

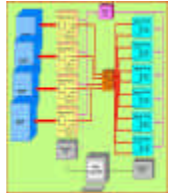
Using S2 VLBI system

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S2 Geodetic Components

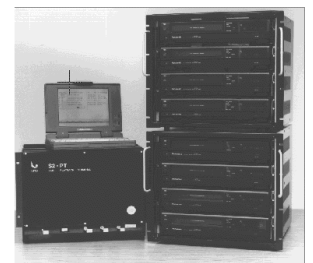
S2 Correlator

- Developed at DRAO with funding from Canadian Space Agency (CSA) to support Space VLBI.
- In operation for more than 6 years.
- 6 station configuration (expandable to 10+).
- Using 6 playback terminals (S2-PT).
- Design to handle S2 frequency-switched bandwidth synthesis data for geodesy.
- Extensive Data Quality Analysis.



S2 Recording terminal (S2-RT)

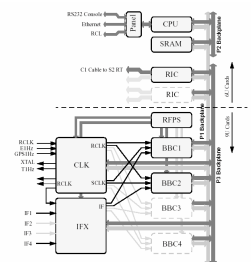
- Utilize commercial video recording (VCR) technology
- Recording at 128Mbits/sec in LP (4hours) and SLP (6hours) modes.
- Data, Signal and Control Module (DSCM)
- 2 Transport Array Modules (TAMs).
- Power On Self Test.
- Monitoring and Control via Console or Ethernet.
- Internal log file. Batch file mode. Default file.
- Supported by PCFS.



