AVANCE

Service Manual

Version 002

BRUKER

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P/N: Z31245
DWG-Nr: 915002

Contents

Introduction 1

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

It is hoped that after reading this manual service engineers will be able to effectively troubleshoot an AVANCE 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 input and outputs.

Copies of this manual entitled "AVANCE Service Manual" are available from SAG (P/N Z31245, DWG-No. 915002)

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RF Paths 2

Introduction 2.1

Tracing the rf paths is very often the first step in troubleshooting an instrument. Therefore before discussing the individual components of AVANCE spectrometers in detail, it may prove useful to give a brief introductory overview of the rf paths and corresponding blanking/gating signals. For simplicity a relatively simple example of a two channel experiment will be used. All of the signals discussed in the following sections are accessible and easy to measure.

RF paths in a DMX 2.2

Regardless of NUCLEUS or final frequency every rf channel begins with a 1Vpp 3-4 MHz cw signal from the appropriate FCU (DDS out). Bit settings from the FCU (Connector F2) are then used to produce a PTS output frequency of SF01/02 ± 440 MHz. This cw signal is then transmitted to the SE451.

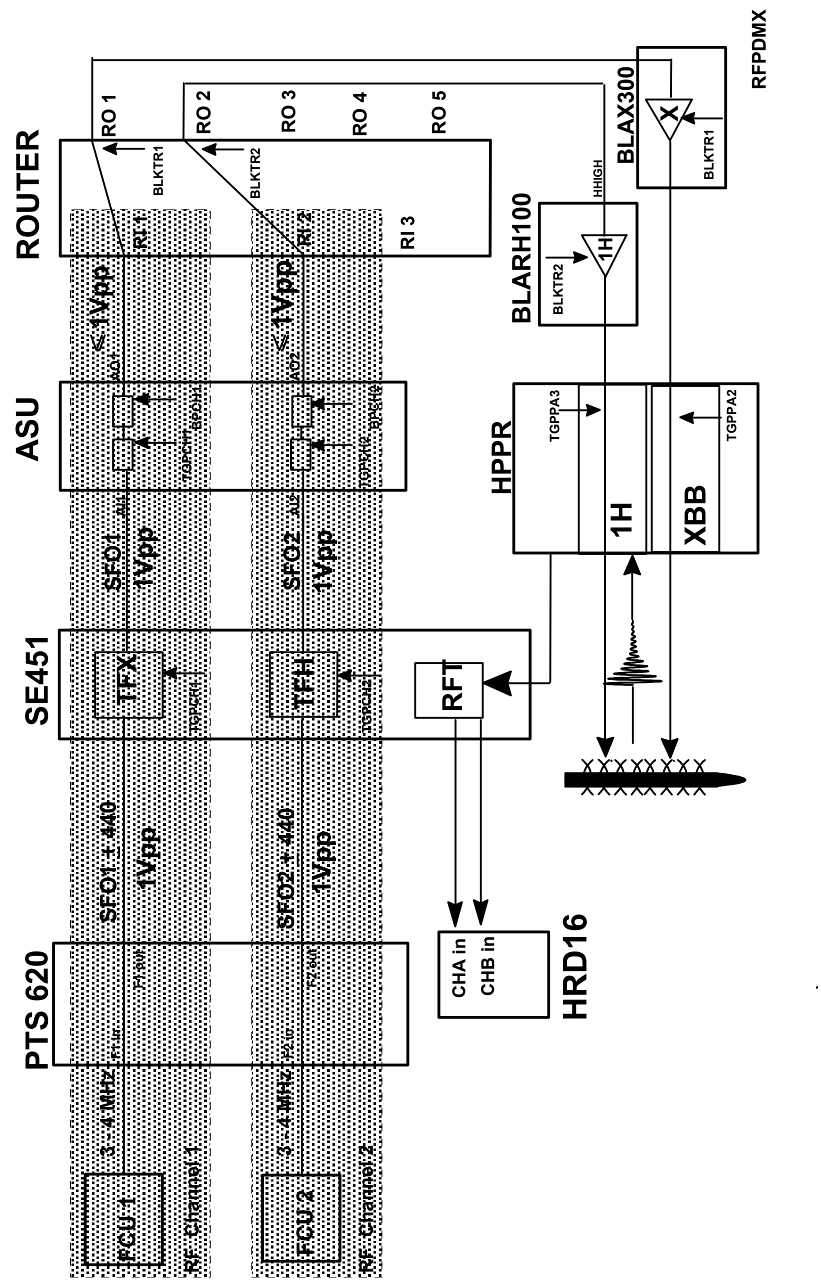
In the SE451:

1. The end frequency (SF01, SF02) is produced by mixing the rf input frequency with 440MHz.
2. For the first time the rf signal is pulsed with the gating signals TGPCH1 and TGPCH2.

The pulsed rf signal is sent to the ASU which adjusts the amplitude according to the attenuation set by software. FCU produced voltages called MOD and MULT are used to implement the fine amplitude adjustment. Fixed 20 and 40 dB attenuators may also be switched in using the FCU produced AT20 and AT40 signals. The max. output of the ASU is 1 Vpp corresponding to a software power level of pl = -6 dB.

Within the ASU the rf signal is blanked twice using the TGPCH and BPCH signals from the TCU.

Figure 2.1. RF Paths in the DMX, OBS 13C DEC. 1H



The router inputs are hard-wired to the ASU outputs and the router outputs are hardwired to the power amplifier inputs. This means effectively that the router is used to connect each rf frequency with the appropriate amplifier. The routing is controlled with the TCU produced RSEL bits. Each router output is blanked by the BLKTR signals from the TCU.

After the router the linear amplifiers amplify the rf signal. No power regulation takes place within the amplifiers, their output amplitude depends solely upon the rf input amplitude. The amplifiers are also blanked using the BLKTR signals.

The final rf blanking takes place in the HPPR using the TGPPA signals. Note however that whereas for all previously discussed blanking signals, the absence of the blanking signal would prevent rf transmission, in the HPPR the gating is required for signals with amplitudes of <1 Vpp only. For all signals with greater amplitude, the diodes in the HPPR would be forward biased by the rf itself. A second blanking used to control the T>R switching in the HPPR OBS module uses the RGP.

The NMR signal from the sample is received in the SE451. The operation of the SE451 receiver module has not changed. Note however that

1. The RG bit settings are now set by the RCU and transmitted to the SE451 via the HRD16 (or HADC).
2. The RGP (EP) signal is generated by the RCU and transmitted to the SE451 via the HRD16 (or HADC).
3. The selection of the OBSERVE channel (H or X) is set by the TCU produced NMRWord 2 bit 11 (OBSCH1)

Table 2.1. AVANCE Gating/Blanking Pulses

Signal Name	Connector	Destination	Connector	Destination
BLK TR 1	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 2	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 3	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 4	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 5	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 6	T5-A	AMPLIFIER	T2	ROUTER
BLK TR 7	T5-B	AMPLIFIER	T2	ROUTER
BLK TR 8	T5-B	AMPLIFIER	T2	ROUTER
TGP PA 1	T4-B	HPPR -2H		
TGP PA 2	T4-B	HPPR-XBB		
TGP PA 3	T4-B	HPPR-1H		
TGP PA 4	T4-B	HPPR-UB		
TGP PA 5	T4-B	HPPR		
TGP PA 6	T4-B	HPPR		
TGP PA 7	T4-B	HPPR		
TGP PA 8	T4-B	HPPR		
BP CH 1	T4-A	ASU1		
BP CH 2	T4-A	ASU1		
BP CH 3	T4-A	ASU2		
BP CH 4	T4-A	ASU2		

Table 2.1. AVANCE Gating/Blanking Pulses

Signal Name	Connector	Destination	Connector	Destination
BP CH 5	T4-A	ASU3		
BP CH 6	T4-A	ASU3		
BP CH 7	T4-A	ASU4		
BP CH 8	T4-A	ASU4		
TGP CH 1	T4-A	ASU1	T4-B	SE451
TGP CH 2	T4-A	ASU1	T4-B	SE451
TGP CH 3	T4-A	ASU2	T4-B	SE451
TGP CH 4	T4-A	ASU2	T4-B	SE451
TGP CH 5	T4-A	ASU3		
TGP CH 6	T4-A	ASU3		
TGP CH 7	T4-A	ASU4		
TGP CH 8	T4-A	ASU4		
BLKGRADX	T5-B	Backpanel		
BLKGRADY	T5-B	Backpanel		
BLKGRADZ	T5-B	Backpanel		

Pulse Names *2.3*

All blanking/gating pulses used in AVANCE spectrometers are active low and produced by the TCU. One of the features of the new ADVANCE range is that rf signals are blanked more frequently than in previous spectrometers which should improve the on/off ratio and give cleaner pulses with shorter rise and fall times. A list of signals and corresponding abbreviations is contained in the Appendix. One of the initial problems is becoming familiar with the new terminology and the following points will hopefully help clarify the situation.

What is the difference between a blanking pulse and a gating pulse?

Effectively none. When the signal goes low (active) rf power transmission is possible. Gating signals are tied exactly to the rf pulse transmission. If a 7 µs rf signal is to be transmitted, than the gating pulse will go low for 7 µs at exactly the moment of transmission. This applies to the TGPCH signals used in ASU's and the SE451.

Blanking pulses are distinguished from gating pulses in that the timing is not necessarily tied exactly to rf power transmission. Instead the blanking pulse may go active slightly prior to rf transmission and remain active for a short period after transmission. The optimal pre and post blanking timing will depend on the physical properties of the various switches but are typically 1-3 µs and may be set using the „edscon“ table (see ***"EDSCON: Edit spectrometer constants:" on page 153***)

In this respect the pulses BPCH (ASU) and BLKTR (Router and amplifiers) are termed blanking pulses.

One inconsistency to this naming is the TGPPA signals used in the HPPR. The timing of these pulses may be altered with the „edscon" table and they should really be called blanking pulses as opposed to gating pulses.

Which pulse is assigned to which channel

A specific rf channel" number" starts at the FCU and ends at the Router input. This rf channel connects FCU**1** through the PTS and SE451/LOT to ASU Input**1**/ Output**1** to Router Input**1**. The corresponding pulses are TGPCH**1** (SE451, ASU) and BPCH**1** (ASU).

Similarly rf channel**2** starts at FCU**2** and ends at Router Input**2** with corresponding pulses TGPCH**2** and BPCH**2**.

Which BLKTR signal is used in the Router is determined solely by which Router output is used. Thus an rf signal at RO**1** is blanked BLKTR**1**, an rf signal at RO**3** is blanked by BLKTR**3** etc.

Since a particular rf channel number can be routed to several different Router outputs, the BLKTR hardwired to the Router output can not be assigned the number of the rf channel.

Since each Router output is hardwired to a particular amplifier the nomenclature for Router blanking and amplifier blanking is identical. Thus an amplifier whose input is taken from RO**2** will be blanked by BLKTR**2**.

The various HPPR gating pulses are effectively hardwired to the TCU via the Periph. Cascode and the pulses are assigned as follows:

The 2H module is gated by TGPPA1

The X-BB module is gated by TGPPA2

The 1H module is gated by TGPPA3

The USER-BOX module is gated by TGPPA4

Table 2.1. is a summary of the various gating/blanking pulses.

Changes in the nomenclature: 2.4

To try to make pulse terminology more meaningful (in English!) the following pulse names are no longer standard

1. SPF (Sender Pulse) and SPFND pulses. These have been replaced by TGPCH and BPCH respectively.
2. EP (Empfänger Pulse) is now called the RGP (Receiver Gating Pulse)
3. SPENAB is now called TGENAB

RF Paths in the DRX 2.5

The first major difference to the DMX is that the end frequency SF01, SF02 is produced directly at the PTS output. There is no subsequent mixing with 440 MHz in an SE451 type device.

The LOT Board carries out the T/R switching on the OBSERVE channel (always channel1 on DRX spectrometers). The output LT01 of the LOT Board will be pulsed with the RGP timing i.e. the signal will be missing during acquisition. The second LOT output (LT02) will be cw.

The operation of the ASU, Router amplifiers and HPPR in DRX and DMX spectrometers is identical.

The receiver used in the DRX is the RX22 which uses an LO of SF01 + 22 MHz as opposed to SF01 + 451MHz with the DMX.

RF Paths in the DPX *2.6*

The operation of the FCU’s and PTS620 in the DRX and the DPX are identical. The first difference is in the LOT/ASU board which is effectively a combined ASU and LOT Board. The limitation of this arrangement is that the MOD module used for shaped pulses can not be fitted. The operation of the Router, amplifiers and receiving section in DPX and DRX spectrometers is the same.

Figure 2.2. RF Paths in the DRX, OBS 13C DEC. 1H

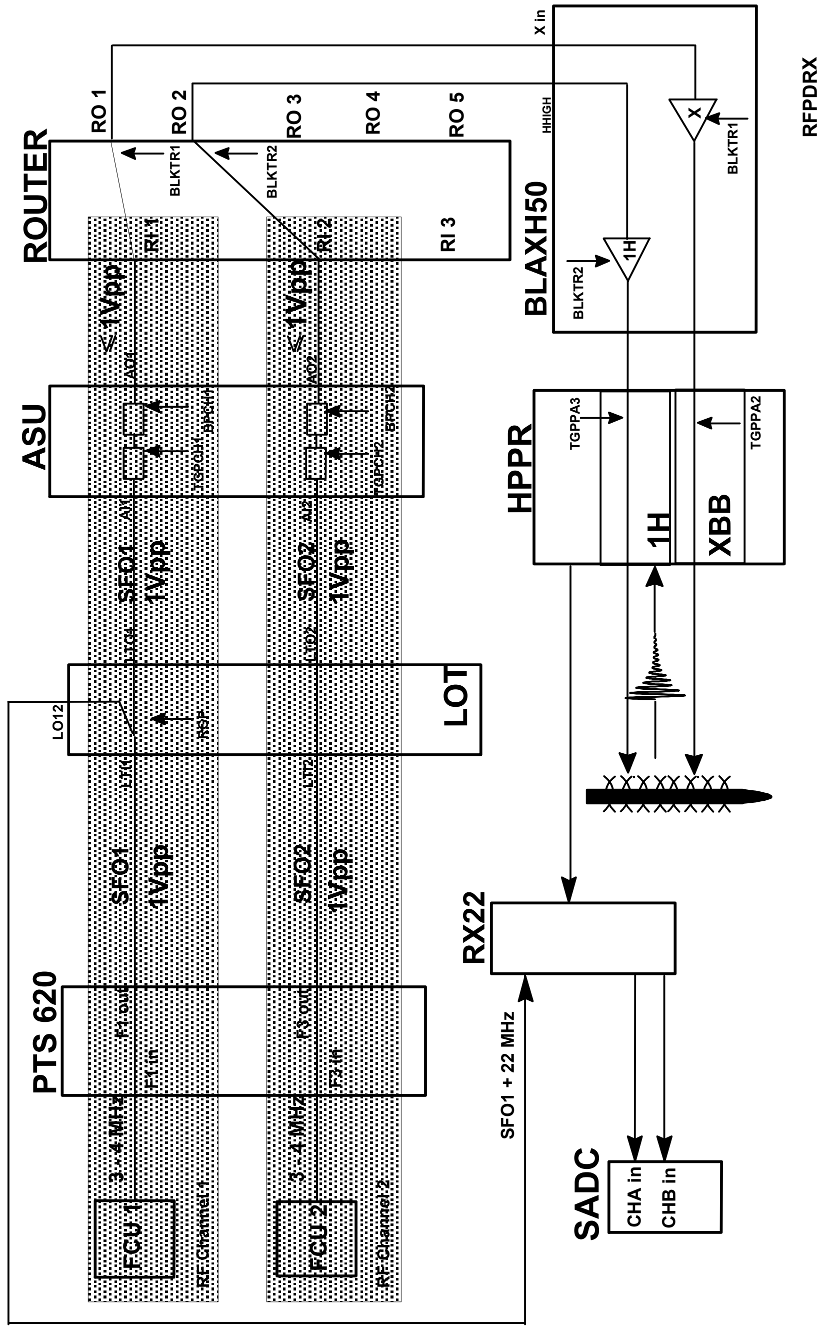
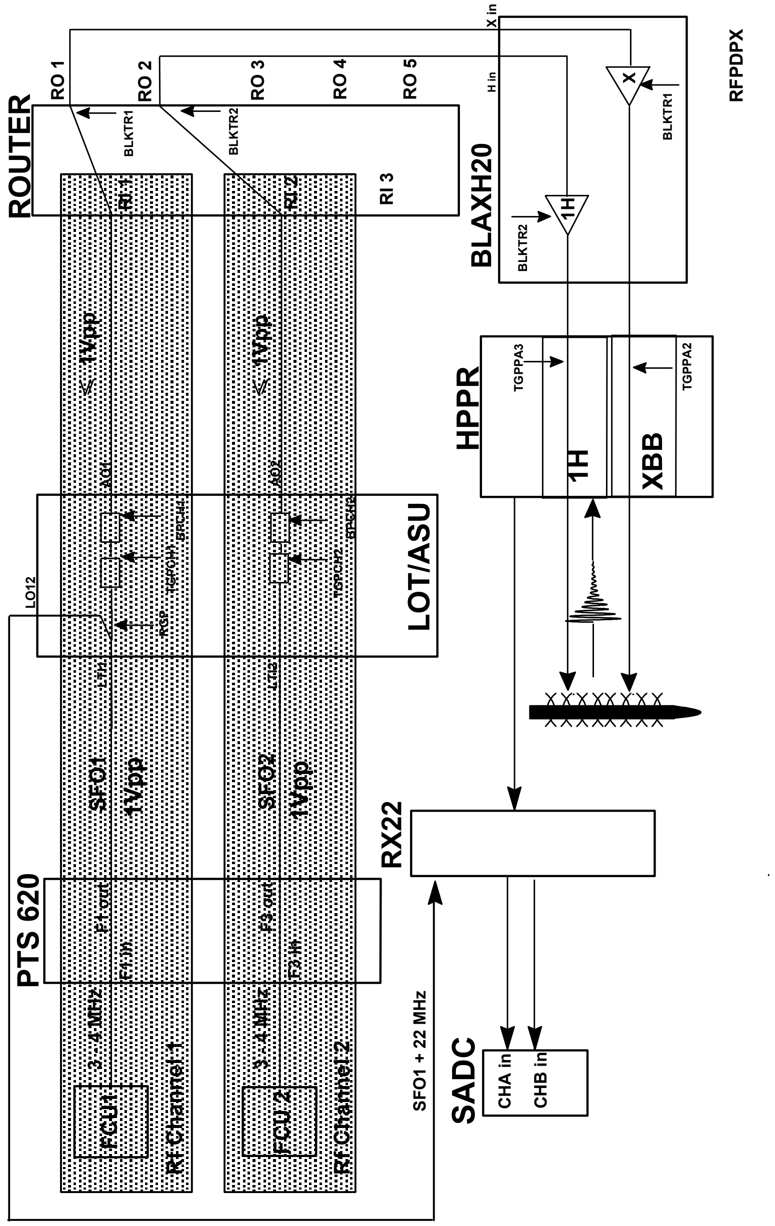


Figure 2.3. RF Paths in the DPX, OBS 13C DEC. 1H



AQX32 Board Layout

3

Acquisition Bus 3.1

This is a real time Bus with interrupt capability. The Bus is designed to interconnect the TCU with the RCU and FCU's (and GCU where installed).The TCU is the one and only master of the Acquisition Bus. In this way the TCU can have uninterrupted control of the Acquisition timing.

The Bus has two sections. One is 16 bit, uni-directional real-time and used to control the FCU's and RCU. The second is 8 bit, bi-directional non real-time and at present used exclusively to control the GCU.

Under certain circumstances (i.e. errors) the RCU or GCU can generate interrupts to the TCU.

The Acquisition Bus connection is made by plugging a Bus backplane onto the X32 backplane. The Bus backplane comes in two versions 8 slot (standard) or 5 slot. The standard 8 slot Bus allows for one TCU (3 slots), one RCU, and 4 FCU's (or 3 FCU's and one GCU).

An 8 slot Bus can be easily combined with a 5 slot to give a 13 slot Acquisition Bus. Ribbon cable (P/N HZ2969) is used to connect the two Buses. When making this modification, the position of the terminating resistors must be changed (see *Figure 3.3.*)

The extended 13 slot Bus allows for one TCU (3 slots), one RCU, one GCU and 8 FCU's.

Board Order 3.1.1

Strictly speaking there is no set board order. However optimum performance is achieved with the TCU and a set of terminating resistors positioned at opposite ends of the Bus. This minimises unwanted reflections at the end of the Bus. The RCU, GCU and FCU's can then be placed in any order in between.

With this in mind a standard layout has been decided upon for all 20 slot X32 computers delivered with DRX and DMX spectrometers (see *Figure 3.1.*).The TCU is placed at the extreme left end (front view) of the Acquisition Bus, the RCU (and terminating resistors) at the extreme right and FCU's and GCU and empty slots in between.

As a result of thermal problems a slightly different layout has been used in the 9 slot X32 as used in DPX spectrometers. The cooling fans are located to the left of the rack. To optimise the cooling of the FCU's and the TCU the board order in *Figure 3.2.* is now standard.

Jumpers *3.1.2*

There are no jumpers on the Acquisition Bus. Just remember to set the terminating resistor networks correctly.

VME BUS *3.2*

This standard bi-directional 32 bit Bus comes in two versions, 9 slot (DPX) and 20 slot (DMX, DRX). It is used for communication between all boards in the AQX32 rack including the CCU. On this Bus only the RCU and CCU can be master (the RCU has priority over the CCU regarding Bus requests.)

The only requirement is that the CCU be placed at the extreme left (front view) of the Bus. This is to ensure that it receives all request messages.

Jumpers *3.2.1*

To ensure that the DMA is not interrupted any vacant slots must have corresponding jumpers inserted at the backplane. If an extra new board is inserted the jumpers must be removed from the backplane.

NOTE: The TCU consists of 2 boards but occupies 3 slots. The middle slot should have the jumpers inserted.

Figure 3.1. Standard 8 Slot Acquisition Bus (DMX, DRX)

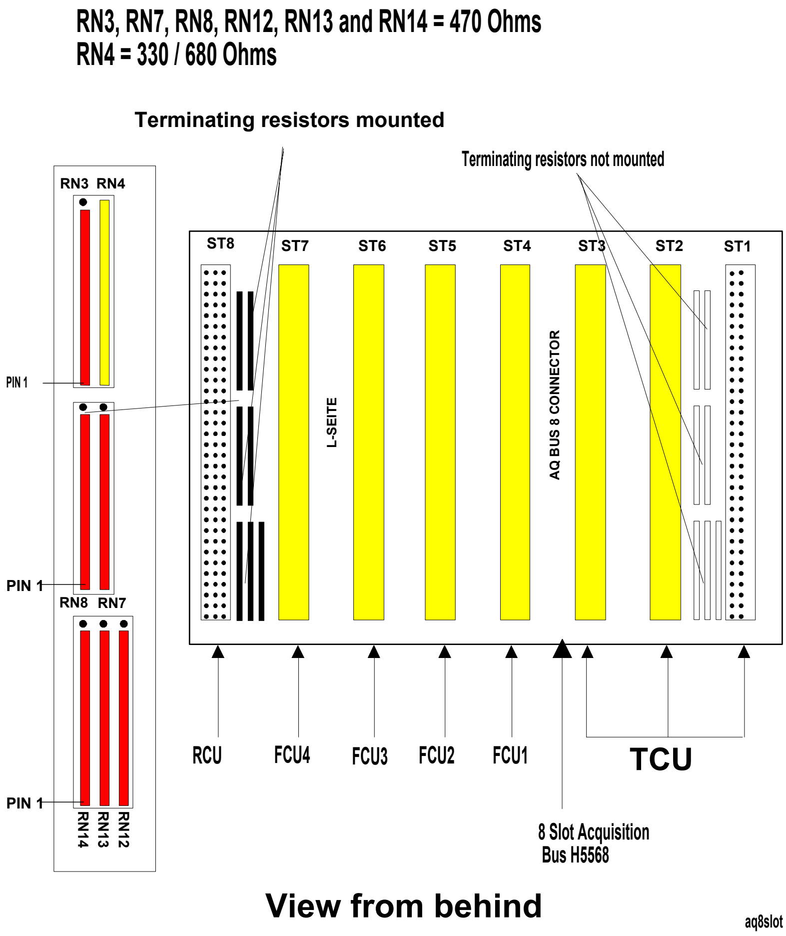


Figure 3.2. Standard 8 Slot Acquisition Bus (DPX)

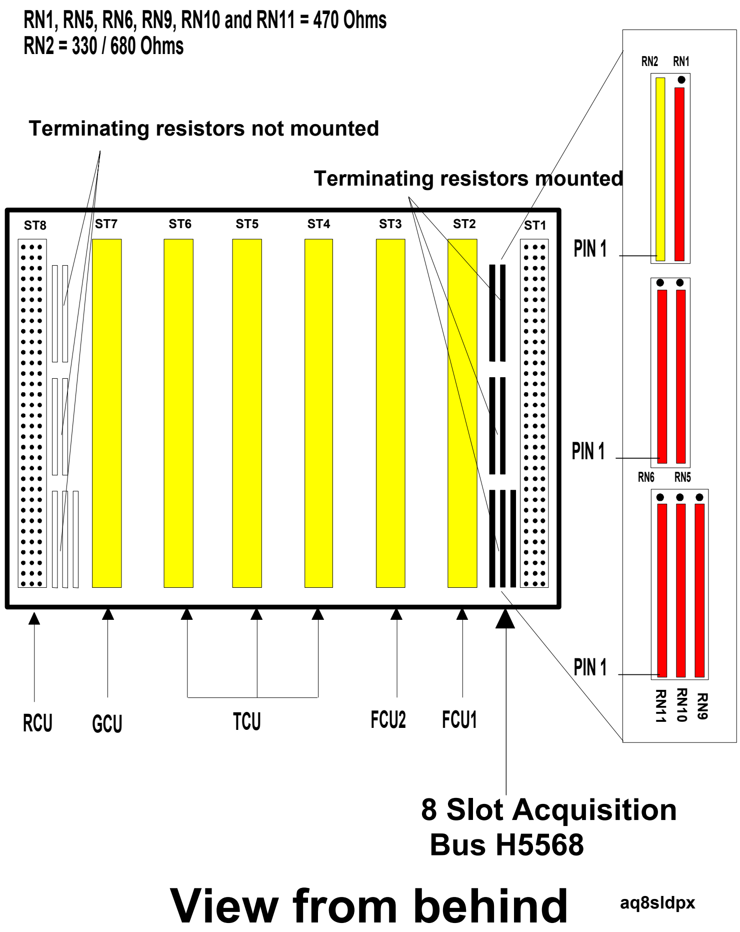
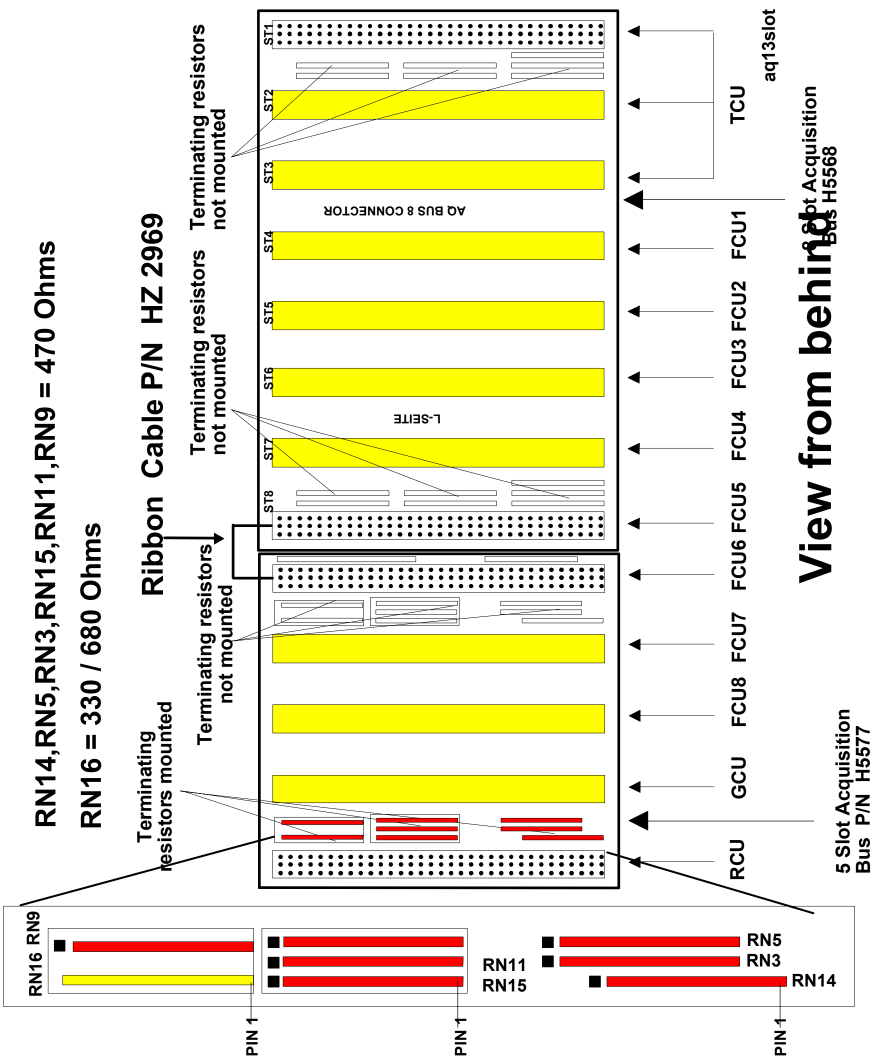


Figure 3.3. Extended 13 Slot Acquisition Bus (DMX, DRX)



CCU 3.3

The latest spectrometers will be delivered with the new CCU, Communication Control Unit (P/N H2570).

This effectively replaces the CPU4 , the CPU3 Fast Ext. Memory and SIB with one board. A separate panel (RS232/485 EXT. Board P/N H5731) which runs across the top of the AQX32 provides the physical space for the RS232 and RS485 connectors.

Layouts A,B and C control 7 x RS232 and 2 x RS485 connectors.

Layout D controls 9 x RS232 and 2 x RS485 connectors.

The two Tables below show the default configuration of the new CCU. To simplify the „**cf**“ routine it is helpful, though not strictly necessary if these default assignments are used.

Table 3.1. Recommended default assignments CCU Layout A,B and C

Default Unit	Type	TTY Default	Location	Label
Terminal/Kermit	RS232	00	CCU Board	TTY0
HPPR	RS232	01	EXT. Board	TTY1
BSMS-CPU	RS232	02	EXT. Board	TTY2
BSMS-Locksig-nal	RS232	03	EXT. Board	TTY3
ACB	RS232	04	EXT. Board	TTY4
Temperature unit	RS232	05	EXT. Board	TTY5
BGU2	RS232	06	EXT. Board	TTY6
MAS	RS232	07	EXT. Board	TTY7
HPCU	RS232	07	EXT. Board	TTY7
Not connected	RS232	08		
Not connected	RS232	09		
RX22/RXC	RS485	10	EXT. Board	RS485-1
BACS	RS232	11	First SIB Board	CH1
	RS232	12	First SIB Board	CH2
	RS232	13	First SIB Board	CH3
	RS232	14	First SIB Board	CH4
	RS232	15	First SIB Board	CH5
	RS232	16	First SIB Board	CH6
	RS485	20	EXT. Board	RS485-2
	RS232	21	Second SIB Board	CH1
	RS232	22	Second SIB Board	CH2
	RS232	23	Second SIB Board	CH3
	RS232	24	Second SIB Board	CH4

Table 3.1. Recommended default assignments CCU Layout A,B and C

Default Unit	Type	TTY Default	Location	Label
	RS232	25	Second SIB Board	CH5
	RS232	26	Second SIB Board	CH6

Table 3.2. Recommended Default Assignments CCU Layout D.

Note that the SIB Boards are optional.

Default Unit	Type	TTY Default	Location	Label
Terminal/Kermit	RS232	00	CCU	TTY00
HPPR	RS232	01	EXT. Board	TTY01
BSMS-CPU	RS232	02	EXT. Board	TTY02
BSMS-Locksig-nal	RS232	03	EXT. Board	TTY03
ACB	RS232	04	EXT. Board	TTY04
Temperature unit	RS232	05	EXT. Board	TTY05
BGU2	RS232	06	EXT. Board	TTY06
MAS	RS232	07	EXT. Board	TTY07
HPCU	RS232	07	EXT. Board	TTY07
BACS	RS232	08	EXT. Board	TTY08
Free use	RS232	09	EXT. Board	TTY09
RX22/RXC	RS485	10	EXT. Board	RS485-10
	RS232	11	First SIB Board	CH1
	RS232	12	First SIB Board	CH2
	RS232	13	First SIB Board	CH3
	RS232	14	First SIB Board	CH4
	RS232	15	First SIB Board	CH5
	RS232	16	First SIB Board	CH6
	RS485	20	EXT. Board	RS485-20
	RS232	21	Second SIB Board	CH1
	RS232	22	Second SIB Board	CH2
	RS232	23	Second SIB Board	CH3
	RS232	24	Second SIB Board	CH4

Table 3.2. Recommended Default Assignments CCU Layout D.

Note that the SIB Boards are optional.

Default Unit	Type	TTY Default	Location	Label
	RS232	25	Second SIB Board	CH5
	RS232	26	Second SIB Board	CH6

TCU: Timing Control Unit 4

The TCU consists of two boards and occupies 3 slots in the AQX32 Rack. The TCU delivered with the first batch of Avance instruments was officially known as TCU0 (TCU0 Main Board P/N H2558 and TCU Ext. Board P/N H2562). In December 94 a new TCU_4K Main Board P/N H5811 was introduced. The main differences between TCU0 and TCU_4K are

a) additional on board memory of 64kB instead of 8kB

b) the new TCU_4K hardware will support the BBIS system

c) the new TCU_4K requires XWIN-NMR software.

Pin assignments have not changed.

The TCU is connected to the FCU's, RCU and GCU where installed, via the Acquisition Bus. The TCU is the one and only master of this Bus.

Principal Functions 4.1

1. To synchronise and control the timing of the RCU, FCU's and GCU where installed.
2. To generate gating and blanking pulses used in the ASU, Router, Amplifiers and HPPR.
3. To control the Router switching via the RSEL bit settings.
4. To generate various switching signals used in Amplifiers, SE451, QNP Pneumatic Unit etc.

A complete list of the TCU outputs is given at the end of this Chapter. A single TCU is designed to provide all the required signals for a spectrometer with up to 8 rf channels.

All outputs of the TCU are TTL active low .The outputs are designed to go high after a hardware reset of the CCU. Up to and including Layout C of the TCU Main Board the required pull up resistors are however missing from the outputs of connector T4. As a result, after a reset, these outputs may be low when measured with the Burndy disconnected. This will be changed with future TCU layouts.

Physical Connections 4.2

1. SCSI connector T2 is connected directly to the Router and transmits the RSEL bit settings as well as BLKTR1 - 10.

2. TGPCH and BPCH signals are wired to the FCU F1 Adapter from where they are connected to the ASU.
3. Connectors T3, T4 and T5 carry various signals to amplifiers, SE451 etc. via the cable harness.
4. Connector T1 is used only for signals required for high power applications.

Note1: The signals TO/F and OBSCH1 are wired to the FCU in DPX spectrometers only. This is because they are required by the combined LOT/ASU Board. In DRX spectrometers the separate LOT Board receives these signals via the cable harness.

Note2: The four signals TGPCH1, BPCH1, TGPCH2, BPCH2 are the required gating/blanking signals for a single two channel ASU. For each subsequent channel the corresponding pair of gating/blanking connections must be added. Kits with correctly labeled cables are available for each extra channel that might be added. When ordering it is important to specify which channel (e.g. 3 or 4 etc) which is to be added.

Note 3: The Burndy connectors T3,T4 and T5 are fitted exclusively with coax pins. This means that it is not possible to use the traditional Burndy Break-out Box. Signals can however be easily checked at the other end of the coax cable.

The Burndy connectors are wired to the TCU via Ribbon connectors A and B i.e DC Pins on the TCU. The tables at the end of this Chapter give not only the Coax Pin assignments but also the corresponding DC Pin assignments of Ribbon connectors A and B..

The use of SCSI connectors as opposed to the traditional Burndy connectors has the following advantages.

a) Less space required

b) The use of twisted pairs reduces unwanted magnetic pickup because the enclosed area is small and the signals induced in successive twists tend to cancel.

TCU Power Supply *4.3*

The TCU is powered from the Backplane and listed below are the relevant test points. You will need the Extension Board P/N H2066. to check the voltages.

Table 4.1.

Voltage	Current	Test Point
+ 5V (digital)	8 A	ST1: A32,B32,C32

Front Panel SMB Connectors *4.4*

Two signals 40 MHz and AQS are daisy chained from the TCU to successive FCU boards (and GCU if fitted).

40 MHz:

This output signal is TTL (3Vpp at 50 Ω) and operates on a 50% duty cycle. Two outputs are provided. One is used to clock the FCU's (and GCU if fitted), the other to clock the RCU.

RCUGO:

This pulse is used to start the RCU and as such must accompany every scan. The timing is so that it goes high for 50 ns, approximately 200 ns before the RGP (EP) pulse.

AQS:

Various instructions are sent from the TCU to the FCU's and GCU via the Acquisition Bus. This TTL strobe pulse is used to synchronise the timing of the Bus.The strobe pulses go low for a minimum of 25 ns. The Data transfer itself is triggered by the rising edge.

80 MHz.:

This input signal comes directly from the PTS620 and is the clocking frequency for the TCU. Note that the voltage level is 0 dBm (0.65Vpp at 50Ω). This signal is used to generate the 40MHz signals described above.

TRIG0:

This input is available should it be necessary to trigger the TCU with an external input.

TRIG 1:

This input is for the signal "scantrigger" which originates in the BSMS.This signal could be used to synchronise the TCU timing with sample spinning

Outputs 4.5

Total number of individual outputs: 147

Connector T1: 28 outputs: 2 inputs (TRIG 2, TRIG3)

Connector T2: 38 outputs

Connector T3: 32 outputs, 2 inputs (TRIG 2, TRIG3) All Coax.

Connector T4: 34 outputs (All Coax).

Connector T5: 34 outputs (All Coax).

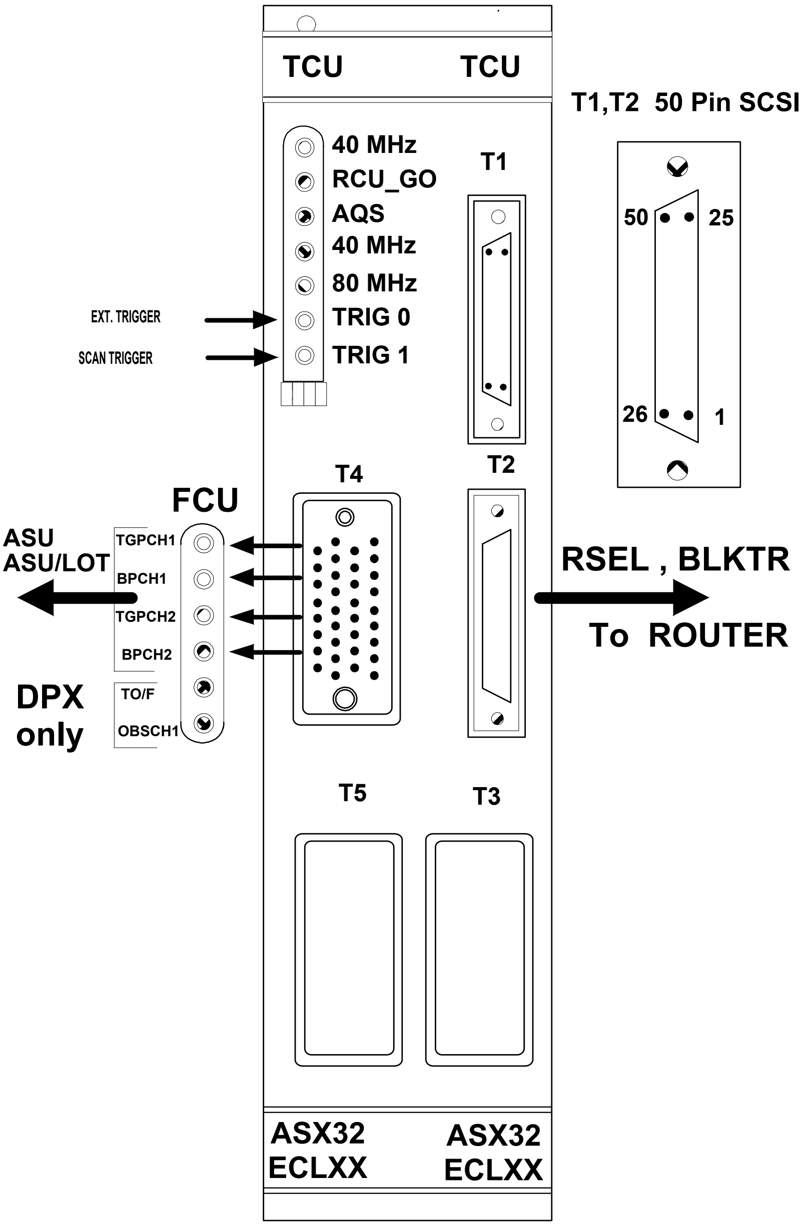
The inputs TRIG 2 and TRIG3 are not used at present. They could be used should it be necessary to trigger the TCU with an external input. Only one set of inputs can be used either T1 or T3. Which are used is set with Jumpers W3 and W4 on the TCU Extension Board. The default factory settings are:

W3: Pin 2-Pin 3 => TRIG3 input is T3 Pin NN and T1 input not connected.

W4: Pin 1-Pin2 => TRIG2 input is T1 Pin 25 and T3 input not connected.

Note that these Trigger inputs are treated in exactly the same way by the TCU as the SMB Trigger inputs on the front panel.

Figure 4.1. TCU Front Panel



Duration Generator *4.6*

The precise timing control of the TCU is achieved by means of an on board Duration Generator

Minimum Duration: 50 ns.

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

Timing Resolution: 12.5 ns.

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 ,87.5 ns etc.

Pulse Rise Times: 5 ns

Pulse Fall times: 4 ns.

TCU control via explicit pulse programming. 4.7

The TCU outputs are normally set automatically from either the "edsp", "edasp" or "eda" tables or from the pulse program itself.

For test purposes however it is sometimes useful to explicitly program the various outputs using the following pulse program command:

d11 setnmr2^3 = set NMRWord 2 bit 3 high (inactive).

d11 setnmr2|3 = set NMRWord 2 bit 3 low (active)**.**

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

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. This syntax applies to all NMR words 0 - 8

A different syntax which is identical to that previously used in conventional RCP pulses can also be used, but only for NMR word 0 .

e.g. to activate (set low) BLKTR3 (see ***table 4.2.***) for the duration p1 use:

p1:c2

e.g. to transmit a pulse p1 on channel 1 and simultaneously activate (set low) BLKTR4 for the duration p1 use:

p1:f1:c3

Note that unlike the "**setnmr**" command the bit will go inactive (high) as soon as p1 has elapsed.

Software Diagnostic Test 4.8

A useful test program is entitled "**tcutest**" which is normally in the directory:

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

Miscellaneous 4.9

The most important TCU outputs will be discussed in various Chapters throughout this manual ,but for completion several signals which will not be dealt with at later stages are explained below

NMRWord8 bit4: SEL2H/DEC:

This signal has been introduced to enable the 2H signal to the sample to be switched. Normally the HPPR module transmits/receives the 2H lock signal. In certain samples certain molecules may be labeled with 2H. At some stage in the pulse sequence we may want to switch off the lock and do normal 2H decoupling. Lockhold is activated and a switching box inserted after the HPPR 2H module switches the signal transmitted to the probe from the Lock signal to the decoupling signal.

NMRWord8 bit5,6:EXT DW: EXT RGP:

These two outputs have been made available for solid applications.

NMRWord3 CAL, REGUL DROOP:

These are signals which could be used to switch the amplifiers into a calibration mode. As of yet the required hardware has not been implemented. In the future it is more likely that these modes will be switched using the RS485 link from the ACB board.

