiers, QNP Pneumatic Unit BSMS etc. have no access to the backpanel and so receive TCU3 signals via external cabling.

Functions / Description   *4.2*

As the name suggests the TCU3 is responsible to a large extent with the synchronized control of the timing of many operations occurring within the spectrometer. Most of the timing control takes place via the F and Acq buses which run along the backplane. From a service point of view relatively few of the TCU3 functions are accessible to test and measurement.

Timing Control Unit TCU3

Specifically the functions of the TCU3 are to

1. synchronize and control the timing of the RCU and GCU.

2. control the implementation of frequency lists by the FCU via a set of timing sequences

3. generate various front panel switching signals used in external amplifiers, QNP Pneumatic Unit, BSMS etc.

4. to provide the RCU and GCU with a 40 MHz TTL clock signal. (This clock signal actually originates from the 20MHz signal supplied by the the REF. unit.)

5. Generation of the RCUGO signal for the RCU and AQS signal for the GCU.

A complete list of the TCU3 outputs is given at the end of this Chapter.

⇨ **All outputs of the TCU3 are TTL active low. The outputs are designed to go high after a hardware reset of the CCU10.**

80 MHz internal signal.

The timing of the TCU3 is implemented using an 80 MHz internal clock. This signal is generated on-board by quadrupling the 20MHz from the REF. unit. Note that the voltage level is TTL.

Backplane bus Connections   4.2.1

The TCU3 is connected to the FCU's, RCU and GCU via three buses , the Acquisition bus, the VME bus and F bus which run along the AQS backplane.

Acquisition bus: This is a 16 bit data, 8 bit address real-time bus .The TCU3 is the one and only master of the Acquisition bus, guaranteeing control over critical acquisition timing.

VME bus: This is a 32 bit bus used for general non timing critical communication and the CCU is normally master of this bus (The TCU and RCU can also be master) . The details of the timing within a pulse program would be made known to the TCU3 via the VME bus.

F bus: This is a new 32 bit communication bus that is used by the TCU3 to communicate (non real time) with the FCU and GCU. The TCU3 is master of this bus. Through this bus the TCU3 effectively ensures that frequency sequences are loaded correctly into the FCU and correctly implemented .

For more details on these buses see

Unit Configuration / Version/Jumpers   4.3

The position in the AQS rack is fixed with the TCU3 immediately to the right of the CCU10 occupying slot 2. This position is fixed regardless of the individual spectrometer configuration. The TCU3 contains the termination resistors of the 20 MHz reference clock signal from the REF. unit and as a result it has to be the last device in this chain.

Figure 4.1. Front panel connections

T C U 3   i n c l .   E C 2 3   *A Q S   T i m i n g _ C o n t r o l _ U n i t*
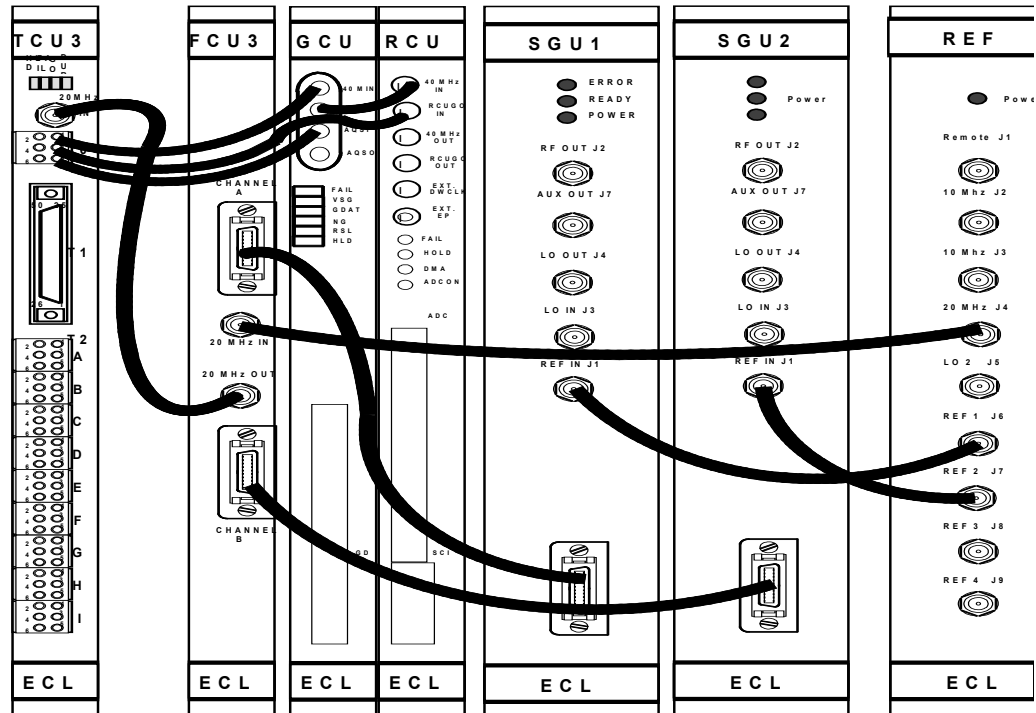
Differences from previous versions.   *4.3.1*

The TCU3 difference from older versions are itemized in the table below:

Table 4.1.   Major differences in the latest TCU3 version

TCU3 AV series	TCU0, TCU1 AVANCE series
single unit occupying a single slot in the AQS	two boards occupy 3 slots in the AQX Rack
90 pin middle connector at rear	30 pin middle connector at rear
no longer controls the router via the RSEL bit settings (now done by the SGU)	direct control of router via the front panel connector T2
BBIS info is mandatory for spectrometer operation	the BBIS info was on-board but was not necessary to get spectrometer to function
no longer generates BLKTR, TGP pulses and EP pulses (now done by the SGU)	generates BLKTR, TGP pulses and EP pulses
new F bus connection to the FCU3	connection to FCU1 via the AQS bus only

Timing Control Unit TCU3

Table 4.1.   Major differences in the latest TCU3 version

TCU3 AV series	TCU0, TCU1 AVANCE series
synchronized by the REF. unit via a 20Mhz signal from FCU. The REF. unit is the source of the overall synchronization	generated 40 Mhz signal which was daisy chained through successive FCU boards (and GCU if fitted). The TCU was the source of the overall synchronization
programmable PALS that can be downloaded in situ using a VME extension board and special connector	to download the PALS they had to be physically removed from the unit.
outputs assigned to NMR words 0,3 and 4 RCP pulses no longer exist	outputs assigned to NMR words 1-8

Jumpers settings for Pal Downloading   4.3.2

The various jumpers are factory set and no adjustment in the field should normally be required .The only possible exception is with W11 which deals with reprogramming PALS. With previous TCU versions the pal had to be physically removed from the unit for the downloading to be carried out. Now however this can be done with the PALS in situ. A connection (ST8) is available on the VME extender board to facilitate PAL downloading via a laptop in the field. A connection is made between ST8 and the laptop parallel port. To download using the VME Extender board W11 is set .If however the download is to be done using a cable directly onto the unit (without extender board) then W11 should be unset. On the TCU3 ST8 is used as the connection to download PALS in chain 1 and ST10 is used as the connection to download PALS in chain 2. To date however downloading of pals with new firmware has not been required.

Front Panel Wiring / Display   *4.4*

⇨ *Note: Connector T1 is connected for signals required for solids only (high power) .Only T2 A,B,C (ST6, ST7, ST8) are normally connected for standard configuration. The remaining T2 connections are not normally required.*

ST4: 20 MHz Input:

This signal is 1Vpp at 50 Ω and operates on a 50% duty cycle. The signal is received from REF Unit after being daisy chained through the FCUs. This signal is to ensure synchronization with the various timing sensitive units. The 50 Ohm termination resistors for this signal are located on-board the TCU3.

Note: This 20 Mhz signal is qaudrupled and used as an internal TCU3 80Mhz clock signal on-board the TCU3 itself.

ST5 :T0 connections:

T0 Pin 1 :40 Mhz TTL clock signal (3.4 Vpp at 50 Ω) and operating on a 50% duty cycle

T0 Pin 2 :identical signal to Pin 1 as described above.

Pins 1 and 2 transmit a 40 MHz clock for the GCU and RCU. Note only pin 1 was connected for earlier consoles. Later consoles used both pins 1 and 2 see ***"Wiring of 40 MHz signal in earlier consoles (above) and in current consoles (below)" on page 55***.

If only Pin 1 is used then it is connected to the GCU and then daisy chained to the RCU. In this case the signal should **not** be terminated on the GCU and so jumper W1 should be open. If both Pin 1 and Pin 2 are used then Pin 1 is connected directly to the GCU and Pin 2 is connected directly to the RCU. To terminate the signal on the GCU jumper W1 should be closed. The signal is always terminated on the RCU and so jumper modifications should never be necessary.

Figure 4.2.   Wiring of 40 MHz signal in earlier consoles (above) and in current consoles (below)
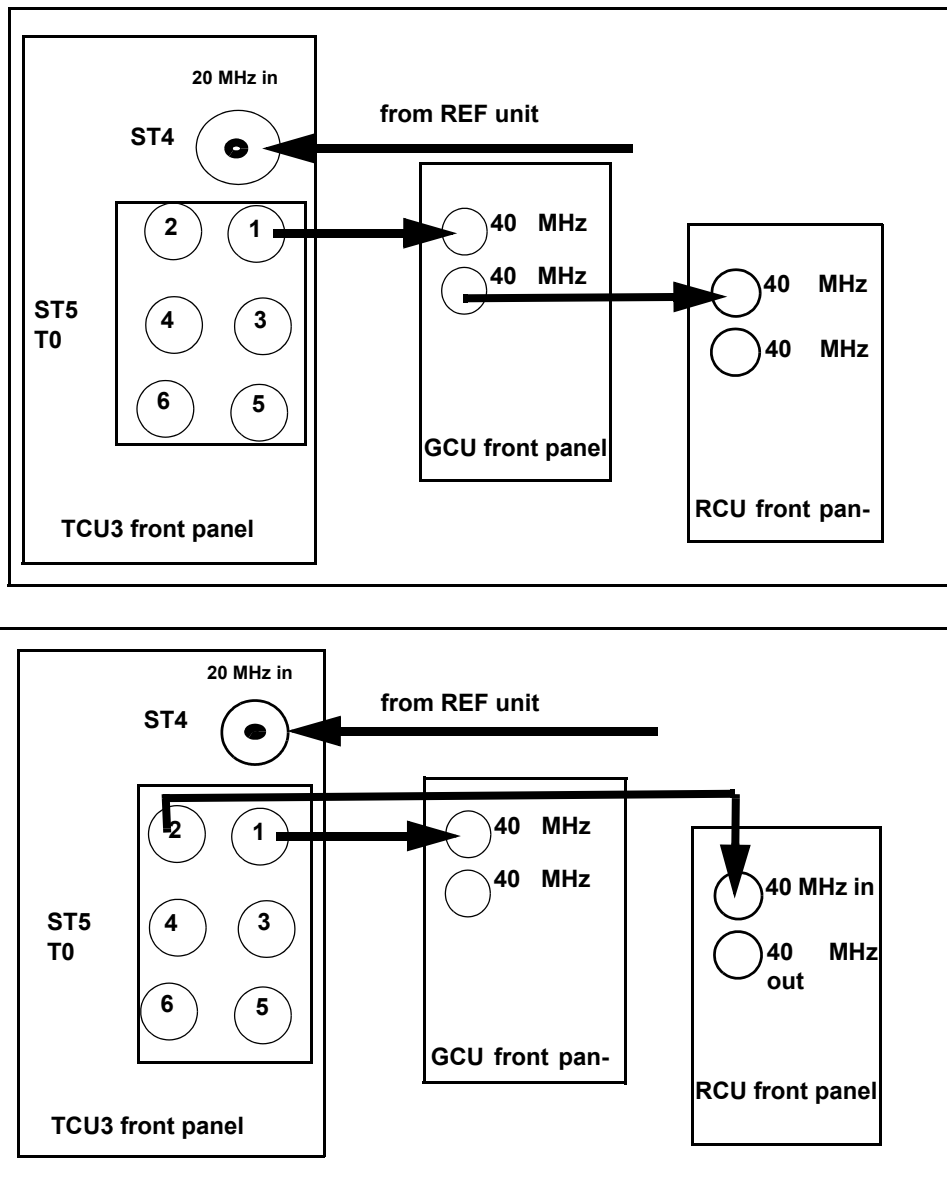
Note that the 40 MHz clocks are themselves derived from the 20 MHz input from the REF. unit.

⇨ *Warning: A strong periodic signal (3 Vpp) may be observed at the 40 Mhz output even when the 20 MHz input from the REF. unit is removed . When the 20 MHz input is missing the resulting undefined state will usually cause random oscillations from an on-board phase locked loop oscillator. This will be seen at the 40 MHz out with frequencies in the range of 10-20 MHz typical. There is no way to predict the frequency of these signals. The important point to note is that when measuring this 40 MHz signal on the scope be sure to measure the precise frequency.*

⇨ *Warning: Powering up the AQS without the 20 MHz connection to the FCU and TCU could eventually damage amplifiers on the FCU.*

T0 Pin 3   RCUGO to RCU

This TTL pulse is used to start the RCU and as such must accompany every scan. The timing is so that it goes low for 100ns, approximately 1.4us before the EP - HPPR pulse. When not active this will appear as a 3V dc signal.

To observe this signal use the J6 EP-HPPR output of the RX22 as a trigger signal and set up short repetitive acquisitions by minimizing the value of AQ (typically about 6 ms is the minimum duration for AQ).

T0 Pin 5   AQS to GCU

Various instructions are sent from the TCU3 to the GCU via the Acquisition bus. This TTL strobe pulse is used to synchronize the timing of the bus. The strobe pulses go low for a minimum of 25ns. The data transfer itself is triggered by the rising edge. When not active this will appear as a 3V dc signal.

T1 Connections:

These outputs are all TTL, active low and detailed in the table.*"T1 Connector Pinouts" on page 63*.

T2 Connections.

These outputs are all TTL, active low and detailed in the table *"T2 Connector Pinouts" on page 64*.

Trigger Inputs

These inputs are available should it be necessary to trigger the TCU3 with external signals.

Table 4.2.   TCU3 trigger inputs

Signal	T2 connection	ST connection	wiring
Trig0	C5	ST9	from backpanel Pin Y/MAS unit
Trig1	C6	ST9	from BSMS SLCB
Trig2	E1	ST12	not hardwired
Trig3	E2	ST12	not hardwired

TRIG 0:

Hardwired to the backpanel Pin Y. This is designed for MAS units which are capable of generating a signal to synchronize the TCU3 timing with MAS sample spinning.

TRIG 1:

This input is for the signal "scantrigger" which is generated on the BSMS. This signal could be used to synchronize the TCU3 timing with standard sample spinning.

TRIG 2, TRIG 3:

These trigger signals are not hardwired and there use is not preassigned.

The TCU3 can be programmed to trigger on either the input signal level or the signal flank.

At the end of this chapter Table 4.4. to Table 4.6.is a summary of all the TCU3 front panel outputs organized by NMR Word. Table 4.7. to Table 4.9. is the same information organized by connector.

Part Numbers and Cables *4.5*

TCU3: H5813

Troubleshooting / Unit replacement / Tips 'n' Tricks *4.6*

Exchange of theTCU3 can be carried out as follows:

1. Use 'init 5' to shut down the CCU10

1. Switch off the AQS

2. Remove the unit and replace

3. Switch on the AQS

4. Observe the booting up using the Hyperterminal icon

5. The message 'system is ready' will signify that the booting is complete.

6. Reconfigure the new TCU3 using the 'cf' routine.

Diagnostic Tests *4.7*

A test program entitled **"tcutest"** is to be found in the directory:

> **/u/systest/tcu** (logged in on 'spect')

to start the program

> enter ./tcutest

> enter auto

to leave the program

> enter quit or simply q.

The message

> "no errors found after 1 loop "

will indicate that the test has been passed.

⇨ *Note the program* "tcutest" *will not detect the absence of the 20MHz input from the REF. unit. This is because of internal on-board frequencies that will kick in should the 20MHz input be missing. The purpose of the diagnostic test is to test the internal features of the TCU3 and deliberately does not depend upon an external clock signal.*

Software   4.8

TCU3 control via explicit pulse programming.   4.8.1

The TCU3 signals are normally set automatically from either the "edsp", "edasp" or "eda" tables or from the pulse program itself. In this way they are not transparent to the operator. The TCU3 does however allow for the possibility of the operator programming various TCU3 outputs and using them as precisely controlled switching signals. The operator is effectively free to use any free outputs for any customized purpose, but will need to write the TCU3 commands explicitly into the pulse program for any non-standard functions.

The TCU3 outputs are now divided into NMRwords 0, 3 and 4 (see tables at end of chapter). Note that the software for previous TCU0 and TCU1 versions used NMRWords 1 to 8. The reduction in the number of TCU3 outputs is partly due to changed functions and partly due to more signals being transmitted over the backplane.

With the exception of NMRWord 0 bits 0-31, all of TCU3 outputs are available at the front panel connectors. Reference to the table entitled ***"NMR control word 3" on page 60*** will show that for example bits 28-31 are effectively unassigned and left to the operator to customize.

To explicitly program the various outputs use the following syntax in a pulse program

d11 setnmr4^3 = set NMRWord 4 bit 3 high (inactive).

d11 setnmr4|3 = set NMRWord 4 bit 3 low (active)**.**

d11 is the switching time and can be set as low as 50ns (the minimum duration.).

It is a simple matter to write a pulse program and observe the appropriate TCU3 output on the scope. Once a bit is set high or low it will remain in this state until a further instruction to alter it's state is received. The above syntax applies to NMR words 0, 3 and 4. Note that the syntax used in previous TCU0 and TCU1 versions for NMRWord 0 (RCP pulses) is not applicable to TCU3.

Specifications   4.9

As mentioned in the introduction the TCU3 can be specified in terms of how precisely it can control the timing of various events (timing resolution) as well as how many events it can control (number of outputs).

Total number of real-time outputs: 67 (available at front panel). This does not include Bits 0-31 of NMRword 0 which are transmitted over the backplane.

The precise timing control of the TCU3 is achieved by means of an on-board Duration Generator clocked at 80MHz.

Minimum Duration: 50ns.

This effectively means that bits can be set high or low for a minimum of 50ns.

Timing Resolution: 12.5ns.

This resolution is set by the 80 MHz clocking frequency . Bits can thus be set high or low for durations of 50, 62.5, 75 ,87.5ns etc.

Pulse Rise Times: 5ns

Pulse Fall times: 4ns.

Number of trigger inputs : 4

Power Supply and Fuses *4.10*

The digital power supply provides the TCU3 with the required voltage via the backplane and the power requirements are listed below. You will need the VME_1 Extender Board P/N H9476 to check the voltages .

Table 4.3. 　 *Power Supply*

Voltage	Current	Extender Board Test Point
+ 5V (digital)	4,7 A	TP3

The TCU3 has no fuses on-board.

Table 4.4. 　 *NMR control word 0*

Bit #	Connector on TCU3	Signal	Destination
Bit0-7	Backplane	NCO1	SGU1-8
Bit 8-15	Backplane	NCO2	SGU1-8
Bit 16-23	Backplane	NCO3	SGU1-8
Bit 24-27	Backplane	reserve	SGU1-8
Bit 29	T2-A4	BLK_GRAD_X	GRASP
Bit 30	T2-A5	BLK_GRAD_Y	GRASP
Bit 31	T2-A6	BLK_GRAD_Z	GRASP

Timing Control Unit TCU3

Table 4.5.   *NMR control word 3*

Bit #	Connector on TCU3	Signal	Destination
Bit 0	T2-B1	! LOCK_HOLD	BSMS/LCB
Bit 1	T2-B2	! HOMOSPOIL	BSMS/SCBR
Bit 2	T2-B4	SEL_! H/F	1H Transmitter
Bit 3	T2-B5	SELX_! X/F	1H Transmitter
Bit 4	T2-B3	!INT_A_(Z0)	BSMS/LCB
Bit 5	T2-B6	MIXCC	BP
Bit 6	T2-C1	reserve	
Bit 7	T2-C2	RCP_PA_SWITCH	HPPR
Bit 8	T2-C3	FXA	QNP
Bit 9	T2-C4	FXB	QNP
Bit 10-15	T2-D1..6	reserve	
Bit 16-21	T2-G1..6	reserve	
Bit 22-23	T2-H1..2	reserve	
Bit 24	T2-H3	ECG_START_TRIG	MED
Bit 25	T2-H4	AUT_TUNG_IN	MED
Bit 26	T2-H5	AKTIV_DEC_RES	MED
Bit 27	T2-H6	AKTIV_DEC_RES	MED
Bit 28-31	T2-I1..4	Customer specified	MED

Table 4.6.   NMR control word 4

Bit #	Connector TCU3	Signal	Destination
Bit 0	T1-2	GAIN_0_TR1	
Bit 1	T1-27	GAIN_1_TR1	
Bit 2	T1-3	C/AB_TR1	
Bit 3	T1-5	GAIN_0_TR2	
Bit 4	T1-30	GAIN_1_TR2	
Bit 5	T1-6	GAIN_2_TR2	
Bit 6	T1-8	GAIN_2_TR1	
Bit 7	T1-10 / T2-E3	RELAY_H	HIGH POWER
Bit 8	T1-35/ T2-E4	RELAY_X	HIGH_POWER
Bit 9	T1-12 / T2-E5	RELAY_Y	HIGH_POWER
Bit 10	T1-37 / T2-E6	RACK_ON/OFF	HIGH_POWER
Bit 11	T1-13 / T2-F1	RCP	HIGH_POWER
Bit 12	T1-14 / T2-F2	RELAY Z	HIGH_POWER
Bit 13	T1-15 / T2-F3	RCP_Scope	HIGH_POWER
Bit 14	T1-16 / T2-F4	RCP_EXT_DEV	HIGH_POWER
Bit 15	T1-17 / T2-F5	RCP	HIGH_POWER
Bit 16	T1-18	STP1_CLK	STRAFI
Bit 17	T1-43	LB_SEL	STRAFI
Bit 18	T1-19	DCM_STRT	STRAFI
Bit 19	T1-20	STP1_CLK	STRAFI
Bit 20	T1-21	STP2_CLK	STRAFI
Bit 21	T1-22	RES_STP1	STRAFI
Bit 22	T1-23	DCM_RES	STRAFI
Bit 23	T1-24	GO_POS	STRAFI
Bit 24	T2-A1	SEL_2H/DEC	2H Lock Switch
Bit 25	T0-4	reserve	
Bit 26	T0-6	reserve	
Bit 27	T2-A3	Q_SWITCH	Q-Switch-Unit
Bit 28	T2-A2	SEL_! X/2H	2H Lock Switch
Bit 29	T2-F6	reserve	
Bit 30-31	T2-I5..6	reserve	

Timing Control Unit TCU3

Table 4.7.   T0 Connector Pinouts

Word Bit #	Connector T0	Signal	Destination
na	T0-1	40 MHz out 1	RCU
na	T0-2	40 MHz out 2	GCU
na	T0-3	RCUGO	RCU
4 Bit 25	T0-4	reserve	
na	T0-5	AQS	GCU
4 Bit 26	T0-6	reserve	

Table 4.8. *T1 Connector Pinouts*

Word Bit #	T1 Connector TCU3	Signal	Destination
4 Bit 0	T1-2	GAIN_0_TR1	
4 Bit 2	T1-3	C/AB_TR1	
4 Bit 3	T1-5	GAIN_0_TR2	
4 Bit 5	T1-6	GAIN_2_TR2	
4 Bit 6	T1-8	GAIN_2_TR1	
4 Bit 7	T1-10	RELAY_H	HIGH POWER
4 Bit 9	T1-12	RELAY_Y	HIGH_POWER
4 Bit 11	T1-13	RCP	HIGH_POWER
4 Bit 12	T1-14	RELAY Z	HIGH_POWER
4 Bit 13	T1-15	RCP_Scope	HIGH_POWER
4 Bit 14	T1-16	RCP_EXT_DEV	HIGH_POWER
4 Bit 15	T1-17	RCP	HIGH_POWER
4 Bit 16	T1-18	STP1_CLK	STRAFI
4 Bit 18	T1-19	DCM_STRT	STRAFI
4 Bit 19	T1-20	STP1_CLK	STRAFI
4 Bit 20	T1-21	STP2_CLK	STRAFI
4 Bit 21	T1-22	RES_STP1	STRAFI
4 Bit 22	T1-23	DCM_RES	STRAFI
4 Bit 23	T1-24	GO_POS	STRAFI
4 Bit 1	T1-27	GAIN_1_TR1	
4 Bit 4	T1-30	GAIN_1_TR2	
4 Bit 8	T1-35	RELAY_X	HIGH_POWER
4 Bit 10	T1-37	RACK_ON/OFF	HIGH_POWER
4 Bit 17	T1-43	LB_SEL	STRAFI

Timing Control Unit TCU3

Table 4.9. T2 Connector Pinouts

Word Bit #	T2 Connector on	Signal	Destination
4 Bit 24	T2-A1	SEL_2H/DEC	2H Lock Switch
4 Bit 28	T2-A2	SEL_! X/2H	2H Lock Switch
4 Bit 27	T2-A3	Q_SWITCH	Q-Switch-Unit
0 Bit 29	T2-A4	BLK_GRAD_X	GRASP
0 Bit 30	T2-A5	BLK_GRAD_Y	GRASP
0 Bit 31	T2-A6	BLK_GRAD_Z	GRASP
3 Bit 0	T2-B1	! LOCK_HOLD	BSMS/LCB
3 Bit 1	T2-B2	! HOMOSPOIL	BSMS/SCBR
3 Bit 2	T2-B4	SEL_! H/F	1H Transmitter
3 Bit 3	T2-B5	SELX_! X/F	1H Transmitter
3 Bit 4	T2-B3	!INT_A_(Z0)	BSMS/LCB
3 Bit 5	T2-B6	MIXCC	BP
3 Bit 6	T2-C1	reserve	
3 Bit 7	T2-C2	RCP_PA_SWITCH	HPPR
3 Bit 8	T2-C3	FXA	QNP
3 Bit 9	T2-C4	FXB	QNP
3 Bit 10-15	T2-D1..6	reserve	
4 Bit 7	T2-E3	RELAY_H	HIGH POWER
4 Bit 8	T2-E4	RELAY_X	HIGH_POWER
4 Bit 9	T2-E5	RELAY_Y	HIGH_POWER
4 Bit 10	T2-E6	RACK_ON/OFF	HIGH_POWER
4 Bit 11	T2-F1	RCP	HIGH_POWER
4 Bit 12	T2-F2	RELAY Z	HIGH_POWER
4 Bit 13	T2-F3	RCP_Scope	HIGH_POWER
4 Bit 14	T2-F4	RCP_EXT_DEV	HIGH_POWER
4 Bit 15	T2-F5	RCP	HIGH_POWER
4 Bit 29	T2-F6	reserve	
3 Bit 16-21	T2-G1..6	reserve	
3 Bit 22-23	T2-H1..2	reserve	
3 Bit 24	T2-H3	ECG_START_TRIG	MED
3 Bit 25	T2-H4	AUT_TUNG_IN	MED
3 Bit 26	T2-H5	AKTIV_DEC_RES	MED
3 Bit 27	T2-H6	AKTIV_DEC_RES	MED
3 Bit 28-31	T2-I1..4	Customer specified	MED
4 Bit 30-31	T2-I5..6	reserve	

Frequency control unit FCU3

5

Introduction   *5.1*

The FCU3 in conjunction with the SGU is responsible for all aspects (phase , frequency, amplitude, timing etc.) of the the RF signals used to excite the NMR sample. Unlike previous FCUs the outputs of the FCU3 is entirely digital and the FCU3 can be viewed as the digital section of the SGU. Put most simply, real-time digital instructions transmitted from the FCU3 are converted into analog RF signals on the SGU. Indeed the LVDS link between the FCU3 and the SGU is in many respects the principal link between the digital and analog sections of the spectrometer as a whole.

A major advance in the AV series has been the reduction in the number of units and associated physical space saving. Effectively an FCU3 and SGU, as configured in the AV series, have replaced an ASU, LOT and external synthesizer (PTS or Schomandl) and two FCU0s, as configured in the AVANCE series. The FCU3s are physically located in the VME section of the AQS between the TCU and the GCU/RCU.

Each FCU3 is capable of providing the required signals for two independent RF channels referred to as Channel A and Channel B. This is a very significant saving of space compared to the FCU0, since 4 FCU3's will suffice for an 8 channel system. The fact that all FCU3s are clocked by the same signal (20 MHz from the REF. unit) ensures synchronous operation between the various channels.

Although the FCU3 to a large extent steers the SGU it should be remembered that ultimately the timing control comes from the TCU3 via real-time instructions transmitted over the AQ bus. The FCU3 has links to the AQ, VME and F buses via the backplane. For more information on these buses see <u>**"VME Section:" on page 12**</u>

Functions/ description   *5.2*

The two principal functions of the FCU3 are

1. Digital control of all aspects of frequency generation: frequency, phase, amplitude (MOD and MULT)

2. Real-time control of all gating signals generated on the the SGU including BLKTR / RGPADC / RGPRX22 / DWCLK signals etc.

Both of the above functions are accomplished via a set of precisely timed instructions transmitted over the LVDS (Low voltage differential signal) link between the FCU3 and the SGU.

Frequency control unit FCU3

This is a new development in the AV series. The LVDS is unidirectional and carries all frequency information to the SGU. Note that the SGU does not have access to the various buses that run along the VME backplane of the TCU, FCU etc. and so the link is achieved via the LVDS. The amplitude, phase, frequency and gating information are loaded sequentially in the FCU3 but implemented simultaneously on the SGU via the LVDS. The LVDS transmits both the frequency information as well as the the command to implement on the SGU

Among the advantages of the LVDS are

1. improved galvanic isolation

2. low voltage(< 1V). The lower signal levels leads to faster risetimes etc.

3. high speed : 28 bits with a transmission rate of 560 Mbits/s

4. LVDS operates in differential mode which results in less distortions or interference from outside.

Unit Configuration / Version / Jumpers   *5.3*

Unlike the FCU0, no jumpers are required to distinguish between different FCU3s. The units are self configuring with the information passed to the CCU10 via the VME bus through the 'cf' routine.

Configuration scheme:

1. Each channel A becomes the odd channel and each channel B becomes the even channel.

1. The leftmost FCU3 (looking from the front) configures itself to be FCU1 and FCU2. An FCU3 in the next position to the right will be FCU3 and FCU4 and so on.

There should be no gaps between FCU3s. Gaps should be left at the end (right) of the chain between the last FCU3 and the GCU or RCU.

The configuration can be checked in uxnmr.information or /u/systest/fcu

The differences between the FCU3 and the principal previous version are itemized in the table below

Table 5.1.   *differences between FCU3 and FCU0*

FCU3 AV series	FCU0 AVANCE series
Single FCU3 controls two channels	Single FCU0 controls one channel
Entirely digital	Contains analog and digital section
No jumpers required due to auto configuration	Jumper settings required to differentiate between neighboring FCUs

Table 5.1.   differences between FCU3 and FCU0

FCU3 AV series	FCU0 AVANCE series
No on-board DDS generation. This function is now performed by the SGU	On-board DDS generation
Frequency **information** transmitted to the SGU via the LVDS	Frequency **bit setting** transmitted to the PTS or Schomandl synthesiser
MOD, MULT signals delivered in digital form and transmitted to the SGU via the LVDS	MOD and MULT delivered to the ASU as analog voltages.
90 pin middle connector at rear	30 pin middle connector at rear
Connection to new F bus. Connection to CCU10 via VME bus and to the TCU3 via the acquisition bus is unchanged.	No F bus. Connection to CCU via VME bus and to the TCU0 via the acquisition bus.

Front Panel Wiring / Display 5.4

The front panel connections consist simply of two analog connections for a synchronization signal and two LVDS connections.

Channel A:

LVDS link to the SGU 1/3/5/7

Channel B:

LVDS link to the SGU 2/4/6/8

20 MHz input:

This signal originates from the REF. board and is daisy chained through all FCU3s and eventually to the TCU. From here the 20 MHz is doubled and used to clock the GCU and the RCU. This ensures synchronization between all VME units. This signal is 1Vpp at 50 Ω and operates on a 50% duty cycle.
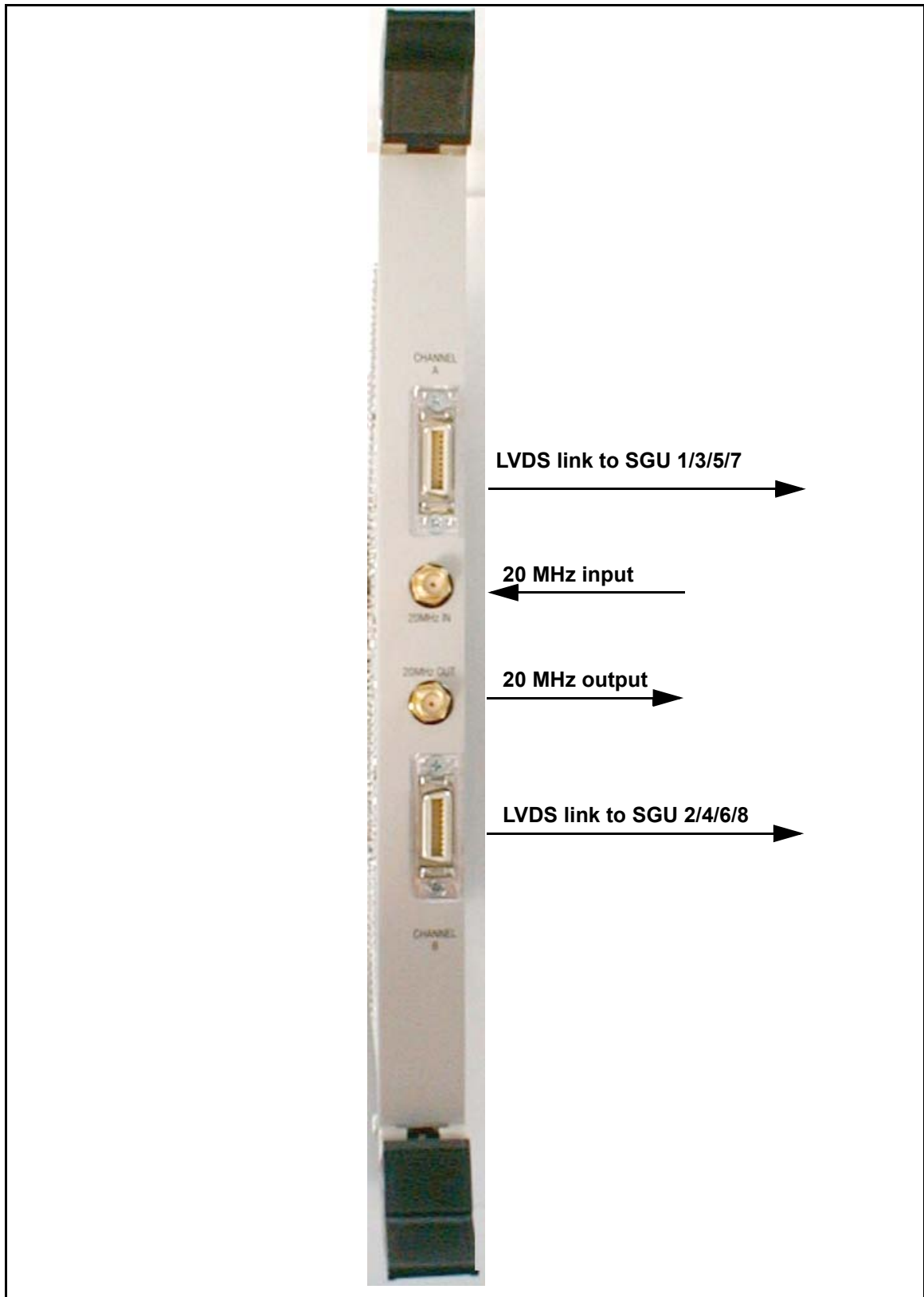
20 MHz output:

as above.