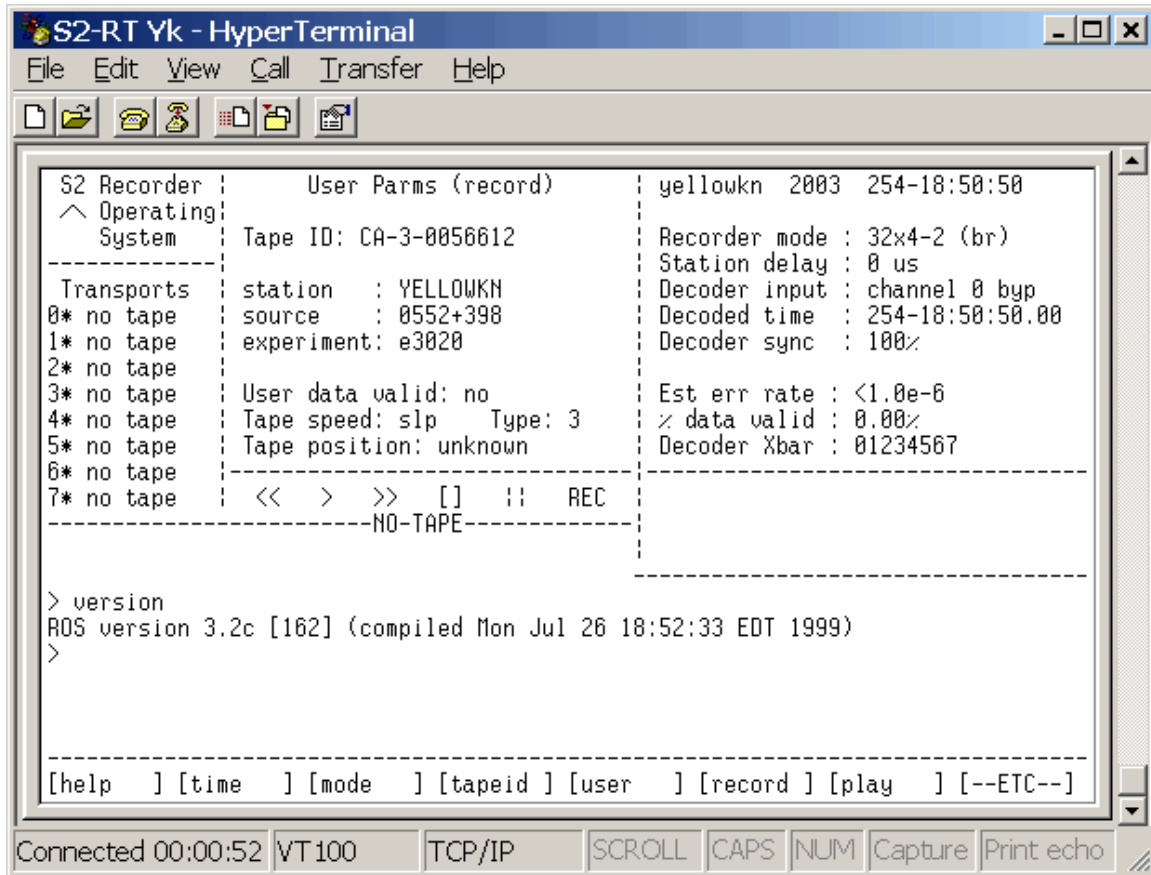
S2 Record/Playback System

S2 Data Acquisition System (S2-DAS)

- Utilize Frequency Switching (FS) method to do bandwidth synthesis.
- 2 BBC boards (100Mhz to 1000Mhz). Tone detectors.
- IFX board.
- CLK board.
- Power On Self test
- Monitoring and Control via Console or Ethernet.
- Internal log file. Batch file mode. Default file.
- Supported by un-official version of PCFS.



S2-RT Console



1. Interaction window. (bottom) (4.2.2)¹
User input and information, soft-keys.
2. Crucial Parms window. (top-right) (4.2.8.1)
Time, mode, decoder, Error rate.
3. Transport window. (middle-left) (4.2.8.5)
Transport related parameters. Time, Lock, Temp, position, AGC...
4. Tape motion state window. (middle) (4.2.8.4)
Overall tape motion states : <<, >, >>, [], ||, REC
5. User Parms window. (upper-middle) (4.2.8.3)
Tape information: ID, type, recording speed and tape position.
Session information: Schedule, source and station names.
User data valid flag (PCFS: data_valid=on)
6. Status window. (middle-right) (4.2.8.2)
Messages summarizing health of the system.
7. Activity Indicator window. (top-left)

¹ S2-RT User's Manual Version 3.2 (162), August 1998

S2-DAS Console

The screenshot shows a HyperTerminal window titled "S2-DAS Ottawa - HyperTerminal". The window contains a text-based interface for the S2-DAS system. The main display area is divided into several sections:

- Top-left:** System status and configuration parameters.

System	#	LO	BW	GAIN	TPI
1U		324.990	16	+9.29	44634
1L			16	+6.70	42733
2U		219.990	16	+11.09	38174
2L			16	+7.22	33443
- Top-right:** Date and time: 2003 254-18:46:25.
- Middle-right:** Station and delay parameters.

DAS mode:	32x4-2-U
Auto Gain Control:	on
Encoding:	ULBA
Station Delay :	0.00 ns
*Wavefront Delay:	0.00 ns
GPS Delay :	[no GPS1Hz]
- Bottom-left:** Source parameters.

Src:	BBC#	1	2
IN	IF4	IF4	
SRC	DIR/14	DIR/14	
IFTP	36171	36171	

Below the main display area, there is a command prompt showing the output of the "version" command: "DASOS version 1.0d (compiled Tue Dec 11 19:53:11 EST 2001)". At the bottom of the window, there is a status bar with various controls: "Connected 00:37:17 VT100 TCP/IP SCROLL CAPS NUM Capture Print echo".

1. Interaction window (bottom) (3.3.2)²
User input and information, soft-keys.
2. Crucial Params window. (top-right) (3.7.1)
Time, mode, agc, encoding, delays.
3. Frequency switching window. (middle-left) (3.7.6)
FS sequence, states.
4. User Params window. (upper-middle)
BBC/IFX (3.7.3).
Tonedetect (3.7.4).
5. Status window. (middle-right) (3.7.2)
Messages summarizing health of the system.
6. Activity Indicator window. (top-left)

² S2 DAS User's Manual Version 1.1 / Nov 28, 2002

Frequency Switching

On the Mk3, Mk4 systems, 14 BBCs are used to sample the entire IF signal. Normally, 8 channels are dedicated to X band and 6 to S band. The S2-DAS has only 2 BBCs. Frequency switching is required to sample the IF signal at many frequencies. At regular intervals (1 sec), the BBCs are rapidly re-tuned at different frequencies. 2 BBCs are used to reduce hardware biases. Frequency switching can be done with only 1 BBC.

