INSTALLATION OF THE VSOP TAPE RECORDER IN GREEN BANK

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OVERVIEW

In this memo we describe the installation of the VSOP tape (VSOPT) recorder at the Green Bank Earth Station (GBES). The VSOPT is on loan to the GBES from the National Astronomy Observatory of Japan (NAO). The VSOPT recorder was shipped to Green Bank in April 1999 and the final hardware installation was achieved on May 26, 1999.

OMISSIONS

The VSOP recorder currently must be run with manual intervention. This includes the clock setting which allows for the possibility of $\pm$n second errors, where n is an integer. We are currently studying the possibility of running the VSOP recorder under complete computer control using the GBES system computer. Such an implementation would eliminate $\pm$n second errors.

THE VSOP RECORDER

The VSOP tape recorder (VSOPT) consists of five separate modules. These modules are:

C1/C2 Data Divider and Switcher

This module receives the input data stream from an S2 C1 cable. The input signal is then divided into two separate outputs, onto another C1 cable for input into the S2 recorder and onto an S2 C2 cable for input into the VSC 7220 module. This module needed slight revision to be compatible with the GBES. This revision is described in a later section of this document. (See [2] for information on the S2 C1 and S2 C2 cables.)

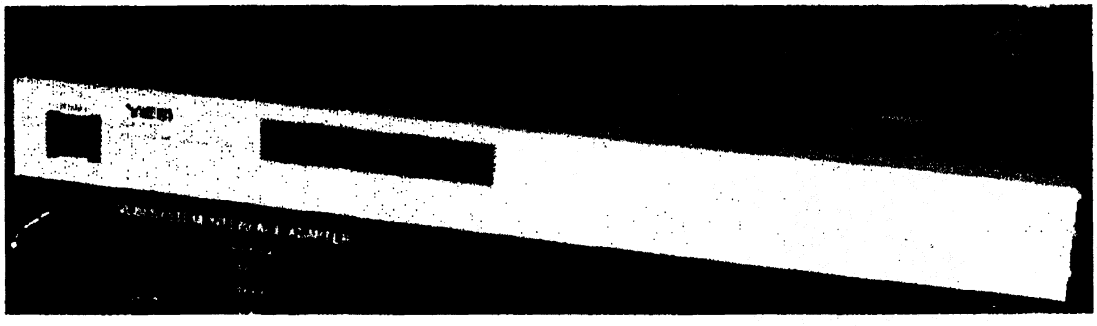

Figure 1: The C1/C2 Data Divider and Switcher (white module).

S2/VSOP VLBI Signal Converter VSC 7220

This module receives the input data stream from an S2 C2 cable and converts the data stream to a format suitable for the DIM-1000M data recorder. This module also is in direct control of the DIM-1000M and the DMS-24 module through an RS-422A cable. The time stamp reference for the DIM-1000M is also provided from this module. The VSC 7220 is capable of changing the wiring connections between the input and output data cables. The operation of the VSC 7220 is described in [3].

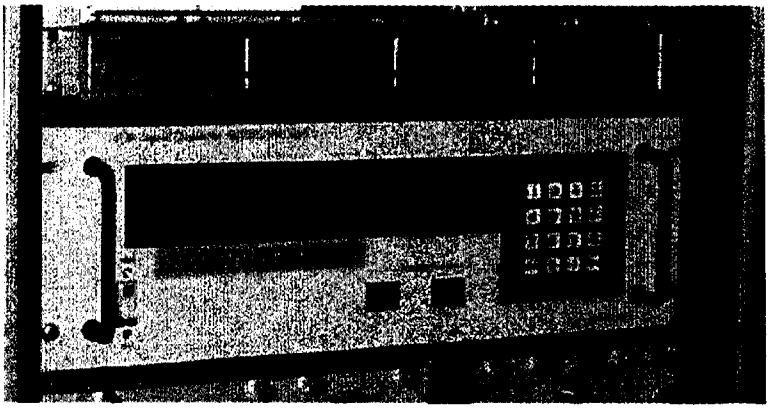

Figure 2: The S2/VSOP VLBI Signal Converter VSC 7220. The upper module is an IRIG clock used to check that the VSOPT recorder is set to the correct time.

Control PC

This is a Fujitsu FMV-BIBLO NUV 16x laptop computer running the Japanese version of Microsoft Windows 95. This computer is used to control the VSC 7220 and to receive log and monitor information from the DIR-1000M. This is done running a program called *CFS* provided by NAO (see [4]). The control pc is located in the GBES Jansky Operations Center room which is adjacent to the Jansky Operations Center tape room where the other modules comprising the VSOP recorder are located.

Cassette Changer DMS-24

This module can store up to 24 VSOP tapes (D1V-94LC Broadcast Video Tapes). It also includes a device for reading the bar-codes on the tapes that is also capable of moving tapes between the DIM-1000M recorder and the storage area. This module was built by SONY.

Data Recorder DIM-1000M

This module is the actual recorder. It was also built by SONY and is described in full detail in [5]. It consists of a commercially available recorder used mainly for television and video production. It is capable of recording at rates from 10.7 Mbps to 256 Mbps.