Part Numbers and Cables 5.5

FCU3: H5822   (64K RAM x 32bit current standard version)
FCU3:H9598   (256K RAM x 32bit)

Frequency control unit FCU3

Figure 5.1.   FCU3 front panel

LVDS link to SGU 1/3/5/7

20 MHz input

20 MHz output

LVDS link to SGU 2/4/6/8

Troubleshooting / Unit replacement / Tips 'n' Tricks   5.6

1. Each FCU3 is identical. If it is suspected that an FCU3 is faulty then you may exchange the order of the units. Remember however to reconfigure the spectrometer with the new unit order.

2. If it is suspected that a cable may be faulty then you can swap the LVDS cables around.

3. Do not turn on the FCU3 before ensuring that the 20 MHz clock signal is present. Unlike all other digital units the FCU3 has no internal clock and needs the ext clock before switching on.

Exchange of the FCU3 can be carried out as follows:

1. Switch off the AQS

2. Remove the unit and replace

3. Switch on the AQS

4. Observe the booting up using the Hyperterminal icon

5. The message 'system is ready' will signify that the booting is complete.

6. Reconfigure the new FCU3 using the 'cf' routine.

Diagnostic Tests   5.7

A test program entitled "**fcutest**" is to be found in the directory:

   /u/systest/fcu (logged in on 'spect')

to start the program

   enter ./fcutest

   enter auto

to leave the program

   enter quit or simply q.

The message

   "no errors found after 1 loop "

will indicate that the test has been passed.

It is recommended that when testing the FCU, the TCU test should also be run. This is to ensure that errors that arise in the FCU test are genuine FCU errors and not errors arising on the TCU via the FBus.

Specifications   5.8

SRAM: Earlier versions had 64 K x 32 Bit .Current versions have 256K X 32 Bit SRAM as standard.

Power Supply / Fuses *5.9*

The digital power supply provides the FCU3 with the required voltage via the backplane and the power requirements are listed below. You will need the VME_1 Extender Board P/N H9476 to check the voltages .

The FCU3 has no fuses on-board.

Table 5.2.   Power Supply

Voltage	Current	Extender Board Test Point
+ 5V (digital)	3,9 A	TP3

RCU: Receiver Control Unit

6

Introduction   *6.1*

The Receiver Control Unit is a slot in type VME unit that is located at the rightmost end of the digital section of the AQS rack. The unit is designed to ensure that critical elements of the NMR experiment, and in particular the data acquisition, are accurately controlled and synchronized. The RCU is the master of the digitizer. It receives data from the digitizer , processes this data and transmits it to the CCU10 via DMA access using the VME bus. Whereas the TCU and the FCU can be considered to be primarily concerned with the transmission of RF signals to the sample, the RCU is concerned primarily with the processing of the signals emitted by the sample. In terms of interaction with other units the RCU interfaces principally with the CCU10 and with whatever type of digitizer which is installed

Regardless of the number of RF channels each spectrometer requires one and only one RCU. There is no difference in performance in the AQX and AQS versions of the RCU. Synchronization is ensured by clocking the RCU with a 40MHz signal from the TCU3.

Functions/ Description   *6.2*

1. Upon receipt of the RCUGO signal from the TCU3, the RCU takes complete control of the acquisition. The RCU will then operate autonomously until the end of the current scan. To perform a second scan however the RCU must wait for a second RCUGO signal from the TCU3. Note that both the RCUGO signal and the the 40MHz clock signal are received from the TCU3. It is important that both these signals are derived from the same source to ensure synchronization.

2. The RCU is responsible for processing the acquired data i.e. digital filtering and decimation as well as accumulation and DMA transfer of processed data (digitized FID) to the CCU10 via the VME bus.

3. The RCU is master of all digitizers (SADC, HADC/2 and FADC) and all digitizer functions. This includes controlling the filter settings (SADC, HADC/2 and FLTP/4M) and the Quadrature Detection Mode (qsim, qf and dqd). For the SADC and HADC/2 the information is sent directly over the front panel 50 way digitizer cable. For the FLTP/4M the information is sent via the rear Adapter of the SADC or HADC/2 to the FLTP/4M via the I^2C Bus.

4. Supply of +12V to the HADC/2 and SADC via the front panel 50 way digitizer cable.

RCU: Receiver Control Unit

The RCU is connected to the TCU via the Acquisition bus. The TCU is the one and only master of this bus. Typical instructions sent from the TCU to the RCU over this bus are:

a) RCU Ze = zero memory

b) RCU SYNC = synchronize the RCU clock (40 MHz) with the TCU clock (80 MHz)

c) RCU_PH 0 = set receiver phase

d) RCU EOA = end of Acquisition

e) WR#0 = write to disc

The above commands can be checked using the file „shm.out" which is automatically created in the users home directory with the command „gotst".

Note that the Acquisition Bus is not used to transmit the RCUGO signal and 40 MHz clocking frequency. Instead they are sent directly to the RCU over the front panel as it was felt that this would lead to cleaner signal transmission.

The RCU is connected to the standard VME bus which runs along the digital section of the AQS backplane. The CCU10 and RCU are the only possible masters of this bus, with the RCU having priority. Typical uses of this bus are:

a) Transfer of processed digitized data from the RCU to the CCU10 (DMA).

b) Transfer of acquisition parameters such as the Filter Widths, Quadrature Detection Mode as set in XWIN-NMR.

c) Upgrading of acquisition parameters e.g. number of scans, etc.

Unit Configuration / Version / Jumpers *6.3*

Although the RCU is electronically compatible with both the AQX (AVANCE) and the AQS (AV) it is mechanically compatible with only one or the other. For AV systems the RCU must have the 90 pin rear middle connector J0. For AVANCE systems the RCU must have the 30 pin rear middle connector The other principal physical difference is that the SCSI front panel connector has been removed . Other differences are that functions previously performed by the RCU have now been taken over by the SGU. These are summarized in the table below.

Table 6.1.   RCU differences between AVANCE and AV

RCU in AQS (AV)	RCU in AQR (AVANCE)
DWELL CLOCK , RGP and ADCON can no longer be measured on the RCU as they are now generated by the OBS SGU and transmitted to the relevant ADC over the AQS backplane.	Generates the DWELL CLOCK , RGP and ADCON signals. These signal are transmitted to the ADC via the front panel 50 pin digitizer cable.
Homodecoupling timing now controlled by the SGU	Homo decoupling timing controlled by the RCU
50 pin SCSI front panel debugging connector removed.	50 pin SCSI front panel debugging connector present though not normally connected
90 pin middle rear connector J0	30 pin middle rear connector

Front Panel Wiring / Display   *6.4*

LEDS:

ADCON: indicates when the digitizer is converting.

DMA: indicates when data is being transferred to the CCU10 over the VME bus.

HOLD:

FAIL:

40 MHz in:

This input signal is used to clock the RCU. It is TTL (3 Vpp at 50 Ohms) and normally operates on a 50% duty cycle. The signal is generated on the TCU3 using the 20MHz clock from the REF unit. The 40 MHz comes directly from the TCU (current consoles) or may be first daisy chained over the GCU (earlier consoles) see *"Wiring of 40 MHz signal in earlier consoles (above) and in current consoles (below)" on page 55*
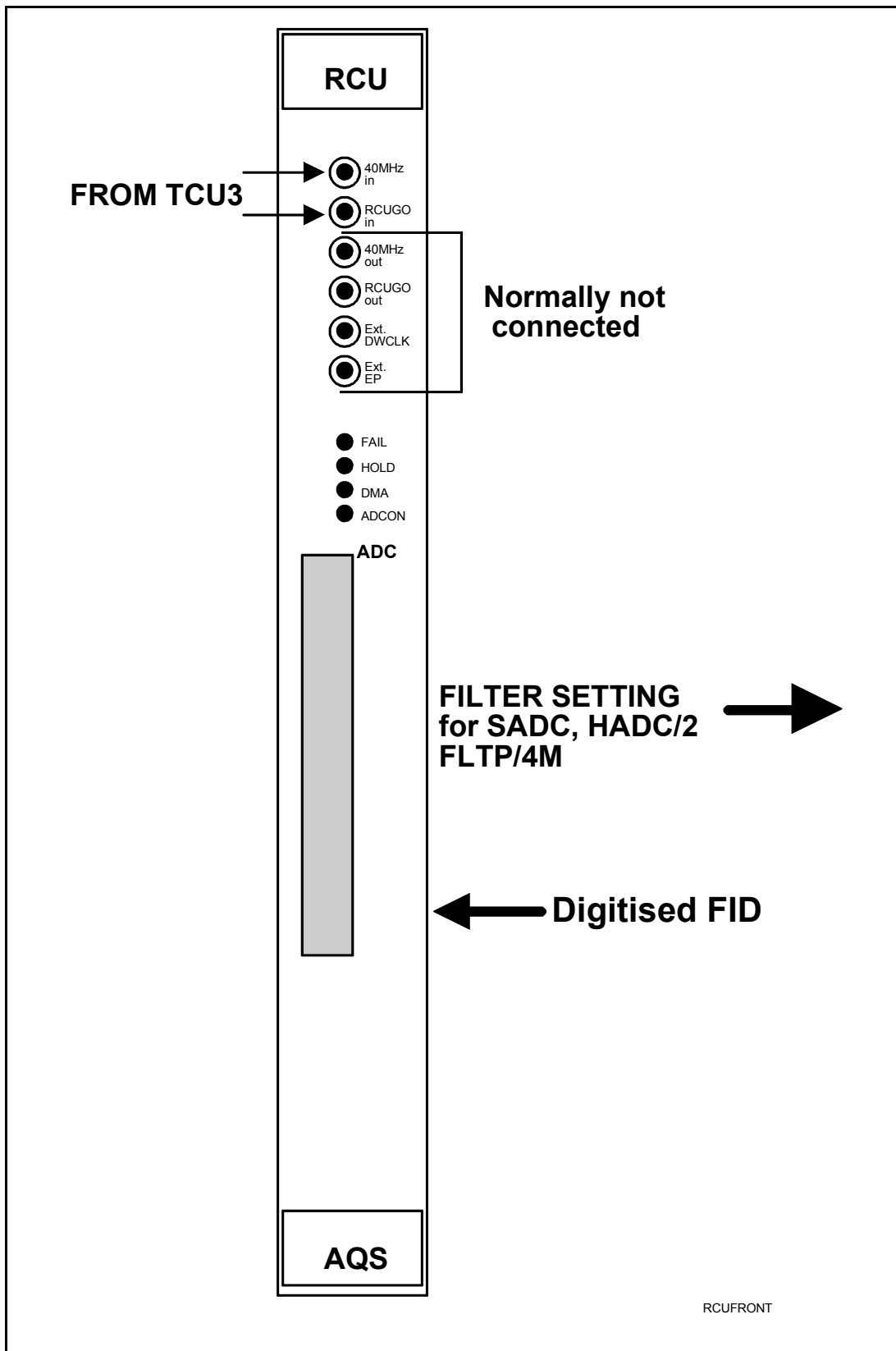
RCUGO in:

The acquisition parameters are first loaded by the software. The RCU will not perform any actions until it receives the RCUGO command from the TCU3. This pulse must accompany every scan and must be synchronized with the 40MHz in signal. The timing of the RCUGO signal is that it goes low for 100ns, approximately 1.4us before the RGP pulse see *"Timing of RCUGO signal" on page 76*.

40MHz out:

This output is normally not connected but can be used for test purposes. The presence of this signals guarantees that the RCU is receiving the 40MHz clock signal from the TCU.

Figure 6.1.   RCU front panel

RCU

40MHz in

RCUGO in

FROM TCU3

40MHz out

RCUGO out

Ext. DWCLK

Ext. EP

Normally not connected

FAIL

HOLD

DMA

ADCON

ADC

FILTER SETTING for SADC, HADC/2 FLTP/4M

Digitised FID

AQS

RCUFRONT

RCUGO out:

This output is normally not connected but can be used for test purposes. It is simply the RCUGO in signal buffered out and is a useful testpoint see _**"Timing of RCUGO signal" on page 76**_.

EXT.DWCLK:

In normal operation this **input** is not connected. However it may be possible to program the RCU to operate on an external clock from the TCU (Connector TO pin 4 / NMRWord 4 bit 25) as opposed to the SGU generated clock. The explicit pulse program commands would be

d11 setnmr4|25 = set NMRWord 4 bit 25 low (active)**.**

d11 setnmr4^25 = set NMRWord 4 bit 25 high (inactive).

This will generate the high/low pattern of the Dwell Clock.

EXT.EP:

In normal operation this input is not connected. It has been provided so that the receiver gating could be synchronized with an external pulse from the TCU.

50 way digitizer cable:

As well as the normal digitized FID the 50 way digitizer cable also transmits the filter setting instructions for the SADC, HADC/2 and FLTP/4M.

Part Numbers and Cables   6.5

RCU1/2: Z003678

Troubleshooting / Unit replacement / Tips 'n' Tricks   6.6

1. If you are using the VME extender board (P/N H2066) to carry out any diagnostics on the RCU you will need an extra long cable for the digitizer connection.

2. Measuring RCUGO in: see _**"Timing of RCUGO signal" on page 76**_

This signal can be measured at the RCUGO out connection at the RCU front panel. To observe the signal set up short (e.g.. AQ = 6msecs, d1 = 3 ms) repetitive acquisitions and trigger the signal with the Ep HPPR signal which is available at the J6 connector on the RX22 front panel.

Diagnostic Tests   6.7

The RCU may be checked using

        /u/systest/rcu/ (logged in on spect)

to start the program

Figure 6.2.   Timing of RCUGO signal
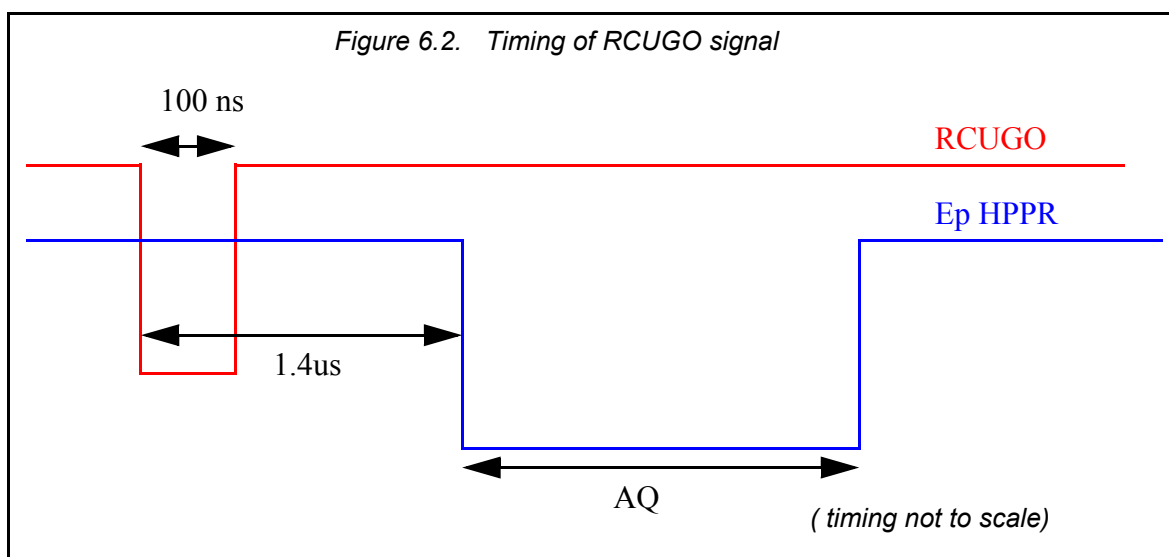
enter   ./rcutest

Useful commands are

„h" = help and prints a list of commands

„res" = performs a software reset of the RCU

„auto" = starts an automatic self test

The directory /u/systest/rcu also contains the file „docu" which describes the „rcutest" commands in detail.

rcutest can also be launched from NMRCheck 2.0

Specifications   6.8

The RCU is capable of having different specifications particularly with respect to on-board memory. The standard version is highlighted.

Acquisition Memory (DRAM) :1MByte/2MByte, **4MByte**/8Mbyte,16MByte/32MByte

Fast Memory (SRAM) : 256/512kByte, 1/2MByte, 4MByte

FIFO Memory: 1kx9Bit, 2kx9Bit, 4kx9Bit, 8kx9Bit

Sampling Rate: max. 40MHz

Power Supply / Fuses   6.9

The digital power supply provides the RCU with the required voltage levels via the backplane and the power requirements are listed below. You will need the VME_1 Extender Board P/N H9476 to check the voltages

Table 6.2. *RCU power requirements*

Voltage	Current	Extender Board Test Point
+ 5V (digital)	2.5 A	TP3

The RCU also supplies +12V to the HADC/2 and SADC via the front panel 50 way digitizer cable.

REFERENCE UNIT 7

Introduction *7.1*

The REF unit is a new development in the AV series . As spectrometers become more sophisticated the importance of coherence and in particular phase coherence between the various channels as well as between the transmission and receiving paths is more and more important. The philosophy of the AV is to ensure that all RF signals as well as all clocks originate from one source. This source is a temperature controlled crystal oscillator at the heart of the REF unit. Apart from clock signal each REF unit will provide the necessary RF signals for up to 4 SGUs. This is to enable the SGU generate frequencies using a so called up converter.If more channels are required then a second REF board will need to be installed. The location of the REF unit will depend on the configuration and electronically it can be placed in any user slot J4 to J8 (slot 1 to 5). Configurations to date for single rack systems have placed it in slot J5 immediately to the right of the RX22/SADC combination. Two rack system place REF1 in slot J7 and REF2 in slot J5.

Functions/ Description *7.2*

The REF is responsible for the synchronization through the generation of various frequencies. Specifically the generated signals are

1. IF of 21.875 MHz for the RX22

2. 20MHz synchronization clock for all SGUs, FCU,\ TCU\ user backplane

3. frequency mixture of 5, 80, 160, 320, 720 and 1280 MHz for up to four SGUs

4. 10 MHz signal for the BSMS LTX

At the heart of the REF unit is a 10 MHz oven controlled oscillator (OCXO) see ***Figure 7.1.***. The 10 MHz signal for the BSMS LTX is ported directly through connector J2. The frequency is then doubled in seven successive stages. This will yield the 80, 160, 320 and 1280 MHz frequencies directly. The 720MHz is derived by mixing 640 MHz and 80 MHz and the 5 MHz signal is generated by dividing the 10 MHz source by two. The six frequencies are summed together on a single line and afterwards ported to the four outputs REF1-4 (J6-J9).

The IF of 21.875MHz for the RX22 receiver is generated on-board by DDS which is clocked by 80MHz also from the same frequency source. This ensures phase coherency with the receiving path. Specifically the DDS can set the phase to a precalculated value, controlled by the RGP LO signal This ensures that the receiver phase is always coherent.

Figure 7.1.   block diagram of REF unit
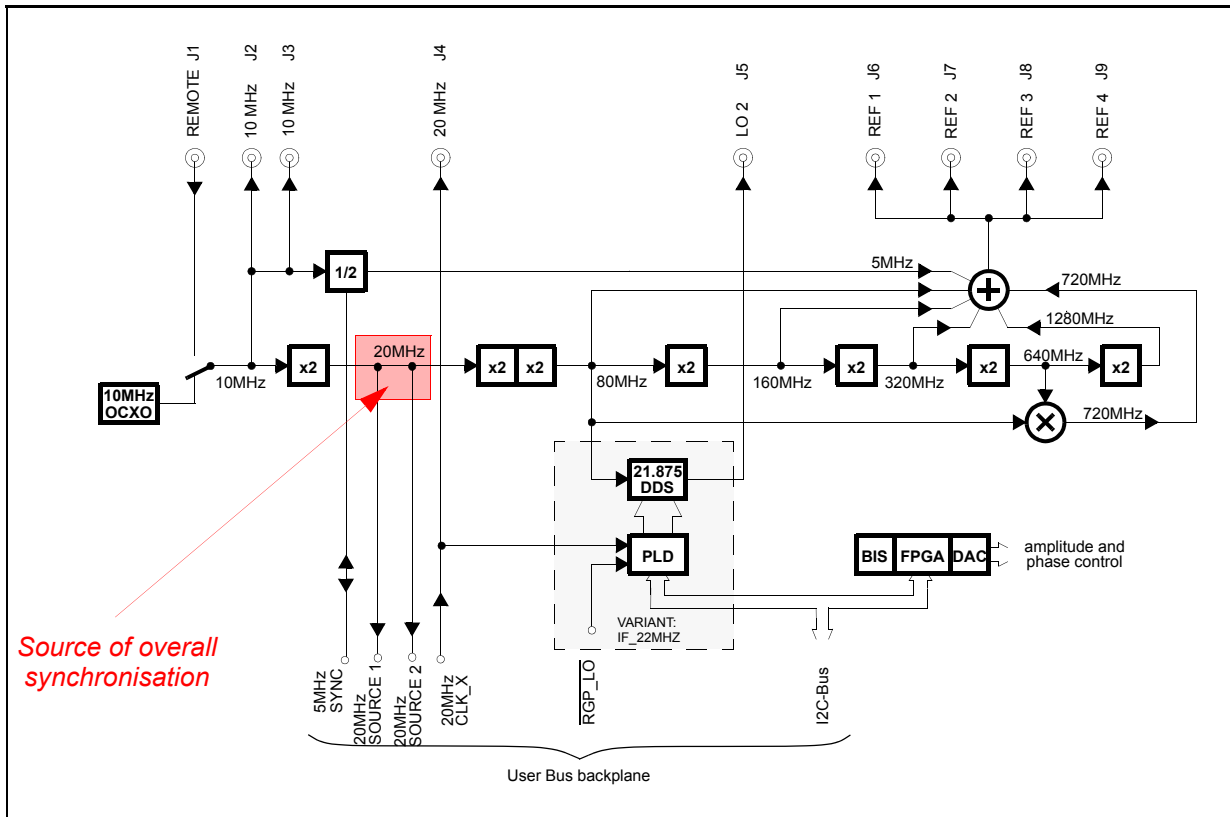
Source of overall synchronisation

Overall synchronization   *7.2.1*

This is achieved using the 20MHz sinusoidal signal generated at the first frequency doubler which is transmitted to the backplane. This is then transformed into a differential clock signal (20MHzclk / 20MHzclk) used to clock all 8 slots of the user bus, which will of course include the SGUs. The same 20MHz clock is returned and is ported out via J4 and used to clock the TCU/FCU chain. In turn the TCU uses the same 20MHz to generate the 40 MHz signal for the RCU and GCU. Essentially all clocking frequencies in both the analog and digital sections of the AQS are synchronized with the 20MHz clock of the REF. unit.

Figure 7.2.   overall synchronisation of spectrometer for single AQS rack
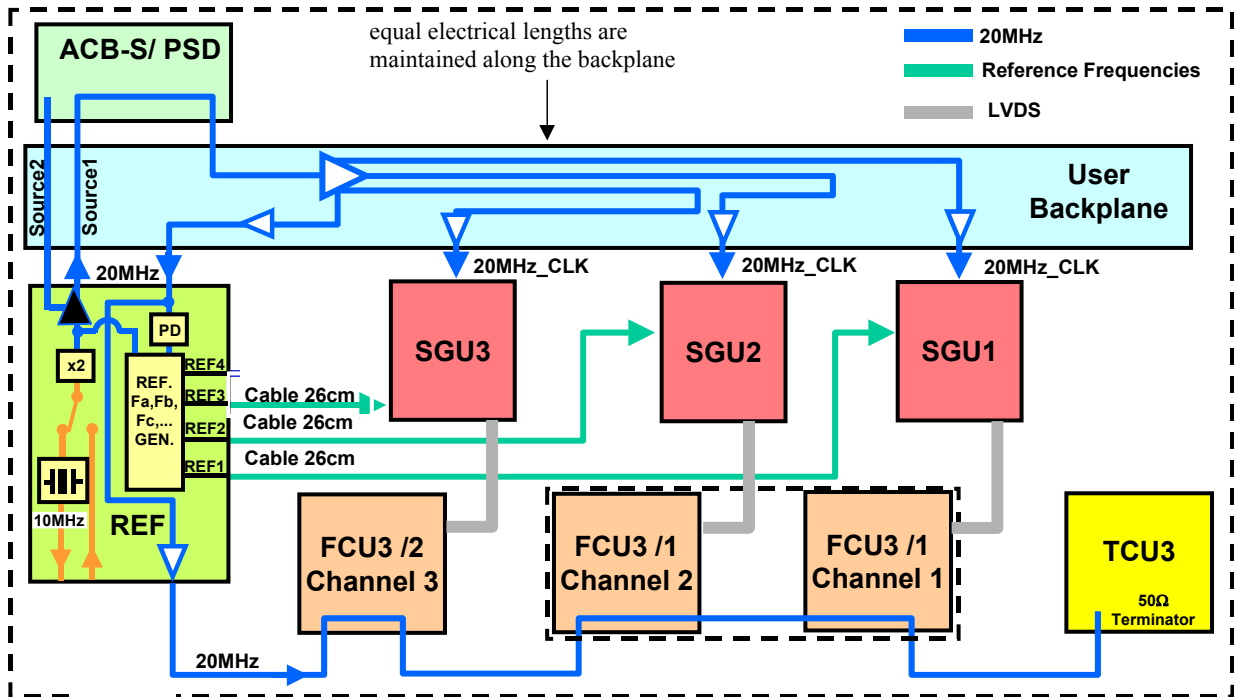
Synchronization between two AQS racks:

To ensure that two AQS racks can be synchronous two (identical) 20MHz signals (source1, source2) are used to generate the clock. In the case of a single AQS rack, Source 2 is not required and is terminated on the PSD or ACB-S, and Source 1 is used for the AQS user bus slots. The cable is extended to ensure that the total length is 895cm (earlier versions 155cm).

In the case of two AQS racks the two REF units must first be synchronized with each other. This will enable up to 8 SGUs to be synchronized. The 10 Mhz out J3 of REF1 is connected to the Remote J1 of REF2. This signal will automatically replace the oscillator in REF2. Both units have then essentially the same oscillator. WIth two REF units there are potentially 4 sources for the 20MHz clock. How they are used is explained in the table below.

Table 7.1.   Synchronization with two REF units.

Signal	use
REF1 source1	used to clock AQS1
REF1 source2	used to clock AQS2
REF2 source1	not used. Terminated at PSD connection
REF2 source2	not used. Terminated at PSD connection

Figure 7.3.   Single rack synchronisation
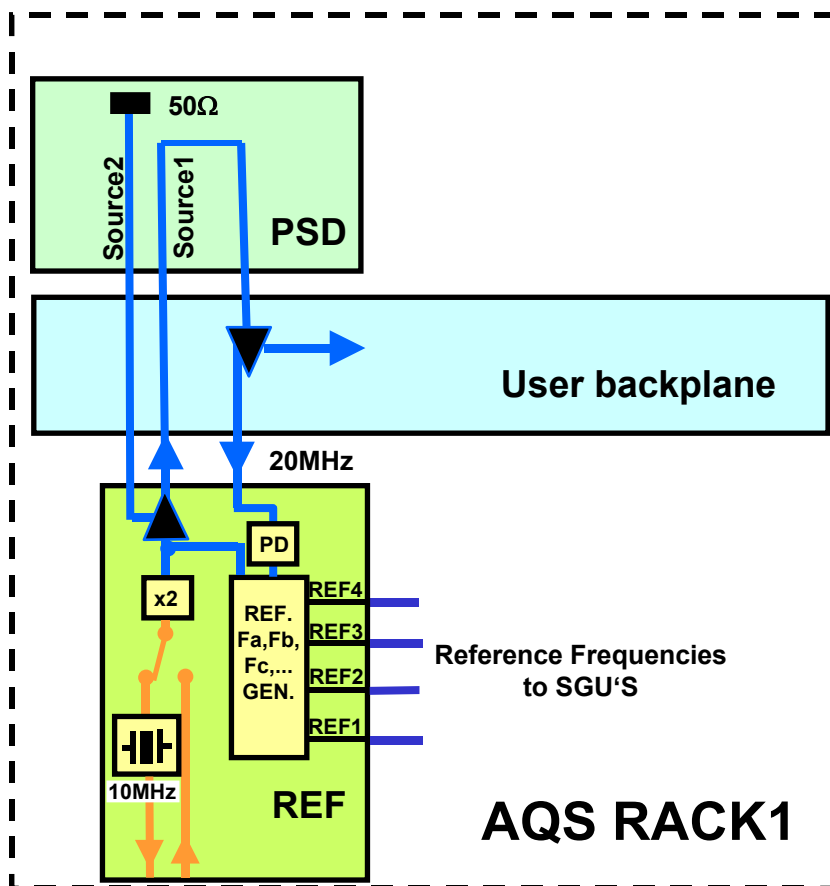
Essentially in a two rack system REF1 is used to clock both racks. The second REF. unit is only required to provide the RF frequency mixtures for SGU 5/6/7/8.

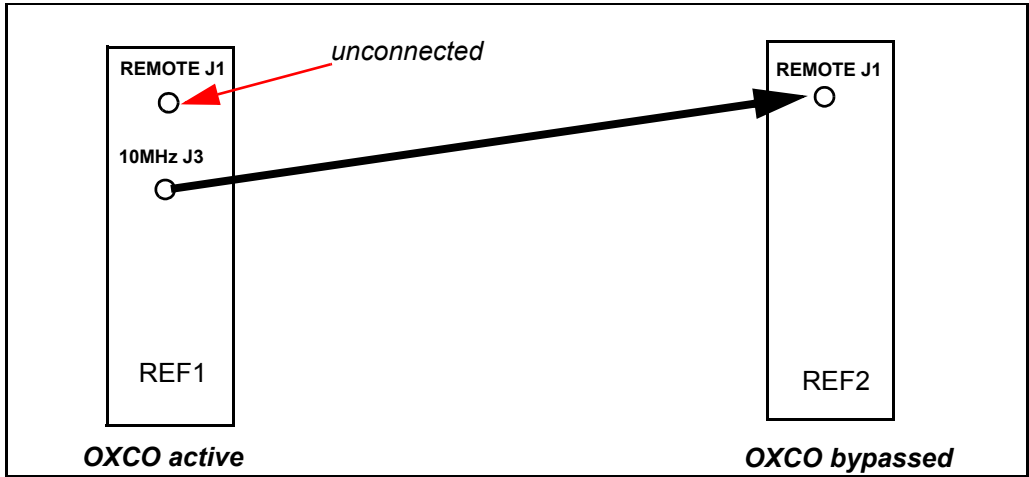*Cable lengths:*   *7.2.2*

To maintain this synchronization particularly with respect to phase all signals should pass through identical electronic circuitry as well as cables of equal length. The circuitry along the user backplane is designed to ensure equal electrical lengths regardless of the physical slot occupied by an SGU.

If cables are to be replaced then the same length cable should be used. For example the cables carrying the mixture of 6 frequencies to the SGUs are a standard length of 26cm. Similarly the cables carrying the 20MHz clock signal signal need to be the same length. To maintain this equal length it will be noticed that extra cable length is connected at the first PSD unit. This is to equalize the cable for PSD1 and PSD2.

Figure 7.4.   double rack synchronisation

Bus interfaces: *7.2.3*

The REF unit is controlled by the I^{2}C bus on the backplane. This bus is used to

1. read the BIS data (Bruker information system, successor to BBIS)

2. control of the 21.875 MHz IF phase

3. allow the master SGU load settings which are stored in an FPGA (fully programmable gate array) on-board into DACs to control the REF signal output.

Unit Configuration / Version / Jumpers   *7.3*

The unit is automatically configured through the 'cf' routine. No jumper settings are required. The distinction between REF1 and REF2 depends entirely on the presence of the J1 REMOTE IN signal. This signal is connected only for REF 2.

Differences from previous versions.   *7.3.1*

This is a totally new development for the AV series and the REF does not have a counterpart in the AVANCE series.

Figure 7.5.   Synchronisation of REF2 by REF1.

