VLBA TEST MEMO NO. 29

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HAYSTACK OBSERVATORY

WESTFORD, MASSACHUSETTS 01886

23 January 1992

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To: VLBA Project

From: Alan E.E. Rogers

Subject: Choice of phase calibration frequencies for processing on Haystack MKIII Correlator

During a recent test experiment, phase calibration tone frequencies (in the baseband) of 10, 20, and 50 KHz were tested. The choice of 10 KHz is traditional for MKIII as it results in the lowest errors at the correlator (see attached memo). However, 10 KHz is more subject to spurious signal pick-up within the DAR. Craig Walker ran a short test experiment on 19 December 1991 and the FRNGE plots are attached for the LA-FD baseline. The residual phases for each frequency for this scan are as follows:

PCAL	FREQ #					
10 KHz	+2.8	-2.3	-2.6	+4.9	+0.9	-3.4
20 KHz	-3.8	+4.2	-1.7	+2.1	+3.3	-5.5
50 KHz	+0.6	+4.1	-7.6	+1.1	-1.6	+1.8

Residual phases in degrees 1σ noise ≈3 degrees.

In this test the residual phases are within expected error - the maximum deviation being about 2 σ for frequency number 3 at 50 KHz. Since there are no large spurious signals in this test also shows that the results are satisfactory at all 3 frequencies. If 10 KHz continues to be a problem (there are some BBC updates that lower the spurious signal levels - see VLBA Acquisition Memo #223) 20 KHz would be a good choice as it can be extracted at the MKIII correlators with less error than 50 KHz (see Table 1 of attached memo).

Attachments (2)
1. Memo (3 pages)
2. FRNGE plots (3 pages)

Choice of Phase Calibration Rail Frequencies for Mark III

Technical Note
TN-1979-6-AEER

The phase calibration correlator in the Mark III processor can extract any rail whose quarter period has an integral number of bits. A list of permissible frequencies (for a 2 MHz bandwidth) are given in Table 1. Owing to the harmonic content of the square wave used to extract the calibrator rail, the signals from other rails (spaced at 1 MHz intervals) or their images result in an error signal. The peak magnitude of the phase errors which result from the error signal are also given in Table 1. For all practical purposes, some of these errors are "static" as the remain unchanged by variations in the local oscillator phases. They change only with a change in receiver delay and undergo a full cycle in 1 microsecond. Futhermore, since the variation in receiver and video converter delay varies by less than 20 nanoseconds with frequency and video converter the phase error should be the same (to within 12% of the maximum phase error) for each bandwidth synthesis channel. Phase errors which result from the video converter images and rails aliased by the sampling frequency are much more serious as they change with local oscillator phase. The calibration rail frequency with lowest non-static error is 10 KHz. 10 KHz can be used as a calibrator rail frequency for all bandwidths down to 0.5 MHz. With bandwidths of 0.25 MHz and smaller there is no calibration rail frequency which can be set-up by the Mark III converters and processed by the phase calibration correlators. For these narrow bandwidths, which will probably only be used for spectral line VLBI, the main fringe rotator can be used to extract the calibration rail. In this case the calibrator rail frequency can be any frequency up to 1/4 of the bandwidth.

Table 2 lists other error sources present in the calibrator and their expected magnitude. All these error sources, with the exception of #8, will probably be present at the same level regardless of the choice of the video rail frequencies given in Table 1. "Static" error sources are benign at least to the extent with which they remain constant during an experiment. Some of the static errors, like those which result from the false extraction of calibration rails owing to the harmonic content of the square wave, are not dependent on the bandwidth synthesis channel and so only affect the phase delay measurement. The largest "static" error is probably that which results from the dispersion present in the front-end waveguide and feed. Some of the "static" errors may change with temperature in which case a worst case estimate of the temperature coefficient is given. Error source #9 can be eliminated by avoiding calibration rails that are harmonics of 5 MHz. Error source #8 could be eliminated by using another video rail frequency. While this study suggests that 10 KHz is the best choice of video rail frequency, zero baseline tests need to be made to make direct measurements of these effects and to check for additional effects which may have been overlooked.

Distribution

T.A. Clark	C.C. Counselman
H.F. Hinteregger	C.A. Knight
E.F. Nesman	I.I. Shapiro
A.R. Whitney	

