GBT Configuration: Requirements and Algorithms

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1.0 Introduction

Configuring the GBT system can be a bewildering task. Setting many switches, filters, frequencies, and other options must be done correctly for successful astronomical observations. The purpose of this document is to present a set of astronomer-friendly keywords, and to specify how they are used to configure the system.

There is a distinction between configuring and observing. In general a configuration remains fixed during a series of observations. Observing procedures direct the antenna to move in various ways, running procedures such as 'track', 'peak', 'onoff', etc. From one scan to the next, certain parameters may change, such as the antenna tracking position, velocity, and receiver tuning frequency. Most other parameters, such as number of spectral windows, filter settings, and backend bandwidth, will stay the same. This document will only discuss configuring, not balancing or observing processes.

1.1 Keywords

We first list the primary and secondary keywords required to completely configure the GBT, and provide default values. Table 1 lists the primary keywords (or meta-parameters) that are required and have no default values. Table 2 lists primary keywords for which reasonable default values exist. Note that in many cases, possible values of a keyword depend on the type of backend or observing type. Following that are secondary keywords (Section 3) that specify options that are specific to particular receivers or back ends.

1.2 Implementation

Following the tables is a discussion of how each keyword value can be implemented (Section 4). A dependency diagram (Section 5) shows how values of keywords may depend on the choices of more basic keywords. Section 6 provides instructions for calculating the LO1, LO2, and RF or IF bandwidths. Wiring the system, connecting the signal paths from receiver to back end, is discussed in Section 7.

The implementation software will consult the cabling file to trace connections through the system. We propose to introduce a ‘quality’ factor for every hardware module that will indicate which modules are substandard or out of service.

The Appendix gives details for implementation from the point of view of the YGOR manager parameters.

1.3 Configuration vs. Tweaking

Previous discussions have distinguished between the configuration and "tweaking" phases of experiment setups. After careful consideration and experience, it now seems that we cannot break apart these two steps. In too many cases a configuration step for one observer is another observer's tweak.

The best implementation of these phases might provide a library of functions or commands that sets the keywords for one or more devices. 'Tweaking' would be accomplished by using a few of these commands to change parameters in certain devices. 'Configuring' software could wrap these tweaking commands into general-purpose modules. Most of these commands would use the keywords described in this document but we will also need low-level commands for setting any YGOR parameter in any manager. The nature of these commands will be discussed by those involved in the next stage of the development of the configuration system, the stage that will encompass the specifications for the user interface.

1.4 What about the antenna?

The configuration software should not try to set any antenna parameters. The operations policy is that only the telescope operator will configure the antenna. This includes putting the correct receiver at the focus and selecting the right pointing and focus tracking models.

2.0 Primary Keywords

There are two classes of primary keywords, those that do or do not have default values. See Section 4 for a discussion of each keyword.

Table 1: Primary Keywords with No Default Values

Keyword	Description	Possible values
Receiver	Name of GBT Receiver	Rcvr_342 Rcvr_450 Rcvr_600 Rcvr_800 Rcvr1_2 Rcvr2_3 Rcvr4_6 Rcvr8_10 Rcvr12_18 Rcvr18_22 Rcvr22_26 Rcvr18_26 Rcvr40_52
Obstype	Observing Type	Continuum, Spectroscopy, Pulsar, Radar, VLBI
Backend	Name of Data Acquisition System	SpectralProcessor, Spectrometer, VLBA_DAR, S2, Radar, BCPM, BCPM/SP, GBPP, DCR_IF, DCR_AF

Restfreq	Rest Frequency to be observed, in MHz. If more than one spectral window, this becomes a list of frequencies. Refer to Section 6.	any frequency. (Note that the LO1 system can only track one frequency. The first frequency in the list will be tracked.)
Bandwidth	Band width per backend input, in MHz.	The possible values depend on the Backend. See Section 4.5.

Table 2: Primary Keywords with Default Values

Keyword	Description	Possible values	Default
Swmode	Switching mode.	tp(total power with cal), tp_nocal, sp(switched power with cal), sp_nocal	tp
Swtype	For switching modes sp and sp_nocal, this is the type of switching. This parameter is not used for tp and tp_nocal modes.	none, fsw(frequency switching), bsw(beam switching), psw(polarization switching), tsw(tertiary switching)	Depends on Swmode. See Section 4.7.
Swper	Switching cycle period.	A time in seconds.	Depends on Obstype. See Section 4.8.
Swfreq	Frequency offsets used for frequency switching.	A pair of frequencies in MHz.	(-0.25*Bandwidth, +0.25*Bandwidth) for fsw, (0,0) otherwise
Tint	Back end integration time.	A time in seconds.	Depends on the Backend. See section 4.10.
Beam	Beam selection: applies to multi-beam receivers.	B1, B2, B3, B4, B12 (both beams 1&2), B34, B1234, etc.	B1
Nwin	Number of frequency windows	Any integer from 1 to 8. See Section 4.11.	1
Deltafreq	Table of sky frequency offsets for each spectral window. Refer to Section 6.0.	List of Nwin frequencies, in MHz.	zero (i.e., no offsets)
Vlow, Vhigh	Velocity range	A pair of velocities, in km/sec	0, 0
Vframe	Velocity reference frame.	topo bary lsrk lsrd galac cmb	topo
Vdef	Velocity definition.	optical radio relativistic	radio

3.0 Secondary Keywords

Secondary keywords specify options that are specific to particular receivers or back ends.

3.1 Secondary Keywords Dependent on the Back End

Some characteristics of the back end are not determined by any of the previous keywords. These are summarized here. Details are given in the Appendix.

- Spectral Processor:
  - spmode : Parallel or Cross polarization products or both.
  - polycoDatFile (used in pulsar mode)
- Spectrometer:
  - Nlevs : Number of levels (3 or 9)
  - Nchannels : Number of spectral channels: Low, Medium, or High.
    Given the bandwidth, number of levels, number of spectral windows, and beams, there are up to 3 choices of the number of spectral channels available. This parameter chooses which of the possibilities are to be used.
- BCPM:
  - submanagers_used :
    the user can select 'bcpm1', 'bcpm2', or 'bcpm1_and_bcpm2'
  - channel_bandwidth : 0.5, 0.7, 1.0, 1.4, or 1.74 MHz
  - sample_time : 'X1', 'X2', or 'X4'
  - sum_polarizations : 'yes' or 'no'
  -
- VLBI:
  - Phasecal :
    The phase cal generator in the LO1 system can be turned on.

3.2 Secondary Keywords Dependent on the Receiver

Table 3: Secondary Keywords Dependent on the Receiver

Keyword	Receiver(s)	Default	Possible values
Polarization	Prime Focus, Rcvr1_2, Rcvr2_3, Rcvr4_6	Default is circular for BCPM, VLBI, or Radar back ends, otherwise linear.	lin or XY(linear), circ or LR(circular)

	Rcvr8_10, Rcvr12_18, Rcvr18_26, Rcvr40_52	Only circular possible.	
Noisecal	All receivers	Default is 'lo-ext', except for BCPM and Radar it's 'off'	'off', 'on-mcb', 'on-ext', 'lo-mcb', 'hi-mcb', 'lo-ext', 'hi-ext' (hi/lo option not available for Rcvr12_18 and higher.)
Notchfilter	Rcvr1_2	'In'	'In' or 'Out'
Beamswitch	Rcvr12_18, Rcvr18_26, Rcvr40_52	If Swtype is 'bsw', then 'ext', otherwise 'thru'	'ext', 'thru', or 'cross'
Polswitch	Rcvr1_2, Rcvr2_3	If Swtype is 'psw', then 'ext', otherwise 'thru'	'ext', 'thru', or 'cross'

4.0 Notes on Keywords and the Implementation of Configuration Process

4.1 Receiver

Receiver names, as listed in Table 1, are standard throughout the system.

The receiver name need only be sent to the Scan Coordinator, since the Scan Coordinator in turn sends it to the IF Rack manager and LO1 manager. The IF Rack manager automatically sets its input switches to select the receiver inputs. The LO1 manager automatically sets its routing switches to send the LO1 signal to the receiver.

4.2 Obstype

The observing type gives the category of observing: continuum, pulsar, spectroscopy, radar, or vlbi. In some cases, this type is synonymous with the Backend selection (only one radar backend, for example). But we allow the possibility of more than one backend per observation type.

The present situation is summarized as follows:

Table 4: Backends Available For Each Obstype

Obstype	Backends

Continuum	DCR_IF; DCR_AF
Spectroscopy	Spectrometer; SpectralProcessor
Pulsar	Spectrometer; SpectralProcessor; BCPM; BCPM/SP; GBPP
Radar	Radar
VLBI	VLBA_DAR; S2

4.3 Backend

The possible names of the backends are listed in Table 1.

