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APPLICATION NOTE NO. 354

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A SIMPLE (SIMPLEST?) SIDE-TRACKING FILTER

An interesting type of analog adaptive filter is the "side-tracking filter" [1-3]. The original forms of this filter involved the use of three filters in parallel (e.g., Fig. 1). The center filter was the working filter. We wanted this filter to track certain input conditions (usually the input frequency) automatically. Whether or not a particular change (i.e., moving the cutoff frequencies up or down) was desirable was determined by the performance in the side filters which were tuned slightly off of the center. Feedback circuitry then adjusted the tuning of the center filter to more optimal values when appropriate.

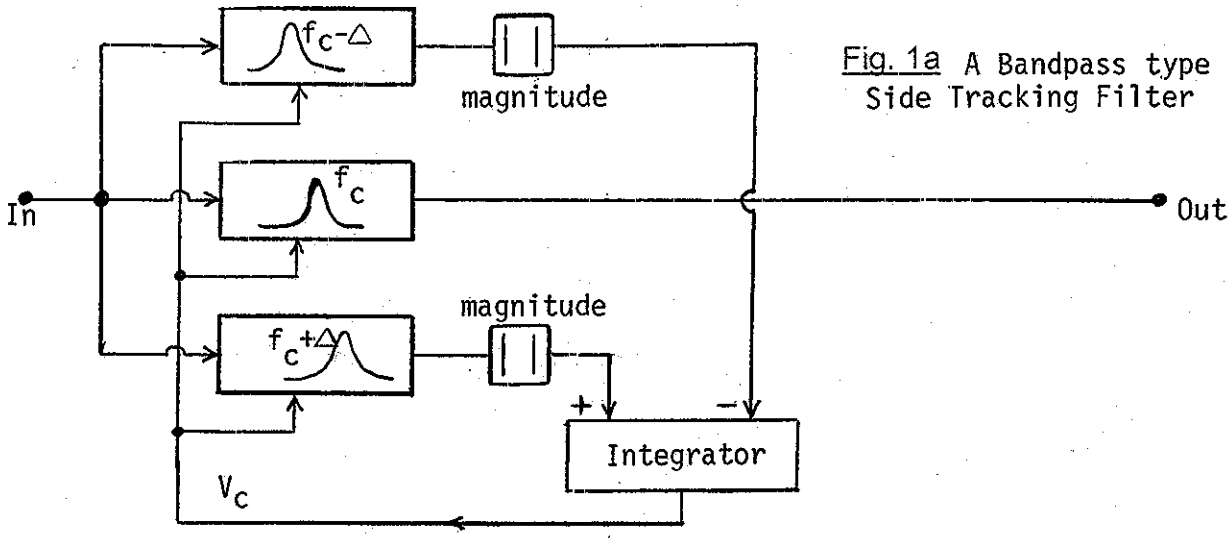

Fig. 1a A Bandpass type Side Tracking Filter

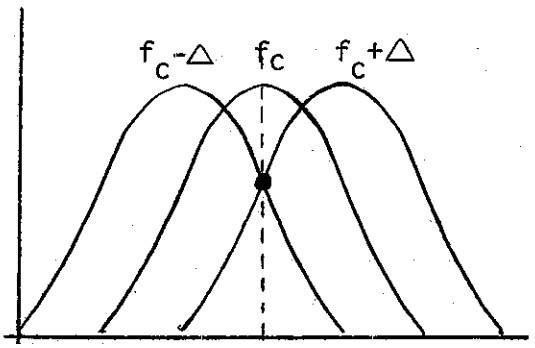

Fig. 1b Side channels in balance used to hold center channel in proper position.

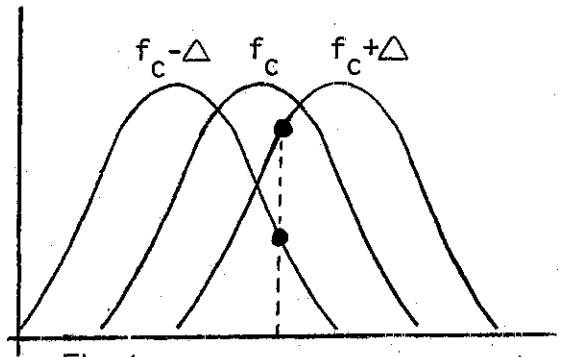

Fig. 1c If input moves upward as shown, side channels are no longer in balance, and differential integrator ramps upward.