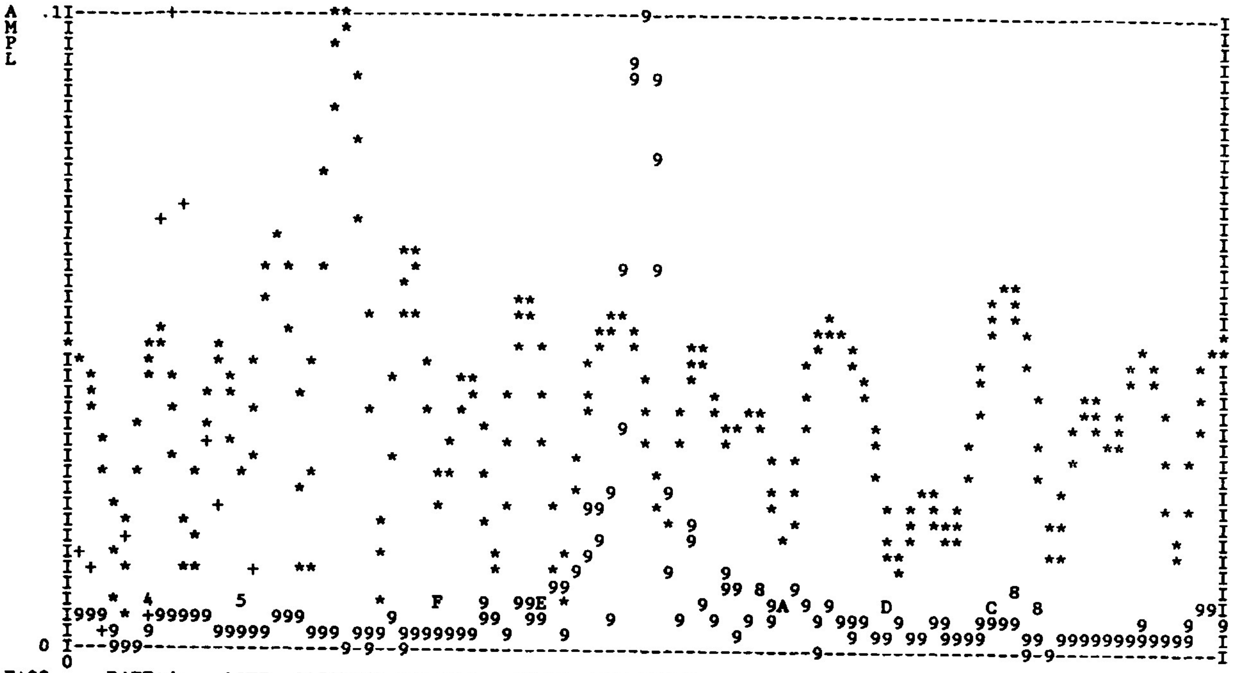
AERTN::57

VIDEO RAIL FREQ. KHz	# BITS IN PERIOD/4	"STATIC ERROR SOURCES"	MAX STATIC ERROR (DEG)	OTHER ERROR SOURCES	MAX ERROR (DEG)
1000	1		0	V.C. image	5
500	2	3rd harmonic	19	V.C. image	5
250	4	5th harmonic	11	aliased 7th harm.	1.7
200	5		0	aliased 9th harm.	1.5
100	10	11th harmonic	5	aliased 19th harm.	1.0
50	20	21st harmonic	2.7	aliased 39th harm.	0.5
40	25		0	aliased 49th harm.	0.4
20	50	51st harmonic	1.1	aliased 99th harm.	0.2
10	100	101st harmonic	0.6	aliased 199th harm.	0.1

Table 1. Permissible "Phase Cal" Frequencies for 2 MHz BW

	SOURCES OF ERROR	MAX STATIC ERROR (DEG)	MAXIMUM L.O. PHASE DEPENDENT ERROR (DEG)	AFFECTED RAIL FREQ. HARMONIC
1	Front-end image rejection		0.2 (50dB)	1
2	Harmonic responses of video converter		0.2	3
3	5KHz signal in cal. electronics		<0.1	3
4	Variation of Differential Phase across v.conv. band	5 (0.2/deg C)		
5	Difference between phase response of USB & LSB	5 (0.2/deg C)		
6	Multiple reflections of injected pulse	5 (20dB)		
7	Dispersion in waveguide (1 meter over 300 MHz at 8.3GHz-WR90)	9		
8	Presence of spurious 10KHz in video output		0.2 (50dB)	1
9	Presence of spurious signals at harmonics of 5MHz		0.5 (40dB)	1

Table 2. Sources of Calibration Error Not Dependent (except #8) on Choice of Video Rail Frequency.

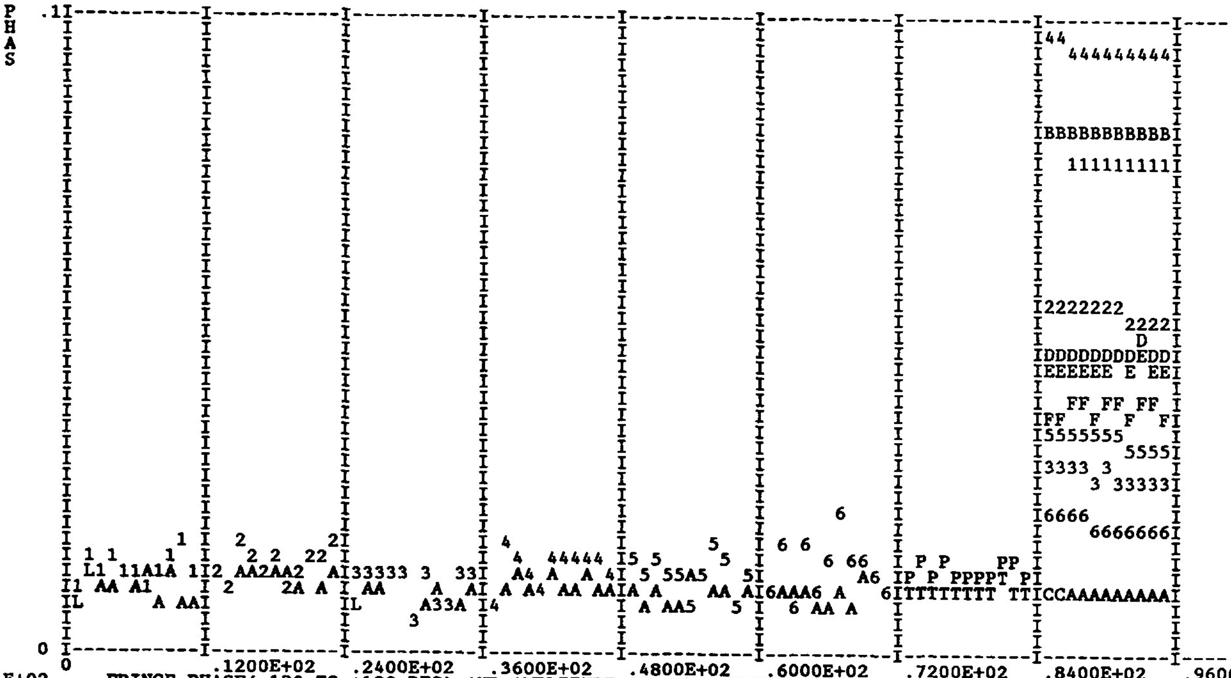


```
353-0009        FRQG X
19DEC.91      0234+285
VLBA LA -VLBA FD =XF
42.9  ELEV(DEG) 43.9
FILE<30009::43,22B 5
BN(FR/ASEC)=    77.68
BE(FR/ASEC)=    17.13
EXP TDE18     #  2270
STARTTIME 000952.000
STOP TIME 001216.000
INTG.TIME 134.000SEC
SEARCH WINDOW WIDTHS
SINGLB(=) 2.000000US
MULTIB(#)   .050000US
RATE  (X)      .250HZ
FREQ SB  INDEX#S CAL
 8150.95  1  2 36 34
 8170.95  3  4 36 37
 8230.95  5  6 33 35
 8410.95  7  8 33 34
 8510.95  9 10 32 30
 8550.95 11 12 32 29
```