PRE-INSTALLATION MEETING AT MITAKA

On March 21 and 24, 1999, Glen Langston, Anthony Minter, S. Kameno and N. Kawaguchi met at NAO, Mitaka, Japan. These meetings were held to clarify any questions regarding the

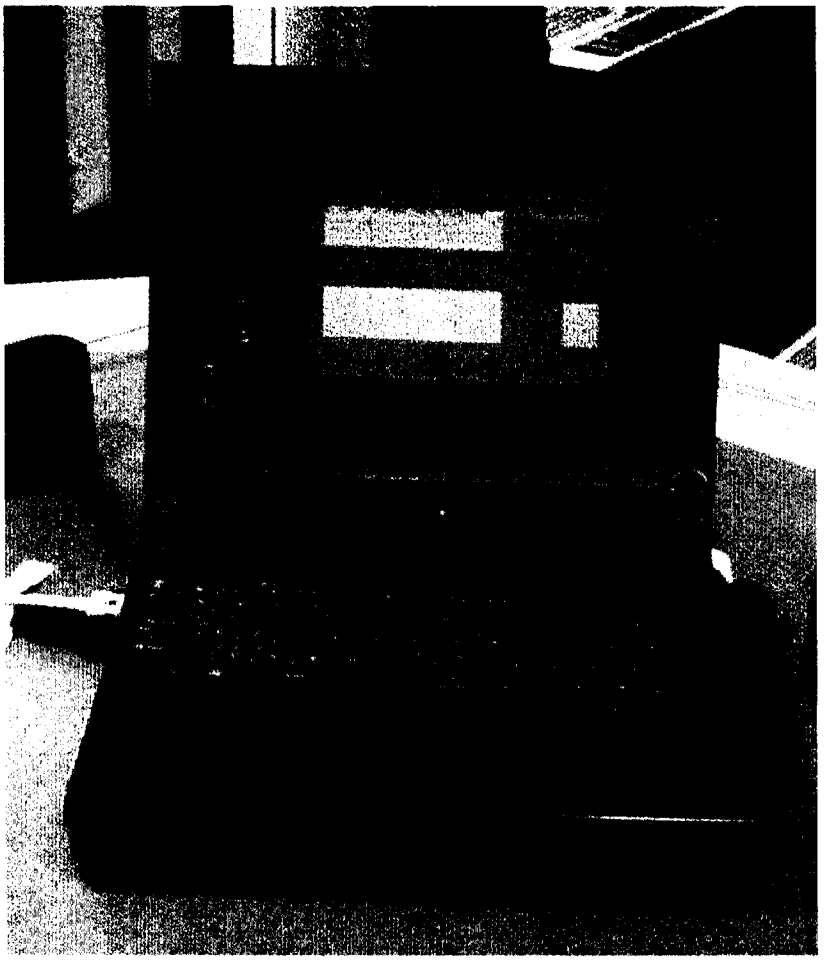

Figure 3: The control PC. Shown running is the *CFS* program used to control the VSOPT recorder.

Figure 4: The cassette changer, DMS-24. Several tapes are loaded in the cassette changer and the tape mover/bar code reader can be seen just above the tapes (with the SONY emblem).

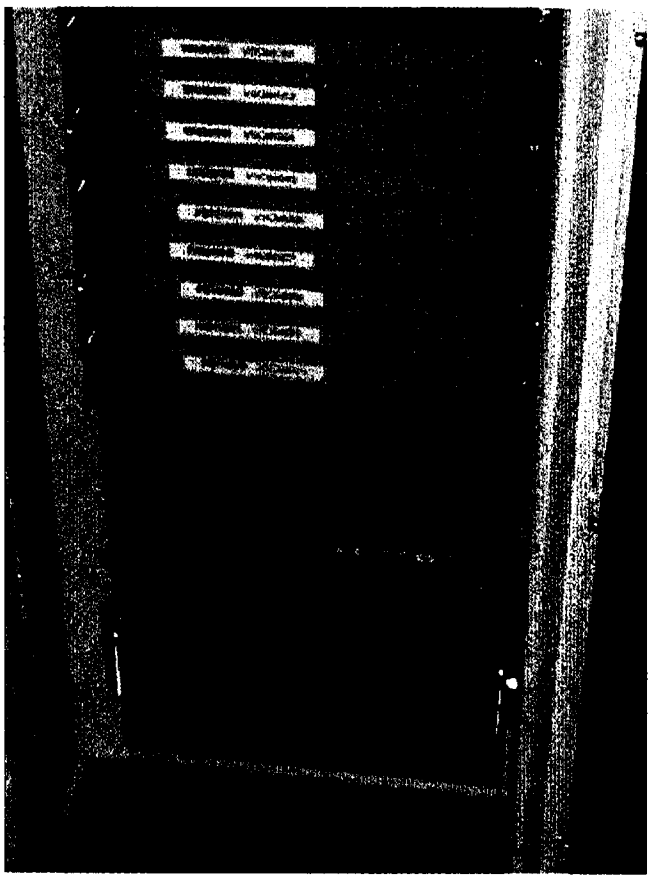

Figure 5: The Data Recorder, DIM-1000M. The recorder is located at the bottom of the rack containing the tape changer.

installation of the VSOPT in Green Bank prior to its shipment to Green Bank. Discussed were the data stream patterns that would be provided by the GBES, the types of connections for these data streams, the types of internet connections used in Green Bank, the power requirements of the VSOPT modules, and the overall configuration scheme of the VSOPT. These meeting proved useful in avoiding most problems with the installation of the VSOPT in Green Bank. At the end of the March 24, 1999 meeting everyone helped load the VSOPT modules onto a NIPPON Express truck for shipping to Green Bank.

INSTALLATION OF VSOPT IN GREEN BANK

The VSOPT modules arrived in Green Bank on March 29, 1999. Seiji Kameno arrived in Green Bank on April 5, 1999, to supervise the installation of the VSOPT recorder. On April 6, 1999 the VSOPT modules were unpacked and the installation began. A flow chart showing the VSOPT setup in Green Bank is shown in Figure 6.

