7.1C SIDELOBE REDUCTION OF BARKER CODES

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Barker codes are simple and inexpensive to implement. In the absence of large and fast computers they can be realized as simple digital preprocessors, or with the use of a delay line, can be realized as an analogue device. Assuming the process observed has an autocorrelation time that is long compared to the code length, a gain in signal to noise, G = N where N is the number of elements in the code, may be realized.

Typically Barker codes are implemented by shifting the phase of the transmitted signal by 0 or 180 degrees according to the code pattern. The known Barker codes are shown in Figure 1a. A typical detection scheme is shown in Figure 1b where the output of the radar receiver is delayed by an analogue delay line or a shift register. The signal in each element of the delay line or shift register is continuously multiplied by the code and all elements are summed.

A principal disadvantage has been the sidelobe response (FARLEY, 1983). In the case of MST or ST radar echoes where there is a dynamic range as large as 60 dB, these unwanted sidelobes cause an increase in the apparent width of atmospheric layers, or some narrow layer to appear at several altitudes. In Table 1 it can be seen that the main lobe to peak sidelobe ratio (PSR) varies from 9.54 dB, for a code of N = 3 to 22.28 dB, for a code of N = 13.

The sidelobes of a Barker code may be reduced by tapering the response of the decoder. Optimum tapers, from BLINCHIKOFF and ZEREV (1976), are shown in Table 2. This tapering is achieved by multiplying the delayed signal elements in Figure 1b by the specified coefficients rather than ±1. The results are shown in Table 1 where G and the PSR are listed for no tapering and optimum tapering. It can be seen that the sidelobe response has been greatly reduced with very little loss in G.

This tapering can be readily achieved in a digital computer with sufficient word length, but difficult to realize in an analogue filter because of the small changes in the coefficients. An alternative is to have one coefficient for A_0 and another for $A_1 \ldots A_N$. These are shown in Table 3 (BLINCHIKOFF and ZEREV, 1976). As can be seen in columns 5 and 6 of Table 3, this simplification works surprisingly well, since there is only a very small increase in the PSR and a corresponding small decrease in G.

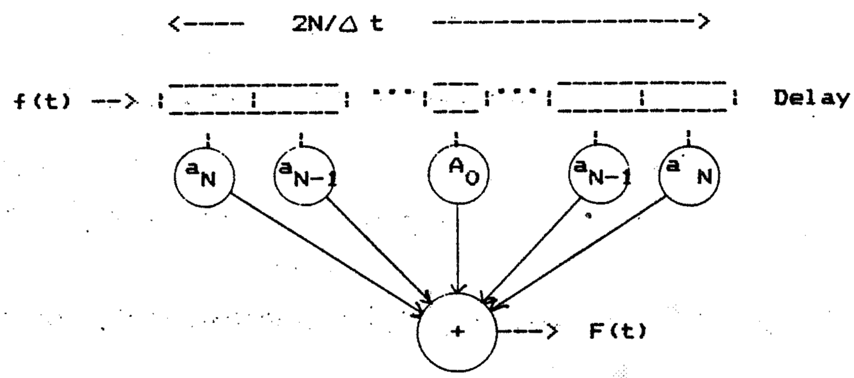
REFERENCES

Blinchikoff, H. J. and A. I. Zerev (1976), Filtering in the Time and Frequency Domains, 353-368, Wiley, New York.

Farley, D. T. (1983), Pulse compression using binary phase codes, Handbook for MAP Vol. 9, 410-413, SCOSTEP Secretariat, Dep. Elec. Eng., Univ. IL, Urbana.

N (code Length)	Code Elements
2	+ −
3	+ + −
4	+ + − + (+ + + −)
5	+ + + − +
7	+ + + − − + −
11	+ + + − − − + − − + −
13	+ + + + + − − + + − + − +

a)



b)

Figure 1. a) Known Barker codes; b) Matched filter for Barker codes.

Table 1: Comparison of nontapered Barker code realizations to optimum, and modified tapering

	PSR			G		
N	Matched	Opt S L Suppress	Mod S. L. Suppress	Matched	Opt S L Suppress	Opt S L Suppress
3	9.54 dB	20.00 dB	20 dB	4.77 dB	4.20 dB	4.2 dB
5	13.98	25.63	25.1	6.99	6.66	6.62
7	16.90	23.00	21.58	8.45	8.15	7.55
11	20.83	25.85	23.86	10.41	10.22	10.10
13	22.28	34.79	33.98	11.14	11.03	10.99

Table 2: Optimum tap weights normalized for peak output of unity (odd tap weights are zero)

Tap	N = 3	N = 5	N = 7	N = 11	N = 13
a_0	0.4	0.22093	0.163084	0.100177	7.97249×10^{-2}
a_2	0.1	-0.023256	0.026687	0.119006	-2.391476×10^{-3}
a_4		-0.029069	0.023721	0.0111222	-2.67558×10^{-3}
a_6			0.020386	0.010267	-2.941092×10^{-3}
a_8				9.33984×10^{-3}	-3.186169×10^{-3}
a_{10}				8.348125×10^{-3}	-3.409138×10^{-3}
a_{12}					-3.60843×10^{-3}

Table 3: Realization with all tap weights equal except a_0 (all odd tap weights set to zero)

N	a_0	$a_{2..N}$	$:a_0/a_N:$	PSR	SNR
3	0.4	0.1	4	20 dB	4.2 dB
5	0.222	-0.277	8	25.1	6.62
7	0.166	0.277	6	21.58	7.25
11	0.102	0.128	8	23.86	10.99
13	0.080	-3.33×10^{-3}	24	33.98	10.99