50 kHz
φ cal.

```
PRG A910904 KSEL=004
AMP      10.359X.01%
SINGLBAND  .002310US
MULTIBAND -.013325US
FR.RATE   -.002654HZ
DC=  9.46% 148.00SEC
XP=.75E-04YP=.87E-04
XCRC=    0.YCRC=   1.
TDIS=    6.NDIS=  18.
DRVS 41  STAT= 000364
SNR     47.2MODE00001
.1280E+03
```

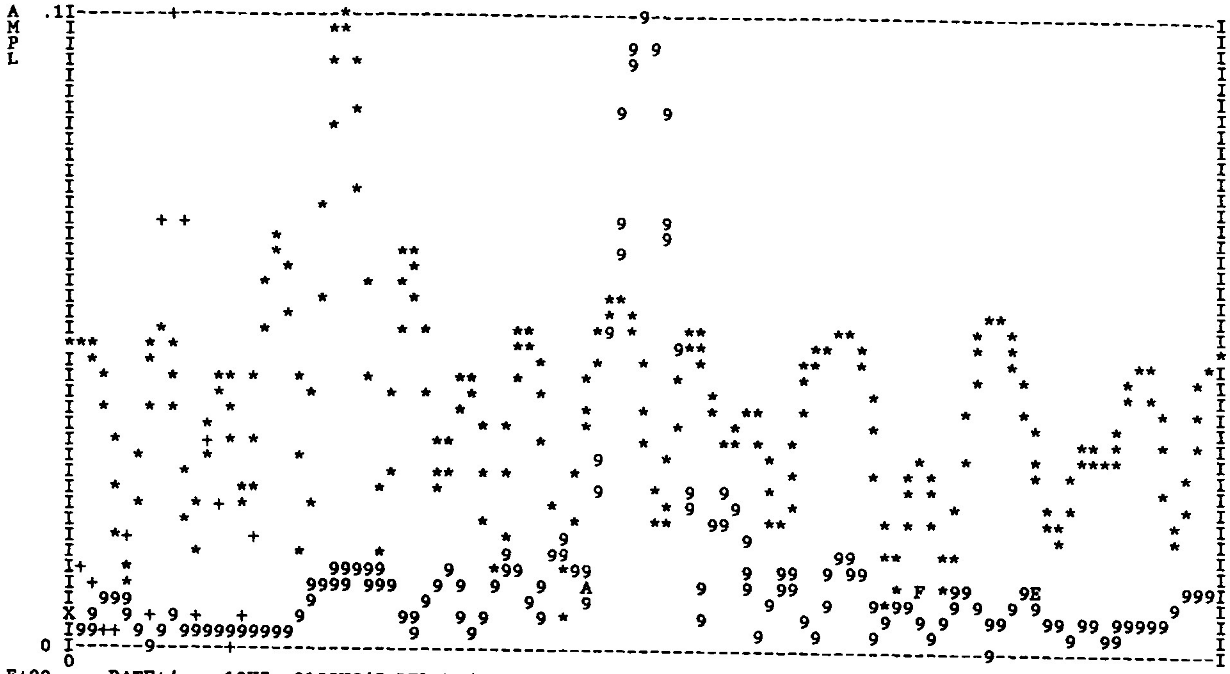
```
E+02     RATE+/-   .13HZ .0153NS/S DELAY+/-  .025US SRCH WIDTH(RATE,SBDLY)+/- RA   36.6,475.7 DEC207.9,104.9ASEC
# FREQUENCY EXT#(R,P) PRC#(R,P)  MS#(R,P)    REFERENCE   REMOTE TRKS  PARTNER      TRKS     FRQ#(R,P)#AP(R,P)COR#(R,P)OFFST(R,P)
 1   8150.95   4, 4 92017,92017  -189, -287  1=5E-05  4  1=5E-05  1 17=9E-05  8 17=5E-05  3   1, -2  29., 34.  401, 409   0,  0
 2   8170.95   4, 4 92017,92017   -42, -172  3=7E-05  5  3=1E-04  5 19=6E-05  3 19=1E-04 10   3, -4  34., 34.  402, 410   0,  0
 3   8230.95   4, 4 92017,92017  -239, -311  5=9E-05  7  5=5E-05  4 21=1E-04 10 21=6E-05  2   5, -6  33., 34.  403, 411   0,  0
 4   8410.95   4, 4 92017,92017  -300, -292  7=6E-05  5  7=1E-04  3 23=8E-05  5 23=2E-04  9   7, -8  34., 34.  404, 412   0,  0
 5   8510.95   4, 4 92017,92017  -233, -319  9=1E-04  3  9=2E-05  1 25=1E-05  1 25=1E-04  4   9,-10  34., 34.  405, 413   0,  0
 6   8550.95   4, 4 92017,92017  -196, -256 11=8E-05  5 11=5E-05  3 27=1E-04  6 27=9E-05  5  11,-12  34., 34.  406, 414   0,  0
#PTS SRCHED  .1311E+06 PRC 92017:1818 PROB OF FALSE DET .00E+00  PCALRATES(US/S) -.211E-07 .289E-08 MAX PER .10E-01 FS 20.00MHZ
```



```
353-0009        FRQG X
19DEC.91      0234+285
VLBA LA -VLBA FD =XF
42.9  ELEV(DEG) 43.9
FILE<30009::43,22B 5
BN(MHZ/ASEC)      .60
BE(MHZ/ASEC)    -3.42
EXP TDE18     #  2270
STARTTIME 000952.000
STOP TIME 001216.000
INTG.TIME 134.000SEC
SEARCH WINDOW WIDTHS
SINGLB(=) 2.000000US
MULTIB(#)   .050000US
RATE  (X)      .250HZ
FREQ SB  INDEX#S CAL
 8150.95  1  2 36 34
 8170.95  3  4 36 37
 8230.95  5  6 33 35
 8410.95  7  8 33 34
 8510.95  9 10 32 30
 8550.95 11 12 32 29

COREL#         000004
AMP      10.359X.01%
SINGLBAND  .002310US
MULTIBAND -.013325US
FR.RATE   -.002654HZ
PEXD=    0.PEYD=   0.
STATM 70202 CRCMSK04
SUPR=  14.PPUP=    0.
XSLP=    0.YSLP=    0.
TSLP=    0 ERCC=    2
ME   0      AP 0 LN 0
