i-f amplifier design

Further comments by a recognized authority on the optimum design of shortwave receivers

Many articles have been published during the past few years on receiver design with emphasis on the front end, but few efforts have been made to exploit the possibilities of good i-f amplifier design. Such design involves several areas: proper i-f selectivity, low distortion, a-m and ssb detectors, agc control, and noise blankers. This article presents some methods of designing these circuits to obtain a high-performance i-f system.

noise blankers

Very few noise-blanker circuits for multipurpose applications have been published. Probably the best noise blanker ever built is the circuit used in the Collins KWM2; however, since this design is based on tubes, it's no longer considered within the state of the art. While the principle of the Collins noise blanker avoids difficulties of crystal-filter ringing, it does produce some distortion because of the circuit used for gating in the i-f path.

The principle of the Collins noise blanker is based on the idea that noise pulses originating either from ignition or other man-made noise are of fairly short duration and therefore, have enough energy, even at frequencies above 30 MHz, to produce radio-frequency interference. Collins uses a multistage 40-MHz amplifier that brings the noise pulses up to a suitable level for detection in a peak detector, and the dc voltage thus derived is used to disable the receiver rf front end and i-f, including the i-f

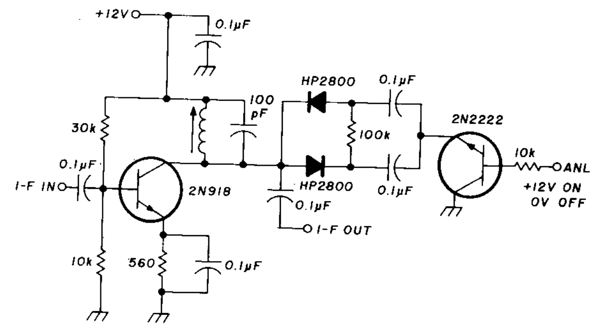

fig. 1. Rf noise limiter with self-adjusting action.

filters, during the detection of the pulses. Since some of the pulses do not have a rectangular response, the gate circuit for switching remains for a few milliseconds in a state between **on** and **off**, during which most of the noticeable intermodulation occurs.

Noise blankers in present amateur transceivers measure the noise pulses in the i-f bandwidth, and rf signals, such as CW key clicks, can't be distinguished by

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the circuit from other interference. Therefore all these circuits suffer from added distortion.

Fig. 1 shows a noise blanker published in the *ARRL Handbook*, which is supposedly derived from TV receivers and suppresses only certain types of noise pulses. A detailed discussion of this circuit is found in reference 1. **Fig. 2** shows the principle of an i-f noise blanker that derives its information from the i-f path. This circuit, in my opinion, however, is only a compromise; however, it is found very often. **Fig. 3** shows a circuit that takes advantage of the idea on which the Collins noise blanker is based and has the additional feature that it can also be used on the 160-meter band for suppressing Loran pulses. Its design is based on a suggestion by Siemens, who are the makers of the IC used in this circuit.

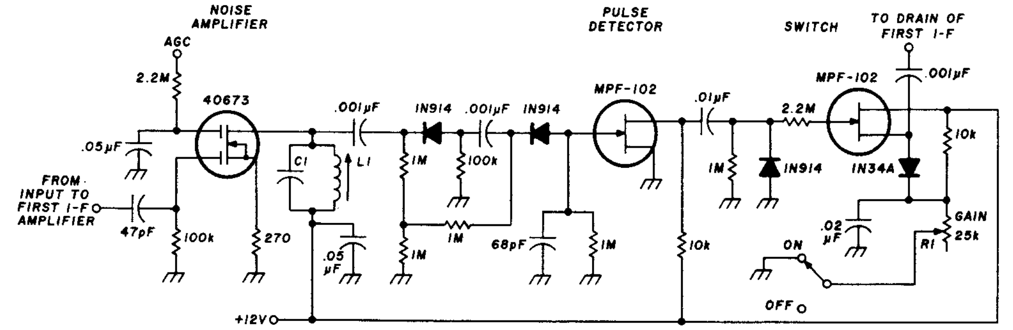

fig. 2. Schematic of a noise-blanker that derives its information from the i-f path.