Front Panel Wiring / Display   **7.4**

Figure 7.6.   REF unit front panel
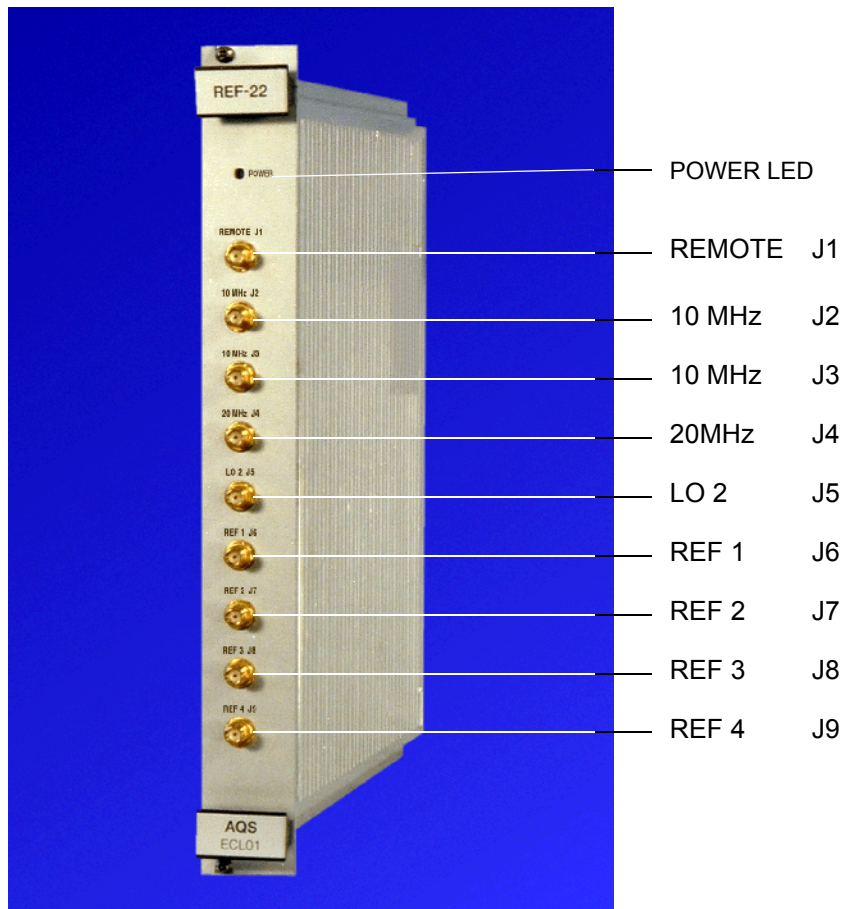
J1 REMOTE IN

Sinusoidal input for external 10 MHz clock and must have a value in the range 6...13dBm . The presence of this signal will automatically switch off the internal 10 MHz clock generated by the crystal oscillator. This is normally not connected except when a second REF unit is synchronized with the first.

J2 10 MHz OUT

Output to BSMS L-TX J2, used to clock BSMS Lock Transmitter board. Sinusoidal wave approx. 7dBm (1.0Vpp) @ 50Ω

J3 10 MHz OUT

Output for synchronization with second REF unit. Sinusoidal wave approx. 7dBm (1.0Vpp) @ 50Ω

J4 20MHz OUT

Clock signal to TCU/FCUs, ECL (emitter coupled logic) square wave approx. ± 1Vpp @ 50Ω This is the principal synchronization signal for the spectrometer.

J5 LO 2 OUT

IF reference to RX22 sinusoidal wave 21.875MHz, approx. 4dBm (1.0Vpp) @ 50Ω

J6 - J9 Ref 1-4 OUT

Frequency mixture to SGUs. 2.2Vpp @ 50Ω

Power LED:

See *"Power Supply / Fuses" on page 87*

The table below shows the pin assignment for the middle rear 90 pin connector. Note the presence of the source and clock signals.

Table 7.2.   Backplane Connector Ref. unit

	z	a	b	c	d	e	f
1	GN	GND		5MHZ_SYNC	GND		GN
2	GN	20MHZ_SOURCE1	GND				GN
3	GN	GND	20MHZ_SOURCE2		GND		GN
4	GN	20MHZ_CLK_X	GND				GN
5	GN	GND	20MHz_CLK_X̄		GND	RGP_LO	GN
6	GN		GND				GN
7	GN				GND		GN
8	GN		GND				GN
9	GN				GND		GN
10	GN		GND				GN
11	GN				GND		GN

23x GND (21%)

	z	a	b	c	d	e	f
15	GN	SLOT2	SLOT1	SLOT0	GND		GN
16	GN		GND	I2C_SDA		GND	GN
17	GN			I2C_SCL	GND		GN
18	GN		GND			GND	GN
19	GN				GND		GN
20	GN		GND			GND	GN
21	GN	P5V		P9V	P9V	P9V	GN
22	GN	P5V		N9V	N9V	N9V	GN
23	GN	P5V	P19V	N19V	RACK1	P12V	GN
24	GN	P5V	P19V	N19V	RACK2	P12V	GN
25	GN	P5V	P19V	N19V	RACK3	P12V	GN

Part Numbers and Cables 7.5

AQS REFERENCE UNIT RX22 P/N Z003351.

Troubleshooting / Unit replacement / Tips 'n' Tricks 7.6

1. Terminate any unused outputs with 50Ω

2. If you suspect the OCXO is faulty switch to an external 10 MHz signal.

3. Ensure that any unused SGU outputs (J6-J9) are properly terminated with a 50 Ohm connector

Diagnostic Tests 7.7

Not applicable.

Specifications 7.8

The principal specification is that of the stability of the crystal oscillator which is specified to 1×10^{-9}/day.

Power Supply / Fuses   *7.9*

The REF uses +5V, +12V, $\pm$9V,+19V from the backplane see ***"Backplane Connector Ref. unit" on page 85***. The power LED on the front panel indicates that all necessary voltages are present and at the correct level. If the voltage level drops then the LED will go out. Thus once the power LED lights then further investigation of the backplane to check the precise voltage is unnecessary.

SGU Signal Generation Unit

8

Introduction

The SGU is one of the most significant advances in the new AV series in that it is the one unit where the generation of all analog characteristics of the RF signal takes place. The SGUs are located in the analog section of the AQS rack between the REF unit and either the Router or internal amplifiers. Each RF channel has a dedicated SGU. If more than 4 channels are required the extra SGUs will be located in a second AQS rack.

On the transmission side the SGU generates the signal frequency, phase and regulates the amplitude (including shape control) as well as the blanking and gating pulses. The information is received from the TCU3 / FCU3 via the LVDS but implemented upon in the SGU. The output of the SGU will be a miniature version of the final transmitted signal. The only change that takes place to the signal after SGU generation is the power increase in the amplifiers. On the receive path the SGU generates the LO frequency as well as the receiver gating pluses as well as the dwell clock.

In hardware terms all SGU's are identical but one SGU will occupy the master slot in the AQS and is referred to as the 'rack master' or 'master SGU'. For single rack systems the master SGU will occupy slot 3 (J6) of the user bus. For a two rack system it is slot 5 (J8) of AQS1. This master SGU recognizes its position automatically and switches into master mode whereas all other SGUs are set to slave mode. The SGU master communicates with various analog units to reduce the needed communication to a minimum for the CCU10 and the subunits. see *"Schematic of VME , User buses and LVDS" on page 16*.

Note that while the master SGU has additional functionality it also performs all the tasks of a standard SGU.The various SGU boards are synchronized by means of a 20 MHz clock signal from the backplane. The clock signal originates on the REF. unit. The synchronization is essential if the various RF channels are to be phase coherent etc.

Apart from the master SGU the only other distinction between the various SGUs is that one SGU is pre allocated as the OBS SGU and generates the LO as well as the receiver timing. This can be any SGU depending upon which FCU in the edsp menu is chosen as the OBS.

Each SGU has a dedicated hardwired LVDS link to an FCU (either channel A or B). The high speed link transfers all NMR relevant real-time events in 50ns time slots to the corresponding SGU (e.g. pulses, shapes, phase jumps, frequency shifts etc.). Each rf channel is controlled by a separate high speed link. It is connected via a cable on the front panels of the two units (point to point connection).

SGU Signal Generation Unit

NB: The SGU is really a DAC. It does nothing without FCU order. The FCU generates for example every dwell clock. It orders the SGU to go high/low/high/low and so the DWCLK is generated. THE LVDS is really the bridge between the digital and analog side.

The SGU has access to the various buses along the AQS backplane.

A special feature of the SGU is the extra shielding. This is because of the importance of ensuring that the generated RF signals are free of distortion.

Functions / Description   *8.2*

The central role played by the SGU is evident from the extensive list functions below. For further details on some of the s[pecific details below see ***"Important signals:" on page 102***

All SGUs.

1. generation of the precise final transmission frequency by means of an onboard frequency generator. The SGU implements all analog aspects of the signal including frequency, frequency shifts, phase shape etc. The information regarding the precise characteristic of the signal is received from the FCU via the LVDS.

2. Amplitude control both in terms of magnitude (mult) and shape (mod). Although the SGU delivers a max voltage of 1Vpp the linear nature of the amplifiers means that the SGU has exclusive control of the final amplitude.

3. generation of blanking signals for use in the various amplifiers. The internal amps receive the blanking directly from the backplane, whereas the the external amps receives the signals from the PSD which in turn receives the signals from the backplane.

OBS SGU only.

4. generation of gating pulses to be used in the HPPR, RX22, SADC

5. generation of the dwell clock for the ADC and LO frequency for the RX22.

Master SGU only

6. Initializes various units after a power up or 'ii' command. A proper initialization of all RF units in the AQS mainframe is highly dependent on a correct power up process of the master SGU1.

7. Communication with the CCU10 via the SBSB1 and with other analog units via a I^2C bus.

8. Router control via the backplane. This also includes control of the mini router in internal amplifiers. The information is transmitted via the I^2C bus mentioned above.

SGU2 only

9. Generation of the 'wobb' signal

The LO will be generated on the OBS SGU and daisy chained through all the succeeding SGUs to the RX22. This daisy chain is unidirectional in the direction of the RX22. If in a four channel system SGU2 is the OBS then SGU2 will generate the LO and this will be daisy chained through SGU3 and SGU4 to the RX22. see ***Figure 8.1.***

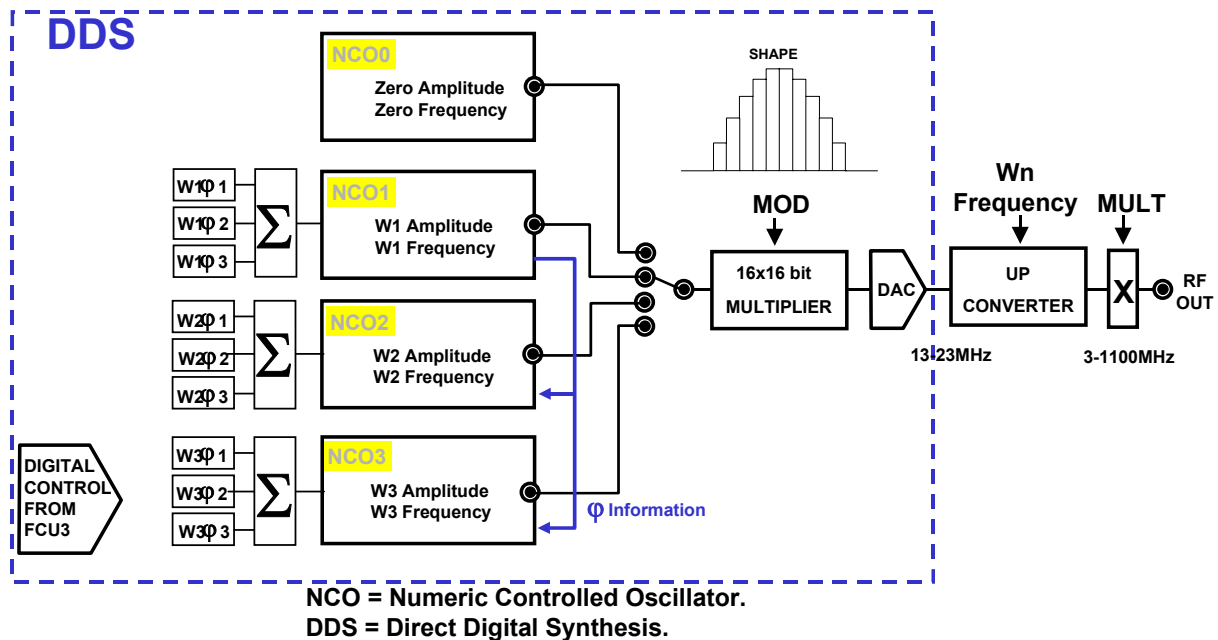Figure 8.1.   LO daisychain for the case where SGU2 is the OBS SGU .
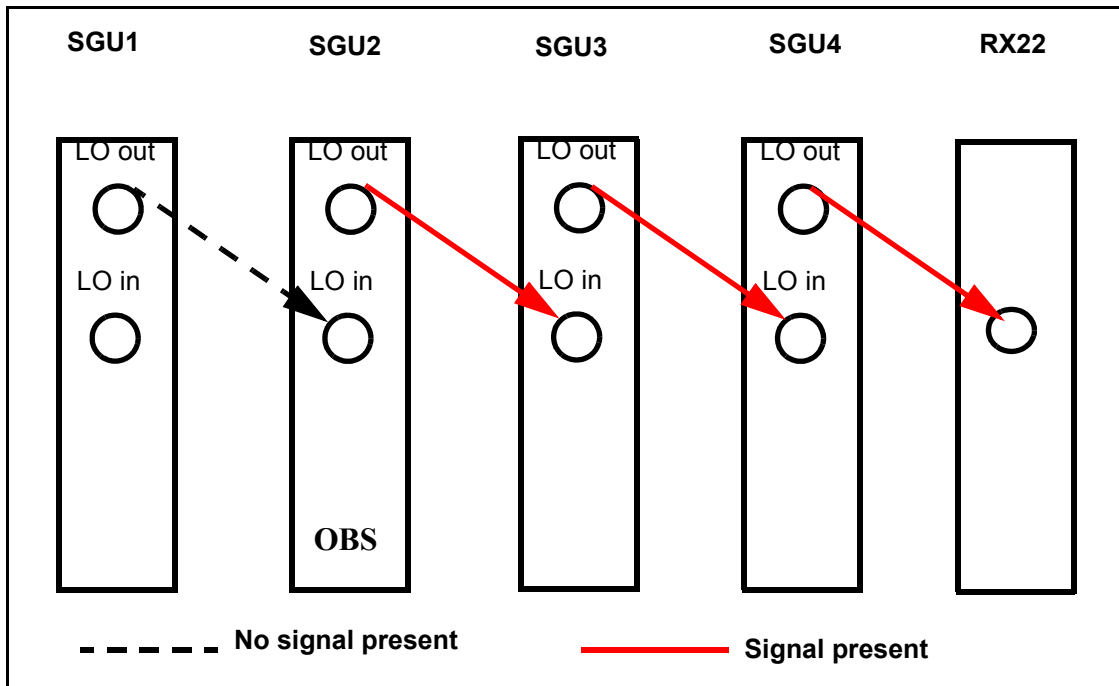
Figure 8.2.   SGU RF paths
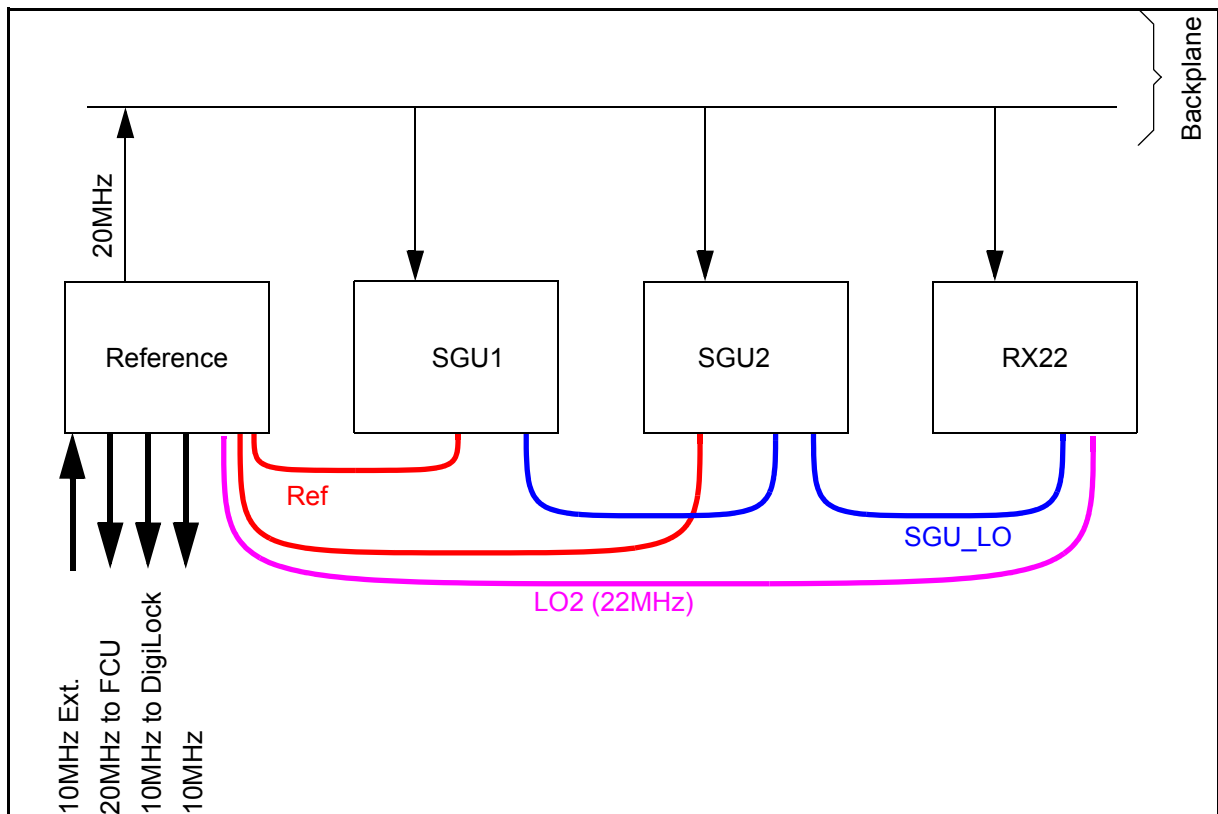
This is shown schematically in ***Figure 8.4.*** Note that the signal path switching is controlled via the LVDS.

Figure 8.3.   signal generation on the SGU

NCO = Numeric Controlled Oscillator.
DDS = Direct Digital Synthesis.

Although from a service point of view the internal workings of the SGU are not relevant, this is a such a new unit and plays such a central role in the spectrometer that it is perhaps worth making a short description of its main features.

At the heart of the SGU are three NCO's (Numerically Controlled oscillators) NCO1, NCO2, NCO3. A fourth NCO, NCO0 is actually a virtual oscillator in that it does not physically exist but is used to represent zero transmission, i.e. all three physical oscillators are switched off.

NCO0 is always used for zero transmission.

NCO1 is always used for for the OBS frequency

Any shifts in frequency are implemented using NCO2.

NCO3 is always used for the LO frequency. This assignment of the various NCOs is illustrated in ***"NCO allocation" on page 95***

The advantage of using multiple NCOs is that frequency, amplitude and phase information can be loaded simultaneously. This facilitates instantaneous switching from one phase or frequency to another etc.

Figure 8.4.   Signal paths within the SGU

Signal path in SGU during transmission.

Signal path in OBS SGU during acquisition

Signal path in non OBS SGUs during acquisition
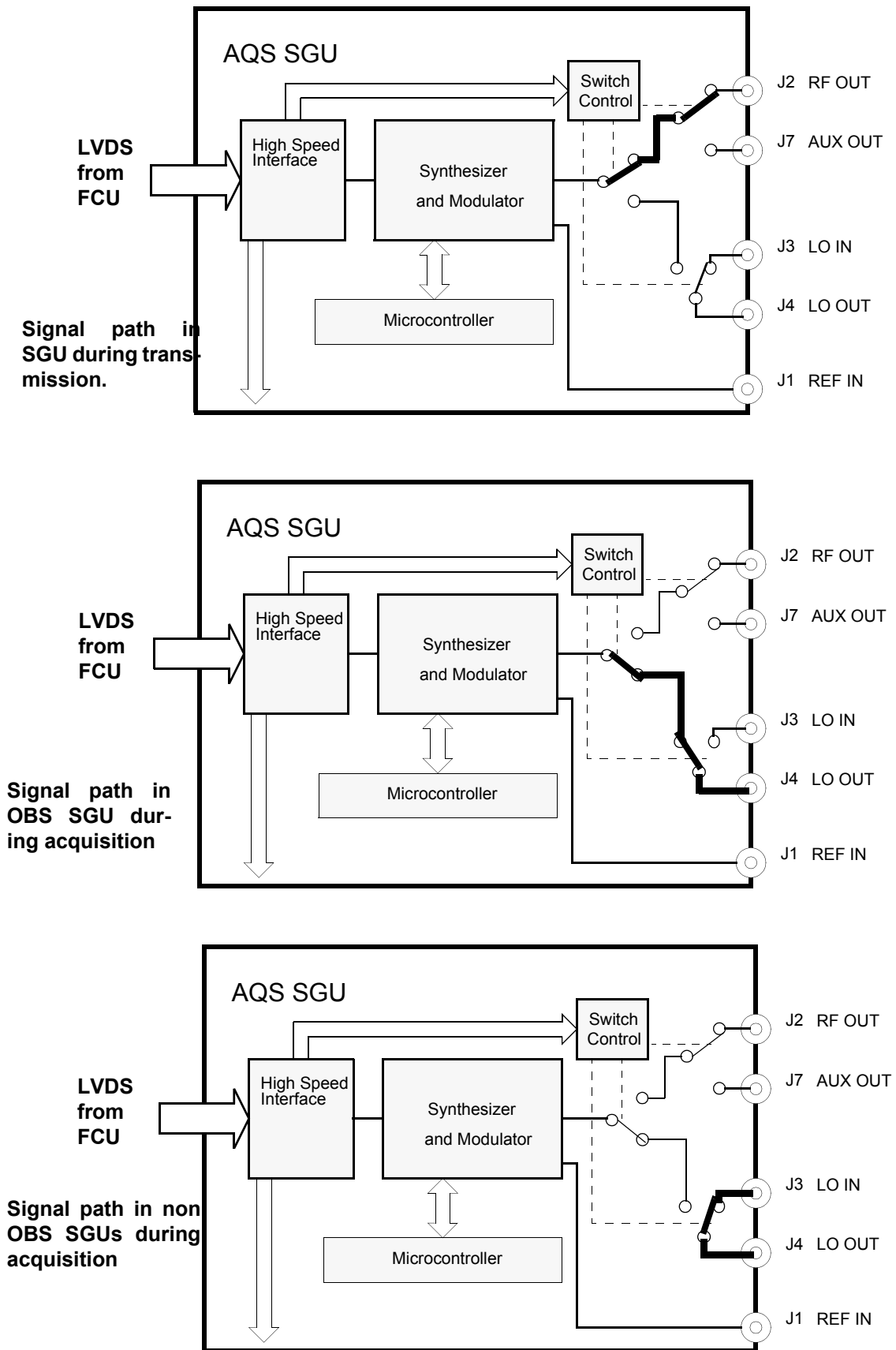
The timing of the NCO output is controlled by a series of instructions delivered by the FCU via the LVDS with a 12.5ns timing resolution.

The output of the various NCOs is a digital representation of all characteristics of the required signal. This digital signal is then modulated using the 'MOD' input to implement the shape of the signal. The signal is still purely digital in nature but is then passed through a DAC to produce an analog output. The frequency at this stage is still not the final frequency, this only happens at the UP Converter which mixes the oscillator frequency with the appropriate frequency from the REF unit to produce the final transmission frequency. The last step is the application of the 'MULT' which sets the overall amplitude of the RF output.

Figure 8.5.   NCO allocation
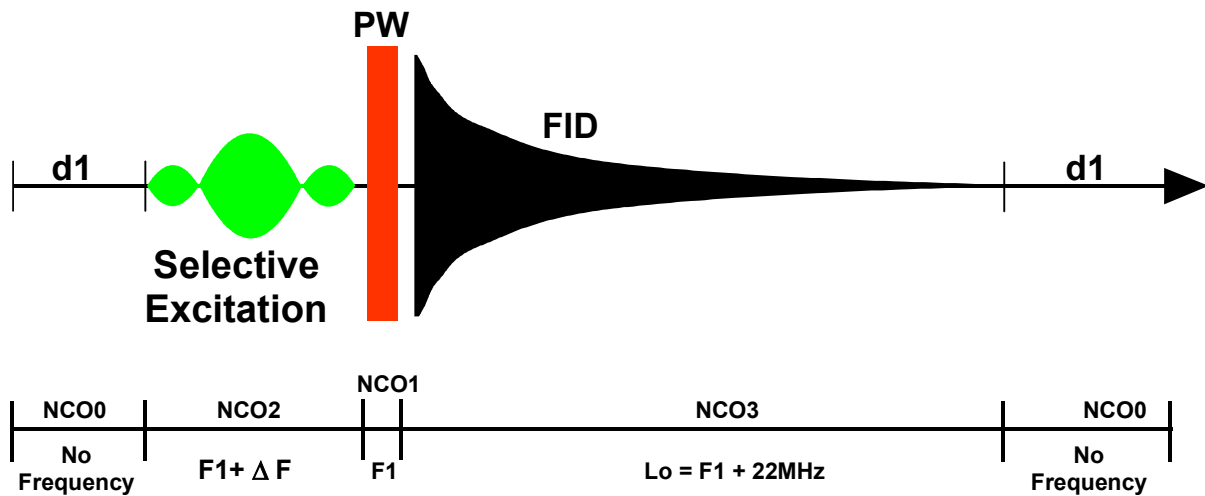
Unit Configuration / Version / Jumpers   8.3

Four versions of SGU's have been produced.

- SGU-C Part-No. Z003329, output frequency range limited to 325MHz

- SGU400 Part-No. Z003642, output frequency range limited to 430MHz

- SGU600 Part-No. Z003831, output frequency range limited to 643MHz

- SGU1000 Part-No. Z003832, output frequency range limited to 1072MHz

Key specifications and digital control behavior remain the same for all versions

Through the 'cf' routine the number and location of all installed SGUs including the master SGU is determined. Each SGU in the user bus has a unique address by virtue of its physical position and this is used to distinguish the various SGUs from each other. There are no jumpers that need to be set.

Regardless of the system the units are lined up immediately to the left of the REF. unit.

A micro bay system will accommodate up to three SGUs.

A one bay system will accommodate up to four SGUs(three if internal amps are used)

A two bay system will accommodate up to 8 SGUs (4 attached to REF1 and 4 attached to REF2)

Any of the SGUs may be selected as the Observe SGU. In the 'edsp' menu the FCU number is equivalent to the SGU number and so this menu will easily tell the operator which SGU is the OBS SGU.

Table 8.1.   Assignment of SGUs

Physical SGU	Physical FCU	edsp display
1	FCU1 Channel A	FCU1
2	FCU1 Channel B	FCU2
3	FCU2 Channel A	FCU3
4	FCU2 Channel B	FCU4

Differences from previous versions.   *8.3.1*

This is a totally new development for the AV series and the SGU does not have a counterpart in the AVANCE series.

Figure 8.6.   SGU front panel
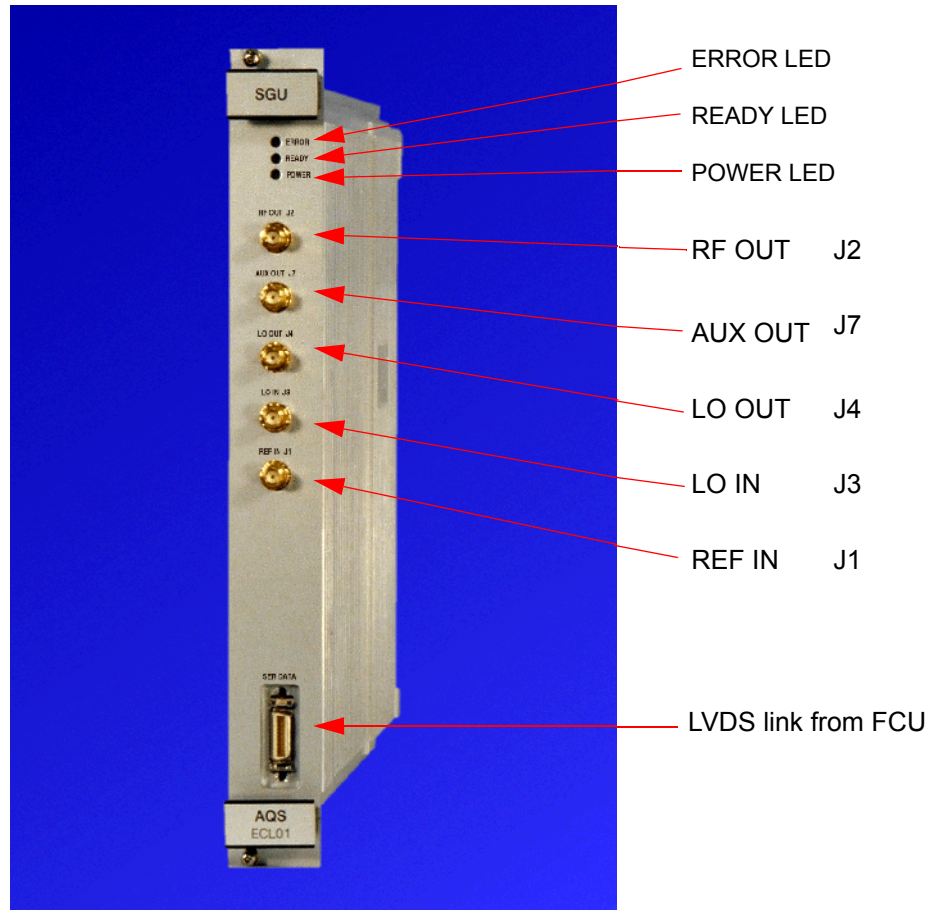
RF OUT J2

This is the single rf output which will be connected either directly to an internal amplifier input or to the router on its way to an external amplifier . This signal will have a max amplitude of 1Vpp at a power setting of -6db. The signal will only be present during pulse transmission as the blanking takes place on the SGU itself.

AUX OUT J7

The wobb signal ALWAYS comes from the AUX out of SGU2 since this is hard-wired to the 'Tuning in' input of the HPPR cover display module. On all other SGUs this output is left unconnected except for the case of SGU1 where it can be connected to the 2HTX on an AQS with internal amplifiers. The wobb signal will appear as a swept frequency whose variations in frequency will depend on the setting of 'wbsw'. On the scope it appears typically as a pulsing frequency of amplitude 1Vpp. (note that the wobble signal amplitude will change with the introduction of the HPPR2)

The LO for the WOBB routine will come from the OBS SGU LO OUT. This will also appear as a swept frequency except that this time the central frequency will be the wobble frequency + 21.875MHz.

SInce all SGU are physically identical the AUX OUT output would be capable of transmitting RF signal from any SGU but this would require explicit pulse programming.

LO OUT J4

RF signal at the SFO1 + 21.875 MHz (1.0Vpp at 50 Ohm). The signal is generated on the OBS SGU and then daisy chained through successive SGUs in the direction of the RX22. This signal will only be present during AQ (acquisition time) and if the SGU in question is the OBS SGU or is located to the right (further along the daisy chain) of the OBS SGU.

LO IN J3

This signal will only be present if the SGU in question is located to the right (further along the daisy chain)of the OBS SGU (1.0Vpp at 50 Ohm).

REF in

Input RF signal from the REF. unit. This is a mixture of frequencies which are used to generate the final transmission frequencies. The frequencies present are 5, 80, 160, 320, 720 and 1280 MHz. On the scope the signal will look like an incoherent pattern and a spectrum analyzer is the best method of detection.

LED Display: *8.4.1*

Power LED:

The power LED indicates that **all** necessary voltages are present and at the correct level. If the voltage level drops then the LED will go out. Thus once the power LED lights then further investigation of the backplane to check the precise voltage is unwarranted.

The table below summarizes the states of the three front panel LEDS.

Table 8.2.   LED States

ERROR	READY	POWER	Description
na	na	off	- power supply not on or operating incorrectly
off	on	on	- Normal operating mode - ready for operation
off	single, short-time flickering	on	- Communication LED. The unit has received a command from the RS485 bus master. The LED switches to off as soon as the SGU acknowledges the command.
blinking slowly (approx.3 Hz)	on	on	indicates warning and not error. The sleep mode during acquisition is disabled ('gs' mode). Caution: Sensitive NMR experiments are not possible in this mode due to disturbances of the controller system.

Part Numbers and Cables *8.5*

- SGU-C Part-No. Z003329 (325MHz)
- SGU400 Part-No. Z003642 (430MHz)
- SGU600 Part-No. Z003831 (643MHz)
- SGU1000 Part-No. Z003832 (1072MHz)

Troubleshooting / Unit replacement / Tips 'n' Tricks *8.6*

1. All SGUs are identical and as such are fully interchangeable. If units are swapped it is advisable to reconfigure to ensure that there are no inconsistencies in unit recognition. Note that for best performance all the SGUs should be of the same type.

2. Ensure that all SGUs are using the same firmware (currently 'birdad.hex). This can be done using UniTool.

3. Even upon rebooting after a power off, the error LED on the master SGU may light. It may be necessary to enter the command 'ii' (initialize interfaces) to clear this error.

4. Do not open the SGU in the field.

5. Ensure that the 20 pin cable to the FCU is connected before powering up the AQS. This will ensure the correct termination and also prevent the SGU from hanging.

Diagnostic Tests *8.7*

Not applicable

Software / Useful Pulse Programs *8.8*

Each SGU has 10 RTP outputs. They are set automatically with the go command in pulse programs. To set specific RTPs permanently, the syntax

setrtp<sgu1..8> | <bit0-8> ^ <bit0-8> is used.