The DCR has inputs from three sources: a) the IF Rack, b) the analog filter rack, and c) the prime focus receivers. We make the simplification that the direct inputs from the prime focus receiver will not be used in normal setups. Thus we have two flavors of DCR, to be designated DCR_IF and DCR_AF.

If the DCR is not given as the principal back end, it will normally always be configured as DCR_IF for the selected receiver and beams. When configured in this way, the DCR will be able to provide constant stream of values for the system temperature and will be ready for pointing observations. Currently there is no automatic method for configuring the DCR phase table so that it is exactly like that in the Scan Coordinator even when the DCR is not the selected backend. We suggest we will need to discuss the software group how we can always keep the DCR 's phase table synchronized with the Scan Coordinator's table.

The backend selection determines which of the converter rack outputs are to be selected. For the Spectrometer (or ACS), the bandwidth parameter is also needed. The type of backend and bandwidth determines also the nominal IF3 frequency, i.e., the center frequency desired by the back end, which, along with the specified rest frequency and table of frequencies and offsets for the spectral windows, determines how the LO2 synthesizers are to be set (refer to Section 6.)

More details on specific backends are given in the Appendix.

4.3.1 What About Multiple Backends?

We will not address the general problem of the simultaneous use of multiple back-ends, but designers should leave open the possibility. The only current exceptions are:

- Unless the backend is DCR_AF, the configuration software should properly route signals to the DCR as if DCR_IF was chosen. If the backend is DCR_IF or DCR_AF, then the DCR will be the switching signal master and will be a selected item in the Scan Coordinator. Otherwise, it will not be in the Scan Coordinator's system selection and the backend of interest will be the switching signal master.

- Regardless of the chosen backend, the DCR's phase table should automatically be kept identical to that in the Scan Coordinator so that the DCR can be used to constantly measure the system temperature.
- Pulsar observers often use both the BCPM and Spectral Processor simultaneously. For this, we use the backend keyword 'BCPM/SP'.

4.4 Rest Frequency

If there is more than one spectral window, RestFreq is a list of rest frequencies. The first frequency in the list is used as the LO1 tracking frequency. Nwin, the number of spectral windows, is the length of the list. This list of rest frequencies and the Deltafreq list are used to determine the RF and IF bandpasses and the LO2 frequencies, as described in Section 6.

4.5 Bandwidth

The Bandwidth keyword is the requested bandwidth that will be entering the desired backend. It determines the spectral line mode for the Spectrometer and Spectral Processor. For cases of multiple beams and multiple spectral windows, we have simplified the system and insist that each window has the same bandwidth. The RF filters (in the receivers that have them) and IF bandpass filters in receivers and in the IF Rack, are set to encompass the range of frequencies spanned by all the specified spectral windows (see Section 6).

Although the Spectrometer allows its banks to have different bandwidths, we do not consider that possibility here since it is likely to be used very rarely.

The possible choices for the bandwidth depend on the back end (and sometime the receiver).

Table 5: Possible Bandwidths

Backend	Bandwidth choices	
	Receiver	**Bandwidth**
DCR_IF	Prime Focus	20, 40, 80, 240 MHz
	Rcvr1_2, Rcvr4_6, Rcvr8_10, Rcvr12_15	20, 80, 320, 1280 MHz
	Other receivers	80, 320, 1280 MHz
Spectrometer and DCR_AF	12.5, 50.0, 200, and 800 MHz	
Spectral Processor	40, 20, 10, 5, 2.5, 1.25, 0.625, 0.3125, 0.15625, 0.078125 MHz	
BCPM	192 MHz	
Radar	20 MHz	

VLBA_DAR or S2	any multiple of 4 MHz up to 500 MHz

4.6 Switching Mode

The switching mode determines the number of phases and selection of cal and sig/ref that is sent to the scan coordinator. The mode also determines the blanking time (in general the blanking time is 2 ms, except for some SpectralProcessor modes, when it it 40 ms.)

The details of setting switching phase tables is given in the Appendix, in the section on the Scan Coordinator.

4.7 Swtype: Switching Type

- none : If mode is 'tp' or 'tp_nocal', the switching type is ignored.
- fsw : Frequency switching: the Swfreq table is sent to the LO1 manager.
- bsw : Beam switching: the receiver beam transfer switch is set to external.
- psw : Polarization switching: the receiver polarization transfer switch is set to external.

The defaults for Swtype depend on the switching mode and the receiver.

- If Swmode is 'tp' or 'tp_nocal', then Swtype is 'none'
- If Swmode is 'sp' or 'sp_nocal', and the receiver has multiple beams, then Swtype is 'bsw'.
- otherwise, Swtype is 'fsw'

4.8 Swper: Switching Cycle Period.

The switching period is passed directly to the corresponding parameter in the Scan Coordinator, which in turn passes it to all selected back ends. Reasonable defaults depend on the observing type:

- Spectroscopy: 1 sec.
- Continuum: 0.2 sec.
- Pulsar: 0.04 sec.
- Anything else: 1 sec.

4.9 Swfreq: Switching Frequency Table.

In the case of frequency switching, these frequency-offset parameters are sent to the LO1 manager.

4.10 Tint: Backend Integration Time.

Most data acquisition backends have an integration or dump time. Samples are written out at this interval. Tint must be an integral number of switching cycle periods. Most backends have limitations on the allowable integration time, due to their internal clock cycles. The user's entry for this parameter will be adjusted upwards to accommodate these restrictions.

Table 6: Defaults for Tint

Obstype	Tint
Continuum	Swper
Spectroscopy	10 sec
Others	30 sec

Some backends have restrictions on the possible range of Tint, as detailed in the following table:

Table 7: Ranges of Tint

Backend	Range of Tint
Spectrometer/ 1 quadrant	0.5 to 40 sec
Spectrometer/ 2 quadrants	0.7 to 40 sec
Spectrometer/ 3 quadrants	1.0 to 40 sec
Spectrometer/ 4 quadrants	1.2 to 40 sec
SpectralProcessor	1.5 to ∞

DCR	0.01 to 60 sec
Other backends	no restrictions

4.11 Nwin: number of spectral windows

The number of spectral windows, along with the beam selection, determines how many paths need to exist between the receiver and backend. Using the cabling file and the module 'quality' designation, the selection of converter modules and analog filter modules can be determined, as discussed in Section 7.

Since we have made the simplifying assumption that the system will always be set up for dual polarization, there will always be at least two signals per spectral window per beam. A signal from each beam of each receiver is split 4 ways at the optical receivers to go to 4 pairs of converter modules. Each polarization pair can be mixed with a different LO2 to provide 4 spectral windows. Splitting the signals from the receiver to go to both converter racks A and B provides the possibility of 8 spectral windows. This splitting is done for Rcvr8_10 and lower frequencies. Eight spectral windows mean 16 signals going to the back end. The only back ends that can acquire 16 signals are the DCR_AF and Spectrometer, when using 12.5 or 50 MHz bandwidths.

The possibilities for Nwin are detailed in the following table. The maximum number of windows listed in the table is for one beam. If using more than one beam, divide by the number of beams, except for the DCR_IF case.

Table 4.11. Maximum Nwin

Backend(s)	Receiver	Max Nwin
Spectrometer, 12.5 or 50MHz BW or DCR_AF, 12.5 or 50MHz BW	< 10 GHz	8
Spectrometer, 12.5 or 50MHz BW or DCR_AF, 12.5 or 50MHz BW	> 10 GHz	4
Spectrometer, 200 or 800 MHz BW or DCR_AF, 200 or 800 MHz BW	Any	4
SpectralProcessor	Any	4
DCR_IF	Any	1 (all beams)
BCPM	Any	2
Radar	Any	1
VLBI	< 10 GHz	2
VLBI	> 10 GHz	1

4.12 Deltafreq: List of Frequency Offsets.

For all backend except DCR_IF, the IF3 band arriving at the back end is centered at a rest frequency which is the sum of the rest frequency (Restfreq) and offset (Deltafreq) in the topocentric frame for each spectral window. See Section 6 for details.

4.13 Vlow, Vhigh, Vframe, Vdef.

Vlow and Vhigh, the range of velocities is used to estimate the range of local frequencies that will be observed. In connection with the Restfreq and Deltafreq arrays, it is used to estimate the total range of frequencies in the local frame that will be required, and to set the RF and IF filters and IF1 parameter accordingly.

The estimated range of frequencies is not meant to be exact. We propose to simply convert velocity to frequency offset using only the velocity definition, but not using the reference frame. For barycentric and LSR reference frames we are making an error of 30 km/sec or so. For the galactic frame, we may make an error of a few hundred km/sec. In all cases, the introduced error is less than 0.1% of the sky frequency, maybe several 10s of MHz at 50 GHz. Refer to the Section 6 for frequency calculation details.

Keyword values for Vframe and Vdef are sent to the LO1 manager.

