Connection to and control of the PC-EVN recorder

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1 Introduction

This document covers use of the VSIB connections and the control software. It describes the connectors and software which will allow recording of data and statistics, bandpass checking, and fringe checking for that data with 16 MHz or 64 MHz bands.

2 VSIB boards and module

Two Metsähovi boards are required for VLBI recording. VSIB, a VSI-H (VLBI Standard Interface, Hardware) compliant DMA card which allows data to be written to or read from the hard drives on the PC. The VSIC is a converter card for many legacy VLBI formats. The VSIC comes with a 50 to 40 way connector which drops many of the duplicate ground lines from the S2 format.

The VSIB module for linux is written by Ari Mujunen and is a character driver for Metsähovi VSIB I/O PCI board. It uses the **bigphysarea** patch to the linux kernel to ensure that there will be sufficient contiguous memory allocated for the card.

The **bigphysarea** is set, in units of 4k pages, at boot time. The usual way is to add this line to the lilo.conf (or whatever the boot controller uses).

> append="bigphysarea=36000"

This can be checked via the /proc/bigphysarea file. Then the module needs to be loaded. It is important to give the bigbufsize parameter as the default size is small (5MB) and quickly over-runs when used (which can be detected as regular zeros in the data file).

> insmod vsib.o bigbufsize=144000000

2.1 Current issues

Discussion is ongoing as to whether the **bigphysarea** patch can be bypassed, and whether it is worth doing.

3 Connectors

The primary data sampler for Australian telescopes will be the ATNF-DAS for the foreseeable future. The DAS has two inputs, IF1 and IF2, which are 64 MHz wide and centred on a $2 \times N + 1$ multiple of 32 MHz. Each of these are filtered and output by a Band Splitter unit (BS) and a Fine Tuner unit (FT). These provide bands of 16-, 8-, or 4-MHz on a 50-way ECL connector designed for the S2. The DAS can also provides the same outputs to the autocorrelators, both AT and MB. The most common modes of operation are;

VSOP	Two contiguous 16MHz bands either side of the band centre
MP16S	16 MHz at the band centre from each input
MPXS	X MHz at the band centre from each input

If we wish to run in parallel with the S2, i.e. in a fringe checker mode, we can sample the data from the output of the S2 formatter feed-through port: C2a. The output is not the same as the input, but a trivial reordering of the pins achieves this. Figure 1a shows the pin connections, and Figure 1b shows the board, known as the BG2 connector. The format selection is via the usual VLBI setup.

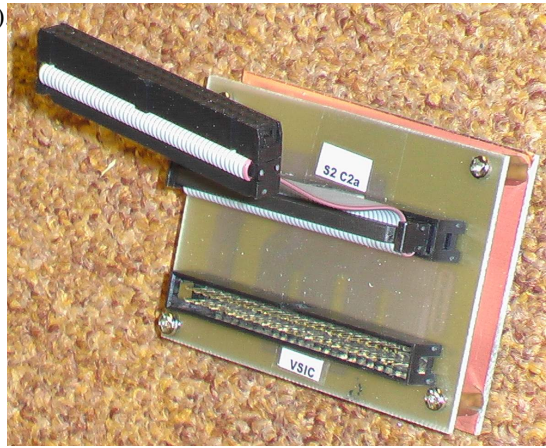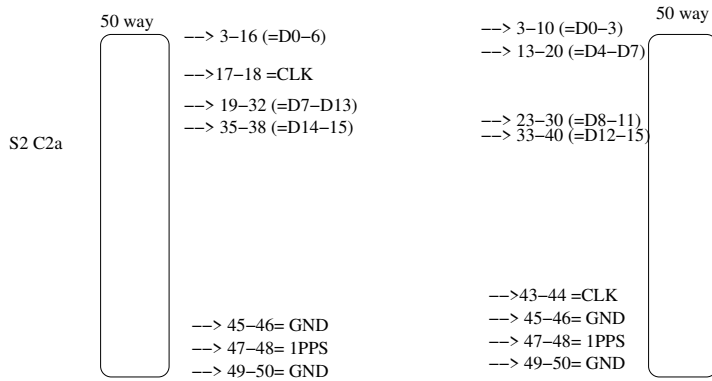Connect the S2 C2a to the PC–EVN recorder (via VSI–C)
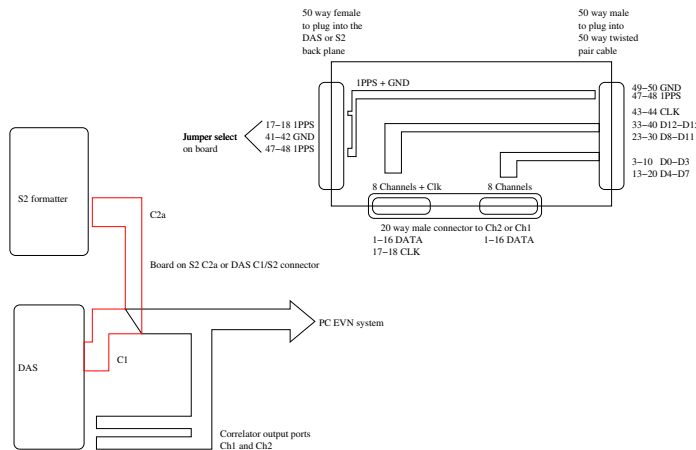

