Spex Software User's Guide
for
BigDog and GuideDog's
IC & XUI applications

Volume Two
Software Concepts and Supplemental Information

1. CAMMODE – The Camera Mode Explained

This section provide a brief description of the camera mode provide by BigDog and GuideDog.

1.1 Sim – Simulation Mode

Simulation mode does not acquire data from the array, but simulates data acquisition by reading and displaying an image from disk. This mode is provided as teaching or demonstration mode, as the spex software can be compiled/run on a generic workstation. The functionality is similar to basic mode. This mode is available on both BigDog and GuideDog.

1. 2 Basic – The Basic camera mode

Basic Mode is the simplest camera mode: just setup you parameter, hit GO, and a FITS image is taken. No special post-processing or setup needed.

Basic Mode Characteristics:

Basic mode is available on BigDog and GuideDog.
General Purpose camera mode for taking images.

1. 3 SlowGuide – GuideDog's Slow Guiding Mode

The GuideDog Slow Guiding mode continuously acquires an image, transfer this images to the SPARC host, and a guiding algorithm is applied to detect an offset. These offsets can be transmitted to the TCS to correct telescope positioning.

SlowGuide characteristics:

SlowGuide is available only on GuideDog.
Correction rates are on the order of many seconds to minutes.
Images can be view and save while this mode is in operation.

1.4 FastGuide – GuideDog's Fast Guiding Mode

The GuideDog Fast provides high-speed centroid corrections. The DSP array controller acquires and applies a centroid algorithm to images in order to calculate an offset. These offsets can be used to provide high frequency correction to the telescope. Because it is optimized for high speed, the images are not transfer from the DSP to the workstation, and therefore cannot be view or save.

Fast Guide characteristics:

FastGuide is available only on GuideDog.
Correction rates are calculated at a high frequency.
Images cannot be view / save while corrections are done.

1. 5 MovieMode – BigDog & GuideDog's Movie Mode.

The movie modes are designed to take a series of sub-array images and record them to disk. This mode is intended for occultation-type events where you wish to record a continuous stream of images, and minimize the gaps between images. It works by packing a series of frames in the DSP RAM and storing these frames as 3D FITS images. Because of size of the DSP RAM is limited, this mode works better using sub-array (not full frame) images. Large images fill up the buffer too quickly, and the SPARC host is unable to keep up.

MovieMode characteristics:

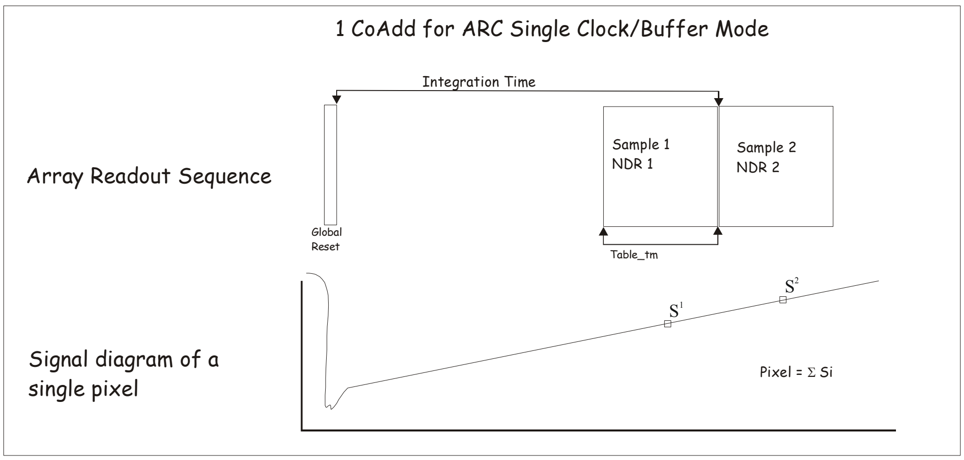
Movie mode is available on BigDog (as BigMovie) and GuideDog (as GuideMovie).
For BigMovie, only data from quadrant 2 is recorded.

