Parkes Radiotelescope Correlator Guide

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1 Preface

This guide outlines the Digital Filterbank and other correlators currently available at Parkes.

2 Digital Filter Bank DFB4

The Digital Filter Bank Mark IV is the digital backend offered for single receiver systems of the Parkes Observatory. The unit is a digital correlator for spectral, continuum and pulsar observations and provides both the power spectrum of each polarisation (Total Intensity) and the complex cross-spectrum (polarization).

The correlator is of the FX type and before the spectral processing the signal is prefiltered in sub-bands by a polyphase filter for high isolation and low RFI contamination into the next bands.

2.1 DFB main features

The samplers are 8-bit units for high dynamic range. This gives high robustness against RFI saturation and a better tolerance of the input power level. The maximum input bandwidth (BW) is 1024 MHz . Only one input frequency is possible with DFB4. The available BW are 8, 64, ..., up to 1024 MHz. The maximum number of channels depends on the observing mode (e.g. pulsar folding, time-binning), the bandwidth, and configuration (e.g. single frequency), with a maximum of 8192.

Table 1 reports a summary of the DFB main futures.

Table 1: Main features of the DFB.

Backend	BW (max) [MHz]	BW (min) [MHz]	# pol	Stokes	# IF	channels (max)
DFB4	1024	8	2	Full	1	8192

2.2 DFB4 Observing Modes

DFB4 can be used in four observing modes:

1. Pulsar folding mode (pulsar observations);
2. Pulsar search mode (pulsar observations);
3. Time binning mode (spectral line/continuum observations at high time resolution);
4. Spectrometer mode (spectral line/continuum observations at low time resolution).

2.3 Pulsar Folding Mode

Spectra are folded on the pulsar period. Used to observe pulsars of known period. Relevant configuration parameters are:

1. The number of time-bins the folding period is divided in;
2. The number of frequency channels;
3. The BW.
4. The minimum folding time depends on the configuration. Examples are:
   - 2k bins, 2k channels, 1024 MHz BW: 8.192 ms
   - 2k bins, 512 channels, 1024 MHz BW: 2.048 ms
5. The max number of frequency channels is limited to 2048.
6. File format is "CFITS".
7. The program to run DFB4 in this mode is "pdfb4" on the computer "pkccc4".

Main features of the *pulsar folding mode* are summarised in Table 2. Configurations are of the type "pdfbX_YYY_BW_CH" where X = 4, YYY is the number of time-bins per folding period, BW the bandwidth (MHz), and CH the number of frequency channels. See Table 9 for supported modes.

Table 2: **Pulsar Folding Mode**

Backend	BW (max)	BW (min)	# pol	Stokes	# IF	channels	file format
	[MHz]	[MHz]				(max)	
DFB4	1024	8	2	Full	1	2048	CFITS

2.4 Pulsar Search Mode

Spectra are dumped to file unfolded and the output is the spectrum as a function of time. Used to search for new pulsars. Relevant configuration parameters are:

1. The number of time-bins the dump time is divided in;
2. The number of frequency channels;
3. The bandwidth (BW);
4. the number of bits (2, 4, or 8).
5. the number of polarizations (1, 2, or full Stokes).

Some of the major features are:

1. The minimum sampling rate depends on the configuration and the computing power required. A typical value is 100 μs.
2. The max number of frequency channels is 8192.
3. File format is "CFITS".
4. The program to run DFB4 in this mode is "pdfb4" on the computer "pkccc4" ("pkccc4").

Main features are reported in Table 3. Configurations are of the type "srch_BW_CH" where BW is the bandwidth (MHz) and CH the number of frequency channels. See Table 6 for supported modes.

Table 3: **Pulsar Search Mode**

Backend	BW (max) [MHz]	BW (min) [MHz]	# pol	Stokes	# IF	channels (max)	file format
DFB4	1024	64	2	Full	1	8192	CFITS

2.5 Time-binning Mode

It is used for spectral line and continuum observations, especially when observations require scans or, more in general, sampling times of 2 sec or shorter. Spectra are integrated in time bins (sampling time). Data are dumped every time–cycle, which is a set of time-bins. Relevant configuration parameters are:

1. The time–cycle: 4-s or longer;
2. Number of time-bins in each time–cycle:
   - The minimum is 8;
   - The maximum depends on the configuration, but cannot exceed 2048 (e.g., with 4096 channels, the maximum number available is 32);
3. The number of frequency channels:
   - The minimum is 512
   - The maximum is 4096 for DFB4 for a bandwidth of 512 MHz or narrower (2048 for a BW of 1024 MHz);
4. The BW.
5. File format is "RPFITS".
6. The program to run DFB4 in this mode is "sdfb4" on the computer "pkccc4"

Main features of the *time-binning mode* are summarised in Table 4. Configurations are of the type "sdfbX_tbYY_BW_CH" where X = 4, YY is the number of time-bins, BW the bandwidth (MHz), and CH the number of frequency channels. See Table 7 for supported modes.

