Chapter 5

Backend Signal Processors

There are two forms of backends at the SMTO: continuum (DRUMBEAT) and spectrometer. Several different types of spectrometers are/will be available at the SMTO: (1) AOSs (Acousto-Optical Spectrometers), (2) Filterbanks, and (3) CHIRP (Summer 2000). Their characteristics are summarized in Table 5.1 .

5.1 Continuum Backend: DRUMBEAT

DRUMBEAT (Digital Recording Using Multichannel BackEnd with AT) is a 64 channel backend derived from the Effelsberg 80-channel backend. The signals from a frontend are digitized by a VFC, the frequency of the pulse train being proportional to the intensity of the signals. DRUMBEAT integrates these pulses, builds up "datablocks" from these values, and transfers these to a reduction machine (PC, VAX, etc.).

DRUMBEAT is controlled through its own AT, which is a part of the system. This AT can be run through its keyboard and monitor, or remotely controlled over the ethernet. The AT reads via a parallel I/O-port a status-byte (e.g. CAMAC interface) of the telescope control computer, which indicates the mode of the observation, and initializes the appropriate control of the backend. A second parallel interface allows to output a 16 bit data word, which can be used to set the gain of the VFC. The data blocks of the backend are manipulated by the AT, saved into a file and transferred over the ethernet to the data reduction computer at the observatory. The synchronisation of the astronomical data with the telescope data is achieved with time signals from the station clock and the interal real-time clock.

The control of DRUMBEAT, as well as the data transfer to the control room is realised though only one ethernet-coaxial cable and in certain cases a parallel (CAMAC) connection. DRUMBEAT is located in the receiver cabin so that the connections to the 64 inputs are short and interference on on the otherwise long channel connections will be avoided.

5.2 AOS

The AOS makes a Fourier transform of the IF input signal of 1/0.25 GHz bandwidth. The conversion from the time domain into the frequency domain is continuous. The spectra are first integrated by accumulating the charge in the CCD. It has to be read out in regular intervals. The time between two readouts is called the readout time, T_R. Do not mix up the readout time and the time it takes to read the 2048 pixels of the CCD (the latter defines the minimum readout time). A number of readouts, N_R, is then integrated (after analog-to-digital conversion) in a data memory and defines one phase. A phase can represent a measurement of the astronomical object, a reference position on the sky, a hot load, a cold load, frequency switch, etc. The different phases are indicated by status signals (TTL-signals) coming from the different devices (wobbler, chopper wheel, mirror switch, LO, etc.). Up to eight different phases can be held in the data memory of the AOS.

The phases are separated by a blanking time, T_B. It is the time it takes to go from one phase, (i.e. hot load) to the next (i.e. reference position on the sky). The phase time, T_P is then:

$T_P = T_R * N_R + T_B$

The sequence of phases N_P (1-8) for the particular measurement is called a cycle. The cycle time, T_C is:

$T_C = N_P * T_P$

A number of cycles, N_C, can be integrated in data memory (each phase is integrated in the appropriate memory portion) before the accumulated data, called a frame, can be read out by the host computer. While the data is read from the Main data memory of the AOS, the AOS continues sampling spectra of the next frame in an Alternate data memory. The time, T_F, to take one frame is:

$T_F = N_C * T_C$

See Chapter 6 for commands.

5.2.1 Available AOSs

We have 3 AOSs available. See Table 5.1.

AOS A and AOS B are generally used for extragalactic observations, bright lines in Giant Molecular Clouds, outflows, and line surverys.

AOS C is used for higher resolution work on galactic lines.

AOS B and AOS C are on the same IF so that they will see the same receiver. Likewise, AOSA and the filterbanks are on the same IF. Plus, you can tie all backends on the same IF.

5.2.2 Getting the best results out of the AOSs

Currently, we have found that if you flatten your IF so that the AOSs have a dynamic range of 2 dB or less (linear scale), you can achieve the best position switch scans. In addition, it is important to make sure that you have at least a minimum level (on the AOS scope, 1 volt), but don't exceed the recommended maximum (4 volts).