5.0 Keyword Dependencies

In Figure 1, we show a diagram indicating how the various keywords depend on others. This is useful to help figure how to set default values. This should also be helpful in implementing this process because possible choices of keyword values often depend on previous choices.

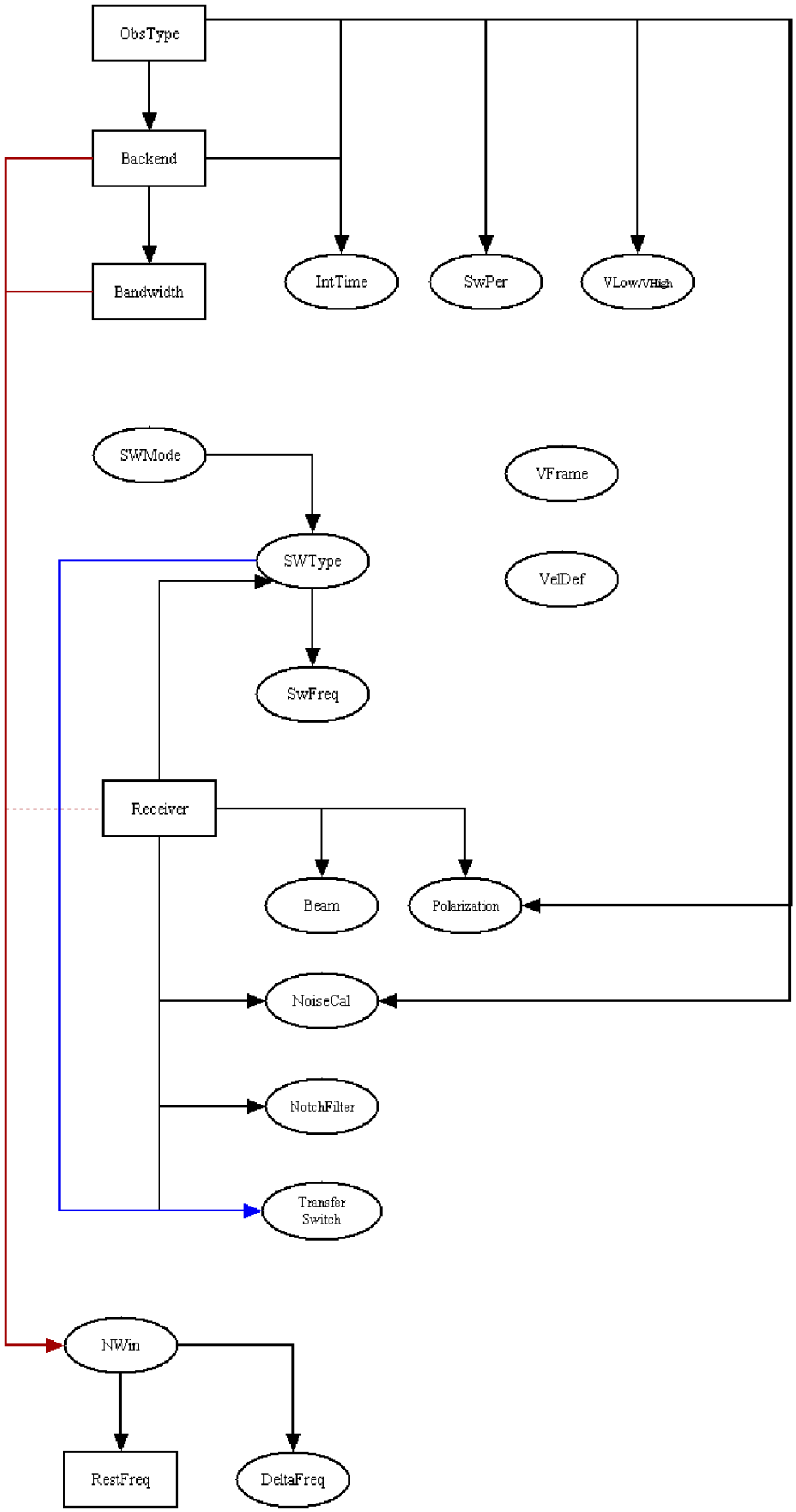

Figure 1: Keyword Dependencies

6.0 Frequency Calculations.

The following summarizes the calculations presented in the memo: "Requirements for Multi-frequency Observing with the GBT".

Let V1 and V2 be the given range of velocity, with V1 > V2 and V1 = Vhigh , V2 = Vlow .

The conversion to the local frame uses the appropriate formula for the selected velocity definition:

Flocal = fvdef(V, Frest)
[1]

Table 8: Formulas for conversion to local frame

Vdef	**Formula**
Radio	fvdef(V, Frest) = Frest(1 - V/c)
Optical	fvdef(V, Frest) = Frest(1+V/c) $^{-1}$
Relativistic	fvdef(V, Frest) = Frest { 1 - $(V/c)^2\}^{1/2}$/(1+V/c)

Let Fk = Restfreq, and dF = Deltafreq. For N spectral windows, our configuration keywords will specify Fk[i] and dF[i], the list of rest frequencies and offsets, for each i = 1,N.

Convert the Fk frequencies to the local frame, and add the offsets:

F1[i] = fvdef(V1, Fk[i]) + dF[i]
F2[i] = fvdef(V2, Fk(i]) + dF[i]
[2]

Determine the center frequency and total bandwidth:

Fcent = 0.5*(MAX(F2[i]) + MIN(F1[i]))
[3]

BWtot = MAX(F2[i]) - MIN(F1[i]) + BW
[4]

(where BW is the backend bandwidth keyword value.)

These quantities are used in the following ways:

- The receiver tuning frequency is set to Fcent.

- The receiver RF filter (if any) is set to include a range from Fcent-0.5*BWtot to Fcent+0.5*BWtot.
- IF filters in the receiver and IF Rack are set to the narrowest value that includes BWtot.

Given that the primary rest frequency, Fk[1], will not in general be at the center of the IF band, we need to modify the IF center frequency (IF1) in the LO1 manager so that the IF band represented by (Fcent, BWtot) is centered.

Let the nominal IF1 frequency be IF1nom, which has values of 1080 MHz for prime focus receivers, and either 3000 or 6000 MHz for Gregorian receivers. Then set the IF1 parameter in the LO1 manager to:

IF1 = Fcent - Flocal[1] + IF1nom [for Rcvr8_10 and lower frequency]
[5]
IF1 = Flocal[1] - Fcent + IF1nom [for Rcvr12_18 and higher frequency]

Where Flocal[1] = fvdef(0.5*(V1+V2), Fk[1]) + dF[1]

Now we can determine the appropriate frequency settings for the LO2 synthesizers. If we define:

Flocal[i] = fvdef(0.5*(V1+V2), Fk[i]) + dF[i]
[6]

then

LO2[i] = Flocal[i] - Fcenter + IF1 + 10.50 - IF3
[7]

where IF3 depends on the chosen back end.:

Table 9: Nominal Center Frequencies (IF3)

Back End	Frequency (MHz)
ACS-12.5MHz	468.75
ACS-50MHz	425
ACS-200MHz	900
ACS-800MHz	1200
Spectral Processor	250
VLBI	750
BCPM	400
Radar	720

7.0 Cabling: Path Finding Through the IF System.

The key to finding the paths through the IF system is the cabling file. We also propose a module quality factor which allows flagging of devices that are substandard or out of service. The actual format or file used to specify a module's quality file and the implementation of path finding through the system is best left to the next phase of this project and consultation with software developers. We outline a procedure, in general terms, which we hope will convey the requirements.

The possible paths through the system can be regarded as a tree structure (figure 2). This structure is defined by the cabling file and knowledge of the internal structure of the IF Rack, Converter Racks, and Analog Filter Rack. The keywords that drive the path finding process are: Receiver, Backend, Bandwidth, Beam, and Nwin.

The first step is connecting the Receiver beams to the IF Router. This is already implemented in the IF Router manager software, so the only action required is to send the receiver name to the Scan Coordinator which, in turn, sends the receiver parameter value to the IF Router manager, and its inputs will be set correctly. The user will have specified the Receiver and Beam keywords, so the desired input ports of the IF Router will be known.

The next step is routing the LO1 signal to the receiver. The LO1 manager takes care of this in response to the setting of its receiver parameter.

Some of the receivers (Rcvr8_10 and lower frequency) have their signals split to go to two pairs of IF Router inputs. In this case the tree has two branches. Any IF Router input can be connected to one of two optical fiber drivers, depending on the IF Router's transfer switches. Once an optical driver is chosen, the cabling file contains information concerning which optical receiver will be used. The optical receiver outputs split to four converter modules.