Table 4: **Time-Binning Mode**

Backend	BW (max) [MHz]	BW (min) [MHz]	# pol	Stokes	# IF	channels (max)	file format
DFB4	1024	8	2	Full	1	4096 (2048 at 1024 MHz)	RPFITS

2.6 Spectrometer Mode

It can be used for spectral line and continuum observations when sampling times of 4-s or longer are required. It is like the *time-binning mode* but with one time-bin a time–cycle. Relevant configuration parameters are:

1. the time–cycle: 4-s or longer;
2. the number of frequency channels:
   - The maximum is 8192 (each IF);
   - The minimum is 512.
3. the BW.
4. File format is "RPFITS".
5. The program to run DFB4 in this mode is "sdfb4" on the computer "pkccc4" ("pkccc4").

Main features are reported in Table 5. Configurations are of the type "sdfbX_BW_CH" where X = 4, BW the bandwidth (MHz), and CH the number of frequency channels. See Table 8 for supported modes.

Table 5: **Spectrometer Mode**

Backend	BW (max) [MHz]	BW (min) [MHz]	# pol	Stokes	# IF	channels (max)	file format
DFB4	1024	8	2	Full	1	8192	RPFITS

3 Supported Correlator Configurations

The configurations below are those currently supported. If your configuration is not listed, please contact Parkes Operations (parkes-operations[at]csiro.au).

Table 6: DFB4 Search modes

Name	Bands	Beams	Chans	BW	Products	nbins
srch_16_512	1	1	513	12	3	1
srch_64_512	1	1	513	64	3	1
srch_64_256	1	1	257	64	3	1
srch_256_512	1	1	513	256	3	1
srch_256_512_s	1	1	513	256	3	1
srch_256_1024	1	1	1025	256	3	1
srch_256_128	1	1	129	256	3	1
srch_512_512	1	1	513	512	3	1
srch_512_128	1	1	129	512	3	1
srch_1024_512	1	1	513	1024	3	1

Table 7: DFB4 Time-binning modes

Name	Bands	Beams	Chans	BW	Products	nbins

Table 8: DFB4 Spectrometer Modes

Name	Bands	Beams	Chans	BW	Products	nbins
sdfb4_8_8192_fqsw	1	1	8193	8	3	1
sdfb4_8_8192	1	1	8193	8	3	1
sdfb4_64_1024	1	1	1025	64	2	1
sdfb4_64_8192	1	1	8193	64	2	1
sdfb4_64_2048	1	1	2049	64	2	1
sdfb4_128_8192	1	1	8193	128	2	1
sdfb4_128_8192_fqsw	1	1	8193	128	2	1
sdfb4_128_1024	1	1	1025	128	2	1
sdfb4_tb16_256_128	1	1	129	256	3	16
sdfb4_256_8192	1	1	8193	256	2	1
sdfb4_256_1024	1	1	1025	256	2	1
sdfb4_tb16_256_512	1	1	513	256	3	16
sdfb4_tb16_1024_512_ncal	1	1	513	1024	3	16
sdfb4_1024_8192	1	1	8193	1024	2	1
sdfb4_tb16_1024_2048_ncal	1	1	2049	1024	3	16
sdfb4_tb16_1024_1024	1	1	1025	1024	3	16