```

```
E+02      FRINGE PHASE(-180 TO +180 DEG) AND AMPLITUDE AS A FUNCTION OF TIME BY FRQ. CHANNEL      PCAL PHASES
            FRQ# 1 FRQ# 2 FRQ# 3 FRQ# 4 FRQ# 5 FRQ# 6 FRQ# 7 FRQ# 8 FRQ# 9 FRQ#10 FRQ#11 FRQ#12 FRQ#13 FRQ#14 ALL CH.00 PASS# 11
PHASE =     -132.0 -128.5 -140.2 -131.5 -134.2 -130.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0 -132.6  NSG=11
FR. AMPL      10.0   12.6    9.5   10.7    9.7    9.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   10.4  GHA=-20.6H
PCALPH1       98.8   14.3  -77.5  163.5  -58.2 -104.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP1= -69.0
PCALPH2     -145.5  116.0 -143.1   -6.2  -14.8  -40.2    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP2= -11.9
SBDBOX#        8.5    9.0    9.2    9.3    9.0    9.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    9.0  BW=2.00MHZ
PARAM FILE #F2270::61,    0 SRCH RNGE PARAMS  -.153356E-04  .153356E-04 -.250000E-01  .250000E-01 -.100000E+01  .100000E+01
GROUP DELAY USEC      -.273658970959D+03 APRIORI DELAY USEC     -.273645646412D+03 RESIDUAL DELAY USEC  -.133245E-01  +/- .21E-04
SNGLBAND DEL USEC     -.273643336649D+03 APRIORI CLOCK USEC     -.709000000000D+00 RESIDUAL DELAY USEC   .230976E-02  +/- .29E-02
PHASE DELAY USEC      -.273645691600D+03 APRIORI CLOCK US/S      .000000000000D+00 RESIDUAL DELAY USEC  -.451885E-04  +/- .41E-06
PHAS DEL RATE US/S    -.277138282930D-01 APRIORI RATE US/S      -.277135265850D-01 RESIDUAL RATE US/S   -.301708E-06  +/- .11E-07
TOTAL PHASE DEG     -126.0 ( 331.8)      APRIORI PHASE DEG              -353.4     RESIDUAL PHASE DEG   -132.6(-132.6)+/-  1.21
EPOCH HHMMSS.          1101. (*  1112. ) REF FREQUENCY MHZ              8150.95    AMP    10.359(   10.351)+/-   .219 QF= 9 QB=93.
RA  23752.406 DEC 284808.991      2000.0 APRIORI ACEL US/S/S  .552502090853D-05 REF.ST.CL.EPOCH MS   .329000E-03 TAPEQ=409408
RMS PH/SEG DG    3.5 RMS AMP/SEG %   6.8 RMS PH/FRQ DG   3.7 RMS AMP/FRQ %  10.4 TH.RMS     3.8     6.7    2.7    4.7  FPT 92018:2222
OUTPUT IN EXTENT#  22       82 RECS IN CR#  43             SEARCH AMP,INTRP AMP      9.665      9.857 ( 64X128) OPT 000005 SG=  0
```