2. CBMODE – The Clock/Buffer Modes Explained

The Clocking/Buffer Mode or CBMode controls how readouts from infrared device are used to create a single image. The different modes are ARC_S, ARC_D, and PRC_PS. The CBMode option indicates how or when each pixel is clocked out, a reset or convert lines are toggled, or how each A/D sample is used to construct and individual images referred to as Coadds.
For the Aladdin devices individual pixel cannot be reset. Resetting the pixel well can only be performed by: (1) globally resetting the entire array, or (2) resetting a row pair.

2. 1 ARC S - Array Reset Clocking Single Samples

In ARC_S, a coadd is produced by Globally Resetting the array. Then after a time interval has elapsed, the array is clocked out to obtain sample values. Note that the sampled image can be made up of individual NDR frames. The figure below illustrated a ARC_S with 2 ndr.

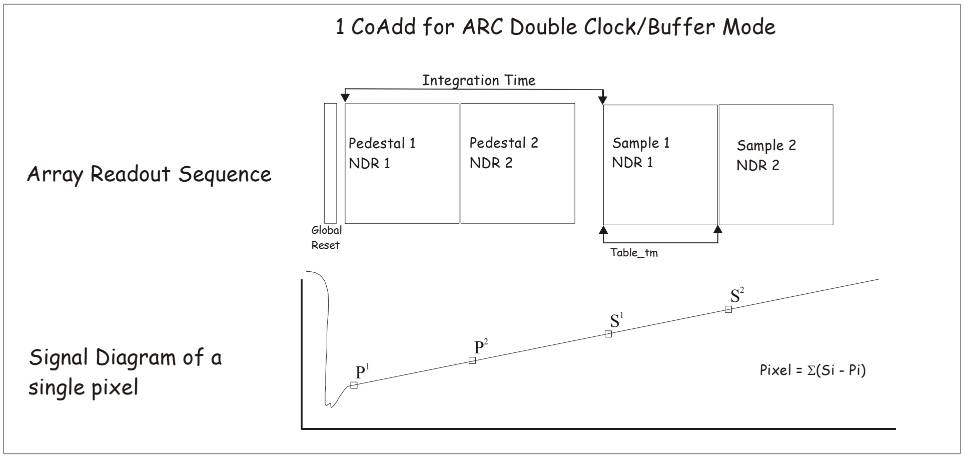


Minimum itime for ARC_S:

if
table_tm = time to clockout array,
then
min integration itime is (table_tm*ndr)/2

2.2 ARC_D - Array Reset Clocking Double Samples.

In ARC_D, a coadd is produced by Globally Resetting the array. Then the array is clocked out to obtain the pedestal values. After a time interval has elapsed, the array is clocked out to obtain the sample values. The coadd image is produced by subtracting the Pedestal from the Samples. Note that the Pedestal and Samples can be made up from 1 to many NDR readouts. The figure below illustrates ARC_D with 2 ndrs.



Minimum itime for ARC_D:

if
table_tm = time to clockout array,
then
min integration itime is (table_tm*ndr)