Each converter module can select between four outputs, but these are determined by the Backend and Bandwidth, so there is no branching here. If using the Spectrometer or DCR_AF, the Analog Filter Rack needs to be considered. The choice of AFR input is determined by which converter modules were chosen, and the filter settings in the AFR are determined by the Bandwidth, so there is again no branching. Each AFR module connects to a particular sampler in the Spectrometer, so there is, again, no choice.

Thus for any beam of the selected receiver, there are at most 2x2x4 or 16 possible paths to a backend port.

The software should consider all possible paths and consult the module quality designations to eliminate paths that contain a substandard module. If there is no path with all good modules, we propose an error message will be issued. We leave as an open question at this point exactly how to rate modules and how each path is to be ranked based on the quality designation. For paths that have equal quality the choice will be to select the lowest numbered modules first, for example, choose converter modules 1&5 first, then 2&6, and so on.

The procedure would be to start with the first beam of the first spectral window, search the tree and decide on the path. Then go to the second beam, if any, and continue through however many beams are required. Next, repeat the process for each remaining spectral window. In this way, all paths are found for the specified observing.

This process of path finding is the first step the configuration software must go through. It determines how the IF Router transfer switches are to be set, and how the input switches of the Converter Modules and Analog Filter Modules are set. It identifies which Converter Modules go with which spectral windows, and thus which LO2 synthesizers are set to which frequency.

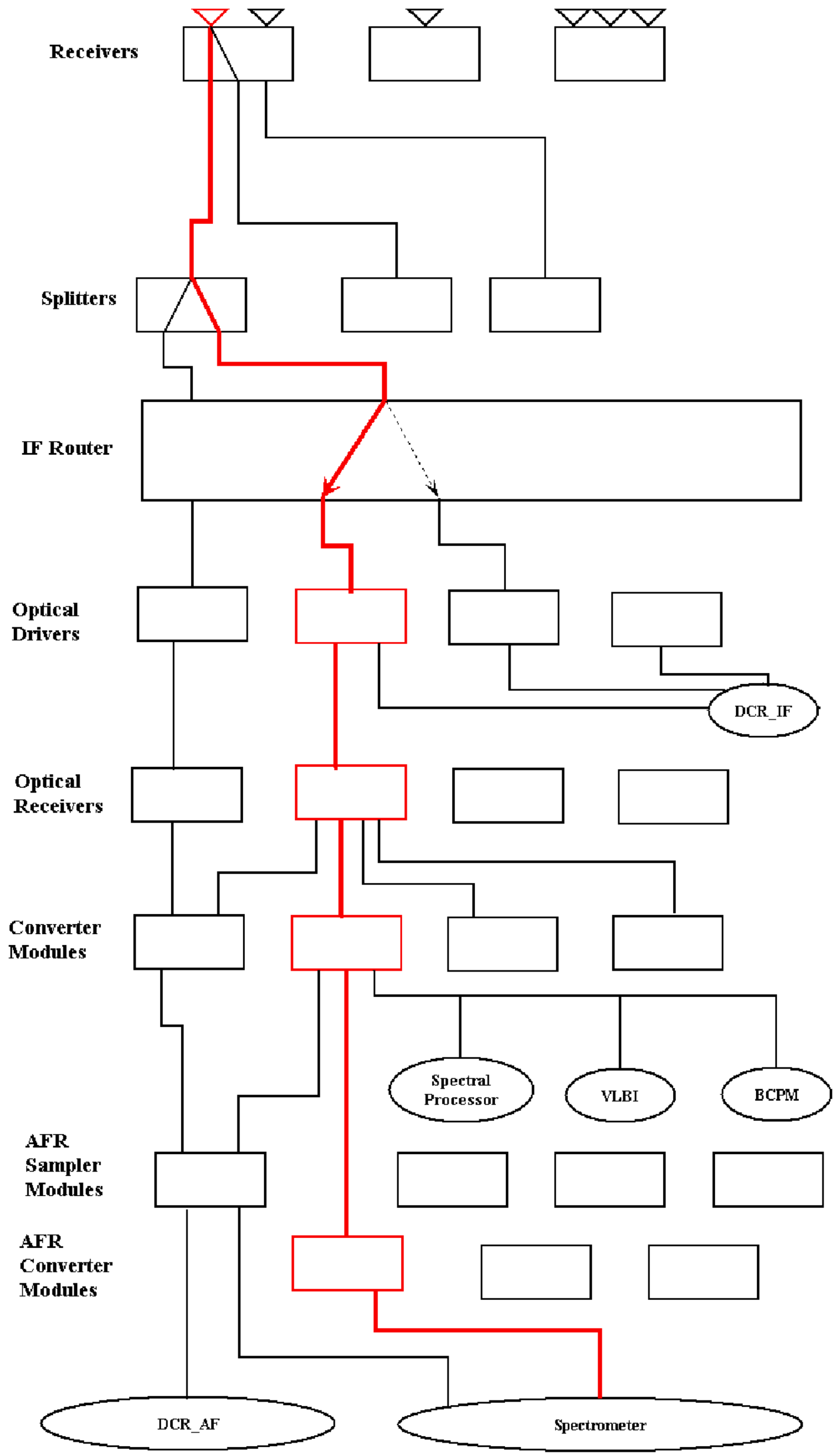

Figure 2: Typical Cabling Diagram for a configuration that uses a slow-speed Spectrometer sampler

Appendix: Configuration of YGOR Managers

In this appendix, we describe, for each YGOR manager, the meta-parameters, or configuration keyword values that are used, and how they relate to the YGOR parameters. Unless we have made an oversight, any parameter not listed here should retain its M&C default value.

Managers: when to ignore:

YGOR Managers that are out of service will be ignored and the configuration process will issue a warning message and go ahead and set up as many of the other managers as it can. If a system that constantly monitors the health of all device is not available, then a manager will be assumed to be out of service if its state is 'off', or if it does not respond within a few seconds. Managers whose state is 'standby' will be turned on.

Managers

A.1. ScanCoordinator

There is some importance in the order in which parameters are set in what managers. First set 'subsystemSelect', so that the devices will inherit subsequent parameters. When setting the switching parameters, first set the number of phases, then the blanking, and then the others.

As is currently implemented, the switching tables, number phases, and related parameters will be passed from the Scan Coordinator to all selected back ends, and whatever other device also needs it, such as the LO1 manager. Regardless of whether the DCR is a selected device, the DCR will have its phase table set up identical to that in the Scan Coordinator.

Likewise, the receiver parameter will continue to be passed on to the IFRack and the LO1 Coordinator.

When finished setting all parameters, do a 'regChange', not 'activate', 'start', or 'prepare'. For all other managers, do a 'prepare'

Table A.1.1. Scan Coordinator	
YGOR Parameters	**Depends on Keyword(s)**
receiver	Receiver
subsystemSelect	Receiver, Backend
switching_signals_master	Backend
number_phases	Swmode
phase_start	Swmode
sig_ref_state	Swmode, Backend, Vframe
cal_state	Swmode
blanking	Swmode, Swtype, Backend
switch_period	Swper

receiver

Set to keyword value for Receiver. The receiver parameter is passed to other managers that need to know it, namely LO1, and IFRack.

subsystemSelect

- Always include the Antenna, Receiver, LO1, IFRack, IFManager, Switching Signal Selector, Active Surface, and Measurements.
- Include the converter rack, unless the only backend is DCR_IF or DCR_PF.
- Include the backend manager if there is one.
- If the backend is the Spectrometer or DCR_AF, include the analog filter rack.

switching_signals_master

Set this to the backend, with a few exceptions:

Table A.1.2.	
Backend	**switching_signals_master**
DCR	DCR
SpectralProcessor	SpectralProcessor
Spectrometer	Spectrometer
BCPM	DCR
GBPP	DCR
BCPM&SP	SpectralProcessor
Radar	DCR
VLBI	VLBA_DAR

Note that the Scan Coordinator automatically sends the switching signal master to the Switching Signal Selector.

number_phases, phase_start, sig_ref_state, cal_state

These parameters all depend on the Switching Mode, as listed in the table.

Table 4.1.3.				
Swmode	**number_phases**	**phase_start**	**sig_ref_state**	**cal_state**
tp (not Spectral Processor)	2	[0.0, 0.5]	['Sig', 'Sig']	['NoNoise', 'Noise']
tp (Spectral Processor)	2	[0.0, 0.5]	['Sig', 'Ref']	['NoNoise', 'Noise']
tp_nocal	1	[0.0]	['Sig']	['NoNoise']
sp	4	[0.0, 0.25, 0.5, 0.75]	['Sig', 'Sig', 'Ref', 'Ref']	['NoNoise', 'Noise', 'NoNoise', 'Noise']
sp_nocal	2	[0.0, 0.5]	['Sig', 'Ref']	['NoNoise', 'NoNoise']

blanking

- If Swmode is 'tp_nocal', blanking = 0.0
- If Backend is VLBI or Obstype is Pulsar, blanking = 0.0
- If Swtype is 'fsw' and Backend is SpectralProcessor, blanking = 0.04
- If Vframe is not Local, and Backend is SpectralProcessor, blanking = 0.04
- For all other cases, blanking = 0.002

switch_period

Set to Swper keyword value.