In addition, the SIS230 GHz and SIS490 receivers have IFs of only 800 MHz available due to the presence of an isolater (and is left justified), so that the last 200 MHz in spectral scans with AOS A or AOS B (the 1 MHz 2048 channel AOSs) will be unusable.

In each of the facility receivers tuning sections, we discuss how to tune that receiver to get the best AOS response. Since it is often easiest to tune when looking at the AOSs, the observer naturally will be optimizing the AOS response.

In general, the steps to optimize the AOS (and receiver) are as follows.

Assume that you have tuned the receiver in question to get a fair bit of total power out.

1. *Setting up on the Computer:*

   For any of the AOSs to work, you first have to set the computer up.

   - *Set up Backends: OBST* > BACKEND AOSA AOSB AOSC
     This will turn on all AOSs. See section 6 for details.
   - *Connect to Frontends: OBST* > BE_FE AOSA 1
     This will connect AOSA to Frontend 1 (whatever you defined with the receiver command. You can do similar things with AOSB and AOSC - see section6 for details.
   - *Give the computer an observing command:*
     For the computer actually do these changes, it will have to be given a command like "go" or "pswitch".

   For more details on the IF interface, see section 5.5.1.

2. *Displaying the AOS bandpass:*

   There are AOS passband displays in the AOS Backend room (i.e. the computer room on the observer's level), the control room, and in the left receiver cabin.

   You will need to switch the Monitor display in the left receiver cabin to AOS. On the AOS/Mixer Monitor Box:

   - Turn the switch to AOS
   - Turn the AOS Dial to appropiate AOS
   - Turn the Setup button on the oscilloscope display to 1
   - Press Recall on the oscilloscope display

In the AOS backend room (i.e. the computer room), you would switch the AOS display between 3 (AOSA), 4 (AOSB), and 5 (AOSC). In the control room, you would switch the Monitor to AOS and then select the appropiate AOS. You would also (if necessary), turn the setup button on the display to 1 and press recall.

Do not reset our default AOS oscilloscope settings. We have set them at reasonable ranges - and there are other ways to change the total display range!

3. *If the AOS shows zero level:*

   Assume there is total power going through that IF, then it is likely that you have tripped the AOS safety circuit. Changing frequencies often does this (as does changing receivers).

   If you are on the third level (computer or control room), then you need to go to the AOS cooled rack in the computer room (3rd rack). If there is an orange button lit, open the cabin door and press the green button below the orange one. It should come on - unless you need to add attenuation to the AOS - where upon the safety might trip out again.

   Most of the time, you will be up in the left receiver cabin. There is a big RESET button on the Monitor box. Press it to reset. You might wish to check any other AOSs looking at that IF and reset them too!

4. *Adjusting the Bandpass Slope/Shape:*

   If the AOS display reveals a steep bandpass or bumps and wiggles, then the ONLY way to adjust it is to tweak your receiver tuning. That's right-you are seeing the RECEIVER response. Check the notes on the particular receiver you are tuning! To allow you to get the best dynamic range over the ENTIRE passband, you will want to have the AOS as flat as possible.

5. *Adjusting the AOS attenuation:*

   Look more closely at the AOS display. As we mentioned earlier, ignore the rightmost 200 MHz for the 230 and 490 GHz receivers. One possible problem is too much (or too little) AOS voltage. Ideally you want your hot load below about 4-5 volts on the display and the cold load at least 0.5 volt over the useful passband.

   You can use the 345 GHz program (below the AOS monitor in the receiver room) to adjust your IF total power level. To do that, switch the program display to the IF window (usually it is already there) and press the desired attenuation button. This will increase (or decrease) the attenuation for that IF - not just the AOS. You should see (if you pressed a button different from the current setting of course) the total power and AOS displays change.