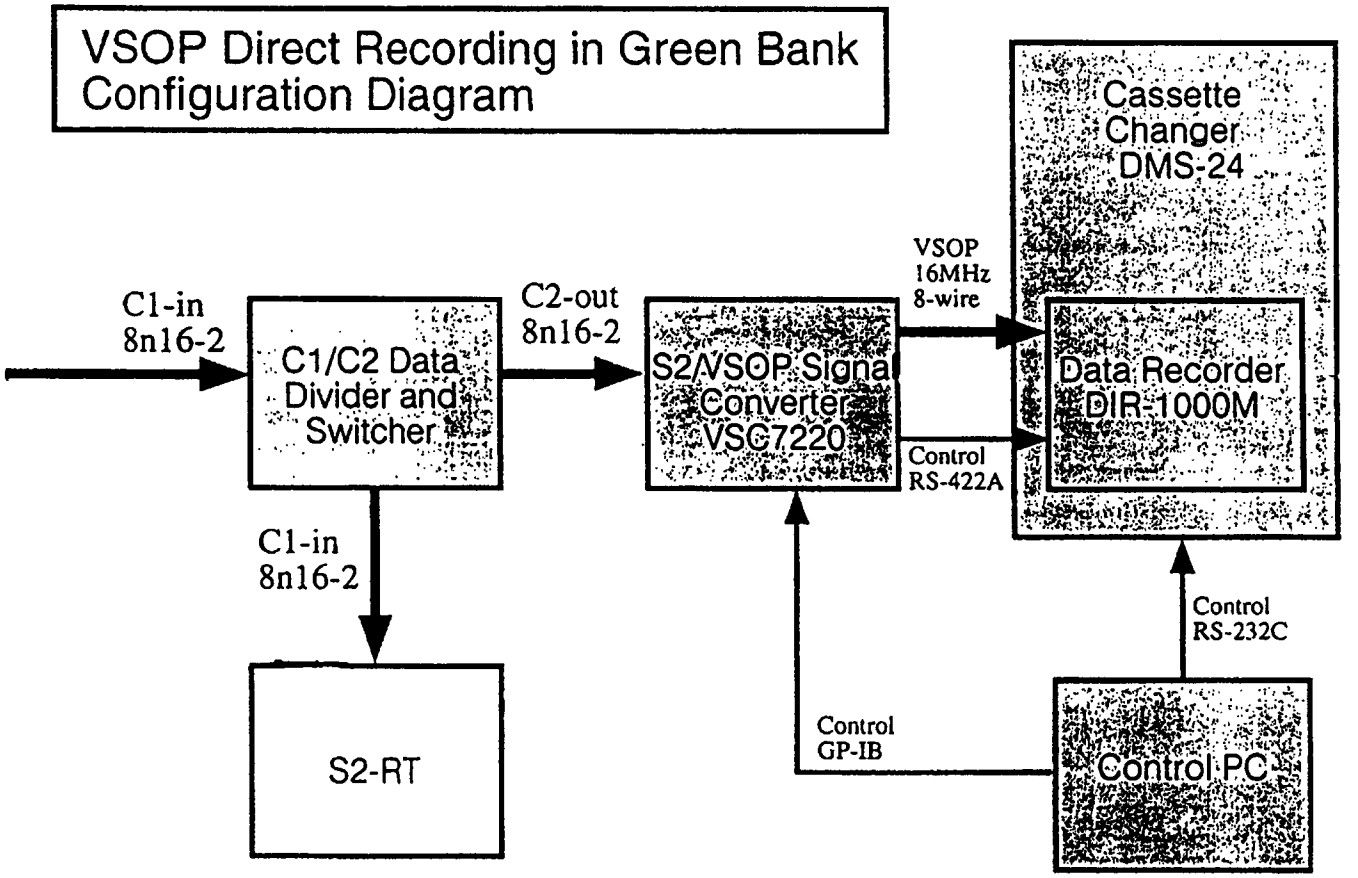

Figure 6: Flow chart of the data path and other connections of the VSOPT recorder.

MODIFICATION OF THE C1/C2 DATA DIVIDER AND SWITCHER

It was quickly recognized that the C1/C2 Data Divider and Switcher was not compatible with the data signal provided by the GBES. The C1/C2 Data Divider and Switcher was

constructed under the assumption that the signal would contain an 8 MHz clock reference signal. The GBES, however, provides a 32 MHZ clock reference signal. Dan Pedtke, the GBES engineer, was able to modify the C1/C2 Data Divider and Switcher within about one days time so that the input 32 MHZ reference clock was divided down by a factor of 4 to 8 MHz while maintaining a proper timing relationship with the 1 PPS signal. The division of the reference clock only affects the output C1 cable which goes to the VSC 7220 module of the VSOPT recorder.

The division of the reference clock down to 8 MHz was done using a 2 bit Johnson counter made out of a 10H131 ECL part, with a Set and Reset tied to the 1 PPS for synchronization. The A flip-flop D input comes from the B-flip-flop !Q (pin 14 to pin 7 and pin 2 to pin 10). This type of counter produces all phases of the divide-by-four clock, so the right one can be selected by changing output pins. With the 1PPS (a positive pulse) connected to the Reset of the A flip-flop (pin 4) and the Set of the B flip-flop (pin 12), the true clock is taken from !Q-B (pin 14) and inverted clock from Q-B (pin15). The clock (pin 9) comes from the original !Clk output from the VSOP circuit (active edge is low to high).

A block diagram of the clock division circuitry is shown in Figure 7.

INSTALLATION, April 1999

After the modification of the C1/C2 Data Divider and Switcher, the rest of the installation of the modules went smoothly. The equipment was then powered up and several tests were performed (see below). All equipment performed as expected. However, at this time the VSC 7220 and the *CFS* control program were only in Japanese and not in English. Also, a firmware upgrade to the VSC 7220 was needed to provide the correct time stamps to the DIR-1000M. Seiji Kameno decided that he would make another trip to Green Bank in May 1999 in order to finalize the installation of the VSOPT (he left Green Bank on April 9, 1999).

FINAL INSTALLATION CONFIGURATION OF THE VSOPT HARDWARE, May 1999

Seiji Kameno returned to Green Bank between May 24 and 27, 1999. He brought with him the updated versions of the VSC 7220 firmware and the *CFS* program - both of which now had English versions. He also brought updated manuals (now in English also) for the VSOPT. The firmware and *CFS* program were installed and the system was then fully tested during a HALCA tracking pass (9905251628). The system was found to be in working order except that the VSC 7220 still did not provide the correct time stamps to the DIR-1000M recorder.