Example:

setrtp1|0|1|2|8^7

; set bits 0,1 , 2 and 8 and clear bit 7 on SGU 1

The RTP-bit-settings of different SGUs are combined at the backplane of the ac-

Table 8.3.   real time pulses

Bit #	Name	Meaning
Bit 0	RGP_ADC	ADC gating pulse
Bit 1	RGP_RX	Receiver gating pulse
Bit 2	RGP_HPPR	Preamplifier gating pulse
Bit 3-5	reserve	
Bit 6	INTERLEAVE_INCR	selector for gain switching in receiver
Bit 7	DWL_CLK	dwell time for receiver ADC
Bit 8	ADC_SEL0	selects HADC/2 or SADC+
Bit 9	ADC_SEL1	selects FADC

quisition rack, so in fact it doesn't matter which SGU issues these pulses, but in order to avoid conflicts one should use the observe SGU for them.

Fast Real Time Pulses (FRTP):   8.9

Each SGU has 4 FRTP outputs. They are set automatically with the pulse commands in pulse programs and CPD programs. To set specific FRTPs permanently, the command setfrtp<sgu1..8>|<bit0-8>^<bit0-8> is used.

Example:

    setfrtp1|1

; set bit 1 on SGU 1 into FRTP register.

Bit1 is used for the amplifier blanking, Bits 0, 2 and 3 are reserve.

The amplifier blanking information is routed to the correct amplifier according to the router setting (edasp command and parameter RSEL, respectively).

Specifications   8.10

Timing:

Minimum Pulse or delay duration: 50ns.

Resolution: 12.5ns

The resolution is set by the internal 80MHz clocking frequency on-board the TCU3. Pulses or delays between pulses can thus be set to 50, 62.5, 75 , 87.5ns, etc.

Frequency:

Frequency Range: 3-1100 MHz.

Frequency Stability: This is governed by the stability of the crystal oscillator on the REF. unit which is specified to 3×10^{-9}/day and 1×10^{-8}/year

Frequency Resolution: The DDS is clocked by 80MHz and the frequency setting is stored in a 34 bit register

$\Rightarrow$80 MHz/2^{34} <0.005 Hz.

Frequency Switching Time: for frequency steps of less than 2.5 MHz < 300ns

Phase:

Phase Resolution: A 16 bit register is used to store phase values.

$\Rightarrow 360°/2^{16} < 0.006°$

Phase Switching Time: <300ns.

Amplitude :

MOD range : The MOD values are stored in a 16 bit register which equates to a voltage dynamic range of 96dB. (20 log(2^{16}) =96 dB).

MOD resolution: The resolution will depend on the range within a particular shape.

For a range of up to 54 dB within a shape the resolution is < 0.01dB

For a range of up to 60 dB within a shape the resolution is < 0.05dB

MULT range: The MOD values are stored in a 15 bit register which equates to a voltage dynamic range of 90dB. (20 log(2^{15}) =90 dB)

MULT resolution: 0.1 dB

Amplitude switching time: 50ns

Amplitude + phase switching time: 100ns

Power Supply / Fuses   *8.11*

See *8.4.1*

Backplane Connector   *8.11.1*

Table below is a list of the various signals transmitted to all user slots via the middle rear 90 pin connector J0.

Table 8.4.   Backplane Connector

	z	a	b	c	d	e	f
1	GND	GND	RESERVE_1	NC	GND	**SAMPLE_INFO0**	GND
2	GND	NC	GND	**SAMPLE_INFO3**	**SAMPLE_INFO2**	**SAMPLE_INFO1**	GND
3	GND	GND	NC	**$\overline{\text{(SGU-STOP)}}$**	GND	**SAMPLE_INFO4**	GND
4	GND	**20MHZ_CLK_X** [a]	GND	**$\overline{\text{INTERLEAVE\_INCR}}$**	**$\overline{\text{ADC\_SEL1}}$**	**$\overline{\text{ADC\_SEL0}}$**	GND
5	GND	GND	**$\overline{\text{20MHz\_CLK\_X}}$**	RESERVE_3	GND	**$\overline{\text{RGP\_LO}}$**	GND
6	GND	**$\overline{\text{BLNKTR1}}$**	GND	**$\overline{\text{BLNKTR2}}$**	RESERVE_6	RESERVE_4	GND
7	GND	**$\overline{\text{BLNKTR3}}$**	**$\overline{\text{BLNKTR4}}$**	NC	GND	**$\overline{\text{RGP\_ADC}}$**	GND
8	GND	**$\overline{\text{BLNKTR5}}$**	GND	**$\overline{\text{BLNKTR6}}$**	RESERVE_7	**DWL_CLK**	GND
9	GND	**$\overline{\text{BLNKTR7}}$**	**$\overline{\text{BLNKTR8}}$**	NC	GND	**$\overline{\text{RGP\_RX}}$**	GND
10	GND	**SBS_TTL_TX**	GND	**SBS_TTL_RX**	**$\overline{\text{SBS\_TTL\_TX\_ENAB}}$**	RESERVE_5	GND
11	GND	**LOCAL_TX**	**LOCAL_RX**	**$\overline{\text{SBS\_TTL\_WUP}}$**	GND	**$\overline{\text{RGP\_HPPR}}$**	GND

Magenta = CCU-Bus galvanically isolated
Blue = Intra Rack Bus

Key Area

	z	a	b	c	d	e	f
15	GND	SLOT2	SLOT1	SLOT0	GND	NC	GND
16	GND	SLOT3	GND	**I2C_SDA**	NC	GND	GND
17	GND	**EMERGENCY_STOP**	**$\overline{\text{I2C\_BUS\_REQ}}$**	**I2C_SCL**	GND	NC	GND
18	GND	NC	GND	**I2C_2_SDA**	**I2C_2_SCL**	GND	GND
19	GND	NC	NC	NC	GND	NC	GND
20	GND	NC	GND	**P2V**	**N2.5V**	GND	GND
21	GND	**P5V**	**P35V**	**P9V**	**P9V**	**P9V**	GND
22	GND	**P5V**	RACK0	**N9V**	**N9V**	**N9V**	GND
23	GND	**P5V**	**P19V**	**N19V**	RACK1	**P12V**	GND
24	GND	**P5V**	**P19V**	**N19V**	RACK2	**P12V**	GND
25	GND	**P5V**	**P19V**	**N19V**	RACK3	**P12V**	GND

a. x = Slot-Nr. (20MHZ_CLK_1 bis 20MHZ_CLK_8)

Important signals: *8.12*

All signals described below are active low and TTL except for the blanking signals which use an open drain configuration.

BLKTR (amplifier blanking pulses)

A SGU can control up to 8 power amplifiers with the corresponding BLKTR. The timing of the blanking pulses is controlled by the FCU via the LVDS which delivers real-time instructions in 50ns second bursts. All SGUs are capable of generating blanking pulses.

The internal amps receive the blanking directly from the backplane, whereas the the external amps receives the signals from the PSD which in turn receives the signals from the backplane.

RGP_PA~ (Preamplifier receiver gating pulse)

This pulse is generated by the observe SGU and is used to gate the OBS module on the HPPR and used to implemented the transmit/ receive switching. The timing of the pulse can be modified with the 'edscon' parameters .This signal is routed via the ACB-S standard (or PSD) to the observe module in the preamplifier HPPR or HPPR/2. All other non lock HPPR modules are left permanently in transmission mode. In contrast to AVANCE systems, the preamplifier RGP will not be connected to the AQR RX22. The EP-HPPR output of the RX22 is left unconnected.

RGP_LO~(Local oscillator gating pulse)

This pulse is generated by the observe SGU and initiates the frequency step to generate the LO frequency (SFO1+22MHz). The pulse is also used to control the LO output of the REF unit which will only be present when *RGP_LO* goes active low..

RGP_RX~ (Receiver gating pulse)

This pulse generated by the OBS SGU controls the opening and closing of the RX22 and is transmitted directly over the backplane. The timing of the pulse can be modified with the 'edscon' parameters.

RGP_ADC~ (ADC gating pulse)

This pulse (also driven by the observe SGU) controls the ADC data. If the pulse is low and a dwell clock is applied, the ADC will perform a conversion. If the pulse is high and a dwell clock is applied, the ADC generates 'zero' data. The RGP_ADC is routed over backplane to the ADC via the RX22. This signal is specially used for digital homodecoupling with oversampling.

Dwell_Clk~ (ADC dwell clock)

The signal is driven by the observe SGU and is used to control the timing of the AD conversions. Every falling edge of the dwell clock executes an ADC conversion. Although the signal is generated on the SGU, the timing is controlled totally by the FCU via the LVDS. The pulse is routed over the backplane to the ADC via the RX22. Homodecoupling experiments are treated as typical pulse programs.

SEL_ADCx~ (Select A/D converter)

The signal is applied to select a required ADC in the case of configurations with more than one ADC. The signal is generated by the observe SGU and is wired directly via the backplane to the specified ADCs. see *"real time pulses" on page 100*

Figure 8.7.   Important signals on a two channel AVANCE (internal amplifiers)
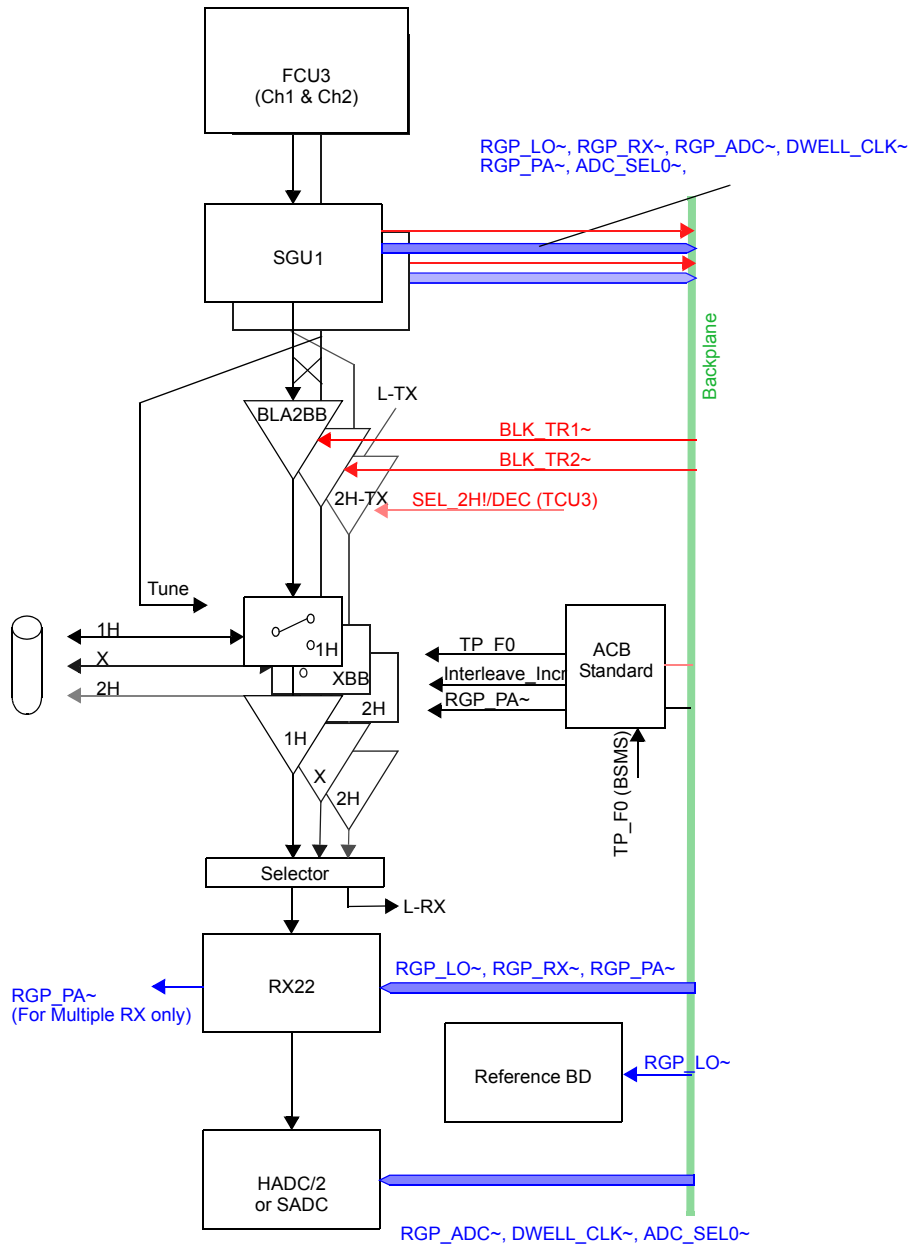
In this configuration exist three amplifiers
but only two SGUs.
SGU2 can either be used for the BLA2BB or
the 2H-TX (for 2H decoupling or 2H shimming).
There is no blanking pulse required for the 2H-TX.
Controlling Lock mode or 2H-TX mode is done
via the signal SEL2H/!DEC) from the TCU3

Figure 8.8.   Important signals on a four channel AVANCE (external amplifiers)
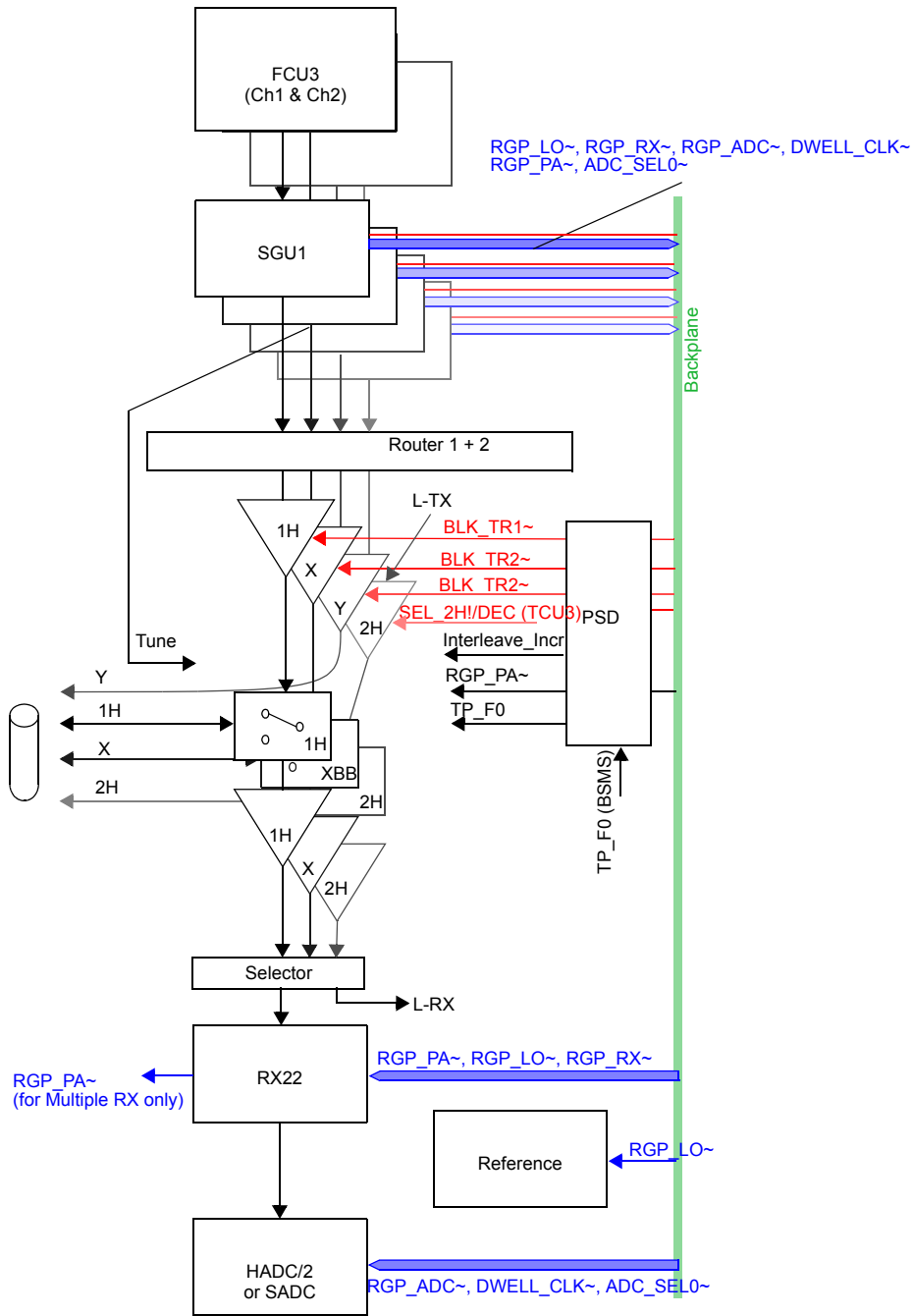
Router/ Combiner

9

Introduction

Any spectrometer using external amplifiers is fitted with at least one router.

Modern spectrometers need to be flexible in terms of allowing the operator to choose multiple routes for the RF signals. Much of the RF paths are by necessity hardwired. The signal path from the FCU to the SGU to the Router input is effectively a one to one hardwired connection. Similarly the Router output and the amplifier inputs are hardwired. Inside the Router itself however the RF path may take a variety of (though not all) paths thus granting the user the flexibility that is required.

The Router is located in the AQS rack and occupies user slot 8 (J11). One Router will accommodate up to three RF channels, if the spectrometer has four RF channels or more a second Router is required. Routers used in AV series are physically identical to AVANCE Routers, though they do need rear adapters and there are differences in the control. The single greatest difference is that the Router output is no longer blanked , since this now takes place of the SGU.

Functions/ Description

9.2

The standard Router has 3 inputs and 5 outputs. Not every routing option is allowed as detailed below.

> Input 1 may be routed to Outputs 1, 2 or 3.
>
> Input 2 may be routed to Outputs 1, 2, 3 or 4.
>
> Input 3 may be routed to Outputs 1, 2, 3, 4 or 5.

RSEL Parameters

9.2.1

How a particular signal is routed is determined by the setting of the RSEL control words. These are software parameters which are automatically set depending on the signal paths chosen by the operator from the „edsp" menu. The values are normally hidden from the user but can be checked by clicking 'PARAM' in the edsp menu.

The routing of INPUT1 is determined by the value of RSEL1, the routing of INPUT2 is determined by RSEL2 etc. see ***Table 9.1.*** Where a Router input is not used then the corresponding RSEL word is assigned a value of 0. The information regarding the router switching is passed from the CCU10 to the SGU master via the tty10/SBSB1 connection. From here the I^2C bus is used to transmit the info to the Router. The actual hardware switching of the Router is realized by means of the so called RSEL hardware bits which are detailed in below.

Router/ Combiner

The software parameter RSEL1 is implemented using hardware bits RSEL_10, RSEL_11, RSEL_12 and RSEL_13. Similarly the software parameter RSEL2 is realized by hardware bits RSEL_20, RSEL_21, RSEL_22 and RSEL_23 etc. With the AVANCE system the bit settings could be checked at the J3 28 Pin SCSI connector at the Router front panel. For AV systems this is no longer the case as the information is passed over the backplane. ***Table 9.2.***shows the various combination of bit settings for the RSEL parameters.

Table 9.1.   Explanation of software RSEL Parameters

Software Parameter	Hardware Routing
RSEL1 = 1	INPUT1 to OUTPUT1
RSEL1 = 3	INPUT1 to OUTPUT3
RSEL2 = 4	INPUT2 to OUTPUT4
RSEL3 = 5	INPUT3 to OUTPUT5

Table 9.2.   Setting of internal hardware bits

Input	Output	RSEL1 RSEL_13 RSEL_12 RSEL_11 RSEL_10	RSEL2 RSEL_23 RSEL_22 RSEL_21 RSEL_20	RSEL3 RSEL_33 RSEL_32 RSEL_31 RSEL_30
RI 1	RO 1	1 1 1 0		
	RO 2	1 1 0 1		
	RO 3	1 1 0 0		
RI 2	RO 1		1 1 1 0	
	RO 2		1 1 0 1	
	RO 3		1 1 0 0	
	RO 4		1 0 1 1	
RI 3	RO 1			1 1 1 0
	RO 2			1 1 0 1
	RO 3			1 1 0 0
	RO 4			1 0 1 1
	RO 5			1 0 1 0

Combining:

The fact that all possible routing is not allowed naturally imposes restrictions on the possible combining.

Output 1 can be any combination of Inputs 1, 2 and 3.

Output 2 can be any combination of Inputs 1, 2 and 3.

Output 3 can be any combination of Inputs 1, 2 and 3.

Output 4 can be a combination of Inputs 2 and 3.

Output 5 is taken directly from Input 3.

Cascading routers   *9.2.2*
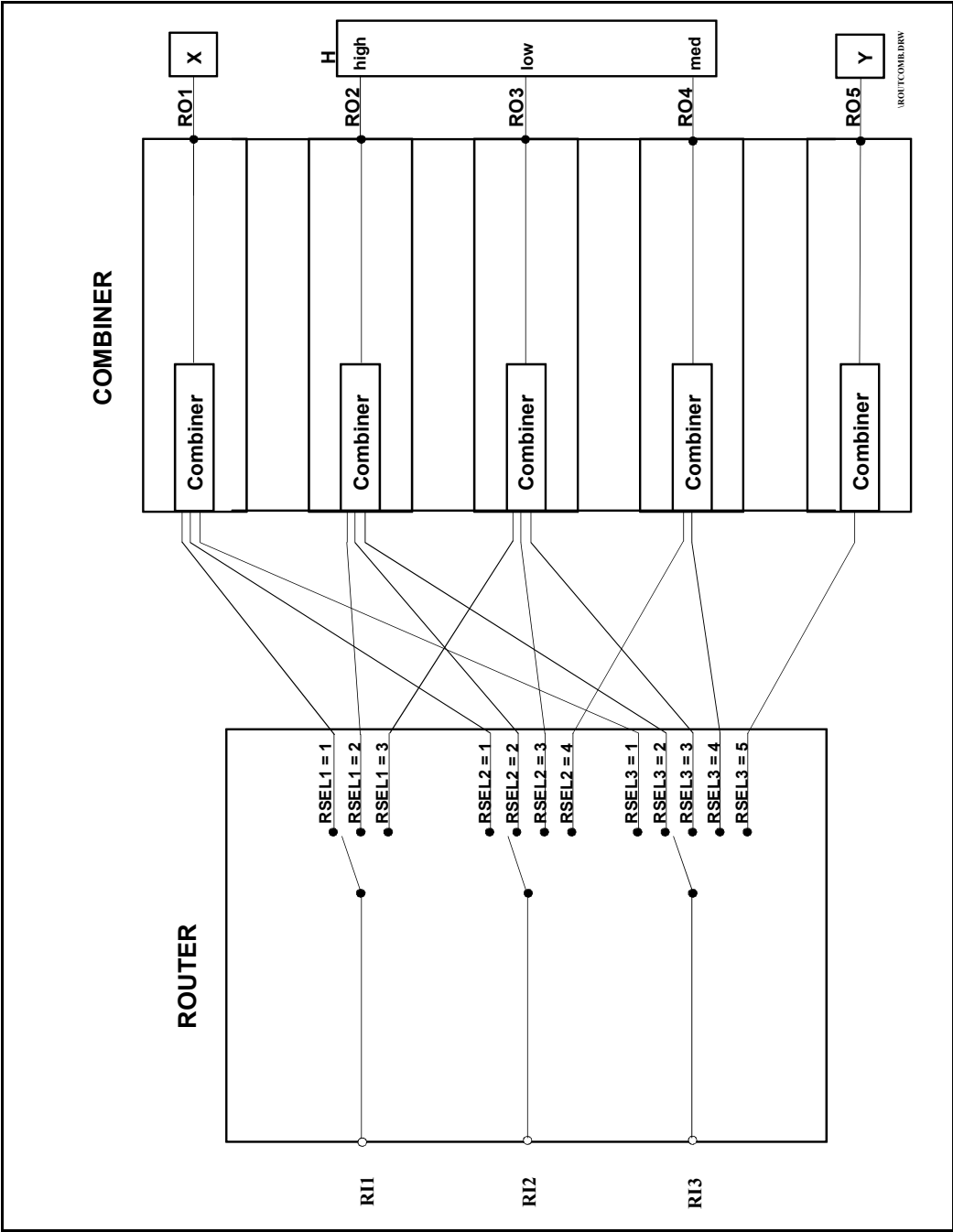
A standard cascade arrangement for two routers has been decided upon. This standard arrangement is necessary if the „**edsp**" display is to correctly control the hardware. Note that if the software detects more than 3 SGUs then it will assume that a second Router is fitted. (A single AQS can accommodate two routers which can, from the hardware viewpoint, be cascaded in different ways but this will not be automatically supported by the software.)

Figure 9.1.shows an example where two routers are cascaded. The software treats the two routers effectively as a single Router. Input 3 of Router 1 is not controlled directly by a separate RSEL software word. Instead the software automatically routes Input 3 of Router1 correctly, depending on the requirements for Output 1 of Router2.

Unit Configuration / Version / Jumpers   *9.3*

The router as used in the AVANCE is electronically identical to the router in the AV system. The principal physical difference is that the AV router must use a rear adapter as it is physically not as deep as the newer AQS units. see ***"rear adapters" on page 22***. Other difference are listed in the table below.

Differences from previous versions.   *9.3.1*

Table 9.3.   differences between AV and AVANCE routers

Router in AV	Router in AVANCE
No output blanking	Output blanked by signals from TCU
RSEL bits delivered by SGU master over I^{2}C bus	RSEL bits transmitted from TCU to front panel via the 28 pin SCSI cable from TCU connector T2.
rear adapter required	no adapter required

Front Panel Wiring / Display   *9.4*

The front panel is shown in ***Figure 9.2.*** All of the inputs and outputs are RF, max 4 dBm ($1V_{pp}$).

The Router has no front panel power display LED

The TCU connection at J3 is used in AVANCE (AQR/AQX) versions where the Router control RSEL bits are generated on the TCU. For AQS systems the Router control takes place over the backplane and so this connection is not required.

Figure 9.1.   standard cascade of two routers

Router: X003624
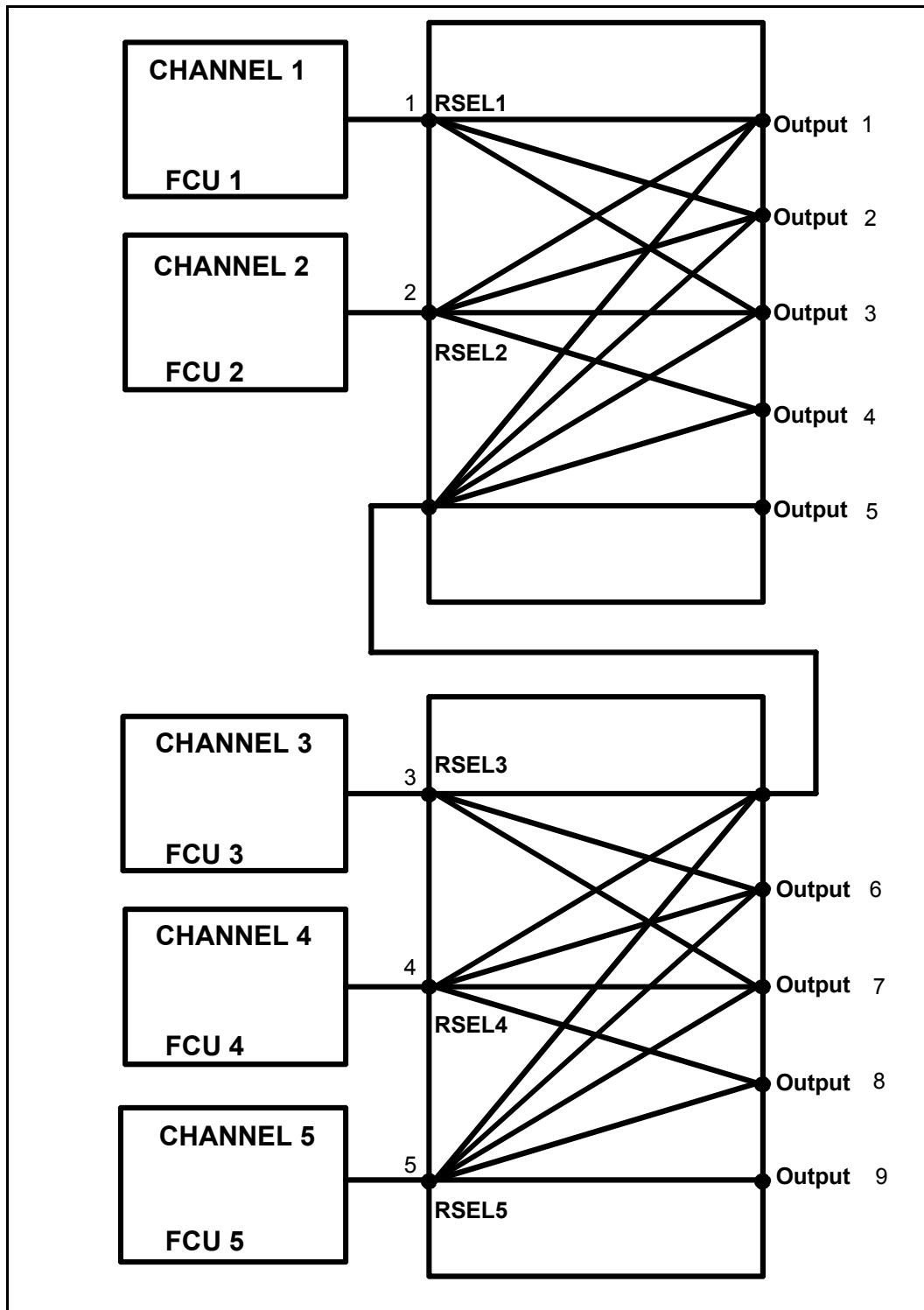
Router/ Combiner

Figure 9.2.   Router front panel
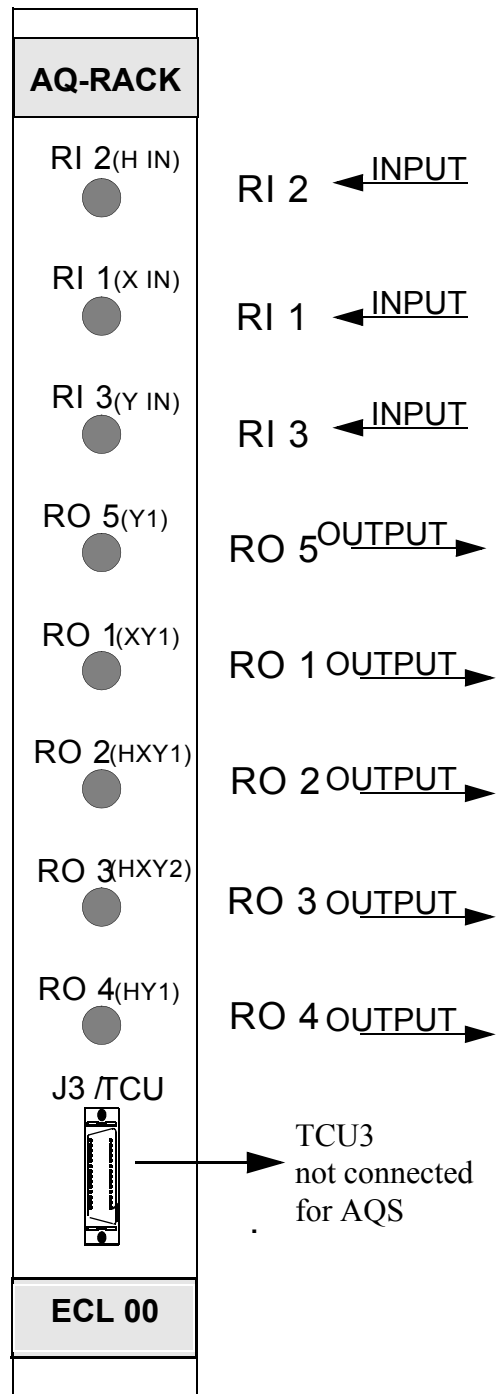
Troubleshooting / Unit replacement / Tips 'n' Tricks   *9.6*

1. Routers are physically identical and if in a system with two routers it is suspected that one is faulty, they can easily be interchanged. If the boards are swapped then you are advised to carry out a new 'cf' routine.

2. The routers are provided to enable the operator to have maximum flexibility in choosing signal paths. The Router can however be bypassed if it is suspected that it is faulty. Simply connect the SGU output directly to the amplifier input. Needless to say this is then a hardwired connection removing any possibility of routing the signal.

3. The Router has no front panel power display LED. However other units share the same voltage sources. A simple method to check if the voltages are actually present at the backplane is to insert another unit at the slot. For example The REF uses +5V, +12V, ±9V,-19V from the backplane The power LED on the front panel indicates that all necessary voltages are present and at the correct level. Thus by inserting the REF unit into the Router slot the presence of some of the required voltages will be quickly established. Note however that this would not rule out a problem with the Router adapter. If you are quickly swapping units to simply check LED displays do not reconfigure the spectrometer.

Diagnostic Tests   *9.7*

Not applicable

Specifications   *9.8*

Table 9.4.   Specifications for the Router/Combiner ECL03 (standard frequency range)

Characteristics	Frequency [MHz]	min.	typ.	max.	Unit
Isolation between Input and Output	5..960	70	80		dB
Crosstalk between two or three routed paths	5..960		-65	-50	dB
Transmission gain	10..960	-2.0		+2.5	dB
Noise figure	5..960	10	14	18	dB
Input VSWR	5..960		1.3	1.7	
Output VSWR	5..960		1.3	1.8	
Switching time on-> off (10%)[a]		60	75	95	ns
Switching time off->on (90%)		70	85	105	ns

a. This means that the rf signal is being switched off by asserting the appropriate blanking
   pulse. The time will be measured when the rf signal has decreased below 10% of its
   original amplitude.

Table 9.5.   Specifications for the Router/Combiner -E (ECL01) (extended frequency range)

Characteristics	Frequency [MHz]	min.	typ.	max.	Unit
Isolation between Input and Output	5..960	70	80		dB
Crosstalk between two or three routed paths	5..960		-65	-50	dB
Transmission gain	5..365 365..960	0.0 -0.5		+3 +3.5	dB dB
Noise figure	5..960	10	14	18	dB
Input VSWR	5..960		1.3	1.7	/
Output VSWR	5..960		1.3	1.8	/
Switching time on-> off (10%)[a]		60	75	95	ns
Switching time off->on (90%)		70	85	105	ns

a. This means that the rf signal is being switched off by asserting the appropriate blanking
   pulse. The time will be measured when the rf signal has decreased below 10% of its
   original amplitude.