   By the way, in general, it should not be necessary to tweak the individual AOS attenuation levels. We *try* to set them so that they would all go up or down together and be on the same range on the various displays.

   This procedure should be done when the receiver is well tuned and you are at the peak of the total power curve.

5.3 Filterbanks

The SMTO has acquired the University of Texas' Millimeter-Wave Observatory (MWO) Filterbanks (often referred to as FBS). The RF filter section has been recalibrated and the old MWO data acquisition system replaced with a VME microcomputer. In addition a new frequency translation system has been built to convert the output of various SMTO receivers down to its 600 MHz center frequency.

The specifications of this backend are included in Table 5.1.

5.3.1 Getting the best results out of the Filterbanks

1. *Setting up on the Computer:*

   For the filterbanks (FBS) to work, you first have to set the computer up.

   - *Set up Backends: OBST* > BACKEND FBS

     This will turn on the FBS. See section 6 for details.

   - *Connect to Frontends: OBST* > BE_FE FBS 1

     This will connect FBS to Frontend 1 (whatever you defined with the receiver command. See section6 for details.

   - *Give the computer an observing command:*

     For the computer actually do these changes, it will have to be given a command like "go" or "pswitch".

   For more details on the IF interface, see section 5.5.1.

2. *Displaying the Filterbank bandpass:*

   Unlike the AOSs, there is no easy way to look at the filterbank display when not actually taking data. If you are taking data, then ONLINE CHEF presents the subscan results as the scan progresses.

   If you go into the computer room (i.e. the AOS room), then on the Filterbank rack (beside the door to the left), you can find the total power meter of the filterbanks. If, when a hot load is inserted, the total power level is between 500 and 750 millivolts, then all is well. If below 500, then you will have decrease the attenuation, and if above 750, you will have to increase the attenuation.

   The current attenuation is displayed beside the filterbank level - usually a number between 3 and 7 (except for the SIS490 or HEBOL where it will be much higher due to the very high system tempatures!)

   If you need to change the attenuation:

   (a) In OBST, type the command:
       OBSINP ATN7 number
       where number is the new filterbank attenuation.

(b) Do some observing command like 'go' or 'pswitch' to force the computer to update the filterbanks.

(c) Insert the hot load and verify the FBS level is now okay.

You can also look at the number of counts (which are displayed in the CAL scans. If the number of counts for the hot load approaches 800,000 or more then you will have to increase the filterbank attenuation. If it gets below 100,000 or so for the hot load, then you will want to decrease the attenuation.

3. *Bad Channels:*

The individual channels of the filterbanks sometimes need adjustment. If you notice a channel (or more than one) is bad, do a cold calibration scan (so that the channels will be displayed by ONLINE CHEF). Then use "mbc ha/pl" in OBST to print out the calibration scan.

Give a copy to the FoT so that he can inform the appropiate staff member for action. If the channel is in an very critical spot in your spectra, we will try and fix pronto. Otherwise, it will be as soon as possible. Note that in most cases, you can shift your spectra changing the source velocity by a couple of km/sec and move the line away from any bad channels.

5.4 CHIRP

Will be updated when CHIRP is installed.

Table 5.1: SMTO Spectrometer Characteristics

	channels	Res.[MHz]	BACKEND ID number
AOSs			
MPIfR 1 GHz	1024	1.021	3 = AOSA
MPIfR 1 GHz	1024	0.996	4 = AOSB
MPIfR 250 MHz	1024	0.4	5 = AOSC
Filterbanks			
250 MHz	256	1.0	7 = FBS
64 MHz	256	0.25	7 = FBS
8 MHz	128	0.0625	7 = FBS
Other Backends IDs			
DRUMBEAT			1
HOLO			2
NASA			6
CHIRP			8

5.5 Connecting the Backends to the Receivers

In the days of old, pre-1997, we had to do lots of re-cabling, which made life complicated. Thanks to the hard work of our staff, we have a much simplier scheme - that still allows considerable flexibility as to the backend/receiver configuration that you can set up.