2.3 CDS_PS - Correlated Double Samples, Pedestal - Sample

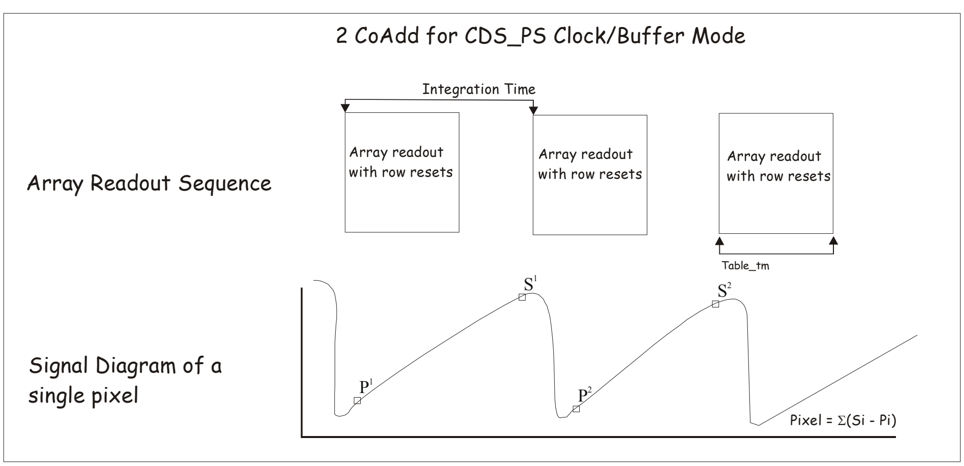
In CDS_PS, a coadd is produced by subtracting the sampled converts from the pedestal converts from the previous array readout. The integration time is the interval between the pedestal and sample.

When reading out the array, the software:

1. Addresses row 1 and reads the sampled values of all the pixels in the row.
2. Addresses row 2 and reads the sampled values of all the pixels in the row.
3. Resets the row-pair.
4. Addresses row 1 and reads the sampled values of all the pixels in the row.
5. Addresses row 2 and reads the sampled values of all the pixels in the row.
6. Goes on to the next row pair.

NDR are not supported.

The figure below illustrates CDS_PS with 2 coadd.



Minimum itime for CDS_PS:

if

table_tm = time to clockout array,

then

min integration itime is (table_tm)

3. BBMODE - The BufferBoard Mode Explained

3.1 General Description

BBModes, or Buffer Board Modes, is a parameter describing the hardware configuration of the array electronics. Bbmode describe the hardware configuration of the acquisition electronic. The IRTF electronic engineer configures the Spex array electronics. The bbmode is usually a fixed parameter in the software, not changeable by the user. This section briefly describes each bbmode.

The quadrant layout of the sensor array is

Q1	Q2
Q3	Q4

The pixel ordering for each quadrant starts from the outer corners. The x-axis increments towards the center and the y-axis increment toward the center.

3.2 BBMODE_S32

S32 is short for Single Fiber, 32 words per channel. This is a 1 fiber up (clock), 1 fiber down (pixel data) configuration for a 4-quadrant (1024x1024) device.

The fiber board delivers the data to the buffer DSP in the following sequence. The notation is Q.P, so 1.2 is quadrant #1, pixel #2. The following table shows the pixel order of the 1st convert sequence. Each table entry represents a word read from the FIFO, and each word contains 2 pixel values (2 16-bits words).

The first convert will deliver these 16 words (32 packed pixels).

(1.1)(3.1)	(1.2)(3.2)	(1.3)(3.3)	…	(1.8)(3.8)
(2.1)(4.1)	(2.2)(4.2)	(2.3)(4.3)	…	(2.8)(4.8)

The next convert will deliver:

(1.9)(3.9)	(1.10)(3.10)	(1.11)(3.11)	…	(1.16)(3.16)
(2.9)(4.9)	(2.10)(4.10)	(2.11)(4.11)	…	(2.16)(4.16)

And so on.

The number_of_pixel in a full image is quad_wid * quad_hgt * 4.
The number of convert need to sample the pixels are number_of_pixels / 32.
Each fiber link delivers 16 words per convert (32 pixel).

3.3 BBMODE_D16

D16 is short for Duel Fiber, 16 words per channel. This is a 1 fiber up (clock), 2 fiber down (pixel data) configuration for a 4-quadrant (1024x1024) device. This mode is improves the S32 mode by splitting the pixel data stream in two. Now each buffer DSP only processes half the amount of data. This speeds up the clocking significantly over the S32 mode.