Power Supply / Fuses   9.9

The Router is powered from the backplane and details are given below

Table 9.6.   Router voltage and current requirements

Voltage	min.	typ.	max.	Unit
+15V supply	400	480	550	mA
+9V supply	210	230	280	mA
-9V supply	150	160	260	mA

RX22 Receiver *10*

The RX22 as used in the AV is almost identical to its use in the AVANCE series. There is no difference in basic function or electronic performance though there is a difference in the implementation of the RS485 interface.

The RX22 is located towards the left end of the analog section of the AQS between the SADC and the REF board. The board is physically not as deep as the newer AQS units and so is attached to the user bus at the rear via an adapter (see ***"View of AQS ADAPTER ADC + RX22/FTLP-4M mounted" on page 23***.

As the name suggests the RX22 receiver is concerned with the amplification of the signal 'received' from the sample and uses an intermediate frequency of approximately 22MHz. THe precise value of the IF for AV series is now 21.875 MHz as opposed to 22 MHz as this frequency results in less spurious noise. The RX22 enables a gain of 93dB to be set in 1dB steps. The correct setting of the RF gain will ensure that the receiver output is matched to the ADC range($\pm$ 5V).

The entire receiver function is controlled by a microprocessor. This allows accurate gain setting, phase and gain adjustment in the quadrature-module via a RS485-Interface which runs over the backplane. Calibration and production data , (BBIS, Bruker Board Information System) are stored in a flash EPROM on the board.

A vital element of any RF receiver is the quality of the shielding to maximize the suppression of noise. In the design of this unit special attention has been paid to good clean signal transmission etc. The RX22 is mounted in a 19" HF cassette type case, the quadrature module is shielded with u-metal.

All communication with the RX22 take place using a SBSB1/ tty10/RS485 type link along the backplane. This enables the application of the RX22tool which is a software diagnostic tool. Although earlier versions of the RX22 (up to and including ECL01) had the capability to interface with a I^2C bus this was never utilized. As of ECL02 the RX22 componentry does not support I^2C bus interface.

Figure 10.1. RX22 Block Diagram
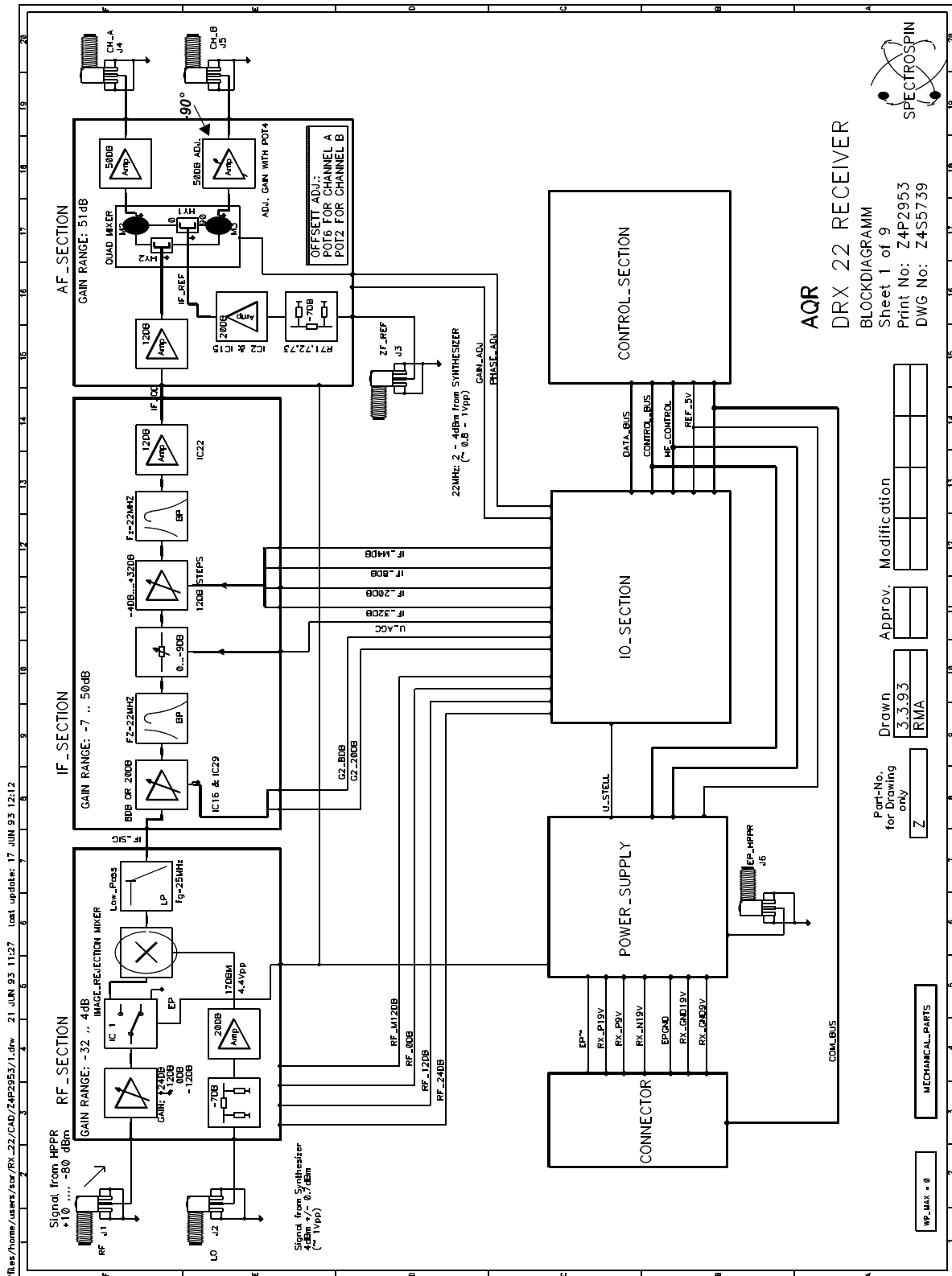
Functions / Description   10.2
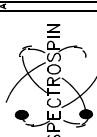
The RX22 has one single function which is to amplify the signal from the sample/HPPR to match the input range of the ADC (±5V). The vital elements of this however are the linear amplification of all frequencies as well as maintaining the precise phase relationship of all rf signals.

The rf input is amplified in several stages to increase the dynamic range. In the rf-section, the gain can be switched in 12dB steps within a range of 36dB. In the IF-Section, a range of 48dB with 12dB steps can be set. The fine adjustment (1dB steps) are done with a pin diode attenuator (PAS) in the IF-Section. see "RX22 block diagram" on page 118 and "3dB GAIN Table" on page 120. The gain steps are summarized below

Table 10.1.   Total gain

Section	Gain dB
rf	36
1st IF	12
PAS	9
2nd IF	36
total	93

The AF section contains a heater and regulation circuit used to monitor and maintain the temperature of the Quad module at a constant 55°C from ECL03 onwards. (Up to and including ECL02 the Quad module temperature was maintained at 65°C). This regulation should further reduce any small phase and gain drift that might be caused by temperature fluctuations.

At the final section the rf signal is split into two channels with phase difference of 90 degrees , a standard method known as quadrature detection used to suppress folded signals. In order to ensure that the two channels provide identical amplification slight adjustment to the phase and gain of these channels may be necessary. This can be done via the RX22 tool. The final outputs (channel A and channel B) are connected directly to the ADC.

Control Section   *10.2.1*

A Flash EPROM allows the following information to be stored:

   1) Gain settings for the various rf sections

   2) Phase and Gain settings for the Quad module

   3) Calibration data for the various amplifiers in the RF, IF, and AF sections

   4) BBIS type information

   5) Firmware used by the micro controller

This information will now be discussed in some detail.

1. **Gain settings:**

The XWIN-NMR RG value is transmitted to the receiver via the SBSB1/ tty10/ RS485 type link along the backplane see ***"Schematic of VME , User buses and LVDS" on page 16***. The data is interpreted by the controller and the appropriate signals are then transmitted to the RF and IF amplifiers. ***Table 10.2.*** displays which combination of gain settings is used for the various sections for the complete range of XWIN-NMR RG values. Note that for simplicity this table uses RG steps of 3 dB. As of ECL00 it is possible to alter the RG in 1 dB steps.

Table 10.2.   *3dB GAIN Table*

RG Value	Real Gain dB (approx)	Relative Gain (dB)	RF Amplifier	1st IF Amplifier	PAS	2nd IF Amplifier

When an XWIN-NMR RG value which does not correspond exactly to a hardware value is entered, then the nearest value is taken.

Note that whereas with older type receivers such as the ARX receiver or the SE451 receiver it was possible to measure the RG bit settings at the Burndy connector this is no longer possible because the RG bit settings are now transmitted over the RS485 link. However it is now extremely easy to test the RG bit settings using the RX22 tool.

2. **Phase and Gain settings for the Quad module**

It is possible to make the Quad Image adjustments by software. Using the RX22 tool program the Gain (resolution $\pm 3.2\%$ of current Gain) or Phase (resolution $\pm 5°$) may be adjusted. When the adjustments are made they should be stored using the „Save Configuration" routine. This will ensures that the correct values are automatically reloaded after a power up.

3. **Calibration data***:*

The calibration of the various amplifiers is carried out in the factory individually for each board. The increased accuracy resulting from the calibration has made it possible for the 1 dB steps of the PAS to be implemented. Although this data may be altered with the aid of the RX22 tool this is not recommended. False calibration data will result in the RX22 operating improperly.

4. **BBIS data:**

The FLASH EPROM also contains BBIS data such as production data, software version, EC level etc. This data is transmitted via the RS485 link.

5. **Firmware**:

The RX22 tool program can be used to download new firmware. Normally no new firmware is required as it has not changed in recent times. The firmware is not updated when a new version of XWIN-NMR is loaded.

Image Rejection Mixer   *10.2.2*

As a result of the relatively low Intermediate Frequency (21.875 MHz) the RX22 uses an image rejection mixer in the RF section to remove unwanted folded noise that might be transmitted through the XBB preamplifier of the HPPR.

Consider the case of 13C OBS on a 300 MHz spectrometer. For a received signal of 75 MHz the signal is mixed with an LO of 97 MHz to produce an IF of 22 MHz (for simplicity we will use 22 and not 21.875 as the IF).

However noise at 119 MHz, when mixed with the LO, would also produce an IF of 22 MHz and hence the need for the image rejection mixer. The rejection mixer transmits signals at LO-22MHz (75 MHz in above example) and attenuates by more than 20 dB noise at LO+22 MHz (119 MHz in above example).

The mixer works for frequencies up to 600 MHz approx. Any stray frequencies above this value would be outside the X frequency range and will be removed by the filters in the 1H HPPR module.

Reset *10.2.3*

The RX22 Controller is normally active only when the RGP signal is high (inactive, receiver closed). In this state RG values may be changed etc. When the RGP signal goes low (active, receiver open) the controller is effectively switched off. No further communication is possible over the RS485 link.* The 12MHz micro-Processor clocking frequency is also switched off. This ensures that no disturbances can occur during the acquisition. When the RGP goes high again the controller is effectively reset and once again operational.

*Two exceptions to this are

> **a)** the special mode activated within the RX22 Tool under the menu point „Debug EP_Blank". This allows Gain and Phase adjustments to be made over the RS485 link even during acquisition.

> **b)** gs mode operation which is typically used to enable parameters to be adjusted dynamically

Unit Configuration / Version / Jumpers *10.3*

There are a series of jumpers on the RX22 many of which are no longer relevant for AQS systems. With respect to the table below please note the following:

The AQS system RX22 use a RS485 interface which sets J7 and J8 to the factory configuration A.

The AQS uses the internal digital 5V supply so J15 and J16 should also be set to the factory configuration B

J20 is no longer applicable for AQS systems since the HPPR gating now comes from the OBS SGU via the PSD or ACB-S.

J19 is also no longer applicable as the AQS has no SE451.

shows not only the location of the jumpers but also that position A is always the jumpers set towards the front panel, while position B means setting the jumpers towards the backplane.

Table 10.3.   Jumper Settings :

Jumper	Setting A	Setting B	Factory Setting
J7,J8	RS485 interface	RS232 interface (if IC36 is placed)	A
J15,J16	True galvanic isolation for RS485 interface .(If external 12V for RS485 interface is available use setting A)	No galvanic isolation for RS485 interface (If external 12V for RS485 interface is not available use setting B)	B
J17	Not a valid setting. Set J17 to B	J17 must be always set to Position B	B
J18	Reserved for further options	Reseved for further options	B
J19	EPA_SE451 and EPB_SE451 low active	EPA_SE451 and EPB_SE451 high active	A
J20	EP_HPPR low active	EP_HPPR high active	A

Differences from previous versions.   *10.3.1*

The table below summarizes the differences between the RX22 as used in AV as opposed to AVANCE .

Table 10.4.   RX22: AVANCE vs. AV

RX22 in AV	RX22 in AVANCE
IF=21.875MHz	IF=22MHz
IF received from REF board	IF received from PTS
LO received from SGU	LO received from LOT board
RS485 interface over backplane	RS485 interface over front panel connector
Receiver gating pulse (RGP) generated by SGU. Transmitted to receiver via Backplane	Receiver gating pulse (EP) generated by RCU. Transmitted to receiver via ADC and Backplane
HPPR gating pulse (RGP_HPPR) connected to the HPPR via the PSD or ACB-S.	HPPR gating pulse (EPHPPR) connected to the HPPR at front panel

Figure 10.2. Location of jumpers

Front Panel Wiring / Display   10.4
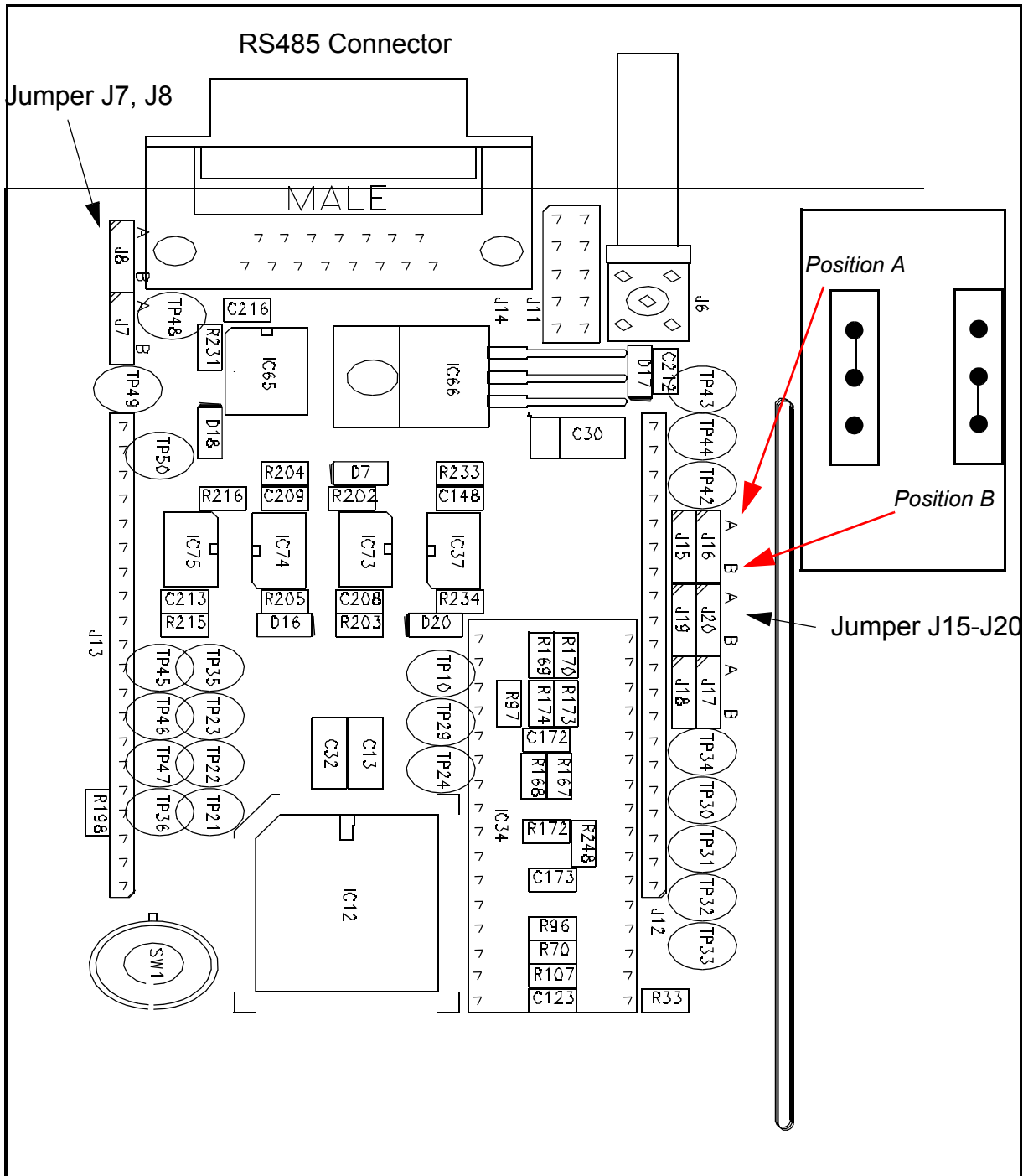
LEDs:

Two LEDs 'READY' and 'ERROR' display the microprocessor status, two LEDs monitor the supply voltages.

Possible combinations of the READY and ERROR LED are described in **_Table 10.5._**.

Table 10.5.   ERROR and READY LED Description

Error LED red	Ready LED green	Status
off	off	- power supply not on
off	on	- Normal operating mode - ready for operation
off	single, short-time flickering	- Communication LED. The board has received a command from the RS485 bus master. The LED switches to off as soon as the RX22 acknowledges the command.
blinking	on	The uP disabled the EP reset logic. (tuning, matching and gs procedure) Caution: NMR experiments are not possible in this mode due to disturbances of the uP system.
on	off	Error state. The firmware triggered an error. The error must be acknowledged by the Master. The RX22 refuses further operation until the error is cleared.
on	on	- The board was powered up. - An active EP disables any uP operations, the uP system is always in a reset state. Check the polarity of the connected EP pulse

Voltage LEDS:

Note that should the voltage levels drop below the required level, the LEDs may not necessarily go out but may simply light with less intensity. This means that even if the LEDs light it may ne be necessary to measure the precise voltage level if it is felt that the levels are incorrect.

J1 RF:

Input from HPPR . This is an RF signal which will only be present when the HPPR is in receive mode. The timing is controlled by the RGP_HPPR signal which is closely linked to the RX22 gating signal.

J2 LO:

RF CW signal with frequency of SFO1 + 21.875MHz. This signal (0.5Vpp at 50 Ω) originates on the OBS SGU and is only present when the receiver is open.

J3 REF.

IF reference from REF. unit . This is a sinusoidal wave 21,875MHz, approx. 4dBm (1.0Vpp) @ 50Ω.

J4 CHA / J5 CHB:

Outputs to ADC. This is the amplified signal and should be in the range of 0-5V. The amplitude of this signal should change with the value of RG. Naturally the signal will only be present when the RX22 is open.

Part Numbers and Cables 10.5

AQR RECEIVER BOARD 22MHZ: Z002810

Troubleshooting / Unit replacement / Tips 'n' Tricks 10.6

To replace the unit simply switch off the AQS, replace the board and switch on. Be aware that the SADC and the RX22 are physically connected to the same rear adapter. Having inserted a new RX22 the spectrometer should be reconfigured and the entry in /u/conf/instr checked.

Testing the overall gain of the Receiver 10.6.1

Column 2 of **_Table 10.2._** lists the approximate overall real gain of the RX22 Receiver for a range of RG values. To check these values carry out the following procedure.

1) Measure the voltage of the 10 MHz output J3 of the REF. unit ~7dBm (1.4Vpp) @ 50Ω

(2) Set SFO1 = 10.0001 MHz. AQ = 60 seconds

3) Set RG = 1

4) Connect the 10 MHz output via a variable attenuator to the receiver input. Set the attenuator to 80 dB.

5) Enter „zg" and observe the voltage at the receiver output CHA or CHB. Adjust the variable attenuator until the voltage at the receiver output is equal to that measured at the 10 MHz output of the REF. unit. The attenuation required can be taken as a measure of the gain of the receiver.

You can repeat using various values of RG, but be sure to increase the attenuation accordingly.

Testing the RS485 link. 10.6.2

The RG value set within XWIN-NMR is transmitted to the RX22 via the SBSB1/ tty10/RS485 type link along the backplane . There are several ways to ensure that this link is functioning.

Method 1:

From within the diagnostic program 'RX22tool' is is possible to set the RG value and then read it back.

Method 2:

change the value of RG (to some uneven value) in XWIN-NMR

1. Enter 'ii'

2. Read the new value of RG with 'RX22tool'

Method 3:

1. In XWIN-NMR set the value of RG (to some uneven value)

2. Perform an acquisition.

3. Check the value of RG that was actually utilized in the 'acqus' file.

Diagnostic Tests   10.6.3

The RX22 has a diagnostic program entitled RX22tool which is accessible under NMR Check.

From the tool you can

1. read and write the RX22 receiver gain

2. adjust the gain, phase and baseline for the quad module

3. measure the quad module temperature

4. download new firmware

5. read the temp of the quad module

6. read / write BBIS to File:

7. read /write calibration data

Be aware that the corruption of calibration data can lead to the incorrect operation of the unit and this menu point should be entered by service personnel only.

Specifications   10.7

Frequency range:

Gain Range: 93dB gain range in -1dB Steps

RS485 Interface

Power Supply / Fuses   10.8

A supply voltage controller monitors the digital supply voltage (+5V). If the supply voltage drops below 4.5V a hardware reset automatically takes place.

The RX22 receives the required power from the backplane and can easily be measured using the Test Extension Board (P/N Z012746). Table 13.3 below shows the test points and corresponding signals.

Table 10.6.   Power Supply

Test Point	Signal
10A, 10B, 10C	RXk+9V
11A, 11B, 11C	RXGND9V
14A, 14B, 14C	RX+19V
15A, 15B, 15C	RXGND19V
16A, 16B, 16C	RX-19V

RX22 Receiver

Digitizers

<div align="right">

11
</div>

Introduction

As with any digitizer the two principal specifications are the maximum sweep width (which is a function of the minimum sample time) and the resolution. These specifications are sufficient to distinguish between the three versions of digitizer which are available.

SADC: **Standard** ADC which as the name suggests is designed for standard spectrometers. This digitizer has 14 bit resolution at a maximum SW of 150kHz (16 bit at a SW of up to 5kHz)

HADC/2: **High** resolution ADC which will yield a resolution of 16 bits at a maximum SW of 1 MHz. The HADC/2 is a successor the the HADC which had a maximum SW of 200kHz

FADC: **Fast** ADC is the third and final type of ADC specifically designed for broadband application such as solids. The maximum SW is 10 MHz with a resolution of 12 bits.

This chapter will deal mostly with the SADC and the HADC/2. A supplement with FADC specific information is included at the end of this chapter see ***"FADC" on page 137***.

In contrast to earlier generation digitizers (before the introduction of digital filtering) the current range of digitizers require limited (three) analog filters on each channel prior to the AD conversion. Since the various types of digitizers have different maximum Sweep Widths, the values of these filters will vary. The purpose of these filters is simply to ensure that no folded signals fall within the digital filter where they would not be suppressed. The performance of the digital filters is far superior to the analog filters.

In all but specification the SADC and HADC/2 are identical and the comments below apply to both.

The SADC/HADC/2 is located at the left end of the analog section of the AQS next to the RX22. The board is physically not as deep as the newer AQS units and so is attached to the user bus at the rear via an adapter (see ***"View of AQS ADAPTER ADC + RX22/FTLP-4M mounted" on page 23***

The SADC/HADC/2 receives two rf inputs from the RX22 receiver and having filtered and digitized the rf signals, transmits the outputs to the RCU for further processing. The digitizer has no role to play in either digital filtering, oversampling or decimation, these all take place on the RCU.

Power as well as the signals DWCLK and RGP_ADC are received from the backpanel. The SADC/HADC/2 have the same interface to the RCU which is made via the 50 way digitizer cable on the front panel.

Functions / Description *11.2*

The SADC/HADC/2 has a single function which is to digitize the two rf signals from the RX22 and transmit the digitized data to the RCU. The full analog signal input range is +/-5V

Filters: *11.2.1*

The incoming rf signal from the RX22 is first filtered. As mentioned previously the purpose of these filters is simply to ensure that no folded signals fall within the digital filter where they would not be suppressed. Consequently only three coarse filters are required. The appropriate analog filter is chosen by the software automatically depending on the chosen SW. The RCU is made aware of the required filter setting by the CCU10 via the VME bus and this is then transmitted to the ADC via the 50 way front panel RCU/digitizer cable.

The analog filters can be bypassed by entering $1e^8$ as the value of FW in the 'eda' menu. This will set an 'FW' of 100000000 which will bypass the filters.

The filters are fourth order Butterworth and the filter widths are listed in the table below.

Table 11.1.   Analog Filter widths in various digitizers

	Filter Width KHz	'FW' in 'eda' KHz
SADC (up to ECL03)	10 45 62.5	20 90 125
SADC (ECLO4 and later)	10 46.875 93.75	20 90 125
HADC	62.5 312.5 625	125 625 1250
FADC	no filters	no filters

Figure 11.1. HADC/2 block diagram
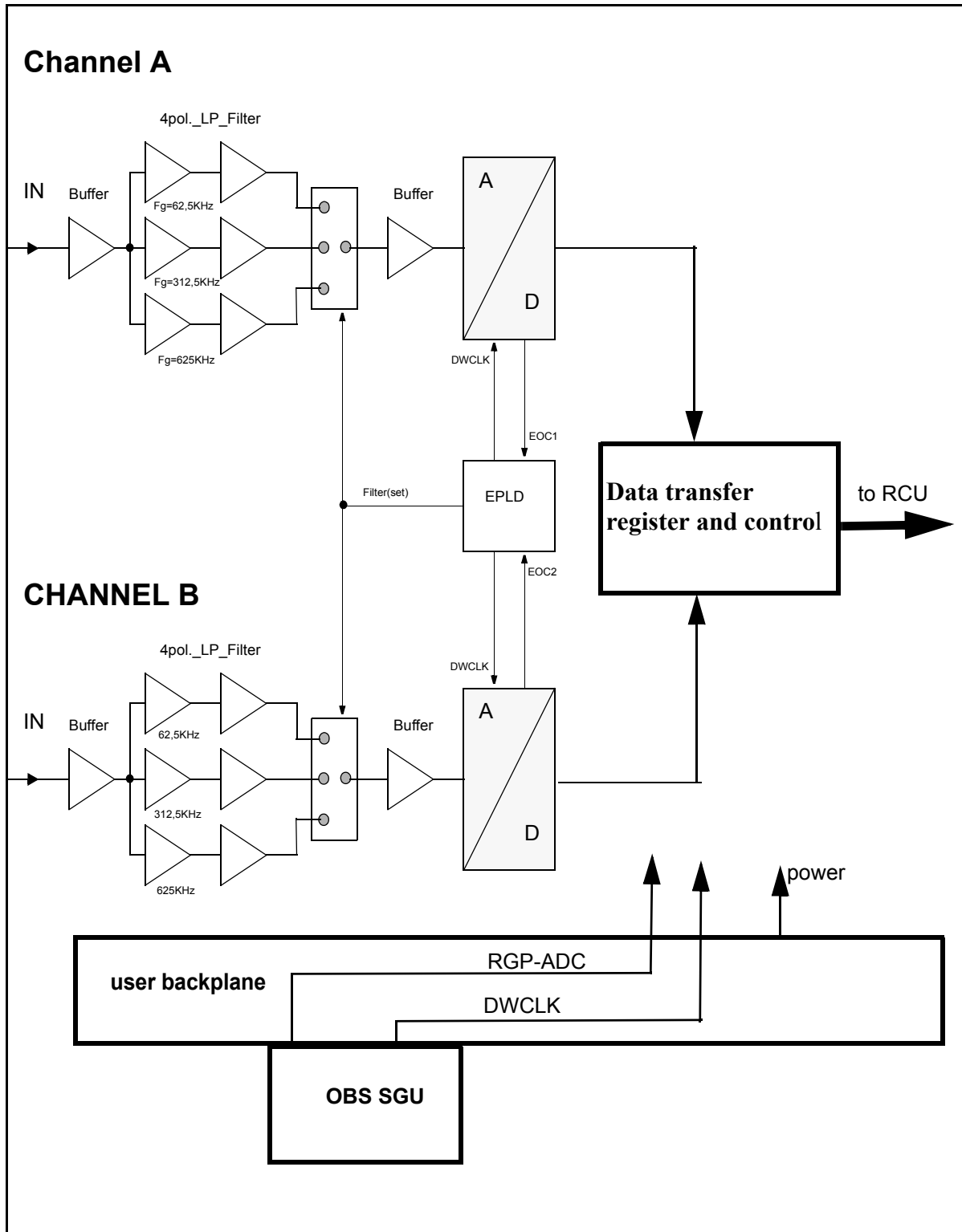
Digitizers

After being filtered, the signal is digitized at a rate determined by the the Dwell-Clock .

All three signals described below are routed over the backplane to the ADC via the RX22

DWCLK

The Dwell Clock *(*DWCLK) is generated by the OBS SGU. Every falling edge executes an ADC conversion. The signal is not generated by a programmable hardware divider as was the case on the AVANCE AQX RCU, but is now treated as a pulse sequence in the pulse program This is implemented via an FCU3 programmed Dwell clock loop . This loop is running on the FCU3 and every dwell clock edge is an instruction on the high speed link (LVDS), which drives the pulse in the observe SGU. Homodecoupling experiments are treated as typical pulse programs. Thus although the signal is generated on the SGU, the timing is controlled totally by the FCU via the LVDS.

RGP_ADC~ (ADC gating pulse)

This pulse (also driven by the observe SGU) controls the ADC data in that it effectively gates the ADC on and off.. If the pulse is low and a dwell clock is applied, the ADC will perform a conversion. If the pulse is high and a dwell clock is applied, the ADC generates 'zero' data. This signal is specially used for digital homodecoupling with oversampling.

SEL_ADCx~ (Select A/D converter)

The signal is applied to select a required ADC in the case of configurations with more than one ADC. see

Several modes are selectable from the 'eda' menu.

In**qsim** (simultaneous) mode both channels are performing D to A conversions simultaneously.

In qseq (sequential) mode each channel performs alternate conversions. This is no longer supported and is not selectable in the 'eda' menu.

In qf (quadrature-off) mode only channel A converts and the benefits of quadrature detection are lost.

DQD:

After the conversion stage the data will be latched into a memory (D-flip-flop) where it remains until the data can be transferred to the RCU. The last step in downconverting is performed digitally on the RCU.

Digital Mode DIGMOD: *11.2.4*

Three modes are selectable in the 'eda' menu and are explained below.

Digital is the normal mode and the minimum dwell time is selected to maximize oversampling.

Homodecoupling-digital is a special case of digital whereby the minimum dwell time is increased to 5us to allow for the complex case of sampling between irradiation.

Analog is without oversampling and would only be used in special cases.

Unit Configuration / Version / Jumpers   *11.3*

The jumper setting which will depend on whether the ADC is configured for an AVANCE (AQR) or AV (AQS) are detailed detailed below.

AQR type:

ECL01/02: JU1, JU4, JU7-JU12

ECL03/04: JU1, JU4, JU10-JU12

AQS type:

ECL00: JU1, JU4, JU10-JU12

Front Panel Wiring / Display   *11.4*

The front panel has a set of LEDs monitoring the power supplies which are described in *"Power Supply / Fuses" on page 136*.

The front panel has of course the two inputs from the RX22 as well as the 50 pin cable connector to the RCU.

The table *"50 pin Digitizer / RCU connector pinouts" on page 133* shows the 12V power supply on pins 11 and 12 of this cable. Also pins 45-50 are the I^2C bus type signals that transmit the information regarding the filter selection and the acquisition mode (qsim, DQD etc.).

The table *"AQS-SADC Backplane Connector" on page 134* shows the various voltages suppled by the backplane as well as the dwell clock, RGP_ADC signals etc.