Figure 1: BG2 connector: Layout and picture

Figure 2: BG3 connector: Layout and picture

If we wish to replace the S2 with the PC-EVN we can connect the DAS directly to the VSIC using the S2 cable (C1). This will provide eight bit streams to the PC-EVN, two each from each of the BS and FT units. The format selection is via the usual VLBI setup.

If we wish to record the full input to the DAS we can connect the DAS to the VSIC using the BG3 connector. This can be run in parallel to the S2 and replaces the ATNF multibeam correlator. Figure 2a shows the pin and port connections, and Figure 2b shows the board. The 1PPS comes from either S2-C2a or the DAS-S2 ports. The data and clocks are read from the two DAS correlator ports, which can be programmed to write in the old AT or sign magnitude MB formats. The latter is required (parameter 75 set to 1). See Figure 3 for the DAS setting. Digital filtering can be applied to this data, but to achieve the maximum bandpass the unfiltered, raw digitised output (64-MHz bandwidth and 2 bit sampled) should be selected. Options are;

CORR bandpass	filter (parameter 76)	comments
64-MHz 2 bits	5	
32-MHz 2 bit	4	Also available via S2
2×16MHz 2 bit	3	A very flexible mode
..	..	..

Both of these modes require the VSIC to be set to mode 1110 (reading left to right). Other VSIC modes of interest are the VSI-H test mode (0111) and the countdown test mode (0110).

3.1 Current issues

The DAS limits us to 512 MBps. Whilst 1024 Mbps is not possible with the VSIB (as it would overload the PCI and IDE bus) it is possible to run at greater than 512 Mbps. Do we wish to take this very non-standard route? The MAXIM AD cards will provide up to 50 MHz of band pass at 10 bits. With 'smart' IO cards to select the

```
Profile:  LBA_DAS.PRO   S 2 - R E C . P O R T   I F   P R O C .  1   (V3.1)

<70> BAND WIDTH SELECT          : 0

        ( 0: BW<=16MHz 2x2Bit DATA, selectable via <71> & <72> )
        ( 1: BW= 32MHz 2x2Bit DATA BSB                         )
        ( 2: BW= 64MHz 4x1Bit SIGN BSB, unprocessed data       )
        ( 3: TEST ONLY 4x1Bit MAGN BSB, unprocessed data       )

<71> S2_IN0 & S2_IN1 SOURCE     : 1     <73> S2_IN0 & S2_IN1 FORMAT     : 1
<72> S2_IN2 & S2_IN3 SOURCE     : 0     <74> S2_IN2 & S2_IN3 FORMAT     : 1
( 0:X-BS, 1:Y-BS, 2:X-FT, 3:Y-FT )          ( 0:AT, 1:VLBA )


        C O R R E L A T O R   P O R T   I F  P R O C E S S O R  1

<75> CORRELATOR FORMAT          : 1
( 0:AT-CORR, 1:MB-CORR )

<76> MB/AT-CORR DATA SOURCE     : 5     <79> MB-CORR DATA  2.SOURCE     : 0
( 0:X-BS, 1:Y-BS, 2:X-FT, 3:Y-FT )     ( 0:X-BS, 1:Y-BS, 2:X-FT, 3:Y-FT )
( 4:32MHz-BS, 5:64MHz-BS )

<77> AT-CORR DATA ADJUST        : 0     ( 0, 1, 2, 3 CLK-Cycles Delay )
        <S> = SETUP, <ENTER> = NEXT SCEEN, <ADDR> = CHANGE VALUE : []
```