The fiber board delivers the data to the buffer DSP in the following sequence. The notation is Q.P, so 1.2 is quadrant #1, pixel #2. The following table shows the pixel order of the 1st convert sequence. Each table entry represents a word read from the FIFO, and each word contains 2 pixel values (2 16-bits words). This table illustrates the Buffer Fiber channel #1.

The first convert will deliver these 8 words (16 packed pixels).

(1.1)(2.1)	(1.2)(2.2)	(1.3)(2.3)	…	(1.8)(2.8)

The next convert will deliver:

(1.9)(2.9)	(1.10)(2.10)	(1.11)(2.11)	…	(1.12)(2.12)

And so on.

The 2nd Buffer DSP channel delivers data from quadrant #3 and #4.

The number_of_pixel in a full image is quad_wid * quad_hgt * 4.
The number of convert need to sample the pixels are number_of_pixels / 32.
Each fiber link delivers 8 words per convert (16 pixel).

3.4 BBMODE_S8

S8 is short for Single Fiber, 8 words per channel. This is a 1 fiber up (clock), 2 fiber down (pixel data) configuration for a 1-quadrant (512x512) device. Only data from a single quadrant is sampled.

The fiber board delivers the data to the buffer DSP in the following sequence. The notation is Q.P, so 1.2 is quadrant #1, pixel #2. The following table shows the pixel order of the 1st convert sequence. Each table entry represents a word read from the FIFO, and each word contains 2 pixel values (2 16-bits words). This table illustrates the Buffer Fiber channel #1.

The first convert will deliver these 8 words (16 packed pixels).

(1.1)(1.2)	(1.3)(1.4)	(1.5)(1.6)	(1.7)(1.8)

The next convert will deliver:

(1.9)(1.10)	(1.11)(1.12	(1.13)(1.14)	(1.15)(1.16)

And so on.

The number_of_pixel in a full image is quad_wid * quad_hgt.
The number of convert need to sample the pixels are number_of_pixels / 8.
Each fiber link delivers 4 words per convert (8 pixel).

4. GPS Time Stamp and Array Timing Information

4.1 General Description

The Instrument Control application time stamps each FITS file by reading the host computer's time when the GO command is transmitted to the DSP. This time is recorded in the FITS header using the DATE_OBS ('dd/mm/yy') and TIME_OBS ('hh:mm.ss.ss') FITS keyword. This time stamp is in Universal Time (UT). Because the host computer uses the Network Time Protocol (NTP) software to synchronize its system clock, this time stamp should be accurate to about 200 milliseconds.

For more precise timing of the array readouts, the DSPs can read the time from a timer board installed in the system. The board is the TPRO-VME from KSI/Odetics. The TPRO-VME maintains its time synchronization from a time code signal (IRIG-B) transmitted from the telescope facility's Global Positioning Satellite (GPS) system receiver. To enable GPS time stamps during data acquisition, the GPSTime parameter should be set to ON. Review this option on the XUI's setup page

The TPRO-VME drives a LED display on its VME faceplate. These LED display the Julian day, hour minutes and seconds (JJJHHMMSS) in maintained by its onboard clock. For example, if the LED display 032061525, the date/time is Julian 32 or February 1st 06:15:25 (Hawaii Standard Time). Just below the coax cable input for the IRIG-B signal, a RED and GREEN LED display the condition of the synchronization signal from the GPS receiver. They provide a visual check to insure the accuracy of the time maintained by TPRO-VME. The TPRO-VME's time stamp is recorded in the FITS header using the TIME_GPS keyword. Here is an example:

```
TIME_GPS=        '20.42.024293' / UT TIMESTAMP from GPS ('mm.ss.usec')
```