Simplier-but not completely simple. The complication is due in part to the large number of receiver/backend possibilities that you, the observer, can choose!

5.5.1 The Receiver/Spectrometer IF Interface

In January 1997, we installed a new Receiver/Spectrometer IF interface. It allows computer control of the receiver and spectrometers desired. Figure 5.1 shows the current setup for how all the facility receivers are connected up to the AOSs and FBS.

If you go upstairs to the facility receiver cabin, you will see a little box that has two sets of lights on the optical bench that holds our facility receivers. The top set refers to Chan A (IF 1) in figure 5.1 and the bottom set refers to Chan B (IF 2). On the left side of the box is the selected IF (coded in terms of SIS 230 or SIS 345). This has to reflect the correct IF selection.

The MPifR IF converter and Total Power Box as well as the MPifR switch box are located above the cooled rack in the computer room. The system is under full computer control, (though we can go to local mode if absolutely necessary). The switches must be set to match either Chan A (IF 1) or Chan B (IF 2) to the X and Y switches. Normally, Chan A (IF 1) connects to X and Chan B (IF 2) connects to Y.

This means that whatever is hooked up on IF 1 (CHAN A) will be seen by AOSA and FBS, and whatever is hooked up on IF 2 (Chan B) will be seen by AOSB and AOSC.

Figure 5.2 reveals how Chan A and Chan B, Backend switch X and Y will have to be set to achieve the desired receiver/backend configuration. *In general, however, the observer controls this through the computer - and never touches a switch!*

5.5.2 Computer Control of the Receiver/Backend Configuration

As mentioned above, the IF interface system is fully computer controlled through the BE_FE and RX commands. The observer should not have to manually set these.

The control is exercised through several possible commands.

- *RX command:* This sets up the defaults for that receiver. An observer has to specify which backend(s) he/she actually wants. See section 6.
- *BE_FE command:* This sets up the particular backend to frontend connection that the observer wishes to use. Note that certain combinations are not possible. (I.e. we do not split AOS A to one IF and the Filterbanks to another.) See section 6.
- *BACKEND command:* This sets the backends that the observer wishes to use. See section 6.

Note you have to use a observing command like "go" or "pswitch" before the IF interface is updated.

