VLBA Acquisition Memo # 50

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21 August 1985

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TO: VLBI Data Acquisition Group

FROM: A. E. E. Rogers

SUBJECT: VLBA Bandpass and Closure Phase Errors

In acquisition memo #48 I suggested the use of Butterworth 7-pole low pass filters. Figure 1 shows the pole locations for 3 basic types of low pass filter. Figure 2 shows the amplitude and group delay characteristics of 7 and 8 pole Butterworth and Chebyschev 0.1 dB ripple filters. The Bessel filter has maximally flat delay but has an unacceptably poor bandpass shape which results in a very high foldover loss. The table below shows the closure phase errors, ripple and foldover loss:

	CLOSURE PHASE ERRORS (Deg)					
FILTER TYPE	10% Fringe Rate[1]	10% Filt. Error[2]	10% All Pass err[3]	RIPPLE[4]	FOLDOVER Loss %[5]	Shape Factor Loss %[6]
7-pole Butterworth	0.12	0.12	0.001	max.flat	2.0	1
8-pole Butterworth	0.13	0.18	0.001	max.flat	1.6	0.5
7-pole Ch.0.1 dB	0.60	0.59	0.001	0.1 dB	1.3	0.1
8-pole Ch.0.1 dB	1.10	1.67	0.001	0.1 dB	0.6	0.1
6-pole Ch.0.005 dB[7]	0.18	0.23	0.001	0.005 dB	1.6	0.3

NOTES:

1.) Closure phase errors which result from bandpass offsets due to 10% fringe rate (i.e., 800 KHz in 8 MHz BW). [Assuming the lower 5% of the bandpass is high pass filtered in the data processing.] This error is approximately proportional to the fringe rate squared on the baseline with the largest fringe rate and goes to zero if the fringe rate on any baseline of the triangle is zero.

2.) Closure error which results from differences between filters of 10% (the highest Q pole being most critical). As the table shows the Butterworth filter is much less sensitive to component differences.

3.) Errors in the all pass filter phases have very little effect on closure phase because closure phase errors are proportional to all pass phase errors cubed.

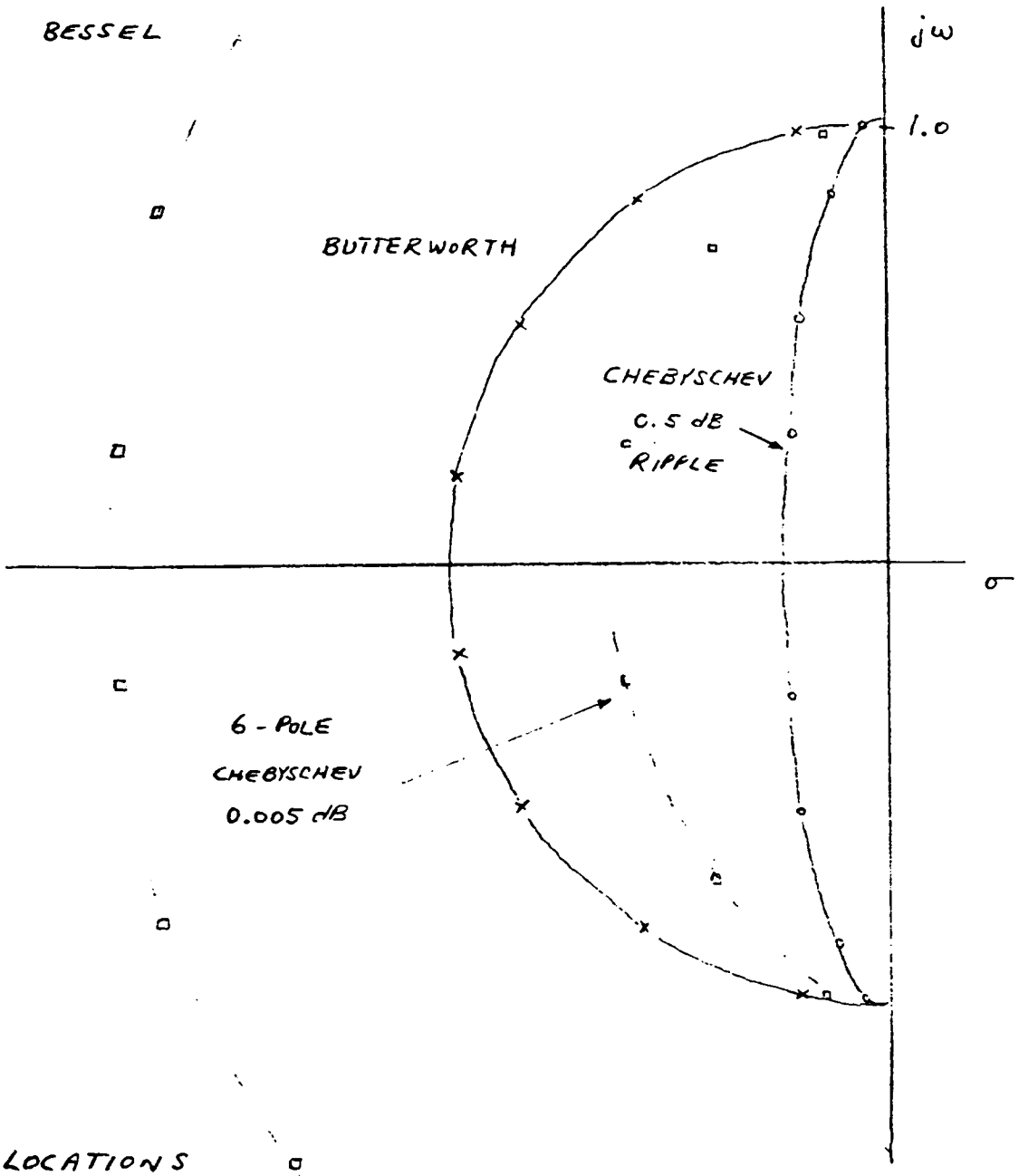
4.) The Chebyschev filters have some ripple - but have a better bandpass without the high frequency "droop" of the Butterworth.