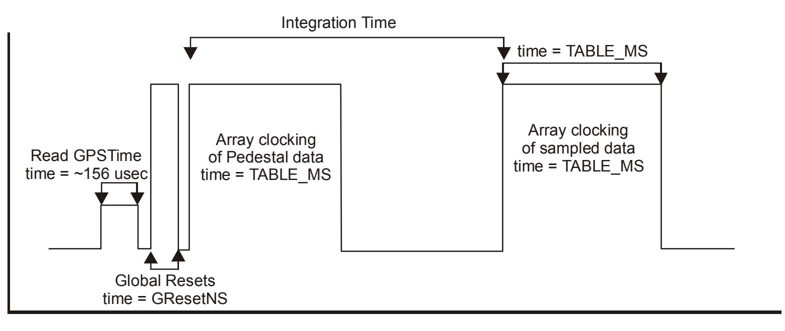
When sync to the GPS receiver the TPRO display local time. This is because the GPS receiver is used as the time source for the TCS, and the TCS only accept HST as its input. You can check the synchronization between the unix and the TPRO by running the 'current/ic/tproShowTime' command on bigdog or guidedog. Here is an illustration:

```
bigdog:/home/bigdog 1> current/ic/tproShowTime
This program does the following:
   1. Reads the UNIX time.
   2. Reads the GPS time.
Then prints this information to the screen.

 Unix UT: yday=303 10/30 19:34:05.315177 local: yday=303 10/30 09:34:05.315177
  GPS UT: yday=303 10/30 19:34:05.320637 local: yday=303 10/30 09:34:05.320637
```

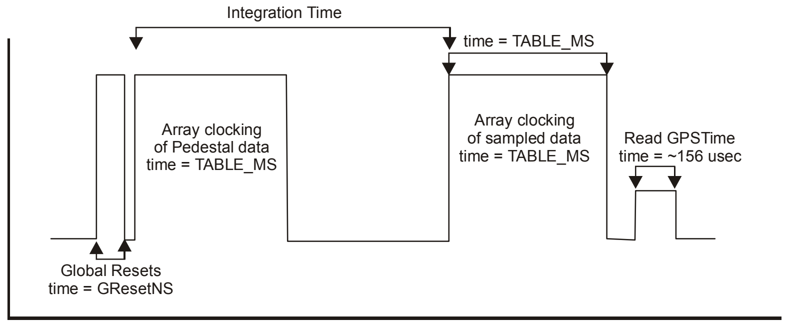
4.2 TIME_GPS timing information.

In Basic, Movie, and Slowguide modes, the clock DSP reads the GPS time information just before the 1st global reset of GO cycle. This time stamp is place in the FIT header associated with the TIME_GPS keyword. The following diagram illustrates the timing.



4.3 CAMMODE Movie Movie (BigMovie & GuideMovie) timing information.

For both the BigMovie and GuideMovie modes, each image of the movie is time stamp. The buffer DSP reads the GPS time information just after the last pixel is sampled for each movie frame. The following diagram illustrates the timing for this mode.



4.4 DSP Timing Information

The time to clock out the device is represented by the TABLE_MS keyword in the FITS header. It is possible to determine when particular pixels are addressed within this clocking sequence to better than a microsecond resolution. In the XUI's setup screen there is a toggle call DSP Output Timing. When selected, the IC produces a text file containing detailed timing information. This text files will have a name such as, *DSPTiming_0001.txt*. These file will be produced in your data directory. The numeric part of the filename should correspond to the image_number of your data files. To use this feature:

Turn Autosave ON
Turn DSP Output Timing ON

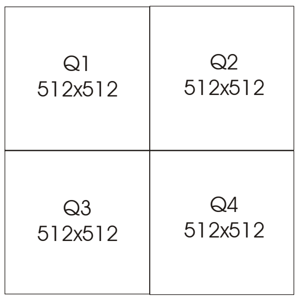
Now anytime a new clock table that affect the DSP timing is loaded, a DSPTiming_9999.txt file is produced. Note, it is not produced on every GO, just when the a new clocking table is load (and the timing information changes).

The format of the text file requires some understanding of the array and spex's clocking algorithms. If you wish to obtain this timing data, please consult with your IRTF support scientist. He will connect you with the application programmer supporting spex. They will advise you on the best method for collecting these files and how to obtain the desired timing information.

