GENERAL RADIO COMPANY

engineering department

REPRINT A-102 NOVEMBER, 1962

DYNAMIC NOTCH FILTER

by

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HOW CAN YOU TRAP OUT a spurious signal of a certain frequency and yet at the same time pass desired signals of the same frequency?

The need to trap out 10 mc noise while passing a 10 mc signal arose in the development of a heterodyne frequency converter to extend the measurement range of a 10 mc counter. A block diagram of the converter is shown in Fig. 1. Applied to the mixer are the signal to be measured (from 10 to 200 mc) and the heterodyne reference frequency, an integral multiple of 10 mc. The mixer output, between 0 and 10 mc, is amplified and applied to the 10 mc counter.

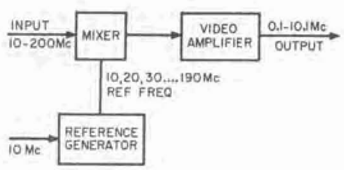

Fig. 1. Block diagram of the heterodyne frequency converter which includes the dynamic notch filter.

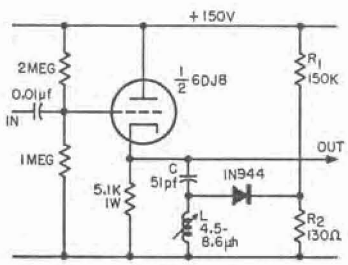

Fig. 2. Schematic of the dynamic notch filter. The series C and L trap out 10 mc noise from low-frequency output signals.

Since the heterodyne reference frequencies are derived from a 10 mc source, small sidebands exist 10 mc on either side of the desired reference frequency. These unwanted sidebands mix with the reference signal in the mixer and produce a small residual 10 mc output, even in the absence of an input signal. In the presence of an input signal, the 10 mc residual appears as noise on the output signal.

If the desired output signal is greater than a few hundred kilocycles, the 10 mc noise causes no difficulty with most counters. For output frequencies below a few hundred kilocycles, however, even a little 10 mc noise can cause the typical 10 mc counter's input circuits to generate spurious extra pulses, producing erratic frequency readings.

It would be simple enough to null out the 10 mc noise with a series or shunt trap, but then how would a desired 10 mc signal get through?

The clue to the solution lies in the difference between the 10 mc noise and the desired 10 mc signal—a difference in level. The noise has a low level of known maximum amplitude, while the desired signal is of higher amplitude. What is needed is a filter that nulls out the low-level 10 mc noise but disappears in the presence of a high-level 10 mc signal. This would be a dynamic notch filter.

Fig. 2 shows a schematic diagram of such a filter. The series C and L, connected across the output of the cathode follower, constitute a 10 mc trap which removes 10 mc noise from a low-frequency output signal. The diode is normally back-biased by the dc voltage across R_2 of the R_1, R_2 voltage divider; it doesn't affect the filtering action.

With a large 10 mc signal, however, the diode conducts, spoiling the Q of the inductor and reducing the efficiency of the notch filter. The diode thus acts as a switch which shorts out the inductor when the inductor voltage exceeds a certain level. The level at which the switching occurs can be adjusted by the voltage divider. (R_2 should be as small as possible to maintain high diode efficiency.)

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Reprinted from *Electronic Equipment Engineering*—September, 1962

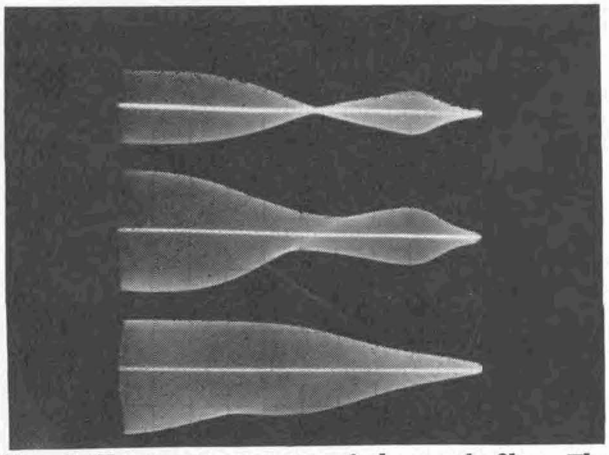

Fig. 3. Frequency response of the notch filter. The vertical scales, from top to bottom, are at 50 mv/cm, 100 mv/cm, and 500 mv/cm.

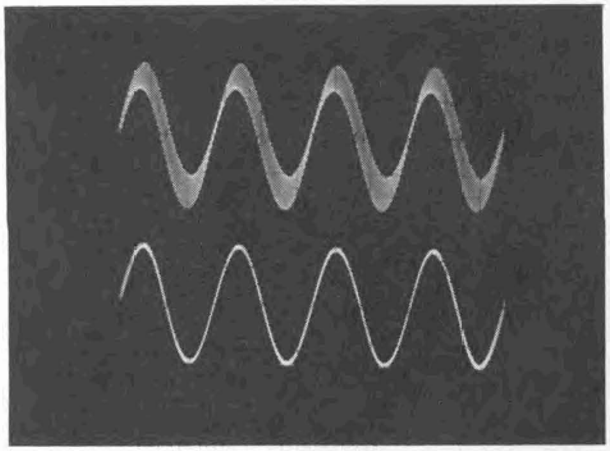

Fig. 4. A noisy, low-frequency signal, before and after filtering.

The action of the filter is shown by the oscillograms of Fig. 3. For all three oscillograms the input frequency was swept from 7 to 14 mc. The filter output was applied to the vertical amplifier of the oscilloscope with the beam swept horizontally in synchronism with the input-frequency sweep.

In the top oscillogram, the vertical scale is 50 mv/cm, and the sharp notch at 10 mc is clearly visible. In the center oscillogram, the scale is 100 mv/cm, and the notch is much shallower. In the bottom oscillogram, with a vertical scale of 500 mv/cm, the notch has essentially disappeared.

Fig. 4 shows before/after oscillograms illustrating the effect of the dynamic notch filter on a noisy, low-frequency signal.

The circuit is used in the General Radio Type 1133-A Frequency Converter, which extends the operation of the GR 10 mc Type 1130-A Digital Frequency Meter up through 500 mc.

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Printed in U.S.A.