Table 4.2. Real Time Digital Outputs NMRWord 0

Bit No	Signal Name	Connector	Destination	Connector	Destination
< 0 >	BLK TR 1	T5-A Pin A	AMPLIFIER	T2	ROUTER
< 1 >	BLK TR 2	T5-A Pin K	AMPLIFIER	T2	ROUTER
< 2 >	BLK TR 3	T5-A Pin U	AMPLIFIER	T2	ROUTER
< 3 >	BLK TR 4	T5-APin Y	AMPLIFIER	T2	ROUTER
< 4 >	BLK TR 5	T5-A Pin CC	AMPLIFIER	T2	ROUTER
< 5 >	BLK TR 6	T5-A Pin MM	AMPLIFIER	T2	ROUTER
< 6 >	BLK TR 7	T5-B Pin J	AMPLIFIER	T2	ROUTER
< 7 >	BLK TR 8	T5-B Pin N	AMPLIFIER	T2	ROUTER
< 8 >	TGP PA 1	T4-B Pin V	HPPR -2H		
< 9 >	TGP PA 2	T4-B Pin X	HPPR-XBB		
< 10 >	TGP PA 3	T4-B Pin Z	HPPR-1H		
< 11 >	TGP PA 4	T4-B Pin BB	HPPR-UB		
< 12 >	TGP PA 5	T4-B Pin DD	HPPR		
< 13 >	TGP PA 6	T4-B Pin FF	HPPR		
< 14 >	TGP PA 7	T4-B Pin JJ	HPPR		
< 15 >	TGP PA 8	T4-B Pin LL	HPPR		
< 16 >	BP CH 1	T4-A Pin A	ASU1		
< 17 >	BP CH 2	T4-A Pin E	ASU1		

Table 4.2. Real Time Digital Outputs NMRWord 0

Bit No	Signal Name	Connector	Destination	Connector	Destination
< 18 >	BP CH 3	T4-A Pin K	ASU2		
< 19 >	BP CH 4	T4-A Pin P	ASU2		
< 20 >	BP CH 5	T4-A Pin U	ASU3		
< 21 >	BP CH 6	T4-A Pin Y	ASU3		
< 22 >	BP CH 7	T4-A Pin CC	ASU4		
< 23 >	BP CH 8	T4-A Pin HH	ASU4		
< 24 >	TGP CH 1	T4-A Pin C	ASU1	T4-B	SE451
< 25 >	TGP CH 2	T4-A Pin H	ASU1	T4-B	SE451
< 26 >	TGP CH 3	T4-A Pin M	ASU2	T4-B	SE451
< 27 >	TGP CH 4	T4-A Pin S	ASU2	T4-B	SE451
< 28 >	TGP CH 5	T4-A Pin W	ASU3		
< 29 >	TGP CH 6	T4-A Pin AA	ASU3		
< 30 >	TGP CH 7	T4-A Pin EE	ASU4		
< 31 >	TGP CH 8	T4-A Pin KK	ASU4		
< 32 >	BLKGRADX	T5-B Pin JJ	Backpanel		
< 33 >	BLKGRADY	T5-B Pin LL	Backpanel		
< 34 >	BLKGRADZ	T5-B Pin NN	Backpanel		

Table 4.3. NMRWord 1

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	RSEL 10	T2	6		ROUTER 1
< 1 >	RSEL 11	T2	5		ROUTER 1
< 2 >	RSEL 12	T2	31		ROUTER 1
< 3 >	RSEL 13	T2	30		ROUTER 1
< 4 >	RSEL 20	T2	9		ROUTER 1
< 5 >	RSEL 21	T2	8		ROUTER 1
< 6 >	RSEL 22	T2	34		ROUTER 1
< 7 >	RSEL 23	T2	33		ROUTER 1
< 8 >	RSEL 30	T2	18		ROUTER 1
< 9 >	RSEL 31	T2	17		ROUTER 1
< 10 >	RSEL 32	T2	43		ROUTER 1

Table 4.3. NMRWord 1

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 11 >	RSEL 33	T2	42		ROUTER 1
< 12 >	RSEL 40	T2	25		ROUTER 2
< 13 >	RSEL 41	T2	24		ROUTER 2
< 14 >	RSEL 42	T2	50		ROUTER 2
< 15 >	RSEL 43	T2	49		ROUTER 2

Table 4.4. NMRWord 2

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	LOCK HOLD	T5-B	15	T	BSMS
< 1 >	HOMOSPOIL	T5-B	17	V	BSMS
< 2 >	SELH !H/F	T5-B	19	X	AMPLIFIER
< 3 >	SELX !X/F	T5-B	21	Z	AMPLIFIER
< 4 >	Z0 COMP ENAB.	T5-B	23	BB	BSMS
< 5 >		T2	22		
< 6 >		T2	23		
< 7 >	RCP PA SWITCH	T4-B	33	NN	
< 8 >	FXA	T5-B	25	DD	QNP
< 9 >	FXB	T5-B	27	FF	QNP
< 10 >	TUNE ON/ OFF	T4-A	33	MM	
< 11 >	OBS CH1	T4-B	1	B	SE 451
< 12 >	OBS CH2	T4-B	5	F	
< 13 >	OBS CH3	T4-B	9	L	
< 14 >	OBS CH4	T4-B	13	R	
< 15 >					

Table 4.5. NMRWord 3

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	CAL TR 1	T5-A	3	C	AMPLIFIER
< 1 >	CAL TR 2	T5-A	11	M	AMPLIFIER
< 2 >	CAL TR 3	T5-A	19	W	AMPLIFIER
< 3 >	CAL TR 4	T5-A	23	AA	AMPLIFIER
< 4 >	CAL TR 5	T5-A	27	EE	AMPLIFIER
< 5 >	CAL TR 6	T5-B	1	B	AMPLIFIER
< 6 >	CAL TR 7	T5-B	6	L	AMPLIFIER
< 7 >	CAL TR 8	T5-B	13	R	AMPLIFIER
< 8 >	REGUL. TR 1	T5-A	5	E	AMPLIFIER
< 9 >	REGUL. TR 2	T5-A	13	P	AMPLIFIER
< 10 >	REGUL. TR 5	T5-A	29	HH	AMPLIFIER
< 11 >	REGUL. TR 6	T5-B	3	D	AMPLIFIER
< 12 >	DROOP TR 1	T5-A	7	H	AMPLIFIER
< 13 >	DROOP TR 2	T5-A	15	S	AMPLIFIER
< 14 >	DROOP TR 5	T5-A	31	KK	AMPLIFIER
< 15 >	DROOP TR 6	T5-B	5	F	AMPLIFIER

Table 4.6. NMRWord 4

Bit No.	Signal	Connector	DC Pin	Coax	Connector	DC Pin	Coax
< 0 >		T3-A	1	A			
< 1 >	BLK TR09	T3-A	3	C	T3-B	19	X
< 2 >	BLK TR10	T3-A	5	E	T3-B	21	Z
< 3 >	BLK TR11	T3-A	7	H	T3-B	23	BB
< 4 >	BLK TR12	T3-A	9	K	T3-B	25	DD
< 5 >	BLK TR13	T3-A	11	M	T3-B	27	FF
< 6 >	BLK TR14	T3-A	13	P	T3-B	29	JJ
< 7 >	BLK TR15	T3-A	15	S	T3-B	33	MM
< 8 >							
< 9 >							

Table 4.6. NMRWord 4

Bit No.	Signal	Connector	DC Pin	Coax	Connector	DC Pin	Coax
< 10 >							
< 11 >							
< 12 >							
< 13 >							
< 14 >							
< 15 >							

Table 4.7. NMRWord 5

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	GAIN 0 TR1	T1	2		HI POWER
< 1 >	GAIN 1 TR1	T1	27		HI POWER
< 2 >	C/AB TR1	T1	3		HI POWER
< 3 >	GAIN 0 TR2	T1	5		HI POWER
< 4 >	GAIN 1 TR2	T1	30		HI POWER
< 5 >	C/AB TR2	T1	6		HI POWER
< 6 >	C/AB TR5	T1	8		HI POWER
< 7 >	RELAY H	T1	10		HI POWER
< 8 >	RELAY X	T1	35		HI POWER
< 9 >	RELAY Y	T1	12		HI POWER
< 10 >	RACK ON/OFF	T1	37		HI POWER
< 11 >	RCP	T1	13		HI POWER
< 12 >	RELAY Z	T1	14		HI POWER
< 13 >	RCP	T1	15		HI POWER
< 14 >	RCP	T1	16		HI POWER
< 15 >	RCP	T1	17		HI POWER

Table 4.8. NMRWord 6

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	STRAFI STP1 DIR	T1	18		HI POWER
< 1 >	STRAFI LB SEL	T1	43		HI POWER

Table 4.8. NMRWord 6

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 2 >	STRAFI DCM STRT	T1	19		HI POWER
< 3 >	STRAFI STP1 CLK	T1	20		HI POWER
< 4 >	STRAFI STP2 CLK	T1	21		HI POWER
< 5 >	STRAFIRES STP1	T1	22		HI POWER
< 6 >	STRAFI DCM RES	T1	23		HI POWER
< 7 >	STRAFI GO POS	T1	24		HI POWER
< 8 >					
< 9 >					
< 10 >					
< 11 >					
< 12 >					
< 13 >					
< 14 >					
< 15 >					

Table 4.9. NMRWord 7

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	RSEL 50	T2	2		ROUTER 2
< 1 >	RSEL 51	T2	1		ROUTER 2
< 2 >	RSEL 52	T2	27		ROUTER 2
< 3 >	RSEL 53	T2	26		ROUTER 2
< 4 >	RSEL 60	T2	4		ROUTER 2
< 5 >	RSEL 61	T2	3		ROUTER 2
< 6 >	RSEL 63	T2	29		ROUTER 2
< 7 >	RSEL 63	T2	28		ROUTER 2
< 8 >	RSEL 71	T3-A	17	U	ROUTER 3
< 9 >	RSEL 71	T3-A	19	W	ROUTER 3
< 10 >	RSEL 72	T3-A	21	Y	ROUTER 3
< 11 >	RSEL 73	T3-A	23	AA	ROUTER 3
< 12 >	RSEL 80	T3-A	25	CC	ROUTER 3
< 13 >	RSEL 81	T3-A	27	EE	ROUTER 3

Table 4.9. NMRWord 7

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 14 >	RSEL 82	T3-A	29	HH	ROUTER 3
< 15 >	RSEL 83	T3-A	31	KK	ROUTER 3

Table 4.10. NMRWord 8

Bit No.	Signal	Connector	DC Pin	Coax	Destination
< 0 >	RSEL 90	T3-B	1	B	ROUTER 3
< 1 >	RSEL 91	T3-B	3	D	ROUTER 3
< 2 >	RSEL 92	T3-B	5	F	ROUTER 3
< 3 >	RSEL 93	T3-B	7	J	ROUTER 3
< 4 >	SEL2H/DEC	T3-B	9	L	
< 5 >	EXT DW	T3-B	11	N	
< 6 >	EXT RGP	T3-B	13	R	
< 7 >		T3-B	15	T	
< 8 >		T3-B	17	V	
< 9 >					
< 10 >					
< 11 >					
< 12 >					
< 13 >					

FCU: Frequency Control Unit

5

Principal Functions 5.1

1. To generate the DDS input for the PTS. (Frequency and phase).
2. To control the frequency setting of the PTS output.
3. To generate MOD, MULT, AT20 and AT40 signals used for power regulation in the ASU Boards.
4. To control the phase of the 4 Phase Modulator using ph1 and ph2 signals (Solids measurements)

In many respects the FCU takes the place of the MCI board (see *table 5.4.*)

Front panel SMB. Connectors 5.2

Two signals, 40 MHz and AQS are daisy chained between successive FCU boards.

40 MHz. In/Out:

This clocking signal originates from the 80 MHz of the TCU. It is TTL (2.5 - 3Vpp at 50 Ω) and operates on a 50% duty cycle.

AQS In / Out:

This is a TTL strobe pulse which is used to validate data transfer over the real-time Acquisition Bus. The strobe pulses go low for a minimum of 25 ns. The Data transfer itself is triggered by the rising edge.

DDS out:

3 - 4 MHz.   0.8 - 1Vpp at 50 Ω.This signal goes directly to the PTS. Note that the DDS unit has a range of 0 - 10 MHz but only 3 - 4 MHz is used.

MOD MULT (Non Differential):

These two outputs have been made available for transmitters with internal amplitude setting (i.e without external ASU). This would enable the FCU to drive transmitters such as the Ecoupler, BSV-10, BLT-4 etc..

The voltages delivered at the MOD and MULT outputs will depend on the load and how the spectrometer is configured.

Table 5.1. Non-differential MOD and MULT Ranges

For Spectrometers configured without AVANCE Router e.g. AMX, ARX

	MULT Voltage	MOD Voltage
Min. Attenuation	5V (1M Ω)	5V (1MΩ)
Min. Attenuation	2.5V (50 Ω)	2.5V (50 Ω)
Max. Attenuation	0V	0V

The non differential outputs will always be present, even when the differential outputs are used (as is normally the case). As such they are a useful test point for checking whether the MOD and MULT voltages are responding to the software. The values of MOD and MULT delivered at the non differential outputs for a spectrometer configured as a AVANCE will be different from those above in table 5.1.

Table 5.2. Non-differential MOD and MULT Ranges

For Spectrometers configured with AVANCE Router

	MULT Voltage	MOD Voltage
Min. Attenuation	2.5V (1M Ω)	2.5V (1M)
Min. Attenuation	1.25V (50 Ω)	1.25V (50 Ω)
Max. Attenuation	0V	0V

Note: The non-differential OP AMPs have a settling time of 180 ns. These outputs have a longer settling time than the differential outputs, which is 90 ns.

PH1, PH2:

These two bits can be used to control the 0×, 90×,180× and 270× fast phase switching in a 4 Channel Modulator.

RUN LED:

This LED will light whenever the FCU loops through a list

FCU Adapter 5.3

Each frequency generating channel of the spectrometer requires its own separate FCU board, with a maximum of 8 channels possible.

A single FCU Adapter is mounted on the front of each pair of boards. This Adapter collects the blanking signals received from the TCU, as well as the MOD, MULT and AT signals generated within the FCU itself, and transmits them to the ASU via the Connector F1 (see *figure 5.1.*). The Adapter, which effectively brings together the outputs of two FCU Boards, is required because two FCU Boards are used to drive a single 2 Channel ASU Board.

Two signals TO/F and OBSF1, generated by the TCU and wired to the FCU are used only in DPX spectrometers.

A three channel spectrometer would contain three FCU boards. A special FCU Montage Kit (P/N H2569) is needed to enable the second FCU Adapter to be mounted. When ordering an upgrade kit to fit a spectrometer with extra FCU Boards it is important to specify which channel is to be added (i.e. channel 3 or 4 etc.) so that the correct cables and ASU etc. is delivered.

Connector F1: *5.3.1*

All TTL signals active low. After reset signals go high by default.

Table 5.3. FCU Connector F1

PIN	Signal (right row)	PIN	Signal (left row)
1			
2		27	
3		28	
4	GND	29	GND
5	MULT1-	30	MULT1+
6	GND	31	GND
7	MOD1-	32	MOD1+
8	AT201	33	GND
9	AT401	34	GND
10	BLK F1 / **BPCH1**	35	GND
11	SPF1 / **TGPCH1**	36	GND
12	OBSF1	37	GND
13	GND	38	GND
14	MULT2-	39	MULT2+
15	GND	40	GND
16	MOD2-	41	MOD2+
17	AT202	42	GND
18	AT402	43	GND
19	BLKF2 / **BPCH2**	44	GND
20	SPF2 / **TGPCH2**	45	GND
21		46	
22		47	

Table 5.3. FCU Connector F1

PIN	Signal (right row)	PIN	Signal (left row)
23	TUNE O/F	48	GND
24		49	
25		50	

Figure 5.1. FCU Front Panel

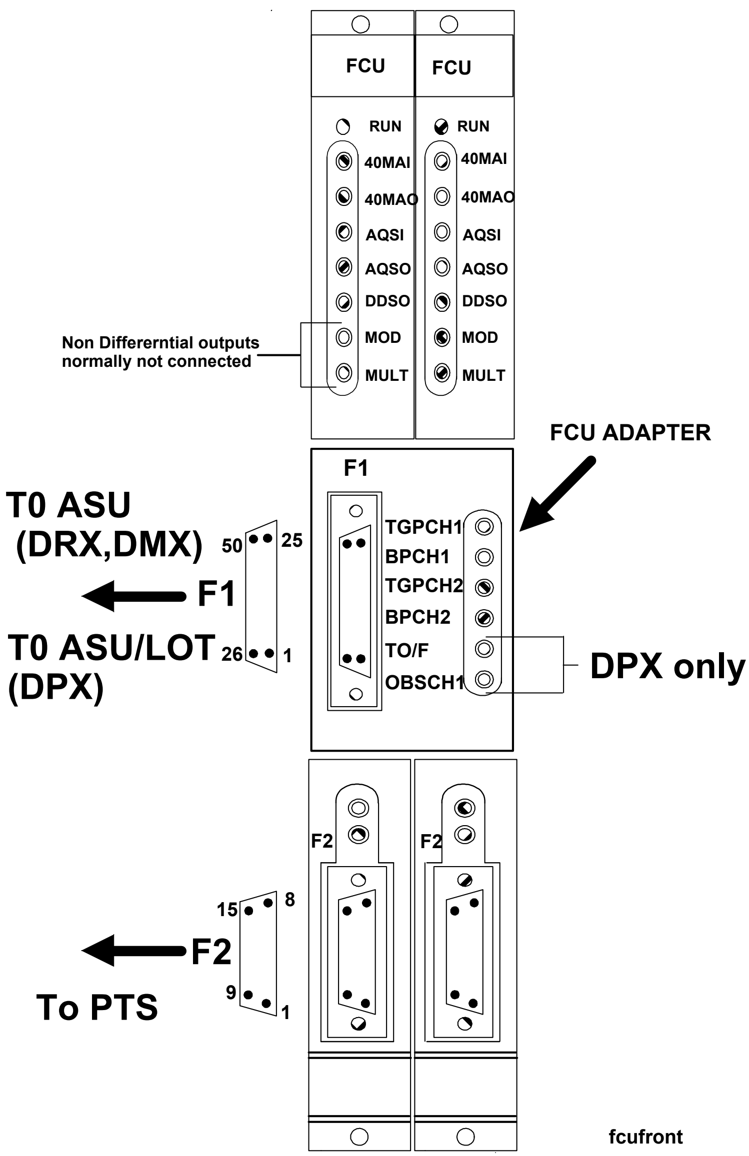


Table 5.4. Comparison of FCU and MCI

FCU	MCI
Separate FCU Board required for each channel, up to a max. of 8 independent rf channels.	Single MCI Board can accommodate up to a max. of 3 independent r.f. channels
Generates no NMR CONTROL WORDS NMR CONTROL WORDS generated by TCU.	Generates NMR CONTROL WORDS
Receiver Gain set by RCU	Sets the Receiver Gain
Connected to TCU via Acquisition Bus and to CCU via VME Bus	Connected directly to Process Controller via 50 way ribbon cable Connected to the Acquisition Controller via A3001 internal bus
Clocked at 40 MHz	Clocked at 20 MHz
DDS Frequency Resolution: 20 MHz/36 bit = 0.0003 Hz	DDS Frequency Resolution: 20 MHz/36 bit = 0.0003 Hz
DDS Phase Resolution: 360^0/14 bit = 0.022^0	DDS Phase Resolution: 360^0/14 bit = 0.022^0
Static RAM:Loaded by VME Bus. Standard: 64K x 32 bit words Option: 256K x 32 bit words Each word comprises of 18 bit data and 14 bit instruction/address Advanced program sequencer 256 Pointer registers 256 Pointers	Static RAM: loaded by internal A3001 Bus Standard:16K x 24 bit words Option:64K x 24 bit words Each word comprises 16 bit data and 8 bit instruction Basic program sequencer 63 Pointer registers 63 Pointers
Min.interval between 2 frequency settings within 1MHz range with constant phase = 100 ns	Min.interval between 2 frequency settings within 1 MHz range with constant phase = 500 ns
Min. interval between 2 phase settings = 50ns	Min. interval between 2 phase settings = 100 ns
MOD/MULT DAC = 12 bit Voltage Range = ± 1 V (50 Ω) Differential	MOD/MULT DAC = 12 bit Voltage Range = 0-2.5V (50 Ω) Non-Differential

FCU Power Supplies 5.4

The FCU is powered from the Backplane and *table 5.5.* lists the various test points. You will need the Extension Board P/N H2066 to check these voltages.

Table 5.5. FCU Power Supply

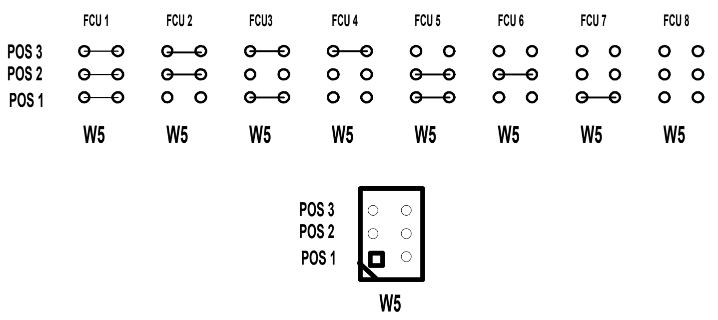
Voltage	Current	Test Point
+ 5V (digital)	3.5 A	ST1: A32,B32,C32
+ 12V	200 mA	ST1: C31
- 12V	300 mA	ST1: A31
+ 5V (analog)	70mA	ST2: C8
- 5V (analog)	330 mA	ST2: C1,C2,C3,C4,C5

Jumper Positions. 5.5

An FCU is designated as FCU 1, FCU 2 etc. depending on the setting of jumpers W5 and not on the position in the AQX32 Rack. Figure 5.2 shows the correct setting of jumper W5 for various FCU Boards.

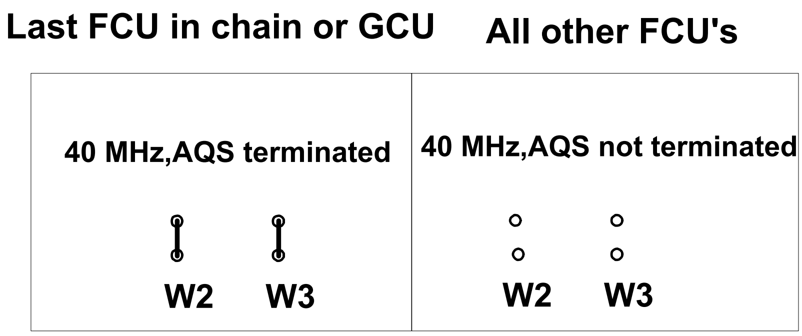
If a spectrometer is being upgraded with additional FCU Boards, or if a board is being exchanged then jumper W5 must be set correctly.

Figure 5.2. Setting of Jumper FCU Jumper W5



To ensure 50 Ohm termination of the 40 MAI/40MAO and AQSI/AQSO signals, jumpers W2 and W3 of the last FCU in the chain should be left in. For all other FCU's jumpers W2 and W3 should be out.

Figure 5.3. Termination of 40 MHz and AQS Signals



Note that if a GCU is installed then this will normally be located as the last link in the 40 MAI/40MAO and AQSI/AQSO signal chain. If this is the case then for all FCU's jumpers W2 and W3 should be out and for the GCU W2 and W3 should be left in.

FCUCHAN *5.6*

Which FCU is to be used for which channel is normally set using the mouse within the „edsp“ or „edasp“ commands.

The relevant software parameter is FCUCHAN. This parameter can be set by hand using the following notation:

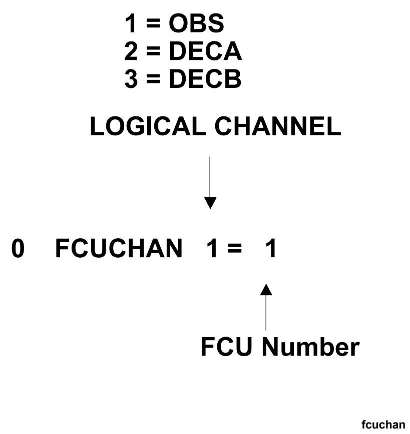
0 FCUCHAN 3= 4

means that FCU number 4 will be used for the logical channel F3.

0 FCUCHAN 4= 5

means that FCU number 5 will be used for the logical channel F4 etc. The default FCUCHAN values can easily be restored by subsequent setting of nuclei with „edsp“ or „edasp“.

Figure 5.4. FCUCHAN



SRAM Memory 5.7

This memory is used to store instructions and data. The information is stored in lists consisting of 32 bit words -14 bit instruction and 18 bit data.

The 14 bit instruction consists of 9 bits instruction itself. Typical instructions might be load MOD, load phase, jump to address xxxx etc. The remaining 5 bits are used to specify the correct destination e.g. MULT DAC or PTS register etc.

The 18 data bits contain the specific values such as frequency values, phase shifts, MOD, MULT and ATT values, etc.

A typical list to produce a shaped pulse might consist of a set of MOD values with or without delays in between. A start signal from the TCU enables the FCU to loop autonomously through the list to produce a digital output corresponding to the required shape. The digital outputs are then loaded in the DAC to produce the analogue MOD output (see ***figure 5.5.***).

Every list stored in the Static RAM must contain a start address which is stored in the pointer register.

Number of pointer registers: Max. of 256

This effectively means that up to 256 lists can be accessed.

Each list requires a pointer.

Number of pointers. Max. of 256

As the FCU loops through a list the current position in the list is incremented. The address of the current position is stored in the pointer.

Two sizes of on board RAM are available:

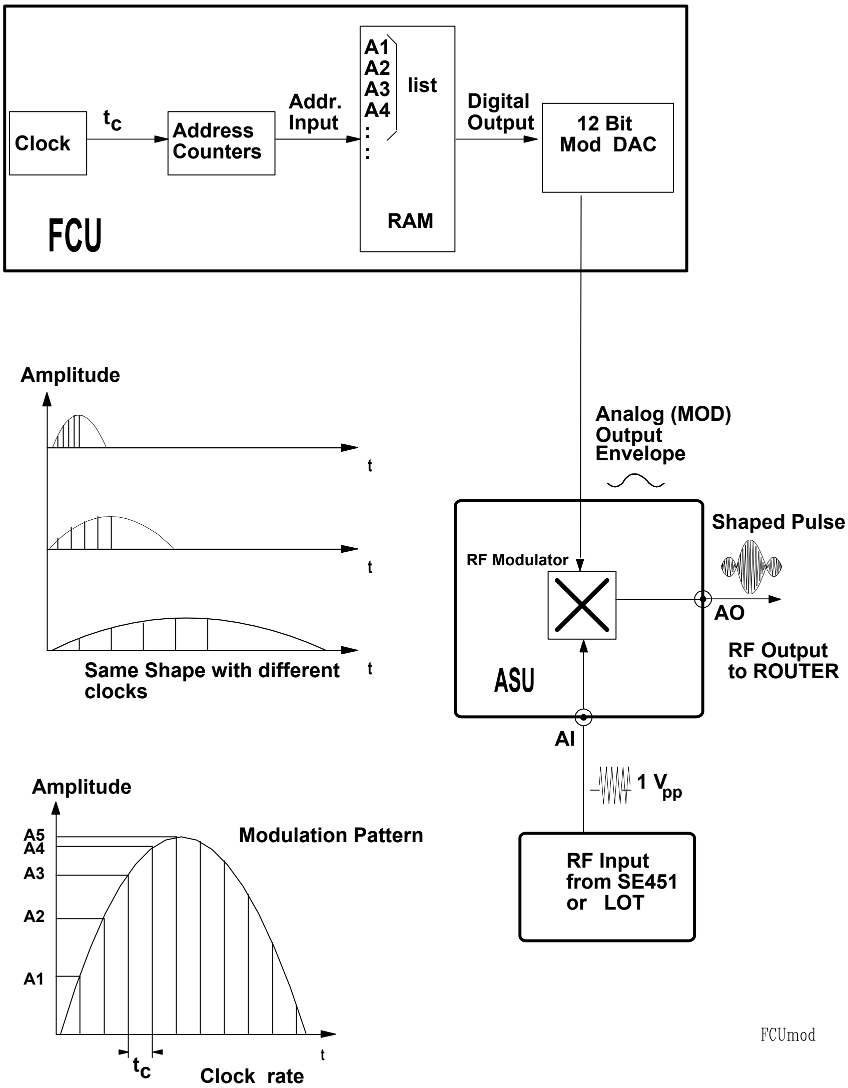
Standard: 64K x 32 bit words

Optional: 256K x 32 bit words.

The FCU Board Part Number depends on the size of the RAM: Standard: 64K (P/N H2556) Optional: 256K (P/N H2564)

NOTE: It is not possible to upgrade from 64K to 256K in the field.

Figure 5.5. DMX/DRX Amplitude Modulation



Duration Generator 5.8

Timing within the FCU is controlled by means of a Duration Generator. This enables the instructions within a list to be implemented independent of the TCU (once the start signal from the TCU is received) The Generator is clocked by 20 MHz.

The minimum duration possible is 50 ns resulting in a minimum time of 50 ns between any two instructions. The FCU has a timing resolution of 25 ns so that durations can have lengths of 50,75,100,125 ns etc.

Table 5.6 contains a list of processes which are carried out by the FCU and the required time to carry out these processes.

Table 5.6. Processes Carried out by the FCU

Operation	Time Taken	Measured At	Comments
Set initial **ampl**.	250 ns	DAC output	Operating under TCU control
Alter **ampl.** setting	100 ns	DAC output	Operating independent of TCU
Set initial **phase**	650 ns	DDS output	Operating under TCU control
Alter **phase** setting	150 ns	DDS output	Operating independent of TCU
Alter **phase** setting	250 ns	DDS output	Operating under TCU control
Set initial **freq.**	770 ns	DDS output	Operating under TCU control
Alter **freq.** setting	200 ns	DDS output	Operating independent of TCU PTS delay not included.

Note that a PTS propagation delay of 2 us is not included.

MOD and MULT DACS 5.9

These DACS are 12 bit with a theoretical dynamic range of 72dB (1:4096) though in practice the full range is not used. For the implementation of the MOD and MULT signals see the Chapter on ASU's.

At the standard differential outputs the generated values of MOD and MULT will always lie in the range of $\pm$ 1V at 50 Ω. A comprehensive list of MULT values for various attenuation levels is listed in Table 6.7

Note: The MULT software control, with the exception of DAC voltage, can be easily checked with the **'cf debug'** command.

Amplitude settling time: 90 ns (incl. OP AMP)

The use of differential voltages for the MOD and MULT control have the following advantages:

a) Less susceptible to interference from clock frequencies such as the 40 MHz used on the FCU.

b) Less susceptible to offsets arising from power supply drifts.

c) Cancelling of induced voltages from 50/60 Hz pick up.

Table 5.7. FCU Power Control

The MULT voltage listed below is the differential voltage as measured between MULT+ and MULT-

Power in dB.	ATT0 40 dB	ATT1 20 dB	Amplitude in%	DAC WORD	MULT Voltage
-6	off	off	199.5	0x5	1.99
-5	off	off	177.8	0xE3	1.77
-4	off	off	158.5	0x1A9	1.58
-3	off	off	141.3	0x25A	1.41
-2	off	off	125.9	0x2F7	1.25
-1	off	off	112.2	0x383	1.12
0	off	off	100.0	0x400	1.00
1	off	off	89.1	0x46F	0.892
2	off	off	79.4	0x4D3	0.794
3	off	off	70.8	0x52B	0.708
4	off	off	63.1	0x57A	0.631
5	off	off	56.2	0x5C0	0.563
6	off	off	50.1	0x5F5	0.501
7	off	off	44.7	0x637	0.446
8	off	off	39.8	0x668	0.398
9	off	off	35.5	0x695	0.355
10	off	off	31.6	0x6BC	0.316
11	off	off	28.2	0x6DF	0.282
12	off	off	25.1	0x6FF	0.251
13	off	off	22.4	0x71B	0.224
14	off	off	20.0	0x734	0.199
15	off	off	17.8	0x74A	0.178
16	off	off	15.8	0x75E	0.158
17	off	off	14.1	0x76F	0.142
18	off	off	12.6	0x77F	0.126
19	off	off	11.2	0x78D	0.112
20	off	off	10.00	0x79A	0.0996

Table 5.7. FCU Power Control

The MULT voltage listed below is the differential voltage as measured between MULT+ and MULT-

Power in dB.	ATT0 40 dB	ATT1 20 dB	Amplitude in%	DAC WORD	MULT Voltage
20.01	off	on	100.0	0x400	1.00
to	off	on	as above	as above.	as above.
40	off	on	11.2	0x78D	0.0996
40.01	on	off	100.0	0x400	1.00
to	on	off	as above	as above.	as above.
60	on	off	11.2	0x78D	0.0996
60.01	on	on	100.0	0x400	1.00
to	on	on	as above	as above.	as above.
80	on	on	11.2	0x78D	0.0996
85	on	on	5.62	0x7C6	0.0566
90	on	on	3.16	0x7E0	0.0313
95	on	on	1.78	0x7EE	0.0176
100	on	on	1.00	0x7F6	0.0098
105	on	on	0.56	0x7FA	0.0059
110	on	on	0.32	0x7FD	0.0029
115	on	on	0.18	0x7FE	0.0020
120	on	on	0.10	0x7FF	0.0010

DDS Connections *5.10*

DRX, DPX:

Two channels of the first PTS620 are used. FCU1 is connected to $F1_{in}$ and FCU2 to $F3_{in}$ of the PTS.

By default FCU1 is always used for F1 and FCU2 for F2 regardless of whether the frequencies are H or X. This is possible because the channels $F1_{in}$ and $F3_{in}$ of the PTS620 are broadband.

DMX:

Three channels of the first PTS620 are used. FCU1 is connected to $F1_{in}$, FCU2 to $F2_{in,}$ and FCU3 to $F3_{in}$ of the PTS.

The $F2_{in}$ channel of the PTS contains a triple mixer to generate magnet specific 1H frequencies suitable for further mixing in the SE451. The only input requirement for this channel is the 3-4 MHz DDS signal. This enables a third channel to be used within the PTS620. The first 1H frequency is by default generated by FCU2 regardless of whether it is F1 or F2. By default FCU1 is used for F1, only when it is an X frequency

DDS Specifications 5.11

The DDS units used by the FCU are identical to those used in the MCI.

Frequency Range: 0 - 10 MHz.

Used Range: 3 - 4 MHz

Frequency Stability: This is set by the stability of the PTS 10 MHz crystal oscillator which is specified to 3 $x10^{-9}$/day.

Frequency Resolution: The DDS unit is clocked by 20 MHz and the frequency setting is stored in a 36 bit register

$\Rightarrow$20 MHz/2^{36} = 0.0003 Hz.

Phase Resolution: A 14 bit register is used to store phase values.

$\Rightarrow$ 360°/2^{14} = 0.022°

Phase Settling Time: 50 ns.

Connector F2 5.12

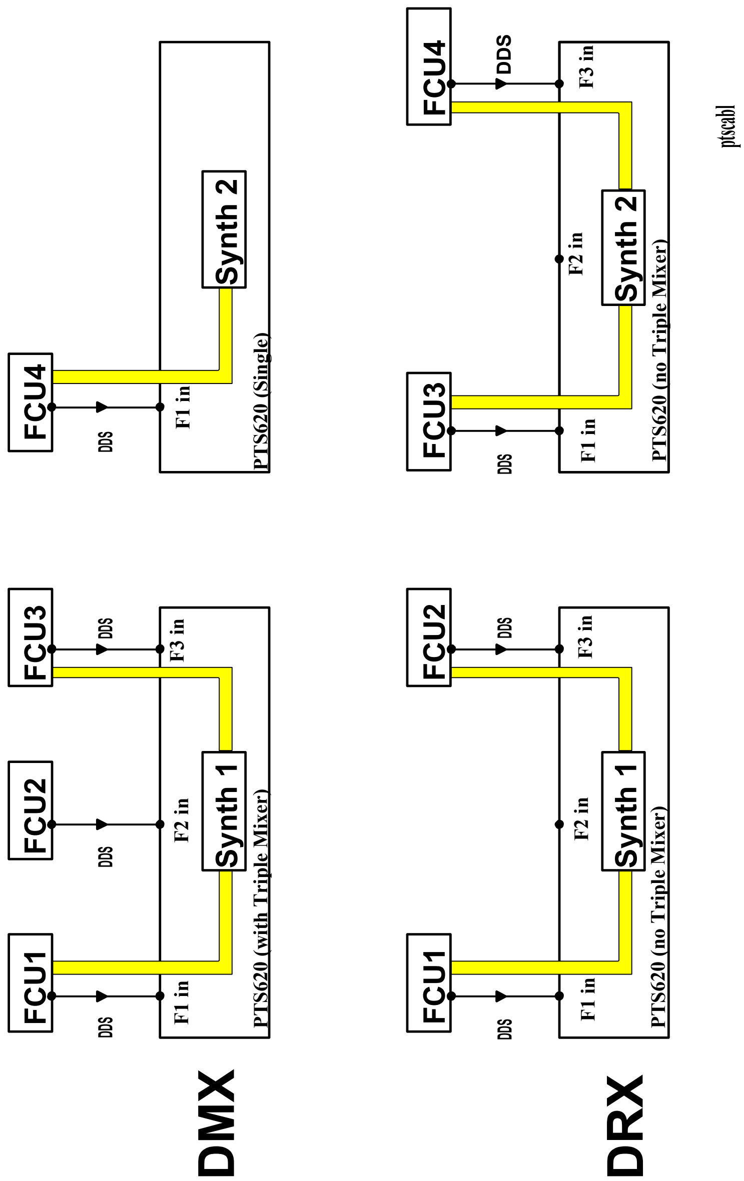
All signals active low except PTS doubling command.

After reset all signals go high by default.

The pin assignments of connector F2 is detailed in the table below.

These signals are used to set the final output of the PTS 620. Unlike the MCI these signals can be measured at the FCU output without the requirement that the PTS620 is connected. A simple way to check if the PTS control is operating in DRX/DPX instruments is to run a series of short acquisitions. The F_1 of the PTS will then switch rapidly from the SFO1 to SFO1 +22 MHz. This will cause some of bits transmitted through connector F2 to switch rapidly. The switching should be synchronized with the acquisition so that the EP_HPPR is a handy triggering signal. To observe the PTS control in DMX instruments a frequency list can be looped through or alternatively the bit settings can be viewed during the wobble routine

Figure 5.6. Cabling of PTS



Note that the signal FDBL is the doubling signal which is active whenever the PTS 620 output is above 287 MHz. Thus for DRX/DPX spectrometers, the doubling signal is required for 1H frequencies at and above 300 MHz and not required for X frequencies. For DMX spectrometers the mixing of frequencies with 440 MHz in the SE451 means that the PTS doubler is not used for proton frequencies up to and including 600 MHz.For very low frequencies e.g. sfo1 = 50 MHz i.e PTS output = 390 MHz the doubler will be used.

For the DMX 750 a PTS 1000 is used with the frequency doubler switched in at 500 MHz.

The signal **REN** is the „Remote Enable“ signal which is normally tied to ground.

Table 5.8. FCU Connector F2

PIN	Signal
1	FDBL
2	1 MHz
3	2 MHz
4	4 MHz
5	8 MHz
6	10 MHz
7	20 MHz
8	40 MHz
9	80 MHz
10	REN (GND)
11	100 MHz
12	200 MHz
13	400 MHz
14	800 MHz
15	GND

For the Pin Numbering (see *figure 5.1.*)

PTS Bit settings *5.13*

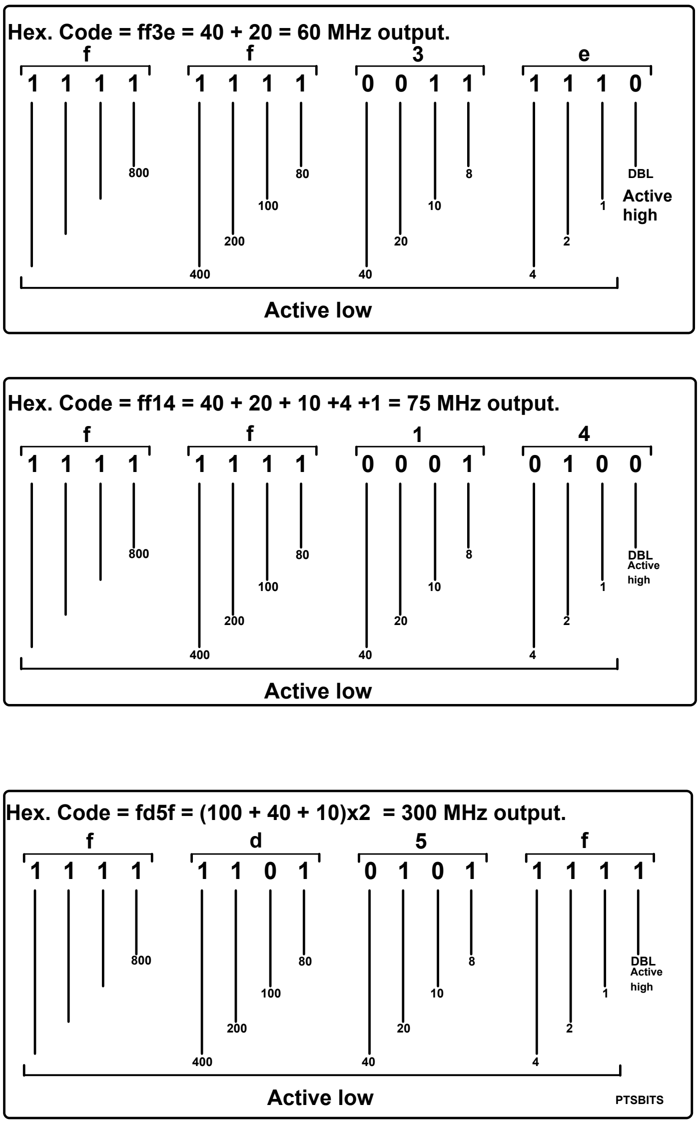
The software setting of the PTS output frequency can be easily checked. After setting the frequency in UXNMR the command „gotst“ will generate the file „shm.output“ in the user's home directory. This file contains the entry CONT FREQLD which is the PTS bit settings in hex. code. Alternatively the hex. code may be checked with the „cf **debug**“ routine where it is stored as the parameter PTS Control Word.

In *figure 5.7.* are listed three examples of the hex. code for PTS output frequencies of 60, 75 and 300 MHz respectively. Remember that the PTS output is equal to the set frequency only for DRX/DPX spectrometers. For DMX spectrometers the PTS output is given by SF $\pm$ 440 MHz.

Software Diagnostic Test 5.14

A useful test program is entitled „fcutest“ which is normally in the directory **/u/systest/fcu**.

Figure 5.7. PTS Bit Settings



PTS 620 6

Type: PTS D 620 Q0020 (P/N O0573)

DDS Connections 6.1

DRX/DPX:

Two channels of the first PTS620 are used. FCU1 is connected to $F1_{in}$ and FCU2 to $F3_{in}$ of the PTS.

By default FCU1 is always used for OBSF1 and FCU2 for DECNUC regardless of whether the frequencies are H or X. This is possible because the channels F1 and F3 of the PTS620 are broadband.

DMX:

Three channels of the first PTS620 are used. FCU1 is connected to $F1_{in}$, FCU2 to $F2_{in}$ and FCU3 to $F3_{in}$ of the PTS.

The F2 channel of the PTS contains a triple mixer to generate magnet specific 1H frequencies suitable for further mixing in the SE451. The only input requirement for this channel is the 3-4 MHz. DDS signal. This enables a third channel to be used within the PTS620. **The first 1H frequency is by default generated by FCU2 regardless of whether it is OBS or DEC. By default FCU1 is used for OBSF1, only when it is an X frequency.**

Outputs 6.2

Range:	1-620 MHz	F1 and F3
	1H frequency ± 0.5MHz	F2
Output amplitude:	+ 4 dBm	(1Vpp at 50Ω).
Frequency Control:	Remote by TTL level.	F1 and F3
Switching time:	20µs	100 MHz digit:
	5 µs	10/ 1 MHz digit:
Transmit\Receive switching time;	<5µs	DRX/DPX
	<2µs	DMX
Aux. outputs:	5 x 10 MHz	+ 4 dBm
	1 x 22 MHz	+ 4 dBm
	1 x 80 MHz	0 dBm (0·65 Vpp at 50Ω)

Inputs 6.3

DDSCH1,2,3: 3-4 MHz 1Vpp at 50Ω

Freq. Resolution: 0·0003 Hz

Phase Resolution: 0·022°

Synth1 Pinouts 6.4

Table 6.1. SYNTH1 Pin Assignment

For corresponding Pinouts of the FCU see table 5.8..

BIT	F1 Channel	F3 Channel	Active
200 MHz	Pin 44	Pin 6	Low
100 MHz	Pin 43	Pin 5	Low
80 MHz	Pin 41	Pin 33	Low
40 MHz	Pin 40	Pin 32	Low
20 MHz	Pin 16	Pin 8	Low
10 MHz	Pin 15	Pin 7	Low
8 MHz	Pin 20	Pin 35	Low
4 MHz	Pin 19	Pin 34Pin	Low
2 MHz	Pin 18	Pin 10	Low
1 MHz	Pin 17	Pin 9	Low
FDBL	Pin 39	Pin 13	High
REN	Pin 42	Pin 42	Low

Overview 6.5

The PTS620 produces the required RF frequency on two identical broadband channels F1 and F3. Each channel produces frequencies in the range of 1 MHz - 310 MHz, but with the aid of a frequency doubler at the final output, this range is extended to 1 MHz - 620 MHz.

In the DRX or DPX there is no subsequent mixing of frequencies in a SE451 type TFX or TFH unit. The PTS620 generates the final RF frequencies SFO1 and SFO2

In the DMX there is subsequent mixing of frequencies in the SE451. For the OBS and DECNUC frequencies the PTS output is given by SF ± 440MHz. The third rf frequency DECNUCB is generated directly.