5.) Loss due to energy which is folded in sampling.

6.) Continuum loss due to shape of bandpass which results in a reduced effective bandwidth. (For 2-level sampling the loss is a minimum because the reduced bandwidth is compensated to some degree by an effective oversampling gain.)

7.) A 6-pole filter which has only slightly higher component sensitivity than Butterworth filter while retaining a good shape factor with fewer components.

AEER/kw



POLE LOCATIONS

LOW PASS FILTERS

Figure 1.

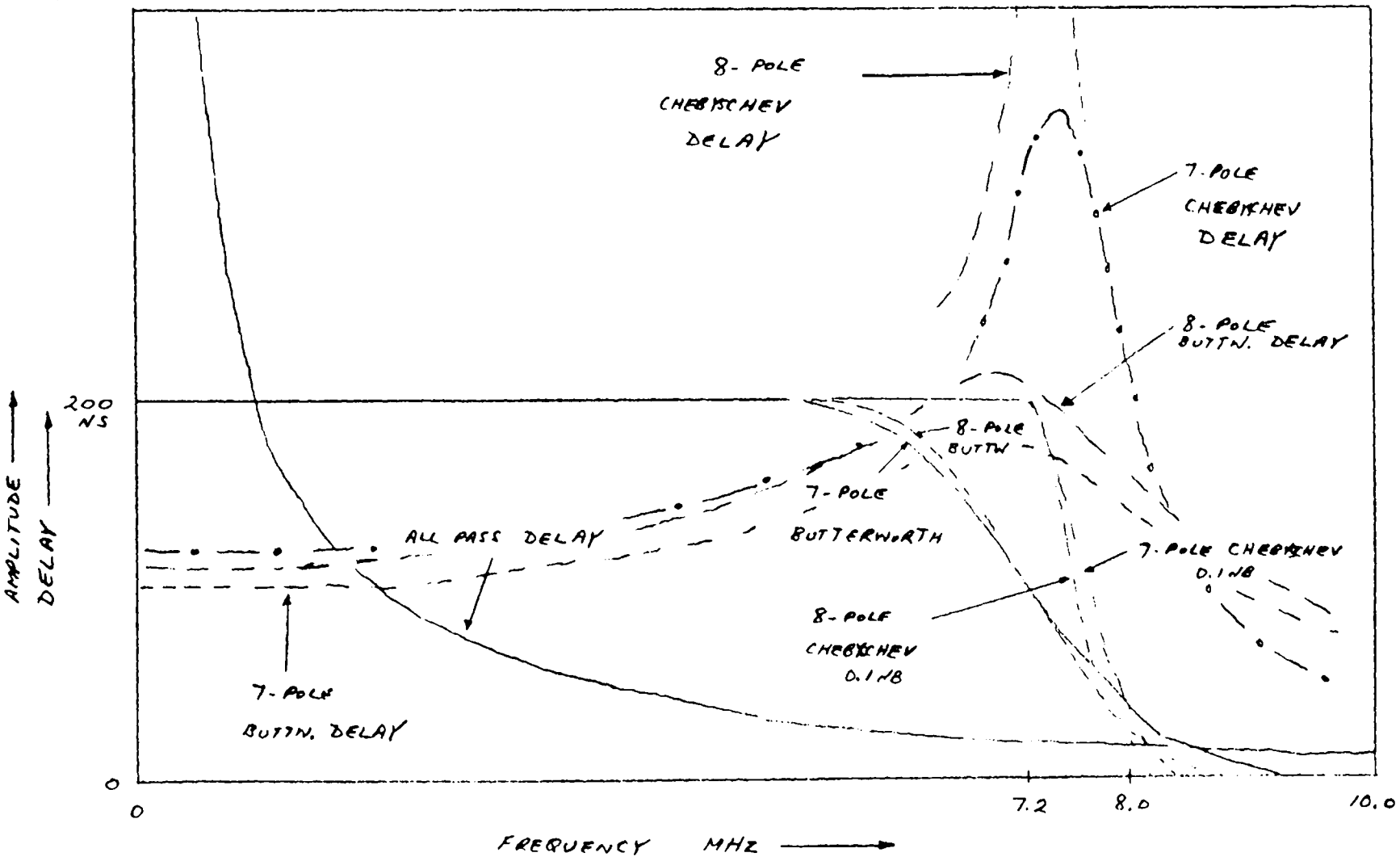


FIGURE 2 BANDPASS + DELAYS