1. Examples of multirate filterbank responses

C. H. Oh and P. M. Grant

These simulations show the comparative responses for filterbanks with different numbers of coefficients in the constituent filters in an 8-channel filterbank. This provides further justification for the comments on frequency response made in the accompanying textbook.

This first figure shows the responses when employing identical lengths or number of taps in each FIR filter in the tree structure.

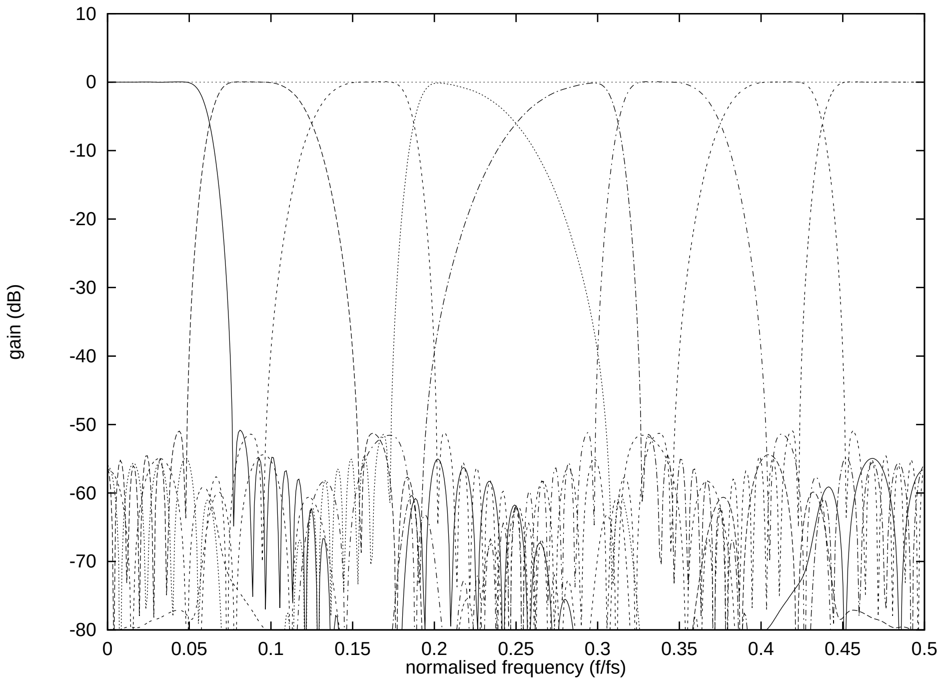

Figure 1 8-channel filterbank designed as in Figure 11.13 with 31-coefficient filters in each of the stages.

This is fine for some of the filters, such as the lowest frequency response, but for others, e.g. H_3, H_4, the cut-off is not sharp enough. As we have decimated by two at the output of the first stage, we must reduce the number of coefficients in the following stage by two to achieve the required constant relative bandwidth design. If we retain the 31-coeficcient design in the high sample rate stage, as shown below, this actually makes the overall response much worse. We have caused the filterbank to loose the previous rectangular passband response as the filters are of insufficient complexity and the short impulse response filters also have an inferior stopband rejection.

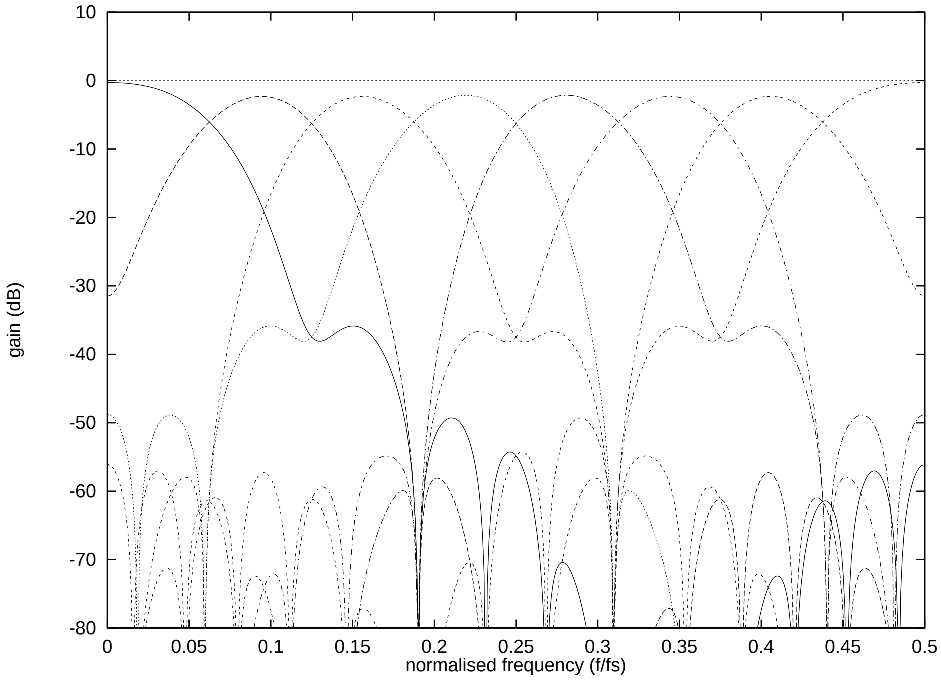

Figure 2 Filterbank redesigned with 31-coefficient filters in first stage, 15-coefficient filters in second stage and only 7-coefficient filters in the third stage.