The fine resolution of the RF output is achieved by mixing frequencies generated internally in the PTS with signals (DDSCH1, DDSCH2) generated by Direct Digital Synthesis in the FCU. In this way a frequency resolution of 0·0003 Hz and phase resolution of 0·022° is achieved. The switching time between frequencies however is limited to that of the PTS.

Abbreviations:

SGA, SGB: Standard Generators A and B

DMA: Digit Module A

IA: Input amplifier.

OA: Output amplifier

IM: Intermediate Mixer

SO: Switched Oscillator

Units *6.6*

For the following section please refer to ***figure 6.2.***.

Crystal Oscillator:

Produces a 10 MHz signal to a very high degree of accuracy (stability 3 x 10^{-9}/ day). This signal acts as a reference standard for all frequencies generated within the PTS.

SGA, SGB:

uses the 10 MHz reference to generate the following frequencies 112, 113, 14, 16, 18, 20 and 22 MHz. Of particular importance is the 18 MHz signal. The SGA module also produces signals of frequency (nx10) MHz where n is any integer from 1 to 16.

Mixer:

In this module the 3-4 MHz is mixed with 18 MHz to give frequencies in the 14-15 MHz range. The DMA unit requires inputs of 14-15 MHz. It is in the mixer that the fine resolution of the RF output is entered.

DMA:

This unit adds the required number of 1 MHz steps to the frequency. It also adds a carrier frequency so that the DMA output frequency always lies in the 140-150 MHz range.

IM, SO, IA, OA:

These modules combine to perform the following functions.

1. Addition of the selected 10 MHz steps
2. Output amplification and level control
3. Doubling of frequencies above 310 MHz and filtering of harmonics.

1. The final RF output frequency is given by the formula:

   RF freq = output DMA freq + (n x 10 MHz)

   where n may have integer values -14 to +16.

MINIMUM frequency = 140 - 140 = 0 MHz (output amplifier limits this to 1 MHz)

MAXIMUM frequency = 150 + 160 = 310 MHz

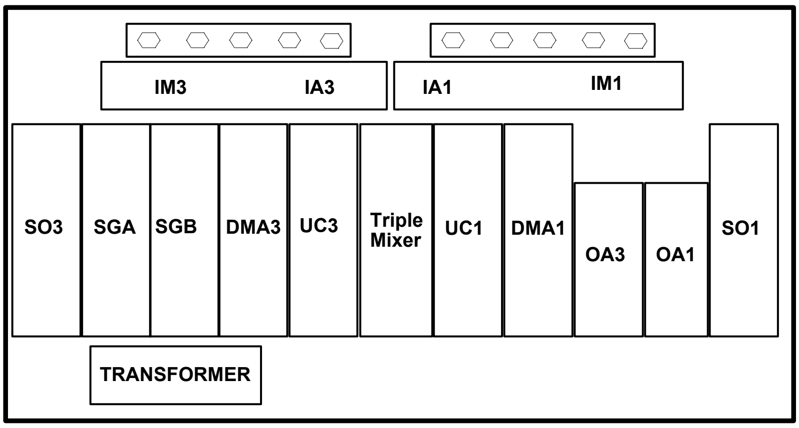
2. Level control is achieved through a feedback loop in the IM module.
3. In the OA module two possible routes may be taken depending on whether the selected frequency is above or below 310 MHz. The routing is controlled by the doubling commands dblF1 and dblF3.

Note: In DRX and DPX spectrometers a 22 MHz IF is used. It is better when the SFO1 and the LO always use the same path i.e. they are both doubled or neither is doubled. To ensure this, the software is programmed to switch in the doubler at SFO1 = 287 MHz. All frequencies below 287 MHz have a corresponding LO below 309 MHz which means that the doubler need not be used. Frequencies above 287 MHz have an LO above 309 MHz and so both the SFO1 and the LO are switched through the doubler.

Interface, AP:

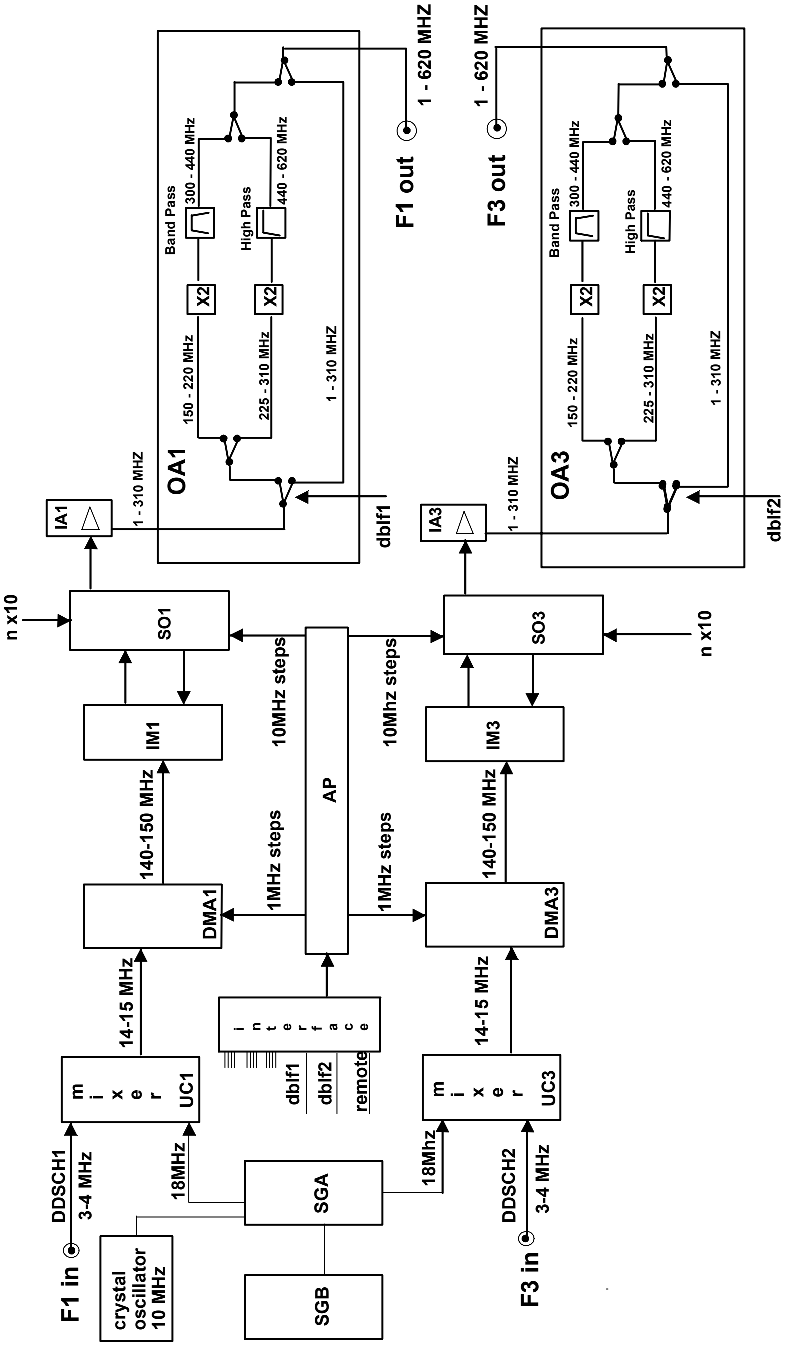
The information containing the frequency settings is ported via the interface to the AP. This module sends appropriate frequency settings to various modules. The 1 MHz step information is sent to the DMA module. The 10 MHz information is sent to the SO module.

Figure 6.1. PTS 620 as seen from above



pts

Figure 6.2. PTS 620 Block Diagram



Trouble shooting 6.7

1. As the two channels F1 and F3 in the PTS620 are identical, you can swap input offset signals i.e. replace "F3 in" with "F1 in" (Set SF01 = SF02). This is useful when trying to establish if a problem is internal or due to incorrect FCU offsets. Furthermore you can interchange modules between the two channels to locate the source of a problem.

2. Checking the frequency of DDSCH1 / DDSCH2

Note that the description below is valid if doubler is not used.

SF01/SF02 = XXX·abcdefg

=> DDSCH1/DDSCH2 = 4·0000000 - 0·abcdefg MHz

eg. observe X nucleus

SF01 = 75·2345678 MHz => DDSCH1 = 3·7654322 MHz

SF01= 150·5124736 MHz => DDSCH1 = 3·4875264 MHz

eg. observe 1H nucleus

SF01 = 300·0000000 MHz => DDSCH2 = 4·0000000 MHz

SF01 = 500·1300000 MHz => DDSCH2 = 3·8700000 MHz

3. Two potentiometers are available with which the output voltages may be adjusted.

   "F3 out" may be adjusted by means of the potentiometer located immediately to the right of the synth1 socket. To adjust the amplitude of "F1 out" it is necessary to open the PTS and adjust the potentiometer located under the OA1 module.

4. Checking the frequency setting:

As mentioned in the Chapter on FCU's it is much simpler to measure the bit settings at the FCU output connector F2 rather than at the Synth1 input.

Adding extra channels *6.8*

DMX:

The first PTS620 will provide three frequencies as long as at least one frequency is proton. The addition of a fourth channel will require a second PTS.

DRX:

The first PTS 620 will provide a max. of two channels. The addition of a third channel will require a second PTS 620.

DPX:

The DPX may be configured with a max of two channels.

When a single extra channel is to be added then a single channel PTS is available. This PTS is fitted

a) **without** the internal time base (10 MHz)

b) **without** 22 MHz and 80 MHz outputs.

c) **with** 5 x 10 MHz outputs.

When two additional channels are to be added then a standard dual channel PTS 620 will be supplied.

The additional PTS units are referenced to an external 10 MHz source taken from the first PTS 620 and in this way the two synthesisers are synchronised.

Note: Always choose 10/5 for the 10MHz input to the LO Board of the SE451 as this PTS output is particularly spurious free.

Figure 6.3. Cabling of the PTS in DRX Spectrometers

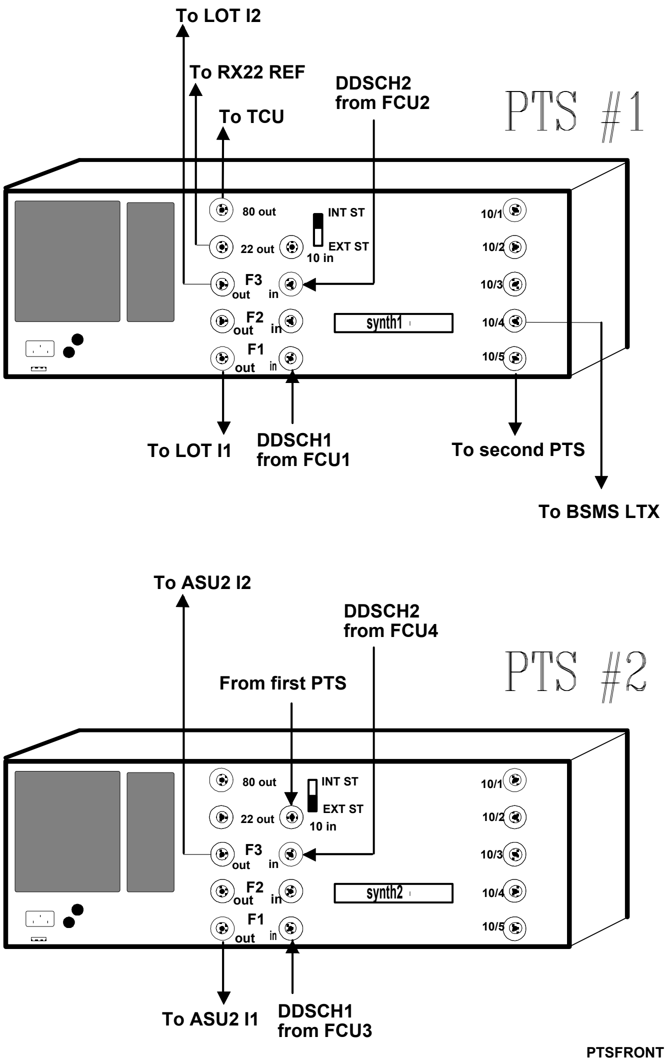
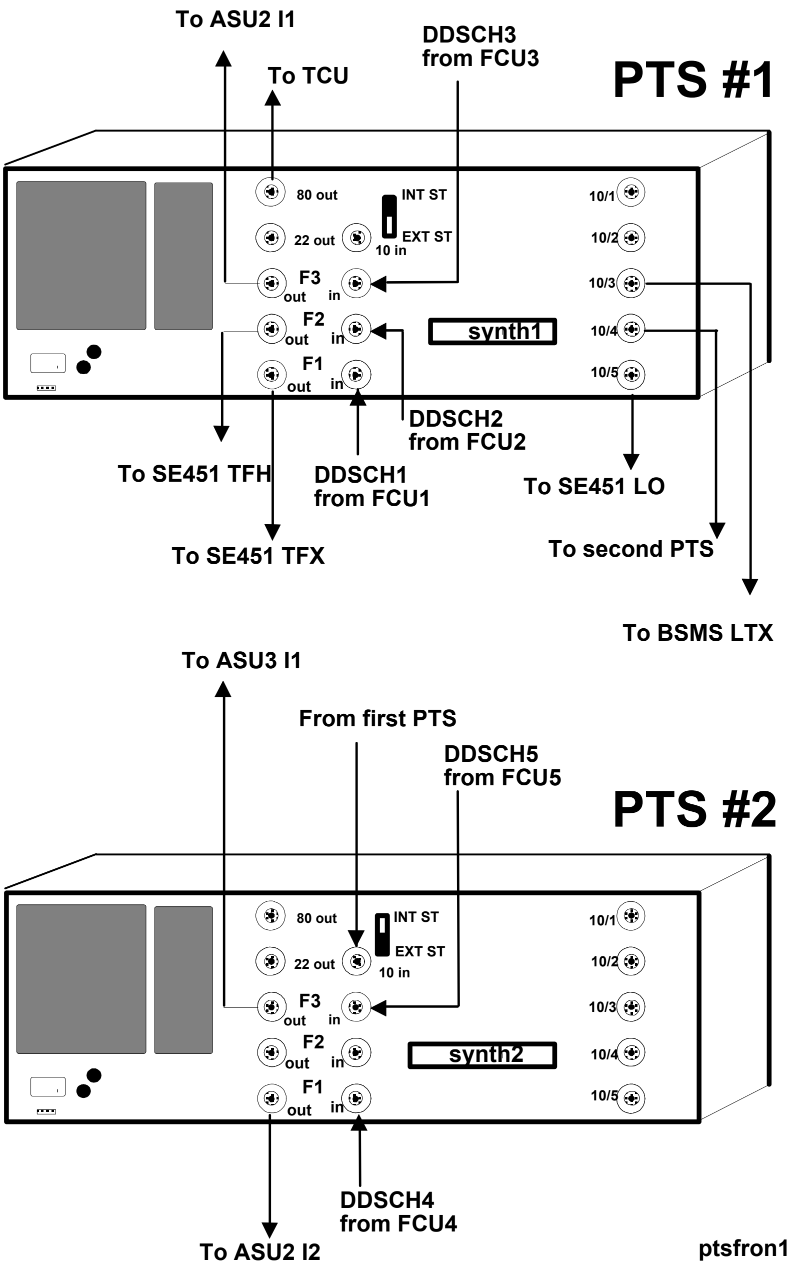


Figure 6.4. Cabling of PTS in DMX Spectrometers



LOT Board 7

The LOT Board (Local Oscillator and Tune Board P/N W1301855) is system frequency independent and used exclusively in DRX spectrometers. The LOT Board is a switching device using FET (GaAs) NE630D components with a switching speed of 20 ns.

A variation of this board, the LOT/ASU (W1301854) is used in DPX spectrometers. The DPX Board combines the T/R switching, the wobble routine and the MULT, ATT functions in one board (The MOD function however is not provided due to space limitations). For the purposes of this manual the LOT Board and the ASU Boards will be described separately.

Functions 7.1

1. To implement the T/R switching on the observe channel.
2. To provide a "tune out" and "LO" signal for the wobble routine.

1. T/R switching:

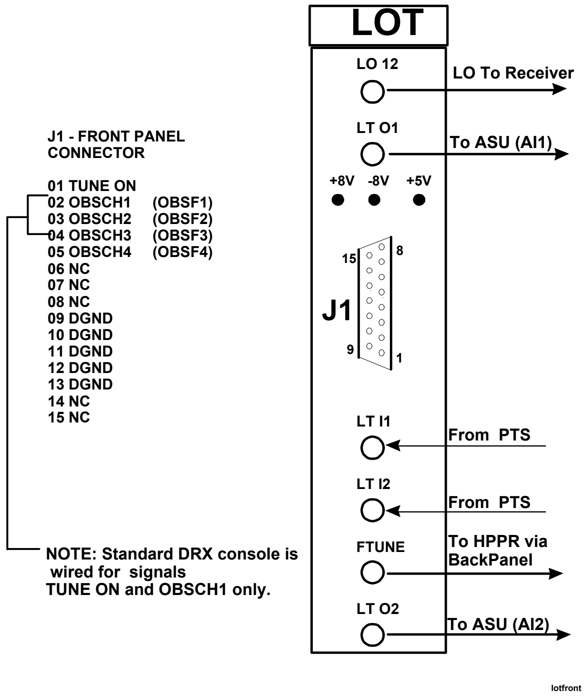
During the **transmit** mode (see *figure 7.2.*) up to two rf inputs (LTI1, LTI2), are connected directly to two corresponding outputs (LTO1, LTO2). In this mode the LOT Board simply lets the rf signals through.

In the **receive** mode the frequency of the rf signal of the observe channel is switched to the LO frequency and redirected to the receiver via the output LO12. The timing of the T/R switching is controlled by means of the RGP (EP) pulse. The LO frequency always has the value SFO1 + 22 MHz. The 22 MHz is added to the SFO1 frequency within the PTS 620. This effectively introduces a switching delay(<5ms). Since DE = 4.5ms by default, the T/R switching has an effect (if any) on the first digitised point only. Note that should the first point be critical then the default DE can be extended.

2. Wobble Routine:

The RF path used by the wobble routine is illustrated in *figure 7.4.*. Note that the LOT hardware is such that Channel 2 is always used to provide the "FTUNE" output.

Figure 7.1. LOT Front Panel



Signals 7.2

OBSCH1, OBSCH2, OBSCH3, OBSCH4:

(OBSF1, OBSF2, OBSF3, OBSF4:)

These signals are generated by the TCU (NMRWORD2 Bits 11,12,13,14) and are active low. They can be used to determine which of the LOT channels is to be used as the source of the LO signal. Since DRX spectrometers in normal mode always use the F1 channel to carry the observe frequency, the signal OBSCH1 is the signal that needs to be correctly set. This signal will automatically be set low once an observe nucleus has been selected in the "edasp" or "edsp" menus and the corresponding interface initialised. The signal will reset high after the "stop" command has been entered or when a hardware reset of the CCU is carried out. (For TCU Boards up to and including Layout C, the pull-up resistors are not mounted on the TCU T4 outputs and so the signal should be checked on the LOT Board itself and not at the TCU output.)

The signal OBSCH2 (OBSF2) allows for the possibility of using the second rf input (LT I2) as the source of the LO signal .This option is normally not used .

The signals OBSCH3 (OBSF3) and OBSCH4 (OBSF4) are not used at present . They allow for the possibility of using the LOT Board to carry up to 4 rf frequencies. This option may be implemented in the future for example to switch the observe nucleus <u>during</u> an experiment.

Table 7.1. Truth Table to Select LO Sources

OBSCH1	OBSCH2	LO Sources
0	0	CH1
1	0	CH2
0	1	CH1
1	1	None

NOTE1:

For the standard LOT Board only signals OBSCH1 and TUNE ON are actually connected in the console wiring.

NOTE2:

In **DMX** spectrometers the signal OBSCH1 is used to select either the H or X channel as the observe channel in the SE451. In the new 19 inch SE451 (3 channel capability) signals OBSCH1, OBSCH2 and OBSCH3 will be used to select the observe channel.

RGP (EP):

This signal, as measured on the board itself, is low for the duration of the acquisition (receiver open) and high at all other times. The RGP (EP) signal, originates in the RCU and is transmitted to the SADC via the 50 pin cable. From here it is connected to the LOT Board via the back panel.

PAL LOT 1 (EP610):

In DRX spectrometers the chief functions of this Pal are to produce the F1>LO and BLKLO signals.

F1>LO :

This signal is used to implement the T/R switching on the F1 channel . It is produced by combining the RGP (EP) and OBSCH1 signals. The signal is high during transmission but goes low for the duration of the acquisition.

BLKLO:

This signal is used to blank the LO12 output to the receiver . The signal is active high for the duration of the acquisition.

TUNE ON (OFF):

This signal is produced by the TCU (NMRWORD2 Bit10). It is active low and set whenever the "wobb" command is entered.

TGPENAB (SPENAB):

This signal is not actually used on the LOT Board but can be measured on the board at the backpanel connection. The signal is low during rf transmission. After a power down from the BSMS keyboard the signal goes high.

Power Supply:

The LOT Board is powered from the back panel via connector J1. The same power supply board (W4P31377) is used for both the LOT and the ASU Boards.

Figure 7.2. Transmission Mode

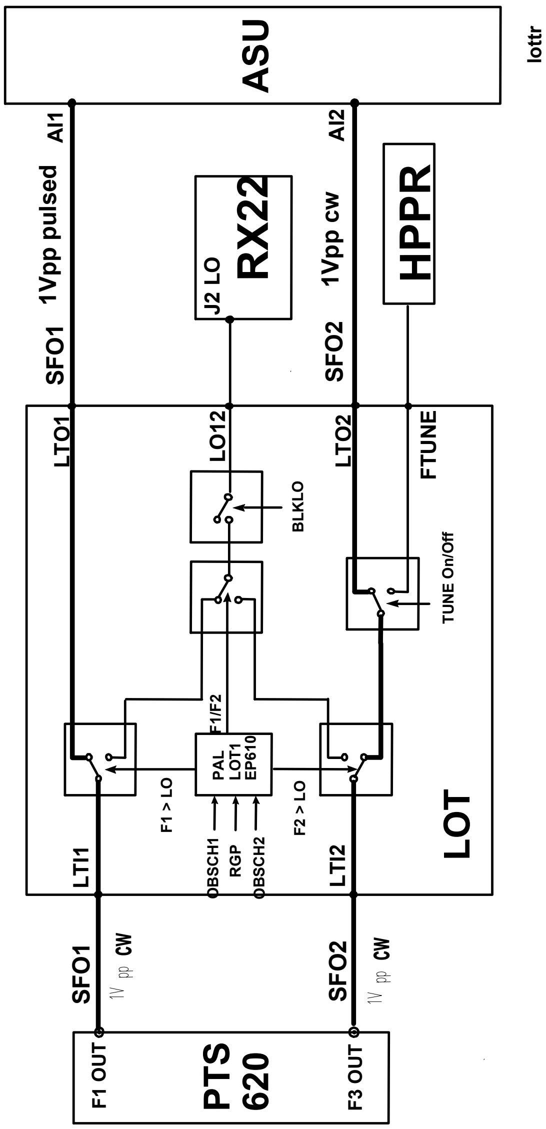


Figure 7.3. Receive Mode

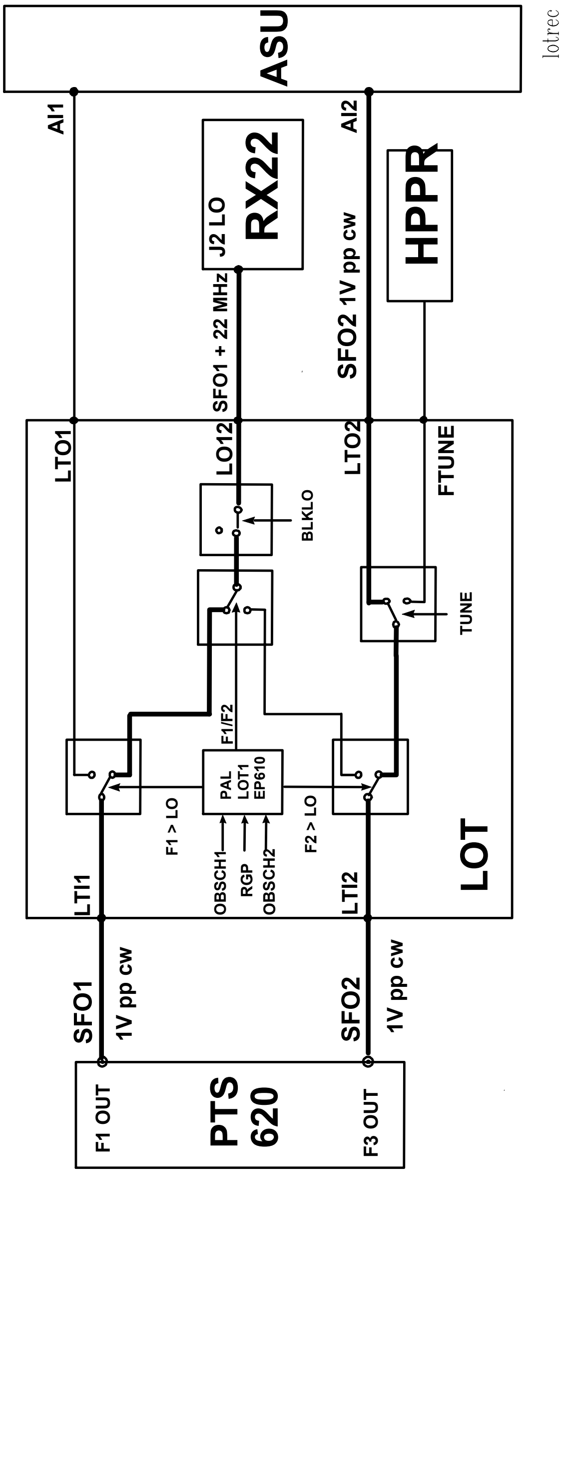
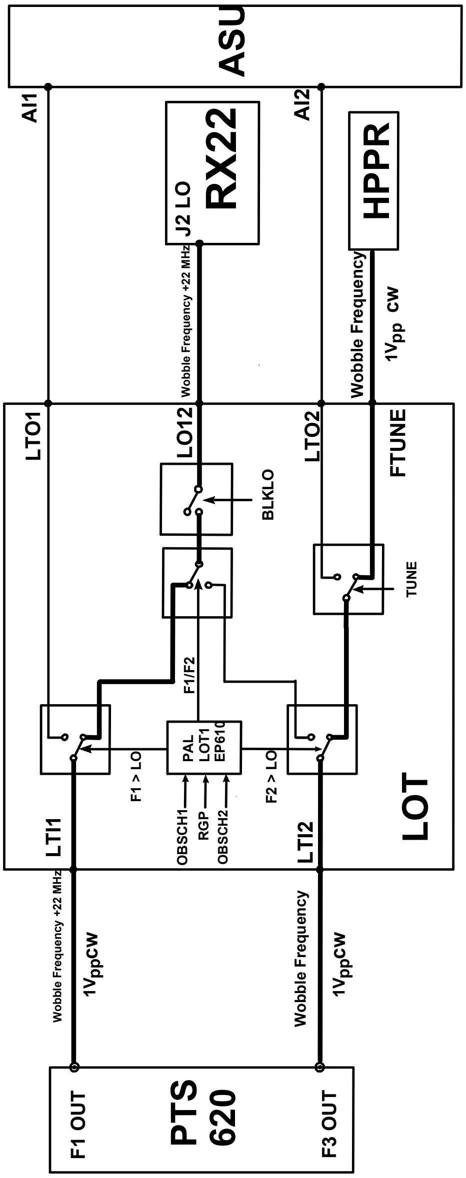


Figure 7.4. Wobble Mode



ASU: Amplitude Setting Unit 8

Functions 8.1

1. To set the amplitude of up to two rf signals using the MOD, MULT, AT20 and AT40 signals.
2. To blank the rf signal using the TGPCH and BPCH signals

The ASU performs functions which in AMX and ARX spectrometers were carried out internally within the transmitters themselves. The AVANCE amplifiers now serve as pure amplifiers, they carry out no power regulation or setting. The final output of the BLAX300, BLAXH40 etc. will be a linear function of the rf input intensity.

The ASU board is system frequency independent up to 600 MHz and compatible with all of the new range of linear amplifiers BLARH100, BLAX300, BLAXH50 etc. (The 750 MHz DMX uses the same ASU board with selected components to extend the bandwidth to 750 MHz.). There is no distinction between ASU boards for DRX and DMX spectrometers. The DPX spectrometer however uses a dual purpose ASU/LOT board without the MOD section. For this reason shaped pulses are not possible with DPX spectrometers.

Standard ASU boards are capable of independently setting the amplitude of two rf channels. The input rf signals (AI1, AI2) have a maximum intensity of $1V_{PP}$ (4dBm at 50W). These inputs come from either the SE451 (DMX) or LOT board (DRX).

Where more than 2 rf channels are used*, then a second ASU board must be fitted.Three channel spectrometers are fitted with a single channel ASU (P/N W1301853). Four channel spectrometers simply use a second standard 2 channel ASU (P/N W1301852) The third and fourth rf input signals are taken directly from the respective PTS outputs.

*Note that the DPX spectrometer has a maximum of 2 channels.

The ASU receives the MOD, MULT, AT20, AT40 and various blanking signals from the FCU via the 50 pin SCSCI Type front panel connector (***table 8.1.***).Note that the connection to the FCU is one to one.

Figure 8.1. 2 Channel ASU Front Panel

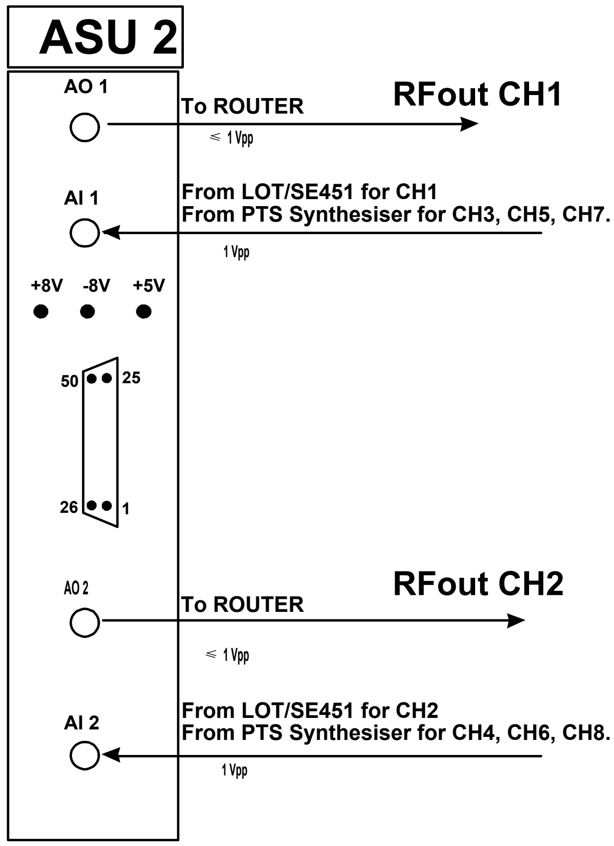


Table 8.1. Front Panel Connector of 2 Channel ASU

Pin	Signal	Pin	Signal
01	NC	26	NC
02	NC	27	NC
03	NC	28	NC
04	AGND	29	AGND

Table 8.1. Front Panel Connector of 2 Channel ASU

Pin	Signal	Pin	Signal
05	MULT1-	30	MULT1+
06	AGND	31	AGND
07	MOD1-	32	MOD1+
08	AT201	33	DGND
09	AT401	34	DGND
10	BLKF1/**BPCH1**	35	DGND
11	SPF1/**TGPCH1**	36	DGND
12	NC	37	DGND
13	AGND	38	AGND
14	MULT2-	39	MULT2+
15	AGND	40	AGND
16	MOD2-	41	MOD2+
17	AT202	42	DGND
18	AT402	43	DGND
19	BLKF2/**BPCH2**	44	DGND
20	SPF2/**TGPCH2**	45	DGND
21	NC	46	DGND
22	NC	47	DGND
23	NC	48	DGND
24	NC	49	DGND
25	NC	50	DGND

Signals *8.2*

MULT:

The fine power control of rectangular pulses is now implemented solely using the MULT voltages. The MOD signal, which in AMX and ARX spectrometers accounted for two thirds of the attenuation, is no longer used for rectangular pulses. The ***table 8.2.*** lists the variation of the differential MULT voltages for the full range of attenuation values.

Table 8.2. FCU Power Control

The MULT voltage listed above is the differential voltage as measured between MULT+ and MULT-.

Power in dB	ATT0 40 dB	ATT1 20 dB	Amplitude in %	DAC Word	MULT Voltage
-6	off	off	199.5	0x5	1.99
-5	off	off	177.8	0xE3	1.77
-4	off	off	158.5	0x1A9	1.58
-3	off	off	141.3	0x25A	1.41
-2	off	off	125.9	0x2F7	1.25
-1	off	off	112.2	0x383	1.12
0	off	off	100.0	0x400	1.00
1	off	off	89.1	0x46F	0.892
2	off	off	79.4	0x4D3	0.794
3	off	off	70.8	0x52B	0.708
4	off	off	63.1	0x57A	0.631
5	off	off	56.2	0x5C0	0.563
6	off	off	50.1	0x5F5	0.501
7	off	off	44.7	0x637	0.446
8	off	off	39.8	0x668	0.398
9	off	off	35.5	0x695	0.355
10	off	off	31.6	0x6BC	0.316
11	off	off	28.2	0x6DF	0.282
12	off	off	25.1	0x6FF	0.251
13	off	off	22.4	0x71B	0.224
14	off	off	20.0	0x734	0.199
15	off	off	17.8	0x74A	0.178
16	off	off	15.8	0x75E	0.158
17	off	off	14.1	0x76F	0.142
18	off	off	12.6	0x77F	0.126
19	off	off	11.2	0x78D	0.112
20	off	off	10.00	0x79A	0.0996

Table 8.2. FCU Power Control

The MULT voltage listed above is the differential voltage as measured between MULT+ and MULT-.

Power in dB	ATT0 40 dB	ATT1 20 dB	Amplitude in %	DAC Word	MULT Voltage
20.01	off	on	100.0	0x400	1.00
to	off	on	as above	as above.	as above.
40	off	on	11.2	0x78D	0.0996
40.01	on	off	100.0	0x400	1.00
to	on	off	as above	as above.	as above.
60	on	off	11.2	0x78D	0.0996
60.01	on	on	100.0	0x400	1.00
to	on	on	as above	as above.	as above.
80	on	on	11.2	0x78D	0.0996
85	on	on	5.62	0x7C6	0.0566
90	on	on	3.16	0x7E0	0.0313
95	on	on	1.78	0x7EE	0.0176
100	on	on	1.00	0x7F6	0.0098
105	on	on	0.56	0x7FA	0.0059
110	on	on	0.32	0x7FD	0.0029
115	on	on	0.18	0x7FE	0.0020
120	on	on	0.10	0x7FF	0.0010

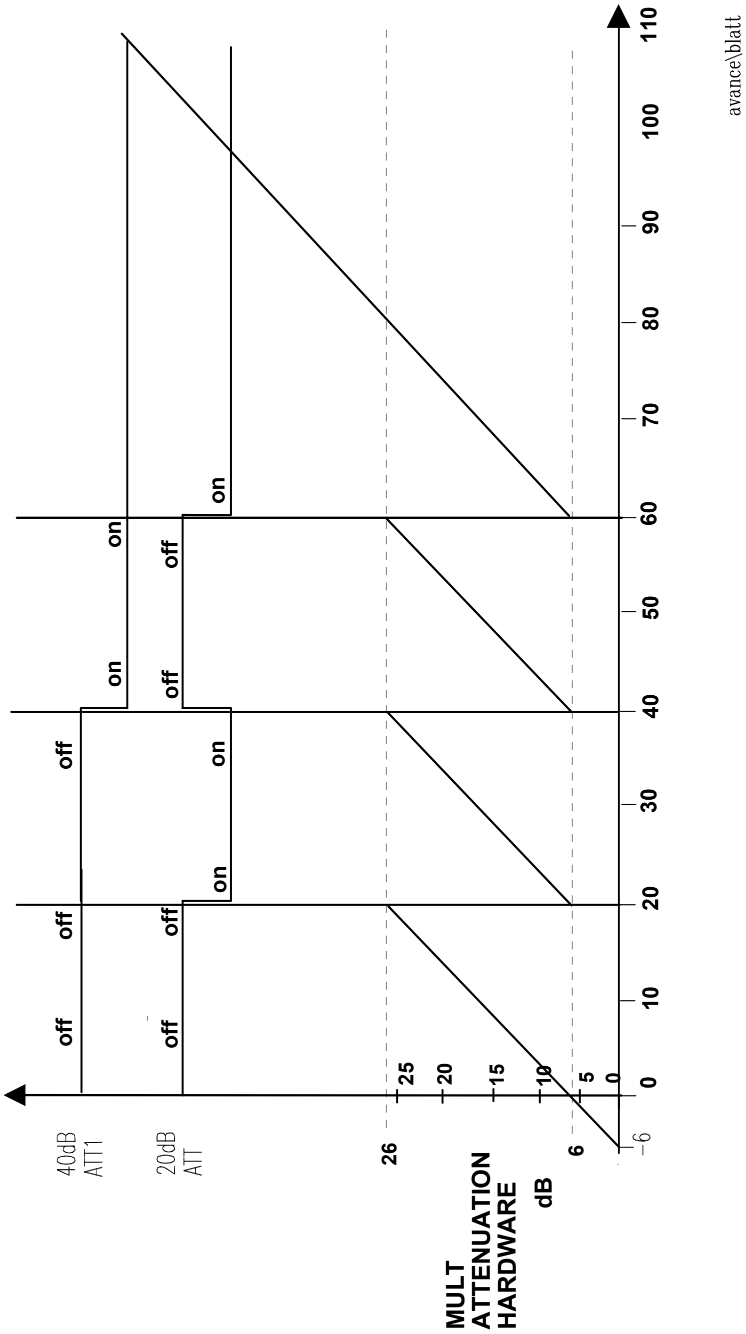
In ARX and AMX transmitters a PAS-2 switch was used to implement the MULT control. To correct for non-linearity, a correction factor had to be applied. In the ASU the PAS-2 switch has been replaced by an analogue multiplier, with a far higher degree of linearity. Other improvements are the switching speed as well as the phase linearity and blanking control. The ***table 8.3.*** summarizes the difference between the previously used PAS-2 and the analogue multipliers which are now used

Table 8.3. Difference between the previously used PAS-2 and the current Analog Multipliers

MULT	Analog Multipliers	PAS-2
Used in	AVANCE Spectrometers e.g. ASU,ASU/LOT	BSV10,BLT4,BLTX300 Ecou-pler etc.
Used Freq. Range	5 - 800 MHz	5 - 600 MHz
Control Voltage Range	Differential ± 1V	Non - Differential 0 - 2.5V
Control Voltage source	FCU	MCI
Max. Attenuation Range	50 dB	35 dB
Linear Range	50 dB (500 MHz) 45 dB (600 MHz) 30 dB (750 MHz)	32 dB (500 MHz) 30 dB (600 MHz)
Used Range for rectangular pulses up to 80 dB.	6 -26 dB	0 - 10 dB
Min. Resolution	0.07dB	
Amplitude Linearity	Requires no correction factor	Requires correction factor
Phase Shifts (without CORTAB)	Typically ±5° over 30 dB range	Typically ±15° over 30 dB range
Switching Speed	70 ns	5 - 10 µs
Blanking	by TGPCH signal	None

The minimum MULT attenuation corresponds to a software Power Level setting of -6dB. For a pl value of -6dB the MULT hardware actually attenuates by 0dB. The corresponding output of the ASU is 1Vpp (4 dBm.). For the commonly used range of 0 to 20dB the corresponding hardware MULT attenuation is 6 to 26 dB (see ***figure 8.2.***). This has been so programmed because within the hardware attenuation range of 6 to 26dB the phase shifts are minimum.

Figure 8.2. AVANCE MULT and ATT Control



MOD:

Shaped pulses are produced by applying a combination of the MOD and MULT voltages. The MOD signal is used to control the shape, the MULT to vary the overall amplitude of the shape envelope. The ASU units use Analogue Multipliers for the MOD control instead of the Ring Mixers used in previous transmitters. The new Multipliers result in smaller phase shifts, have a slightly larger range and better linearity. The ***table 8.4.*** summarizes the difference between the previously used Ring Mixers and the analogue multipliers which are now used

Two analogue multipliers set in series allow a modulation of up to 60 dB within a single shape. The MULT signal is used to vary the overall amplitude of the shaped pulse and is normally maintained within the range of 0 to 30 dB. In conjunction with the 20 and 40 dB fixed attenuators, this gives a range in attenuation of over 90 dB.

Larger MULT attenuation (between 30 and 50 dB) is possible but slightly larger phase shifts may arise at frequencies beyond 500 MHz.

Table 8.4. Difference between the previously used Ring Mixers and the current Analog Multipliers

MOD	Analog Multipliers	Ring Mixers
Used in	e.g. ASU,ASU/LOT	BSV10,BLT4,BLTX300 Ecoupler etc.
Freq. Range	5 - 800 MHz	5 - 800 MHz
Control Voltage Range	Differential $\pm$ 1V	Non - Differential 0 - 2.5V
Control Voltage source	FCU	MCI
Max. Attenuation Range	2 x 30 dB	2 x 25 dB
Used Range for shaped pulses	2 x 30 dB	2 x 25 dB
Min. Resolution	0.14dB	
Amplitude Linearity	Requires no correction factor	Requires no correction factor
Phase Shifts for 600 MHz over 50 dB. (without CORTAB)	$<\pm 10°$	$> \pm 20°$
Switching Speed	70 ns	70 ns
Blanking	by TGPCH signal	None

MOD and MULT gating *8.3*

Nomenclature: SPF1 = TGPCH1 SPF2 = TGPCH2 (Transmitting Gating Pulses)

TGPENAB(SPENAB) is normally permanently low, unless a power down reset is activated from the BSMS keyboard. The TGPCH signals from the TCU are simply combined with the TGPENAB through an „or“ gate to produce the SPFMULT and SPFMOD signals. The SPFMULT and SPFMOD signals (active low) are then used to gate the MOD and MULT sections. Thus the gating signals will go low (active) only when either TGPCH1 or TGPCH2 is low. This allows precise gating control of the MOD and MULT units which improves the on/off ratio. This gating was not implemented with the internal MOD and MULT units of previous transmitters. Note that the timing of TGPCH signals may not be altered using the „edscon „table.

AT20 and AT40 Blanking *8.4*

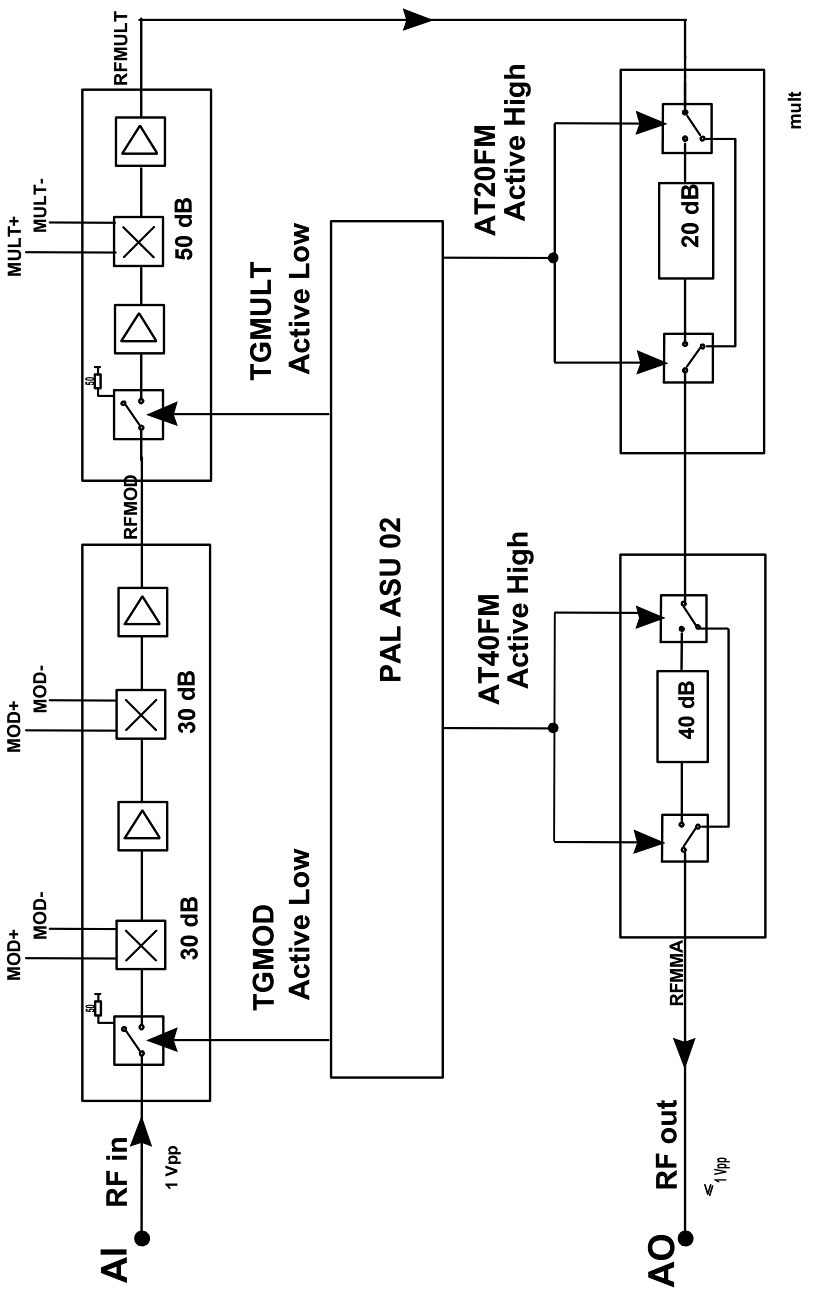
Nomenclature: BLKF1 = BPCH1   BLKF2 = BPCH2

The signals AT20FM1, AT40FM1, AT20FM2 and AT40FM2 are used to blank the attenuators and are active high (attenuator switched on).