The TCA440 IC, to the best of my knowledge, has no equivalent American replacement. It contains a complete a-m receiver. Because of the wideband application, oscillator stability is no problem, and a fairly simple single-conversion receiver can be built to convert the arbitrarily chosen input frequency of 50 MHz to a 2-MHz i-f, where the noise pulses are then amplified to a suitable level for detection. In addition, a 2-MHz input is provided, which can be used when operating in the 160-meter band.

The IC output, which can be monitored by a special test output, is fed into a limiter and amplifier using an fet and a bipolar transistor. The TTL output is then fed into a 74LS122 IC for pulse processing, and a TTL-level noise-blanking output is available.

This circuit has substantial advantage over the Collins noise blanker but does not solve the problem of suitable

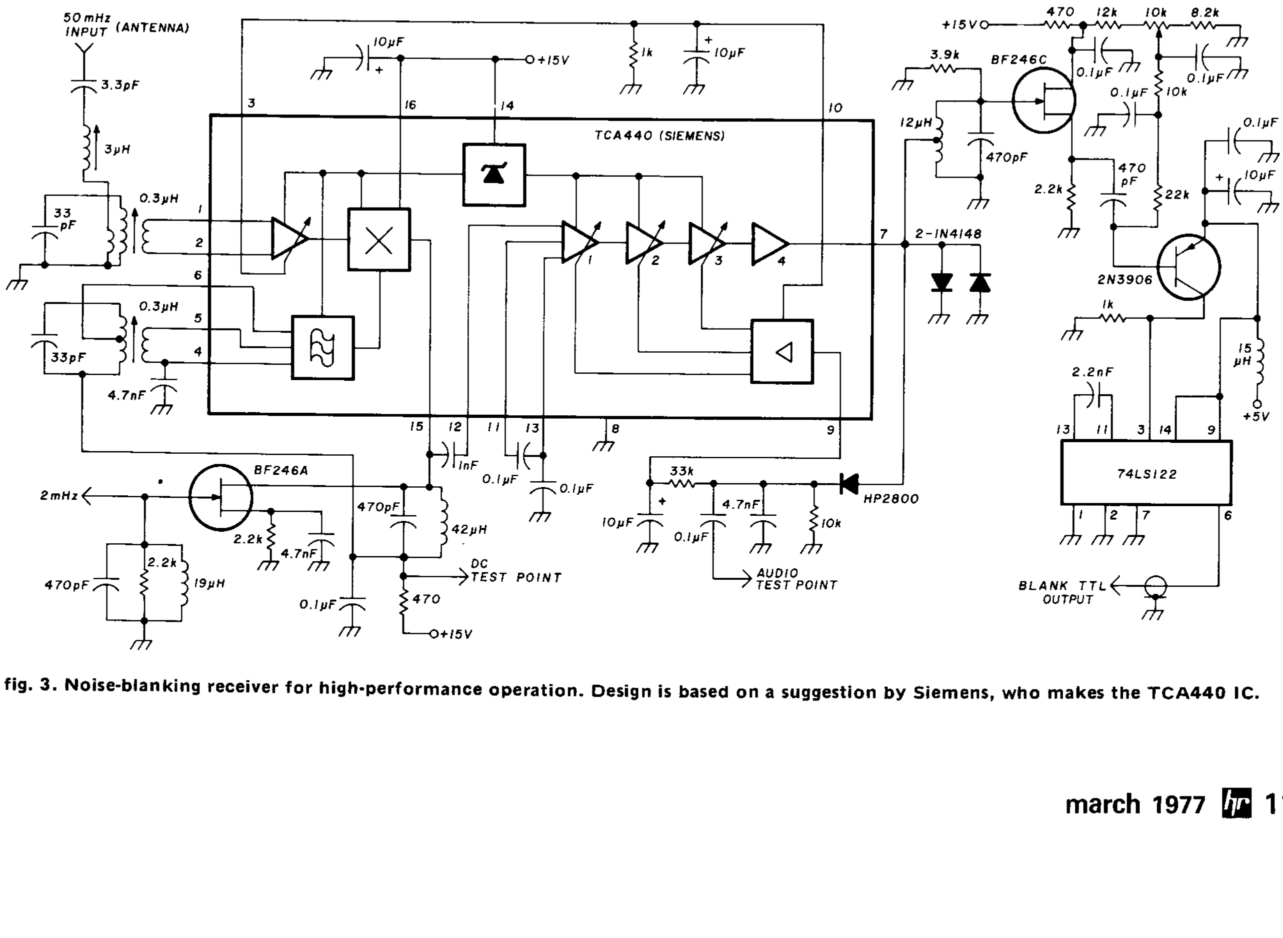

fig. 3. Noise-blanking receiver for high-performance operation. Design is based on a suggestion by Siemens, who makes the TCA440 IC.

gating. **Fig. 4** shows an rf input stage described earlier,[2] which has a suitable push-pull arrangement that accepts these blanking pulses without producing the distortion found in most circuits. A similar gating circuit had been proposed by Swan in their SS200 series; however, since the noise-blanker circuit was extremely critical, it did not operate too successfully.

input selectivity

For reasons explained in reference 2, selectivity should be used immediately following the first mixer to prevent overload of a possible second mixer and to avoid spurious signals. General-coverage receivers require the first i-f to be higher in frequency than the highest frequency of reception, and i-fs between 30 and 120 MHz have been used. As discussed in reference 2, the selectivity is provided by vhf crystal filters, which have 4-8 poles and are commonly called cross-modulation filters. They are available either in discrete components or as monolithic filters. Probably the most popular is the 75-MHz monolithic filter made by Piezo Technology in Florida.

Because of the losses of this filter, the stage immediately following the filter must have an extremely low noise figure and simultaneously a high intercept point. A good choice for this requirement is the circuit shown in **fig. 5**, which uses a neutralized field-effect transistor to obtain stability and low noise figure through rf feedback. Such a stage has about 10 dB gain. A second i-f stage with presettable gain can be used ahead of the second mixer. Because of the voltage step-down transformer, overall gain is kept very low; however a large, highly distortion-free agc range is possible.