The solution we require is to employ a much larger complexity filter in the high sample rate stage so that when the number of coefficients following each decimation operation is halved the complexity of the final stage is sufficient to achieve the required overall frequency response, see below. Now we have retained the same absolute roll-off at each of the filter edges in the filterbank design and achieved a more practical filter shape.

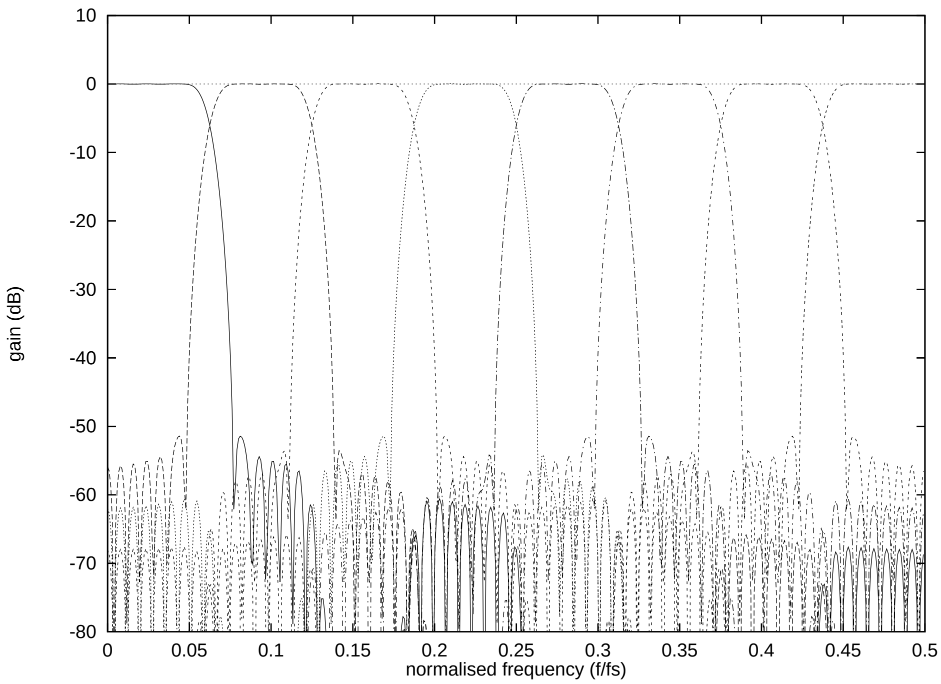

Figure 3 Redesign with 127-coefficient filters in first high sample rate stage, 63-coefficient filters in

second stage and 31-coefficient filters in the third or final stage.

This next simulation shows the results from designing a nonlinear spaced filterbank with identical filters at each stage in the tree.

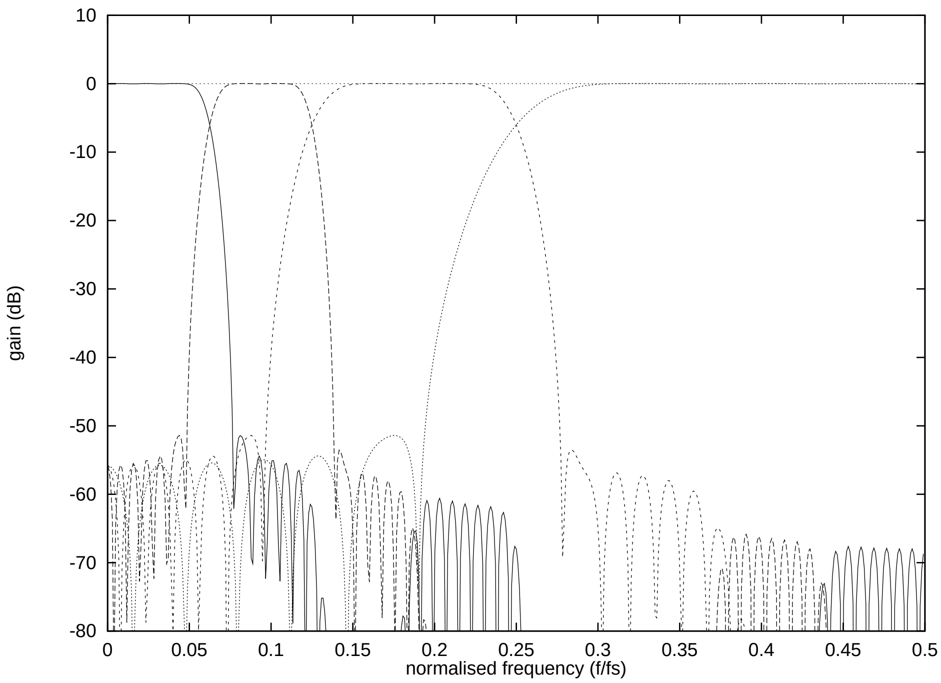

Figure 4 Frequency response of a nonlinear spaced filterbank with 31-coefficient filters in each stage.

We could improve the filter performance here to achieve a constant relative bandwidth design by increasing the complexity of the early stages, as above.

Reference

C.H. Oh, "Advanced Spectrum Analyser Simulation", B.Eng. Honours Project Report, HSP 1354, University of Edinburgh, May 1998.