The logic of the PAL ASU02 is such that the 20 and 40 dB attenuators are automatically active whenever rf signals are **not** being transmitted. Outside of pulse transmission BPCH is high and therefore the 20 and 40 dB attenuators are by default active. This new feature ensures minimum noise outside of the transmitted pulses. Whether the 20 or 40 dB attenuation is applied **during** the pulse transmission itself depends on the signals AT20 and AT40. If these signals are low then the attenuators will be switched off.

The timing of BPCH signals may be altered using the „edscon „table. The corresponding edscon parameters are BLKTR[1-8].

Figure 8.3. ASU Gating and Blanking



Router/Combiner 9

Introduction 9.1

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.

The implementation of all possible routing would

a) make the physical size of the router too large

b) increase crosstalk

c) increase cost.

RSEL Parameters 9.2

How a particular signal is routed is determined by the setting of the RSEL control words. These are software parameters which are set from the „edsp“ menu. The values are normally hidden from the user but can be simply checked by entering the parameter at the keyboard*.

The routing of INPUT1 is determined by the value of RSEL1, the routing of INPUT2 is determined by RSEL2 etc.

* Note that the syntax is „**0 space RSELspace 1 enter** “ etc.

Where a router input is not used then the corresponding RSEL word is assigned a value of 0.

The actual hardware switching of the router is realized by means of the RSEL bits which are detailed in ***figure 9.1.***. These bits are active low, generated by the TCU and transmitted to the Router via the 50 pin SCSI cable from TCU connector T2.

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. The bit settings can be checked at the J3 28 Pin SCSI connector at the router front panel.

Table 9.1. Explanation of 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

Figure 9.1. Explanation of RSEL Parameters

0 = 0V
1 = 5V

		Input-Section Switches			Output-Blanking
Input	Output	RSEL_13 RSEL_12 RSEL_11 RSEL_10	RSEL_23 RSEL_22 RSEL_21 RSEL_20	RSEL_33 RSEL_32 RSEL_31 RSEL_30	BLK_TR1 BLK_TR2 BLK_TR3 BLK_TR4 BLK_TR5
RI 1	RO 1	1 1 1 0			0 1 1 1 1
	RO 2	1 1 0 1			1 0 1 1 1
	RO 3	1 1 0 0			1 1 0 1 1
RI 2	RO 1		1 1 1 0		0 1 1 1 1
	RO 2		1 1 0 1		1 0 1 1 1
	RO 3		1 1 0 0		1 1 0 1 1
	RO 4		1 0 1 1		1 1 1 0 1
RI 3	RO 1			1 1 1 0	0 1 1 1 1
	RO 2			1 1 0 1	1 0 1 1 1
	RO 3			1 1 0 0	1 1 0 1 1
	RO 4			1 0 1 1	1 1 1 0 1
	RO 5			1 0 1 0	1 1 1 1 0

ROUTER

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

Combining:

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

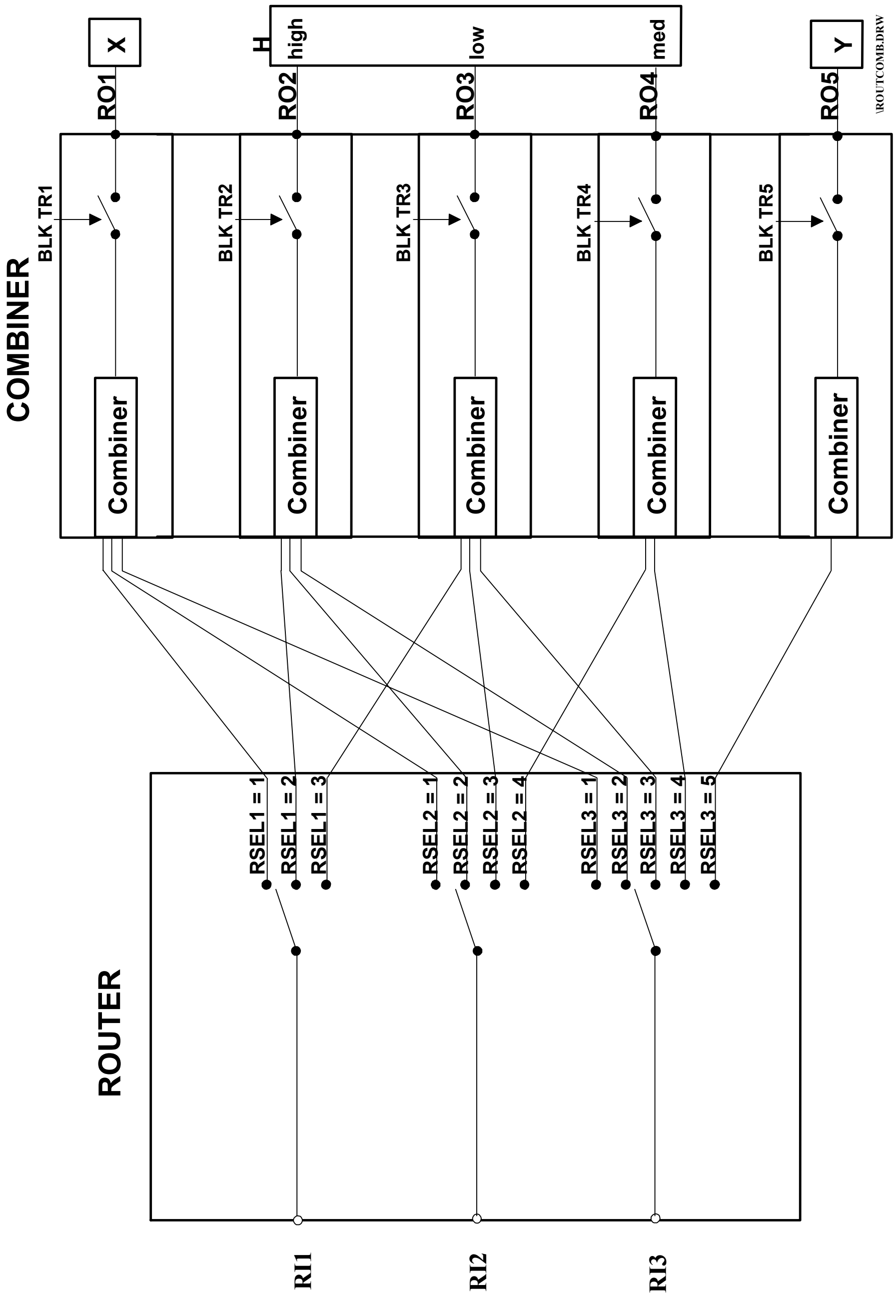
Output 2 can be any combination of Inputs 1, 2 and 3.

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.

Figure 9.2. Router Selection and Output Blanking



Output Blanking 9.3

Each router output must be blanked by the corresponding pulse i.e. Output 1 by BLKTR1, Output 2 by BLKTR2 etc.

All the output blanking pulses are active low, generated by the TCU and transmitted to the Router via the 50 pin SCSI cable from TCU connector T2.

The banking pulses can be checked at the J3 28 Pin SCSI connector at the router front panel.

The precise timing of the output blanking pulses can be altered with the „**edscon**“ parameters BLKTR[1 - 15].

TGPENAB 9.4

The router is designed to be completely disabled if the TGPENAB signal should go high. This will happen if the TRANS P-DOWN key of the BSMS keyboard is pressed. The signal is transmitted via the ACB to the ASU's, the LOT and router along the AQR backplane. To check this signal you will need the AQR EXT. Board (P/N Z012746). The signal can be measured between Pins 9a and 9b and for power transmission must be low.

Cascading routers 9.5

For the present 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 FCU’s then it will assume that a second router is fitted. (The AQR can accommodate up to 3 routers which can, from the hardware viewpoint, be cascaded in different ways but this will not be automatically supported by the software.)

Table 9.2. Hardware and Software Control of a Second Router

Input	Software Word	Corresponding Hardware Bit
RI1 Router 2	RSEL 3	RSEL_ 40, RSEL_41, RSEL_42,RSEL_43,
RI2 Router 2	RSEL 4	RSEL_ 50, RSEL_51, RSEL_52,RSEL_53,
RI3 Router 2	RSEL 5	RSEL_60, RSEL_61, RSEL_62,RSEL_63,
Output	Software Output	Corresponding Hardware Blanking pulse
RO1 Router 2		BLKTR6
RO2 Router 2	6	BLKTR7
RO3 Router 2	7	BLKTR8
RO4 Router 2	8	BLKTR9
RO5 Router 2	9	BLKTR10

The *figure 9.3.* shows an example where two routers are cascaded. **The software treats the two routers effectively as a single router. Input 3 of Router 1 can not be 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.**

For router2 the three inputs are controlled by **software** words RSEL 3,4 and 5. The corresponding hardware bits are:

RSEL_ 40, RSEL_41, RSEL_42, RSEL_43

RSEL_ 50, RSEL_51, RSEL_52, RSEL_53

RSEL_60, RSEL_61, RSEL_62, RSEL_63

This inconsistency in the numbering is unavoidable since all routers are identical in terms of hardware.

For router3 the corresponding software words would be RSEL 6,7 and 8 with corresponding hardware words are:

RSEL_ 70, RSEL_71, RSEL_72, RSEL_73

RSEL_ 80, RSEL_81, RSEL_82, RSEL_83

RSEL_90, RSEL_91, RSEL_92, RSEL_93

The software is programmed to automatically take account of the cascade arrangement. For example if as in figure 10.3 the third rf channel is linked to the amplifier connected to RO5 then the software will set RSEL3=5 and automatically set Hardware bits RSEL_ 30, RSEL_31, RSEL_32, RSEL_33 and RSEL_40, RSEL_41, RSEL_42, RSEL_43 correctly. Furthermore the BLKTR5 and BLKTR6 pulses will automatically be generated.

Similarly referring once again to ***figure 9.3.***, if software route RSEL4=6 is chosen then RSEL_ 50, RSEL_51, RSEL_52, RSEL_53 are set correctly and BLKTR7 is generated.

The input connector to each Router is a 28 pin SCSCI type J3. Output T2 of the TCU is capable of controlling one or two Routers.

For one Router Cable (P/N H5570) is used, for two Routers the cable (P/N Z002814) is used.

Figure 9.3. Standard Configuration of 2 Routers

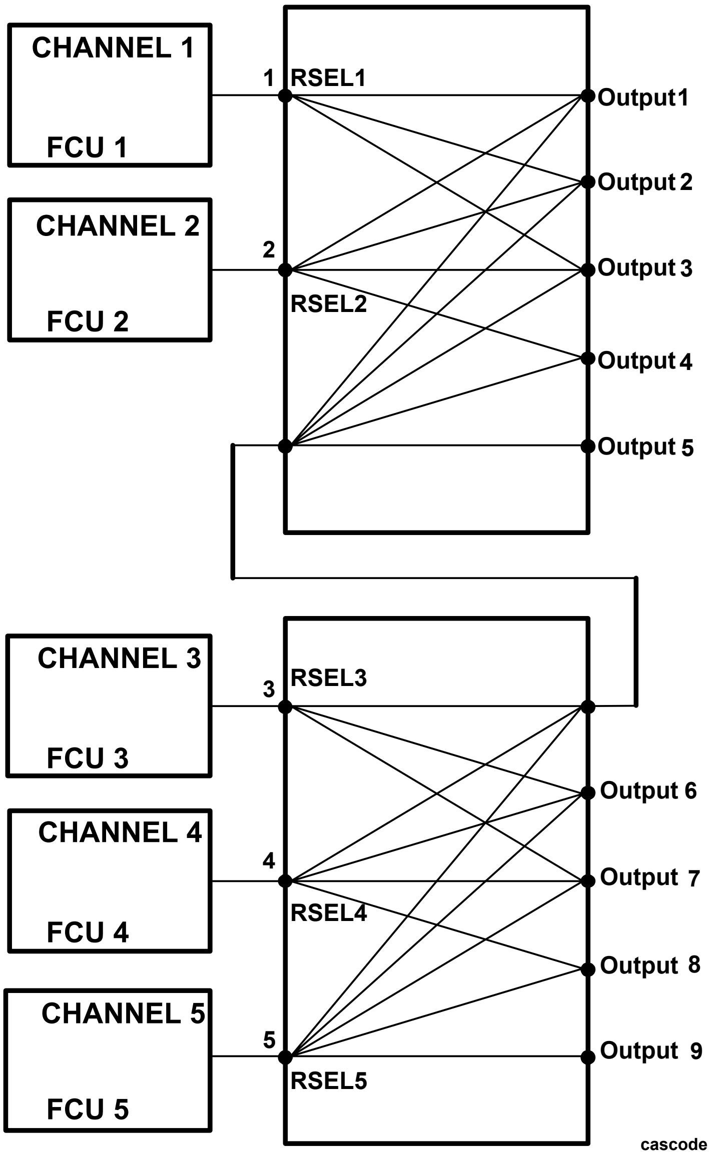


Table 9.3. Signals which can be measured at the J3 connector of router 1 front panels

Pin Number	Signal	Pin Number	Signal
1	RSEL 11	15	RSEL 13
2	RSEL 10	16	RSEL 12
3	extgnd	17	extgnd
4	RSEL 21	18	RSEL 23

Table 9.3. Signals which can be measured at the J3 connector of router 1 front panels

Pin Number	Signal	Pin Number	Signal
5	RSEL 20	19	RSEL 22
6	extgnd	20	extgnd
7	BLKTR1	21	BLKTR1 gnd
8	BLKTR2	22	BLKTR2 gnd
9	BLKTR3	23	BLKTR3 gnd
10	BLKTR4	24	BLKTR4 gnd
11	BLKTR5	25	BLKTR5 gnd
12	extgnd	26	extgnd
13	RSEL 31	27	RSEL 33
14	RSEL 30	28	RSEL 32

Figure 9.4. Board View

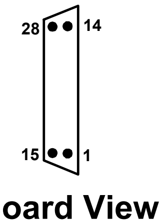


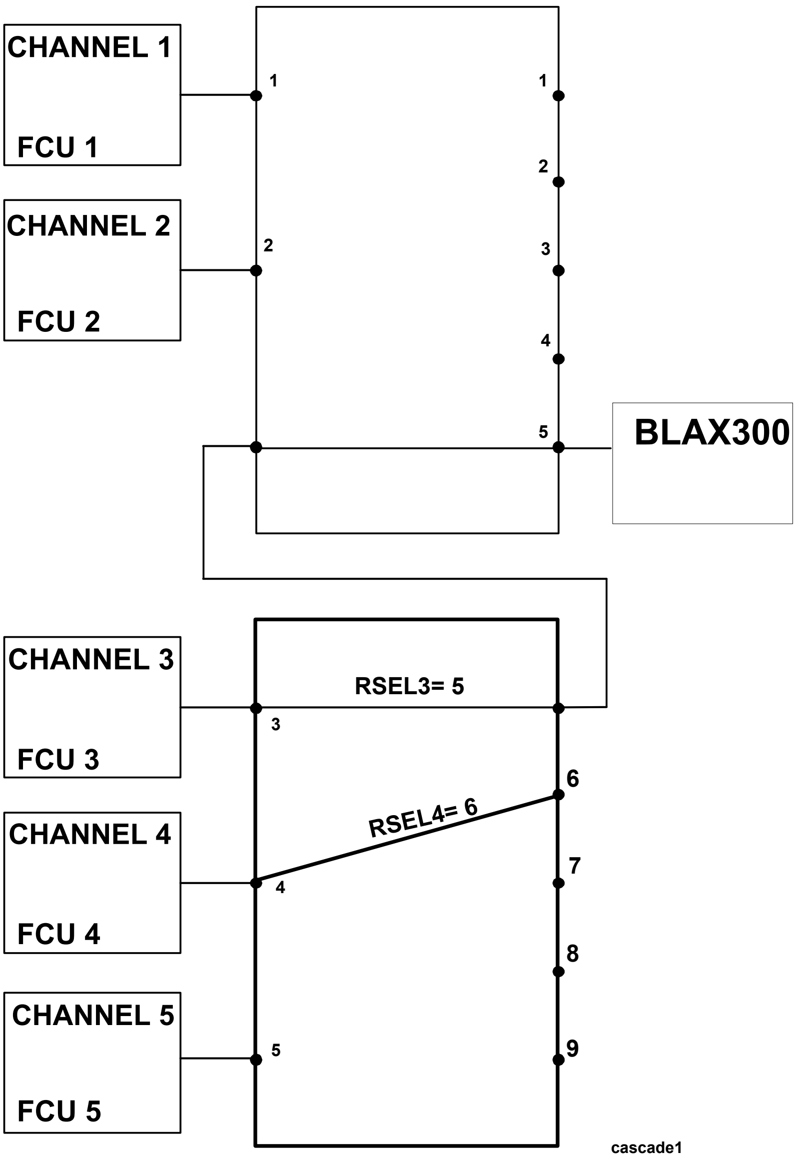
Table 9.4. Signals which can be measured at the J3 connector of router 2 front panels

Pin Number	Signal	Pin Number	Signal
1	RSEL 41	15	RSEL 43
2	RSEL 40	16	RSEL 42
3	extgnd	17	extgnd
4	RSEL 51	18	RSEL 53
5	RSEL 50	19	RSEL 52
6	extgnd	20	extgnd
7	BLKTR6	21	BLKTR6 gnd
8	BLKTR7	22	BLKTR7 gnd
9	BLKTR8	23	BLKTR8 gnd
10	BLKTR9	24	BLKTR9 gnd

Table 9.4. Signals which can be measured at the J3 connector of router 2 front panels

Pin Number	Signal	Pin Number	Signal
11	BLKTR10	25	BLKTR10 gnd
12	extgnd	26	extgnd
13	RSEL 61	27	RSEL 63
14	RSEL60	28	RSEL 62

Figure 9.5. Standard Configuration of 2 Routers



BRUKER Linear Amplifiers 10

New features 10.1

Among the new features of the latest range of power amplifiers are:

1. The output amplitude is a linear function of the amplitude of the rf input. Unlike previous transmitters no power setting takes place within the amplifier itself. As such they are referred to as amplifiers and not transmitters.
2. New 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.
3. The amplifiers are controlled by the ACB (Amplifier Control Board) via an RS485 type link (SBS 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 BLA Control board II is possible via the ACB Board.
4. Improved 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.

Terminology 10.2

BLARH 100 = **B**RUKER **L**inear **Ar**ray Amplifier for 1**H** with **100**W High Power channel**.**

The „array“ refers to the fact that the unit contains more than 1 amplifier connected to the same output channel.

BLAX 300: **B**RUKER **L**inear **A**mplifier for **X** frequencies with single channel **300**W amplifier.

Brief Summary of standard Amplifier Types 10.3

1. **BLARH 100:**

   This is a standard DMX amplifier with three 1H/19F rf channels.

   Input **HHigh** - 100 W 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** - 10 W output for rf input of 4 dBm.

A variation of this transmitter is the BLARH50 with a HHigh channel max. output of 50W instead of 100W. At the moment this amplifier is fitted to 750 MHz spectrometers, but a 100W version will be introduced if required.

2. **BLAX 300**:

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

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

3. **BLAXH 50:**

   This is the standard DRX amplifier with 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 **Xin** - 100W output power for rf input of 4 dBm.

4. **BLAXH 20**:

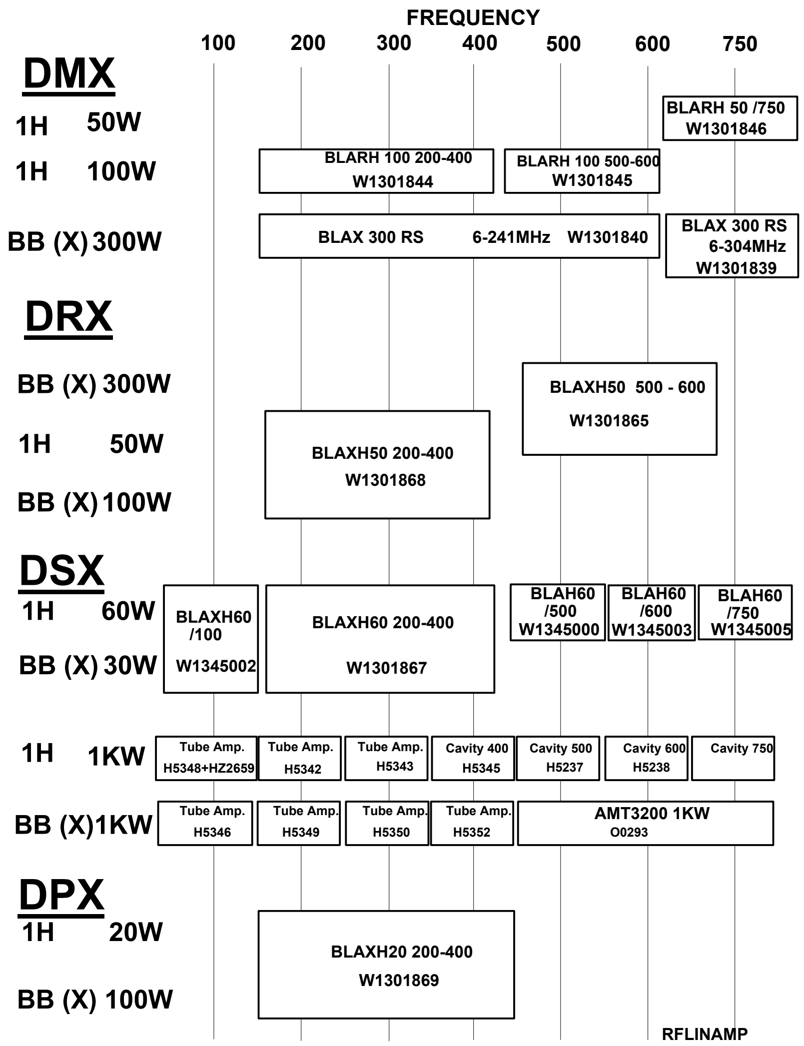
   This is the standard DPX amplifier with two rf channels, one for 1H/19F, one for X frequencies.

   Input **H** - 20W output power for rf input of 4 dBm.

   Input **X** - 100W output power for rf input of 4 dBm.

   A comprehensive list of available amplifiers with Part Numbers is given on the next page. Data sheets in the Appendix give precise specifications of the above amplifiers.

Figure 10.1. Overview of Standard Amplifiers



RF Output Power: Comparison with previous transmitters *10.4*

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

Using the standard DMX BLARH 100 HHigh channel this input would produce a minimum output of 100W. The corresponding output for pl = 0 dB is 25W. Thus pl = 0 dB with the BLARH 100 corresponds roughly to HL = 3 dB using the standard 50W Ecouplers as in AMX spectrometers.

The BLT 4 transmitter used in ARX transmitters had output powers of 40 W(1H) and 100 W (X) respectively for an input of 1Vpp (4 dBm at 50 Ω). The outputs of the BLAXH50 will be 50 W (1H) with a software setting of pl = - 6 dB. The corresponding X output is 100 W (200 - 400 MHz) and 300 W (500 - 600 MHz)

Amplifier Blanking 10.5

The blanking pulses (BLKTR 1... 15) are active low TTL level and produced by the TCU. They are easily measured at the BNC connections on the amplifier front panel. Which blanking pulse is required for which amplifier will depend solely upon which router output provides the rf amplifier input. This is because the same blanking pulses are used to blank the router output as the amplifier. 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 timing of the BLKTR[1... 15] pulses can be adjusted with the „edscon“ table.

Configuration for DMX spectrometers (1 Router) 10.6

Table 10.1 lists the connections between the router outputs and a possible arrangement of amplifiers in a DMX spectrometer. In order for the „**edsp**“ display to function properly certain requirements are necessary. Firstly that 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 BLAXH50 this is Xin, for the BLARH100 this is HHigh)

Table 10.1. Standard Connections between the Router Outputs and the Amplifiers

Amplifier	Hex. Address	AMP Input		Router	BLKTR PULSE
BLAX 300:	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

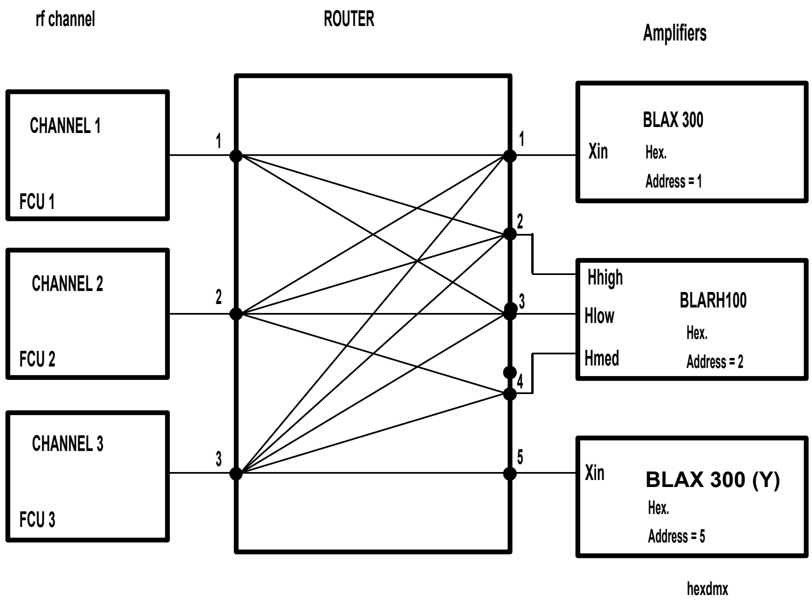
Secondly auxiliary amplifier inputs must be connected in the correct order.

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.

Figure 10.2. Standard DMX with one Router



Configuration for DMX spectrometers (2 Routers) *10.7*

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 ***figure 10.3.*** 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.

The ***table 10.2.*** lists the connections and corresponding Hex. addresses for the sample arrangement in ***figure 10.3.***.

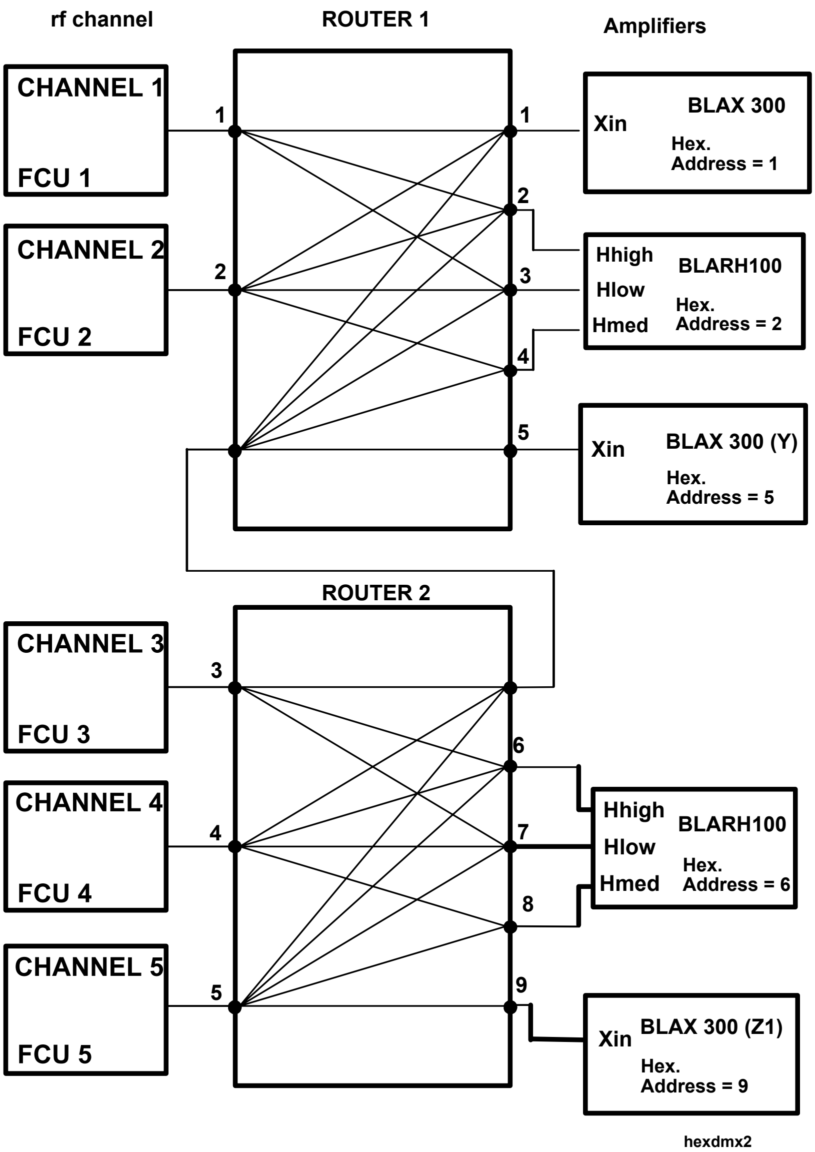
Table 10.2. Connections and Corresponding Hex Addresses for DMX with 2 Routers

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	BLKTR7
		Low	connected to	Router2 RO3	BLKTR8

Table 10.2. Connections and Corresponding Hex Addresses for DMX with 2 Routers

Amplifier	Hex Address	AMP Input		Router	BLKTR PULSE
		Med	connected to	Router2 RO4	BLKTR9
BLAX 300(Z1)	9	Xin	connected to	Router2 RO5	BLKTR10

Figure 10.3. DMX with 2 Routers



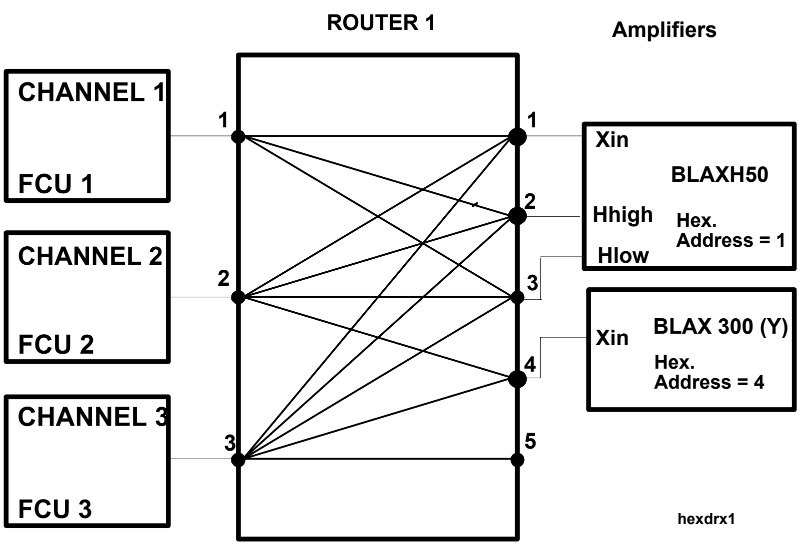
Configuration for DRX spectrometers (1 Router) 10.8

The standard amplifier, the BLAXH50, is given Hex. address 1. The software will then assume that Router outputs RO1, RO2 and RO3 are connected as in table 10.3. If an optional BLAX300 were added then it would be connected to RO4 and given Hex. address 4.

Table 10.3. Connections and Corresponding Hex Addresses for DRX with 1Router

Amplifier	Hex Address	Input		Router	BLKTR PULSE
BLAXH 50:	1	Xin	connected to	Router1 RO1	BLKTR1
		HHigh	connected to	Router1 RO2	BLKTR2
		HLow	connected to	Router1 RO3	BLKTR3
BLAX 300(Y)	4	Xin	connected to	Router1 RO4	BLKTR4

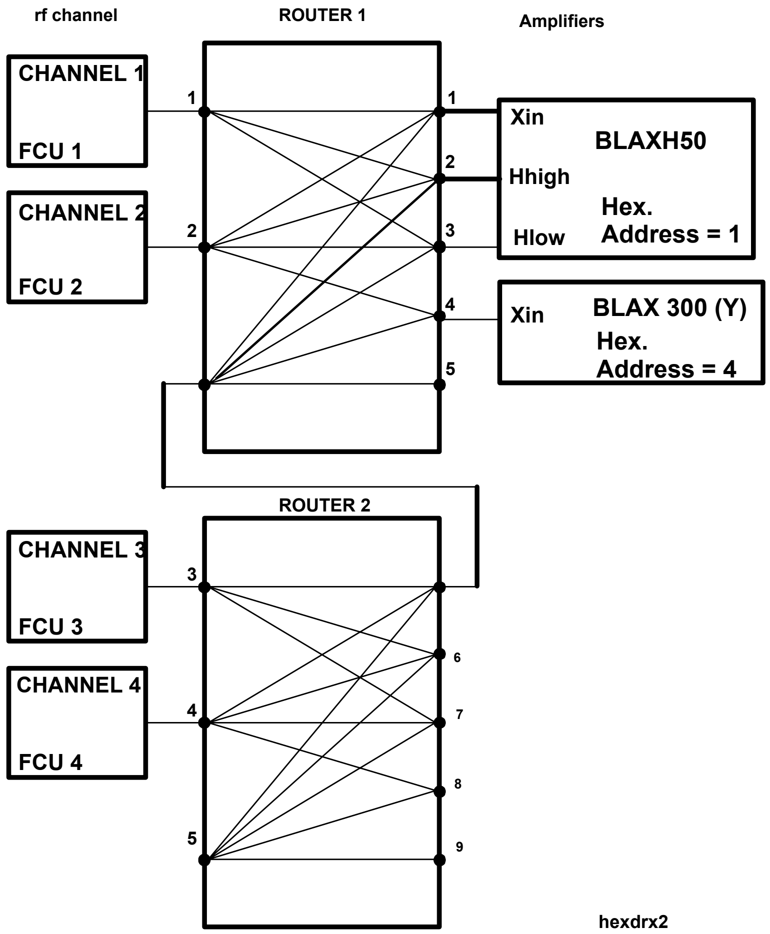
Figure 10.4. DRX with optional extra X Amplifier



Configuration for DRX spectrometers (2 Routers) 10.9

The two Routers are cascaded as in the DMX.

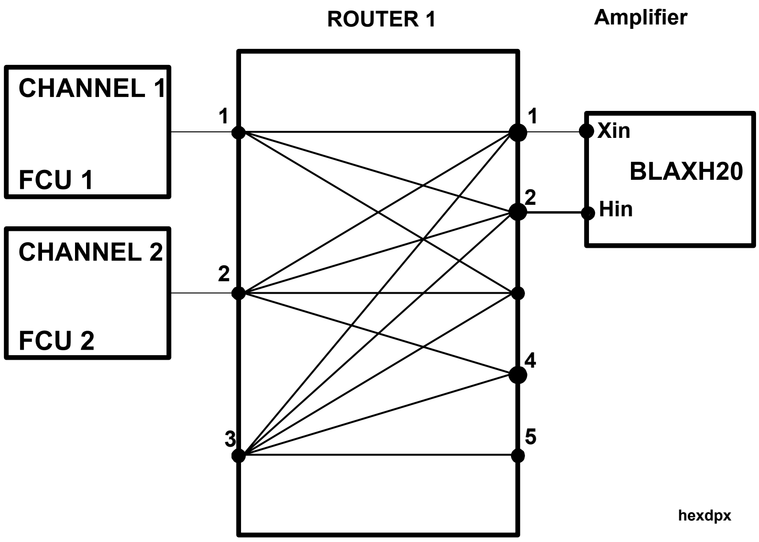
Figure 10.5. DRX with 2 Routers



Standard configuration for DPX spectrometers 10.10

The DPX is limited to a maximum of two independent rf channels. Amplifier input Xin is connected to RO1 and amplifier input Hin is connected to RO2. The standard BLAXH20 has no RS485 interface and requires no Hex. addressing. If an optional BLAXH50 were to replace the BLAXH20 then the amplifier would be given Hex. address of one and connected to outputs RO1, RO2 and RO3.

Figure 10.6. Standard DPX Configuration



BLA Controller board II — *10.11*

Among the functions performed by the BLA II Controller board is the operation of the PULSE WIDTH and DUTY CYCLE functions.

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 30 W 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 then 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 30 W the power is deemed low enough to allow 100% duty cycle i.e. cw.

Front Panel Display DMX, DRX Amplifiers — *10.12*

HIGH CHANNEL ON:

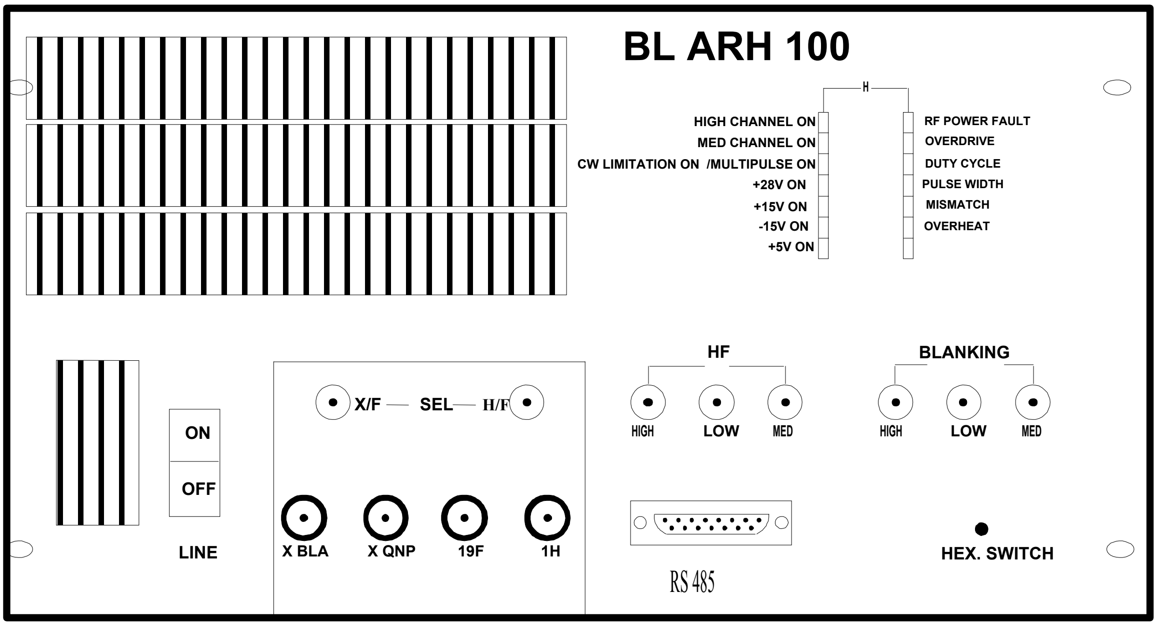
RF pulses whose power level is within approximately 30dB of the HHigh max output (100W, 50W) will cause this LED to light.

MED CHANNEL ON:

RF pulses whose power level is within approximately 20 dB of the HMED max. output (10W) will cause this LED to light. Note that this display is active for BLARH100 amplifiers only.

Note: There is no corresponding LOW CHANNEL ON simply because the power levels are too low.

Figure 10.7. Amplifier Front Panel



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 - 4 s. 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 - 4 s. 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.

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.

Note that 10W and 1W 1H/19F amplifiers have no DUTY CYCLE limitations.

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.

Note that the 10W and 1W 1H/19F amplifiers have no PULSE WIDTH limitation.

MISMATCH:

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

CW LIMITATION ON:

In normal operation the CW LIMITATION ON LED is not lit.

With an RS485 command the normal operating status can be altered to switch off the internal DUTY CYCLE and PULSE WIDTH limitations. In this mode the CW LIMITATION ON LED will light. The OVERDRIVE function will still however be active. If the average output power is above the specified limits then the amplifier will automatically switch off for 1 - 4 s.

This CW LIMITATION feature is due to be replaced by the MULTIPULSE ON feature (see below)

MULTIPULSE ON:

This function is not implemented in the earliest amplifiers and is intended to replace the CW LIMITATION ON function. In normal operation the MULTIPULSE ON led is not lit.

With an RS485 command the normal operating status can be altered to switch off the DUTY CYCLE limitation (the PULSE WIDTH function is still active!). In this mode the MULTIPULSE ON LED will light.

This was designed for experiments such as CRAMPS where the Duty Cycle may typically be 50% even though this represents no risk to the probe. The OVERDRIVE function will still however be active. If the average output power is above the specified limits then the amplifier will automatically be disabled for 1 - 4s.

Note that the software setting of the MULTIPULSE ON function is not yet implemented.

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 light.

Front Panel Display for DPX amplifier 10.13

In order to reduce costs and due to it's reduced power capabilities this amplifier has not the same protection features or front panel display as with other amplifiers. The LED on the front panel will light to signify power transmission (up to 25dB of max. output).

Note that the only protection feature is an OVERHEAT function which effectively switches the amplifier off should the output power cause the amplifier to warm sufficiently. The amplifier will remain disabled until the temperature has dropped. The corresponding power at which the temperature cut out is activated will depend on factors such as room temperature and console ventilation. However the customer should be advised not to operate at full power with a Duty Cycle above 10%. Furthermore the customer should ensure that cw operation at too high a power does not damage the probe. As a general rule cw operation should not exceed 2 - 3 W. This would correspond to a power level setting of pl = 10 dB (X channel) and pl =3 dB(1H channel)

BLARH100 Block Diagram 10.14

The unit has 3 separate rf inputs see ***figure 10.9.***. 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 figure 11.8). 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. The ***figure 10.10.*** and the ***figure 10.11.*** 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 recabling.

Figure 10.8. Increased Dynamic Range using Amplifier Array

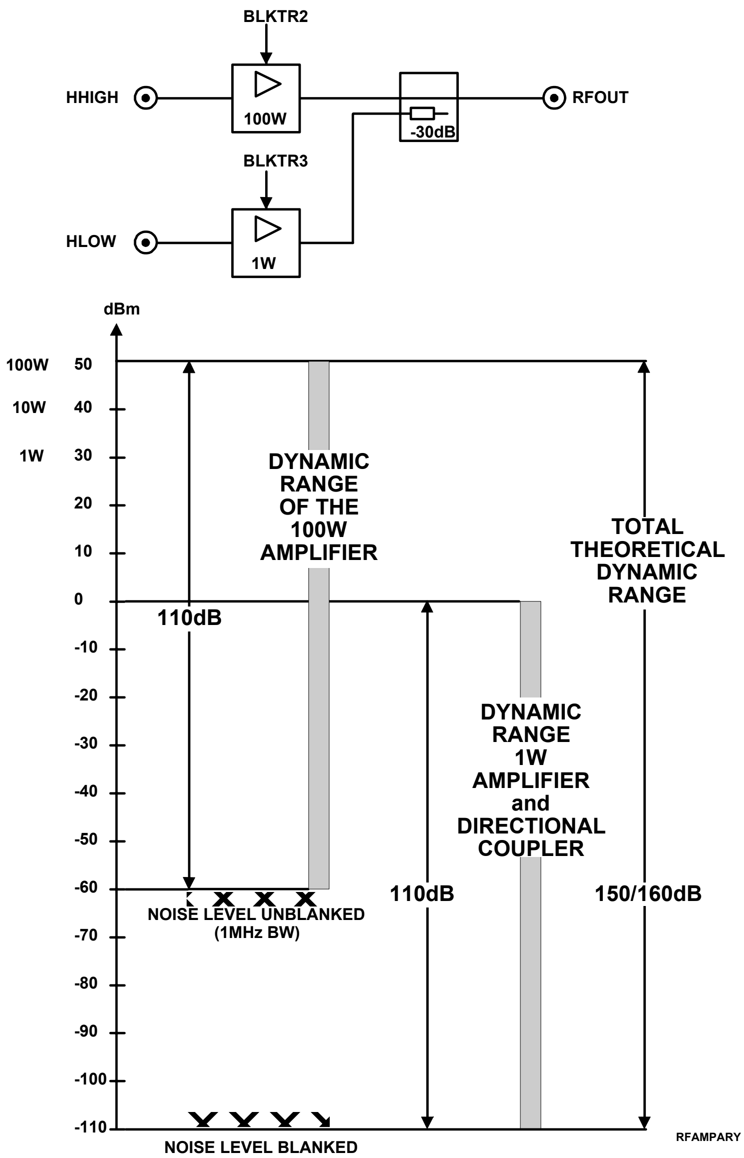
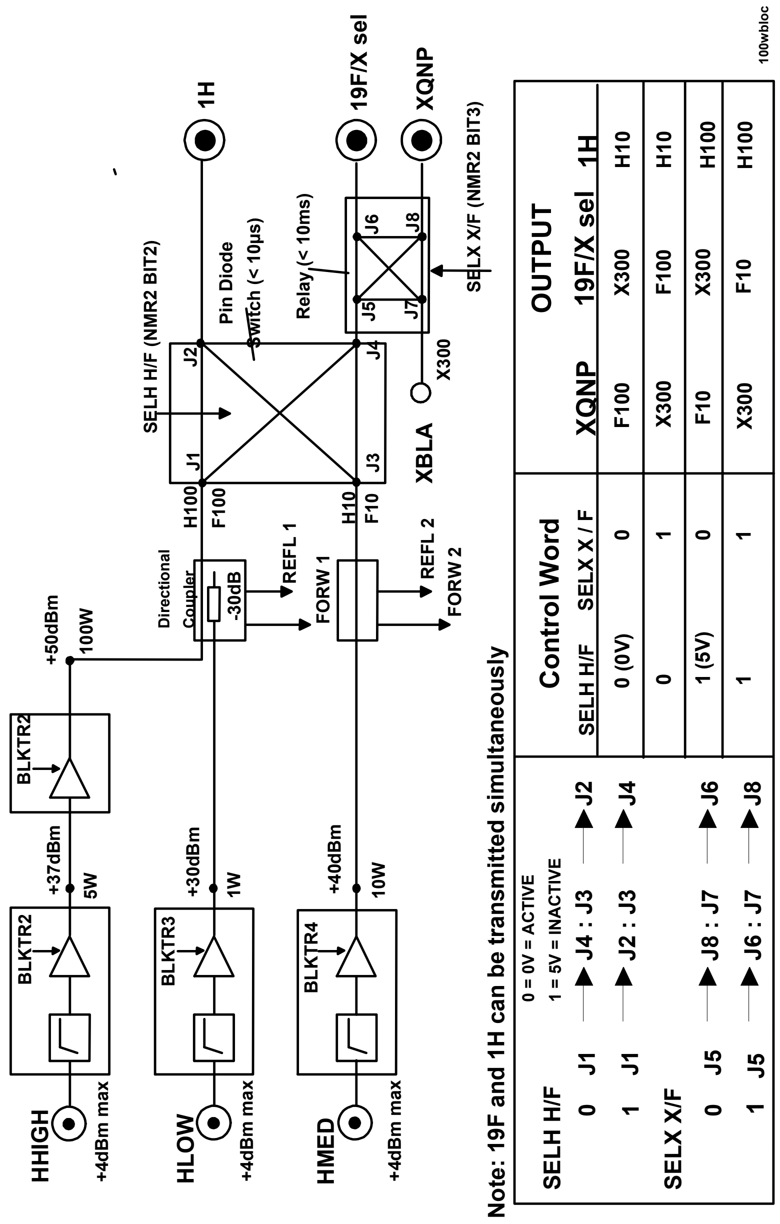


Figure 10.9. BLARH 100 Block Diagram



BLARH 100 Output Switches *10.15*

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] (see *chapter 18*).