Table 9: DFB4 Pulsar Fold modes

Name	Bands	Beams	Chans	BW	Products	nbins
pdfb4_256_64_1024	1	1	1025	64	3	256
pdfb4_512_64_1024	1	1	1025	64	3	512
pdfb4_128_64_512	1	1	513	64	3	128
pdfb4_512_64_512	1	1	513	64	3	512
pdfb4_128_64_1024	1	1	1025	64	3	128
pdfb4_256_64_512	1	1	513	64	3	256
pdfb4_512_128_1024	1	1	1025	128	3	512
pdfb4_512_128_512	1	1	513	128	3	512
pdfb4_512_128_2048	1	1	2049	128	3	512
pdfb4_512_256_1024	1	1	1025	256	3	512
pdfb4_256_256_1024	1	1	1025	256	3	256
pdfb4_512_256_512	1	1	513	256	3	512
pdfb4_512_256_2048	1	1	2049	256	3	512
pdfb4_256_256_512	1	1	513	256	3	256
pdfb4_256_256_2048	1	1	2049	256	3	256
pdfb4_512_512_512	1	1	513	512	3	512
pdfb4_512_512_2048	1	1	2049	512	3	512
pdfb4_512_512_1024	1	1	1025	512	3	512
pdfb4_512_1024_2048	1	1	2049	1024	3	512
pdfb4_512_1024_512	1	1	513	1024	3	512
pdfb4_256_1024_1024	1	1	1025	1024	3	256
pdfb4_512_1024_1024	1	1	1025	1024	3	512
pdfb4_256_1024_512	1	1	513	1024	3	256
pdfb4_256_1024_2048	1	1	2049	1024	3	256

4 HIPSR

The HI Parkes Swinburne Recorder (HIPSR) has been developed by a collaboration of: the Pulsar Group of the Swinburne University, Melbourne; ICRAR University of Western Australia, Perth; University of Oxford; CASS. HIPSR is a multibeam digital backend designed for pulsar searching and limited spectral–line modes; currently only the "wide-band" mode of 400MHz/8192 channels is available, with a "narrow-band" 200MHz/16k channel configurations. HIPSR is used in combination with the 13-beam 20 cm receiver array (MB20).

General background information can be found at the following link: HIPSR documentation

A PDF guide is availble on how to observe using the Multibeam receiver and HIPSR in 400 MHz/8192 chans spectral-line mode, with a focus on HI observations. It is available here.

HIPSR has limited support and is currently offered on a shared-risk basis. Enquiries about its use in proposals should be directed to Jimi Green (James.Green[at]csiro.au).

5 Other pulsar observation resources

More information on using Pulsar backends is available from the ATNF Pulsar site.

6 Starting Correlator GUIs

The GUI displays information about the configuration of the correlator (i.e. bandpass, number of channels etc.), integration cycle, name of the current data file and diagnostic information about the correlator activity. It is handy during observations for changing the configuration file and for checking whether or not a file is open. The DFB4 correlator and HIPSR GUIs are usually displayed on *joffrey:2*. If not present, for DFB4, open an xterm and type:

ssh pkccc4

For HIPSR, refer to documentation above. The login and password are available from staff. You start the relevant correlator program by typing the following:

pdfb4 (DFB4 in pulsar mode)

sdfb4 (DFB4 in spectral-line mode)

This will start a number of iconised xterms, CFG (CONFIG), CD (CORDAT) and XF (XFER), which you can ignore, plus the main correlator GUI. In the **State box**, the message:

Awaiting Connection

should be in yellow. From the xterm you started the program in you should also see the message:

SYNCCC: WAIT for CONNECTION from TCS .....

You are now in a position to start TCS. It is preferable that the DFD (HIPSR) GUI is up and running before TCS is started. If they should exit for any reason, you will need to exit from TCS and get the correlator GUI going again before restarting TCS. Once TCS has started, the **State box** should show: **Connected** In general you will not need to interact further with the correlator GUI. All the necessary control commands will be sent by TCS.

7 GUI description

This section describes some of the features of the GUI.

- **Cycle:** Shows the number of cycles per integration (one cycle = 4, 10, ... seconds).
- **State:** State of the correlator. Can be 'Awaiting Connection' or 'Connected'.
- **File:** Status of output (FITS) file. Can be 'OPEN' or 'CLOSED'.
- **Avg:** The number of cycles averaged before writing to file.

8 Configuring the Correlator

Occasionally you may need to manually reconfigure the correlator. This can be done by clicking the CONFIG button. This button is active only when a scan/track has stopped. The CONFIG xterm, which logs the progress of the reconfiguration, will appear briefly and display a 'bubble race', showing the configuration taking place.

9 Commands

On the bottom right hand corner, there is a **Command:** entry box where you can enter commands. Note that many of the possible commands do not have any meaning for the Parkes correlator. For completeness, a listing of these commands is available here. It should be noted not ALL commands will be compatible with ALL correlator GUIs.