A.2. SwitchingSignalSelector

YGOR Parameters	Keyword(s)
disableLOBlanking	Backend, Vframe, Swtype
disableLocalBlanking	Backend

disableLOBlanking

Always enable LO Blanking

disableLocalBlanking

Enable Local Blanking for all backends except VLBI.

A.3. LO1

The LO1 manager controls two synthesizers, LO1A and LO1B, and can route signals from either synthesizer to any of the recievers. For standard configurations, we will always use LO1A as the tracking LO, and LO1B as the test tone. The configurator will always disable the test tone. To use the test tone, the user must use a tweaking command.

Several parameters are always set the same way; for these there is nothing in the "Keyword" column.

Table A.3.1. LO1 Parameters

YGOR Parameters	Keyword(s)	Comments
loConfig	--	Set to 'TrackA_BNotUsed'
restFrequency	Restfreq	
ifCenterFreq	Restfreq, Deltafreq, Nwin	See Section 6.0
switchDeltas	Swfreq, Swtype	If Swtype is not 'fsw' set to zeros.
sourceVelocity	(Vlow+Vhigh)/2	
restFrame	Vframe	
velocityDefinition	Vdef	
tolerance	Backend, Nchannels	
phaseCalCtl	Obstype, Phasecal	VLBI only
phaseCalMode	Obstype, Phasecal	VLBI only
subsystemSelect	-----	set to [1,1,0,1]
useOffsets	-----	set to 'false'
autoSetLOPowerLevel	-----	set to 1
testToneFreq	-----	set to 17000.0
testTonePowerLevel	-----	set to -110 db

restFrequency

restFrequency is set to the first item in the Restfreq list.

ifCenterFreq

Set the 'ifCenterFreq' to the value of IF1 as explained in Section 6.0.

switchDeltas

Set the switchDeltas to the value of keyword Swfreq. If not frequency switching set them to zero. The other switching table parameters (number_phases, phase_start, sig_ref_state, switch_period, switching_signals_master, blanking, cal_state) are set by the Scan Coordinator so they do not have to be explicitly set by the Configurator.

restFrame

Vframe keywords may be abbreviated for convenience, but must be translated to the parameter values required by the LO1 manager, as listed in the following table.

Table A.3.2. restFrame values

Vframe	LO1 restFrame
topo	Local
bary	Barycentric
lsrk	KinematicalLSR
lsrd	DynamicalLSR
galac	Galactocentric
cmb	CosmicBackground

velocityDefinition

Likewise, the parameter values accepted by LO1 for velocityDefinition are as follows.

Table A.3.3. velocityDefinition values

Vdef	LO1 velocityDefinition
rad	Radio
opt	Optical
rel	Relativistic

tolerance

The frequency tolerance should be set to 1% of the spectral channel spacing used by the back end.

phaseCalCtl and phaseCalMode

- If the Obstype is not VLBI, then phaseCalCtl is set to 'Off'
- If the Obstype is VLBI and Phasecal keyword is 'M1' or 'M5', then phaseCalCtl is set to 'on', and phaseCalMode is set to 'M1' or 'M5'.
- Otherwise, phaseCalCtl should be 'off'.

- If phaseCalCtl is 'on', then the switches that route the phase cal signal to the receiver must also be set.

A.4. IFRack

The IF Rack receives the IF signals from all the receivers after the first down conversion. Eight switches, each with eight positions, select signals from the receivers. The signals pass through IF filters, and on to optical drivers. Each signal can go to one of two optical drivers, depending on how the transfer switches are set (S9 .. S12).

Table A.4.1. IF Rack Parameters		
YGOR Parameters	**Keyword(s)**	**Comments**
analog_power_level	Receiver, Bandwidth	
filter_select	Bandwidth, Nwin, etc.	
laser_auto_level_control		Set all to 'swOn'
subsystemSelect		Set all to ones.
noise_bandwidth		Set to 'narrowband'
S9 ... S12		Transfer switches: See Section 7.0

analog_power_level

The 'balance' operation adjusts attenuators to bring the power of each signal to the level specified in the 'analog_power_level' parameter. The configurator does not do a balance in the initial setup, but it does set 'analog_power_level'. The appropriate analog power levels depend on the IF center and bandwidth. The engineering department will provide a table of recommended power levels for IF center and bandwidth.

filter_select

- For Prime Focus receivers, filter_select is always 'pass_all', and the IF filter is set by the receiver manager.
- For Gregorian receivers, the IF filters are set to the smallest value that includes "BWTOT", as explained in Section 6. But if BWTOT is greater than 1280 MHz, set the filter to 1280.
- Set the filters for all the optical drivers that are to be used.

S9 ... S12 (transfer switches)

These are set according to the results of the path optimization that was discussed in Section 7.

A.5. ConverterRack

The Converter Rack receives signals from the optical receivers. The signal from each receiver is split to 4 converter modules. There are a total of 16 modules, organized into two racks, known as "Rack A", in which resides modules numbered 1-8, and "Rack B", which has modules numbered 9-16. Each module can select between one of two fibers as its input, using the 'CMInput' parameter.

Eight frequency synthesizers (G1- G8) provide a second down conversion frequency (LO2) to two converter modules each. 'Gfrequency' is the list of these frequencies.

Table A.5.1. Converter Rack Parameters

YGOR Parameters	Keyword(s)	Comments
CMInput	Receiver, Beam	
ABselect	Receiver, Beam	Ignored unless backend is the Spectral Processor
CMOutput	Backend, Bandwidth	
Gfrequency	Receiver, Backend, Bandwidth, Nwin, Restfreq, Dfreq, Vlow, Vhigh, Vdef	Refer to Section 6
Glevel	---	Set them all to 10
CMAttenuator	Backend, IF Center	

CMInput

CMInput is an array of size 16, giving for each of the 16 converter modules "A" or "B" indicating which of two fiber receivers it can select. The cabling file will need to be consulted to determine which CMInputs are from which optical receivers.

ABselect

ABselect is used only for the Spectral Processor. Set this to "A" to connect the 8 SP inputs to CM1-8; "B" for CM9-16.

CMOutput

CMOutput is a list of 16 numbers indicating filter and output switch settings for each of the 16 converter modules. The switch settings are listed in the table.

Table A.5.3.		
CMOutput[n]	**Filter**	**Destination**
1	All Pass	Analog Filter Rack : Bandwidth = 200 or 800 MHz
2	500-1000 MHz	VLBI or Radar backends
3	All Pass	unused
4	550 MHz Low-pass	Analog Filter Rack - Bandwidth = 12.5 or 50 MHz Spectral Processor BCPM

Note that certain backends (VLBI, BCPM, Radar) connect to only a few of the converter modules. One must consult the cabling file to find out which modules connect to which backends. For example, the current cable file specifies:

- VLBI: CM1&5, CM9&13
- Radar: CM10&14
- BCPM1: CM4&8, CM12&16
- BCPM2: CM3&7, CM11&15

Gfrequency

Gfrequency is a list of LO2 frequencies as explained in Section 6. The path finding process (Section 7) determines the assignment of synthesizer to spectral window.

CMAttenuators

The engineers need to provide a list of suggested values that depend upon the backend and IF Center frequency.

A.6. ActiveSurface

YGOR Parameters	Keyword(s)
correctionSelect	Receiver

For receivers for frequencies 8 GHz and higher (i.e., X-band, Ku-band, K-band, Q-band, W-band), the active surface FEM model should be enabled. For lower frequency receivers (prime focus, L-, S-, and C- bands), the FEM model should be turned off and the Zero Points mode should be enabled.

correctionSelect

- For receivers of frequencies < 8 GHz, correctionSelect = [zero=1, fem=0, random=0].
- For receivers of frequencies > 8 GHz, correctionSelect = [zero=1, fem=1, random=0]

A.7. AnalogFilterRack

The Analog filter rack receives signals from the Converter Rack, passes them through filters, and sends them to samplers in the Spectrometer or DCR.

There are two flavors of filter module:

- "Sampler Filters" handle the wide-band signals (200 or 800 MHz)
- "Converter Filters" handle the narrow-band signals (12.5 or 50 MHz)

There are eight Sampler Filter modules. They get their inputs from the "all pass" outputs of the ConverterRack. The 'SGInput' parameter tells these modules to select between ConverterRack modules in either rack A or B. The 'SGFilter' parameter selects the bandpass filter: use 'wide' to select 800 MHz bandwidth, and 'narrow' to select 200 MHz.

The outputs of Sampler Filter modules 1 through 8 go to high speed samplers 1 through 8 in the Spectrometer.