The pin diode has a switching speed of less than 10us and is controlled by the TCU produced NMRWORD2 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 NMRWORD2 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 10.10.OBS 1H DEC 19F using 19FSEL HPPR

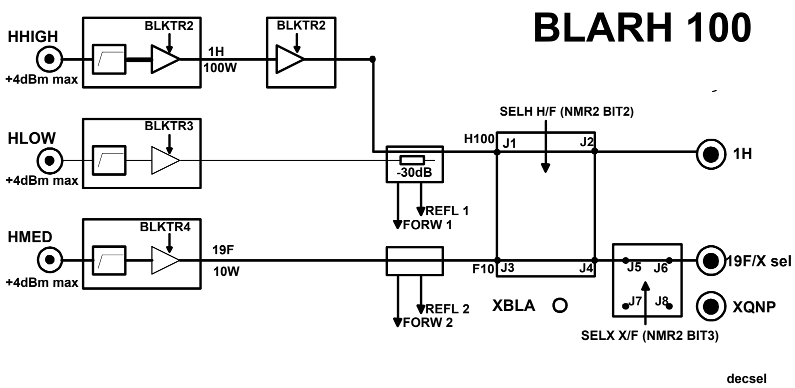
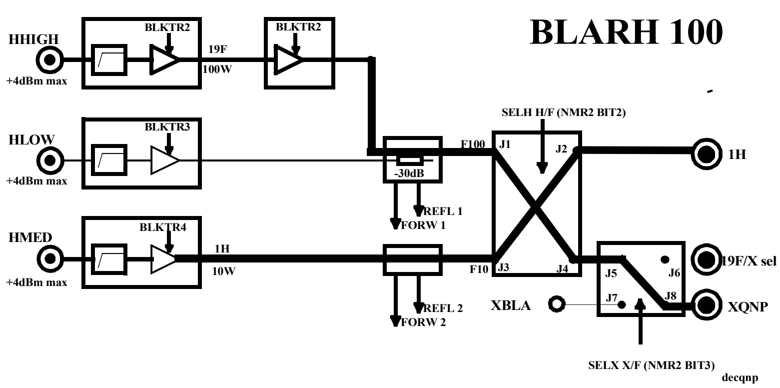


Figure 10.11.OBS 19F DEC 1H using XQNP HPPR



BLAXH 50 Block Diagram *10.16*

The use of the HHIGH and HLOW amplifiers to expand the overall dynamic range is identical to the BLARH 100 (see *figure 10.13.*). 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 of the HHIGH output for the same rf input amplitude. The X in input of the BLAXH50 comes directly from the router whereas in the BLARH100 it can be taken from the output of the BLAX300.

BLAXH 50 Output Switches *10.17*

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] (see ***chapter 18***).

The pin diode has a switching speed of less than 10us and is controlled by the TCU produced NMRWord2 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. The corresponding software commands are „foh“ (switch to 1H) and „fox“ (switch to either 19F/Xsel or XQNP). Note that with the BLAXH 50 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 NMRWord 2 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 10.12.OBS 1H

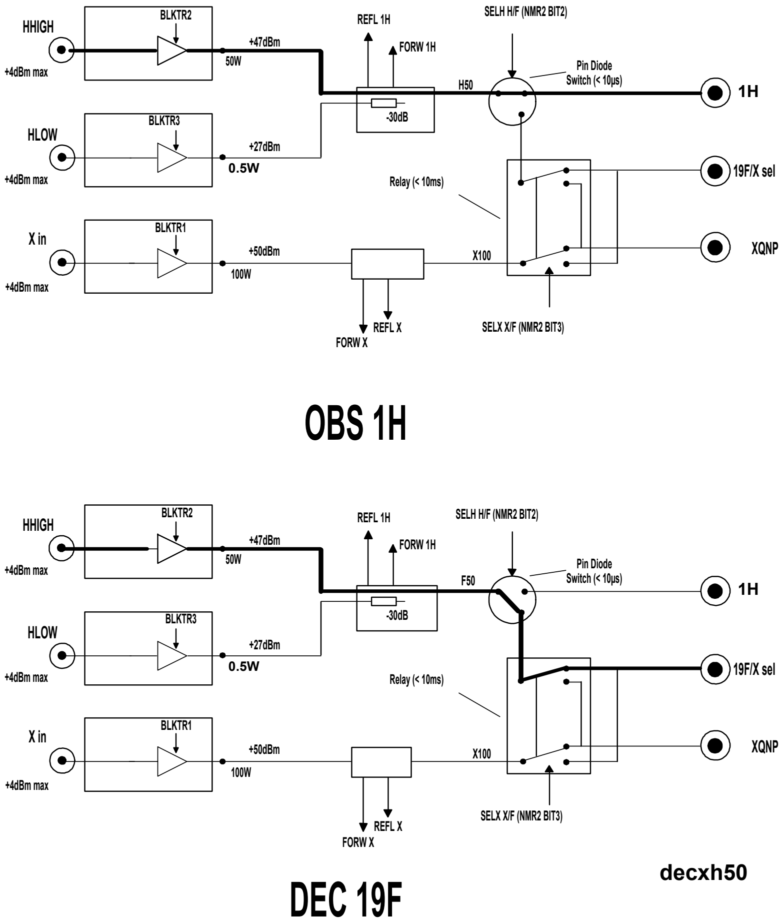
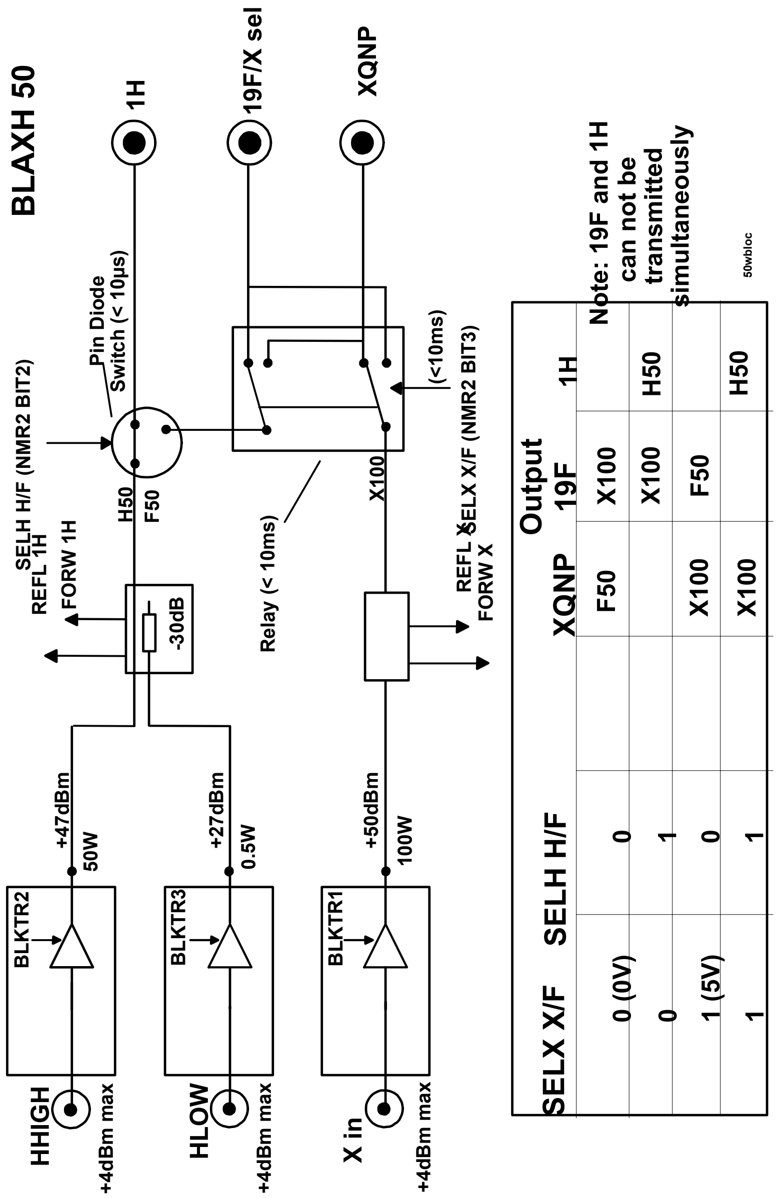


Figure 10.13.BLAXH50 Block Diagram



SELX X/F	SELH H/F	XQNP	19F	1H
0 (0V)	0	F50	X100	
0	1		X100	H50
1 (5V)	0	X100	F50	
1	1	X100		H50

RS485Interface Board 10.18

General Description 10.18.1

Each of the new range of Bruker Linear Amplifiers is fitted with a single RS485 Interface Board. This board interfaces between the ACB 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 BLAXH50 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 SBS standard of 8 bits data with 1 start bit and 1 stop bit.

The principal elements of the RS485 board are:

U22:

Among other subunits this microprocessor contains eight 8 bit sample and hold units. Four are used to digitize the Forward and Reflected signals (2 channels), the other four are reserved for internal diagnostic tests.

U10:

This EPROM contains the boot software. Note that new boot software cannot be downloaded over the RS485 link. In the unlikely event of new boot software being required then the EPROM itself must be exchanged.

U2:

This FLASH EPROM contains the application software used by the board. New application software can be downloaded over the RS485 link.

U9:

This contains 32K of RAM.

U4:

This chip has 4 x 8 bit DACs used to set the Duty Cycle, max. Pulse Width and OVERDRIVE cut out level.

U14, U15:

These monoflops are used to extend the duration of the BLKTR pulses to a fixed duration 70 ms regardless of the pulse length. This is so that the power display may be more easily observed.

U27, U28:

These monoflops perform the same function to the Forward and Reflected signals.

U11:

This EEPROM contains the BBIS information regarding the board itself as well as information regarding the number and type of amplifiers.This information, combined with the Hex. address is used to customize the „**edsp**“ display to the particular spectrometer. The BBIS data may be read from or written to over the RS485 link. The EEPROM stores up to 256 bytes of data.

U24:

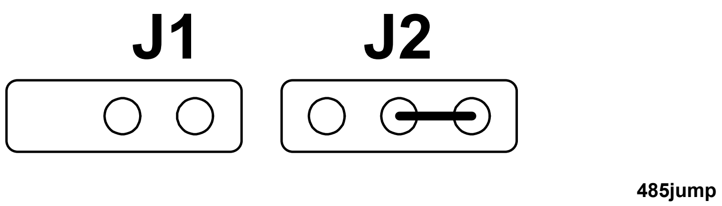
This PAL is used to decode the various select signals.

Jumper Settings 10.18.2

J1, J2

To ensure galvanic isolation of the RS485 front panel connector from the Interface Board jumpers J1 and J2 should be set as in the figure below.

Figure 10.14.Jumper Settings to ensure Galvanic Separation



J4, J6:

These jumpers are populated **only** for transmitters with three amplifiers and no piggyback board. At the moment this is either the BLARH100 or BLARH50. For all other transmitters these jumpers are not populated.

J7:

Normally this jumper is not populated. However in certain circumstances it can be advantageous if only the Boot software runs and the application software is not activated. This can be helpful if a crash of the application software results in a blockage in the downloading of new application software. If this is the case jumper J7 can be inserted and the Boot software will run without attempting to activate the application software. The new application software can then be downloaded.

Reset button:

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

Hex switch:

This is used so that each RS485 board (and consequently each amplifier housing) has a unique SBS address.

NOTE: To avoid a blockage of the SBS Bus the RS485 cable should first be disconnected before switching an amplifier off. Switch on the amplifier before reconnecting the RS485 cable.

RS485 Pinouts *10.18.3*

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

Figure 10.15.RS485 Pinouts

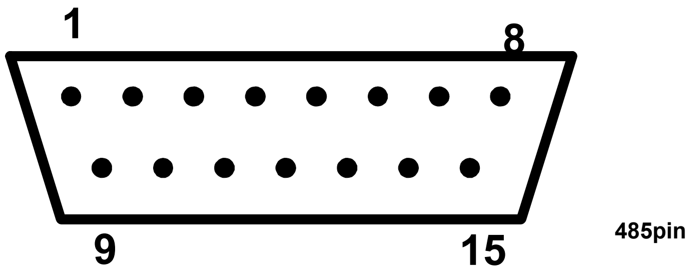


Table 10.4. RS485 Pinouts

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
9	RXD-	INPUT	OUTPUT
10	—	—	—
11	TXD-	OUTPUT	INPUT
12	—	—	—
13	VRS	POWER	POWER
14	VRS	POWER	POWER
15	VRS	POWER	POWER

RS485 signals 10.18.4

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 during 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)

Amplifier Specifications 10.19

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 300 RS 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

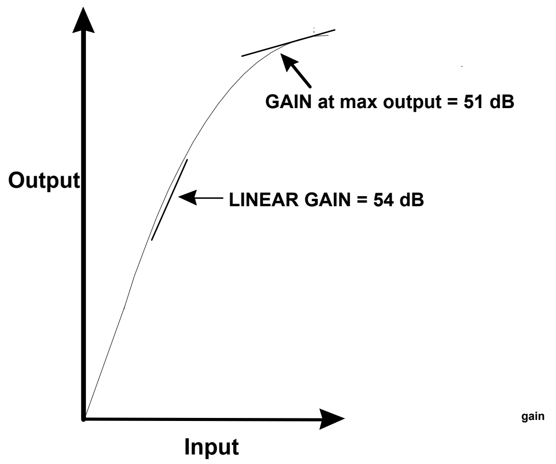
The amplifier gain will be somewhat dependent on the absolute frequency. The GAIN FLATNESS is quoted for the specified frequency range. e.g. for the BLAX 300 RS the gain is specified not to vary by more than 1.5 dB for any frequency within the 6 - 241 MHz range.

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 300 RS an input of 1Vpp (4 dBm) will produce an output of 300 W(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 10.16.Linear Gain for BLAX300 (not to scale)



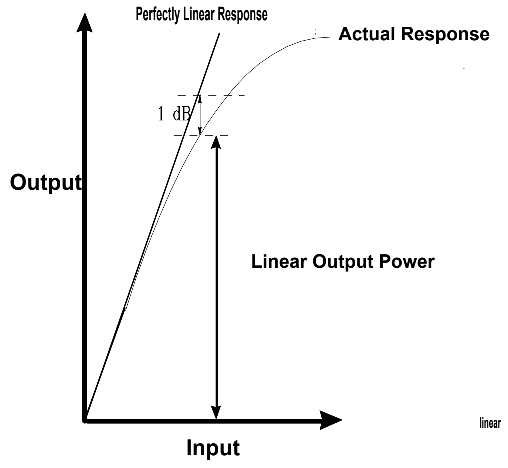
CW OUTPUT POWER:

The BLA Control Board II 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 10.17.*)

Figure 10.17.Linear Output Power (not to scale)



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 arrival 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 300 K 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 300 RS 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%.

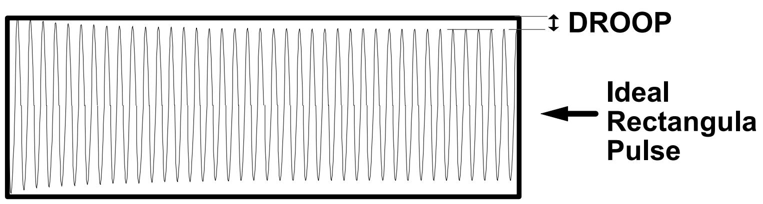
OUTPUT HARMONICS:

RF power amplifiers may produce harmonics of the amplified frequency. Harmonic levels at the output of the BLAX 300 RS 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 10.18.Amplitude Droop



HPPR 11

HPPR Signals 11.1

The following table displays a list of signals which may be conveniently measured at the Cover Display module of the HPPR.

Table 11.1. HPPR Signals

Periphery Socket	Signal	HPPR Cover Display
A	+19V	J0A/J0C
B	DGND	J0B
C	+19V	J0A/J0C
D	RCP	J0D
E	TGPPA2	J0E
F	SPF0	J0f
G	RGP(EP)	J0G
H	DGND	J0H
J	TGPPA3	J0J
K	not used	
L	-19V	J0L
M	DGND	J0M
N	+9V	J0N
P	n.c.	
R	TGPPA1	J0R
S	n.c.	
T	n.c.	
U	+14V	J0U
V	GND	J0V

TGPPA1, TGPPA2, TGPPA3:

These Transmission gating pulses are assigned as follows:

TGPPA1 2H Module

TGPPA2 X BB Module

TGPPA3 1H Module

These pulses are produced by the TCU and may or may not be inverted in the LAB (up to Console wiring ECL04) depending on the HPPR Cover Module configuration (see *section 11.2*). As of Console wiring ECL5 the signals are wired directly to the HPPR Periph and the HPPR cover module **must** be configured for active low gating.

The module selected as the OBS module is gated by the RGP signal. The TGPPA pulses are used to gate any preamps selected to transmit **decoupling** pulses by acting on the polarization of the diodes in the Transmit/Receive section. Note that the TGPPA signals are very often not required. An rf pulse with intensity >1Vpp is likely to bias the diodes even in the absence of a gating pulse.

The pre blanking delay of the TGPPA signals may be adjusted in the „**edscon**" table using the BLKPA[1 -3] parameters.

SPFO:

This is the gating pulse for the lock preamplifier. This signal is pulsed at the frequency of 6.6 KHz regardless of whether a 2H or 19F lock is being used.

RGP (EP):

Normal receiver gating pulse. This signal goes high for the duration of the acquisition. This pulse is used to control the diodes in the preamp module selected as the **OBS** module. The **OBS** module is gated separately by the RGP pulse to ensure that the T/R switching in the HPPR Hot Switch is synchronized with the acquisition. This pulse is connected to the HPPR Periph. from:

the output labelled EP_HPPR of the RX22 (DRX,DPX)

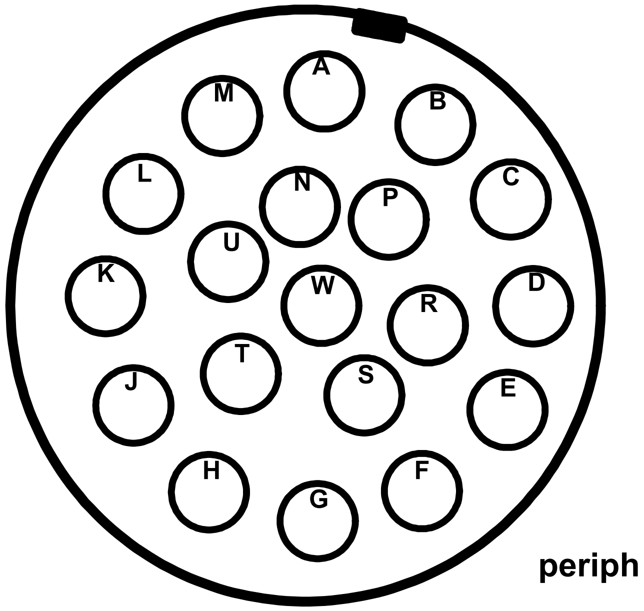
the output labelled EP_HPPR of the RXC (DSX)

the output labelled EPc of the HRD16 Controller II (DMX)

RCP:

This signal is not used at present. This signal could be used for fast switching between selected preamps during a pulse program where the RS232C control would be too slow. This would allow the selected OBS module to be switched during an acquisition. This feature may be implemented in the future.

Figure 11.1. Wiring of Preamp Periphery



Note that the connection to HPPR is one to one.

Polarity of gating signals 11.2

The latest HPPR cover modules (ECL02) allow for the possibility of using gating signals which may be active high or active low. Up to now all signals to the HPPR had to be active high and hence the need to invert the TCU produced signals (active low) via the LAB2 connection.

A piggyback board (Z4P2996) mounted on the HPPR cover module now allows the polarity to be selected with jumpers. Which jumpers correspond to which signal is clearly shown on a label inside the cover module.

Note that

SPPAH = TGPPA1

SPPAX = TGPPA2

SPPAF19 = TGPPA3

Clearly the standard polarity of gating pulses will in future be active low which would remove the need for the LAB2 connector. However this board will be continued to be used for the time being as the LAB1 also inverts signals to the SE451 and BSMS signals such as Lock Hold and Homospoil.Future systems, fitted with the new active low SE451 and with modifications to the LCB and SCB of the BSMS, will be so wired as to make the LAB redundant.

X-BB Modules 11.3

Three versions of the X_BB module are available.

1. X-BB/^{31}P ^{2}H stop: This module will transmit up to ^{31}P for all spectrometer ranges.
2. X-BB/^{19}F ^{2}H stop: This module will transmit up to 19F for all spectrometer ranges.

Module types 1) and 2), are recognized by the HPPR cover display and the „edsp“ display (in the earliest UXNMR software versions- up to May 94-) simply as X_BB.

In later software versions it is planned to call them by their full title in the „dsp“ display i.e. either X-BB31P2HS or X-BB19F 2HS.

As a result of the ^{2}H stop filter and the 1H suppression these modules are system frequency dependent.

3. A third type of module is the X-BB/^{19}F ^{2}H pass.

This module was previously referred to as a QNP module and is recognized as USER BOX on the HPPR cover display. In the earliest software versions (up to May 94), this module was recognized by the „edsp“ display simply as QNP. In later software versions it is planned to call it by the full title X-BB19F 2HP

As a result of the 1H suppression this module is also system frequency dependent.

QNP switching *11.4*

The switching between the various QNP positions is achieved with two signals FXA and FXB which are sent from the Backpanel socket BP1 directly to the QNP control module. The signals are generated in the TCU (NMRWord 2 Bits 8,9)

The switching is achieved by setting the QNP parameter in the **eda** table.

The table below shows the state of Pins BB and FF for the 3 QNP positions.

Table 11.2. QNP Switching

QNP Parameter in „eda“	Pin BB FXA	Pin FF FXB	Frequency	Position
1	High	Low	Minimum	top
2	Low	High	Middle	middle
3	High	High	Maximum	bottom

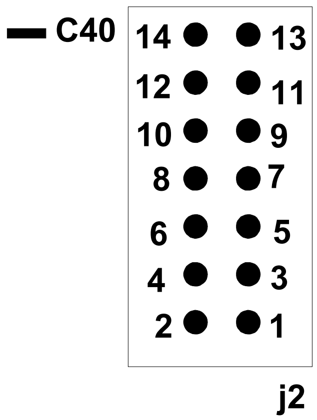
Preamplifier Selection *11.5*

The selection of the correct module as either OBS or Lock preamp is set by software according to the „edsp“ and „eda“ tables respectively. Note that the previously used PHP parameter which could be used to select the OBS module when a choice was available is now redundant. The HPPR module which is selected as the destination of the F1 channel in edsp is automatically selected as the OBS module. On receipt of the command „ii“ the information is relayed to the HPPR controller via the RS232 link and is easily checked on the illuminated HPPR cover display. For hardware troubleshooting purposes the selected preamps can be monitored at the 14 pin socket J2 of the cover/display module. This connector is linked to the Preamp Selector Box via the short ribbon cable.When a particular module is selected either as OBS or Lock then the corresponding pin will go high (+5V). Which pins correspond to which modules is given in the table below.

Table 11.3. Pinouts of J2 on HPPR Cover Display Module

Pin	Function	Pin	Function
1	OBS 2H	8	DGND
2	DGND	9	OBS 19F
3	OBS X BB	10	Gain Plus
4	19F SEL	11	19V
5	OBS 1H	12	-19V
6	19F UB*	13	2H LOCK
7	OBS UB*	14	DGND

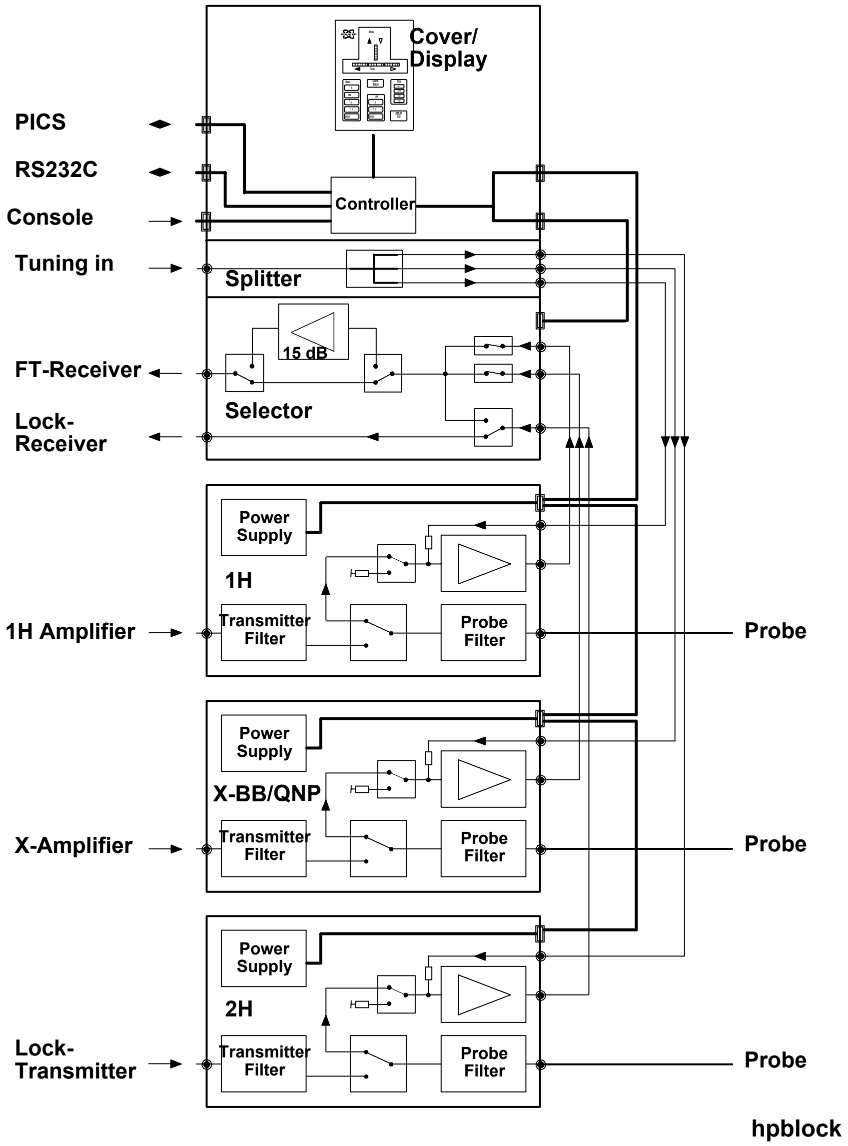
Figure 11.2. J2 Pinouts of J2



HPPRGN *11.6*

The **eda** table contains the parameter HPPRGN which for standard work is set to „normal“. However setting this parameter to „plus“ will switch in an extra 15-17 dB amplifier in the cover display module. This extra amplification might be useful in cases where, even using a large value of RG, the signal sent to the digitizer is too weak. The switching can be checked by measuring the signal „Gain Plus“ at Pin 10 of the 14 pin socket J2 of the cover/display module.

Figure 11.3. HPPR Block Diagram



HPPR Module Coding *11.7*

The types and EC Levels of the modules installed in a particular system must be made known to the software. This is achieved using jumper settings which are read whenever commands such as „ii“, „zg“ or „gs“ are entered. The jumper coding system is outlined in ***table 11.5.***. The jumpers are located on the Power Supply Board of each module. The first three jumpers are used to define the ECL of the module. **This is an internal ECL determined by jumpers and may not correspond with the ECL written at the rear of the module.**

Two systems of identification are used depending on the ECL

1) Modules with ECL A or ECL B

2) Modules from ECL C onwards.

From ECL C onwards the system was altered to enable a greater number of module types to be defined. Note that AVANCE systems is likely only be delivered with ECL level C and onwards and this system only will be explained.

Modules from ECL C onwards *11.7.1*

Only one set of jumpers, JM1 to JM8 on the Power Supply Board, are used.

Note that the frequency of the Module is no longer included in the coding as was the case with ECLA and ECLB.

The first three jumpers are used to define the ECL of the module. The other five jumpers are used to determine the type of module.

Checking the module identification via the software *11.8*

Information on how the software has decoded the jumpers can be obtained as follows:

1. Configure the spectrometer with the command „cf **debug**"
2. A normal configuration will then proceed.
3. After the configuration is complete enter the command „ii".
4. After a short delay this will produce a window entitled „ii" command standard output listing. This display contains information about which modules have been identified by the software.

The type of Module, the ECL and a hexadecimal code will be given.

The ECL will have numbers 1,2 etc., where 1 corresponds to ECL A in table 1.

The hex code is the binary equivalent of the jumpers settings in table 12.5 without the first three bits, used for ECL determination.

Example of „cf debug" entry

Module 2 = 1H Module ecl 3 code 0x18.

ECL 3 is ECL C of ***table 11.5.***

Jumper settings for 1H in ***table 11.5.*** are 00011XXX binary = 24 decimal = 18 hex.

Each time the command „ii" is entered the debug window will be displayed. If you no longer need this information then reconfigure the spectrometer with the normal „**cf**" command.

QNP module coding:

This module is not included in *table 11.5.* because it has one and only one jumper configuration (shown below) regardless of ECL.

Table 11.4. Jumper Settings for all QNP Modules

JM8	JM7	JM6	JM5	JM4	JM3	JM2	JM1	JUMPER
0	0	0	0	0	0	1	0	X-BB_19F_2HP (Former QNP)

Table 11.5. Jumper Coding of HPPR Modules

	JM8	JM7	JM6	JM5	JM4	JM3	JM2	JM1	JUMPER
1	0	0	0	0	0	0	0	0	No Preamp available
2	X	X	X	X	X	0	0	1	Module ECL A (1)
3	X	X	X	X	X	0	1	0	Module ECL B (2)
4	X	X	X	X	X	0	1	1	Module ECL C (3)
5	X	X	X	X	X	1	0	0	Module ECL D (4)
6	X	X	X	X	X	1	1	1	Module ECL E (5)
7	X	X	X	X	X	1	0	0	Module ECL F (6)
8	X	X	X	X	X	1	1	1	Module ECL G (7)
9	X	X	0	0	1	X	X	X	3H Module
10	0	0	0	1	0	X	X	X	3H Module HP
11	0	0	0	1	1	X	X	X	1H Module
12	0	0	1	0	0	X	X	X	1H Module HP
13	0	0	1	0	1	X	X	X	19F-Sel. Module
14	0	0	1	1	0	X	X	X	19F-Sel.ModuleHP
15	0	0	1	1	1	X	X	X	19F/1H/3H/ Mod-ule HP
16	0	1	0	0	0	X	X	X	X-BB_19F_2HS Module
17	0	1	0	0	1	X	X	X	X-BB_19F Module HP
18	0	1	0	1	0	X	X	X	X-BB_31P_2HS Module
19	0	1	0	1	1	X	X	X	X-BB_31P Module HP

Table 11.5. Jumper Coding of HPPR Modules

	JM8	JM7	JM6	JM5	JM4	JM3	JM2	JM1	JUMPER
20	0	1	1	0	0	X	X	X	2H Module
21	0	1	1	0	1	X	X	X	2H Module HP
22	0	1	1	1	0	X	X	X	Reserve
23	0	1	1	1	1	X	X	X	Reserve
24	1	0	0	0	0	X	X	X	Reserve
25	1	0	0	0	1	X	X	X	Reserve
26	1	0	0	1	0	X	X	X	Reserve
27	1	0	0	1	1	X	X	X	Reserve
28	1	0	1	0	0	X	X	X	Reserve
29	1	0	1	0	1	X	X	X	Reserve
30	1	0	1	1	0	X	X	X	Reserve
31	1	0	1	1	1	X	X	X	Reserve
32	1	1	0	0	0	X	X	X	Reserve
33	1	1	0	0	1	X	X	X	Reserve
34	1	1	0	1	0	X	X	X	Reserve
35	1	1	0	1	1	X	X	X	Reserve
36	1	1	1	0	0	X	X	X	Reserve
37	1	1	1	0	1	X	X	X	Reserve
38	1	1	1	1	0	X	X	X	Reserve

RX22 Receiver 12

This chapter will highlight the differences between the ARX Receiver and the new DRX Receiver the RX22.

The RX22 Receiver is used in DRX and DPX instruments and is in principle very similar to the ARX Receiver in terms of the rf sections. Only minor modifications have been made to the RF and IF sections. This has resulted principally in a larger bandwidth in comparison to the ARX receiver.

A significant modification to the AF section is the introduction of a heater and regulation circuit used to monitor and maintain the temperature of the Quad module at a steady of 55°C from ECL03 onwards. (Up to and including ECL02 the Quad module temperature was maintained at 65°C). This should further reduce any small phase and gain drift that might be caused by temperature fluctuations. Further improvements are the introduction of improved metal shielding in the Quad module.

The RX22 is a cassette-module plugged into the AQR.

Figure 12.1. RX22 Front Panel

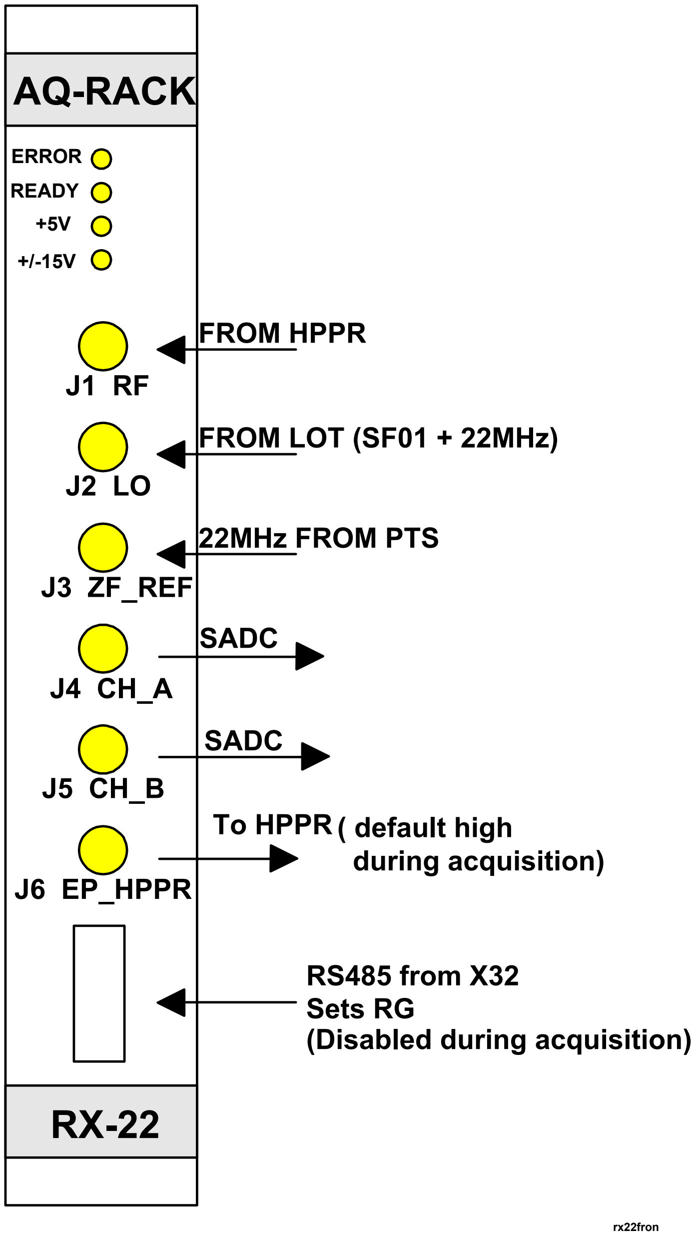


Table 12.1. Comparison of ARX22 and RX22

	ARX22	RX22
IF	22 MHz	22 MHz
LO Frequency	Provided by SY Router	Provided by LOT Board
Frequency Range	6 - 540 MHz	6 - 600 MHz
Sweep width (3 dB)	600 KHz	2 MHz
Loss over 1 MHz SW		< 0.3 dB

Table 12.1. Comparison of ARX22 and RX22

	ARX22	RX22
Gain Range	93 dB	93 dB
Min. Gain Step	3 dB	1 dB
Gain	Set by MCI via BURNDY connector	Set by RS485 Link
Temperature stability	Quad module subject to drift	Quad module regulated to 55°C
Quad peak adjustment	Hardware pot. trimming	Software adjustment via RS485 link
I^2 C Interface	None	Yes
RS485 Interface	None	Yes
EP Pulse	Generated by process controller Transmitted to receiver via Burndy	Generated by RCU. Transmitted to receiver via SADC and Backplane
EP_HPPR	Direct from Process Controller Low during Acquisition	Via RX22 Active High/Low set by Jumpers (ECL01)
Power supply	Supplied via front panel BURNDY	Supplied from back panel

Apart from performance by far the greatest differences between the ARX22 and the RX22 is in the controller module which makes software control of hardware features possible via the RS485 link.

Controller module 12.1

The controller module of the ARX22 receiver was used principally to handle the RG settings, EP pulse and power supplies. The RX22 controller has a much greater capability including interfacing with both an RS485 link and an I^2C Bus (The I^2C Bus is not actually used by the RX22). 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 microcontroller

1. Gain settings:

The UXNMR RG value is transmitted to the receiver via the RS485 link. The data is interpreted by the controller and the appropriate control signals are then transmitted to the RF and IF amplifiers. The *table 12.4.* displays which combination of gain settings is used for the various sections for the complete range of UXNMR RG values. Note that this table uses RG steps of 3 dB. As of ECL00 it is possible to alter the RG in 1 dB steps.

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

Note that whereas before with the ARX 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 now 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.

Downloading Firmware *12.2*

When installing UXNMR use the command „rx22_copy“. This will ensure that the newest firmware contained in the currently installed UXNMR is copied to the appropriate files. If this is not done then firmware which is not up to date may be downloaded.

To download the firmware use Menu Point 3 of the „RX22“ tool.

File to be downloaded **/u/conf/instr/rx22tool/tool/rx22.hex**

Future RX22 tool versions will have an auto-download feature so that the file path name need not be explicitly entered.

Reset *12.3*

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 EP signal goes low (active, receiver open) the controller is effectively switched off. No further communication is possible over the RS485 link.* The 12MHz mProcessor clocking frequency is also switched off. This ensures that no disturbances can occur during the acquisition. When the EP 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.

I^2C Bus:

The Controller interfaces with the I^2C Bus of the back panel. The RCU is master of the 4 slots of the receiver section

Jumper Settings, Polarity of RGP(EP) 12.4

As of **ECL01** it is possible to set the polarity of RGP(EP) output signals using Jumpers on the RX22 and RXC. Note that the RX22 and RXC are active low devices i.e. they use an RGP input that is low when the Receiver is open. However they also use this input to generate EP outputs used elsewhere in the spectrometer. The Table below shows the assignment of J19 and J20 for active high/low outputs. Note that active high means high during acquisition.

Table 12.2. Assignment of J19 and J20 for active high/low outputs

Device	Jumper	Setting A	Setting B	Factory Configuration
RXC	J19	EPA, EPB (SE451) Low Active	EPA, EPB (SE451) High Active	Setting B
RXC,RX22	J20	EP_HPPR Low Active	EP_HPPR High Active	Setting B

The figure 12.2. below and figure 12.3. show the jumper settings which correspond to the two possible configurations.

Figure 12.2. EP Output Signals Active Low

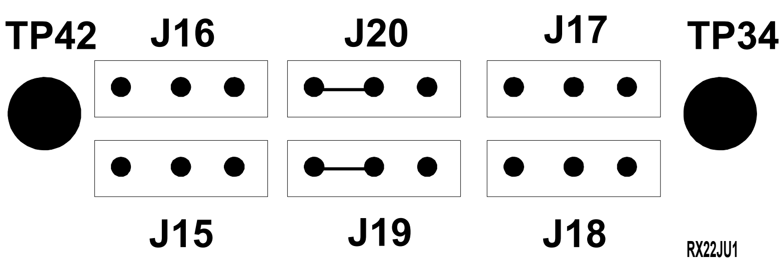
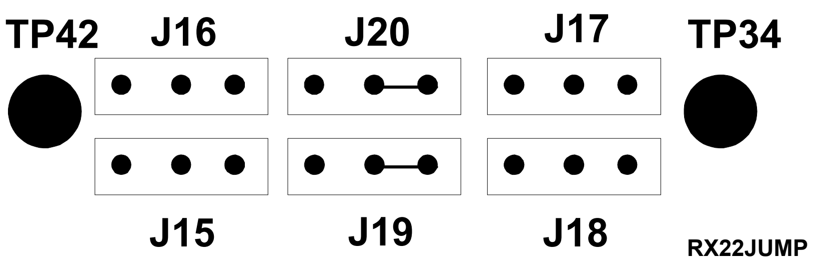


Figure 12.3. EP Output Signals Active High



Power Supply 12.5

The RX22 receives the required power from the AQR Mainframe and can easily be measured using the Test Extension Board (P/N Z012746). The following table shows the test points and corresponding signals.

Table 12.3. Power Supply

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

Image Rejection Mixer 12.6

As a result of the relatively low Intermediate Frequency (22 MHz) the RX22 uses an image rejection mixer to remove unwanted folded noise that might be transmitted through the XBB preamplifier.

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.

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.

Testing the overall gain of the Receiver *12.7*

Column 2 of *table 12.4.* 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 80 MHz output of the PTS620 (~1V_{pp} at 50 Ω)
2. Set SFO1 = 80.0001 MHz. AQ = 60 seconds
3. Set RG = 1
4. Connect the 80 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 80 MHz output of the PTS. 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.