A frequency switching sequence is a series of separate states that optimally sample the IF signal at separate times.

Considerations:

1. No limit to # of states but requires integral # of cycles/day and cycles/scan.
2. Losing data (1ms) when switching frequencies.
3. Losing data (up to 20ms) due to geometrical delay.
4. S and X data are not simultaneous creating bias in ionospheric correction.
5. Faster switching reduces bias due to changes in the ionosphere.
6. Slower switching reduces data losses due to switching (1ms) and clock misalignment (~20ms).
7. Faster switching requires delay tracking model (not implemented).
8. Frequency switching rate of 1Hz has been selected for our Geodetic Observation. Correlator data blanking between switches has been set to 30ms, a 1.5% loss in SNR.

Notes:

During frequency switching, data in user parms window are switching to reflect active state. The window can be halt to a specific state with the console command.

fs displaystate 1

return to switching window with

fs displaystate current

Frequency Switching Sequence E3-IVS

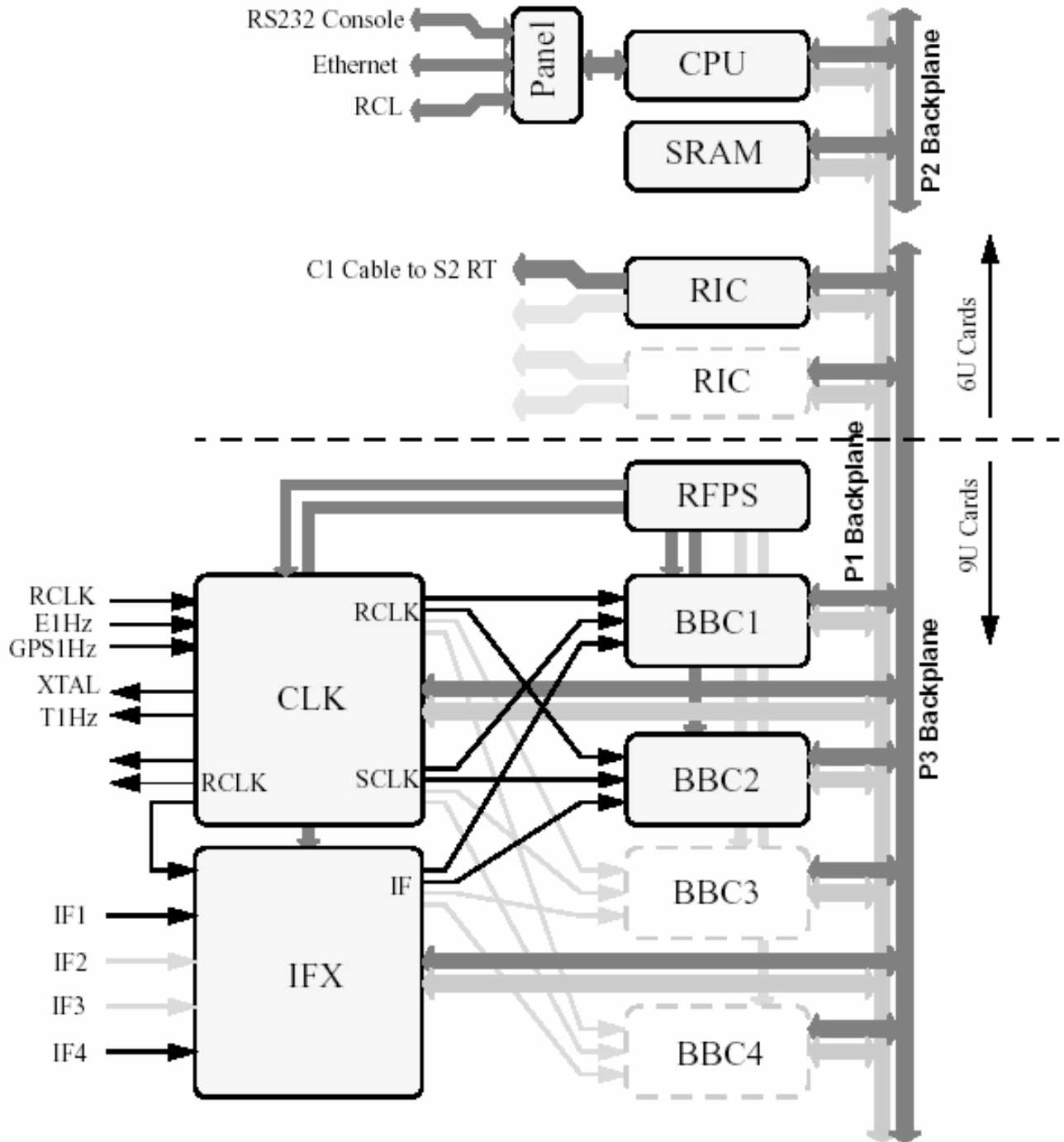
State	BBC 1	IF	BBC2	IF
1	8212.99	X	8932.99	X
2	2229.99	S	2354.99	S
3	8932.99	X	8212.99	X
4	2354.99	S	2229.99	S
5	8682.99	X	8462.99	X
6	2304.99	S	2279.99	S
7	8462.99	X	8682.99	X
8	2279.99	S	2304.99	S
9	8922.99	X	8222.99	X
10	2234.99	S	2349.99	S
11	8222.99	X	8922.99	X
12	2349.99	S	2234.99	S
13	8832.99	X	8312.99	X
14	2344.99	S	2339.99	S
15	8312.99	X	8832.99	X
16	2239.99	S	2344.99	S
17	8242.99	X	8902.99	X
18	8902.99	X	8242.99	X

