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To: VLBA Data Acquisition Group

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Subject: Improved 16 MHz Bandpass and Further Tests of the Bandpass Stability

The major deficiency in the 16 MHz bandpass of the prototype converter was that the 3dB point was about 15% too low in frequency. This has been corrected by increasing the number of bits in the bandwidth control from 7 to 8.

1] Original 7-bit Design

In the original 7-bit design each bit increased the bandpass by a factor of 2 with ØH corresponding to 62.5 KHz, 4ØH to 8 MHz and 7FH to 16 MHz. Owing to the delay through the NE5539 operational amplifiers, the weight of each bit is reduced at large bandwidths and hence every combination of bits is always less than 16 MHz unless the weight of a bit is made to exceed one of the narrower bandwidths.

2] Modification to 8-bit Control

With 8-bits there is sufficient flexibility to allow every bandwidth to be covered. In fact with bits weighted so that

2***N = BW-62.5 KHz

The most significant bit has a weight of 15.9375 MHz and if it were not for the reduced weight of each bit at wide bandwidths a range of 62.5 KHz to 31.4 MHz could be covered. In practice, making the MSB have a weight of 15.9 MHz results in a value of resistance (5Ø ohms) which is too close to the series resistance of the switch. Scaling all resistors up results in values of capacitance that are too small. The solution is to taper the three most significant bits so that they have values which increase by less than a factor of two. Table 1. shows the chosen weights and Table 2. gives the codes for the standard bandwidths. Non-standard bandwidths can be synthesized and standard values can be matched by digitally trimming the bandwidths.

3] Modifications Required to Implement Changes

The active filter sections were originally designed for 8-bits (with the two most significant bits being connected together in the control circuit) so that the only changes needed here are the modification of the resistor value for the MSB from 133 ohms to 6Ø ohms. The digital control circuits need minor modification to accommodate the extra bits. The modification has been performed on converter #1. Serial numbers 2 through 4 are presently in DAR #1 and can be modified with a few hours work. A new P.C. board will be designed for the first converters to go into DAR #3. P.C. boards for DAR #2 will have to be modified.

4] Figure 1. shows bandpasses after modification of BB #1. The 3 dB points all line up (within 2%) quite well compared with those in Acquisition Memo #69 for which the 3 dB points do not line up so well.

BIT #	WØ MHZ	W1 MHZ	W2 MHZ
Ø	Ø.Ø625	Ø.Ø625	Ø.Ø625
1	Ø.1875	Ø.1875	Ø.1875
2	Ø.4375	Ø.4375	Ø.4375
3	Ø.9375	Ø.9375	Ø.9375
4	1.9375	1.9375	1.84
5	3.9375	3.9375	3.51
6	7.9375	3.9375	3.51
7	15.9375	7.9375	6.35
RANGE	31.4375	2Ø.Ø	16.8

WØ = weights for maximum bandwidth range.
W1 = weights chosen.
W2 = approximate effective weights with op.amp. delay taken into account.

Table 1. Weights of each bit in bandpass selector.

Standard Bandwidth MHz	Code
Ø.Ø625	ØH
Ø.125	1H
Ø.25Ø	2H
Ø.5ØØ	4H
1.ØØ	8H
2.ØØ	11H
4.ØØ	24H
8.ØØ	6FH
16.ØØ	FBH

Table 2. Codes for standard bandwidths (3 dB point equal to 9Ø% of the standard bandwidth value)