There are 16 "Converter Filter" modules. Their inputs are connected to the "550MHz Lowpass" outputs of the Converter Rack modules. Converter filter module numbers 1-16 connect to corresponding numbered converter rack modules. Parameter 'CFFilter' sets the bandpass in these modules. Set CFFilter to 'wide' for 50 MHz and 'narrow' for 12.5 MHz.

Although the possibility exists of setting different bandwidths in different modules, we will not do this for this version of the configurator. All modules that will be used will be set the same.

Table A.7.1. AnalogFilterRack parameters		
YGOR Parameters	**Keyword(s)**	**Comments**
SGInput	Receiver, Beam	SGInput = 1(input from CR "A") or 2(input from CR "B"
SGFilter	Bandwidth	SGFilter = 'wide' for 800 MHz, or 'narrow' for 200 MHz

CFFilter	Bandwidth	CFFilter = 'wide' for 50 MHz, or 'narrow' for 12.5MHz
subsystemSelect		Set them all to 1

"Sampler Filter" (wideband) Connections

Input switch selection and output connections to the Spectrometer and DCR. The cabling file must be searched to find the actual connections. The current connections are:

Table A.7.2. Wideband filter module connections

SGInput= 1 / 2	SF Module	Spectrometer Sampler Connection
CM 1 / 9	1	J1
CM 2 / 10	2	J2
CM 3 / 11	3	J3
CM 4 / 12	4	J4
CM 5 / 13	5	J5
CM 6 / 14	6	J6
CM 7 / 15	7	J7
CM 8 / 16	8	J8

"Converter Filter" Connections

The outputs of the Converter Filter modules are hardwired to the low-speed samplers in the Spectrometer. The current connections are listed in the following table but, again, the cabling file will need to be consulted. Samplers are identified by connection numbers J9 to J40, sometimes also designated as low-speed samplers number 0 through 31.

Table A.7.3. Narrow filter module connections

ConverterRack module	AFR "Converter Filter Module	Spectrometer Sampler Connection	Sampler number
1	1	J9	0
2	2	J10	1
3	3	J17	8
4	4	J18	9
5	5	J13	4
6	6	J14	5
7	7	J21	12
8	8	J22	13
9	9	J25	16
10	10	J26	17
11	11	J33	24
12	12	J34	25
13	13	J29	20
14	14	J30	21
15	15	J37	28
16	16	J38	29

(Yes there is actually a good reason for this strangeness!)

A.8. DCR

The Digital Continuum Receiver records detected power from one of two banks of inputs, bank A and bank B. Sixteen channels of continuum data can be recorded from the selected bank.

Data comes to the DCR from three different devices, the IF Rack, the Prime Focus Receiver, and the Analog Filter Rack. For the purpose of configuring, we are considering only the IF Rack and Analog Filter Rack inputs, and are treating these cases as two different back ends, called "DCR_IF" and "DCR_AF".

The parameters that the configurator needs to be concerned with are:

Table A.8.1. DCR Parameters	
YGOR Parameters	**Keyword(s)**
Bank	Receiver, Beam
Channel	Receiver, Beam
CyclesPerIntegration	Tint, Backend

Switching phase table information will be sent from the scan coordinator, so there is no need to set explicitly 'switching_signals_master', 'switch_period', 'number_phases', 'phase_start', 'cal_state', 'sig_ref_state', or 'blanking'.

Bank and Channel

Naturally the cabling file must be consulted to find the connections from any receiver/beam to DCR channel. The nominal connections are summarized in Table A.8.2.

Table A.8.2 DCR Inputs		
Device	**Bank**	**Channels**
IF Rack	A	1 - 8
AFR SG1 - SG8 (wide band channels)	A	9 - 16
AFR CF1,3,5,7,9,11,13,15 (narrow band channels)	B	9 - 16

CyclesPerIntegration

- If the DCR is the switching signal master, then: CyclesPerIntegration = Tint/Swper
- If the DCR is not the switching signal master, then it is being used to monitor Tsys, so just set CyclesPerIntegration to 1.0/Swper so its integration time is one second.

A.9. Spectrometer

The Auto-Correlation spectrometer can produce high-resolution spectra with a choice of 4 bandwidths, in a vast variety of modes. The configurator will set up in a limited set of modes. Cross-polarization and pulsar modes will not be considered.

Although it is possible to set up different banks with different bandwidths and modes, we will not consider that. All spectra will have the same bandwidth and number of channels.

Table A.9.1. Spectrometer Parameters

YGOR Parameters	Keyword(s)
configuration	Bandwidth, Nwin, Beam, Nchannels
relative_bandwidth	Bandwidth
slow_samplers	Nwin, Beam
fast_samplers	Nwin, Beam
number_slow_samplers	Nwin, Beam
slow_samplers_level	Nlevels
requested_integration_time	Tint
polarization	Obstype

As is the case for all backends, the switching phase tables parameters are not directly set by the configurator, but by the Scan Coordinator.

configuration

The 'configuration' is a string specifying the number of banks and how many quadrants per bank. Of the vast number of possible configurations, we can accomodate all observing setups with six of them. as named in the following table.

Table A.9.2. ACS Configurations

Configuration	Num.Banks	Num.Quads per bank
Spectrum_A1	1	1
Spectrum_A2	1	2
Spectrum_A4	1	4
Spectrum_A1_B1	2	1
Spectrum_A2_B2	2	2
Spectrum_A1_B1_C1_D1	4	1

relative_bandwidth

relative_bandwidth is an array whose length is the number of banks.
If the Bandwidth is 12.5 MHz or 200 MHz, set this parameter to 'narrow'. Otherwise, set it to 'wide'. Set all banks that will be used to the same value.

slow_samplers

The slow samplers are assigned to banks in groups of 8. slow_samplers is an array of size four corresponding to the four groups of samplers: 0-7, 8-15, 16-23, 24-32. (If one refers to Table A.7.3, one notes that only 4 out of each of these groups of 8 are ever used.) For each group, the parameter is set to "Bank_A", "Bank_B", "Bank_C", or "Bank_D' to assign the group of samplers to a bank. It may also be set to "not_used", if a group of samplers is not assigned to any bank. Only one group of samplers may be assigned to a bank.

fast_samplers

fast_samplers is an array of length 8, corresponding to the eight fast samplers. For each sampler, the parameter is set to "Bank_A", "Bank_B", "Bank_C", or "Bank_D" to assign the sampler to a bank. If the sampler is not assigned to a bank, the parameter is set to "not_used".

For Bandwidth=200MHz, no more than 4 fast samplers may be assigned to a bank.
For Bandwidth=800MHz, no more than 2 fast samplers may be assigned to a bank.

number_slow_samplers

number_slow_samplers is an array whose length is the number of banks.
Set them if using slow samplers, i.e., the Bandwidth is 12.5 or 50 MHz.
The TOTAL number of samplers is the number of spectral windows (Nwin) times the number of beams (Nbeams) times two (we always set up for dual polarization. Divide the total number of samplers by the number of banks to get the number of samplers per bank. Set all banks to this number.

slow_samplers_level

slow_samplers_level is an array whose length is the number of banks.
Set them all to Nlevels (i.e., 3 or 9).

requested_integration_time

requested_integration_time is an array whose length is the number of banks.
Set them all to Tint.

polarization

polarization is an array whose length is the number of banks.
Set them all to zero for non-cross-polarization mode.

How to choose the configuration

The appropriate configuration and assignment of samplers to banks depends on the Bandwidth, the number of spectral windows (Nwin), number of beams, and number of channels. We set up always for dual polarization.

The allowed combinations of Nwin and number of beams for the slow samplers (of which we can use up to 16 at a time), are given in Table A.9.3.

Table A.9.3. Total number of samplers for Low-speed modes.

Nwin	one beam	two beams	four beams
1	2	4	8
2	4	8	16
4	8	16	
8	16		

The next table, A.9.4, shows a typical set of configuration choices to use for each choice of Nwin and beam for the slow samplers. The cabling file will describe the actual routing between a beam and the backend. In the table, beam designations B1, B2, B3, and B4 apply not only to multi-beam receivers, but also to any receiver at all. Each "beam" indicates a pair of inputs to the IF Rack, as follows:

- B1 : IF Rack inputs S1,S3; (route thru conv. Rack A)
- B2 : IF Rack inputs S5,S7; (route thru conv. Rack B)
- B3 : IF Rack inputs S2,S4; (route thru conv. Rack A)
- B4 : IF Rack inputs S6,S8; (route thru conv. Rack B)

Currently, eight-IF (Nwin=8) mode requires the receiver IFs to be split to both converter racks A and B. Thus the receiver output is going to fibers 1,3,5,7 for beam B12, or to fibers 2,4,6,8 for beam B34. Sampler groups are designated as: G1 = (0-7); G2 = (8-15); G3 = (16-23); G4 = (24-31)

Table A.9.4. Low-Speed Configuration and sampler assignment.