States were selected to optimize delay peak resolution at the correlator, reduce bias in ionospheric correction, and avoid RFI caused by digital satellites.

Frequency switching rate : 1Hz
 Number of states : 18
 Number of independent channels X band : 10
 Number of independent channels S band : 8

Losing 1 BBC : Delay peak resolution not affected. SNR / $\sqrt{2}$.

S2-DAS



S2-DAS Block Diagram

S2-DAS (continue)

RFPS: Power supply that distributes power to various modules.

powermon (display measurements of DC power supply voltages)

CLK: Clock module distributes the 5or10Mhz to other modules.
Synchronize DAS to external 1pps. Determine offset between internal 1pps and GPS receiver. Manual sync to external 1pps can be done by typing

clk sync

IFX: controls IF signal levels. It is also use for IF test signal generation (self-test).

ifx atten ifall ifadjust (automatic adjustment of attenuation)

ifx input ifall direct (external IF signal used)

ifx avper 1.0 (to set TPI integration period to 1 second)

BBC: Baseband converter to sample and digitize the incoming signal.

bbc (to display BBC/IFX user window)

bbc 1 lofreq 299.99 (set frequency of bbc 1)

bbc 1 ifsource if1 (set if1 as the input IF signal)

bbc 1 bw 16.0 (set bandwidth to 16Mhz)