INITIAL TESTING OF THE VSOPT

C1/C2 DATA DIVIDER AND SWITCHER

Due to the addition of the C1/C2 Data Divider and Switcher into the S2 recorders data path and the modifications needed for the C1/C2 Data Divider and Switcher, a simple test was performed to make sure that the signals reaching the S2 recorder were not affected. The GBES decoder [6] was put into its RadioAstron 72 MHz clock rate mode producing pattern data. Without the C1/C2 Data Divider and Switcher installed, the S2 recorder was used to capture parts of the data stream. This was done by first issuing the "uic feedthru on"

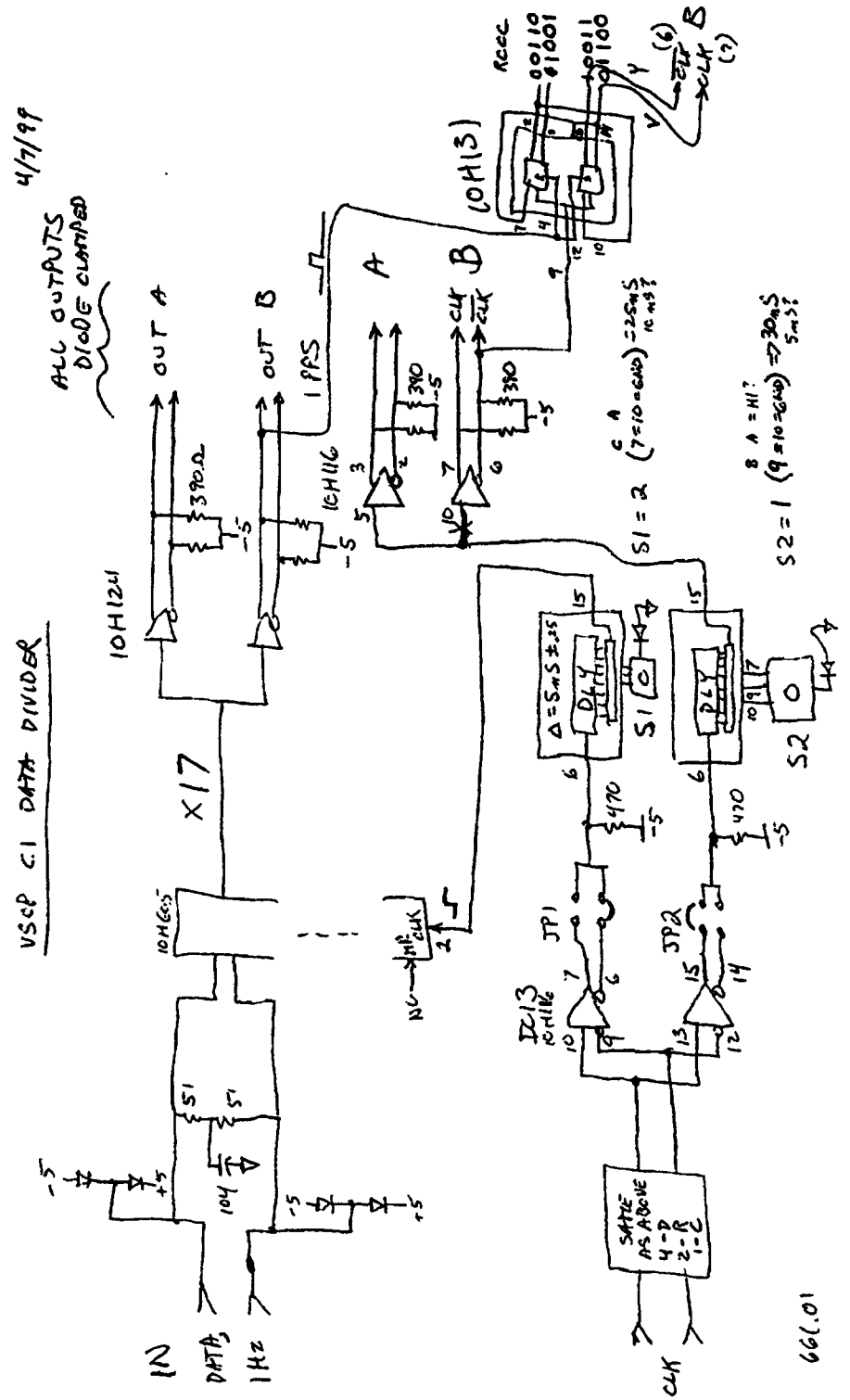

Figure 7: A block diagram showing how the 32 MHz reference clock is divided down to 8 MHz within the C1/C2 Data Divider and Switcher.

Table 1: Data bit streams extracted from the S2 recorder with the GBES decoder in the RadioAstron 72 MHz pattern data mode.

Wire	Hex Value
0	bb 9d 99
1	01 a4 05
2	ee 8e 67
3	3b ca 98
4	75 51 3f
5	d3 a6 e9
6	a9 bd f5
7	de 86 c7
8	46 93 97
9	8a d5 3e
10	b3 11 aa
11	8e 71 25
12	0f 58 23
13	e0 4a 41
14	3b c4 98
15	b6 e3 b6

command to the S2 recorder, setting the S2 recording mode to 8x16-1 and then issuing the "uic dataextract 20 n" command. This extracts the data starting at the 20th bit within a given frame for the data stream on wire n. The results of this data extraction are shown in Table 1 and were found to be what was expected. After the C1/C2 Data Divider and Switcher was installed this test was repeated and the same results were obtained. This indicates that the C1/C2 Data Divider and Switcher does not affect the signals going to the S2 recorder.

VSOPT Tests, April 1999

Once the VSOP recorder was installed and powered up, S. Kameno began testing the recorder to make sure that it was functioning properly. First, a test tape with pattern data recorded onto it was played back using the VSOPT. The data from the recorder were captured using the DEC-1500 module and stored to disk on a SUN-ULTRA workstation. The DEC-1500 module was brought to Green Bank specifically to test the VSOP recorder and has since been shipped back to Japan (on June 17, 1999). This module contains a large memory buffer that can capture the output of the VSOPT when playing back a tape. The initial playback test using the test tape was found to be successful.