Nwin	Beam	Total num. samplers	Configuration	Levels	num.samplers per bank	Sampler Group	Nchannels
1	B1	2	A1 A2 A4 A1 A2 A4	3-lev 3-lev 3-lev 9-lev 9-lev 9-lev	2	G1	32768 65536 131072 8192 16384 32768
1	B2	2	same as for B1		2	G3	
1	B3	2	same as for B1		2	G2	
1	B4	2	same as for B1		2	G4	
1	B12	4	A1_B1 A2_B2 A1_B1 A2_B2	3-lev 3-lev 9-lev 9-lev	2	G1_G3	32768 65536 8192 16384
1	B34	4	same as for B12		2	G2_G4	
1	B1234	8	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	2	G1_G2_G3_G4	32768 8192
2	B1	4	A1 A2 A4 A1 A2 A4	3-lev 3-lev 3-lev 9-lev 9-lev 9-lev	4	G1	16384 32768 65536 4096 8192 16384
2	B2	4	Same as 2 IFs, B1		4	G3	
2	B3	4	Same as 2 IFs, B1		4	G2	
2	B4	4	Same as 2 IFs, B1		4	G4	
2	B12	8	A1_B1 A2_B2 A1_B1 A2_B2	3-lev 3-lev 9-lev 9-lev	4	G1_G3	16384 32768 4096 8192
2	B34	8	Same as 2 IFs, B12		4	G2_G4	
2	B1234	16	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	4	G1_G2_G3_G4	16384 4096
4	B1	8	A1_B1 A2_B2 A1_B1 A2_B2	3-lev 3-lev 9-lev 9-lev	4	G1_G2	16384 32768 4096 8192

4	B2	8	same as 4 IFs, B1		4	G3_G4	
4	B3	8	same as 4 IFs, B1		4	G1_G2	
4	B4	8	same as 4 IFs, B1		4	G3_G4	
4	B12	16	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	4 4	G1_G2_G3_G4 G1_G2_G3_G4	16384 4096
4	B34	16	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	4 4	G1_G2_G3_G4 G1_G2_G3_G4	16384 4096
8	B1 or B2	16	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	4 4	G1_G2_G3_G4 G1_G2_G3_G4	16384 4096
8	B3 or B4	16	A1_B1_C1_D1 A1_B1_C1_D1	3-lev 9-lev	4 4	G1_G2_G3_G4 G1_G2_G3_G4	16384 4096

Now for the fast samplers, i.e., Bandwidths of 200 or 800 MHz, Table A.9.5 shows the possible combinations of Nwin and number of beams. There are a maximum of 8 fast samplers.

Table A.9.5. Total Numbers of Fast Samplers.

Nwin	one beam	two beams	four beams
1	2	4	8
2	4	8	
4	8		

A typical set of possible fast sampler configurations are listed in Table A.9.6. The actual set depends upon the cabling file.

Table A.9.6. Configurations for Fast Samplers.

Nwin	# beams	NSamp	Configuration	Bandwidth	Sampler assignment	NChannels
1	1	2	A1 A2 A4 A1 A1_B1 A2_B2	200 200 200 800 800 800	01 01 01 01 0_1 0_1	8192 16384 32768 2048 4096 8192
1	2	4	A1 A1_B1 A2_B2 A1_B1 A1_B1_C1_D1	200 200 200 800 800	0123 01_23 01_23 01_23 0_1_2_3	4096 8192 16384 2048 4096
1	4	8	A1_B1	200	0123_4567	4096

			A1_B1_C1_D1 A1_B1_C1_D1	200 800	01_23_45_67 01_23_45_67	8192 2048
2	1	4	A1 A1_B1 A2_B2 A1_B1 A1_B1_C1_D1	200 200 200 800 800	0123 01_23 01_23 01_23 0_1_2_3	4096 8192 16384 2048 4096
2	2	8	A1_B1 A1_B1_C1_D1 A1_B1_C1_D1	200 200 800	0123_4567 01_23_45_67 01_23_45_67	4096 8192 2048
4	1	8	A1_B1 A1_B1_C1_D1 A1_B1_C1_D1	200 200 800	0123_4567 01_23_45_67 01_23_45_67	4096 8192 2048

Note: the sampler assignment column shows which samplers are assigned to which banks, for example, '01' means samplers 0 and 1 are assigned to bank A; '01_23' means samplers 0 and 1 are assigned to bank A and samplers 2 and 3 are assigned to bank B.

A.10. SpectralProcessor

The Spectral Processor is a general purpose Fourier-transform spectrometer which may be used either for normal spectroscopy or for pulsar timing. It will do autocorrelations of its input signals, and will also do cross-correlations of pairs of inputs (usually cross-polarization pairs).

The first table lists the YGOR parameters that the configurator needs to set. Following the table are descriptions of how each YGOR parameter relates to the configuration keywords. Finally, there is an explanation of how to connect the Spectral Processor to the GBT IF system.

A.10.1. Parameters set directly by configurator	
YGOR Parameters	**Dependent on Keyword(s)**
processorMode	Obstype
multiplierMode	spmode
reqBandwidth	Bandwidth
reqNumChan	Nchannels, Bandwidth, Nwin, Beam
numSpectr	Nwin, Beam
observeFreq	Nwin, Beam, Restfreq, Dfreq
rfSideband	Receiver
reqIF	(normally these are always 250 MHz
sampleTime	Tint
calPhase	always set to 0.0
calDuration	always set to 0.5
atodLevMode	set to 'Immediate'
balance	set to 'NotBalance'
reqPulsarPeriod	set to Swper
reqDispersionMeasure	set to zero
polycoDatFile	optional user input in pulsar mode.

The switching phase table and related information is set by the Scan Coordinator, and does not need to be set explicitly by the configurator. These parameters include: number_phases, cal_state, sig_ref_state, phase_start, blanking, switch_period, and switching_signals_master.

processorMode

- For Obstype = 'Spectroscopy', processorMode = 'StdSpecLine'
- For Obstype = 'Pulsar', processorMode = 'SyncFreqTime'

multiplierMode

This is a parameter selected by the user. The values are 'Square', 'Cross', or 'SqrCross'. 'Square' means parallel polarization products; 'Cross' means crossed polarization products; 'SqrCross' means both. See the table below for how this relates to other parameters.

reqBandwidth

- For Bandwidth = 40 MHz, reqBandwidth = '_40MHz'
- For Bandwidth = 20 MHz, reqBandwidth = '_20MHz'
- etc.

reqNumChan and numSpectr
The possible values for these parameters are listed in the following table:

Table A.10.2. Spectral Processor Configurations

Bandwidth	multiplierMode	NIF	reqNumChan	numSpectr
40 MHz	Square or Cross	1	1024	1
20 MHz	Square or Cross or SqrCross	1	1024	1
20 MHz	Square or Cross	2	512	2
10 MHz	Square, Cross, or SqrCross	1	1024	1
10 MHz	Square, Cross, or SqrCross	2	512	2
10 MHz	Square or Cross	4	256	4
<= 5 MHz	Square, Cross, or SqrCross	1	1024	1
<= 5 MHz	Square, Cross, or SqrCross	2	512	2
<= 5 MHz	Square, Cross, or SqrCross	4	256	4

Note that NIF = Nwin x Number of beams.

observeFreq

observeFreq is an array of NIF frequencies. Calculation of these frequencies is described in Section 6. Use "Flocal[i]" from Section 6.0 for spectral window i.

rfSideband

rfSideband is an array of size NIF containing the sideband designation (either 'Upper' or 'Lower') for each IF. These are the net sideband, and depend on the receiver:

- 'Lower' for Rcvr8_10 and lower frequencies.
- 'Upper' for Rcvr12_18 and higher frequencies.

reqIF

reqIF is an array of size NIF. For standard configurations (which is all that we are considering), all members are set to 250 MHz.

atodLevMode and balance

The configurator should always set these to 'Immediate' and 'NoBalance' for the initial setup.

SpectralProcessor connections

Here we make an attempt to explain the logic of connecting the SpectralProcessor to the GBT IF system.

The Spectral Processor has 8 inputs, designated A1,A2,A3,A4, and B1,B2,B3,B4. The "A" inputs connect to one polarization, usually X or LCP, the "B" inputs to the other polarization. For normal dual-polarization observing, A1 and B1 are used for the first spectral window, A2 and B2 for the second, and so on. There is no flexibility in these assignments, i.e., one cannot use A2 and B2 for the first window. If using one spectral window one must always use A1 and B1; if using two windows, one must always use A1,A2, B1,B2; and so on.