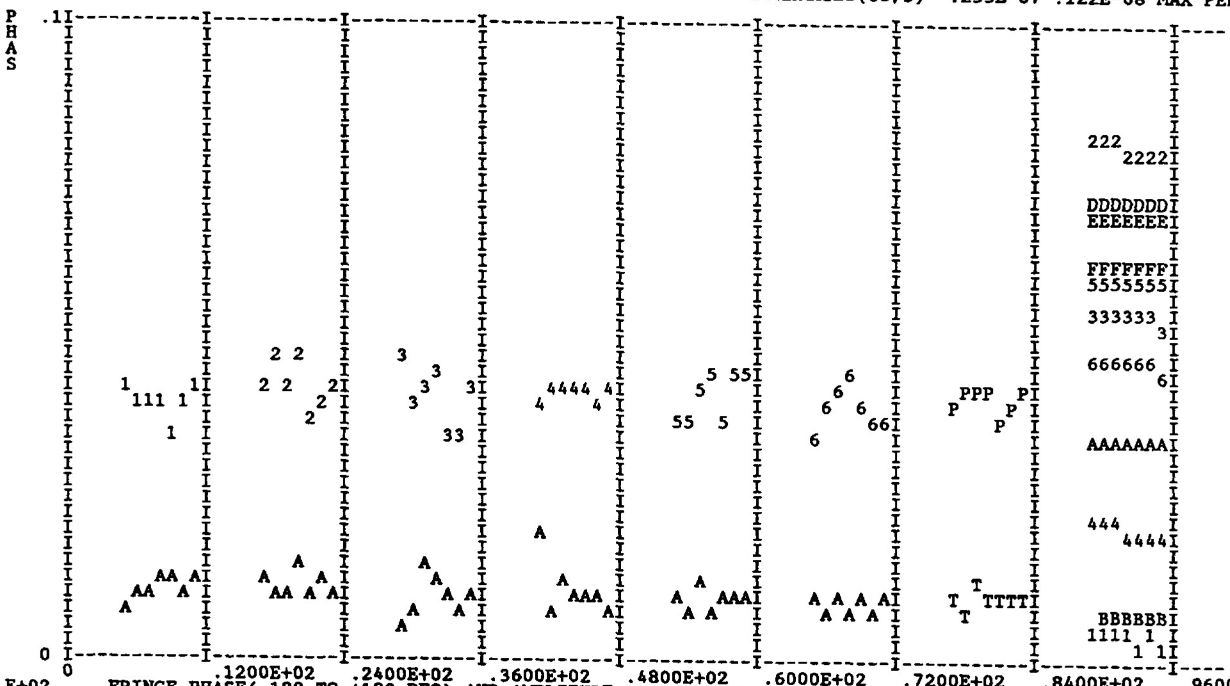



```
353-0007           FRQG X
19DEC.91         0234+285
VLBA_LA -VLBA FD =XF
42.4  ELEV(DEG) 43.4
FILE<30007::43,13B 5
BN(FR/ASEC)=       77.58
BE(FR/ASEC)=         67
EXP TDE18        #    70
STARTTIME 0007      00
STOP TIME 000940.000
INTG.TIME  80.000SEC
SEARCH WINDOW WIDTHS
SINGLB(-) 2.000000US
MULTIB(#)  .050000US
RATE  (X)      .250HZ
FREQ SB INDEX#S CAL
 8150.98  1  2 35 33
 8170.98  3  4 34 37
 8230.98  5  6 33 34
 8410.98  7  8 31 33
 8510.98  9 10 32 30
 8550.98 11 12 32 29
```

20kHz ϕ ca

```
PRG A910904 KSEL=004
AMP          10.959X.01%
SINGLBAND  -.000077US
MULTIBAND  -.013270US
FR.RATE    -.001938HZ
DC= 44.44% 144.00SEC
XP=.48E-04YP=.98E-04
XCRC=     0.YCRC=    1.
TDIS=     0.NDIS=   12.
DRVS 41 STAT= 000364
SNR      38.6MODE00001
.1280E+03
```