Next the GBES decoder was put into a mode in which it produced pattern data. This data was then recorded using the VSOPT and subsequently played back using the DEC-1500 to capture the recorded data stream. It was found that the correct data pattern was being recorded by the VSOPT.

Finally, the *CFS* program was used to perform a test recording. This showed that all the modules comprising the VSOP recorder were functioning. This test also found that the

VSC 7220 was not producing the correct time stamps to the DIM-1000M recorder.

VSOPT Tests, May 1999

After the VSC 7220 firmware and *CFS* program upgrades were installed in May, 1999, a test recording using the VSOPT during a HALCA navigation tracking pass was made. The MIT Near Real Time (MITNRC) correlator was used to produce autocorrelation spectrum of both channels of the HALCA signal in real time. The VSOPT was used to record the astronomical data from HALCA during the entire tracking pass beginning on May 25, 16:28 UTC. The VSOPT was used to playback the recorded data and the DEC-1500 was used to capture the data. An autocorrelation spectrum was then obtained for the data recorded using the VSOPT. This was found to agree with the autocorrelation spectra produced by the MITNRC (see Figures 8 and 9). This test revealed that there was still a problem with the VSC 7220 providing the correct time stamps to the DIM-1000M recorder.

W035n RECORDING TEST

On June 30, 1999 a new version of the firmware for the VSC 7220 was installed to fix the time stamp problem. On July 23, 1999, a full recording test of the VSOPT was performed. The 9907231131 tracking pass was scheduled to be an S2 recording pass for experiment W035n. It was decided that this would be a good tracking pass to make a dual recording using the S2 recorder and the VSOPT. S. Kameno provided a "drg" file for the *CFS* program and the data from this pass were recorded on both S2 and VSOP tapes. Both tape sets were shipped to the Mitaka correlator where the S2 tape was copied to VSOPT format. The S2 tape was then shipped on to the Penticton correlator for correlation of the W035n experiment.

Data from the original VSOPT tape and the copied S2 tape were then captured upon playback using the DEC-1500. Autocorrelation spectra where made for each tape set. These spectra are shown in Figures 10 and 11. As can be seen from these figures, the S2 recording autocorrelation spectra agree with what is to be expected. The VSOP recording autocorrelation spectra obviously have an error.

The cause of the error in the VSOP recording for W035n was investigated by S. Kameno [1]. It was concluded that the wire mapping in the VSC 7220 between the input and output data streams was not performed correctly. S. Kameno proved this by taking the data captured by the DEC-1500 from the VSOP tape recording and rearranging the bits in accordance with what the proper wiring scheme should have been. This then produced autocorrelation spectra which agreed with the autocorrelation spectra obtained from the S2 tape recording. The corrected spectrum is shown in Figure 12.

The GBES is currently awaiting a fix to the firmware of the VSC 7220 or the *CFS* program from NAO in order to correct this problem.

Use of VSOPT with the GBT

It should be possible to use the VSOPT with the Green Bank Telescope (GBT). Two things need to be done in order to use the VSOPT recorder with the GBT. The first is to build a piece of hardware that will combine the GBT IF signal and the local 1PPS signal on a VLBA signal cable. Currently such a device does not exist and there are no current designs