The Spectral Processor inputs connect to an "A/B" switch to the outputs of the converter modules. The switch in the "A" position connects the 8 SP inputs to outputs of converter modules 1-8, and the "B" position to modules 9-16. Do not confuse the "A/B" switch with the "A" and "B" of the Spectral Processor inputs!!

Given a particular instance of the cabling file, there are only two ways to connect the Spectral Processor, one through Converter Rack A ("A/B" switch in "A" position), the other through Converter Rack B.

The following table describes how the GBT IF system connects to the Spectral Processor. It shows the typical use of converter modules, but keep in mind that the cabling file must be consulted to determine how the modules are actually cabled up. Polarization pairs (X,Y) or (LCP,RCP) are normally routed through fiber pairs (1,3), (2,4), (5,7), or (6,8), which can be selected by converter module pairs CM1&5, CM2&6, CM3&7, CM4&8, CM9&13, CM10&14, CM11&15, or CM12&16. The actual fiber pairs must be determined by consulting the cabling file in case one or more fiber drivers are out of service.

The output switch of the converter module in all cases is set to 'LPF550MHz'.

Table A.10.3. Spectral Processor Inputs				
Fibers	**Polarization**	**Converter Modules**	**A/B Switch position**	**Spectral Processor Input**
1 or 2	XL	CM1	A	A1
3 or 4	YR	CM5	A	B1
1 or 2	XL	CM2	A	A2
3 or 4	YR	CM6	A	B2
1 or 2	XL	CM3	A	A3
3 or 4	YR	CM7	A	B3
1 or 2	XL	CM4	A	A4
3 or 4	YR	CM8	A	B4
5 or 6	XL	CM9	B	A1
7 or 8	YR	CM13	B	B1
5 or 6	XL	CM10	B	A2
7 or 8	YR	CM14	B	B2
5 or 6	XL	CM11	B	A3
7 or 8	YR	CM15	B	B3
5 or 6	XL	CM12	B	A4
7 or 8	YR	CM16	B	B4

For the single-beam receivers (Rcvr8_10 and lower frequencies), signals are routed to both converter racks. If there is a bad module in converter rack A (CM1-8), then an alternate route is to use rack B.

For multi-beam receivers, typically each beam is routed through either rack A or B, but not both. Beams usually work in pairs that can be toggled if beam switching. One member of the pair goes through converter rack A (selected by A/B switch in A position), the other through rack B (selected by A/B switch in B position). Since the Spectral Processor can connect to either rack A or B, but not both, it cannot record both beams of a pair simultaneously.

A.11. BCPM

The BCPM is a pulsar data acquisition machine designed and built at the universities in Berkely and CalTech. It can do pulsar timing observations (operating_mode='timing'), and can also write out the raw high-speed samples for later pulsar searches (operating_mode='search'). Before any data taking, one must set it up in 'monitor' mode to set its power levels.

There are two BCPMs, designated BCPM1 and BCPM2. Each can accept an input signal with a bandwidth of 192 MHz. With one BCPM, one spectral window can be observed. With two BCPMs, two spectral windows can be observed. The "normal" situation will be that spectral window #1 goes to BCPM1 and spectral window #2 goes to BCPM2. Since at the moment, only BCPM1 is working only one spectral window is currently possible.

A complication is that BCPM2 will have the ability to collect cross-polarization data and BCPM1 does not. Some observers will want to use only BCPM2.

The first six YGOR parameters in the table are really the only configuration parameters, specified by user keywords. The remaining ones may change from one observation to the next. The table gives reasonable values to use for the initial setup.

Table A.11.1. BCPM Parameters

YGOR Parameters	Keyword(s)
submanagers_used	Nwin
setif	Receiver
center_frequency	Restfreq, Deltafreq
channel_bandwidth	(user selected)
sample_time	(user selected)
sum_polarizations	(user selected)
cal_used_flag	(initialize to 'no')
operating_mode	(initially set to 'monitor')
data_storage	(initially set to 'disk'
file_size	(initialize to 60)
base_name	(source name)
target_name	(source name)

submanagers_used

- Use the user-set keyword from Secion 3
- If Nwin=2 and both BCPMs are working, set to 'bcpm1_and_bcpm2'

setif

- setif=1 to select the BCPM "A" inputs, A1 and A2, which connect to modules in converter rack A.
- setif=2 to select the BCPM "B" inputs, B1 and B2, which connect to modules in converter rack B.
- setif=3 to receive inputs from telescope 85-3. So if the path that the configurator has chosen for the selected receiver leads to converter rack A, setif=1, otherwise setif=2.

center_frequency

This is an array of two frequencies, the first for BCPM1, the second for BCPM2. These are the two sky frequencies, Flocal[i], at described in Section 6.0.

BCPM Connections

Each BCPM has two inputs, one for each polarization. Each BCPM is connected to a pair of converter modules. The converter module output switch is set to 'LPF550MHZ'. A typical setup is described in the following table. But of course the cabling file must be consulted to find which modules actually connect to the BCPMs.

Table A.11.2. BCPM Inputs

Polarization	Converter Module	BCPM: Input
XL	3	BCPM2 : A1
YR	7	BCPM2 : A2
XL	4	BCPM1 : A1
YR	8	BCPM1 : A2
XL	11	BCPM2 : B1
YR	15	BCPM2 : B2
XL	12	BCPM1 : B1
YR	16	BCPM1 : B2

A.12 Receivers

Most of the receivers use the same parameter names. We will list the common parameters then discuss each receiver in turn. In the table, 'xx' will be different from one receiver to another. Note that one has to be aware that the consistency of parameter names between receivers is not very good. We are assuming that 'tuning_frequency' will be implemented for all receivers so that polarization hybrids and LNA bias settings can be set by the manager and not the configuration tool..

Table A.12.1 Parameters for most receivers

Parameter	Depends upon Keywords	Notes
xxBiasSwitch		Always on
xxExtToMCBCtrlSel		Always ext
cpuLoCalPwrSw		Always on
xferSwCtlMode	SwType	Ext if polarization switching, otherwise MCB
xx IfFilterSwitch or ifChannelXFilterBank	Bandwidth, Nwin, etc.	In many cases, the filter is an RF, not an IF filter.
loOrHiCalSel	Noisecal	
polarizationSelect	Polarization	
xferSwitch	Polswitch	Ignored by the manager if xferSwCtlMode is in ext
Tuning_frequqncy	Restfreq, Velmin, velmax, etc.	Not implemented on some receivers
IfChannelXAttenuator		Only available on the PF receivers. Set to value determined by the engineer
Notch_filter	Notchfilter	Currently available on Rcvr1_2.

Table A.12.2 Parameters for Rcvr12_18, Rcvr18_26, and Rcvr40_52

Parameter	Depends upon Keywords	Notes
xxBiasSwitch		Always on
calState		Always ext
noiseSourcePwrSwX		Always on
xferState	SwType	Ext if beam switching, otherwise MCB
xx IfFilterSwitch	Bandwidth, Nwin, etc.	Most receivers do not have a set of filters
XferSwX or xxXferSw	Beamswitch	Ignored by the manager if xferState is in ext
ChopperCtrl		Always off; available currently available only on Rcvr40_52.
Tuning_frequqncy	Restfreq, Velmin, etc.	Not yet implemented

xxBiasSwitch

Turns on the LNA amplifiers

xxExtToMCBCtrlSel or **calState**

Specifies that the noise diode should be controlled by the switching signal master

NoiseSourcePwrSwX or **cpuLoCalPwrSw**

Turns on the noise diode

xferState or **xferSwCtlMode**

Specifies that the polarization or beam switch should be in external control for either polarization or beam switching. Some receivers do not have transfer switches.

XferSwX, xxXferSw or **xferSwitch**

If not beam or polarization switching, specifies the position of the transfer switch. Some receivers do not have transfer switches. Ignored if the xferState or xferSwCtlMode are set to external.

notch_filter

Whether the notch filter is to be used. Only the RCvr1_2 currently has such a filter.

loOrHiCalSel

Whether high or low noise diode are to be used.

polarizationSelect

Whether the observation will use linear or circular polarizations. Not all receivers have this capability.

xxIfFilterSwitch or **ifChannelXFilterBank**

The name implies these are I.F. filters but in fact the name is used for either IF or RF filters. Whether it is an I.F. or R.F. filter depends upon the receiver. The filter should encompass the full range of sky frequencies or I.F. as described in section 6.

Tuning_frequqncy

As described in section 6, this should be the frequency at the middle of the observer's observing frequency range. All receivers need this parameter so that the manager can automatically set polarization hybrids settings, attenuators, or LNA biases. Unfortunately, only a few receivers have this capability.

IfChannelXAttenuator

Attenuators currently are only on the PF receivers. The receiver engineer should provide the attenuator values and the criteria by which they are set

chopperCtrl

Currently chopperCtrl is only available on the 40-52 GHz receiver. The chopper should be ‘retracted’ or off.