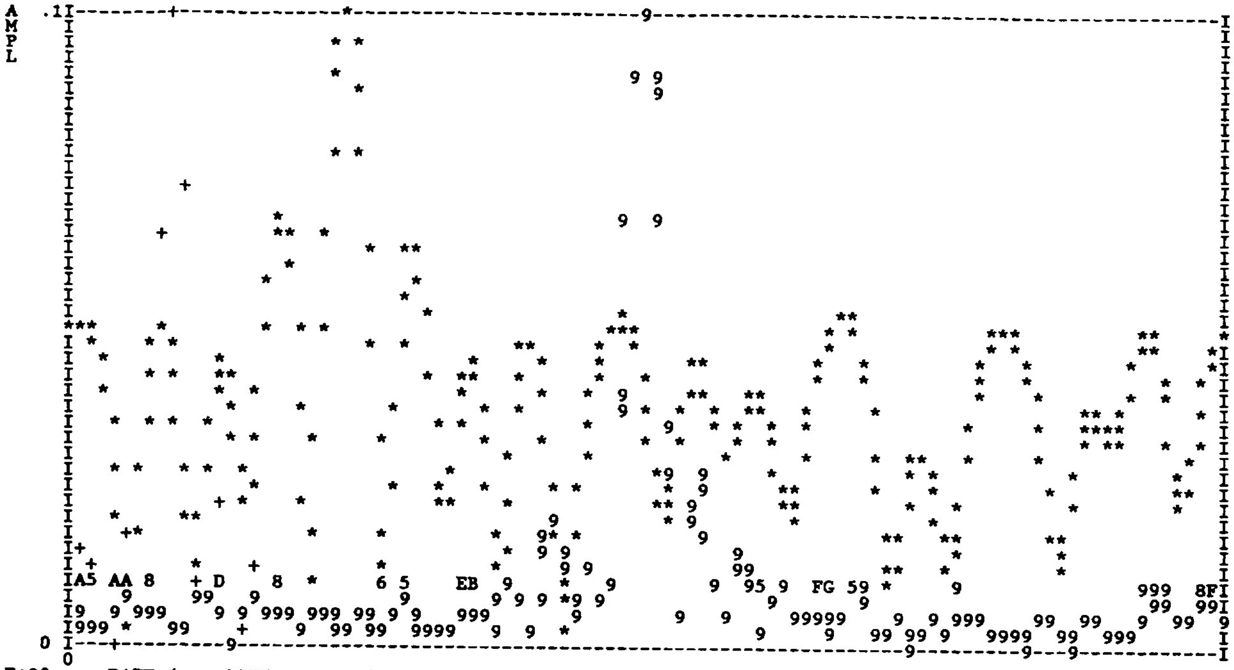
```
E+02      RATE+/-  .13HZ  .0153NS/S DELAY+/-  .025US SRCH WIDTH(RATE,SBDLY)+/- RA   36.8,461.4 DEC201.6,105.1ASEC
# FREQUENCY EXT#(R,P) PRC#(R,P)   MS#(R,P)     REFERENCE     REMOTE TRKS   PARTNER        TRKS       FRQ#(R,P)#AP(R,P)COR#(R,P)OFFST(R,P)
 1   8150.98  4, 4 92017,92017  -189, -287  1=7E-05  2   1=9E-05  3 17=6E-05  3 17=8E-05  3   1, -2   20., 20.  401, 409   0,  0
 2   8170.98  4, 4 92017,92017   -42, -172  3=4E-05  1   3=6E-05  0 19=4E-05  1 19=9E-05  2   3, -4   20., 20.  402, 410   0,  0
 3   8230.98  4, 4 92017,92017  -239, -311  5=1E-05  0   5=1E-04  6 21=3E-05  2 21=8E-05  2   5, -6   20., 20.  403, 411   0,  0
 4   8410.98  4, 4 92017,92017  -300, -292  7=6E-05  2   7=2E-04  5 23=6E-05  3 23=2E-04  3   7, -8   20., 20.  404, 412   0,  0
 5   8510.98  4, 4 92017,92017  -233, -319  9=6E-05  3   9=7E-05  3 25=3E-05  1 25=1E-04  4   9,-10   20., 20.  405, 413   0,  0
 6   8550.98  4, 4 92017,92017  -196, -256 11=8E-05  3  11=2E-05  0 27=3E-05  1 27=1E-04  2  11,-12   20., 20.  406, 414   0,  0
#PTS SRCHED  .1311E+06 PRC 92017:1812 PROB OF FALSE DET .00E+00  PCALRATES(US/S) -.233E-07 .122E-08 MAX PER .10E-01 FS 20.00MHZ
```




```
353-0007           FRQG X
19DEC.91         0234+285
VLBA_LA -VLBA FD =XF
42.4  ELEV(DEG) 43.4
FILE<30007::43,13B 5
BN(MHZ/ASEC)         .62
BE(MHZ/ASEC)          40
EXP TDE18        #    70
STARTTIME 00072     000
STOP TIME 000940.000
INTG.TIME  80.000SEC
SEARCH WINDOW WIDTHS
SINGLB(-) 2.000000US
MULTIB(#)  .050000US
RATE  (X)      .250HZ
FREQ SB INDEX#S CAL
 8150.98  1  2 35 33
 8170.98  3  4 34 37
 8230.98  5  6 33 34
 8410.98  7  8 31 33
 8510.98  9 10 32 30
 8550.98 11 12 32 29

COREL#            000004
AMP          10.959X.01%
SINGLBAND  -.000077US
MULTIBAND  -.013270US
FR.RATE    -.001938HZ
PEXD=     0.PEYD=    12.
STATM 70202 CRCMSK04
SUPR=     0.PPUP=     0.
XSLP=     0.YSLP=     0.
TSLP=     0 ERCC=      0
ME  0          AP 0 LN 0
```

```
E+02      FRINGE PHASE(-180 TO +180 DEG) AND AMPLITUDE AS A FUNCTION OF TIME BY FRQ. CHANNEL     PCAL PHASES
          FRQ# 1 FRQ# 2 FRQ# 3 FRQ# 4 FRQ# 5 FRQ# 6 FRQ# 7 FRQ# 8 FRQ# 9 FRQ#10 FRQ#11 FRQ#12 FRQ#13 FRQ#14 ALL CH.00 PASS# 11
PHASE =    -35.3  -27.3  -33.2  -29.4  -28.2  -36.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0  -31.5  NSG= 7
FR. AMPL    11.9   11.7   10.6   11.3   10.3   10.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   11.0  GHA=-20.7H
PCALPH1   -165.9  111.6   14.6 -104.6   37.2  -12.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP1= -65.0
PCALPH2    -57.0 -157.2  -54.9   82.8   69.1   48.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP2= -39.0
SBDBOX#      8.6    8.8    9.3    9.4    9.0    8.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    9.0  BW=2.00MHZ
PARAM FILE #F2270::61,   0 SRCH RNGE PARAMS  -.153356E-04  .153356E-04 -.250000E-01  .250000E-01 -.100000E+01  .100000E+01
GROUP DELAY USEC      -.269268471961D+03 APRIORI DELAY USEC   -.269255201775D+03 RESIDUAL DELAY USEC  -.132702E-01  +/-  .26E-04
SNGLBAND DEL USEC     -.269255278424D+03 APRIORI CLOCK USEC   -.709000000000D+00 RESIDUAL DELAY USEC  -.766497E-04  +/-  .36E-02
PHASE DELAY USEC      -.269255212524D+03 APRIORI CLOCK US/S    .000000000000D+00 RESIDUAL DELAY USEC  -.107497E-04  +/-  .51E-06
PHAS DEL RATE US/S    -.285738314853D-01 APRIORI RATE US/S    -.285736181893D-01 RESIDUAL RATE US/S   -.213296E-06  +/-  .22E-07
TOTAL PHASE DEG      -306.8 ( 175.6)     APRIORI PHASE DEG            -275.2     RESIDUAL PHASE DEG   -31.5( -31.5)+/-  1.48
EPOCH HHMMSS.           825. (*   904. ) REF FREQUENCY MHZ            8150.98     AMP    10.959(   10.987)+/-   .284 QF= 9 QB=100
RA  23752.406 DEC 284808.991      2000.0 APRIORI ACEL US/S/S    .550167544794D-05 REF.ST.CL.EPOCH MS    .329000E-03 TAPEQ=409405
RMS PH/SEG DG    5.9 RMS AMP/SEG %    9.9 RMS PH/FRQ DG    3.4 RMS AMP/FRQ %    6.3 TH.RMS    3.6    6.3    3.3    5.8  FPT 9201    26
OUTPUT IN EXTENT#  13     82 RECS IN CR#  43                   SEARCH AMP,INTRP AMP    10.519    10.519 ( 64X128) OPT 000005    0
```

