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OPTIMAL FIR-FILTER DESIGN SUBJECT TO INEQUALITY CONSTRAINTS BY MEANS OF THE COMPLEMENTARITY ALGORITHM

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For an optimal design of digital FIR filters a new method is proposed. On the base of the equations for FIR filters with linear phase the idealized frequency response is approximated via a least-squares solution with inequality constraints (ICLS-solution). The advantages of this method are:

(i) one obtains optimal impulse response coefficients in the sense of an idealized frequency approximation,

(ii) it can be used easily for the design of optimal two-dimensional FIR filters.

While the design of optimal Chebyshev FIR filters makes use of the REMEZ Exchange Algorithm, efficient algorithms for the ICLS-solution are available, too, particularly those of [1] and [5], as described by [6]. The extension of the REMEZ Exchange Algorithm for a two-dimensional frequency approximation is difficult so that point (ii) is an important feature of this method.

The approximation problem of an idealized frequency response with an ICLS-solution is solved by means of Lemke's linear complementarity algorithm. This procedure differs completely from that of [3,4] developed for a similar case; confer also with [2]. The application is demonstrated by the following example.

Example: Design of a 24-point linear phase lowpass filter with passband cutoff frequency of 0.08 and stopband cutoff frequency of 0.16 and ripple ratio of 1.0.

Table 1 shows the solutions of the impulse response and their confrontation with the optimal Chebyshev solution taken from [7] (including the run time on a PDP11 64 KByte computer). The ICLS-solution was obtained from a simple least-squares solution (LS-solution) by add of 18 inequality constraints within the frequency response.

Parts of the frequency response of the LS- and ICLS-solution are figured in Fig.1.

As shown by table 1 and Fig.1b the ICLS-solution comes up to an optimal Chebyshev solution.

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Table 1: Solutions for the impulse response

	LS-solution	ICLS-solution	Chebyshev solution	
h(1)	0.004544	0.005068	0.003374	h(24)
h(2)	0.009389	0.010702	0.014938	h(23)
h(3)	0.010116	0.011664	0.010569	h(22)
h(4)	0.002094	0.003090	0.002542	h(21)
h(5)	-0.014654	-0.014728	-0.015930	h(20)
h(6)	-0.032364	-0.033422	-0.034085	h(19)
h(7)	-0.036970	-0.038406	-0.038112	h(18)
h(8)	-0.014707	-0.015820	-0.014629	h(17)
h(9)	0.039111	0.038705	0.040090	h(16)
h(1o)	0.114442	0.114694	0.115407	h(15)
h(11)	0.188270	0.188900	0.188507	h(14)
h(12)	0.234014	0.234774	0.233546	h(13)
	Band 1	Band 2		
Lower band edge	0.00	0.16		
Upper band edge	0.08	0.50		
Desired value	1.00	0.00		
Weighting	1.00	1.00		
Deviation $\lvert\delta_{max}\rvert$ for the solutions above:				
	0.023182	0.012500	0.012434	
Time:	60 [sec]	75 [sec]	140 [sec]	

Fig. 1: Parts of the frequency response