Table 12.4. 3dB GAIN Table

RG Value	Real Gain dB (approx)	Relative Gain (dB)	RF Amplifier	1st IF Amplifier	PAS	2nd IF Amplifier
1	12	1	-12dB	+8dB	-9dB	-4dB
1·4	15	4	-12dB	+8dB	-6dB	-4dB
2	18	7	-12dB	+8dB	-3dB	-4dB
2·8	21	10	-12dB	+8dB	0dB	-4dB
4	24	13	0dB	+8dB	-9dB	-4dB
5·7	27.1	17	0dB	+8dB	-6dB	-4dB
8	30.1	19	0dB	+8dB	-3dB	-4dB
11.3	33.1	22	0dB	+8dB	0dB	-4dB
16	36.1	25	+12dB	+8dB	-9dB	-4dB
22.6	39.1	28	+12dB	+8dB	-6dB	-4dB
32	42.1	31	+12dB	+8dB	-3dB	-4dB
45.3	45.1	34	+12dB	+8dB	0dB	-4dB
64	48.1	37	+12dB	+8dB	-9dB	+8dB
90.5	51.1	40	+12dB	+8dB	-6dB	+8dB

Table 12.4.   3dB GAIN Table

RG Value	Real Gain dB (approx)	Relative Gain (dB)	RF Amplifier	1st IF Amplifier	PAS	2nd IF Amplifier
128	54.1	43	+12dB	+8dB	-3dB	+8dB
181	57.2	46	+12dB	+8dB	0dB	+8dB
256	60.2	49	+24dB	+8dB	-9dB	+8dB
362	63.2	52	+24dB	+8dB	-6dB	+8dB
512	66.2	55	+24dB	+8dB	-3dB	+8dB
724.1	69.2	58	+24dB	+8dB	-0dB	+8dB
1K	72.2	61	+24dB	+20dB	-9dB	+8dB
1.4K	75.2	64	+24dB	+20dB	-6dB	+8dB
2K	78.2	67	+24dB	+20dB	-3dB	+8dB
2·8K	81.2	70	+24dB	+20dB	0dB	+8dB
4K	84.2	73	+24dB	+20dB	-9dB	+20dB
5·7K	87.3	76	+24dB	+20dB	-6dB	+20dB
8K	90.3	79	+24dB	+20dB	-3dB	+20dB
11.3K	93.3	82	+24dB	+20dB	0dB	+20dB
16K	96.3	85	+24dB	+20dB	-9dB	+32dB
22.6K	99.3	88	+24dB	+20dB	-6dB	+32dB
32K	102.3	91	+24dB	+20dB	-3dB	+32dB
45.3K	105.3	94	+24dB	+20dB	0dB	+32dB

HRD 16 Controller Board 13

The HRD 16 digitizers as used in AVANCE spectrometers have a modified Controller Board II (P/N Z02478)

Functions 13.1

1. To provide RGPa, RGPb and RGPc outputs.

   These three outputs (labelled EPa, EPb, EPc on the board itself) are identical and generated from a single RGP pulse transmitted from the RCU via the 50 way digitizer cable.

   In a DMX, 2 of these outputs are used in the SE451 (RFT and LO), the third is used to blank the OBS module of the HPPR. As such the three outputs are active high (i.e. high during acquisition).

   In a DRX, fitted with HRD 16 as option, only the RGPa output is required. This output is connected to the LAB1 where it is inverted (to active low during acquisition) and transmitted to the RX22 via the AQR backplane. From this signal the EP_ HPPR output (active high during acquisition) is also generated (see ***figure 13.2.***).

2. To provide an ADC ON output

   This signal is generated by the RCU and transmitted to the HRD 16 via the 50 way cable. The signal as well as controlling the ADC of the HRD16 itself, is required to control the ADC LED of the BSMS keyboard. A modification (EC no. 1865, see APPENDIX) may be required with earlier LAB's in order to observe this LED on the BSMS keyboard. The ADC ON signal is simply wired through the LAB to the AQR backplane. It is not inverted on the LAB. From here it is transmitted to the BSMS via the ACB.

   Future AVANCE spectrometers will be fitted with the HADC (instead of the HRD16) which will have direct access to the AQR backplane and the LAB will not be required (The spectrometer must also be fitted with an RXC and the new 19 inch SE451).

3. Transmission of bits DRG 0 - 7 to SE451 via the canon mini sub 9.

   These signals are actually generated by the RCU and simply transmitted to the HRD16 via the 50 way digitizer cable. The Bit settings can easily be checked either at the HRD16 output or at the RFT Burndy of the SE451(***table 13.1.***).

Note that bits DRG 0 - 5 are used to set the receiver gain in the SE 451 from 1 to 32K. DRG 7 is used to switch the High Pass / Low Pass filters in the RFT. Bit 6 is not used. For DRX spectrometers the sub mini 9 connector is not required. The receiver gain is set via the RS485 link to the RX22.

Two final functions of the Controller II board have not changed. Transmission of the digitized signal and setting of the analogue filters.

Note however that since the HRD16 will normally be operated at minimum dwell time (2.5 µs) a single filter setting (SWH=250K i.e. FW=312K) is all that is required. Changing the SWH will not alter the DW and so the filter setting will not change.

Table 13.1. SE 451 RG Bit Settings

RG Value	Burndy Pin at SE 451					
	D	E	N	P	T	A
1	1	0	0	0	0	0
2	1	0	0	0	0	1
4	1	0	0	1	0	0
8	1	0	0	1	0	1
16	1	0	0	0	1	0
32	1	0	0	0	1	1
64	1	0	0	1	1	0
128	1	0	0	1	1	1
256	0	0	0	1	1	0
512	1	0	0	1	1	1
1K	0	0	1	1	1	0
2K	0	0	1	1	1	1
4K	0	0	1	1	1	0
8K	0	0	1	1	1	1
16K	0	1	1	1	1	1
32K	0	1	1	1	1	1
	8	7	6	4	3	9
	Pin number at HRD16 canon sub 9 output					

Figure 13.1. Controller Board Front Panel

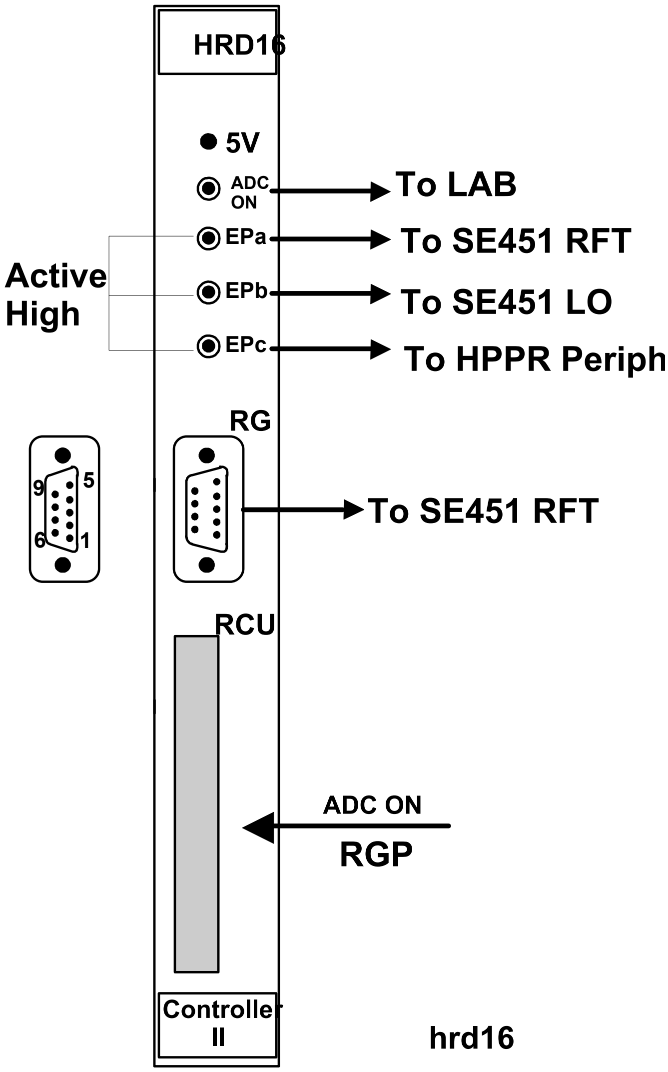
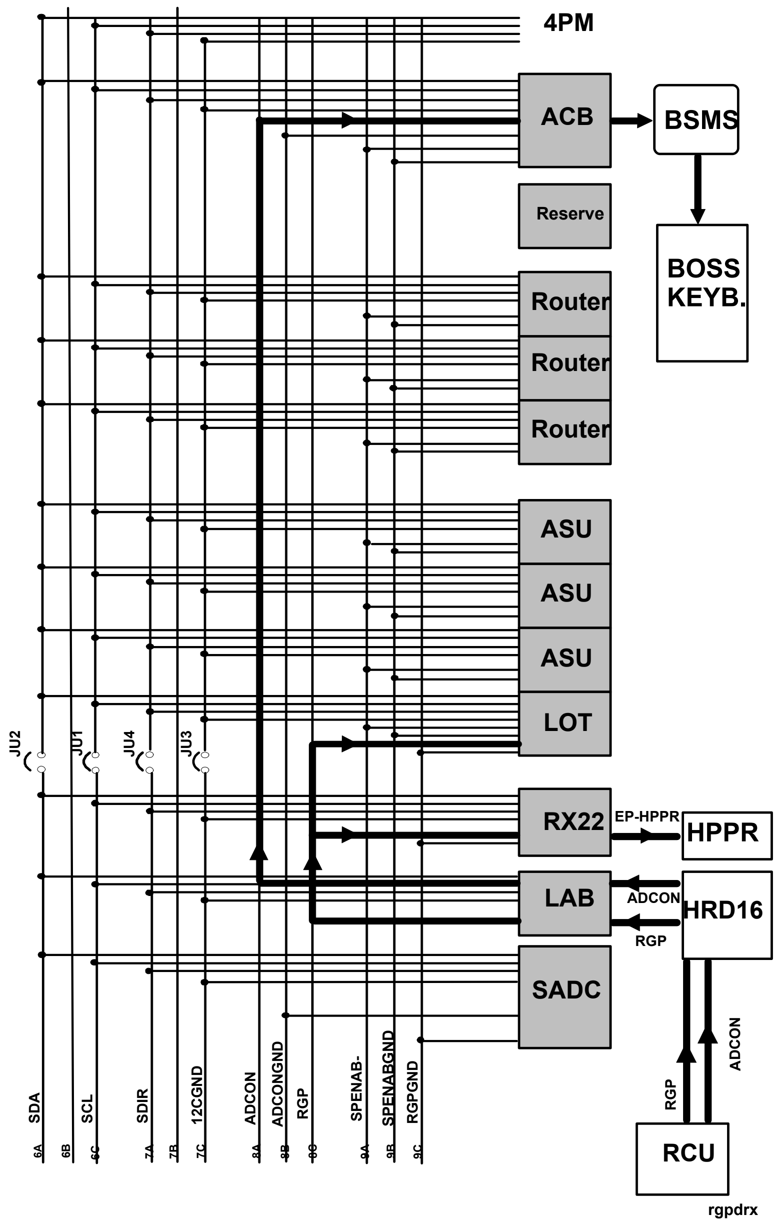


Figure 13.2. DRX with HRD16 Option



RCU: Receiver Control Unit 14

Functions 14.1

1. Upon receipt of the RCUGO signal from the TCU, 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 TCU

   Note that the RCUGO signal is synchronized with the 40MHz in signal, both of which are received from the TCU. It is important that both these signals are derived from the same source.

2. As part of the acquisition control the RCU generates the DWELL CLOCK as well as the RGP and ADCON signals. It also handles the receiver phase.
3. The RCU is responsible for processing the acquired signal i.e. digital filtering and decimation as well as accumulation and the DMA transfer of processed data to the CCU.
4. The RCU is master of all digitizers (SADC, HADC, FADC and HRD16) and all digitizer functions. T. This includes the filter settings (SADC, HADC, FLTP/4M and HRD16FT) and Quad. Mode (qsim, qf). For the SADC, HADC and HRD16 the information is sent directly over the 50 way digitizer cable. For the FLTP/4M the information is sent through the SADC or HADC and then to the FLTP/4M via the I^2C BUS of the AQR.
5. For homo-decoupling the timing of the decoupling pulses is set by the RCU. The RCU generates two signals SPHD and RGP (EPHDON EPHDOFF SPHDON SPHDOFF). These signals are then combined in a PAL (TCU0AE40) on the TCU to synchronize the receiver gating with the decoupling pulses.
6. Setting of the SE451 receiver gain in DMX and DSX spectrometers. In DMX spectrometers the RG bit settings are first ported through the HRD16 Controller II Board and then connected to the SE451 via the 9 way cable. In DSX spectrometers the RG bit settings are transmitted to the RXC from the CCU over the RS485 link and then connected to the SE451 via the RXC front panel connection.

   Future machines will no longer be fitted with the HRD16 and the RG will always be set with the RXC.

Front Panel Connections 14.2

40 MHz in:

This input signal is used to clock the RCU and thereby generate the Dwell clock and homo-decoupling timing. It is TTL (3 Vpp at 50W) and normally operates on a 50% duty cycle.

RCUGO in:

The acquisition is prepared first by the software. The RCU will not perform any actions until it receives the RCUGO command from the TCU. This pulse must accompany every scan and must be synchronized with the 40MHz in signal. The timing is so that it goes high for 50 ns, approximately 200 ns before the RGP pulse.

40MHz out:

This output is normally not connected but can be used for test purposes.

RCUGO out:

This output is normally not connected but can be used for test purposes

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 as opposed to the internally generated clock.

EXT.EP:

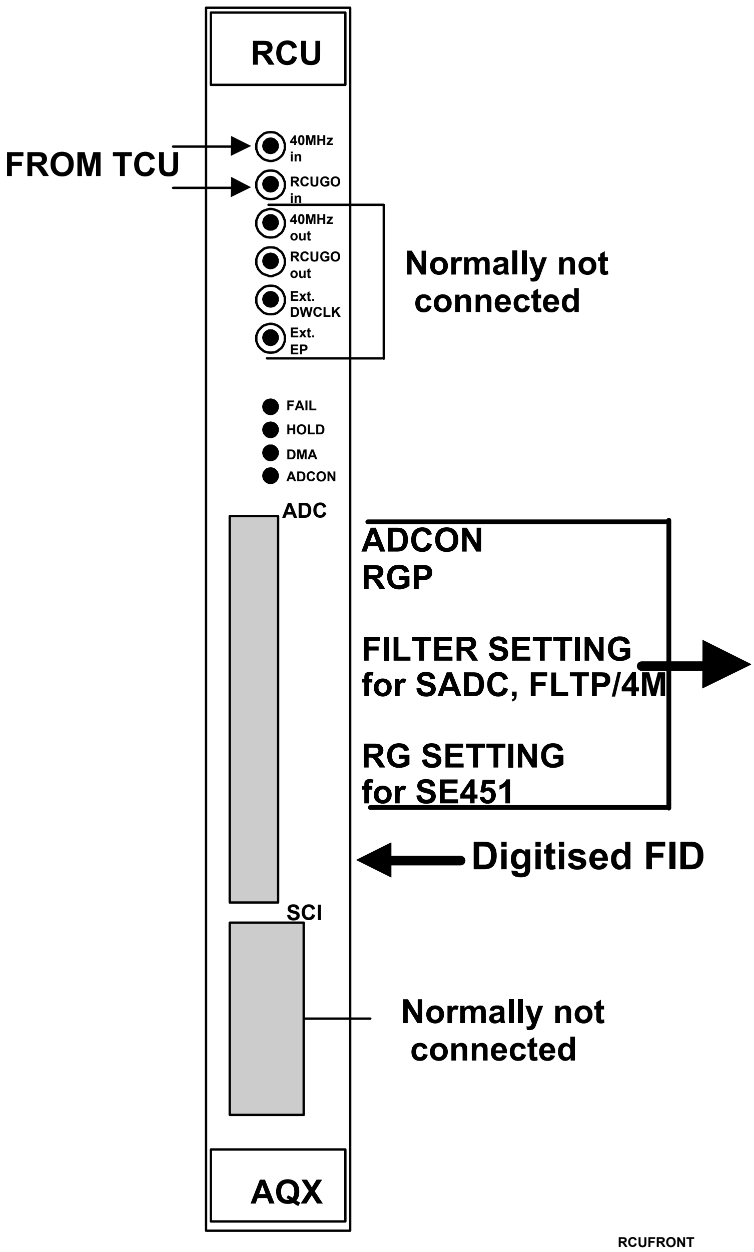
In normal operation this input is not connected. It has been provided so that the receiver gating could be synchronized with an external pulse from the TCU.

50 way digitizer cable:

As well as the normal digitized FID the 50 way digitizer cable also transmits the ADCON,RGP and I^2C bus signals.

The SCI connection is an RS485 type connection which is used for debugging purposes and so normally not used.

Figure 14.1. RCU Front Panel



Checking the DWELL CLOCK 14.3

For this the Test Extension Board (P/N H2066) is required. The DWELL CLOCK signal may be measured at J2 C30 of either the RCU or the TCU.

If the Test Extension Board is not available then the DWELL CLOCK can be measured at C30 of the Acquisition Bus along the back of the AQX32.

The following table illustrates the Min. dwell time and corresponding max. dwell clock for various digitizers.

Table 14.1. Minimum dwell time and corresponding maximum dwell clock

Digitizer	Minimum Dwell Time (Quad Mode)	Dwell Clock	Maximum SW (Quad Mode)
SADC	3.3us	300 KHz	150 KHz
HRD16	2.5 us	400 KHz	200KHz
FADC	0.05 us (High speed)	20 MHz	10MHz
FADC	2.5 us (Normal mode)	400 KHz	200KHz

Note that for the FADC the oversampling is redundant at rates above the normal mode.

Note also that the actual dwell clock is determined not by the parameter DW („eda“) but rather DWOV.

Acquisition Bus 14.4

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.

VME Bus 14.5

The RCU is connected to the standard VME bus which runs along the AQX32 backplane. The CCU 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 CCU (DMA).

b) Transfer of information regarding the Filter Widths, Receiver Gains as set by UXNMR.

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

Transfer of data to CCU 14.6

The RCU operates an automatic overflow and diskwrite. The accumulated digitized FIDs are stored in a 32 bit x1 M DRAM. The number of scans that can be stored will depend on the digital resolution that is used (see ***figure 14.2.***). Note that the RCU can be fitted with optional extra DRAM expanding the memory to 32 bit x2 M DRAM

At higher sample rates, when using the FADC, a 32 bit x 64K SRAM which is faster than the DRAM is used for accumulation.The use of the SRAM is automatically handled by the software

Diagnostic test 14.7

The RCU may be checked using

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

Useful commands are

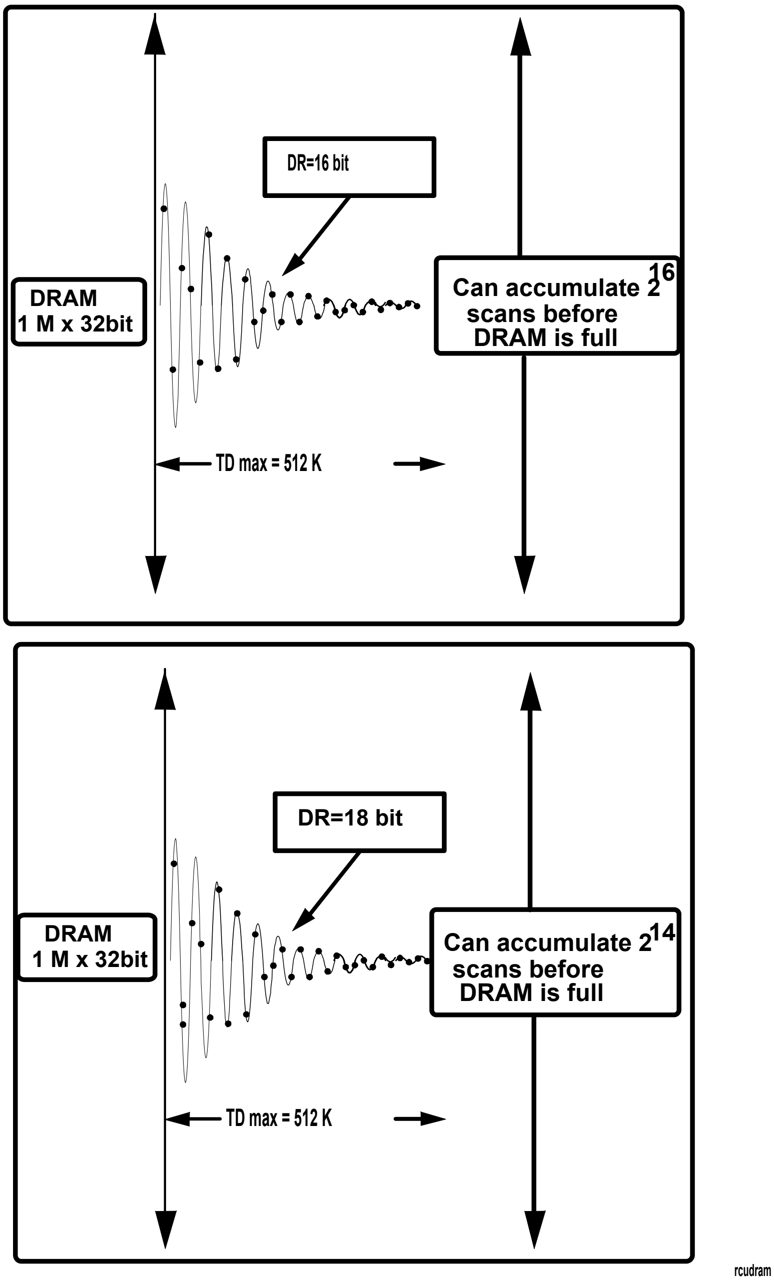
„h“ = help and prints a list of commands

„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.

Figure 14.2. Number of scans that can be stored with standard 1M DRAM



1^2C Bus in the AQR

15

BBIS 15.1

This term stands for **B**ruker **B**oard **I**nformation **S**ystem and is a component of the on-board local intelligence which is now a feature of all AQR boards. In the future it will be expanded to include the AQX32 boards. The system is designed to store information about a particular board on the board itself in an EEPROM. The type of information stored is Date of manufacture, Part and Serial number, Engineering Level etc. This information is burnt onto the EEPROM at manufacture. At the moment it is only possible to access this information using a P.C. and special software. However it is envisaged that in the future engineers will be able to access this information via a service tool. When the system is fully implemented it should be possible to login remotely to a customer's spectrometer and have access to information such as the Engineering Level of all boards. The transfer of information within the AQR boards is achieved using the I^2C Bus.

I^2C Bus 15.2

This is a bi-directional, real time 8 bit serial bus. The bus is non differential and uses TTL levels. Two independent I^2C buses run along the AQR backplane (see figure 16.1). Although both buses use the same protocol they perform different functions and shall be described separately.

Note: In order to separate the two I^2C buses of the backplane jumpers JU1, JU2, JU3 and JU4 must <u>not</u> be populated.

I^2C Bus 1 15.3

This bus interconnects a maximum of eight slots of the AQR Backplane and is used exclusively to support the BBIS. The ACB is the one and only master of this bus. This essentially fixes the position of the ACB in the AQR. The eighth slaves have hardware addresses 0 - 7. The address of a particular slot is fixed in that it is hardwired at the backplane. Vacant slots do not interrupt the bus. An ASU can be placed in any of the slots corresponding to Address 4, 5 or 6. Similarly a router can occupy Address 1, 2 or 3.

The lines of the I^2C bus are as follows:

SDA:

This is the serial data transfer line. Data may only be sent in 8 bit words. For addressing purposes the 8 bits are subdivided as follows:

Three bits determine which board is to be addressed. This limits the bus to a maximum of eight boards. Four bits determine which chip of the board is addressed. For I^2C Bus 1 this address must always correspond to the EEPROM which stores the BBIS data. The last bit determines whether the bus is operating in read or write mode.

SCL:

The I^2C bus can operate at various clocking frequencies as set by the master. The ACB Board uses a clocking frequency of 100 KHz which is the maximum for I^2C bus operation.

SDIR:

The SDIR Signal determines whether the master ACB is sending data (SDIR low) or receiving data (SDIR high).

The 8 bit data words mean that each BBIS EEPROM contains a maximum of 256 storage registers, each containing up to 8 bits of data.

II^2C Bus 2 *15.4*

A second I^2C bus interconnects the remaining three slots. For DRX Spectrometers the slots are occupied by the RX22*, LAB and SADC. For DMX Spectrometers only the LAB slot is occupied. For DSX Spectrometers the three slots are occupied by the RXC, FLT/4P and SADC (see figure 16.2).

The master of this I^2C bus is the RCU. Access to the bus is gained via the SADC using the 50 way digitizer cable. The I^2C bus can be used to:

a) Support the BBIS as with I^2C Bus 1.

b) Set the filters in the SADC (DRX).

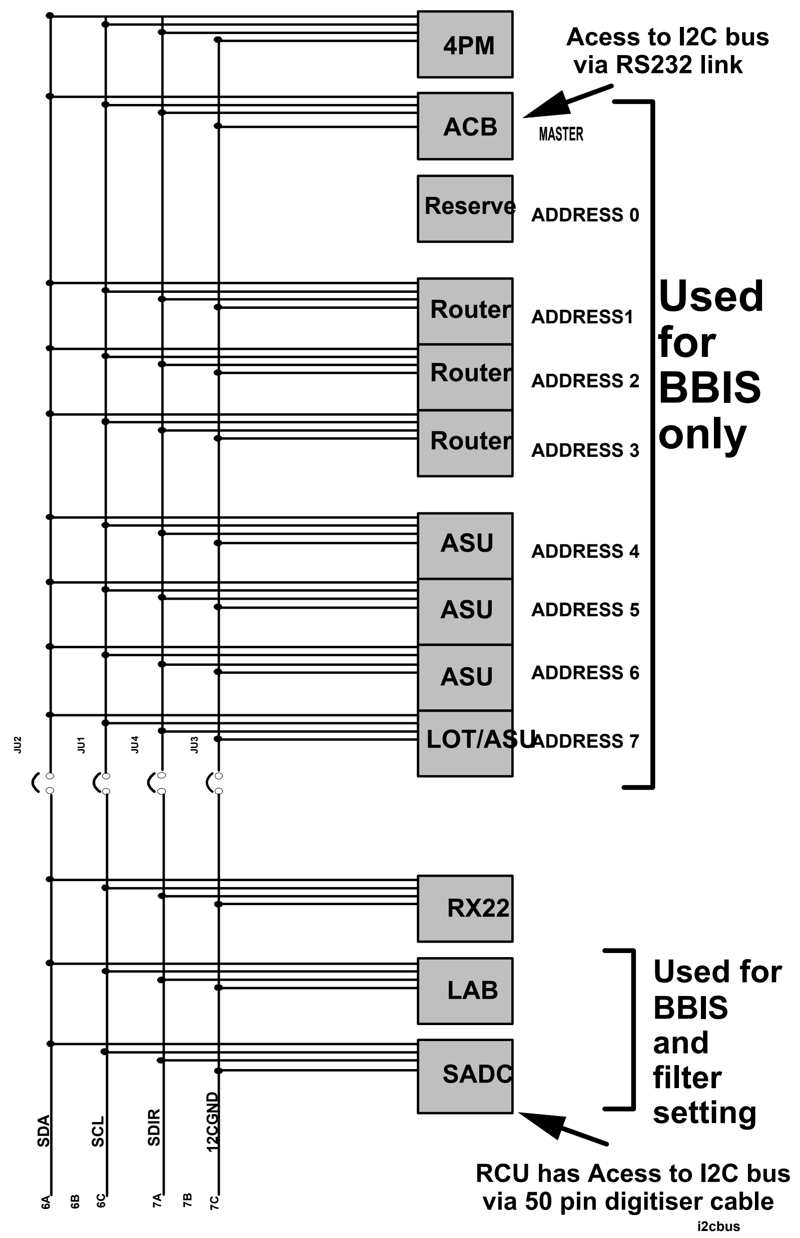
c) Set the filters in the FLTP/4M (DSX).

d) Turn the quadrature detection off (qf in eda).

The software hex. addresses for these boards starting at far left (SADC) are 4E, 4C and 4A.

* Note that while the RX22 has access to the second I^2C it does not use it.

Figure 15.1. I²C Backplane in Standard DRX



DSX Configuration: 15.5

The *figure 15.2.* shows the standard configuration of a DSX. The following is a brief outline of the functions of the various boards.

SADC:

This standard DRX board is fitted so as to give the RCU access to the AQR backplane. In this way filters in the FLTP/4M can be set. Furthermore the customer has the option of using the SADC which has a higher resolution than the FADC.

FLTP/4M:

This is the filter board so named because of the max. Bandwidth of 4MHz. The filters are set by the RCU via the I^{2}C bus. This board also provides the power supply for the FADC

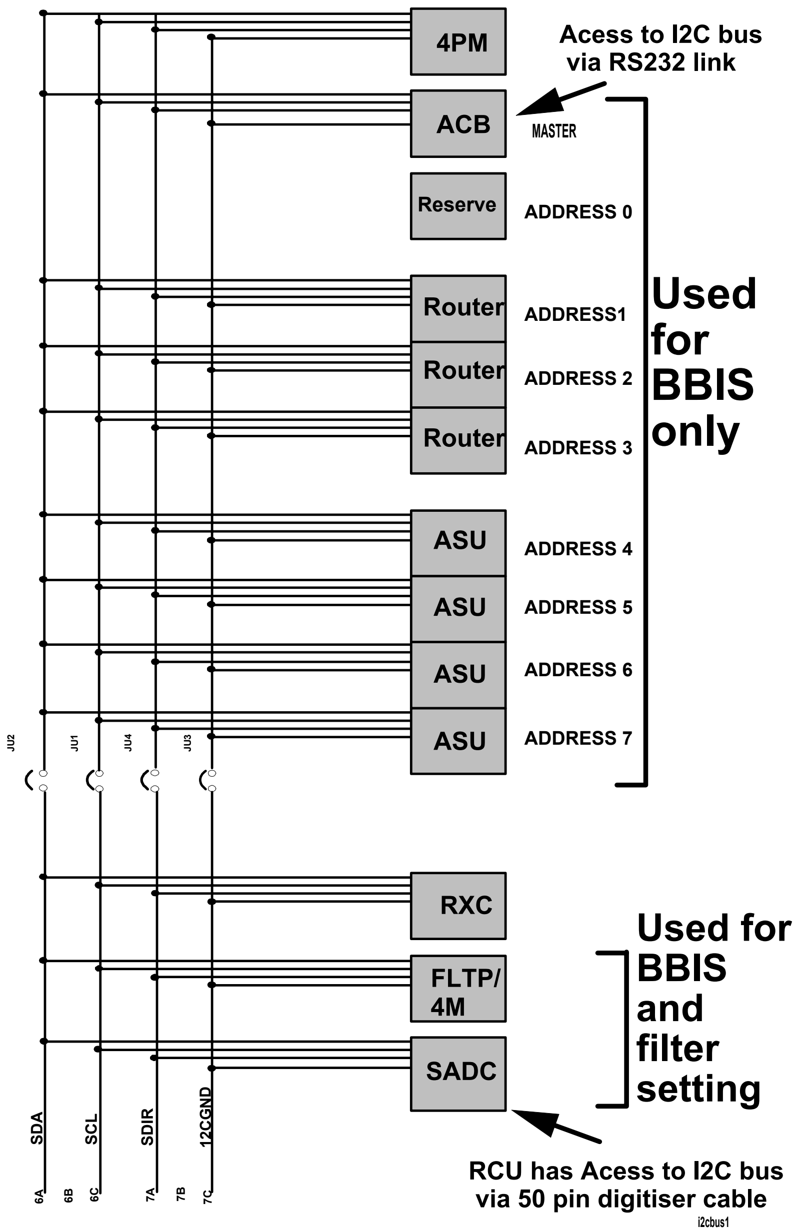
RXC:

This is effectively an RX22 minus the RF section. The DSX is fitted with an FADC instead of the HRD16. The RXC board in a DSX fulfills the functions of the HRD16 Controller II Board in a DMX. This board receives the RGP(EP) from the RCU via the SADC and AQR backplane. This gating pulse is then used to produce three outputs RGPa, RGPb and RGPc. These three outputs (labelled EPA_SE451, EPB_SE451 and EP_HPPR on the board itself) are identical.

A second function is to set the RG bits for the SE451. The information is transmitted via the RS485 link from the CCU

A future function of the RXC will be BBIS identification of the new SE451. This will be done via a direct I^{2}C link from the RXC front panel to the SE451.

Figure 15.2. I²C Backplane in Standard DSX (with new 19“ SE451)



ACB 16

The ACB acts in may ways as an interface between various spectrometer units and shall be discussed in terms of the various communication links with these units (see *figure 16.1.*).

SBS Bus 16.1

The ACB can control up to a maximum of 16 linear amplifiers via the SBS (Serial Bruker Spectrospin) Bus. This is an RS485 type bus of which the ACB is the one and only master. The ACB uses the bus to determine the type and number of installed amplifiers. Each amplifier housing is given a unique address via a Hex. switch on the amplifier front panel. From the Hex. address the router outputs to which the amplifier is connected is made known to the software. This information is then used to customize the „**edsp**“ display for each individual spectrometer.

Amplifier parameters such a Max. Duty Cycle, Max Pulse Width etc. may also be accessed via the SBS Bus.

This bus also carries the „FORW“, „REFL“ and „BLKTR“ signals from the Amplifiers to the ACB. From here these signals are displayed either on the graphic monitor or on the BOSS keyboard.

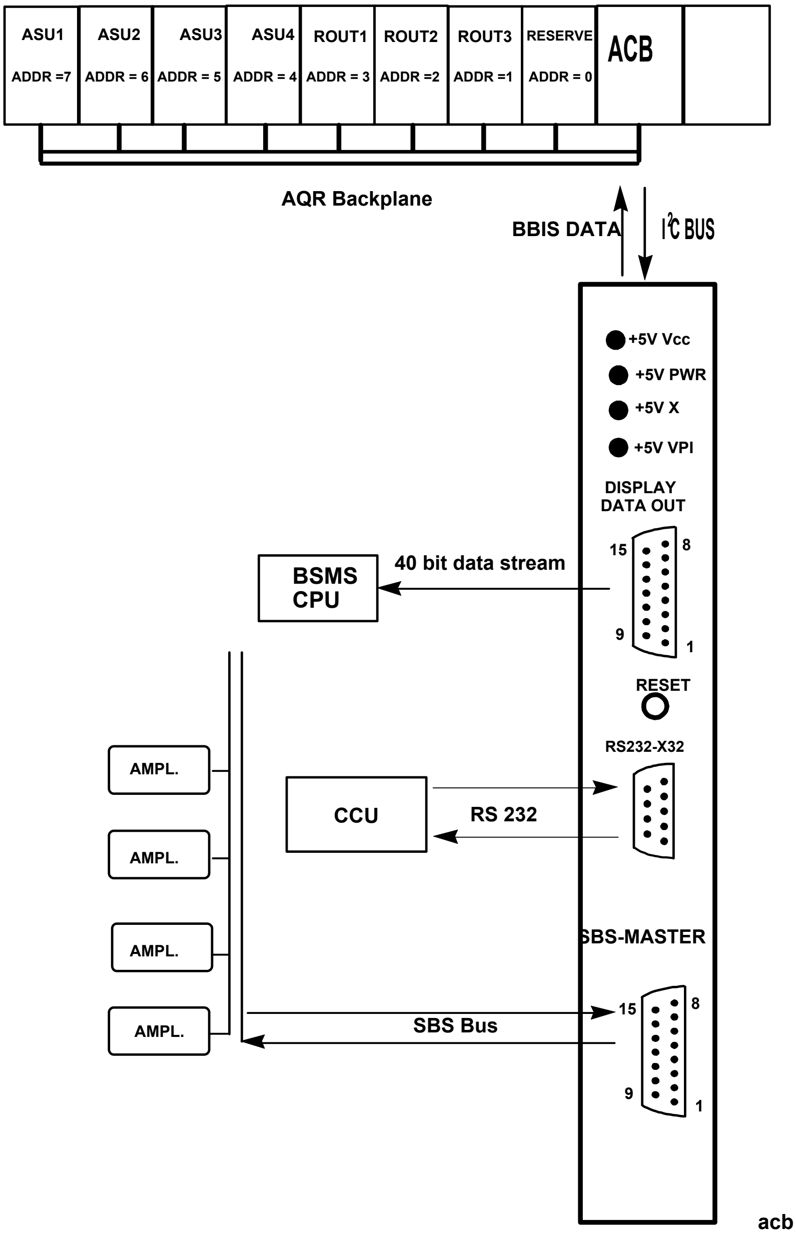
Note: For correct operation the SBS Bus cable (P/N H5624) must be fitted with the terminating plug (P/N H5167).

RS232 Connection 16.2

This connection is used:

1. During initial ACB start-up/reset and to transmit amplifier status and parameters to the CCU.
2. To transmit the data for the screen display of forward and reflected power etc. The data is transmitted to the CCU and then displayed on the graphics monitor. Only those amplifiers which are required for the power display are scanned by the ACB.
3. Read/Write BBIS data via a software tool. This tool is still in development but it will soon be possible to access all BBIS data of the 8 AQR boards connected to the ACB via the I^2C bus.

Figure 16.1. ACB Interfaces



I²C Bus — *16.3*

The ACB is master of the I²C Bus which interconnects 8 slots in the AQR. The addressing of various boards is determined solely by the position of the slot in the AQR. The position of the ACB in the AQR is fixed to the second slot from the end. The position of other boards is more flexible i.e. a Router can occupy any Router slot, an ASU any ASU slot etc. The I²C Bus is used to transfer BBIS data.

Link to BSMS 16.4

This is a 40 Bit unidirectional data stream used to operate the power display on the Boss keyboard (one bit for each LED). The information is received from the amplifiers via the SBS Bus. The power display has a refresh rate of between 300 and 600 Hz. depending on the number of amplifiers that are scanned.

This connection also carries the ADC ON (from AQR Backpanel) and OBS (from Computer) signals to the Boss Keyboard.

Then final function of this link is the „Chan Select“ and „TRANS P-DOWN“ functions.

The „TRANS P-DOWN“ button on the BOSS keyboard will cause the ACB to set the SPENAB signal high when pressed. This will disable all ASU’s, Routers and Amplifiers.

The „Chan Select“ button on the Boss Keyboard simply causes the ACB to toggle through the various channels with regard to the power display.

Note: If the cable to the BSMS CPU is not attached all signal transmission is automatically disabled.

Reset 16.5

This will:

a) reactivate the SPENAB signal.

b) re-enable any disabled amplifiers.

A hardware reset is carried out by pressing the reset button on the front panel.

A software reset is carried out during the „cf“ routine or by clicking on „ACB-Reset“ in the „acbdisp“ menu.

LAB: Level Adapter Board 17

This board is used to invert signals from active low (AVANCE standard) to active high. This is required for units such as the SE451 and HPPR which were developed prior to the introduction of the AVANCE series.

Note: Newly developed SE451 units and HPPR cover modules will make the LAB redundant. In the case of the SE451 the logic will be altered to active low. The newest HPPR cover modules have a piggyback board with which the HPPR can be configured to accept active low gating pulses. Modifications to the BSMS will also enable the LockHold and Homospoil outputs to be inverted by software.

The LAB has two connectors LAB1 and LAB2.

LOWER CONNECTOR LAB1 17.1

The functions of the main LAB board which takes it's inputs from Connector LAB1 will depend on whether the instrument is a DMX or DRX. Jumper settings can be used to determine

a) whether a signal is inverted or not

b) whether a signal is connected to the AQR backplane or not.

STANDARD DMX

The board is used to invert signals used in the SE451. Listed below are the relevant signals and required jumper settings.

To invert TGPCH1 (SPFX to SE451) J6 in

To invert TGPCH2 (SPFH to SE451) J5 in

To invert OBSCH1 (SELOBS X/H) J2 in

STANDARD DRX

For a DRX fitted with a RX22 receiver the Connector LAB1 is not used. This is because the RX22 logic is active low. Note however that one jumper position is relevant. Jumper J9 should not be inserted. This is to ensure that the RGP pulse which is transmitted along the AQR backplane is not connected to the LAB.

DRX with HRD16:

The RGPa pulse is normally transmitted from the RCU to the SADC via the 50 way digitizer cable. From here it is connected to the RX22 via the AQR backplane. When the SADC is not fitted then the HRD16 must provide the RX22 with RGPa. A cable connects RGPa out (SMB connector of the HRD16) to pin P of Connector

LAB 1 (see *figure 13.2.*). From here it is inverted and transmitted to the backplane. The required jumper settings are listed below:

To invert RGPa (EPa) J7 in

To connect RGPa (EPa) to backplane J9 in

BSMS Signals:

Two further signals may be inverted **if required** using Connector LAB 1:

Table 17.1. BSMS Signals

Signal	Input	Output	Comments
Homospoil	L	M	J4 in to invert
Lock Hold	R	U	J3 in to invert

UPPER CONNECTOR LAB2 *17.2*

The piggyback board handles signals received from Connector LAB2 and is normally used to invert signals for the HPPR. Three inputs (TGPPA1, TGPPA2, and TGPPA3) are taken from the TCU and the inverted outputs are connected to the PREAMP PERIPH Connector.

The piggyback board is designed to invert any connected inputs. There are no jumper settings to determine whether a signal is inverted or not. The board is used identically in DMX, DRX, and DSX spectrometers.

DPX Spectrometers *17.3*

For these spectrometers the LAB is not required because

a) The RX22 logic is active low. This makes Connector LAB1 redundant.

b) They are fitted with the newer HPPR cover modules as standard. This makes Connector LAB2 redundant.

Note that for some of the earliest DPX spectrometers it may be necessary to modify the BSMS for Lockhold inversion.

Software 18

EDSCON: Edit spectrometer constants: 18.1

It is now possible to edit the delays before rf pulses using the table called up with the UXNMR command „edscon“. Note that the edscon table does not allow one to make all adjustments that are supported by the hardware. Instead a simplified version has been developed in the interest of user friendliness. The engineer should however be aware that the pre and post blanking delay may be set individually for every individually produced TCU output. In the edscon table the user can set the pre blanking delays only. To set the post blanking delays, with the software as it is presently configured, would require explicit pulse programming. A further simplifying feature is that the same timing is used for Router, amplifiers and ASU's. However with explicit pulse programming these could also be set individually. If deemed necessary the edscon table could be expanded to support all hardware timing features.

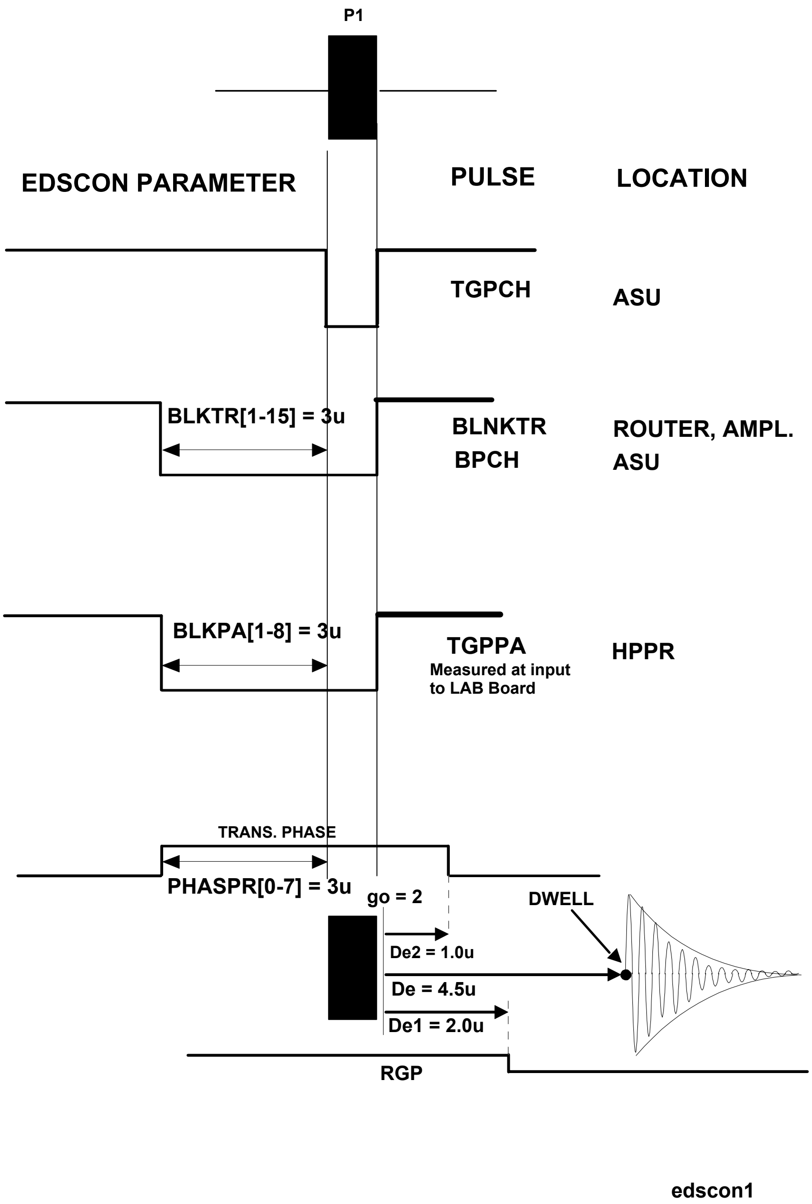
The constants set in the „edscon“ table are stored in the file /u/conf/instr/<name>/scon

The constants are set for the spectrometer and will automatically be implemented for each new acquisition. Individual values may not be stored in different data sets. Figure 19.1 shows the relationship between the „edscon“ parameters and the corresponding blanking pulses for an rf pulse of length p1 on channel 1. All values are in ms.

Default values for all preblanking is 3ms. The BLKTR,TGPCH,TGPPA and BPCH pulses have already been explained in various chapters. Note that while the table displays BLKTR0-15 only BLKTR1-15 are relevant as regards amplifier and router blanking. Furthermore as regard the ASU only BLKTR1-8 are actually used. The PHASPR parameter is the phase preset time which can be set individually for each FCU.