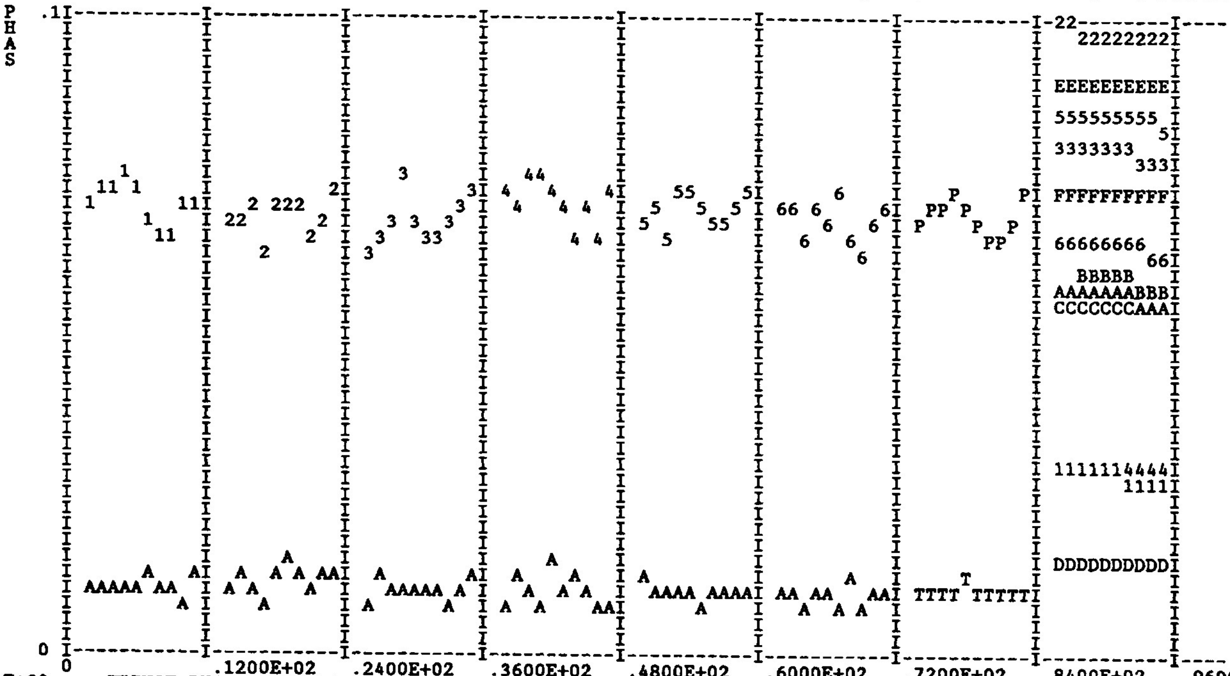


```
353-0004        FRQG X
19DEC.91      0234+285
VLBA LA -VLBA FD =XF
41.9  ELEV(DEG) 42.9
FILE<30004::43,13B 5
BN(FR/ASEC)=    77.48
BE(FR/ASEC)=    18.19
EXP TDE18     #  2270
STARTTIME 000444.000
STOP TIME 000704.000
INTG.TIME 120.000SEC
SEARCH WINDOW WIDTHS
SINGLB(=) 2.000000US
MULTIB(#)  .050000US
RATE  (X)      .250HZ
FREQ SB INDEX#S CAL
 8150.99  1  2 30 30
 8170.99  3  4 29 32
 8230.99  5  6 29 31
 8410.99  7  8 29 30
 8510.99  9 10 28 28
 8550.99 11 12 27 26
```