Figure 11.2. SADC front panel

```
                    ⊕

              SADC

           ○ +15V
           ○ -15V
           ○ +5V (D)
           ○ +12V
          CH A
                          INPUT CHA from RX22
           ◯         ◄────────────────────

          CH B
                          INPUT CHB from RX22
           ◯         ◄────────────────────




          RCU




                          DATA to RCU
                     ────────────────────►

                          Filter settings, AQ _Mod
                     ◄────────────────────


          AQS / AQR
            ECL 01

                    ⊕
```
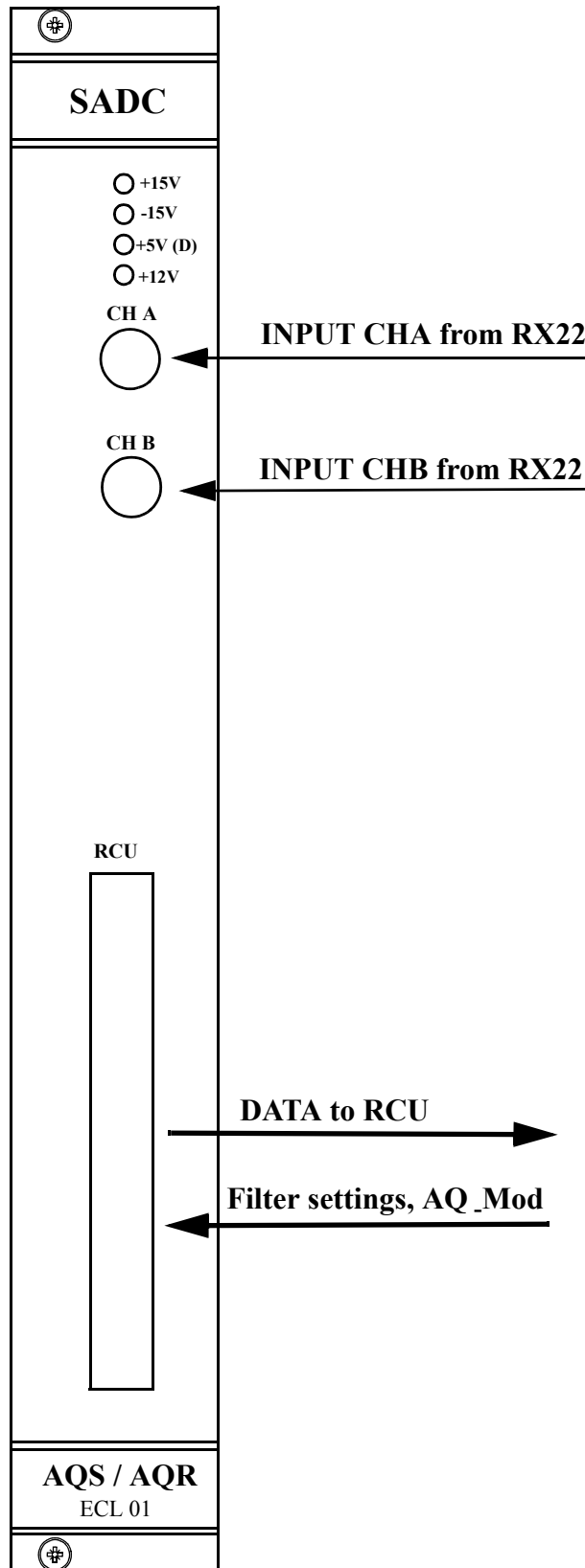
Figure 11.3. HADC/2 front panel
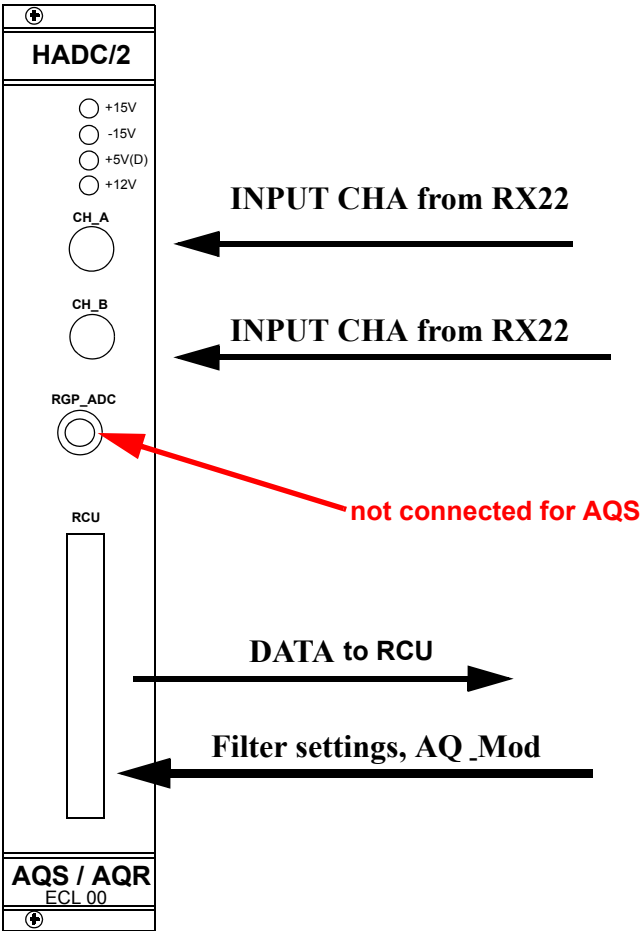
Table 11.2.   50 pin Digitizer / RCU connector pinouts

Digitizers

J1	Signal-Name	J1	Signal-Name	J1	Signal-Name
1	VPWRGND	18	DATA 6~	35	TU0IN
2	VPWRGND	19	DATA 7	36	TU0IN~
3	DATA 0	20	DATA 7~	37	XVDD 12
4	DATA 0~	21	VPWRGND	38	XVDD 12
5	DATA1	22	VPWRGND	39	DWCLKIN
6	DATA 1~	23	DST 1	40	DWCLKIN~
7	DATA 2	24	DST 1~	41	VPWRGND
8	DATA 2~	25	UNIT 0	42	VPWRGND
9	DATA 3	26	UNIT 0~	43	ADC IN
10	DATA 3~	27	SRT 1	44	
11	XVDD 12	28	SRT 1~	45	SDATA IN
12	XVDD 12	29	RES RT	46	SDATA IN~
13	DATA 4	30	RES RT~	47	SERCLK
14	DATA 4~	31	XVDD 12	48	SERCLK~
15	DATA 5	32	XVDD 12	49	SERDIR
16	DATA 5~	33	EP IN	50	SERDIR~
17	DATA 6	34	EP IN~		

Table 11.3.   AQS-SADC Backplane Connector

J 6	A	B	C
1			
2			
3			
4		SEL_AQX_AQS	ADC_SEL_AQS
5			DWLCLK_AQS
6	SDA 1		SCL 1
7	SDIR 1		I2C GND

J 6	A	B	C
8	ADC ON	ADC ON GND	EP~
9			EPGND
10	RX +9V	RX +9V	RX +9V
11	DGND	DGND	DGND
12			
13			RGP_ADC_AQS
14	XP 19V	XP 19V	XP 19V
15	PWGND	PWGND	PWGND
16	XM 19V	XM 19V	XM 19V

Part Numbers and Cables 11.5

AQS SADC: Z003570

HADC/2:

Digitizer cable:

Troubleshooting / Unit replacement / Tips 'n' Tricks 11.6

The ADC should only ever be opened by service personnel.

To function the ADC will need

1. Power from the backplane as well as from the RCU via the digitizer cable

2. Dwell clock and RGP_ADC from the SGU

3. rf input in the range of $\pm 5V$

Testing the digitizer should be done in 'qsim' mode and not 'dqd'.DQD mode will display a signal on both channels even if only one channel is working. If the acquired signal is missing it can sometimes be difficult to establish if the fault lies with the RX22 or the ADC. It is relatively simple to bypass RX22 and use a signal generator to input a 1Vpp signal directly into either or both the ADC channels.

Remember that if only one channel is in use then only either the real or the imaginary spectrum will be present. Also the input frequency should be well below the maximum SW. There is also unlikely to be any phase coherence since the RX22 is bypassed but it is easy to establish if the ADC is converting. Remember that if a 10KHz signal is used as an input the spectrometer will interpret this as a signal 10KHz from the SFO1 frequency.

If the 12V power LED is not lighting check the connecting cable to the digitizer.

Digitizers

Diagnostic Tests 11.7

Not applicable

Specifications 11.8

The **SADC** has a maximum sample rate of 300 Ksps (kilosamples per sec.) which is achieved by each channel having a maximum sample rate of 150 Ksps. This corresponds to a minimum dwell time of 3.33us with corresponding maximum SW of 150KHz in quadrature detection mode. The resolution is nominally 16 Bit but this is only fully available at Sweep Widths up to 5 KHz. At maximum sweep widths of 150KHz, where the oversampling is nil, the resolution drops to 12 bit.

The HADC/2 has a maximum sample rate of 2 Msps (Megasamples per sec.) which is achieved by each channel having a maximum sample rate of 1MSPS. This corresponds to a minimum dwell time of 0.5us with corresponding maximum SW of 1MHz in quadrature detection mode.

The following table illustrates the minimum. dwell time and corresponding maximum dwell clock for various digitizers.

Table 11.4. Minimum dwell time and corresponding maximum dwell clock of various digitizers

Digitizer	Minimum Dwell Time DWOV (Quad Mode)	Dwell Clock	Maximum SW DQD
SADC	3.3 µs	300 KHz	150 KHz
HADC/2	0.5 µs	2 MHz	1 MHz
FADC	0.05 µs (High speed)	20 MHz	10 MHz
FADC	2.5 µs (Normal mode)	400 KHz	200 KHz

Power Supply / Fuses 11.9

The ADC and the HADC/2 power supplies of $\pm$ 19V and + 9V are derived from the backplane and from these analog voltages of $\pm$ 15V and $\pm$ 5V are derived as well as a separate digital voltage of +5V. The $\pm$ 15V analog and the +5V digital voltages operate the front panel LEDs of the ADC. The $\pm$ 5V analog voltages which are not shown, are derived from $\pm$ 15V voltages.

A separate +12V supply derived from the RCU and connected via the 50 pin digitizer cable is also monitored with a front panel LED.

➭ *Note that should the voltage levels drop below the required level the LEDs may not necessarily go out but may simply light with less intensity. This means that even if the LEDs light it may ne be necessary to measure the precise voltage level if it is felt that the levels are incorrect.*

FADC *11.10*

The **Fast** ADC is the third and final type of ADC specifically designed for broadband application such as solids. The maximum SW is 10 MHz with a resolution of 12 bits. Since the FADC has no analog filters the FADC is always accompanied by the FTLP/4M to provide the filters.With the AQS the SADC or HADC/2 are no longer necessary to provide access to set these filters.The filter setting is now implemented over the backplane.

AQS Connection to FADC *11.10.1*

The FADC is plugged directly onto the RCU. Solid - NMR

Figure 11.4. FADC connections with high resolution capability
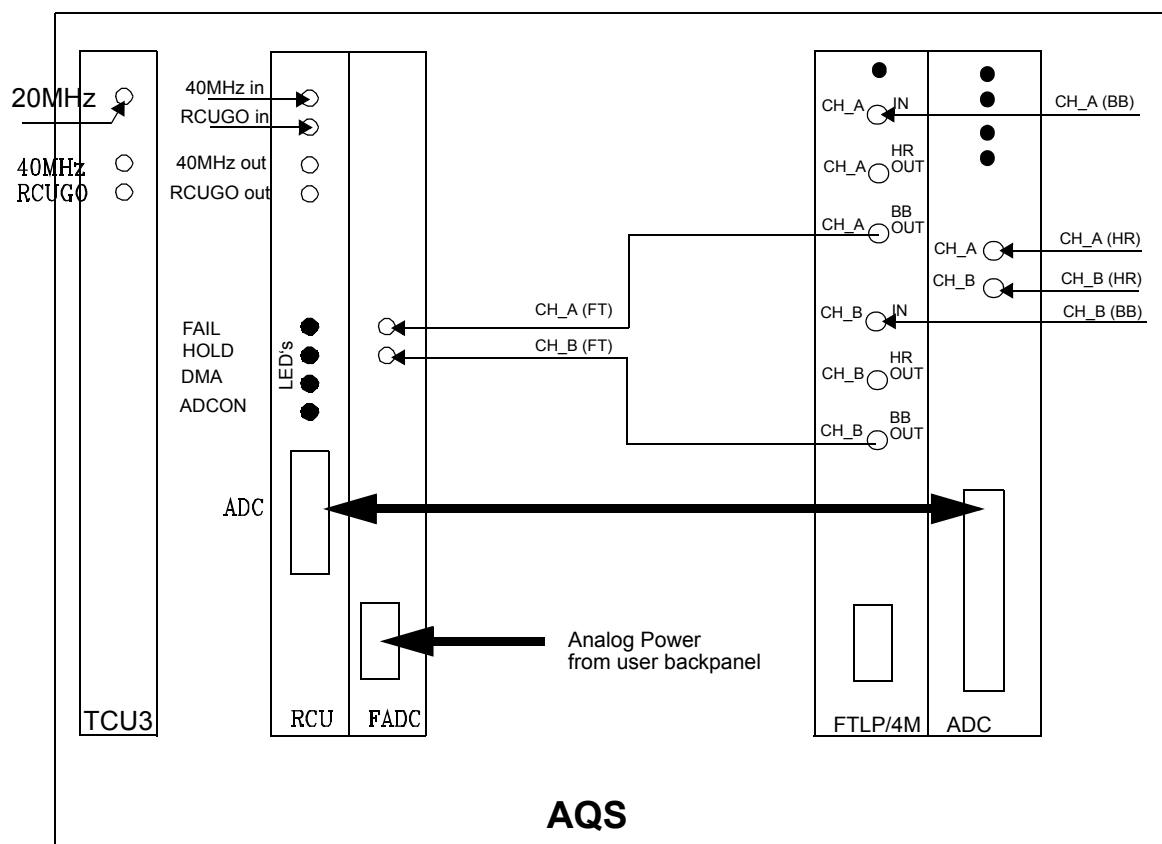
The power for the analog part of the FADC is supplied by the user backpanel via the front panel cable. The filter board delivers an analog signal based on the broadband input signals (BB) for the SADC / HADC/2 (HR) high resolution input, if a direct HR signal from the receiver is not available.

Note: The BB signals of the receiver are connected to the filterboard, and its BB output is connected to the FADC. The HR output of the receiver is always connected to the HADC/2 or SADC directly. The HR output of the filter board is optional and for testing purpose.

Digitizers

Internal Amplifiers

12

Introduction

The internal amplifiers have been designed to facilitate customers who prefer a low cost and particularly compact spectrometer. With the AV series two versions of internal amplifiers are available, the BLA2BB and the BLAX300. The BLA2BB has two channels, one for proton and one for X frequencies and is the standard internal amplifier. Additionally an optional BLAX300 can be fitted for a third channel for X frequencies.

The amplifiers are internal in the sense that they are slot-in type units with fixed positions in the front of the AQS rack. Both amps require dedicated power units located at the rear of the AQS rack.

BLA2BB stands for **B**ruker **L**inear **Array B**road**B**and. As with all rf amplifiers the output varies strongly with frequency as is evident in_**Figure 12.1.**_ Although the actual electronic amplifiers on both channels are identical they are specced differently due to this variation. In standard configuration the BLA2BB is capable of delivering 60W at the proton frequency and 150W for X frequencies up to ^{31}P. A single version is capable of delivering the specified output for 200/300/400 MHz spectrometers. A separate version is available for 500 and 600 MHz spectrometers.

If additional power or an extra channel is required then the system can be fitted with a BLAX300. There ia a single version of the BLAX300 capable of delivering 300W on all frequencies up to ^{31}P on a 600MHz spectrometer.

The maximum rf input of the amplifiers is 1Vpp or 4 dbm and the specified output powers assume this level of input. The mechanism that implements output switching within the amplifier itself is sometimes referred to as the minirouter.

The combination of the two internal amplifiers gives three channel capability. If a greater number of channels is required the customer should consider the use of external amplifiers. Although it is unusual the combination of internal and external amplifiers is possible, but if more than three channels is required then a second AQS rack must be fitted.

Each internal amplifier is capable of detecting the level of forward rf power output which can be displayed on the BOSS keyboard. Display of the output power on the graphics monitor is not supported.

Finally it should be noted that the amplifier output is a fixed linear amplification of the input since amplitude control is implemented solely on the SGU prior to the internal amplifier.

Figure 12.1. BLA2BB: Variation of output power with frequency for three levels of input power.
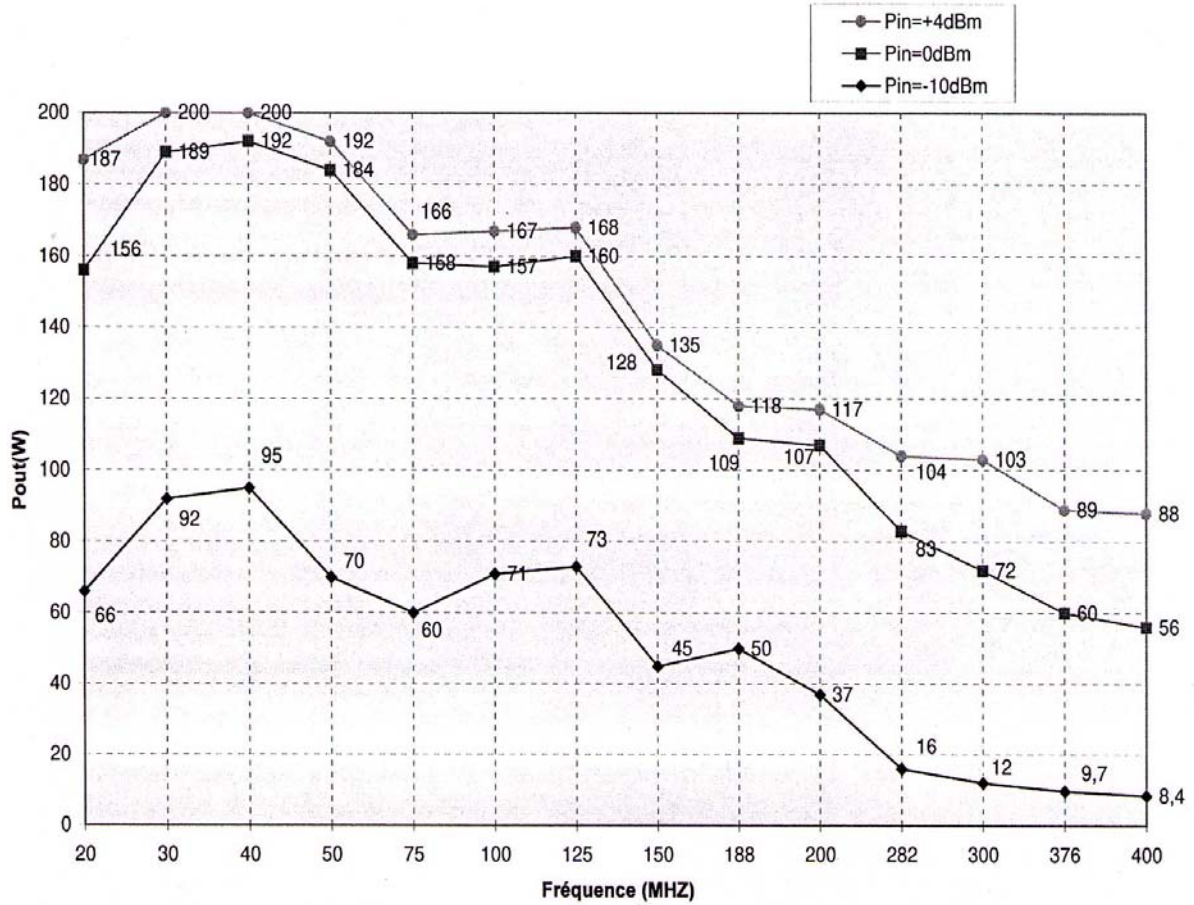
Functions /Description 12.2

1. to provide a fixed linear amplification of an rf input.

2. to blank rf signals to ensure sharp and clean pulses with maximum noise suppression.

3. to provide an indication of the level of rf output power.

Blanking 12.2.1

Blanking pulses generated by the SGU are delivered over the backplane

Switching signals P0 and P1.   12.2.2

These signals operate the minirouter .The edsp selection will be known by the
CCU10. An incoming command from the CCU10 via the SBSB1 bus is converted
by the master SGU to a I^{2}C command. This I^{2}C command will set the minirouter
inside the BLA2BB.

edsp Display: 12.2.3

The software will take account of the hard wiring between the SGUs and the amplifiers as well as any
required internal switching. From the operator point of view the user need only select the desired output
and the software will automatically select the appropriate SGU as well as set any required internal switch-
ing within the amplifier. For example if channel F1 is connected to the 300W amplifier in the edsp menu the
software will automatically generate this signal on SGU3 as this SGU is hardwired to the BLAX300 ampli-
fier.
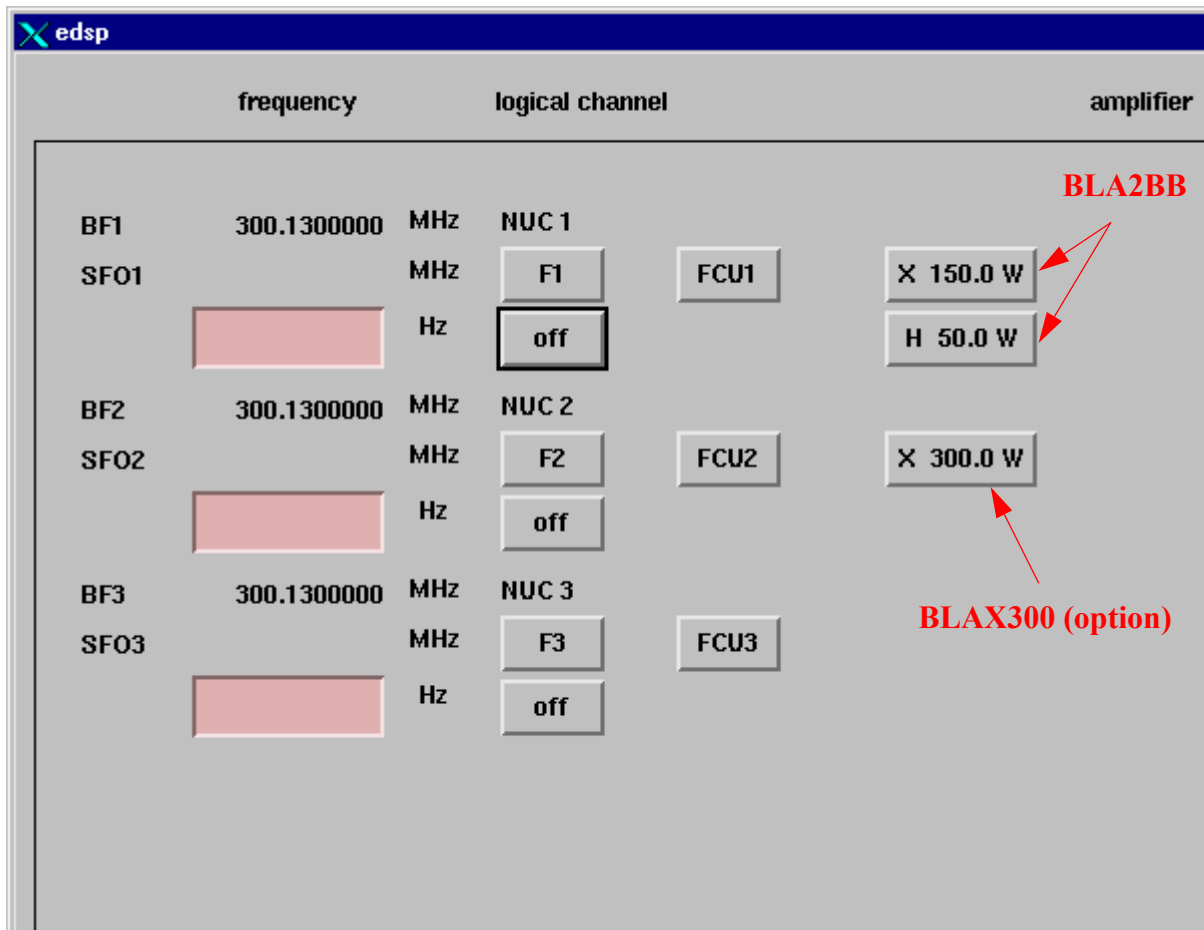
Figure 12.2. Block diagram of internal amplifiers and connections with SGUs and probe.
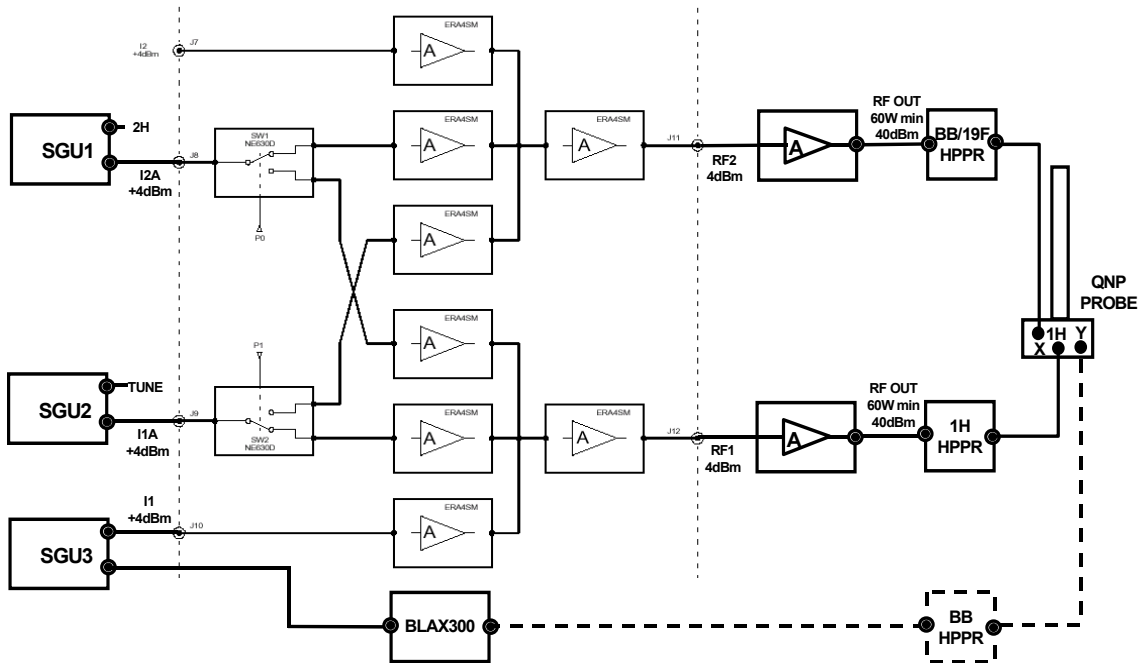
Figure 12.3. BLAX300 Block diagram
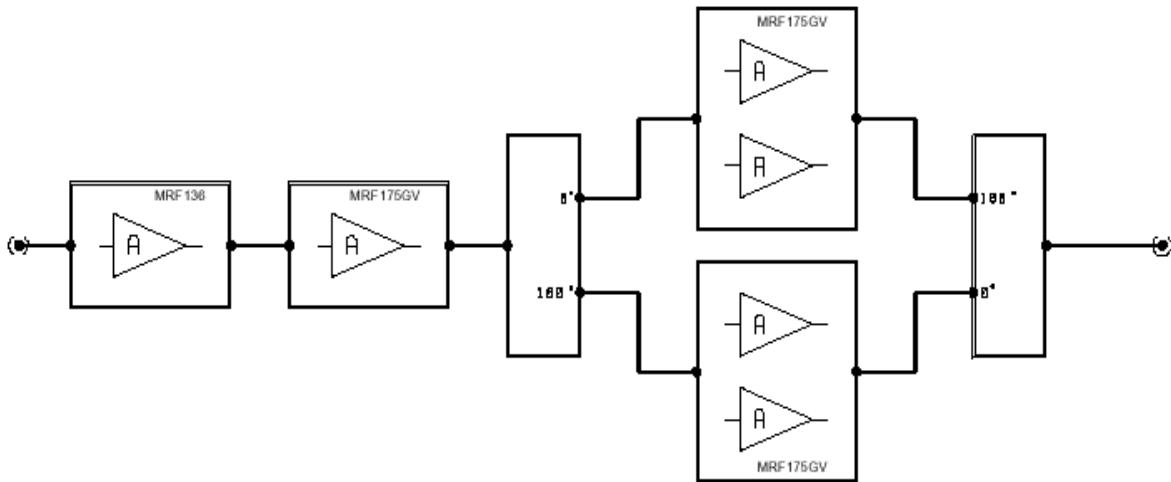
Board Configuration / Version / Jumpers   12.3

A summary of the various units is given in the table below.

Table 12.1.   Internal amplifier versions

Unit	Spect. Freq. range	Channels	P/N
BLA2BB	200 - 400	Separate ^{1}H and X channels	W1345049
BLA2BB	500 - 600	Separate ^{1}H and X channels	W1345072
BLAX300	200 - 600	Single X channel	W1345052

The positions of the amplifiers in the AQS rack are fixed due to the heavy duty connectors J20 and J21 see

Front Panel Wiring / Display   *12.4*

As already mentioned both channels of the BLA2BB are electronically identical in terms amplifying units. Therefore the distinction of X and ^{1}H channels is made to simplify operation for the operator. As long as the output connections to the probehead are compatible the user is is effectively free to transmit whatever frequencies they wish on either channel.

Figure 12.4. BLA2BB and BLAX300 front panel
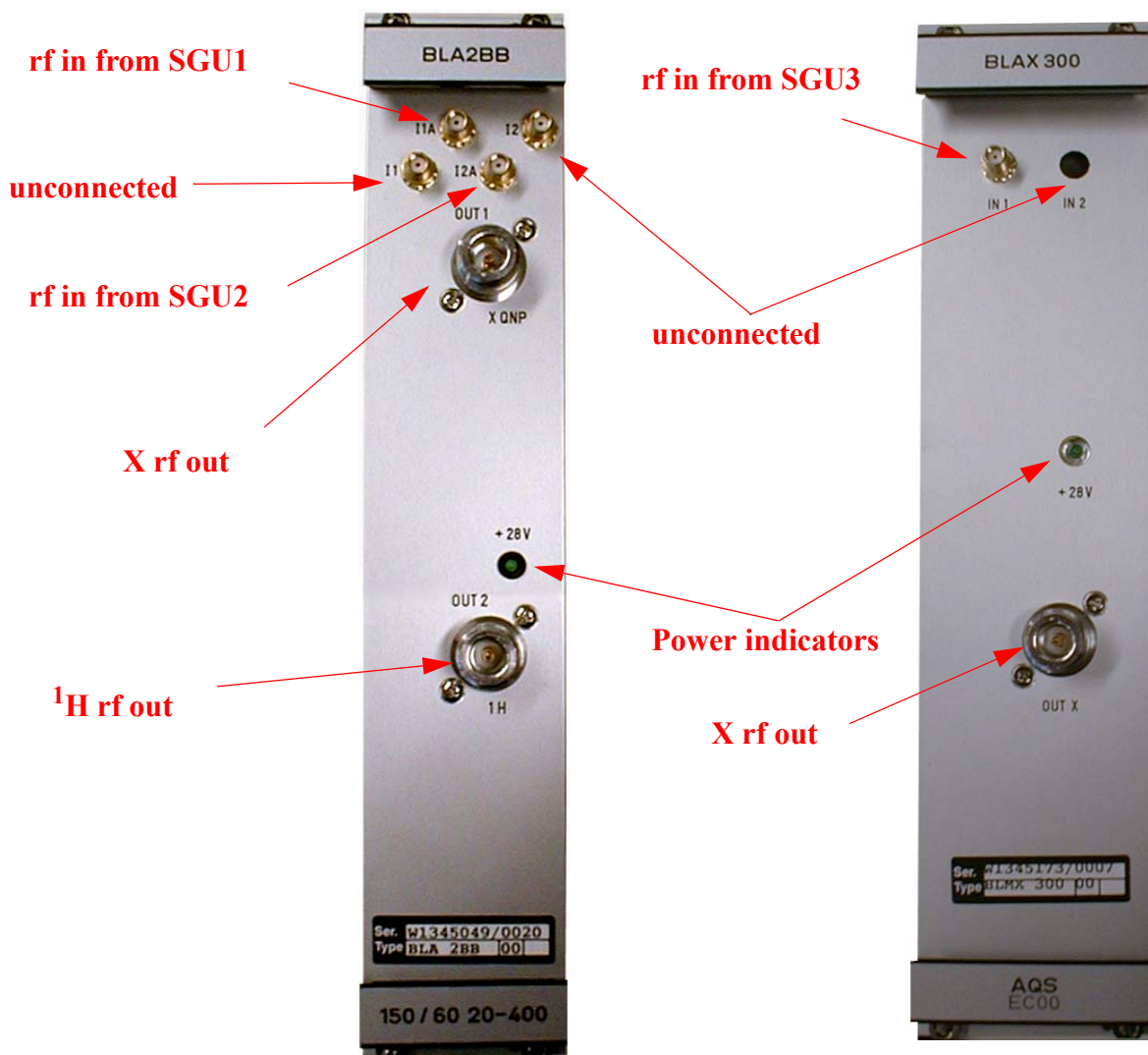
Input 1A (J9)

This is the default ^{1}H frequency input and is hardwired directly to the rf output of SGU1. The amplified signal can be connected to either the ^{1}H or the X QNP output using the minirouter. Default is the ^{1}H output, though this can be switched using the edsp / edasp menu.

Input 2A (J8)

This is the default X frequency input and is hardwired directly to the rf output of SGU2. The amplified signal can be connected to either the ^{1}H or the X QNP out-

put using the minirouter. Default is the X QNP output, though this can be switched using the edsp / edasp menu.

Input 1 (J10) and Input 2 (J7)

Both of these inputs are not connected in standard configurations. They have been provided to enable additional frequencies to be amplified . For example Input 1 could be connected to the output od SGU 3 if fitted. Input 1 is hardwired internally to the ^{1}H output and Input 2 is hardwired internally to the X QNP output . Note however that the limitation of two outputs is fixed regardless of the number of inputs.

Note: At time of writing the current edsp/edasp screens the 60W 1H output appears as 50W.

28V LED

This LED has a dual function.

1. It is an indication that the 28V voltage supply is present though does not necessarily mean the voltage is sufficient. If the voltage supply for some reason were to drop, then the LED will still light but less brightly.

2. It is an indication that the temperature sensor within the amplifier has not been overstressed. A bimetallic sensor will cause the power output to be shut down at sensor temperatures exceeding approximately 70C. When this happen the LED will go out. When the sensor has cooled down sufficiently the bimetallic strip will remake the contact and the LED will light again.

Note: In the case of the BLA2BB (dual channel) the 28V LED is effected by the the temperature sensor of the on the 1H channel only. As a consequence of that , thermal overstress of the second channel (X channel) will not switch 28V LED off.

BLAX300:   *12.4.2*

Input1:

This input is hardwired directly to the rf output of SGU3. There is no internal switching within the BLAX300 as there is a single X output.

Input2:

not connected.

28V LED:

This is identical in operation as described for the BLA2BB. As there is only a single channel then the temperature sensor is operative for this channel.

Part Numbers and Cables   12.5

Troubleshooting / Unit replacement / Tips 'n' Tricks *12.6*

1. To replace a unit simply power off the AQS, replace the unit, power on and re-boot. To check that the unit has been correctly identified you should reconfigure the spectrometer and check that the amplifier has been correctly identified in the edsp menu.

2. Although the technical manuals refer to test points they are not accessible in the field. They are designed to aid fault diagnosis at the production facility.