5] Bandpss Stability

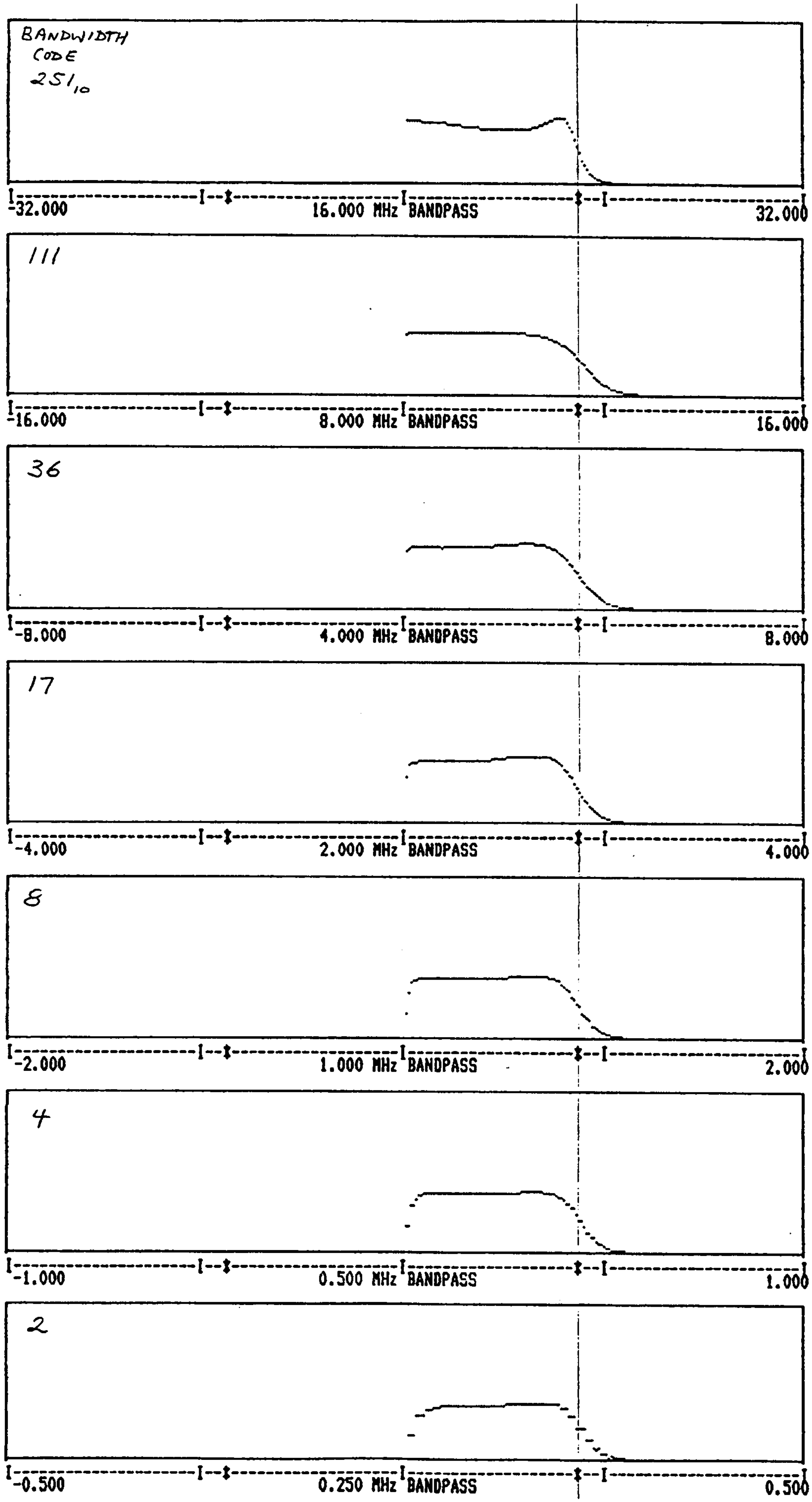
Bandpass drift will occur if ambient temperature of the active filters changes. Since the voltages supplied to the active filters are well regulated changes in A.C. power have a negligible effect on the bandpass curves. Figure 2. shows the temperature coefficient for phase and amplitude as a function of bandwidth and frequency within a fixed bandpass. Most of the phase change with temperature at bandwidths wider than 1 MHz is the result of the variation of drain to source resistance (0.15 ohms/deg C) in the FET switches which control the bandwidth.

6] Estimates of Instrumental Closure Phase Errors

The bandpass variation with temperature is approximately equivalent to a shift in 3dB frequency. At 16 MHz bandwidth the equivalent frequency shift is -0.1% per deg. C. In Acquisition Memo #50, it was shown that a 10% frequency shift produces an instrumental closure phase of 0.2 degrees. For small phase mismatch the closure phase is proportional to the phase mismatch cubed. Thus instrumental closure phases can be maintained less than 0.1 degrees provided the equivalent frequency shift of the 3dB point is kept below 8% between units. Typical variations between filters (without careful trimming by setting codes which are serial number dependent) are 5% peak to peak. Without frequency trimming or software correction of bandpass phases in the processor the instrumental closure errors should be less than 0.03 degrees and virtually independent of temperature. With frequency trimming or software correction the instrumental closure errors should be less than 0.0002 degrees for temperature variations under 10 deg. C even at 16 MHz bandwidth and even less at narrower bandwidths.