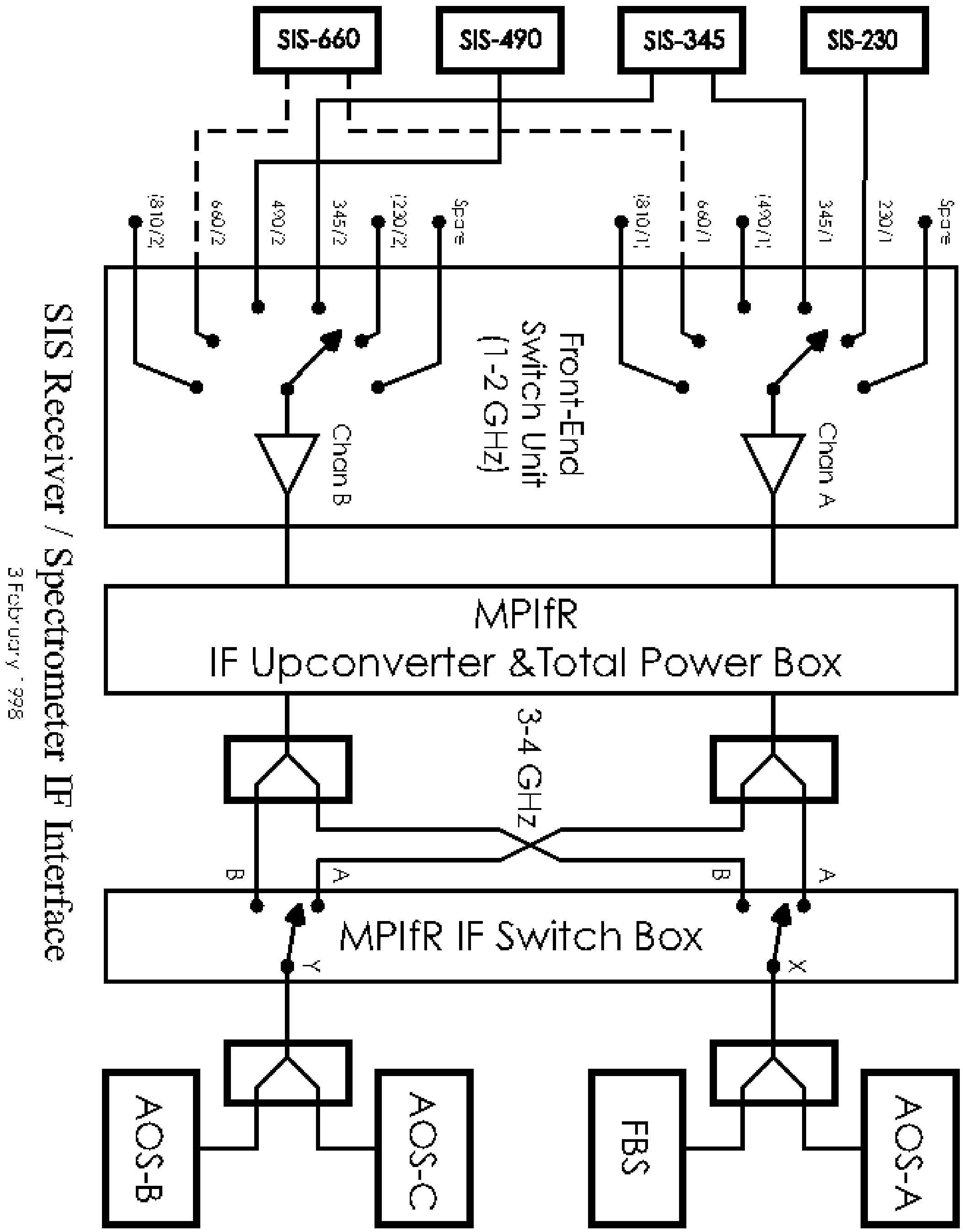

Figure 5.1: The IF Interface Selection Chart

SIS Receiver ⇨ Spectrometer
Configuration Options

(3 February 1998)

AOS-A	FBS	AOS-B	AOS-C		Front-End Switch A	Front-End Switch B	Back-End Switch X	Back-End Switch Y
230	230				230		A	
		230	230		230			A
230	230	230	230		230		A	A
345/1	345/1				345/1		A	
		345/1	345/1		345/1			A
345/1	345/1	345/1	345/1		345/1		A	A
		345/2	345/2			345/2		B
345/2	345/2					345/2	B	
345/2	345/2	345/2	345/2			345/2	B	B
		490	490			490		B
490	490					490	B	
490	490	490	490			490	B	B
230	230	490	490		230	490	A	B
490	490	230	230		230	490	B	A
345/1	345/1	345/2	345/2		345/1	345/2	A	B
345/2	345/2	345/1	345/1		345/1	345/2	B	A

Figure 5.2: The Receiver/Spectrometer Configuration Options

5.5.3 Making the Most of the Receivers

A quick inspection of Fig 5.2 reveals that we now have the option of looking at:

- SIS230 alone,
- SIS345 chan1 alone,
- SIS345 chan2 alone,
- both SIS345 channels,
- the SIS490 alone
- HEBOL alone
- the SIS230+SIS490

In the last case, you take advantage of the RX command's ability to define two receivers.

When CHIRP comes on line, we will have the ability to look at two channels or two receivers with high resolution at the same time!

In all cases, you have to set the BE_FE, BACKEND, and RX properly to get the software and hardware configured properly!

The neat thing-when looking at your data come in (via ONLINE CHEF), you can see all the defined backends! See both 230 and 490 spectra (or SIS345 channel 1 and 2)!

Have fun!