The software is so programmed that 4.5ms after the „go = 2“ statement in the pulse program the first point will be digitised. This value can be changed but only in the source program. However at what particular point within this 4.5ms the Receiver is opened may be set by the user with the parameter De1. This has the default value of 2ms. A second parameter De2 which determines how soon after the RCU_Go pulse the transmitter phase is reset may be adjusted with the parameter De1 (default value 1ms).

Figure 18.1. Timing of „edscon“ parameters



EDSP display 18.2

One of the most impressive new features of the AVANCE series is the „edsp“ display. This allows the user to define the experiment details in a user friendly way. The edsp menu is implemented using several new parameters which will now be explained. Note that all these parameters are set most conveniently using the mouse and the values are normally hidden from the user. They can also however be entered or checked from the keyboard.

FCUCHAN:

This parameter determines which physical FCU is assigned to which software channel. This parameter can be set by hand using the following notation:

0 FCUCHAN 3= 4*

Which means that FCU number 4 will be used for the logical channel F3.

0 FCUCHAN 4= 5

Which means that FCU number 5 will be used for the logical channel F4 etc.

* Note that the keyboard syntax is „0 space FCUCHAN space 3 enter " etc. This syntax applies to all edsp parameters.

The default FCUCHAN values can easily be restored by clicking on „DEFAULT" with the mouse.

RSEL:

How a particular signal is routed is determined by the setting of the RSEL control words. Since each FCU is effectively hardwired (via the PTS) to a specific Router input and each Router output is hardwired to a specific amplifier, the edsp display simply displays the FCU connections to the amplifier.

The routing of FCU1 is determined by the value of RSEL1, the routing of FCU2 is determined by RSEL2 etc. The destination amplifier determines the value assigned to RSEL1, RSEL2 etc.

For example:

0 RSEL1 = 3 means that FCU1 is routed to amplifier 3

0 RSEL2 = 5 means that FCU2 is routed to amplifier 5

Each amplifier is numbered from 1 to 16 as in *figure 18.2.*.

Where a router input is not used then the corresponding RSEL word is assigned a value of 0.

SWIBOX:

The output of the various individual amplifiers may be switched to different N-type outputs labelled 1H, 19F and X QNP on the amplifier housing front panel (see chapter 11).

The parameter SWIBOX is used to control the internal switching within the amplifier housing. The amplifier outputs can be switched to different N-type outputs depending upon the value assigned to the SWIBOX parameter.

For example: 0 SWIBOX 1 = 3 means switch amplifier output 1 to N-type output 3

The numbering of the various inputs and outputs of the DMX and DRX standard amplifiers can be seen in *figure 18.2.* and *figure 18.3.*

Where an amplifier output is not used then the corresponding SWIBOX word is assigned a value of 0.

Note that in order for the edsp display to work properly the output of the first BLAX300 in a DMX should be hardwired to the Xin of the BLARH100.

PRECHAN:

This parameter is used to determine the connections from the amplifier output to the HPPR module. Note however that this parameter has no physical influence It is up to the operator to ensure that the cabling is correct. The parameter is required so that the contents of the edsp display may be stored and called up at a later date. The PRECHAN parameter is however used to determine the OBS module. The module chosen as the destination of the F1 (NUC1) channel will be selected as the OBS module.

Up to 5 HPPR modules may be displayed in edsp and they are numbered 0 to 4 as in ***figure 18.2.***

For example: 0 prechan 1 = 3 means that amplifier output 1 is connected to HPPR module 3.

Note that when an amplifier output is not used then the corresponding PRECHAN parameter defaults to a value of 5.

Figure 18.2. Standard DMX edsp Display

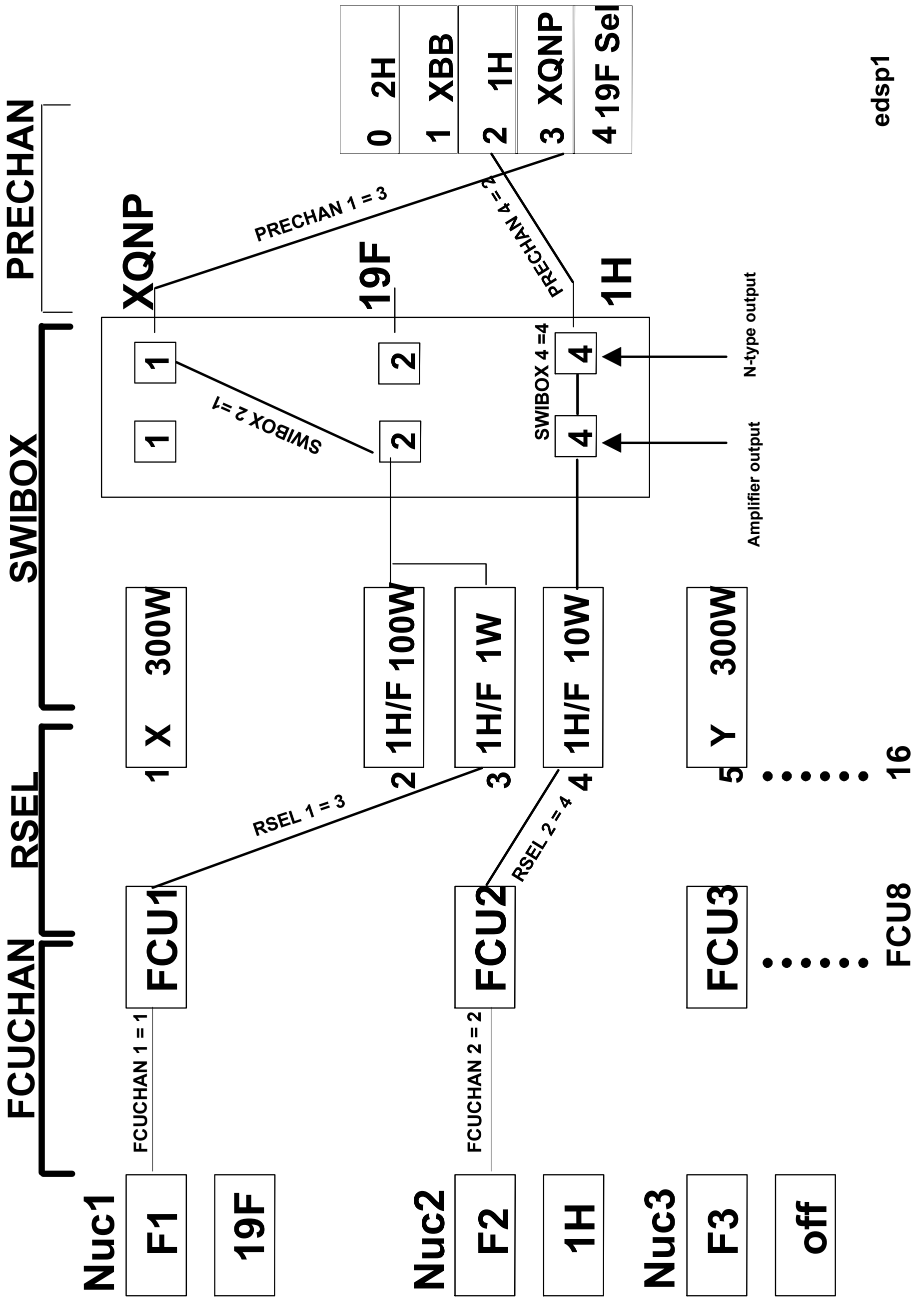
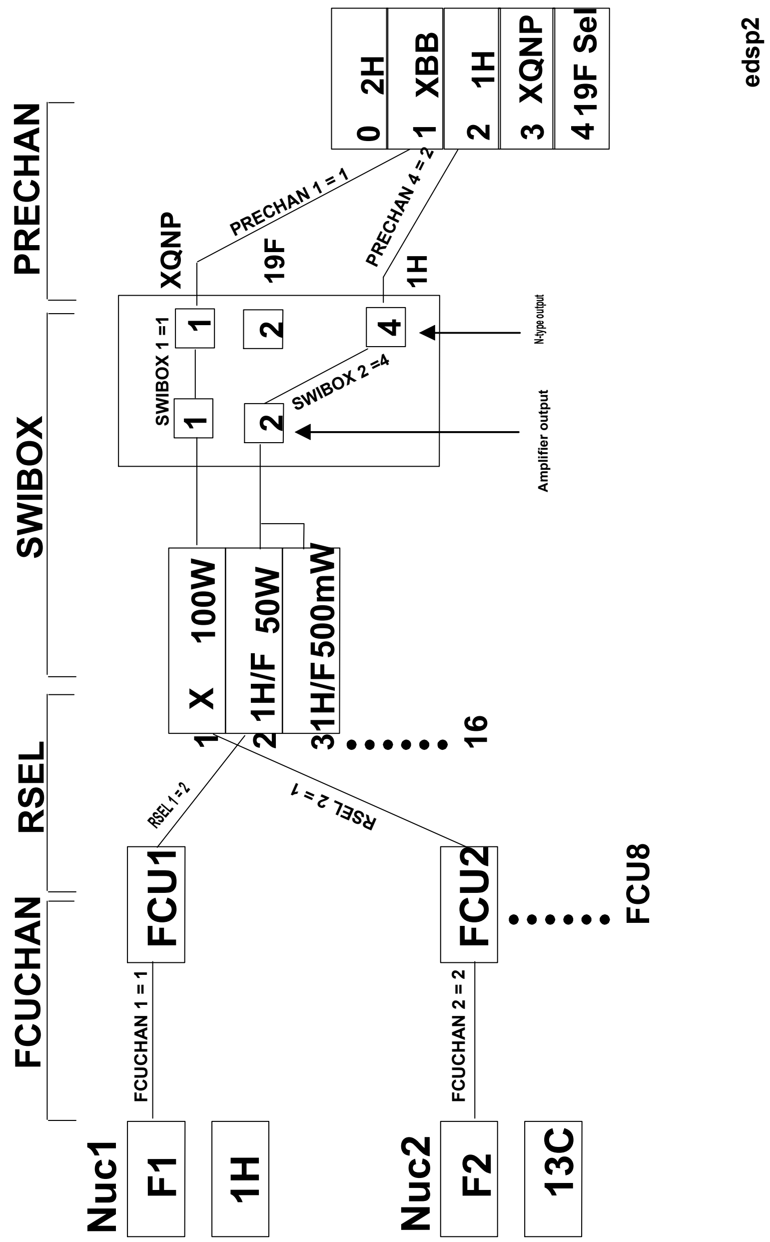


Figure 18.3. Standard DRX edsp Display



Conversion Tables

Table A.1. Conversion Tables

dBm	Vpp	Watt	dBm	Vpp	Watt	dBm	Vpp	Watt	dBm	Vpp	Watt	dBm	Vpp	Watt
-6	0,317	2,51E-04	9	1,783	7,94E-03	24	10,024	0,251	39	56,368	7,943	54	316,981	251,19
-5	0,356	3,16E-04	10	2,000	0,0100	25	11,247	0,316	40	63,246	10,00	55	355,658	316,23
-4	0,399	3,98E-04	11	2,244	0,0126	26	12,619	0,398	41	70,963	12,59	56	399,055	398,11
-3	0,448	5,01E-04	12	2,518	0,0158	27	14,159	0,501	42	79,622	15,85	57	447,747	501,19
-2	0,502	6,31E-04	13	2,825	0,0200	28	15,887	0,631	43	89,337	19,95	58	502,381	630,97
-1	0,564	7,94E-04	14	3,170	0,0251	29	17,825	0,794	44	100,238	25,12	59	563,681	794,34
0	0,632	1,00E-03	15	3,557	0,0316	30	20,000	1,000	45	112,469	31,62	60	632,460	1000,01
1	0,710	1,26E-03	16	3,991	0,0398	31	22,441	1,259	46	126,192	39,81	61	709,632	1258,94
2	0,796	1,58E-03	17	4,477	0,0501	32	25,179	1,585	47	141,590	50,12	62	796,220	1584,92
3	0,893	2,00E-03	18	5,024	0,0631	33	28,251	1,995	48	158,867	63,10			
4	1,002	2,51E-03	19	5,637	0,0794	34	31,698	2,512	49	178,251	79,43			
5	1,125	3,16E-03	20	6,325	0,100	35	35,566	3,162	50	200,001	100,00			
6	1,262	3,98E-03	21	7,096	0,126	36	39,906	3,981	51	224,405	125,89			
7	1,416	5,01E-03	22	7,962	0,158	37	44,775	5,012	52	251,787	158,49			
8	1,589	6,31E-03	23	8,934	0,200	38	50,238	6,310	53	282,510	199,53			

Linear Amplifier Specifications

Table R.1.   RF Pulsed Amplifier BLARH 100 200-400 MHz

RF Pulsed Amplifier BLARH 100 200-400 MHz W1301844 ECL02			
RF Specifications	Channel HHigh	Channel HMed	Channel HLow
Frequency range	180 to 400 MHz (3H on request)	180 to 400 MHz	180 to 400 MHz (3H on request)
Linear Gain	48 dB +/- 1	38 dB +/- 1	- 2 dB +/- 1
Gain Flatness	+/- 1,5 dB max.	+/- 1 dB max.	+/- 1,5 dB max
Minimum Pulsed Output Power	100 W typ. (at nominal input + 4 dBm)	8 W typ. (at nominal input + 4 dBm)	-50 dB of HHIGH Channel Linear
CW Output Power	25 W max. (internal limitation)	No limitation	Power Region
Linear Output Power	60 W min. at 1 dBm compression	5 W min. at 1 dBm compression	no limitation
Amplifier Biasing	Class AB Operation	Class AB Operation	full linear
Blanking Delay	< 1 µs typ.	< 1 µs typ.	Class A Operation
RF Rise Time	< 100 ns	< 100 ns	< 1 µs typ.
RF Fall Time	< 50 ns	< 50 ns	< 100 ns
DC Ringing	200 mV typ. (due to blanking signal)	200 mV typ. (due to blanking signal)	< 50 ns
Input Noise Figure	7 dB max.	7 dB max.	100 mV typ. (due to blanking signal)
Output Noise Power	- 119 dBm @ 1 Hz	- 129 dBm @ 1 Hz	7 dB max.
(Unblanked)	- 174 dBm @ 1 Hz (thermal Noise)	- 174 dBm @ 1 Hz (Thermal Noise)	- 169 dBm @ 1 Hz
Output Noise Power (Blanked)	50 ohms	50 ohms	- 174 dBm @ 1 Hz (thermal noise)
IN/OUT Impedance	1,5 max.	1,5 max.	50 ohms
Input V.S.W.R.	30 dBc min. at 100 W (full range)	30 dBc min. (full range)	1,5 max.
Output Harmonics	500 ms @ 100 W (up to CW at 25 W)	No limitation	40 dBc min. (full range)
Pulse Width (int. limitation)	25 % @ 100 W (up to 100 % at 25 W)	No limitation	no limitation
Duty Cycle (int. limitation)	< 4 % @ 100 W for 100 ms Pulse Width	< 4 % @ 10 W for 500 ms Pulse	no limitation
Amplitude Droop	< 3 % @ 50 W for 100 ms Pulse Width	Width	< 1 % (full power ; full range)

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.2. RF Pulsed Amplifier BLARH 100 500-600 MHz

RF Pulsed Amplifier BLARH 100 500-600 MHz W1301845 ECL02			
RF Specifications	Channel HHigh	Channel HMed	Channel HLow
Frequency range	470 to 600 MHz (3H on request)	470 to 600 MHz (3H on request)	470 to 600 MHz (3H on request)
Linear Gain	48dB +/- 1	38 dB +/- 1	-2 dB +/- 1
Gain Flatness	+/- 1,5 dB max.	+/- 1 dB max	+/- 1,5 dB max.
Minimum Pulsed Output Power	100 W typ. (at nominal input + 4 dBm)	8 W min.	- 50 dB of HHIGH Linear Power
CW Output Power	25 W max. (internal limitation)	no limitation	Region
Linear Output Power	60 W min. at 1 dBm compression	5 W min. at 1 dBm compression	no limitation
Amplifier Biasing	Class AB Operation	Class AB Operation	full linear
Blanking Delay	< 1 µs typ.	< 1 µs typ.	Class A Operation
RF Rise Time	< 100 ns	< 100 ns	< 1 µs typ.
RF Fall Time	< 50 ns	< 50 ns	< 100 ns
DC Ringing	200 mV typ. (due to blanking signal)	200 mv typ. (due to blanking signal)	< 50 ns
Input Noise Figure	7 dB max.	7 dB max.	100 mV typ. (due to blanking signal)
Output Noise Power	- 119 dBm @ 1 Hz	- 129 dBm @ 1 Hz	7 db max.
(Unblanked)	- 174 dBm @ 1 Hz (Thermal Noise)	- 174 dBm @ 1 Hz (Thermal Noise)	- 169 dBm @ 1 Hz
Output Noise Power (Blanked)	50 ohms	50 ohms	- 174 dBm @ 1 Hz (Thermal Noise)
IN/OUT Impedance	1,5 max.	1,5 max.	50 ohms
Input V.S.W.R.	40 dBc min. at 100 W (full range)	30 dBc min. (full range)	1,5 max.
Output Harmonics	500 ms @ 100 W (up to CW at 25 W)	no limitation	40 dBc min. (full range)
Pulse Width (int. limitation)	25 % @ 100 W (up to 100 % at 25 W)	no limitation	no limitation
Duty Cycle (int. limitation)	< 6 % @ 100 W for 100 ms Pulse Width	< 4 % @ 10 W for 500 ms Pulse	no limitation
Amplitude Droop	< 3 % @ 50 W for 100 ms Pulse Width	Width	< 1 % (full power, full range)

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.3. RF Pulsed Amplifier BLAx 300 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

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.4. 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

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.5. RF Pulsed Amplifier BLARH 50 200-400 MHz

RF Pulsed Amplifier BLARH 50 200-400 MHz W1301868 ECL02			
RF Specifications	Channel HHigh	Channel HMed	Channel HLow
Frequency range	180 to 400 MHz (3H on request)	180 to 400 MHz (3H on request)	6 to 162 MHz
Linear Gain	45 dB +/- 1	- 5 dB +/- 1	49 dB +/- 1
Gain Flatness	+/- 1,5 dB max.	+/- 1 dB max	+/- 1,5 dB max.
Minimum Pulsed Output Power	40 W typ. (at nominal input + 4 dBm)	-50 dB of HHIGH Channel Linear Power Region	100 W typ. (at nominal input + 4 dBm)
CW Output Power	10 W max. (internal limitation)	no limitation	25 W max. (internal limitation)
Linear Output Power	30 W min. at 1 dBm compression	full linear	80 W typ. at 1 dBm compression
Amplifier Biasing	Class AB	Class A	Class AB
Blanking Delay	< 1 µs typ.	no blanking	< 1 µs typ.
RF Rise Time	< 100 ns	< 100 ns	< 100 ns
RF Fall Time	< 50 ns	< 50 ns	< 50 ns
DC Ringing	200 mV typ. (due to blanking signal)	none	100 mV typ. (due to blanking signal)
Input Noise Figure	6 dB max.	8 dB max.	7 db max.
Output Noise Power (Unblanked)	- 123 dBm @ 1 Hz	- 171 dBm @ 1Hz (own Noise) added to HHIGH	- 118 dBm @ 1 Hz
Output Noise Power (Blanked)	- 164 dBm @ 1 Hz	Channel Blanked Noise (-164 dBm@1Hz)	- 153 dBm @ 1 Hz
IN/OUT Impedance	50 ohms	50 ohms	50 ohms
Input V.S.W.R.	1,5 max.	1,3 max.	1,3 max.
Output Harmonics	40 dBc min. at 40 W (full range)	40 dBc min. (full range)	15 dBc min. at 100 W (full range)
Pulse Width (int. limitation)	10 ms @ 40 W (up to CW at 10 W)	no limitation	10 ms @ 100 W (up to CW at 25 W)
Duty Cycle (int. limitation)	25 % @ 40 W (up to 100 % at 10 W)	no limitation	25 % @ 100 W (up to 100 % at 25 W)
Amplitude Droop	< 5 % @ 40 W for 10 ms Pulse Width	< 1 %	< 3 % @ 100 W for 10 ms Pulse Width

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.6. RF Pulsed Amplifier BLARH 50 500-600 MHz

RF Pulsed Amplifier BLARH 50 500-600 MHz W1301865 ECL02			
RF Specifications	Channel HHigh	Channel HMed	Channel HLow
Frequency range	470 to 600 MHz (3H on request)	470 to 600 MHz (3H on request)	6 to 241 MHz
Linear Gain	45 dB +/- 1	- 5 dB +/- 1	54 dB +/- 1
Gain Flatness	+/- 1,5 dB max.	+/- 0,5 dB max	+/- 1,5 dB max.
Minimum Pulsed Output Power	50 W typ. (at nominal input + 4 dBm)	-50 dB of HHIGH Channel Linear Power Region	300 W typ. (at nominal input + 4 dBm)
CW Output Power	12,5 W max. (internal limitation)	no limitation	25 W max. (internal limitation)
Linear Output Power	40 W min. at 1 dBm compression	full linear	250 W typ. at 1 dBm compression
Amplifier Biasing	Class AB Operation	Class A	Class AB Operation
Blanking Delay	< 1 µs typ.	no blanking	< 1 µs typ.
RF Rise Time	< 100 ns	< 100 ns	< 100 ns
RF Fall Time	< 50 ns	< 50 ns	< 50 ns
DC Ringing	200 mV typ. (due to blanking signal)	none	100 mV typ. (due to blanking signal)
Input Noise Figure	7 dB max.	8 dB max.	7 db max.
Output Noise Power (Unblanked)	- 122 dBm @ 1 Hz	- 171 dBm @ 1 Hz (own Noise) added to HHIGH Channel Blanked Noise (-174 dBm @ 1 Hz)	- 113 dBm @ 1 Hz
Output Noise Power (Blanked)	- 174 dBm @ 1 Hz		- 154 dBm @ 1 Hz (< 20 dB over Thermal)
IN/OUT Impedance	50 ohms	50 ohms	50 ohms
Input V.S.W.R.	1,5 max.	1,3 max.	1,3 max.
Output Harmonics	40 dBc min. at 50 W (full range)	40 dBc min. (full range)	20 dBc (70 to 242 MHz) at 300 W
Pulse Width (int. limitation)	10 ms @ 50 W (up to CW at 12,5 W)	no limitation	3 ms @ 300 W (up to CW at 25 W)
Duty Cycle (int. limitation)	25 % @ 50 W (up to 100 % at 12,5 W)	no limitation	8 % @ 300 W (up to 100 % at 25 W)
Amplitude Droop	< 5 % @ 50 W for 10 ms Pulse Width	< 1 %	< 3 % @ 300 W for 3 ms Pulse Width

Common Characteristics:

RF Input Connector	SMA (F)

Table R.6. RF Pulsed Amplifier BLARH 50 500-600 MHz

Table R.6. RF Pulsed Amplifier BLARH 50 500-600 MHz

	RF Pulsed Amplifier BLARH 50 500-600 MHz W1301865 ECL02
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Table R.7.   RF Pulsed Amplifier BLARH 20 200-400 MHz

RF Pulsed Amplifier BLARH 20 200-400 MHz W1301869 ECL01		
RF Specifications	Channel H	Channel X
Frequency range Linear Gain Gain Flatness Minimum Pulsed Output Power CW Output Power Linear Output Power Amplifier Biasing Blanking Delay RF Rise Time RF Fall Time DC Ringing Input Noise Figure Output Noise Power (Unblanked) Output Noise Power (Blanked) IN/OUT Impedance Input V.S.W.R. Output Harmonics Pulse Width (int. limitation) Duty Cycle (int. limitation) Amplitude Droop	180 to 400 MHz (3H on request) 45 dB 1 1,5 dB max. 25 W typ. (at nominal input + 4 dBm) No limitation (no protection) 15 W min. at 1 dBm compression Class AB < 1 µs typ. < 100 ns < 50 ns 200 mV typ. (due to blanking sig- nal) 7 dB max. - 124 dBm @ 1 Hz - 174 dBm @ 1 Hz (thermal noise) 50 ohms 1,5 max. 20 dBc min. at 20 W (full range) No limitation (no protection) No limitation (no protection) < 5 % @ 20 W for 1 ms Pulse Width	6 to 161 MHz (3H on request) - 5 dB 1 1 dB max 100 W typ. (at nominal input + 4 dBm) No limitation (no protection) 80 W min. at 1 dBm compression Class AB < 1 µs typ. < 100 ns < 50 n 200 mV typ. (due to blanking signal) 7 dB max. - 120 dBm @ 1 Hz - 157 dBm @ 1 Hz 50 ohms 1,3 max. 15 dBc min. at 100 W (full range) No limitation (no protection) No limitation (no protection) < 2 % @ 100 W for 1 ms Pulse Width

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)

Table R.8.   RF Pulsed Amplifier BLARH 60 200-400 MHz

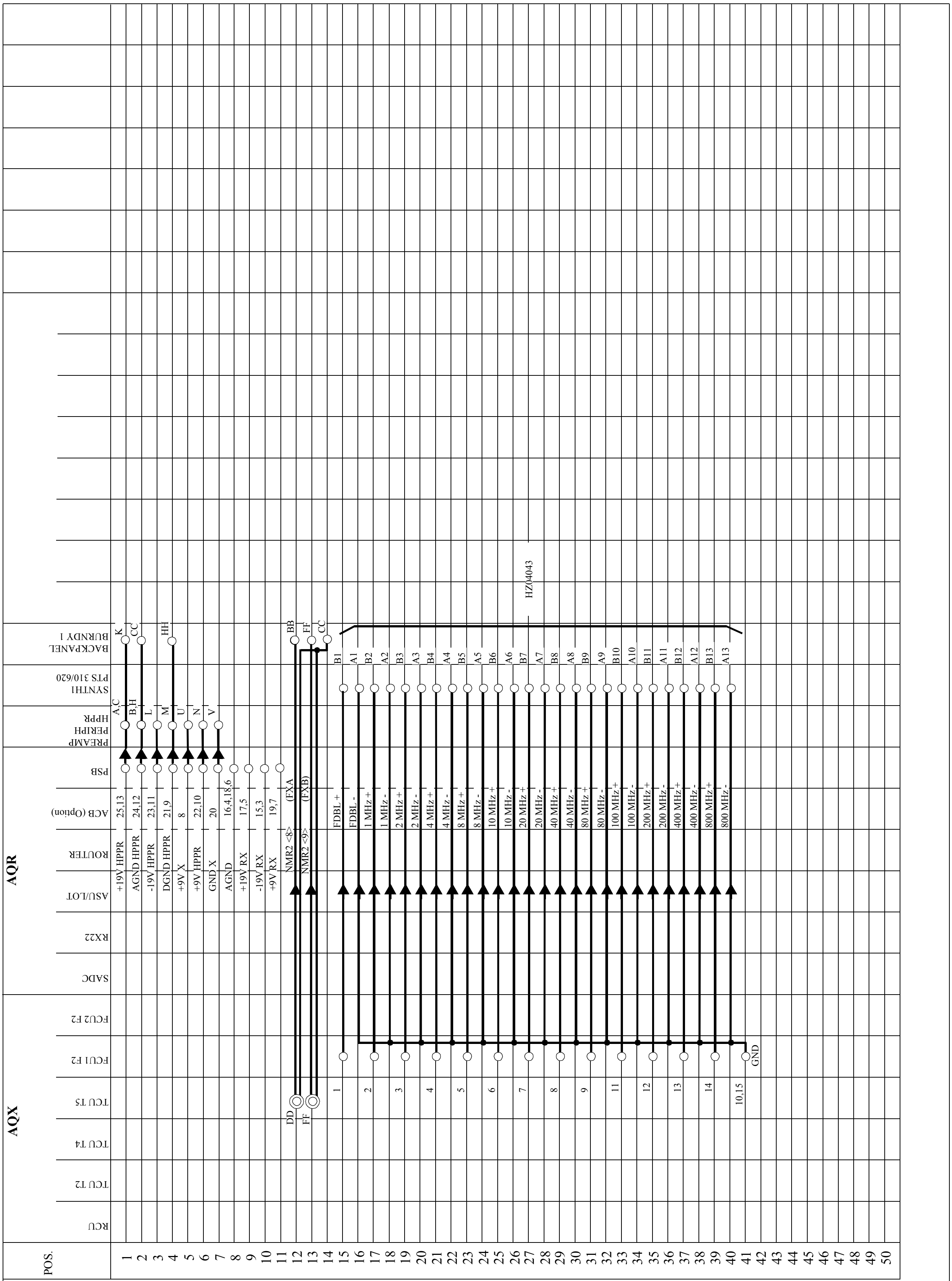
RF Pulsed Amplifier BLARH 60 200-400 MHz W1301867 ECL01		
RF Specifications	Channel H	Channel X
Frequency range Linear Gain Gain Flatness Minimum Pulsed Output Power CW Output Power Linear Output Power Amplifier Biasing Blanking Delay RF Rise Time RF Fall Time DC Ringing Input Noise Figure Output Noise Power (Unblanked) Output Noise Power (Blanked) IN/OUT Impedance Input V.S.W.R. Output Harmonics Pulse Width (int. limitation) Duty Cycle (int. limitation) Amplitude Droop	180 to 400 MHz (3H on request) 46 dB 1 1,5 dB max. 60 W typ. (at nominal input + 4 dBm) 15 W max. (internal limitation) 50 W min. at 1 dBm compression Class AB < 1 µs typ. < 100 ns < 50 ns 200 mV typ. (due to blanking signal) 7 dB max. - 121 dBm @ 1 Hz - 174 dBm @ 1 Hz (Thermal Noise) 50 ohms 1,5 max. 30 dBc min. at 60 W (full range) 500 ms @ 60 W (up to CW at 15 W) 25 % @ 60 W (up to 100 % at 15 W) < 3 % @ 60 W for 100 ms Pulse Width < 3 % @ 30 W for 1s Pulse Width	4 to 162 MHz 43 dB 1 1 dB max 30 W typ. (at nominal input + 4 dBm) no limitation 20 W min. at 1 dBm compression Class AB < 1 µs typ. < 100 ns < 50 ns 200 mv typ. (due to blanking signal) 7 dB max. - 124 dBm @ 1 Hz - 160 dBm @ 1 Hz 50 ohms 1,3 max. 20 dBc min. at 20 W (full range) no limitation no limitation < 1 % @ 20 W for 500 ms Pulse Width

Common Characteristics:

RF Input Connector	SMA (F)
RF Output Connector	N (F)
Blanking Pulse Connector	BNC (F)
RF Switch Control System	BNC (F)
* Duty Cycle Limitation	Disabled by „Multi-pulses Mode“ Control

Wiring Diagrams

Figure R.4. DPX DC Wiring Diagram Page 1



DC WIRING DIAGRAM DPX

Part-No. for Drawing only	Drawn	Modification					ECL: 05	Sheet 1 of 3
	DPXDC1	FDU	ESH	KST	24.02.95	20.09.95		
FDU	01.07.93	15.07.94	25.10.94	ESH	FDU	22.03.94		

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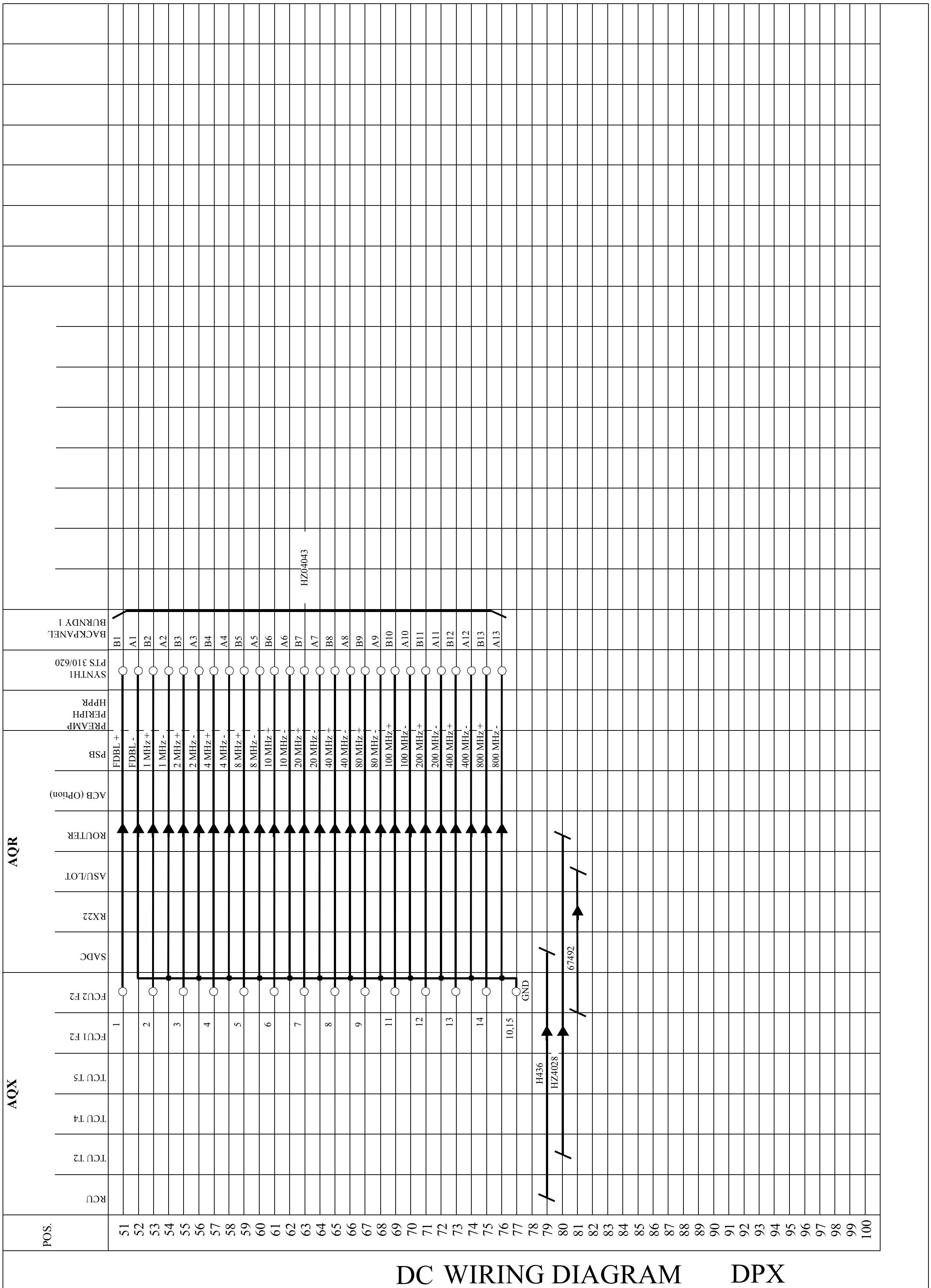
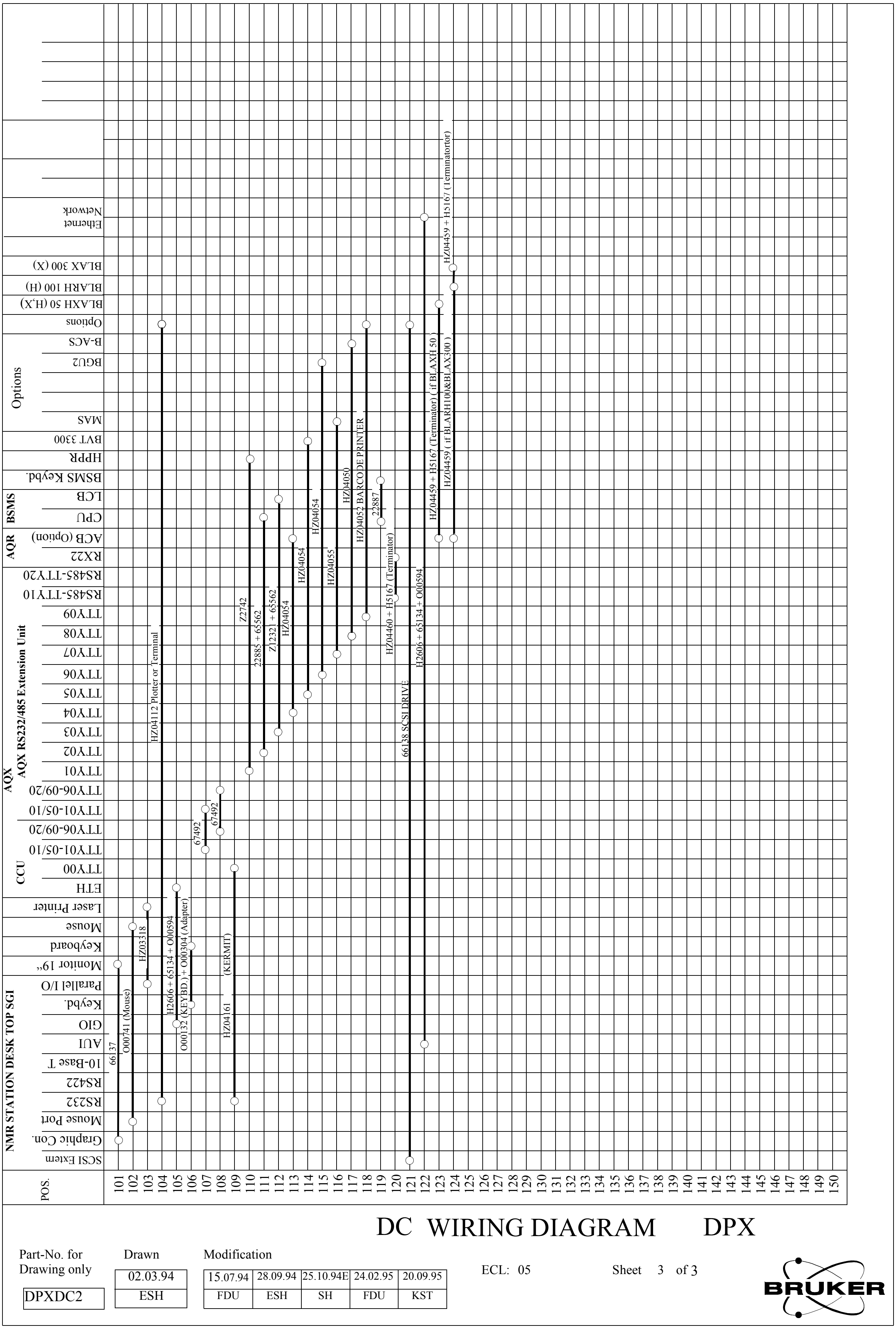
Figure R.5. DPX DC Wiring Diagram Page 2



Part-No. for Drawing only	Drawn	Modification					ECL: 05	Sheet 2 of 3	
	DPXDC2	FDU	ESH	KST	24.02.95	20.09.952			
FDU	12.04.94	15.07.94	25.10.94	ESH	FDU	2.07.94			