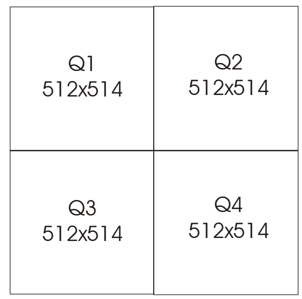
5. Software Issues resulting from the SBRC-206 Muliplexers.

The Aladdin 2 (SBRC-152) 1024x1024 arrays are composed of four 512x512 Array. Each 512x512 are refereed to as quadrant on the 1024x1024 device. The improved Aladdin 3 (SBRC-206) multiplexes are not completely compatible with the 152-multiplexers.

The 206-mux modification essentially cuts the last row-pair from the lower quad (Q3/Q4) and attaches it to the upper quadrant.
An additional row-pair shift register was added to address these 'new' rows. So the 206 device 'looks' like four 512x514 device (1024x1028).



SBRC-152 Format.



SBRC-206 Format.

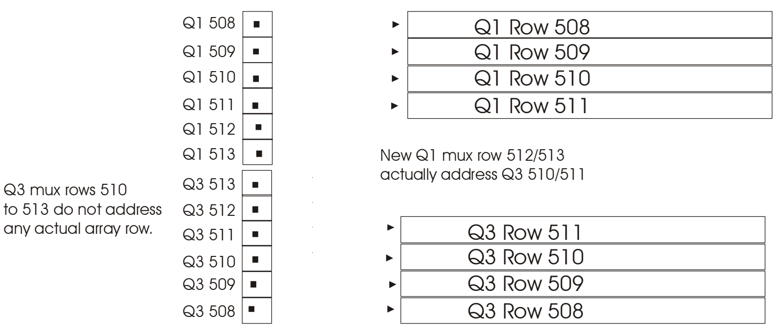


Illustration of 206 Modifications

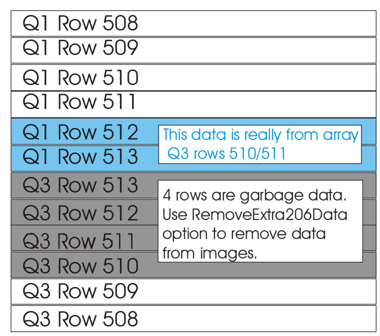


Illustration of sampled pixel data.

The data from the new rows on Q1/Q2 (rows 512/513) are actually obtained from rows 510/511 from the Q3/Q4. The data from rows 510/511/512/513 on Q2/Q3 are garbage. These 4 dummy rows should be removed from the final image to maintain the spacial relationship between pixels.

BigDog uses the SBRC-206 device.
GuideDog uses the SBRC-152 device.

6. Bigdogio and Guidedogio

Installed on all the IRTF suns is a program that performs a single command/reply sequence to both bigdog and guidedog's IC. This program is intended to be used for applications that need to communicate with the spex IC. Rather than building the network protocol into your application, you can issue a system command.

A string is returned by the io application indicating the result of the command. If there was no error, a "OK" is return.
If the requested command returned an error, the string "ERR %d %s" is returned. %d is a negative integer representing the error code. %s is a descriptive string of the error code.

'ERR -12 unable to execute, object is busy' is a busy error. This error is normally cleared when an operation is completed: A GO is completed, or a motor move is completed. Any other error indicated a failure with the instrument and user intervention is usually required.

SYNOPSIS

```
Bigdogio [ -h hostname] [-v] string
Guidedogio [-h hostname] [-v] string
```

OPTIONS

-h hostname – specify the hostname running the IC. The default hostname should normally be used.

-v – the io prints verbose message.

EXAMPLE

```
> bigdogio go
OK
> bigdogio isready
ERR -12 unable to execute, object is busy
> bigdogio isready
OK
```