S2 RECORDER PORT:	IF Processor One	IF Processor Two
Bandwidth:	BW=64MHz 4x1Bit Sign BS, unprocessed data	BW=64MHz 4x1Bit Sign BS, unprocessed data
S2_IN0 & S2_IN1 Source:	Y-BS	Y-BS
S2_IN2 & S2_IN3 Source:	X-BS	X-BS
S2_IN0 & S2_IN1 Format:	VLBA	VLBA
S2_IN2 & S2_IN3 Format:	VLBA	VLBA
CORRELATOR PORT:		
Correlator Format:	Multibeam Correlator	Multibeam Correlator
MultiBeam/AT Corr Data Source:	64MHz-BS	64MHz-BS
Multibeam Corr Data 2nd Source:	X-BS	X-BS
AT Correrlator Data Adjust:	3 Clock-Cycles Delay	3 Clock-Cycles Delay

Done

Figure 3: The required DAS setting for 64 MHz bandwidth recording

3

best bits we could run at any combination of speeds and bandpasses (within the VSIB limitations). The bandpass formation would need to be before the AD card. One option would be 12 16-MHz bandpasses. In this mode the ATNF multibeam correlator can not be run, but the PC-EVN could be run as a replacement for this, as it has all the necessary data.

The narrower DAS outputs have not been carefully considered for useful operation, but should be straight forward as the same number of bits are supplied with a reduced clock speed.

4 Recording

The recording programme is based on the one provided by Metsähovi: **wr**. The flags as follows and the input (or output) should be the the vsib character device, e.g,

> wr -r 32 -t 3600s -o /i1/t/file_%03d.dat < /dev/vsib

-r N,	the recording rate in MB/s. Defaults to 32
-t N[s],	the recording amount, if in seconds rate should be given
-b N,	size of one block in bytes, default is 32,000
-f N,	the number of blocks per file, default is 10,000
-o s,	the filename, with standard formating commands
-c s,	the compacting mode
-m N,	the recording mode
-l	loop the recording endlessly
-h	usage message
-v	verbose mode

The VSIB has 13 record modes, of which the first five are fully documented. These four are;

- mode 0 all 32 bits read, i.e. four words

- mode 1 the even bits read into two words

- mode 2 the lower 16 bit read into two words

- mode 3 the lower 8 bits read into one word.

- mode 4 the lower 8 even bits read into one word.

The other modes are autocorrelation, test and VLBA modes. These are unlikely to be useful because we can sub-select the bits required in software unless we are overclocking the data. See wr.c for discussion of them.

The adapted version of wr adds a header;

- Header style 0.1 was a 16 character time stamp.

- Header style 0.9 is the same 16 time stamp, and a 800 char free format description. It is based on the gico header, which is VSI-E compliant. This should include at the beginning **$HEAD_SIZE %d**.

- Header style 1.0 will drop the 16 bit timestamp (as it is included in the header).

The items defined in the header are;

$HEAD_SIZE	%d
$EXP_BMODE	%d
$START	%8d:%2d?%2d?%2d
$EXP_CODE	%s
$EXP_MODE	%s
$SOURCE_NAME	%s
$SOURCE_RA	%d:%d:%f
$SOURCE_DEC	%d:%d:%f
$STATION_NAME	%s
$STATION_POSITION	%g %g %g
$STATION_CLOCK	%g %g ...
$FREQUENCY_CH00	%g
$OTHER	%s

All are passed as strings, but parsing will need to take account of the nature of the information, i.e. three exponential values for the position, a single integer for the header size, any number values for the clock polynomial, any format for the time or position strings.

A subroutine **read_head** will be prepared to do all these tasks. Currently it handles any of the header standards, and extracts the time from that.