10kHz ϕ cal

```
PRG A910904 KSEL=004
AMP       10.574X.01%
SINGLBAND  .008411US
MULTIBAND -.013199US
FR.RATE    -.002224HZ
DC= 16.67% 144.00SEC
XP=.76E-04YP=.76E-04
XCRC=    0.YCRC=    0.
TDIS=    0.NDIS=    0.
DRVS 41 STAT= 000364
SNR      45.5MODE00001
.1280E+03
```

```
E+02     RATE+/-   .13HZ .0153NS/S DELAY+/-  .025US SRCH WIDTH(RATE,SBDLY)+/- RA   36.9,448.0 DEC195.7,105.2ASEC
# FREQUENCY EXT#(R,P) PRC#(R,P)  MS#(R,P)    REFERENCE   REMOTE TRKS  PARTNER       TRKS        FRQ#(R,P)#AP(R,P)COR#(R,P)OFFST(R,P)
 1   8150.99  4, 4 92017,92017  -189, -287  1=3E-05  2  1=8E-05  3 17=5E-05  3 17=8E-05  4   1, -2  30., 30.  401, 409   0,  0
 2   8170.99  4, 4 92017,92017   -42, -172  3=7E-05  4  3=3E-05  0 19=1E-04  3 19=9E-05  4   3, -4  30., 30.  402, 410   0,  0
 3   8230.99  4, 4 92017,92017  -239, -311  5=6E-05  2  5=5E-05  3 21=2E-05  1 21=7E-05  2   5, -6  30., 30.  403, 411   0,  0
 4   8410.99  4, 4 92017,92017  -300, -292  7=9E-05  5  7=1E-04  3 23=9E-05  4 23=6E-05  2   7, -8  30., 30.  404, 412   0,  0
 5   8510.99  4, 4 92017,92017  -233, -319  9=8E-05  4  9=2E-05  2 25=1E-04  8 25=2E-04  8   9,-10  30., 30.  405, 413   0,  0
 6   8550.99  4, 4 92017,92017  -196, -256 11=1E-04  7 11=3E-05  4 27=9E-05  4 27=9E-05  2  11,-12  30., 30.  406, 414   0,  0
#PTS SRCHED  .1311E+06 PRC 92017:1806 PROB OF FALSE DET .00E+00  PCALRATES(US/S) -.244E-07-.342E-08 MAX PER .10E-01 FS 20.00MHZ
```



```
353-0004        FRQG X
19DEC.91      0234+285
VLBA LA -VLBA FD =XF
41.9  ELEV(DEG) 42.9
FILE<30004::43,13B 5
BN(MHZ/ASEC)      .64
BE(MHZ/ASEC)    -3.39
EXP TDE18     #  2270
STARTTIME 000444.000
STOP TIME 000704.000
INTG.TIME 120.000SEC
SEARCH WINDOW WIDTHS
SINGLB(=) 2.000000US
MULTIB(#)  .050000US
RATE  (X)      .250HZ
FREQ SB INDEX#S CAL
 8150.99  1  2 30 30
 8170.99  3  4 29 32
 8230.99  5  6 29 31
 8410.99  7  8 29 30
 8510.99  9 10 28 28
 8550.99 11 12 27 26

COREL#          000004
AMP       10.574X.01%
SINGLBAND  .008411US
MULTIBAND -.013199US
FR.RATE    -.002224HZ
PEXD=    0.PEYD=    0.
STATM 70202 CRCMSK04
SUPR=    0.PPUP=    0.
XSLP=    0.YSLP=    0.
TSLP=    0 ERCC=    0
ME  0        AP 0 LN 0
```

```
E+02     FRINGE PHASE(-180 TO +180 DEG) AND AMPLITUDE AS A FUNCTION OF TIME BY FRQ. CHANNEL      PCAL PHASES
          FRQ# 1 FRQ# 2 FRQ# 3 FRQ# 4 FRQ# 5 FRQ# 6 FRQ# 7 FRQ# 8 FRQ# 9 FRQ#10 FRQ#11 FRQ#12 FRQ#13 FRQ#14 ALL CH.00 PASS# 11
PHASE =     72.3   67.2   66.9   74.4   70.4   66.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   69.5  NSG=10
FR. AMPL    10.9   12.0   10.7    9.8   10.4    9.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0   10.6  GHA=-20.7H
PCALPH1    -76.4  173.2  105.0  -71.8  124.9   52.2    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP1= -65.0
PCALPH2     22.6   31.2   18.5 -128.2  147.1   79.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0         EP2= -19.0
SBDBOX#      8.6    9.0    9.3    9.5    9.0    9.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    9.1  BW=2.00MHZ
PARAM FILE #F2270::61,   0 SRCH RNGE PARAMS  -.153356E-04  .153356E-04 -.250000E-01  .250000E-01 -.100000E+01  .100000E+01
GROUP DELAY USEC       -.264744069056D+03 APRIORI DELAY USEC   -.264730869805D+03 RESIDUAL DELAY USEC  -.131993E-01  +/- .22E-04
SNGLBAND DEL USEC      -.264722459236D+03 APRIORI CLOCK USEC   -.709000000000D+00 RESIDUAL DELAY USEC   .841057E-02  +/- .30E-02
PHASE DELAY USEC       -.264730846122D+03 APRIORI CLOCK US/S    .000000000000D+00 RESIDUAL DELAY USEC   .236826E-04  +/- .43E-06
PHAS DEL RATE US/S     -.294302641550D-01 APRIORI RATE US/S    -.294300123339D-01 RESIDUAL RATE US/S   -.251821E-06  +/- .12E-07
TOTAL PHASE DEG     -172.6 ( 333.4)       APRIORI PHASE DEG              -242.1   RESIDUAL PHASE DEG     69.5(  69.5)+/-  1.26
EPOCH HHMMSS.           549. (*    608. ) REF FREQUENCY MHZ              8150.99  AMP    10.574(    10.618)+/-    .232 QF= 9 QB=100
RA  23752.406 DEC 284808.991       2000.0 APRIORI ACEL US/S/S  .547761809027D-05 REF.ST.CL.EPOCH MS     .329000E-03 TAPEQ=409407
RMS PH/SEG DG   6.7 RMS AMP/SEG %   7.9 RMS PH/FRQ DG   3.1 RMS AMP/FRQ %   7.4 TH.RMS     3.8   6.6   2.8   4.9  FPT 92017:1820
OUTPUT IN EXTENT#  13     82 RECS IN CR#  43                SEARCH AMP,INTRP AMP     9.606    9.766 ( 64X128) OPT 000005 SG=  0
```