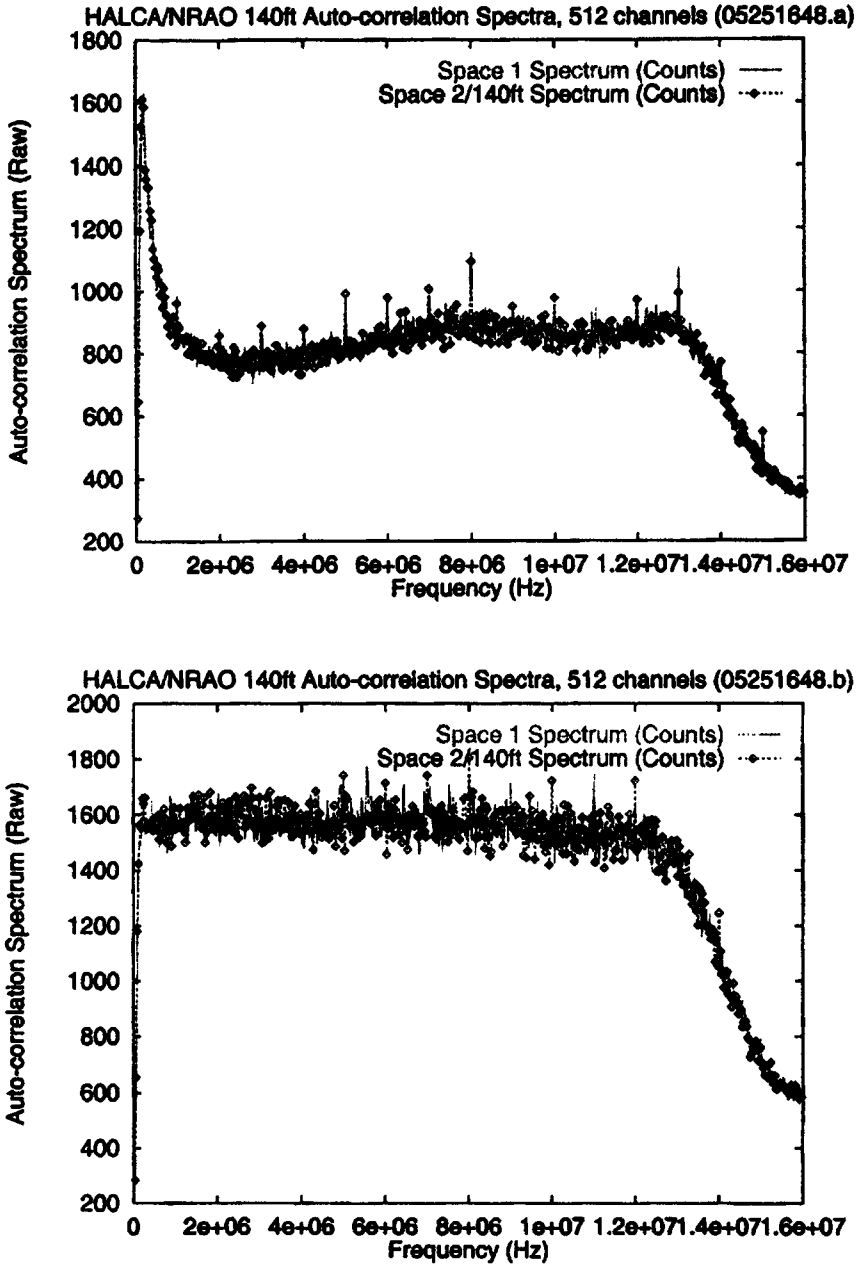

Figure 8: Autocorrelation spectra obtained from the MITNRC during the May 25, 1999, 16:28 UTC HALCA tracking pass. Channel A is shown in the upper plot and channel B is in the lower plot.

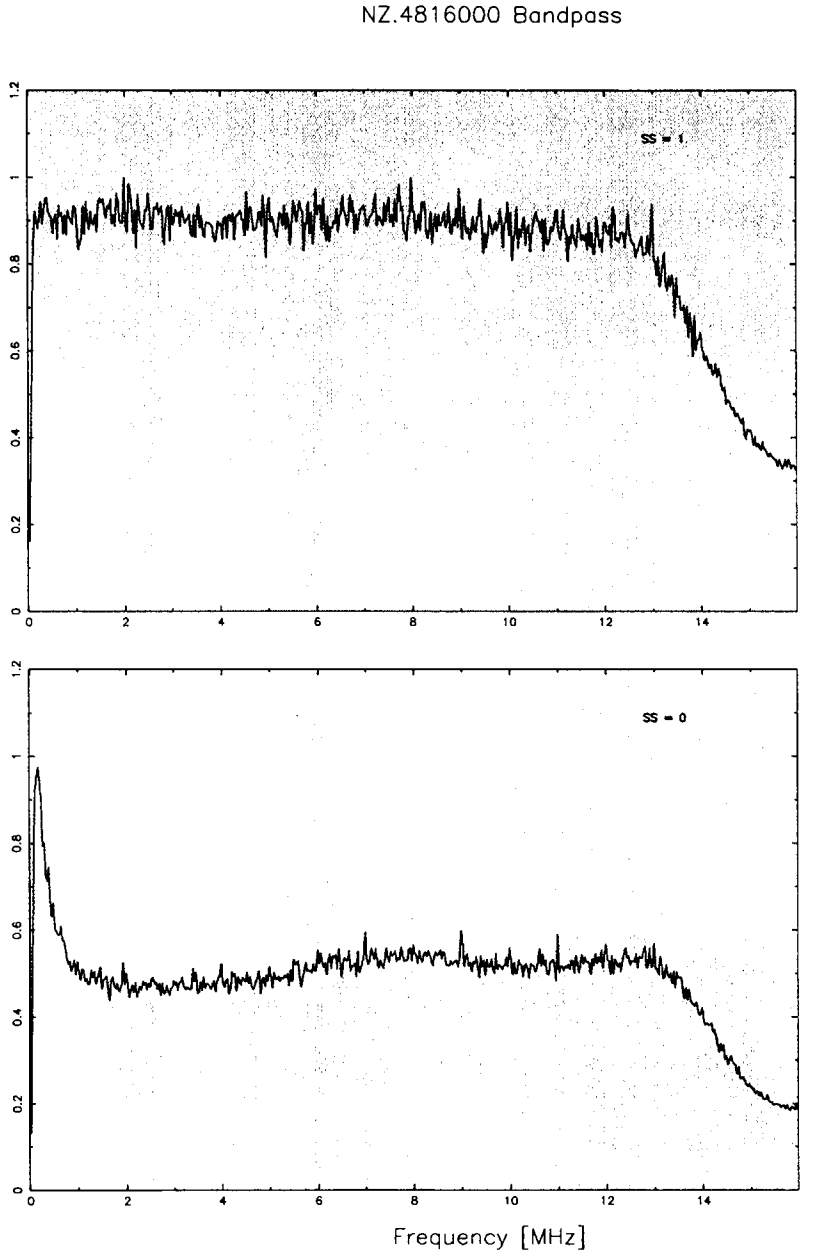

Figure 9: Autocorrelation spectra obtained from the VSOPT during the May 25, 1999, 16:28 UTC HALCA tracking pass. Note that the channel B spectrum is the upper spectrum and the channel A spectrum is the lower spectrum. This is the reverse of what is shown in Figure 8 for the MITNRC. This plot was provided by S. Kameno.