7] Conclusion

Bandpass variations in units which are operating correctly should not result in any significant closure errors. However, the active filter is more complex than an individual passive filter and component failure can lead to subtle errors. For example, if an FET switch section should fail, bandpasses will be distorted. The solution is to provide software for checking bandpasses in the field in order to identify units which malfunction.



REJECTED SIDEBAND SCALED UP BY 10 dB __TIME=18:52:51 11/08/87 SLOT# 31 FREQ=_520

FIGURE 1.

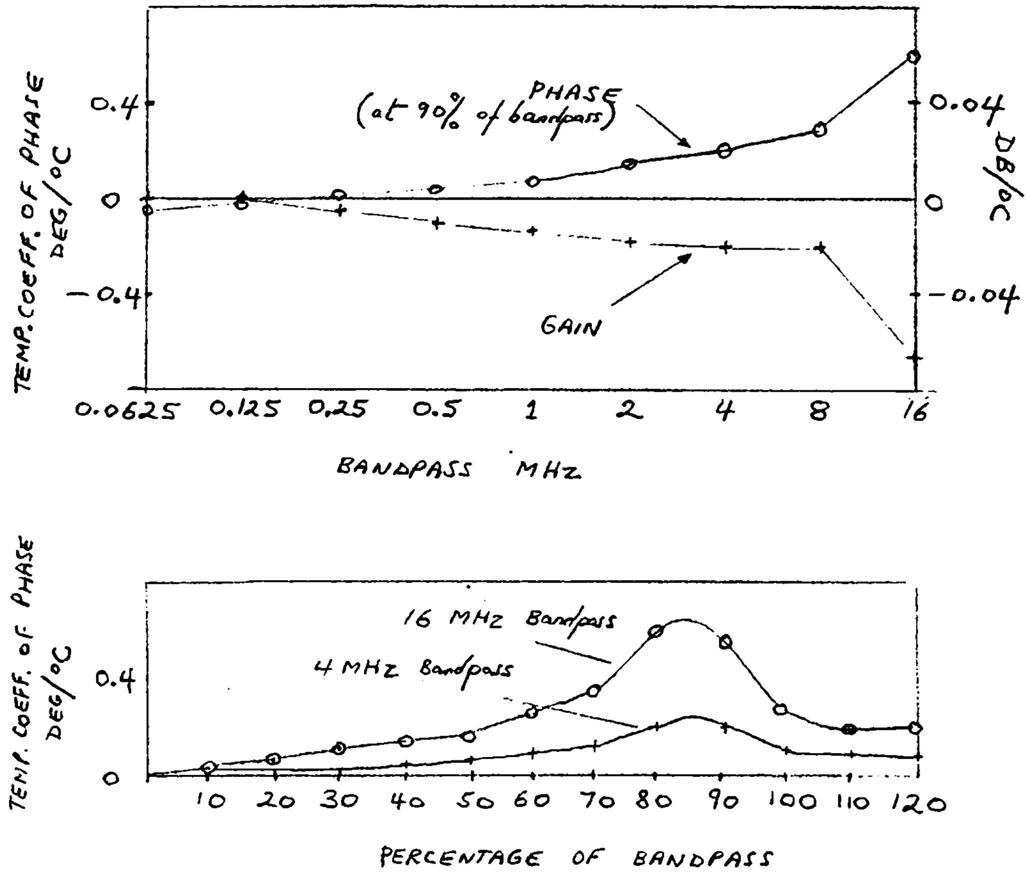


FIGURE 2. TEMPERATURE COEFFICIENTS OF PHASE AND AMPLITUDE

Notes:

1] Positive temp. coeff. of phase = increasing delay with temperature

2] Negative temp. coeff. of gain = decreasing gain with temperature

3] Max. phase temp. coeff. (after removal of 0.1 ns/°C delay drift) of 80% of bandpass

BW	Max. phase temp. coeff. deg/°C
16 MHz	0.20
8 MHz	0.08
4 MHz	0.05
2 MHz	0.02