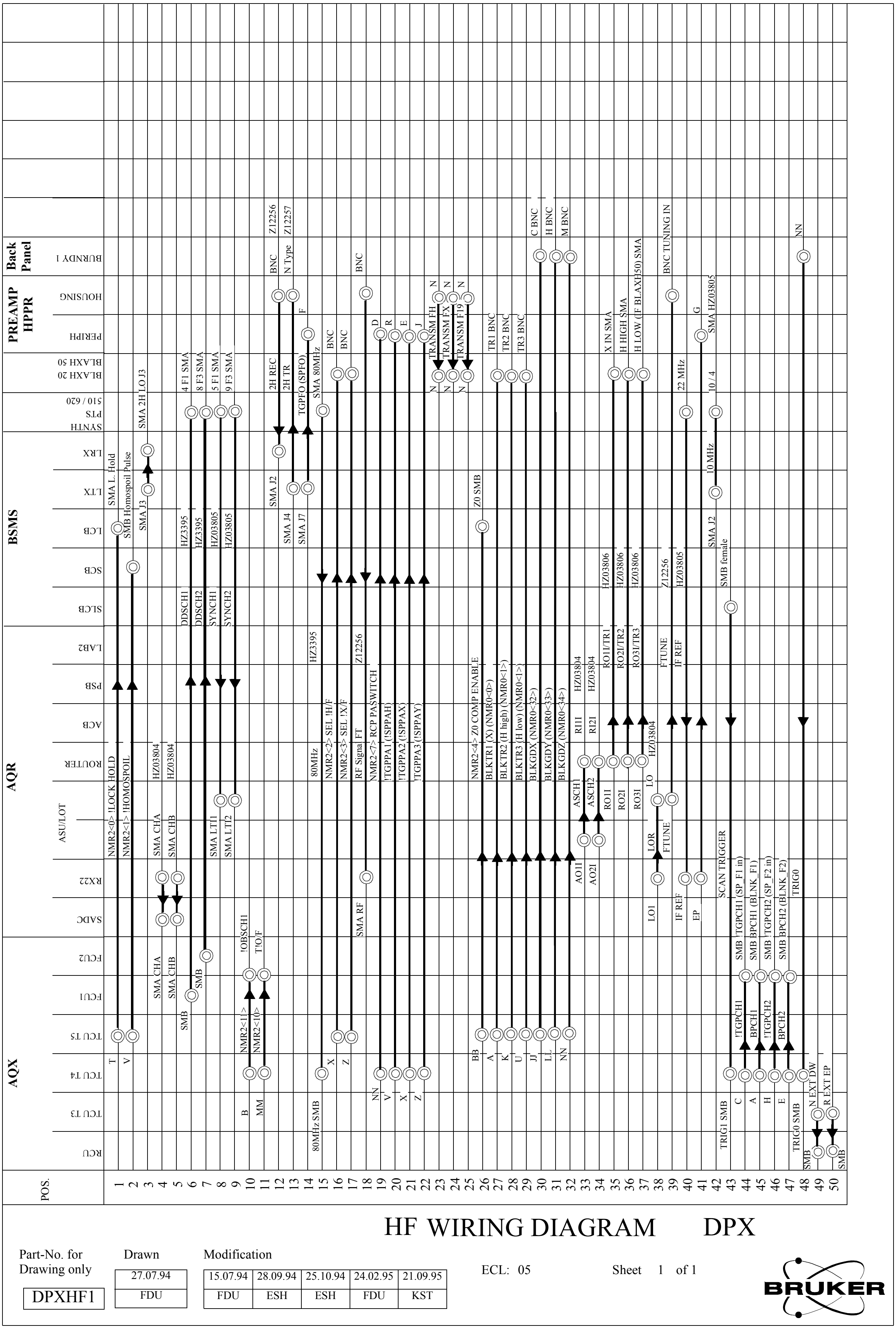
Goto

Figure R.6. DPX DC Wiring Diagram Page 3



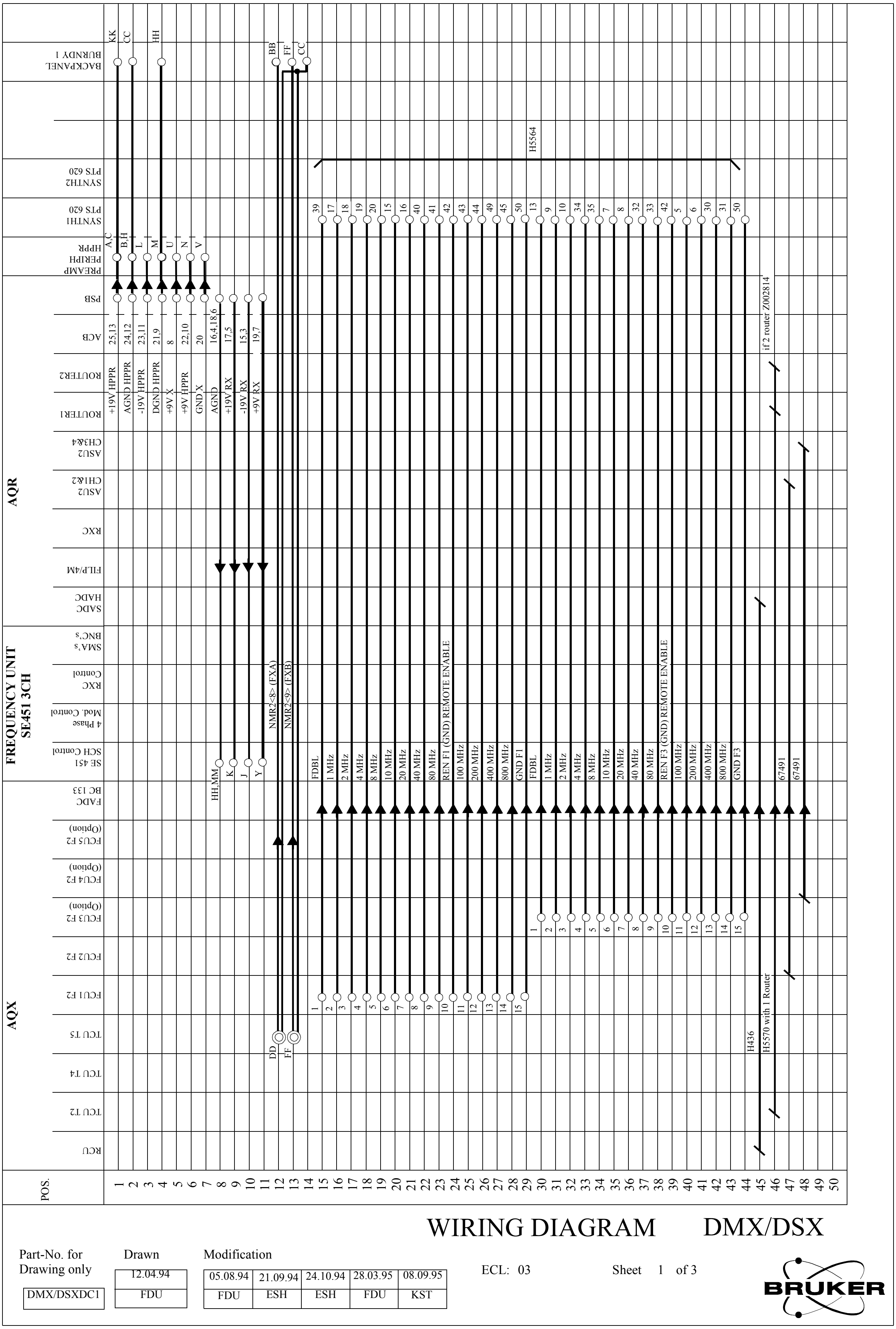
Goto

Figure R.7. DPX HF Wiring Diagram Page 1



Goto

Figure R.8. DMX / DSX DC Wiring Diagram Page 1



Goto

Figure R.9. DMX / DSX DC Wiring Diagram Page 2

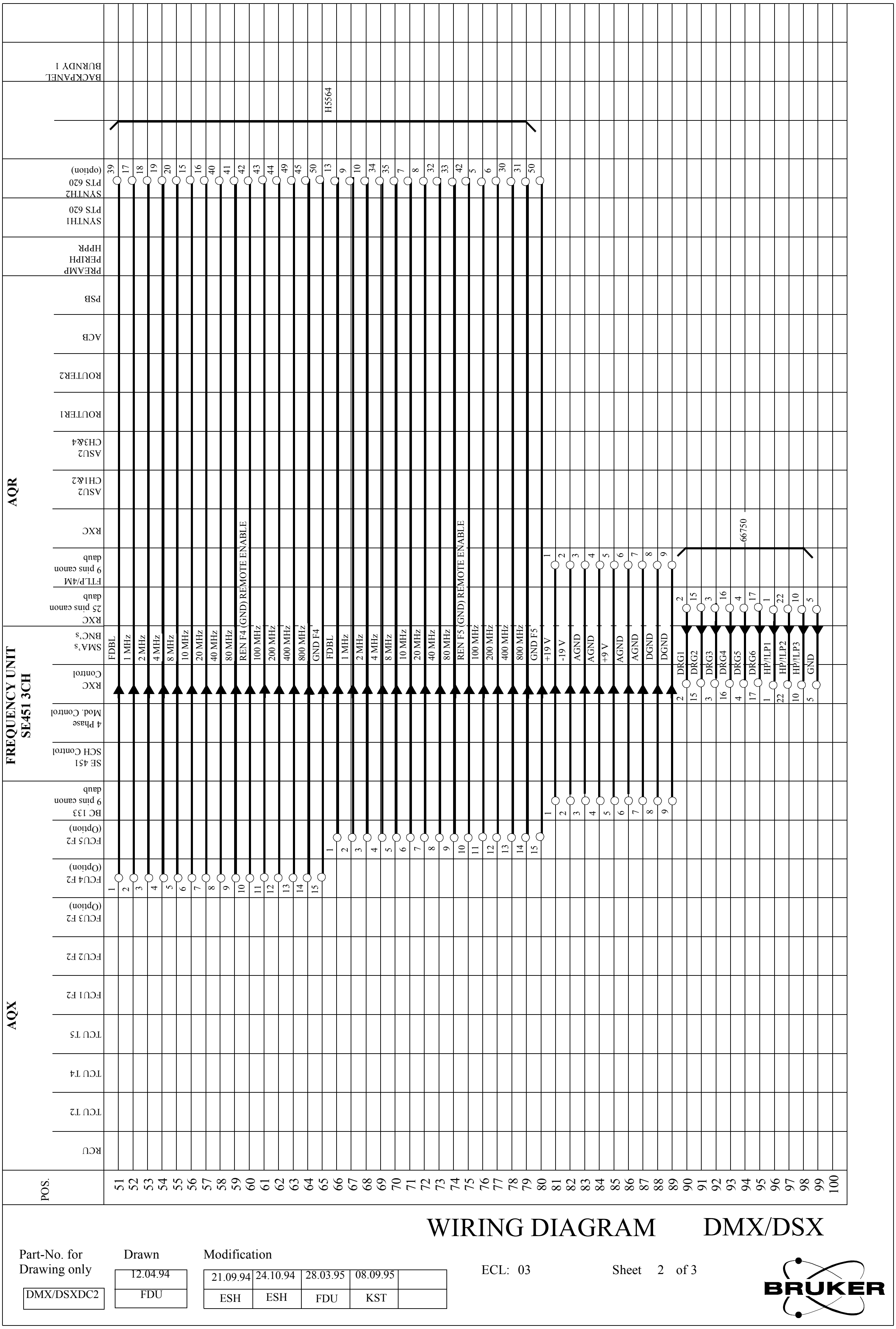
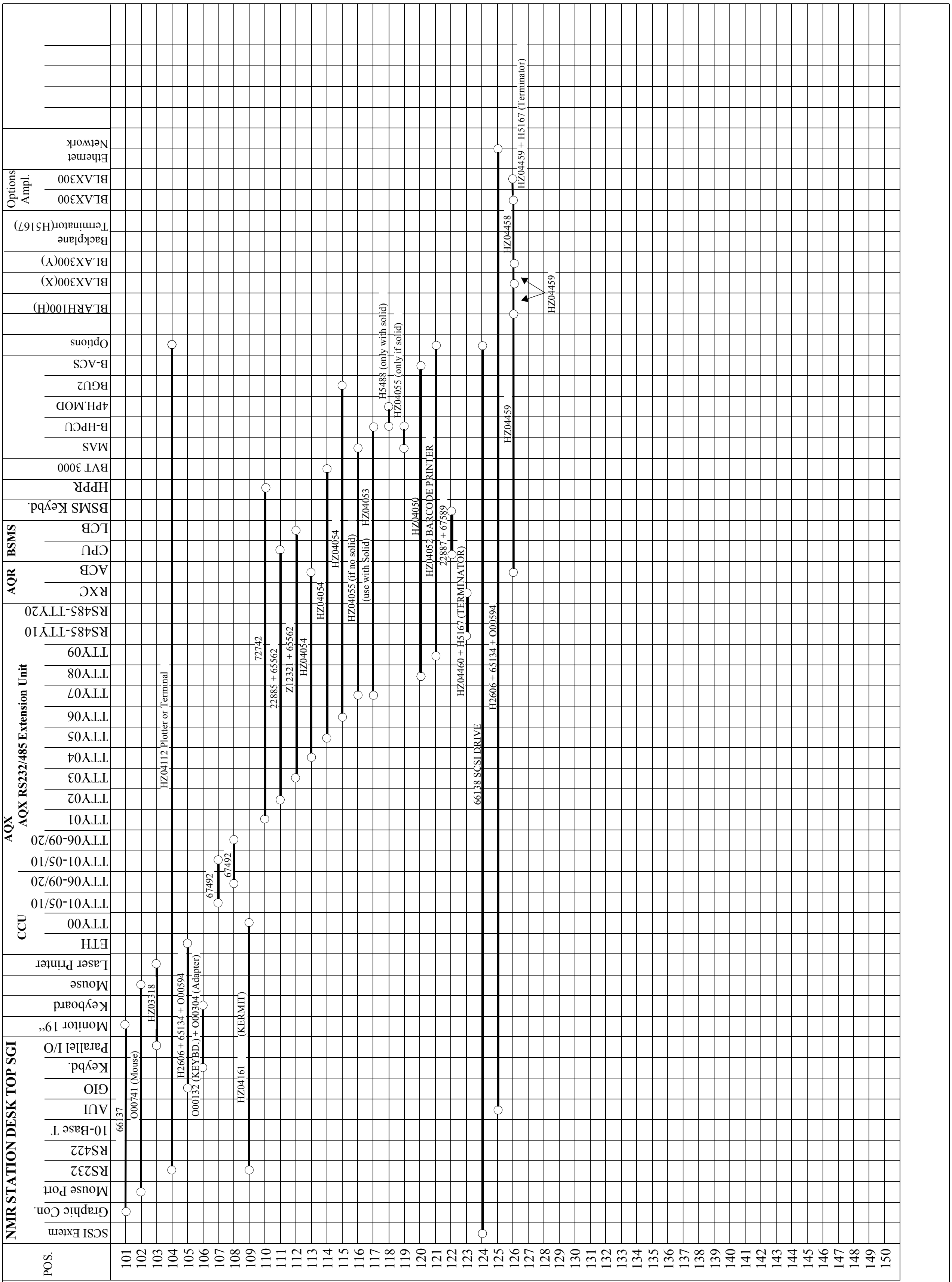


Figure R.10. DMX / DSX DC Wiring Diagram Page 3



WIRING DIAGRAM DMX / DSX

Part-No. for Drawing only	Drawn	Modification				
	02.03.94	06.07.94	28.09.94	24.10.94E	28.03.95	08.09.95
DMX/DSXDC3	ESH	FDU	ESH	SH	FDU	KST

ECL: 03

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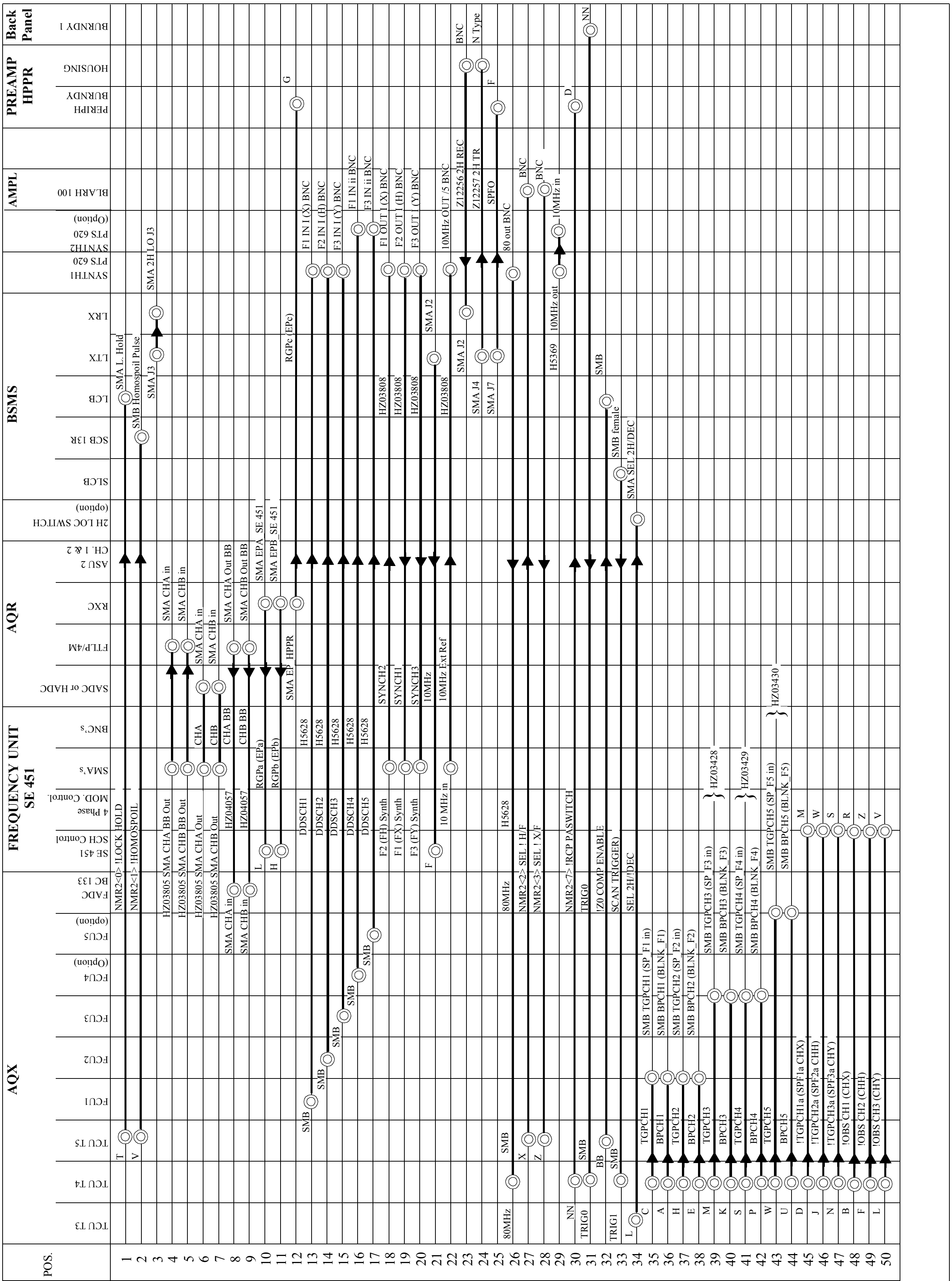
Figure R.11. DMX / DSX HF Wiring Diagram Page 1



HF RING DIAGRAM DMX / DSX

Part-No. for Drawing only	Drawn	Modification					ECL: 03	Sheet 1 of 3
	12.04.94	04.08.94	28.09.94	24.10.94	28.03.94	14.09.95		
DMX/DSXHF1	FDU	FDU	ESH	ESH	FDU	KST		

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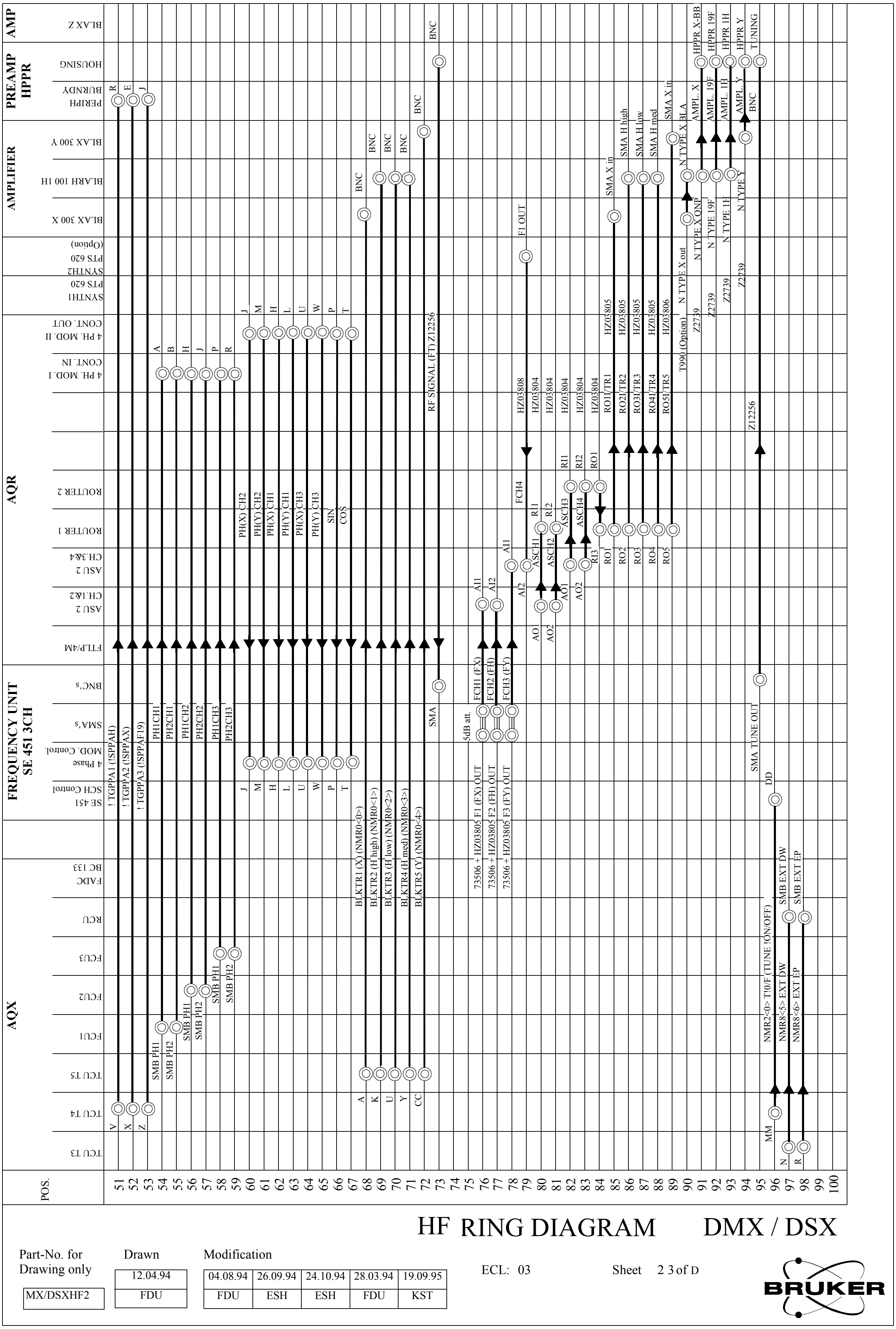
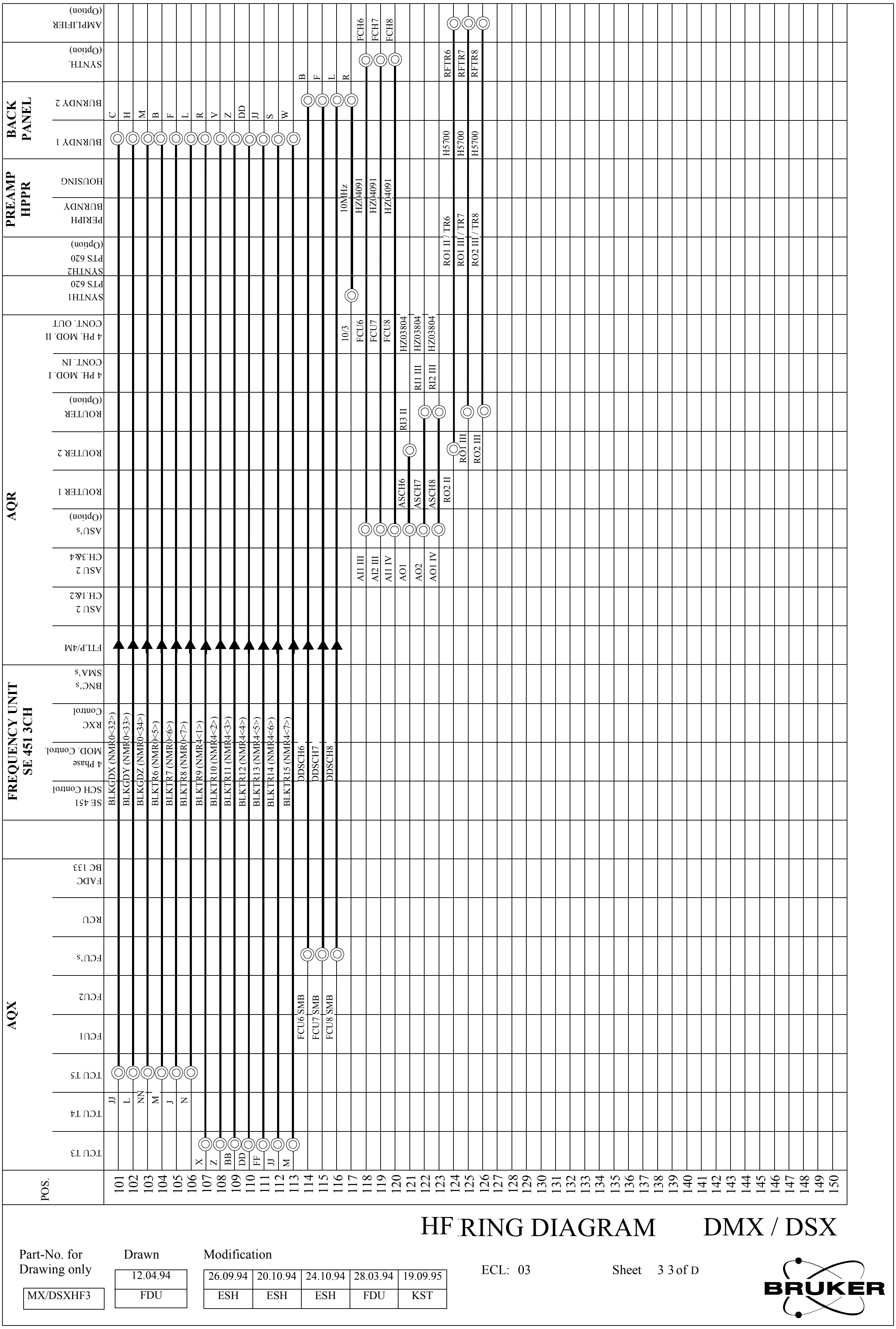
Figure R.12. DMX / DSX HF Wiring Diagram Page 2



Goto

Figure R.13. DMX / DSX HF Wiring Diagram Page 3



Goto

Figure R.14. DRX DC Wiring Diagram Page 1

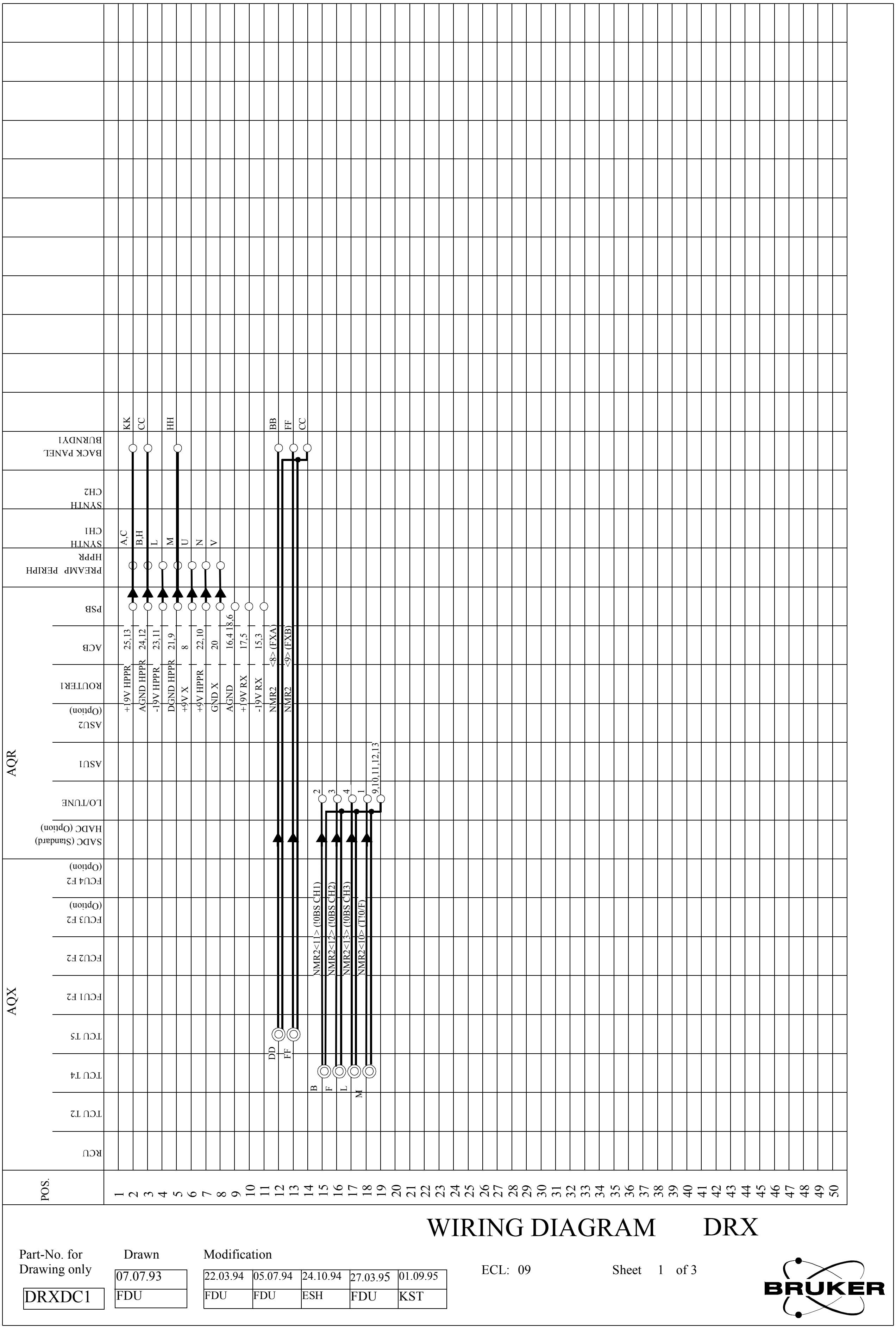
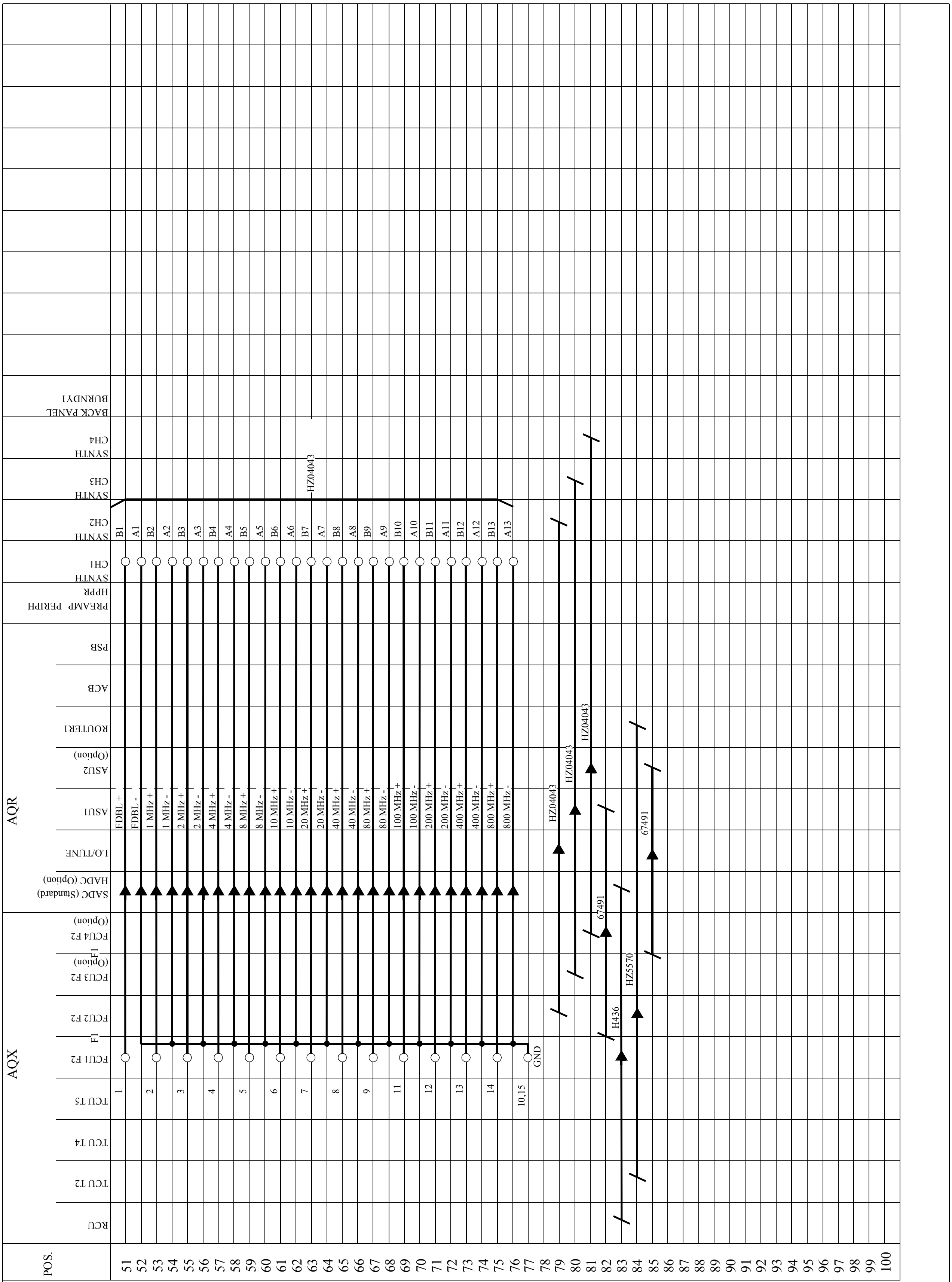


Figure R.15. DRX DC Wiring Diagram Page 2



WIRING DIAGRAM DRX

Part-No. for Drawing only	Drawn	Modification					ECL: 09	Sheet 2 of 3
	07.07.93	22.03.94	05.07.94	24.10.94	27.03.95	01.09.95		
DRXDC2	FDU	FDU	FDU	ESH	FDU	KST		

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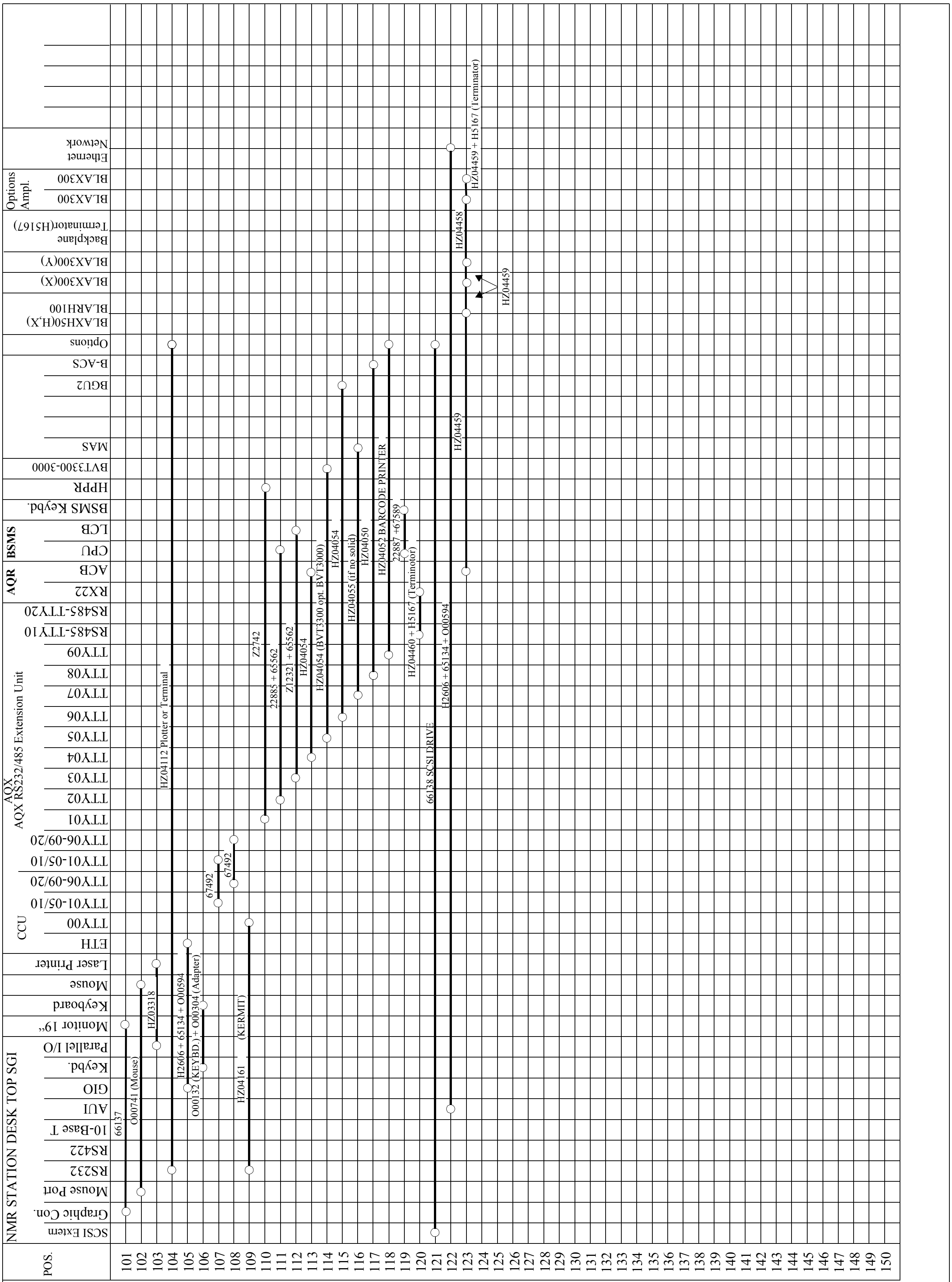
Figure R.16. DRX DC Wiring Diagram Page 3



WIRING DIAGRAM DRX

Part-No. for Drawing only	Drawn	Modification				
	02.03.94	06.07.94	28.09.94	24.10.94E	27.03.95	01.09.95
DRXDC3	ESH	FDU	ESH	SH	FDU	KST

ECL: 09 Sheet 3 of 3

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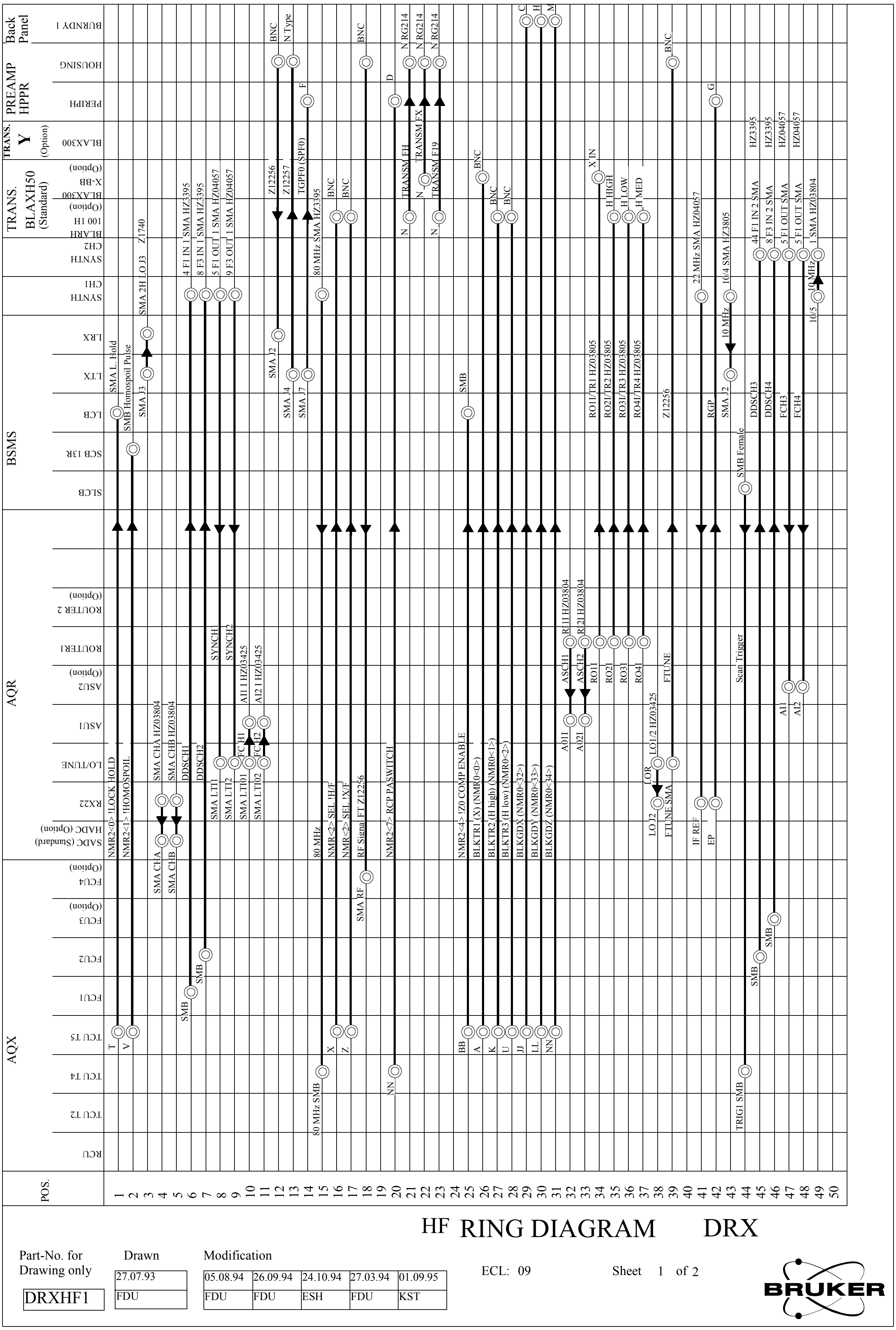
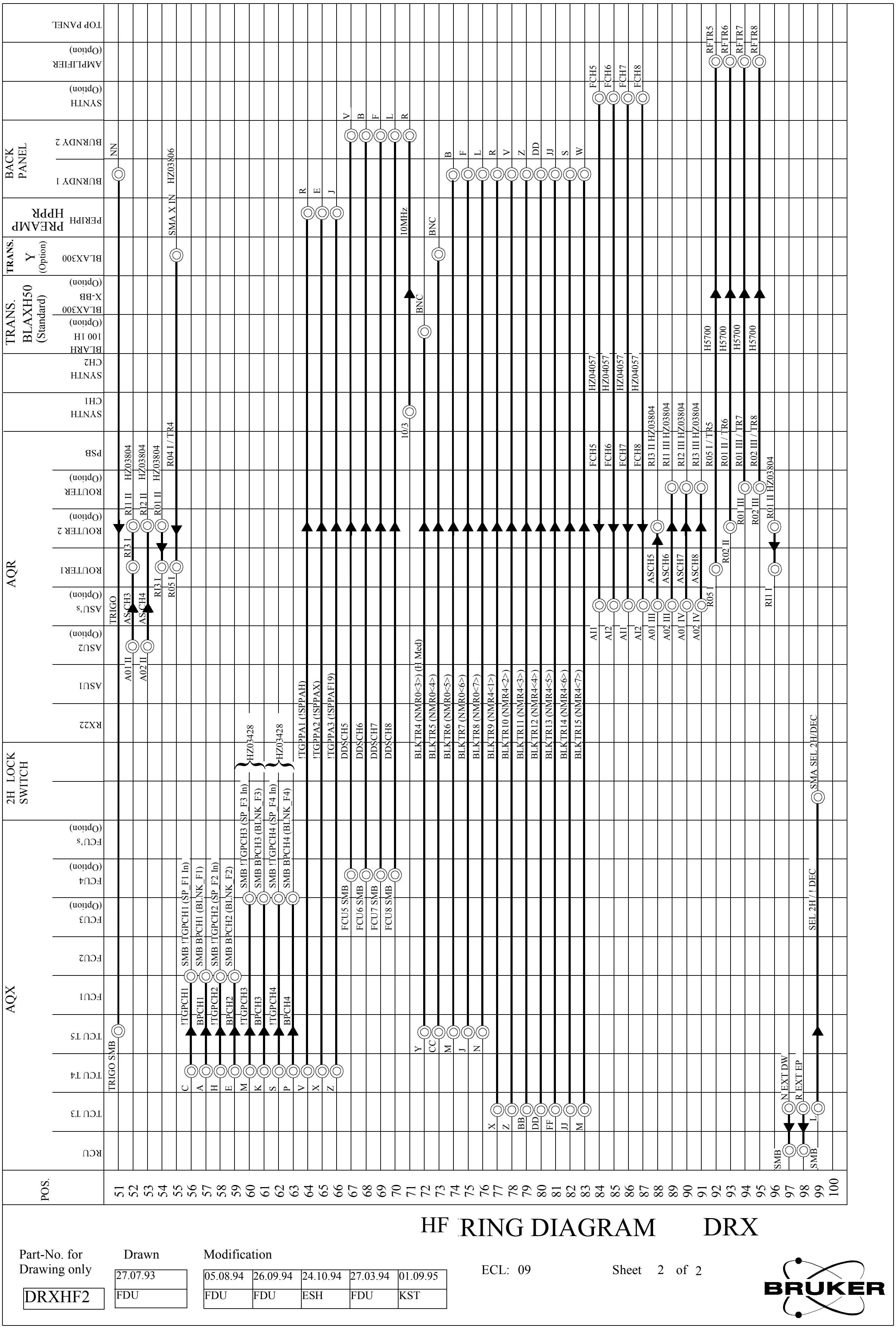
Figure R.17. DRX HF Wiring Diagram Page 1



Goto

Figure R.18. DRX HF Wiring Diagram Page 2



List of Abbreviations

Table R.9. List of Abbreviations

ACB	Amplifier Control Board (in AQRACK)
ACU	Acquisition Control Unit (TCU + nFCU + RCU + GCU)
AI1	ASU Input Connector 1
AO1	ASU Output Connector 1
AQRACK	Acquisition Rack (19“ x 7U)
AQS	Acquisition Synchronization (from TCU to FCUs)
AQSI	Acquisition Synchronization Input (FCU)
AQSO	Acquisition Synchronization Output (FCU)
AQX32	Acquisition Computer (19“ x 7 U)
ASCH1	RF-Output Signal from ASU Channel 1
ASU	Amplitude Setting Unit
AT201	20 dB Attenuator Input 1 on ASU
AT401	40 dB Attenuator Input 1 on ASU
AT20CH1	Control of 20 dB Attenuator for Channel 1
AT40CH1	Control of 40 dB Attenuator for Channel 1
BGU	Bruker Gradient Analog Control Unit
BLAH	Bruker Linear Amplifier for H Range
BLARH	Bruker Linear Amplifer Array for H Range
BLAX	Bruker Linear Amplifier for X Range
BLAXH	Bruker Linear Amplifier for X & H Range
BLKTR1	Blanking Transmitter 1
BLTX	Bruker Linear Transmitter for X Range
BP1	Blanking Pulse Input 1 on ASU
BPCH1	Blanking Pulse Channel 1 (former SPFND)

Table R.9. List of Abbreviations

BPF0	Lock Blanking Pulse
BSMS	Bruker Smart Magnet Control System
BTO	Bruker Thermocouple Oven
BVT	Bruker Variable Temperature Unit
DDS	Direct Digital Synthesizer
DDSCH1	DDS RF-Output Signal FCU 1
DDSO	DDS Output Connector
DUR	Duration and Real Time Unit Fail or Stop LED
F1...3	Connectors 1...3 on FCU
FAIL	Fail LED (TCU)
FCH1	RF-Input Signal to ASU Channel 1
FCU	Frequency Control Unit
FCU1	Frequency Control Unit Channel 1
FTUNE	RF Signal for Probe Tuning
GCU	Gradient Digital Control Unit
GO	Go LED (TCU)
HLD	Hold LED (TCU)
HPCU	High Power Control Unit (in High Power Cabinet)
HPPR	High Performance Preamplifier
HRD16	High Resolution Digitizer 16 bit
LAB	Level Adapter Board
LCB	Lock Control Board
LO	Local Oscillator
LO1	LO RF-Signal
LO/F	LO/FTUNE Switching Control (TTL Signal)
LOT	LO/TUNE Switching Module
LTI1	LOT RF-Input Connector 1

Table R.9. List of Abbreviations

LTO1	LOT RF-Output Connector 1
MMA	MOD, MULT, Attenuator Module inside ASU
MOD	Modulation
MOD1	Modulation Input 1 on ASU
MODCH1	Modulation Control of Channel 1
MULT	Multiplication
MULT1	Multiplication Input 1 on ASU
MULTCH1	Multiplication Control of Channel 1
OBSCH1...4	Observe Control Bit Channels 1...4
PH1	90 Phase Switch Control Bit (FCU, 4PM)
PH2	180 Phase Switch Control Bit (FCU, 4PM)
RCU	Receiver Control Unit
RCUG	RCU Go Pulse (from TCU)
RGP	Receiver Gating Pulse (former EP)
RGPF0	Lock Receiver Gating Pulse
RI1	Router Input Connector 1
RO1	Router Output Connector 1
RO1I	Router Output Connector 1 of Router I
SADC	Standard ADC (in AQRACK)
SCB	Shim Control Board
SE451	Transceiver Control at IF = 451 MHz.
SIB	Serial Interface Board
SYNCH1	RF Output Signal of PTS Synthesizer Channel 1
T1...5	Connectors 1...5 on TCU
TCU	Timing Control Unit
TGP1	Transmission Gating Pulse Input 1 on ASU

Table R.9. List of Abbreviations

TGPCH1	Transmission Gating Pulse Channel 1 (former SPF1)
TGPF0	Lock Transmission Gating Pulse
TGPPA1	Transmitter Gating Pulse 1 for Preamplifier (former SPPA)
TO/F	Tune ON/OFF
TR1	Transmitter 1
TRIG0...4	External Event Trigger Inputs (TCU)
4PM	4 Phase Modulator
40MA	40 MHz A Output (TCU)
40MAI	40 MHz A Input (FCU)
40MAO	40 MHz A Output (FCU)
40MB	40 MHz B Output
80M	80 MHz Input (TCU)

Figures

Tables