3. The unused RF inputs should be terminated with 50Ohm connectors(P/N 84200).

4. If the switching signals P0 and P1 are missing the amplifier will still function with the default path transmission.

5. The 1H channel may have an extra 10/12 dB attenuation to reduce the output power

Diagnostic Tests *12.7*

Not applicable

Specifications *12.8*

Table 12.2.   BLAX300 Specifications

RF SPECIFICATIONS	CHANNEL X
Frequency Range	6 to 423 MHz
Linear Gain	54 dB +/- 1 typ.
Gain Flatness	+\- 1.5 dB max.
Minimum Pulsed Output Power	300W min. (at nominal input +4dBm)
CW Output Power	30W max.
Linear Output Power	250W min. at 1dB compression
Amplifier Biasing	Class AB Operation
Blanking Delay	< 1µs typ.
RF Rise Time	< 100 ns
RF Fall Time	< 50 ns
DC Ringing	+\- 100 mV typ. (due to blanking signal)
Input Noise Figure	7 dB max.
Output Noise Power (Unblanked)	-113 dBM @ 1 Hz
Output Noise Power (Blanked)	< -164 dBm @ 1 Hz (<10 dB over Thermal Noise)
IN/OUT Impedance	50 ohms
Input V.S.W.R.	1,3 max.
Pulse Width	up to 10 ms @ 300 W
Duty Cycle	up to 10% @ 300 W
Amplitude Droop	< 6 % @ 300 W for 10 ms Pulse Width < 3 % @ 30 W for 500 ms Pulse Width

Power Supply / Fuses *12.9*

Both internal amplifiers are powered by dedicated power supplies. Note however that the 28V delivered by the power supplies is not the only voltage used by the internal amplifiers. They also use standard power voltages available on the back-plane.

Internal Amplifiers

External Amplifiers 13

Introduction 13.1

External amplifiers are distinguished from internal amplifiers in that they are not located in the AQS rack. Other general distinguishing features are that they have their own internal power supply and typically have greater output power and flexibility than the internal amplifiers.

Unlike the internal amplifiers the external amplifiers have no connection to the AQS backplane and so all signals need to be delivered at the front panel. From a service point of view this makes the external amplifiers very accessible to troubleshooting.

The principle function of the amplifiers is to amplify the RF input generated by the SGU to a level sufficient to stimulate the NMR sample. The amplifier output is a direct linear function of the input amplitude , all amplitude regulation takes place on the SGU. Blanking signals used in the amplifiers are generated by the SGU and delivered via the PSD unit.

There are very few differences between the amplifiers as configured in the AV series and amplifiers configured in the AVANCE series , the principal one being that the amplifier blanking is generated on the SGU as opposed to the TCU3. Also the original BLA controller has been replaced by a more sophisticated controller the BLAD with on-board DSP (Digital Signal Processing) see <u>***"External amplifier differences between AVANCE and AV" on page 169***</u>

Brief Summary of standard Amplifier Types 13.1.1

1. Proton amplifier

BLARH 100:

This is the standard proton amplifier with three 1H/19F RF channels .

Input **HHigh-** 100W output for RF input of 4 dBm.

Input **HLow** - Output power 50 dB lower than high power channel. This would correspond to an output of 1mW for RF input of 4 dBm.

Input **HMed** - 10W output for RF input of 4 dBm.

2. BB amplifier

BLAX300RS:

This is the standard X frequency amplifier with a single channel X frequency amplifier.

Input **Xin** - 300W output for RF input of 4 dBm.

3. Combined Proton and BB amplifier.

Two versions are available

BLAXH 300/50 and BLAXH 100/50 :

This has three RF channels, two for 1H/19F, one for X frequencies.

Input **HHigh**: - 50W output power for RF input of 4 dBm.

Input **HLow** - Output power 50 dB lower than high power channel.

Input **X** - 300W (BLAXH 300/50**) or** 100W (BLAXH 100/50) output power for RF input of 4 dBm.

A comprehensive list of available amplifiers with Part Numbers is given in _**Figure 13.1.**_. Data sheets in the Appendix give precise specifications of the various amplifiers.

Figure 13.1. Overview of Standard Amplifiers
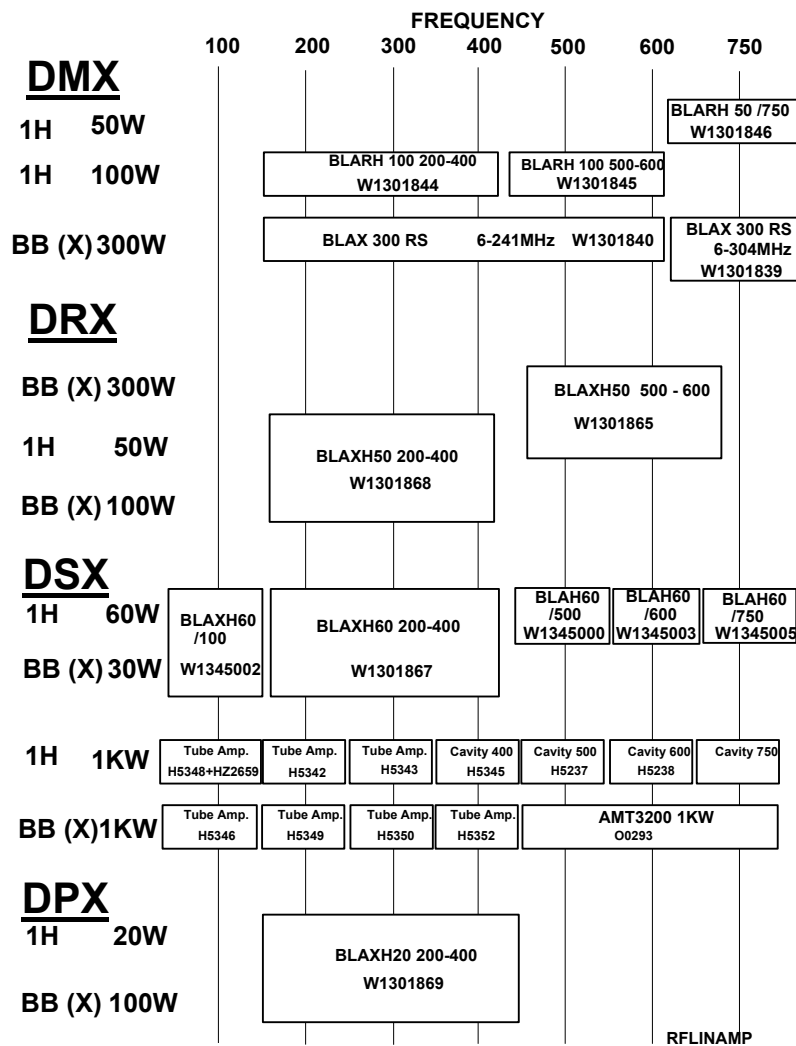
Functions/ Description   13.2

The basic function of the amplifier are

1. to amplify the RF input generated by the SGU to a level sufficient to stimulate the NMR sample

2. to provide forward and reflected power display for the BOSS keyboard or graphics monitor

3. to implement a final blanking of the signal before transmission to the HPPR

Among the features of power amplifiers are:

1. The output amplitude is a linear function of the amplitude of the RF input. Unlike early generation transmitters no power setting takes place within the amplifier itself. As such they are referred to as amplifiers and not transmitters.

2. Safety features (OVERDRIVE, PULSE WIDTH, DUTY CYCLE) which will temporarily disable the amplifier whenever output power is above a specified limit. Each amplifier has on board information stored in the RS485 Interface Board regarding amplifier type, max. Duty Cycle, max. Pulse Width etc. These parameters can be changed by software if necessary using the 'edacb' command.

3. The amplifiers are controlled by the ACB-X (Amplifier Control Board Extended) via an RS485 type link (SBSB2 / tty20 Bus). Individual amplifiers can be addressed. Hardware address codes are set via a HEX. switch located on the amplifier front panel. Read and write access to the BLAD Control board is possible via the ACB-X Board.

4. LED front panel display with diagnostic information regarding Pulse Width, Duty Cycle, Temperature etc.

5. Precise software timing control of the amplifier blanking pulses (BLKTR1..15) via the „**edscon**" table.

The input and output impedance of all linear amplifiers is 50 Ohm. The RF input for each amplifier comes directly from the router. The max. RF input amplitude is 1Vpp (4 dBm at 50 Ohm) corresponding to a software power level setting of pl = -6dB.

Amplifier Blanking   *13.2.1*

The blanking pulses (BLKTR 1... 15) are active low TTL level and generated by the SGU. They are transmitted to the PSD via the backplane and then to the amplifier via external cabling. They are easily measured at the BNC connections on the amplifier front panel. Which blanking pulse is required for which amplifier will depend upon which router output provides the RF amplifier input. . Thus an amplifier channel connected to router output RO1 will be blanked by BLKTR1. An amplifier channel connected to router output RO3 will be blanked by BLKTR3 etc. The source of an individual BLKTR signal will be the SGU on which the corresponding RF signal has been generated. This ensures coherence between the SGU blanking and the external amplifier blanking. The timing of the BLKTR[1... 15] pulses can be adjusted with the „edscon" table.

Configuration for 1 Router   *13.2.2*

The wiring of the spectrometer will depend very much upon whether 1 router (up to and including three RF channels) or two routers (four RF channels or more) are installed. _**Table 13.1.**_ lists the connections between the router outputs and a

typical arrangement of amplifiers for a single router. The sample system has two BLAX300 amplifiers (designated X and Y) as well as a BLARH100. The corresponding edsp display is shown in **_Figure 13.3._** In order for the „**edsp**" display to function properly certain requirements are necessary. Firstly the Hex Address which is set on the front panel of each amplifier must correspond to the router output to which the first amplifier input is connected. (For the BLAXH this is Xin, for the BLARH100 this is HHigh)

Table 13.1.   Hex. addresses for single Router system

Amplifier	Hex. Address	AMP Input		Router	BLKTR PULSE
BLAX 300(X):	1	Xin	connected to	Router1 RO1	BLKTR1
BLARH 100	2	HHigh	connected to	Router1 RO2	BLKTR2
		HLow	connected to	Router1 RO3	BLKTR3
		HMed	connected to	Router1 RO4	BLKTR4
BLAX 300(Y)	5	Xin	connected to	Router1 RO5	BLKTR5

Secondly auxiliary amplifier inputs must be connected in the correct order.

For example when the software detects that a BLARH100 has Hex. address of 2 then it will assume:

a) that output 2 of the router is connected to HHigh.

b) that outputs 3 and 4 of the router are connected to HLow and HMed respectively.

Configuration for 2 Routers

When 2 Routers are installed then a standard cascade arrangement is required in order for the „**edsp**" display to function properly. This involves connecting RO1 of Router 2 to RI3 of Router 1. The third RF channel is connected to RI1 of Router 2. A brief glance at **_13.4_** will show that this arrangement allows any combination of RF channels 3,4 and 5 to be routed to any output of Router1. The customer is then at liberty to connect any arrangement of amplifiers as long as the front panel Hex. addresses are numbered in sequence.

Table 13.2. lists the connections and corresponding Hex. addresses for the sample arrangement in **_Figure 13.4._**.

Figure 13.2. single router configuartion
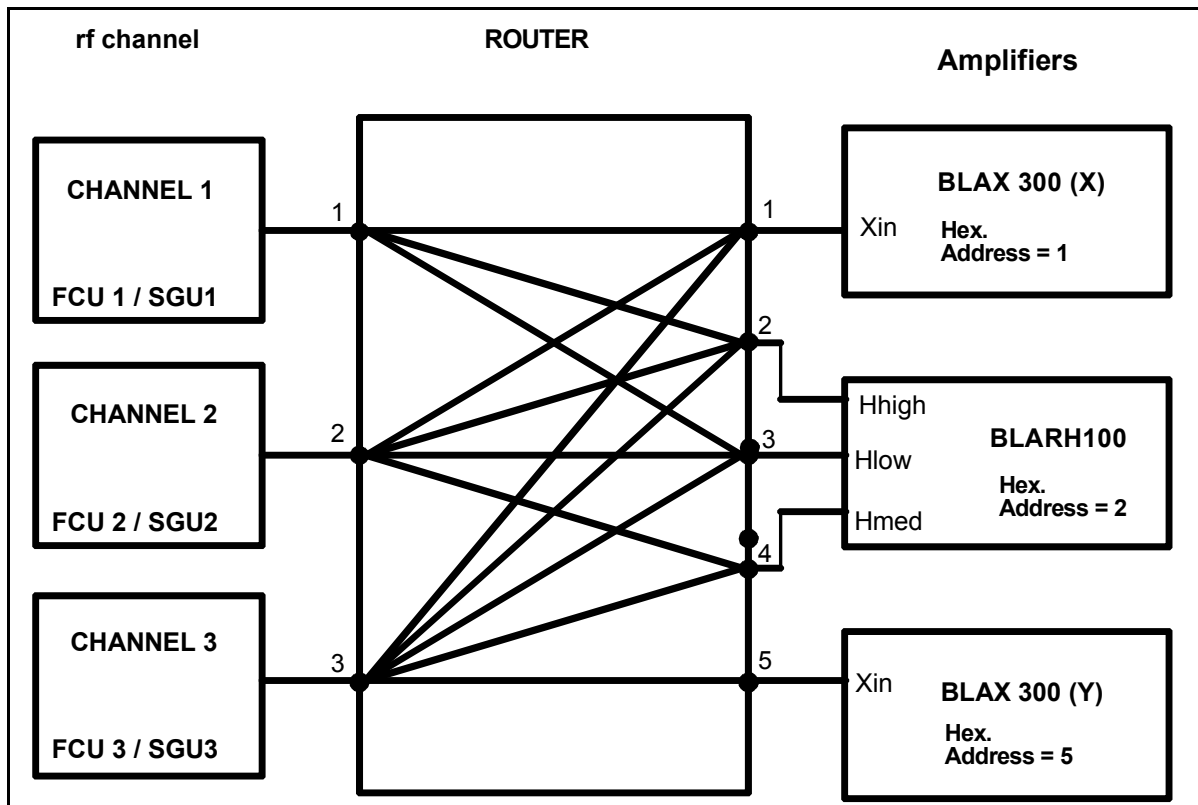
Table 13.2.   Connections and corresponding Hex Addresses for 2 Routers

Amplifier	Hex Address	AMP Input		Router	BLKTR PULSE
BLAX 300:	1	Xin	connected to	Router1 RO1	BLKTR1
BLARH 100	2	High	connected to	Router1 RO2	BLKTR2
		Low	connected to	Router1 RO3	BLKTR3
		Med	connected to	Router1 RO4	BLKTR4
BLAX 300(Y)	5	Xin	connected to	Router1 RO5	BLKTR5
BLARH 100	6	High	connected to	Router2 RO2	BLKTR6
		Low	connected to	Router2 RO3	BLKTR7
		Med	connected to	Router2 RO4	BLKTR8
BLAX 300(Z1)	9	Xin	connected to	Router2 RO5	BLKTR9

External Amplifiers

Figure 13.3. edsp display for typical single router configuartion
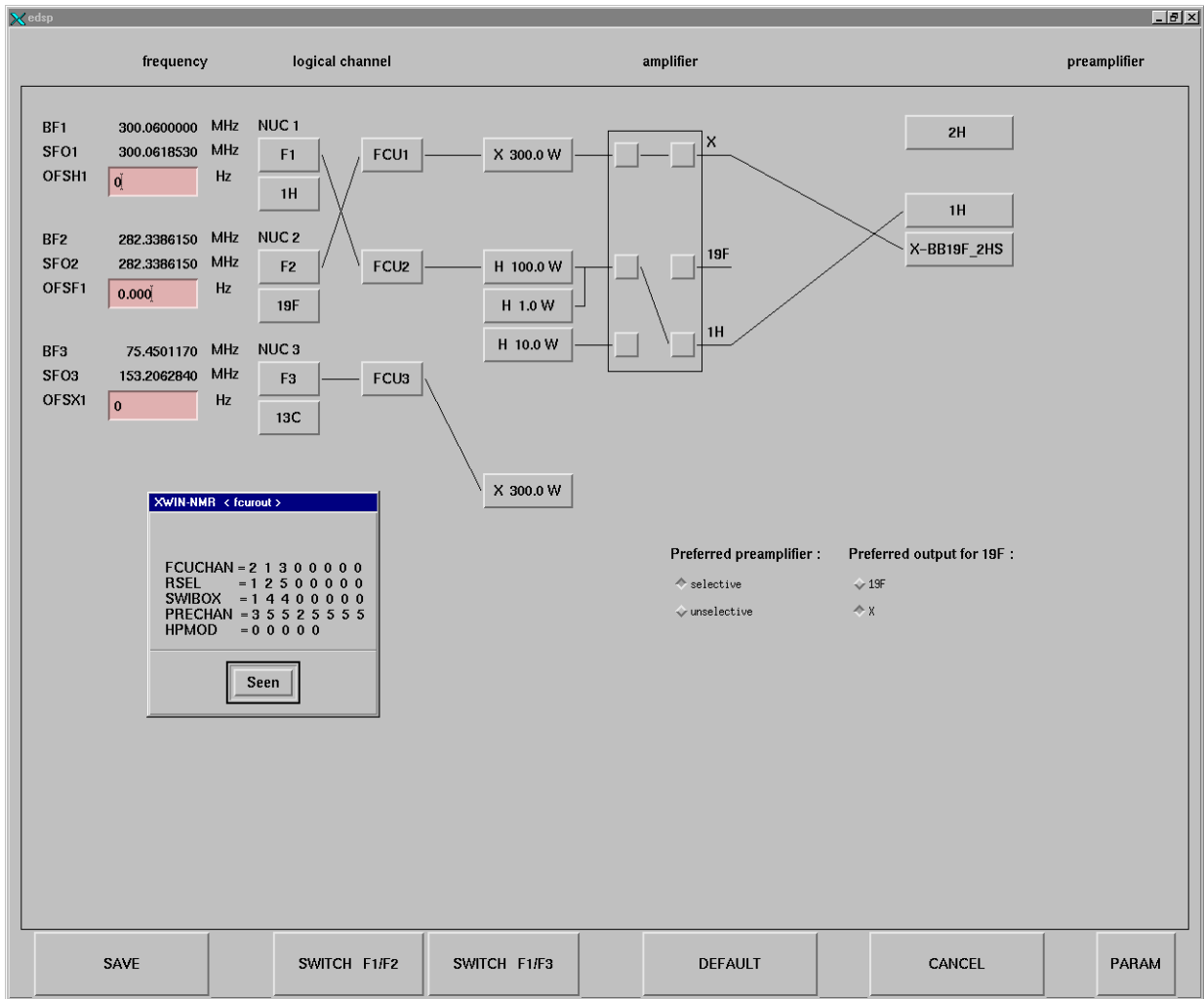
Figure 13.4. two Router configuration
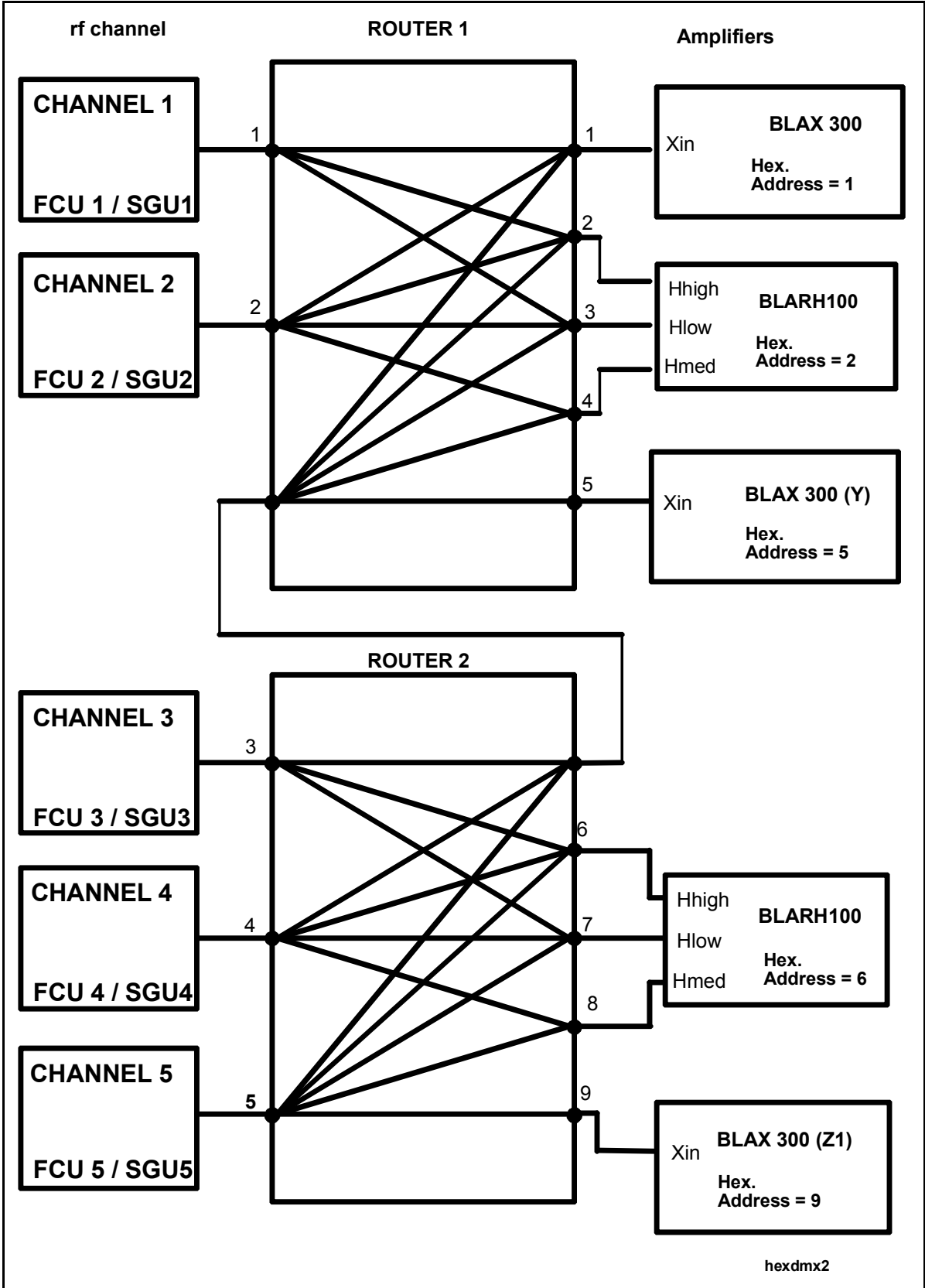
The unit has 3 separate RF inputs, HHigh, Hlow and Hmed. see ***"BLARH100 block diagram" on page 157***. For inputs of equal amplitude the HHigh channel will have an output 20 dB higher than the HLOW when measured before the directional coupler. In the directional coupler the HLOW channel is further attenuated by 30 dB. Thus the HLOW channel final output power will be 50 dB of the HHigh output for RF inputs of equal amplitude. The use of this amplifier arrangement has the advantage of expanding the overall dynamic range from a max. of 110 dB available from a single amplifier to 160 dB available from the combination see ***"Increased dynamic range using amplifier array" on page 158***. The HLOW channel is designed for applications that require long pulses with corresponding very low power.

The HMED channel option should prove particularly useful for 1H/19F decoupling experiments. ***Figure 13.7.*** and ***Figure 13.8.*** show the RF paths for OBS1H/Dec. 19F and vice versa. Note that there is no need for switching within the BLARH 100 for this type of experiment as long as the decoupling power is less than 10W.

The XBLA input is designed to be taken from the BLAX 300 output. With the aid of the internal switching different RF inputs can be easily switched to the same output. This is particularly useful if a QNP HPPR module is connected to the QNP amplifier output because 19F or X frequencies can be transmitted without any need for re cabling.

Figure 13.5. BLARH100 block diagram

External Amplifiers

Figure 13.6. Increased dynamic range using amplifier array
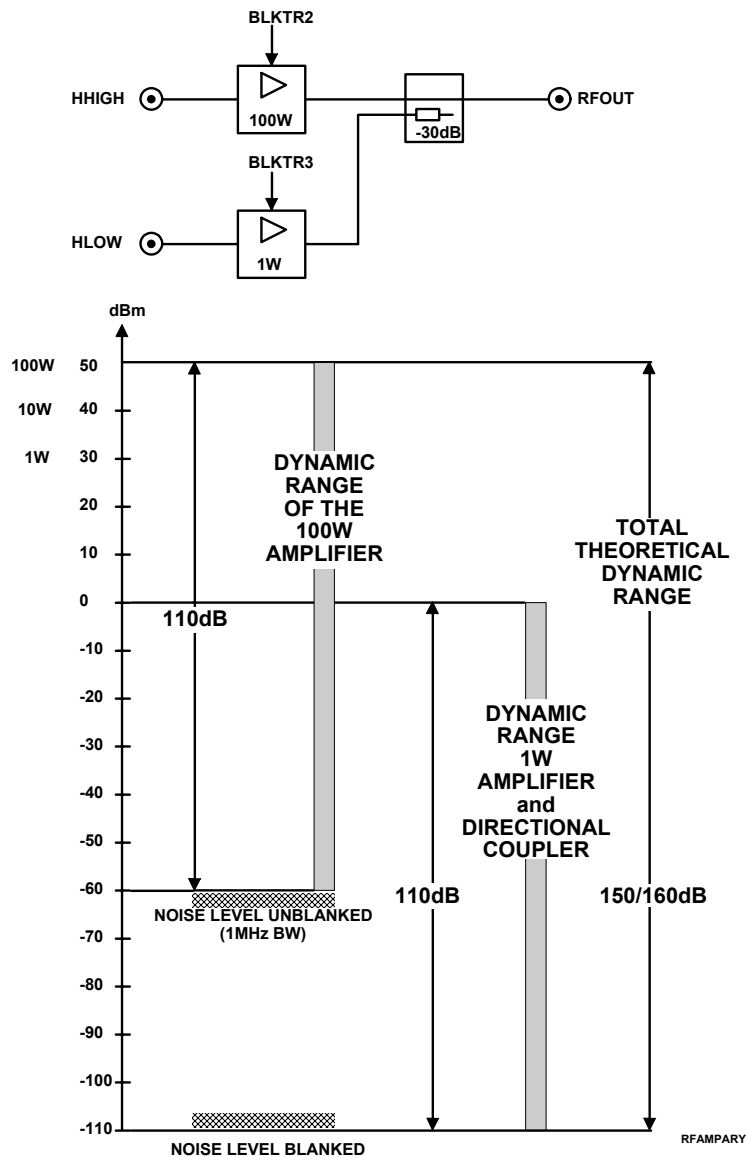
The three 1H/19F inputs and the XBLA input (from BLAX300) may be switched between the outputs 1H, 19F/Xsel and XQNP using any combination of the pin diode and relay switches. These switches are specified as having:

a) Typical Isolation of >50 dB at 600 MHz

b) Insertion Loss of < 2 dB at 600 MHz. (includes Directional Coupler)

The setting of these switches can be controlled within the „**edsp**" display using the mouse. The relevant software parameters are SWIBOX [1 - 8]

The pin diode has a switching speed of less than 10us and is controlled by the TCU produced NMRWORD3 bit 2. The rapid switching speed is required only for 19F or 1H decoupling experiments where the decoupling power is greater than 10W.

The mechanical relay has a switching speed of less than 10ms and is controlled by the TCU produced NMRWORD3 bit 3. The setting of the mechanical relay will decide whether:

> a) a 19F signal is switched to the 19F/Xsel or XQNP output

> b) the XBLA input is switched to 19F/Xsel or XQNP output

Since the switch will be set at the start of the experiment (depending on HPPR configuration) a switching speed of less than 10ms is more than adequate. ***Figure 13.5.*** shows the four possible settings of the two control words and the consequent output selection.

Figure 13.7. OBS 1H DEC 19F using 19FSEL HPPR
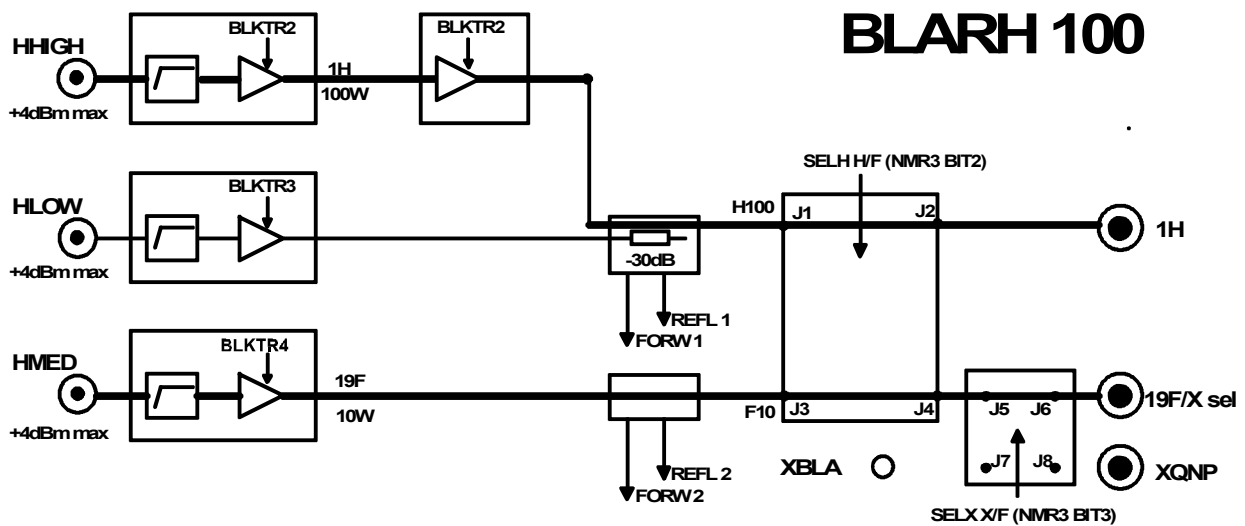
Figure 13.8. OBS 19F DEC 1H using XQNP HPPR
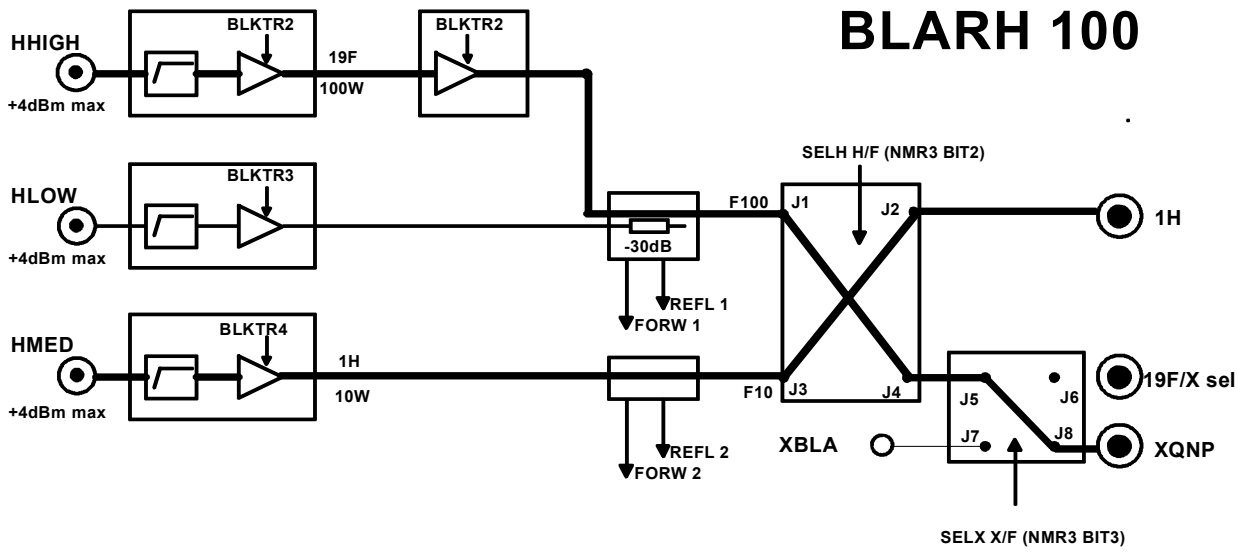
BLAXH 100/50 and BLAXH300/50 Block Diagram   13.2.5

**Figure 13.9.** is a block diagram of the BLAXH 100/50. The only difference to the BLAX300/50 is that the X output is 300W instead of 100W. The use of the HHIGH and HLOW amplifiers to expand the overall dynamic range is identical to the BLARH 100. The only difference is that 50W and 0.5W amplifiers are used instead of 100W and 1W. As with the BLARH100, the output of the HLOW channel will always be 50dB less than the HHIGH output for the same RF input amplitude. The X in input comes directly from the router whereas in the BLARH100 it can be taken from the output of the BLAX300.

BLAXH 100/50 and BLAXH300/50 Output Switches: 13.2.6

The two 1H/19F inputs (HHIGH and HLOW) and the X in input may be switched between the outputs 1H, 19F/Xsel and XQNP using any combination of the pin diode and relay switches.

These switches are specified as having

a)   Typical Isolation of >50 dB at 600 MHz

b)   Insertion Loss of < 2 dB at 600 MHz.(includes Directional Coupler)

The setting of these switches can be controlled within the 'edsp' display. The relevant software parameters are SWIBOX [1 - 8] .

The pin diode has a switching speed of less than 10us and is controlled by the TCU3 produced NMRWord3 bit 2. The rapid switching speed will be required for 19F/1H decoupling experiments where the RF signal is switched between the 1H and either of the other two outputs. Note that it is not possible to transmit 19F and 1H simultaneously.

The mechanical relay has a switching speed of less than 10 ms and is controlled by the TCU produced NMRWord3 bit 3 .

The setting of this mechanical relay will decide whether

a.   a 19F signal is switched to 19F/Xsel or XQNP output

b.   the Xin input is switched to 19F/Xsel or XQNP output

Since the switch will be set at the start of the experiment (depending on HPPR configuration) a switching speed of 10 ms is more than adequate.