Fig. 1b and Fig. 1c shows a set of three bandpass responses. We note that when the center filter is not on the input frequency (Fig. 1c), that the levels in the side filters are out of balance, and that balance returns only if all three filters move so that the response tracks the input frequency (Fig. 1b). Typically, the levels in the side channels were rectified and differentially integrated to provide the correction signal in the correct sense [2, 3].

Since our filters were generally adjusted though voltage-control, and since a favorite approach to voltage-control was through use of a state-variable filter, the notion of using the simultaneous low-pass and high-pass of the central channel (one VCF) in lieu of actually building three VCF's was attractive (Fig. 2).

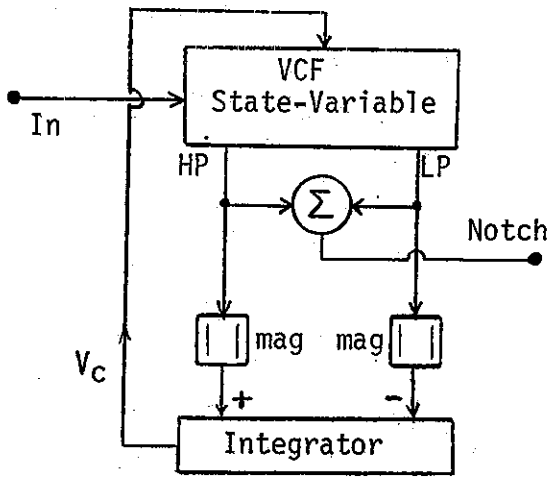

Fig. 2a A single VCF state variable filter may be used to do its own side-tracking under certain circumstances.

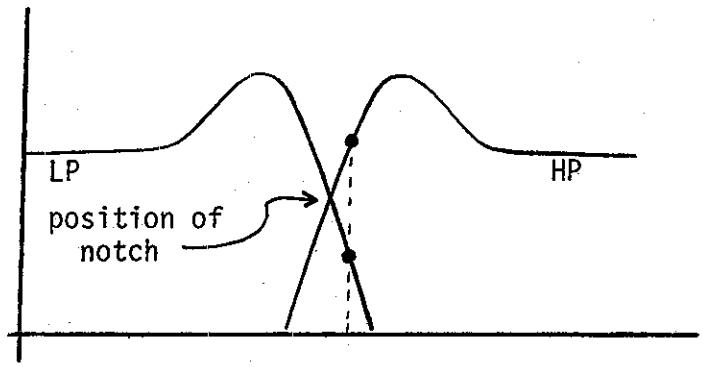

Fig. 2b An out of balance condition that would cause the frequency of the VCF of Fig. 3d to move up so that the overlap point matches the new input frequency.

The actual circuit for our simplified side-tracking filter is shown in Fig, 3. The heart is the upper portion which is a standard five-IC VCF [4]. At the bottom, we have a manual control-voltage source as a switched option, along with the tracking loop option, shown attached with dashed lines. Here rather than have two precision full-wave rectifiers (at a cost of two diodes, one or two op-amp, several resistors each) and a differential integrator, we have just used a single phase integrator, and then and pointed single diodes in different directions to achieve a differential integration. Dirt cheap, and it still works.