10 Using the Correlator in Stand-Along Mode: Dummsy

By using the program 'DUMMSY', it is possible to bypass the dependency of TCS to display spectral information for a particular receiver. The DFB command starts all the essential processes, including the main GUI. However to actually run the correlator a client has to connect to it. This is usually TCS, but there is a simplified client on pkccc4 itself called 'dummsy', which can also be used. However the main correlator processes have to be running already before you start dummsy. There can also be only one client at a time, so starting a second copy of dummsy, or failing to kill TCS first will also cause errors.

To use dummsy, telnet to the relevant correlator computer (see Table **??**) and startup two xterms:

```
xterm &
xterm &
```

Now in one xterm, type the relevant command to start up the correlator GUI. In the other xterm, enter **dummsy**. The GUI will resize itself and the state will go from "Awaiting connection" (yellow) to just "STOPPED" (grey). Entering the "GO" command changes the state to "GO"

(grey). Commands are passed to the correlator via the '}' prompt (press the ENTER/RETURN key a few times until you see it). If you haven't done so already, you will also need to start up the SPD (Spectral Display) display (see the Online Programs section of the Parkes User Guide). Commands for using DUMMSY can be found here.

Note there is also a GUI for dummsy: tkdummsy (or tkds). Instead of passing commands on the command line, with tkds, commands are passed to the correlator via an entry widget at the bottom of the GUI labelled 'Command'.

11 Using SPD with DFB4

SPD displays data from the correlator, either in the frequency domain - the spectrum which results from the products of the Fourier transforms of the two polarization signals (DFB4 is an FX correlators), or in the time domain - all frquency channels in the selected range binned together and plotted versus the time bin within the last time cycle acquired (time-binning mode only). The user can select which of the products contained within the correlator configuration to display and in what form to display them. Go to *joffrey* (bourbon, before the remote observing era starts) and in an xterm, ssh to the appropriate machine (user "corr", passwd to be enquired to the project support):

Machine	Correlator
pkccc4	PDFB4/SDFB4

once in, at the prompt type: **spd**,

and then type the following (press <CR> after each):

```
/xs
sel *          (to plot all available spectra -- all polarizations, all IFs)
on aa, bb, ab  (to plot auto and cross-products)
bins x-y       (to plot spectra of bins x to y of a time-cycle)
ch LL HH       (to plot only channels LL to HH)
ch             (to plot all channels)
scale a XX YY  (to scale amplitude in the range XX YY)
scale a        (to auto-scale)
sel pp11       (to set time-domain plotting)
sel 11         (to set back to frequency-domain)
```

You won't get anything meaningful out of it until you start observing. Online documentation for SPD is available here. Other commands for both SPD and MBTP are available from sheets in the control room.

12 Troubleshooting

12.1 Block Control Computers

For reference, the location of each block control computer (bcc) is summarised below:

- l-bcc06 - block 6 Embedded within DFB3, on private network with pkccc3
- l-bcc11 - block 11, ditto

12.2 DFB4

12.2.1 GUI unresponsive or corrupt spectra

If you have issues getting DFB4 going, follow the procedures below.

1. Try reconfiguring the DFB (click CONFIG button on DFB GUI);
   Try this at least 2 times before moving to #2.
2. If #1 is not sufficient, quit and restart DFB GUI (pdfb4/sdfb4 according to the observing mode)
   Try this at least 2 times before moving to #3;
3. If #2 is not sufficient, use the bcckill and corkill procedures:
   - quit DFB GUI
   - type "bcckill"
   - type "corkill"
   - restart DFB GUI

   Try this at least 2 times before moving to #4
4. If #3 is not sufficient, reboot the l-bcc11 board:
   - quit DFB GUI
   - from two pkccc3/pkccc4 terminals (user corr), login us root
   - ssh root@l-bcc11 (passwd required)
   - on each of them, type "reboot"
   - wait 2 mins
   - type bcckill
   - type corkill
   - start DFB GUI

   Try this 2 times before moving to #5
5. If #4 has been unsuccessful, power cycle the DFB (very last resort!):
   - quit DFB GUI
   - power-cycle DFB
   - wait 2 minutes
   - reboot the l-bcc boards; see #4
   - type bcckill
   - type corkill
   - start DFB GUI