The data are written with bit stream D0 on the least significant bit (LSB), and so on for as many bits are read (i.e., depending on the mode, 1,2,4,8,16 or 32). With offset binary format, i.e. VLBA statistics mode on the DAS the value can be read as the integer value is the unsigned character value logically ANDed with 0x1,0x3 or 0xF for 1,2 or 4 bit numbers, less 2 to the power of the number of bits less one. That is, for 2 bit numbers, in C, data=c&0x3-2. If full digital sampling correction is not performed the two bits are usually mapped as 1,-1,3,-3 for ATNF statistics, and 3,-1,1,-3 for VLBA.

wr can also write a subset of the data input, this feature is primarily for use with the parallel S2 observations, collected from the S2 formatter C2a port. The output here corresponds to the S2 mode, **32x4-2** or **32a4-2** or other. In these cases the data is either first 4 channels (UIC 0 to 3) or the first two and skip two (UIC 0,1 and 4,5). **wr** band selection can be any of the pairs of bit streams, and is referred to in the same way as vsipack. Mode "ooxx" selects the first four bitstreams and "oxox" the odd ones. These two modes match the S2 modes **32x4-2** and **32a4-2**.

The header values can be set via **control_wr**, which also stops, pauses and starts the recording. These are transferred via a shared memory segment.

4.1 Current issues

Full compliance to VSI-E standards would be an obvious approach, but as the Swinburne baseband library is being used conforming to their header style also makes sense. A final choice is yet to be made, but an additional header routine will probably be added to the bandband libraries. Digital filters could be included.
read_head is a work in progress.

5 Monitoring the data

Obviously monitoring the data quality is an important task as collecting it. Two programs have been written for this: **maxim_stats** for offset binary data: two, four or eight bits in length and **make_cross_fft** a XF correlator for VLBI data.

At a station **make_cross_fft** is run in autocorrelation mode, where it checks for the presence of the 1PPS, calculates the statistics for the results (17%,33%,33%,17% for a perfectly sampled Gaussian noise dataset). It can also calculate the lag spectra, and plot these as lag amplitude, real or imaginary, and bandpass amplitude or phase. With the delay information it is also a simple cross correlator, which requires no extra or special libraries. A configuration file example.

```
0.1 0 1 512 1600 J1037-2934.DELAY 1 0
#nsec refant IFno nchan freq delayfile record_mode bit_type
PKS /mnt/cdrom/pks-bpass-mode3-000 2 0
#Station file_name delay_column offset_usec
CAT /mnt/cdrom/cat-bpass-mode3-000 6 0
```

The program is run as
> make_cross_fft configure.file h:m:s [pgplot_device type]
Types are a,r,i,b,p for lag amplitude, real and imaginary, bandpass amplitude and phase. Figure 4 shows the statistics for a BG2 recording (when the data from IF2 are all held high) and the bandpass for IF1.

5.1 Current issues

make_cross_fft does not have a 64 MHz option as yet, and assumes the bandpasses are 16 MHz wide. It can run as real time correlator, with one 2-GHz CPU per product. It has also been demonstrated as a fringe checker. It can be run in correlate-rotate mode, or vice versa. Only narrow band multichannel (spectral line) VLBI observations require the slower rotate-correlate mode. A FX version has been written but further development depends on demand.
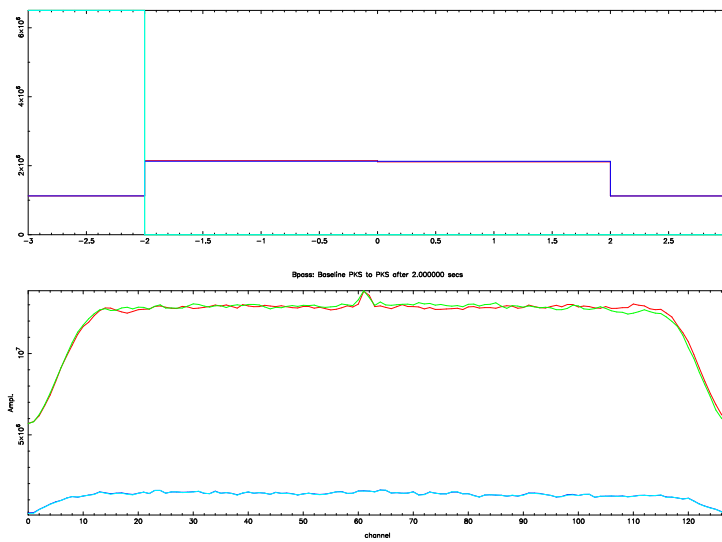
Figure 4: Autocorrelation output from make_cross_fft, showing the statistics distribution, and the bandpass for all four stokes.