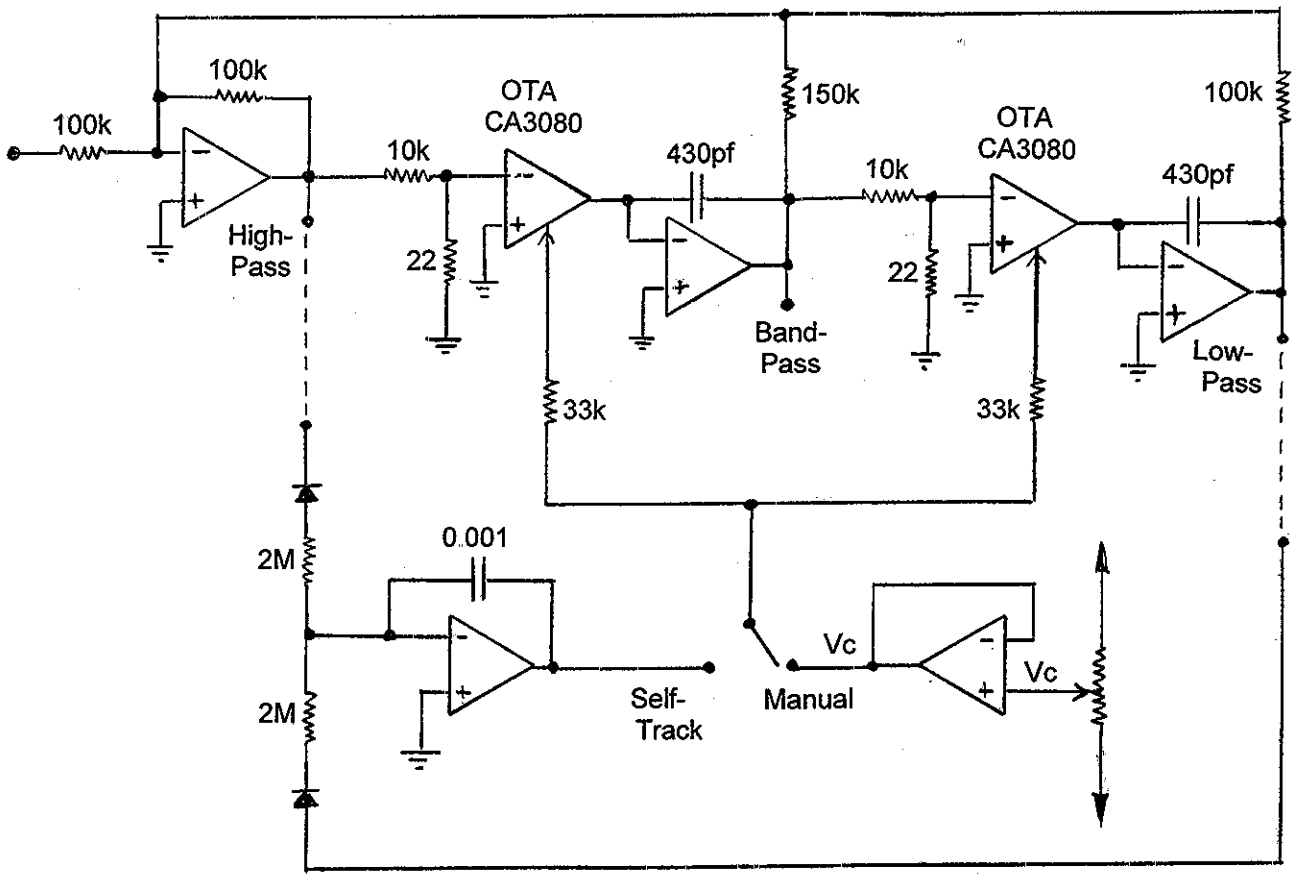

Fig. 3 Implementation of the Simple Side-Tracking Filter

References:

[1] B.A. Hutchins & W.H. Ku, "An Adapting Delay Comb Filter for the Restoration of Audio Signals Badly Corrupted with a Periodic Signal of Slowly Changing Frequency," J. Audio Eng. Soc., Vol 30, No 1/2, Jan/Feb 1982, pp 24-27.

[2] B, Hutchins, "An Introduction to Adapting Filters of Several Types," Electronotes, Vol. 16, No 170, Feb. 1988, pp 8-9

[3] B. Hutchins, "Analog Adapting Filters," Chapter 10 of Analog Signal Processing, Electronotes, Vol. 20, No. 196, Dec. 2000, pp 26-29

[4] B. Hutchins, "Voltage-Controlled Filters," Chapter 8 of Analog Signal Processing, Electronotes, Vol. 20, No. 196, Dec. 2000, pp 3-12