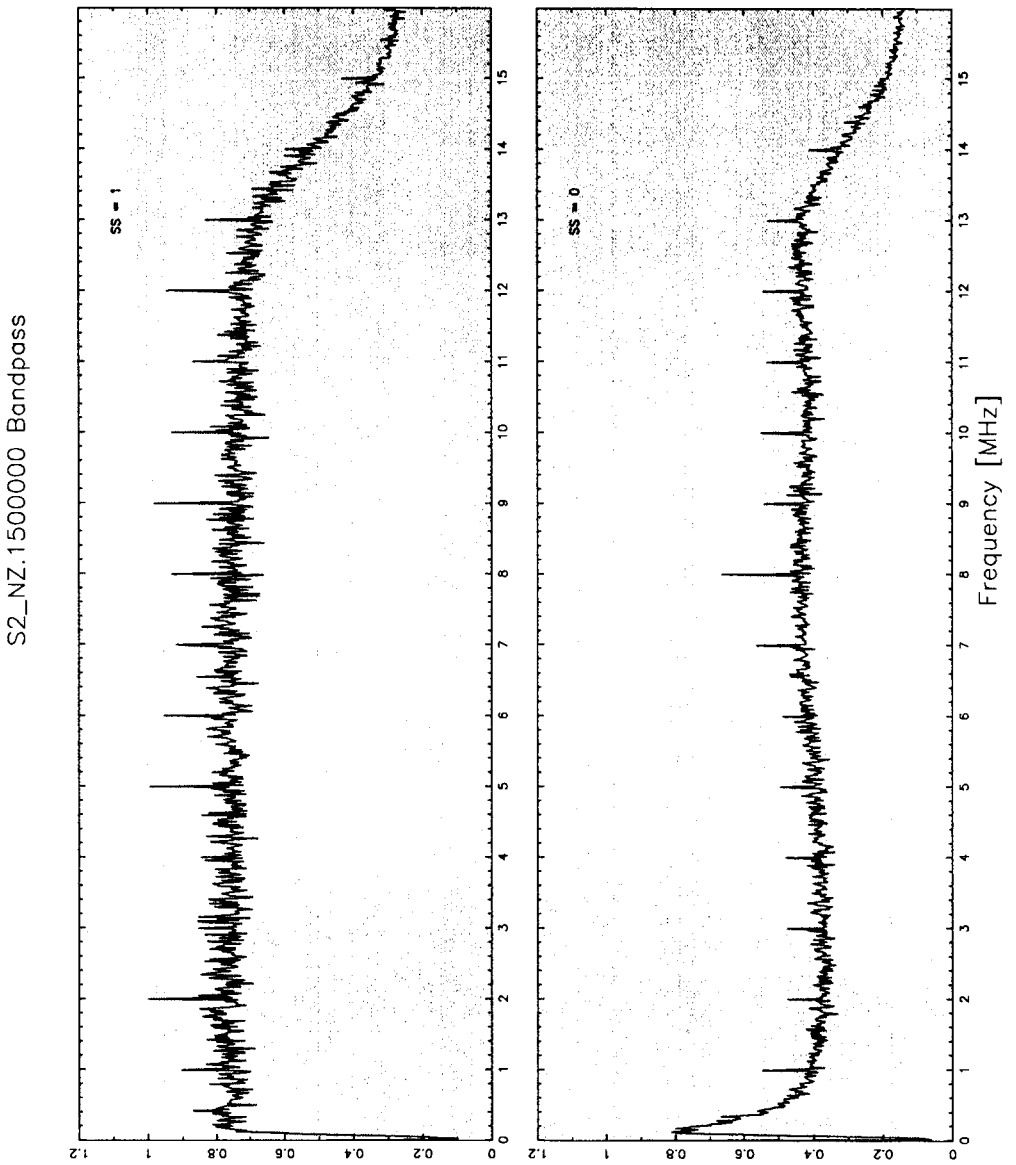

Figure 10: Autocorrelation spectra obtained from the W035n experiment tests on July 23, 1999 from the S2 tape recording. This plot was provided by S. Kameno.