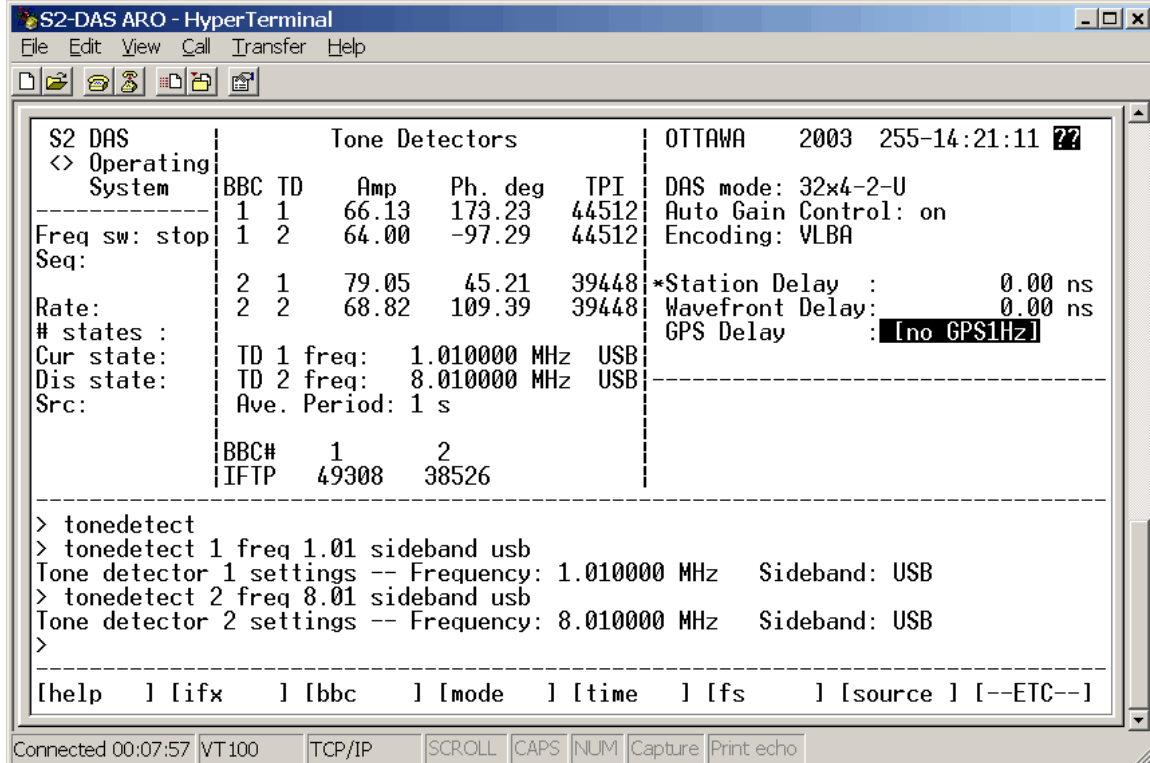
bbc (to display BBC/IFX user window)

Monitoring Phase Calibration Signal

There are 2 tone detectors on each BBC, each of which can be set to examine either upper or lower sideband. Type

tonedetect

to bring the tone detect window.



```
S2-DAS ARO - HyperTerminal
File Edit View Call Transfer Help

S2 DAS
<> Operating System
-----
Freq sw: stop
Seq:
Rate:
# states :
Cur state:
Dis state:
Src:

Tone Detectors
BBC TD Amp Ph. deg TPI
1 1 66.13 173.23 44512
1 2 64.00 -97.29 44512
2 1 79.05 45.21 39448
2 2 68.82 109.39 39448
TD 1 freq: 1.010000 MHz USB
TD 2 freq: 8.010000 MHz USB
Ave. Period: 1 s
BBC# 1 2
IFTP 49308 38526

OTTAWA 2003 255-14:21:11 ??
DAS mode: 32x4-2-U
Auto Gain Control: on
Encoding: VLBA
*Station Delay : 0.00 ns
Wavefront Delay: 0.00 ns
GPS Delay : [no GPS1Hz]

> tonedetect
> tonedetect 1 freq 1.01 sideband usb
Tone detector 1 settings -- Frequency: 1.010000 MHz Sideband: USB
> tonedetect 2 freq 8.01 sideband usb
Tone detector 2 settings -- Frequency: 8.010000 MHz Sideband: USB
>

[help ] [ifx ] [bbc ] [mode ] [time ] [fs ] [source ] [--ETC--]

Connected 00:07:57 VT100 TCP/IP SCROLL CAPS NUM Capture Print echo
```

The tone detect frequency is relative to the baseband bandpass and must be from 0 to the BBC bandwidth.

tonedetect 1 freq 1.01 sideband usb

tonedetect 1 freq 8.01 sideband usb

The field system command is

tonedet=1.01,usb,8.01,usb,1.0

Amplitude and phase can be used to monitor stability of phase cal. The field system can be used to extract phase and amplitude data that can be plot with **logpl** software.