**Figure 13.9.** shows the four possible settings of the two control words and the consequent output selection.

Figure 13.9. BLAXH100/50 block diagram

SELX X/F	SELH H/F	XQNP	Output 19F	1H
0 (0V)	0	F50	X100	
0	1		X100	H50
1 (5V)	0	X100	F50	
1	1	X100		H50
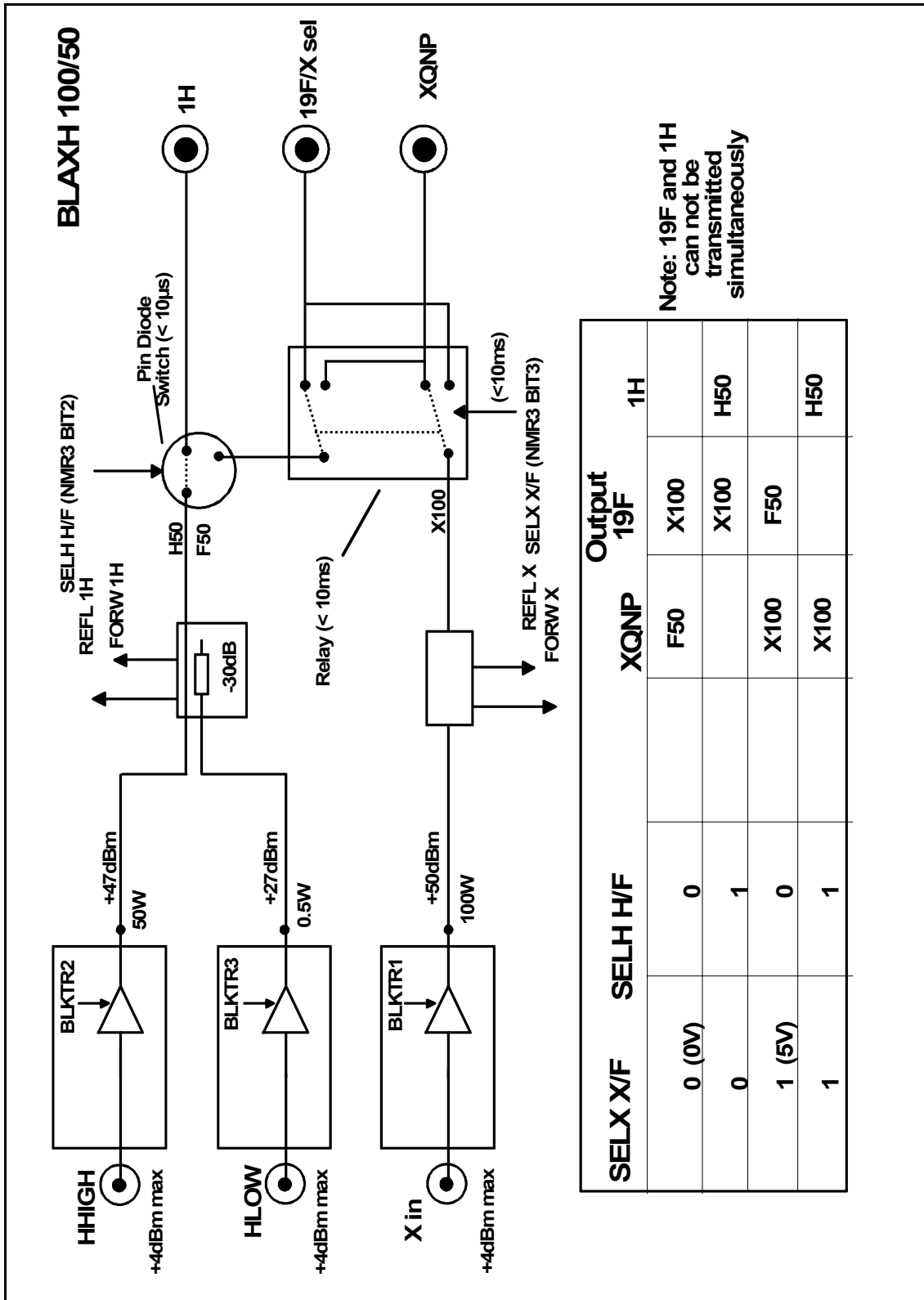
Note: 19F and 1H can not be transmitted simultaneously

Figure 13.10.Observe1H and decouple 19F with the BLAXH100/50
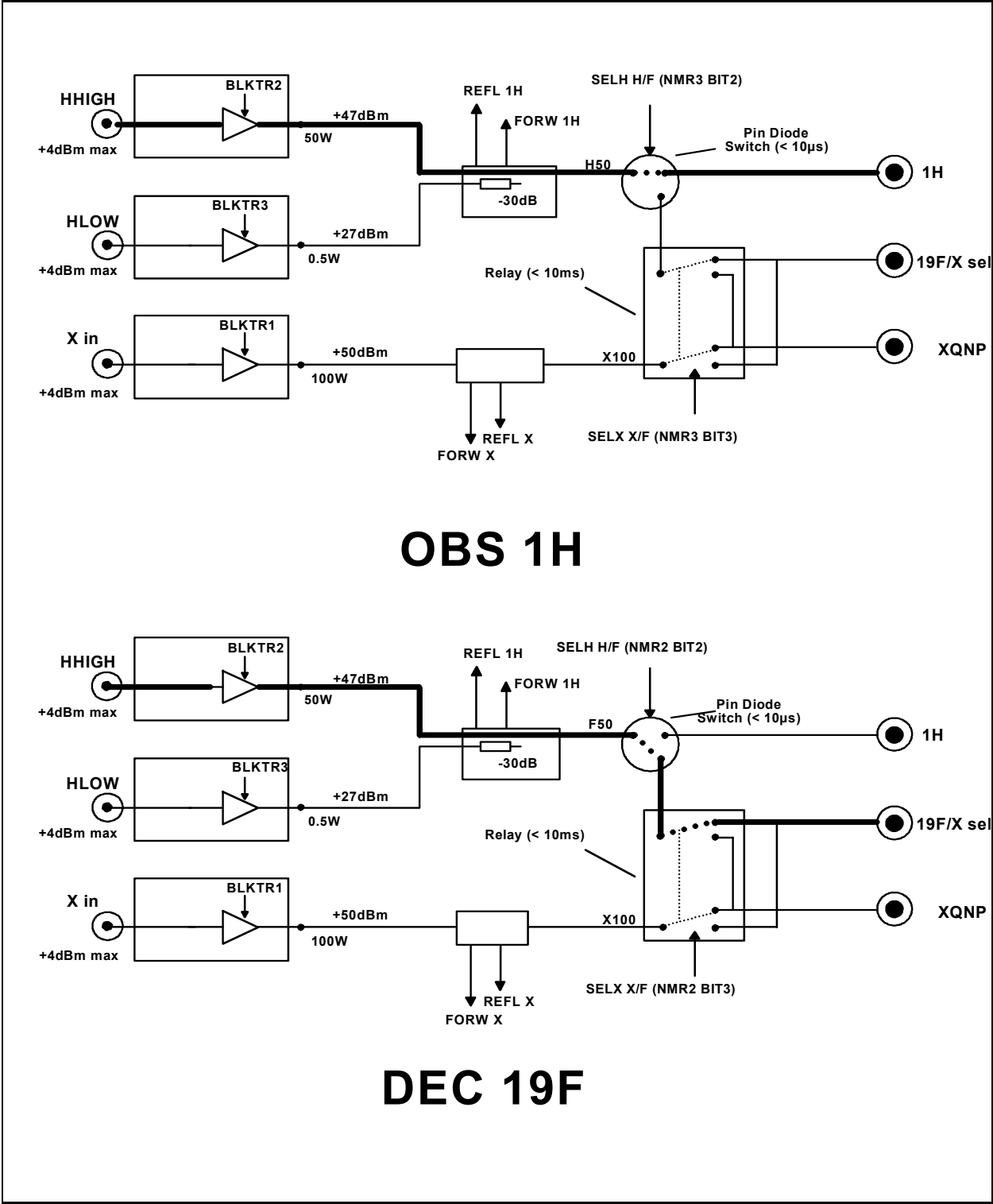
OBS 1H

DEC 19F

The original BLA controller has been replaced by a more sophisticated controller the BLAD with on-board DSP (Digital Signal Processing). Directional couplers at the amplifier output enable the forward and reflected power to be sampled every 100ns . On board DSP is then used to analyze the forward and reflected power and so control various functions such as Duty Cycle/ Pulse width limitation etc.

A saw tooth signal is used to measure the pulse width. This is then combined with the transmitted power as detected by the directional coupler. If the product of the power and pulse width exceeds specified limits then the PULSE WIDTH function will be activated and the amplifier temporarily disabled. The maximum allowed pulse width is inversely proportional to the transmitted power.

e.g. the BLAX300 is specified as having a maximum pulse width of 20ms at 300W. At 200W the max. allowed pulse width is 30ms, at 100W 60ms etc. until at 30W the power is deemed low enough to allow cw operation.

The DUTY CYCLE function operates as follows. The extent to which a capacitor is charged can be taken as a measure of the duty cycle. This is then combined with the transmitted power as detected by the directional coupler. If the product of the power and duty cycle exceeds specified limits then the DUTY CYCLE function will be activated and the amplifier temporarily disabled. The maximum allowed duty cycle is inversely proportional to the transmitted power.

e.g. the BLAX300 is specified as having a maximum duty cycle of 10% at 300W. At 200W the max. allowed duty cycle is 15%, at 100W 30% etc. until at 30W the power is deemed low enough to allow 100% duty cycle i.e. cw.

With the capabilities of the new BLAD Control Board , CW LIMITATION and MULTIPULSE ON functions are no longer necessary

Figure 13.11.amplifier front panel

Front Panel Display 13.3
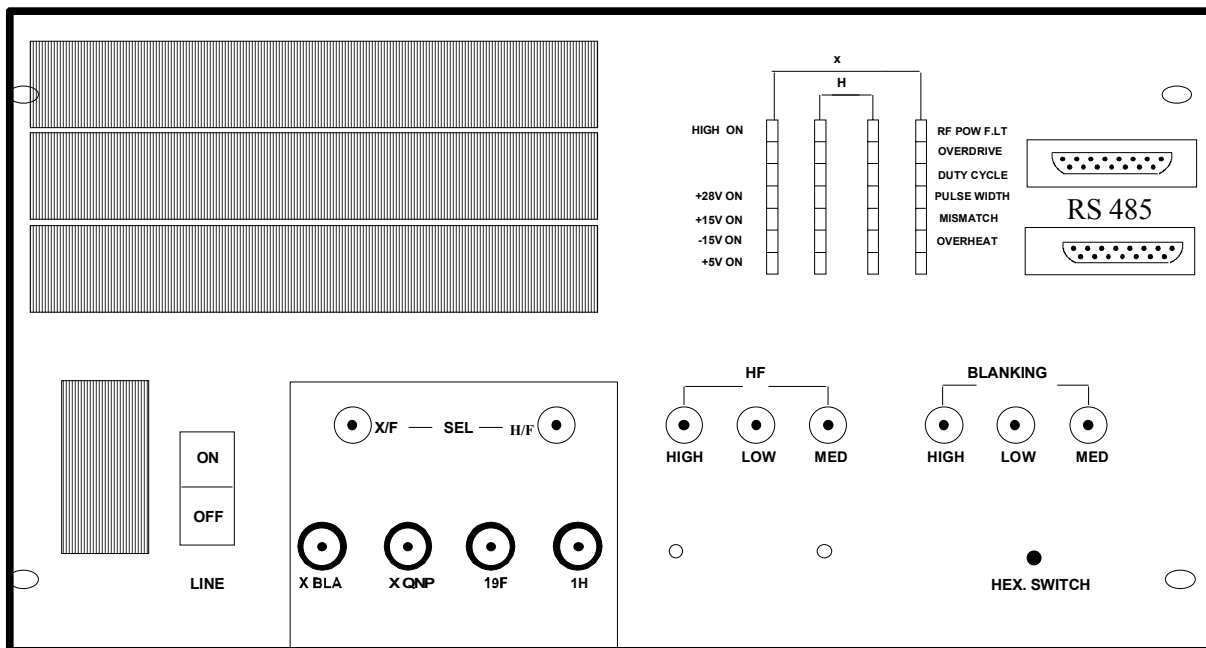
Although the front panels of the various amplifiers differ slightly they are sufficiently similar to enable a general description to be given. The font panel has the following connections

RF inputs:

There will be one SMA type RF input (labelled 'HF' for each amplifier channel. Max input amplitude of 4dBm ($1V_{pp}$).

blanking inputs:

These are TTL active low blanking signals generated by the SGU and delivered via the PSD unit. The signals go low for the the period of the pulse. The timing can be modified using the 'edscon' menu.

Sel signals:

These are generated by the TCU3 (TTL active low)and responsible for selecting the final output to the HPPR. see *"BLARH 100 Output Switches" on page 158* and *"BLAXH 100/50 and BLAXH300/50 Output Switches:" on page 161*.

hex switch:

Each amplifier housing must have a unique RS485 address to enable the software control the amplifiers.

RS485 ports: These are the SBSB2 / tty20 connections with the CCU10. Two ports are available to support a daisy-chained between up to 16 amplifiers. The last amplifier in the chain should be terminated with the appropriate connector .On earlier amplifier housings only a single port was available and the in and out connectors had to be piggybacked onto each other.

RF output to HPPR:

N type connector transmitting amplified RF signal to the HPPR.

Reset button:

This is located on the amplifier front panel near the Hex. switch . With a reset all parameters such as Duty Cycle, Max. Pulse Width etc. are reset to the default value set in the factory.

LED display:

the various LEDs are described below. Many of the features are to protect the amplifier or NMR sample from too much power and consequently apply to the high power channel only.

HIGH ON:

RF pulses whose power level is within approximately 20-30dB of the max output be that 300 , 100 or 50W will cause this LED to light. Any power levels below this will still be transmitted but will not light the LED. Note that this is a real measurement of the RF made at the directional coupler and is not merely activated by the presence of a blanking pulse.

OVERDRIVE:

This LED will light whenever the output power of the high power channel exceeds the specified cut out level. The default cut out level is twice the nominal output power. A cut out might be caused when the input RF was somehow greater than

1Vpp. The amplifier would then be temporarily disabled for 1 - 4s. After this period has elapsed the amplifier will be automatically re-enabled. Further detection of excessive output power will disable the amplifier for a further 1 - 4s. This process will continue until the cause of the overdrive is removed. The specified cut out level may be adjusted within the range of [0.5 - 2] x [Nominal Output Power]. e.g. the specified cut out level for a BLAX300 can be varied between 150W and the default value of 600W.

D.C. (*DUTY CYCLE):*

This LED will light if the specified max. Duty Cycle of the amplifier is exceeded. The amplifier itself will be temporarily disabled as described in the section OVERDRIVE above. The Duty Cycle function is active for the high power output only.

PW (PULSE WIDTH):

This LED will light if the max. specified pulse width of the particular amplifier is exceeded. The amplifier itself will be temporarily disabled as described in the section OVERDRIVE above. The Pulse Width function is active for the high power output only.

MISMATCH:

This LED will light whenever the reflected power is above a specified level. This level corresponds at maximum power to a VSWR (Voltage Wave Standing Ratio) of 6 which corresponds to 50% reflection of forward power. The MISMATCH function is active for the high power output only.

OVERHEAT:

A temperature sensor located within the amplifier monitors the temperature. Should the temperature rise above specified limits (non-adjustable) then the amplifier will automatically be disabled. The amplifier will remain disabled until the temperature has dropped sufficiently whereupon it will be automatically re-enabled.

RF POWER FAULT:

This is a general diagnostic LED which lights whenever any other LEDs in the same display column (with the exception of 'overheat') light.

Voltage LEDs:

These LEDs will light whenever the power voltage lies within a specified range (typically + 10%) of the nominal value. The amplifier controller board checks the voltage level and if within the range sends a "power good" signal to light the LED

RS485 I n t e r f a c e   B o a r d   13.3.1

General Description   13.3.2

Each of the new range of Bruker Linear Amplifiers is fitted with a single RS485 Interface Board. This board interfaces between the ACB-X and the BLA Controller Board(s) of the amplifier. The same board is used for all linear amplifier units regardless of type or frequency.

Note however that for BLAXH amplifiers the board is fitted with an additional piggyback board to cater for the second BLA Controller Board.

Functions:

1. To digitize the Forward, Reflected and Blanking signals received from the BLA Controller Board and transmit them to the ACB. From here they are either displayed on the Boss Keyboard or the graphics monitor.

2. To provide read/write access to amplifier parameters such as Pulse Width Limitation, Max. Duty Cycle, FORW and REFL power.

3. To enable new application software to be downloaded.

4. Storage of data regarding number of amplifiers and amplifier type.

The RS485 link operates at a fixed baud rate of 62500. The RS485 data transmission uses the SBSB standard of 8 bits data with 1 start bit and 1 stop bit.

RS485 Pinouts   13.3.3

15 Pin SUB miniature connectors are used. The ACB-X is female, all slaves (amplifiers) are male.

Figure 13.12.RS485 Pinouts
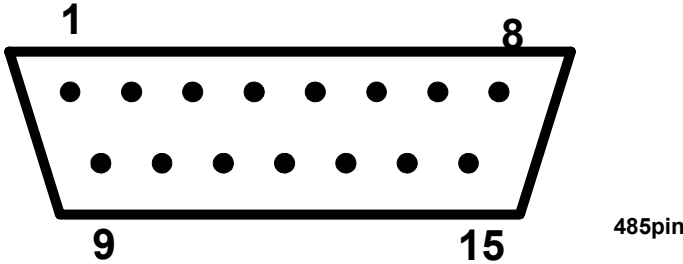
Table 13.3.   RS485 Pinouts

Pin	Function	Type at Master	Type at Slave
1	Shield	PASSIVE	PASSIVE
2	RxD+	INPUT	OUTPUT
3	/WUP	OUTPUT	INPUT
4	TXD+	OUTPUT	INPUT
5	—	—	—
6	GND	POWER	POWER
7	GND	POWER	POWER
8	GND	POWER	POWER

External Amplifiers

Table 13.3.   RS485 Pinouts

Pin	Function	Type at Master	Type at Slave
9	RXD-	INPUT	OUTPUT
10	—	—	—
11	TXD-	OUTPUT	INPUT
12	—	—	—
13	VRS	POWER	POWER
14	VRS	POWER	POWER
15	VRS	POWER	POWER

RS485 signals   *13.3.4*

TXD+, TXD-:

TXD+ and TXD- form a twisted pair. The RS485 link uses differential transmission lines. These transmission lines can be driven only by the master (ACB). Because the slaves (amplifiers) cannot drive these lines (they can only receive) a bus conflict is avoided

RXD+, RXD-:

RXD+ and RXD- form a twisted pair. The receive lines are also differential. The slaves use these lines to transmit data. The master cannot drive these lines, it can only receive. A bus conflict caused by more than one slave attempting to transmit is prevented by software.

Note: Slave to slave data transmission is not allowed!

WUP:

This is a Bruker specific RS485 compatible signal. To avoid interference the software can switch off some slaves <u>during</u> acquisition (sleep mode). To restart the slaves outside of acquisition the WUP signal is used to carry out a hardware reset on the slaves. The WUP is active low and driven by the master only.

VRS:

Power supply of 12 V. This is provided by the ACB

Termination:

The RS485 bus must be terminated correctly. A special connector is provided (P/N H5167)

Unit Configuration / Version / Jumpers   *13.4*

Any jumpers are set at the factory and should not require adjustment in the field. Configuration is automatic as long as the hex. addresses are correct. During the

'cf' routine the ACB-X unit uses the RS485 link to establish the type of amplifiers present as this information is stored on the BLA controller board. From here the tty20/SBSB2 link with the CCU10 enables the 'edsp' display to be set correctly.

Differences from previous versions. 13.4.1

Table 13.4.   External amplifier differences between AVANCE and AV

AV	AVANCE
RF input from SGU / Router	RF input from ASU / Router
blanking signals from SGU / PSD	blanking signals from TCU
power display/ amplifier parameter control via the ACB-X	power display/ amplifier parameter control via the ACB
new advanced BLAD controller	standard BLA controller
two RS485 connectors on front panel	single RS485 connector on front panel

Part Numbers and Cables 13.5

For part numbers refer to *"Overview of Standard Amplifiers" on page 150*

Troubleshooting / Unit replacement 13.6

The amplifiers are relatively easy to test in that they require RF input and blanking signals to operate.

A blanking signal can always be generated by explicitly programming a spare TCU output see *"TCU3 control via explicit pulse programming." on page 58*. Remember that these signals are active low.

Any source of RF input can be supplied but be careful not to use cw of too high an amplitude. There are plenty of 1Vpp RF sources in the spectrometer and you can use this RF as long as it has been attenuated by at least 50 dB before inputting it into the amplifier.

Diagnostic Tests 13.7

na

External Amplifiers

Specifications 13.8

A full explanation of the amplifier specifications as well as data on the BLARH100 and the BLAX 300RS are at the end of this chapter.

Power Supply / Fuses 13.9

The external amplifiers generate their power supply from the mains voltage and front panel LEDs display the presence of the required voltages see ***"Front Panel Display" on page 165***.

Amplifier Specifications 13.10

A comprehensive list of specifications is now available for all Bruker linear amplifiers. This section describes how these specifications are defined. Example figures quoted here refer to the specifications of the BLAX 300RS which are contained at the end of this chapter

FREQUENCY RANGE:

A measure of the frequency range over which the amplifier is designed to be used. RF signals at frequencies outside this range may have significantly reduced gain.

GAIN FLATNESS

The amplifier gain will be somewhat dependent on the absolute frequency. The GAIN FLATNESS is quoted for the specified frequency range. e.g. for the BLAX 300RS the gain is specified not to vary by more than 1.5 dB for any frequency within the 6 - 241 MHz range.

LINEAR GAIN:

This is measured well within the linear region of the amplifier, typically at 10 dB below max. output. The linear gain will differ from the gain at the specified max. output. For the BLAX 300RS an input of 1Vpp (4 dBm) will produce an output of 300W (55 dBm) i.e. gain = 51 dB.

A brief glance at figure 11.17 should show however that the gain within the linear region will be greater (in the case of the BLAX300 54 dB).

Figure 13.13.Linear Gain for BLAX300 (not to scale)

Output

GAIN at max output = 51 dB

LINEAR GAIN = 54 dB

Input

gain
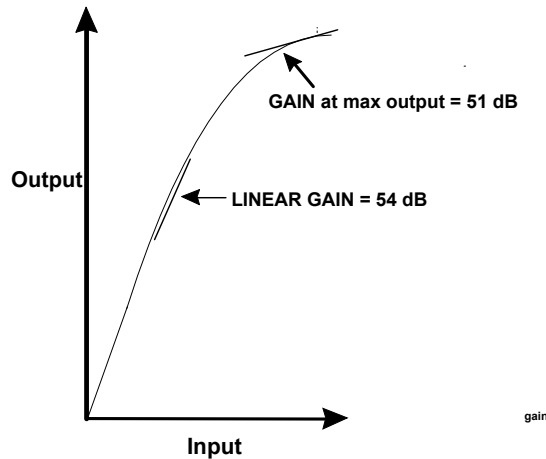
CW OUTPUT POWER:

The BLA Control Board limits the maximum allowed output power in CW mode to the specified value.

LINEAR OUTPUT POWER:

At high output powers the linearity of the amplifier will suffer. The amplifier is defined as linear up to the power level where the actual output deviates from the perfectly linear output by 1 dB. This level is referred to as the 1 dB compression point (see figure 11.18)

Figure 13.14.Linear Output Power (not to scale)

Perfectly Linear Response

Actual Response

1 dB

Output

Linear Output Power

Input
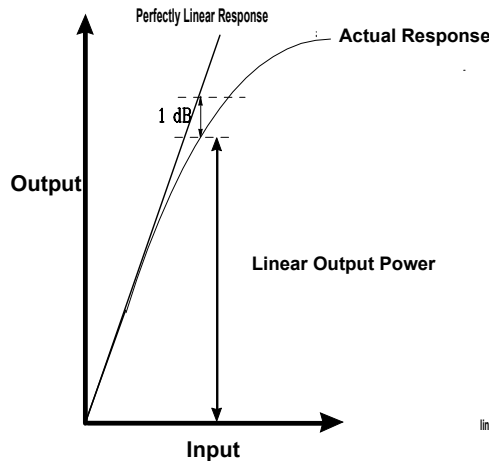
linear

AMPLIFIER BIASING:

All Bruker linear amplifiers are class AB.

BLANKING DELAY:

The blanking within the amplifier is implemented using MOSFET's. These transistors have a certain response time and should ideally be activated prior to the arriv-

al of the RF signal. The blanking delay is the time which should be allowed to ensure that the MOSFET's are correctly biased to allow RF transmission.

RF RISE TIME

The time taken for an RF pulse to rise from 10% to 90% of its final voltage.

RF FALL TIME:

The time taken for an RF pulse to fall from 90% to 10% of its final voltage.

D C RINGING

This is a consequence of the sharp rise and fall of the blanking pulses (BLKTR1 - 15) applied within the amplifier. The ringing will occur at the start and end of the blanking pulse and may last several µseconds. The ringing is independent of the RF power.

INPUT NOISE FIGURE:

If the amplifier were perfect then noise and signal would both be amplified by the same factor i.e. the Gain 'G'. In reality the amplifier will add it's own noise to the output and the output noise will be greater than Nt x G where 'Nt' is the thermal noise at the input. The output noise can be represented by Nt x(G + F) where G is the Gain and F the Noise Figure in dB.

OUTPUT NOISE POWER (UNBLANKED)

The thermal noise at 300K has a power level of - 174 dBm measured over a bandwidth of 1Hz. Add to this the 7 dB Noise Figure along with the 54 dB LINEAR GAIN to yield an output noise power of - 113 dBm/Hz.

OUTPUT NOISE POWER:(BLANKED)

The blanking will remove the amplification of the final stage of the amplifier as well as the 1W driver amplifier. There will still inevitably be some crosstalk between the first two amplifier stages which in the BLAX 300RS has a net effect of 20 dB amplification of the thermal noise when blanked.

INPUT V.S.W.R.

A measure of the Voltage Standing Wave Ratio which can be used to quantify the ratio of the forward power to reflected power. The typical max. value of 1.3 represents a reflection factor of 13%.

OUTPUT HARMONICS:

RF power amplifiers may produce harmonics of the amplified frequency. Harmonic levels at the output of the BLAX 300RS are specified to be at least 20 dB below the carrier amplitude. Note: The 'c' in dBc refers to the carrier power which is 300W.

AMPLITUDE DROOP:

The output of any amplifier may decrease over the duration of a long pulse as a result of fluctuations in the power supply, input and output impedances, operating point etc. The droop is defined in terms of the percent drop in amplitude compared to an ideally stable output.

Figure 13.15.Amplitude Droop
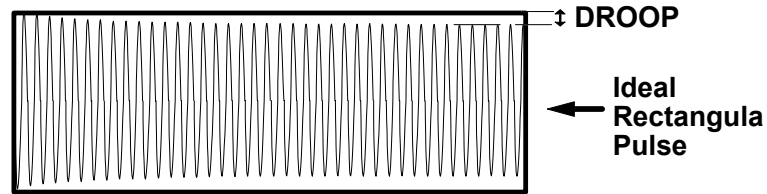
Table 13.5.   RF Pulsed Amplifier BLARH 100 200-400 MHz

RF Pulsed Amplifier BLARH 100 200-400 MHz W1301844 ECL02		
RF Specifications	Channel HHigh	Channel HMed
Frequency range	180 to 400 MHz (3H on request)	180 to 400 MHz
Linear Gain	48 dB +/- 1	38 dB +/- 1
Gain Flatness	+/- 1,5 dB max.	+/- 1 dB max.
Minimum Pulsed Output Power	100 W typ. (at nominal input + 4 dBm)	8 W typ. (at nominal input + 4 dBm)
CW Output Power	25 W max. (internal limitation)	No limitation
Linear Output Power	60 W min. at 1 dBm compression	5 W min. at 1 dBm compression
Amplifier Biasing	Class AB Operation	Class AB Operation
Blanking Delay	< 1 µs typ.	< 1 µs typ.
RF Rise Time	< 100 ns	< 100 ns
RF Fall Time	< 50 ns	< 50 ns
DC Ringing	200 mV typ. (due to blanking signal)	200 mV typ. (due to blanking signal)
Input Noise Figure	7 dB max.	7 dB max.
Output Noise Power (Unblanked)	- 119 dBm @ 1 Hz	- 129 dBm @ 1 Hz
Output Noise Power (Blanked)	- 174 dBm @ 1 Hz (thermal Noise)	- 174 dBm @ 1 Hz (Thermal Noise)
IN/OUT Impedance	50 ohms	50 ohms
Input V.S.W.R.	1,5 max.	1,5 max.
Output Harmonics	30 dBc min. at 100 W (full range)	30 dBc min. (full range)
Pulse Width (int. limitation)	500 ms @ 100 W (up to CW at 25 W)	No limitation
Duty Cycle (int. limitation)	25 % @ 100 W (up to 100 % at 25 W)	No limitation
Amplitude Droop	< 4 % @ 100 W for 100 ms Pulse Width < 3 % @ 50 W for 100 ms Pulse Width	< 4 % @ 10 W for 500 ms Pulse Width

External Amplifiers

Table 13.6.   RF Pulsed Amplifier BLARH 100 500-600 MHz

RF Pulsed Amplifier BLARH 100 500-600 MHz W1301845 ECL02			
RF Specifications	Channel HHigh	Channel HMed	
Frequency range	470 to 600 MHz (3H on request)	470 to 600 MHz (3H on request)	
Linear Gain	48dB +/- 1	38 dB +/- 1	
Gain Flatness	+/- 1,5 dB max.	+/- 1 dB max	
Minimum Pulsed Output Power	100 W typ. (at nominal input + 4 dBm)	8 W min.	
CW Output Power	25 W max. (internal limitation)	no limitation	
Linear Output Power	60 W min. at 1 dBm compression	5 W min. at 1 dBm compression	
Amplifier Biasing	Class AB Operation	Class AB Operation	
Blanking Delay	< 1 µs typ.	< 1 µs typ.	
RF Rise Time	< 100 ns	< 100 ns	
RF Fall Time	< 50 ns	< 50 ns	
DC Ringing	200 mV typ. (due to blanking signal)	200 mv typ. (due to blanking signal)	
Input Noise Figure	7 dB max.	7 dB max.	
Output Noise Power (Unblanked)	- 119 dBm @ 1 Hz	- 129 dBm @ 1 Hz	
Output Noise Power (Blanked)	- 174 dBm @ 1 Hz (Thermal Noise)	- 174 dBm @ 1 Hz (Thermal Noise)	
IN/OUT Impedance	50 ohms	50 ohms	
Input V.S.W.R.	1,5 max.	1,5 max.	
Output Harmonics	40 dBc min. at 100 W (full range)	30 dBc min. (full range)	
Pulse Width (int. limitation)	500 ms @ 100 W (up to CW at 25 W)	no limitation	
Duty Cycle (int. limitation)	25 % @ 100 W (up to 100 % at 25 W)	no limitation	
Amplitude Droop	< 6 % @ 100 W for 100 ms Pulse Width < 3 % @ 50 W for 100 ms Pulse Width	< 4 % @ 10 W for 500 ms Pulse Width	

Table 13.7.   RF Pulsed Amplifier BLAX300 RS 6-243 MHz

RF Pulsed Amplifier BLAX 300 RS 6-243 MHz W1301840 ECL 02	
RF Specifications	Channel X
Frequency range	6 to 243 MHz
Linear Gain	54 dB +/- 1
Gain Flatness	+/- 1,5 dB max.
Minimum Pulsed Output Power	300 W typ. (at nominal input + 4 dBm)
CW Output Power	30 W max. (internal limitation)
Linear Output Power	250 W min. at 1 dBm compression
Amplifier Biasing	Class AB Operation
Blanking Delay	< 1 µs typ.
RF Rise Time	< 100 ns
RF Fall Time	< 50 ns
DC Ringing	100 mV typ. (due to blanking signal)
Input Noise Figure	7 dB max.
Output Noise Power (Unblanked)	- 113 dBm @ 1 Hz
Output Noise Power (Blanked)	- 154 dBm @ 1 Hz (< 20 dB over Thermal)
IN/OUT Impedance	50 ohms
Input V.S.W.R.	1,3 max.
Output Harmonics	20 dBc (70 to 243 MHz) at 300 W
Pulse Width (int. limitation)	20 ms @ 300 W (up to CW at 30 W)
Duty Cycle (int. limitation)	10 % @ 300 W (up to 100 % at 30 W)
Amplitude Droop	< 6 % @ 300 W for 20 ms Pulse Width

External Amplifiers

Table 13.8.   RF Pulsed Amplifier BLAX 300 RS 6-304 MHz

RF Pulsed Amplifier BLAx 300 RS 6-304 MHz W1301839 ECL 01	
RF Specifications	Channel X
Frequency range	6 to 304 MHz
Linear Gain	54 dB +/- 1
Gain Flatness	+/- 1,5 dB max.
Minimum Pulsed Output Power	300 W typ. (at nominal input + 4 dBm)
CW Output Power	30 W max. (internal limitation)
Linear Output Power	200 W min. at 1 dBm compression
Amplifier Biasing	Class AB Operation
Blanking Delay	< 1 µs typ.
RF Rise Time	< 100 ns
RF Fall Time	< 50 ns
DC Ringing	100 mV typ. (due to blanking signal)
Input Noise Figure	7 dB max.
Output Noise Power (Unblanked)	- 113 dBm @ 1 Hz
Output Noise Power (Blanked)	- 154 dBm @ 1 Hz (< 20 dB over Thermal)
IN/OUT Impedance	50 ohms
Input V.S.W.R.	1,3 max.
Output Harmonics	20 dBc (70 to 304 MHz) at 300 W
Pulse Width (int. limitation)	20 ms @ 300 W (up to CW at 30 W)
Duty Cycle (int. limitation)	10 % @ 300 W (up to 100 % at 30 W)
Amplitude Droop	< 6 % @ 300 W for 20 ms Pulse Width

Figures

Figures

Figures

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Block Diagram 2 CHANNEL AVANCE

Block Diagram 4 CHANNEL AVANCE