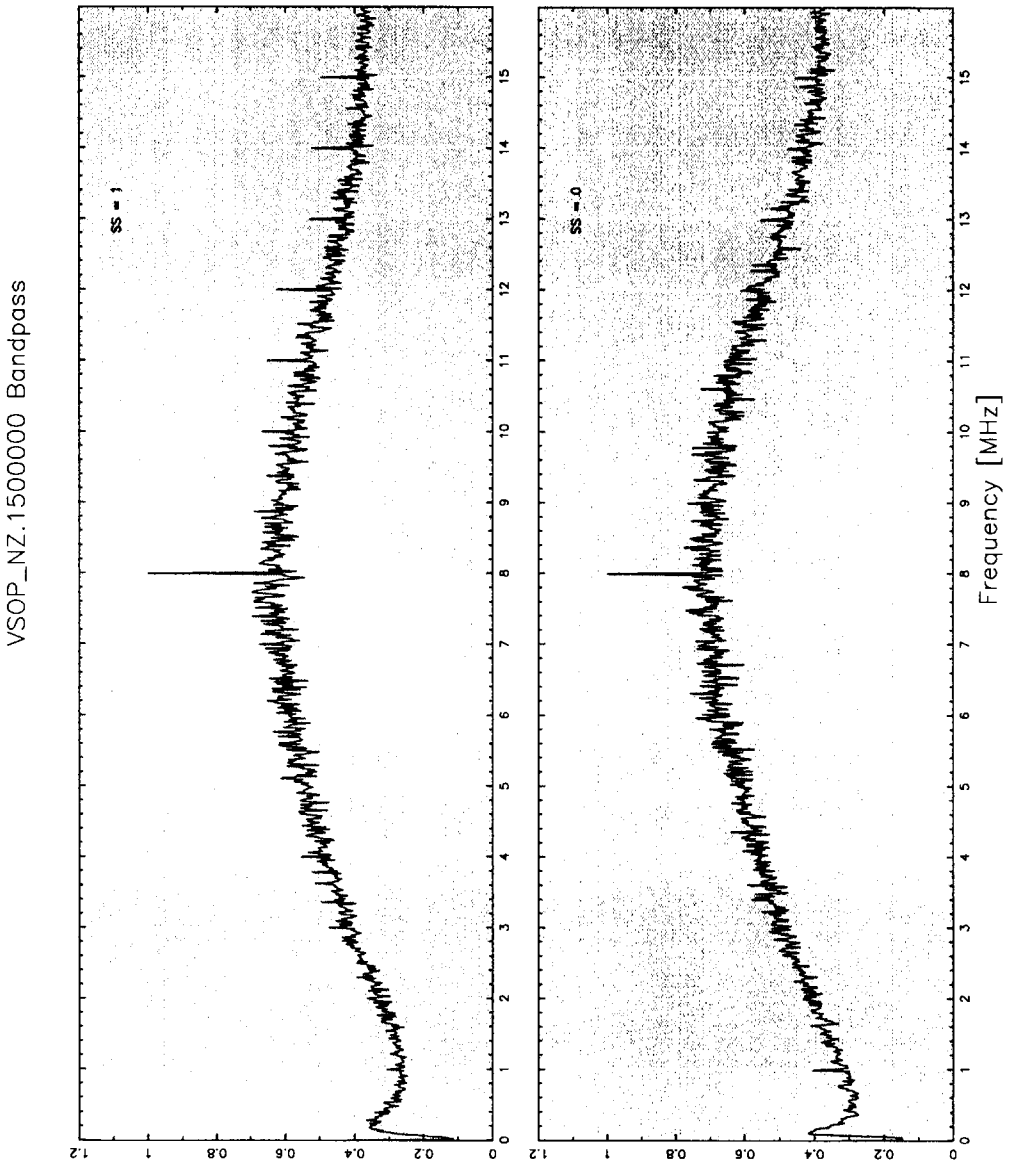

Figure 11: Autocorrelation spectra obtained from the W035n experiment tests on July 23, 1999 from the VSOP tape recording. This plot was provided by S. Kameno.

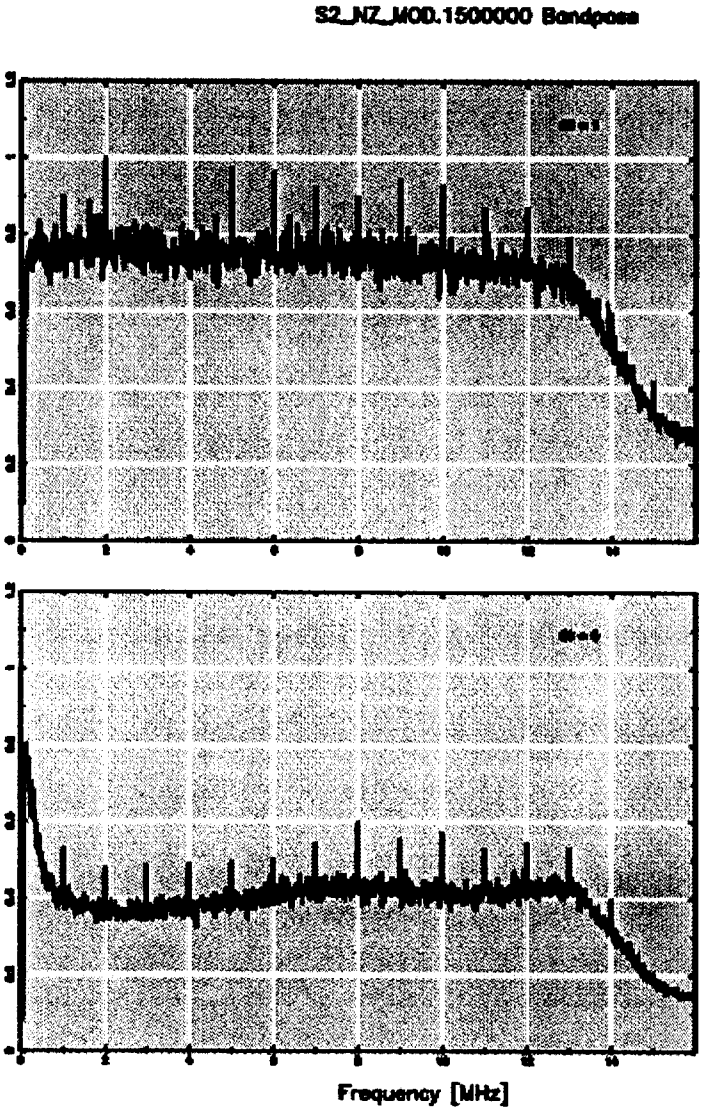

Figure 12: Autocorrelation spectra obtained from the W035n experiment tests on July 23, 1999 from the VSOP tape recording after correction for the wiring error. This plot was provided by S. Kameno.

for such a device. The current plans are for the GBT to provide the astronomical data to the GBT VLBA and GBT S2 recorders on a VLBA cable and that the clock signal will be provided separately. The second is to then manually hookup the GBT VLBA signal to the GBES C1/C2 Data Divider and Switcher.

Operating the VSOPT recorder with the GBT would require an extra operator to run the *CFS* program since the control PC is not located in the GBT control room. Thus the use of the VSOPT with the GBT would have to be negotiated and can not be expected to occur on a regular basis.

Concluding Remarks

Although the VSOPT is installed in Green Bank, it is not yet fully operational. An upgrade in needed for the VSC 7220 to produce the correct signal conversion for the VSOPT [1]. This correction is understood and the GBES is awaiting the appropriate firmware/software from NAO. Once this firmware/software is installed the VSOPT should be fully operational and ready for regular use by the GBES.

References

[1] "VSOP Recording Test In Green Bank", by S. Kameno, dated October 28, 1999

[2] "S2-Pt User's Manual", Version 3.2 (162), dated August 1998, available from Crestech, 4850 Keele Street, North York, Ontario, Canada, M3J 3K1.

[3] "VLBI Signal Converter VSC 7220 Operation Manual", Seiji Kameno, VSOP Project, National Astronomical Observatory, Japan, dated May 15, 1999.

[4] "VLBI Field System for VSC72xx Operation Manual", Seiji Kameno, National Astronomical Observatory, Japan and Takayuki Morino, Yamatake & Co., Ltd., dated May 11, 1999.

[5] "SONY Digital Instrumentation Recorder DIR-1000 Users's Manual", anonymous document provided by SONY with the DIR-1000M.

[6] R. Escoffier, "The OVLBI decoder test fixture.", OVLBI-ES Memo No. 49, 94/08/29. [http://www.gb.nrao.edu/ovlbi/memoseries/es49_testfixture.txt]