E3-IVS mode of operation

Setting S2-RT

PCFS commands	PCFS commands
user_info=1,label,station	user info 1 label station
user_info=2,label,source	user info 2 label source
user_info=3,label,experiment	user info 3 label experiment
rcl=r1,consolecmd,log clear	log clear
user_info=3,field,e3019	user info 3 e3019
rec_mode=32x4-2,0	mode 32x4-2 groupe 0 barrelroll on
user_info=1,field,,auto	user info 1 Algonquin
user_info=2,field,,auto	user info 2 3c84
data_valid=off	user dv no
label=ca-3-002530b	tapeid ca-3-002530b
st=for,slp	speed slp record

Setting S2-DAS

PCFS commands	PCFS commands
fs=stop	fs stop
mode=32x4-2-u	mode 32x4-2-u
encode=vlba	encode vlba
agc=on	agc on
ifx=auto,,,auto,dir,,,dir,1.0	ifx atten ifall ifadjust ifx input ifall dir ifx avper 1.0
tonedet=1.01,usb,8.01,usb,1.0	tonedet 1 freq 1.01 sideband usb tonedet 2 freq 8.01 sideband usb tonedet avper 1.0
fs=start,e3-ivs	fs start e3-ivs

S2 check list

1. After bootup of DAS or RT.

Check result of self-test (automatic)

diag self1

Adjust time

Time (fmset on PCFS)

2. Check that data path from S2-DAS to S2-RT with diag16/diag32 tests.

Set up the RT and DAS by entering the following console commands:

DAS setup	RT setup
agc off	barrelroll off
mode diag16	uic feedthrough on
	mode c1test16

Note: the UIC error counter will appear in the Status Box of the RT, this is OK.

Run the following commands checking that the ber's are 0.0:

Enter the RT console command **uic berc X** (where X is 0 .. 7)

Wait a few seconds to make the measurement and then hit 'q' to stop the scrolling.

Do the same for diag32 and c1test32. X is now 0...3.

3. Bit Error Rate tests (berlp.tst, inter.tst) on the S2-RT (1.5hours)

On the RT type

batch berlp.tst

Record estimated error rates.
Do the interp test (rotate tapes)

batch inter.tst

Record estimated error rates
Estimated error rates should not be $> 1.0 \text{ E-3}$

4. Monitoring pcal

Look at stability of pcal phase and amplitude for X and S band. PCFS can be used to automate the process and generate plots. Make sure to have ifx TPI around 40000.

```
bbc all lofreq 149.99 ifsource if1 bw 16  
agc on  
tonedetect  
tonedetect 1 freq 1.01 sideband usb  
tonedetect 2 freq 8.01 sideband usb
```

BBC TPIs should be around 40000, the phase should remain stable to a few degrees and the amplitude should be over 100. If amplitude is less the 40, check your equipment.

5. BBC noise floor check

This test that level of signal level at the BBC is appropriate.

```
mode 32x4-2-u  
encode vlba
```

Setup the X band test using this command sequence:

```
ifx input ifall direct  
ifx atten ifall ifadjust  
bbc all lofreq 149.99 ifsource if1 bw 16  
agc on
```

After the agc has fully adapted, record BBC TPI's.
Turn off the agc, i.e. type 'agc off'. (BBC TPI should be ~40000)

```
agc off
```

Apply maximum attenuation to the input signal.

```
ifx atten ifall 30
```

BBC TPI's should be now lower than 10000 (5000 is preferable)

Repeat same test for frequency 829.99.

```
bbc all lofreq 829.99 ifsource if1 bw 16
```

Repeat test at S band (if4) at frequency 199.99.

```
bbc all lofreq 199.99 ifsource if4 bw 16
```

6. TSYS

TSYS measurements are possible but not tested yet in PCFS.

During experiment checks

Check time on DAS and RT (PCFS could do it during midob). Check there are no error status.

On the RT, check tapes are rolling. It could happen that one of the transport does not start after issuing label command. You can restart all transport with the RT command.

Record (all tapes)

Transport 1 record (start transport 1)

It could happen that tapes reach end of tape EOT before the end of scan. Wait the schedule to eject tapes.

On the DAS, make sure the Frequency Switching is running and Pcal is fine. You can use the command

fs displaystate 1

To look at specific state.

S2 contacts at Geodetic Survey

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References

S2-RT User's manual Version (162) August 1998

S2-DAS User's manual Version 1.1 November 28, 2002