The main selectivity is always achieved at lower frequencies. While the commonly used frequency for vhf/uhf receivers is 21.4 MHz, most attempts to make ssb or CW filters at these high frequencies have failed. For CW and ssb, crystal filters are available at frequencies of 10.7 MHz, 9 MHz, 8.8 MHz, 5.5 MHz, and 1.6 MHz, while the intermediate frequencies of 525 kHz, 455 kHz, 200 kHz, and 100 kHz take advantage of available mechanical filters. Some receivers still use LC filters at 50 or 30 kHz, but the shape factors obtainable are not very impressive.

Variable-bandwidth system. In military receivers that require a substantial number of bandwidths, seven or more individual filters may be required, which makes the i-f portion both bulky and expensive. To overcome this problem a double mixing scheme, as briefly discussed in reference 2, permits quasi-continuous selection of bandwidths between 75 Hz and 6 kHz at a constant shape factor of 1:1.6, independent of the bandwidth setting. **Fig. 6** is a selectivity curve of a filter that provides quasi-continuous selection of i-f bandwidths.

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An additional advantage of this system is that ringing from mechanical or crystal filters of very narrow bandwidths is dramatically reduced. The filter is based on a) a dual-mixing system using four mixers and two ganged local oscillators to vary bandwidths, and b) two high-grade 30-kHz lowpass filters to provide the steep slopes. **Fig. 7** shows the block diagram of this circuit.

By correct choice of oscillator frequencies and, in one case, the use of sideband inversion, the two sidebands of the incoming i-f signal can be shifted toward or away from the sharp cutoff characteristics of two identical 30-kHz lowpass filters. After the two sharp edges have been imposed on the i-f signal, it is then converted back to the original i-f center frequency, which is 300 kHz. In effect, a variable bandpass filter is synchronized with two fixed lowpass filters. The basic relationship between the oscillator frequency, intermediate frequency, lowpass frequencies, and the bandwidths are:

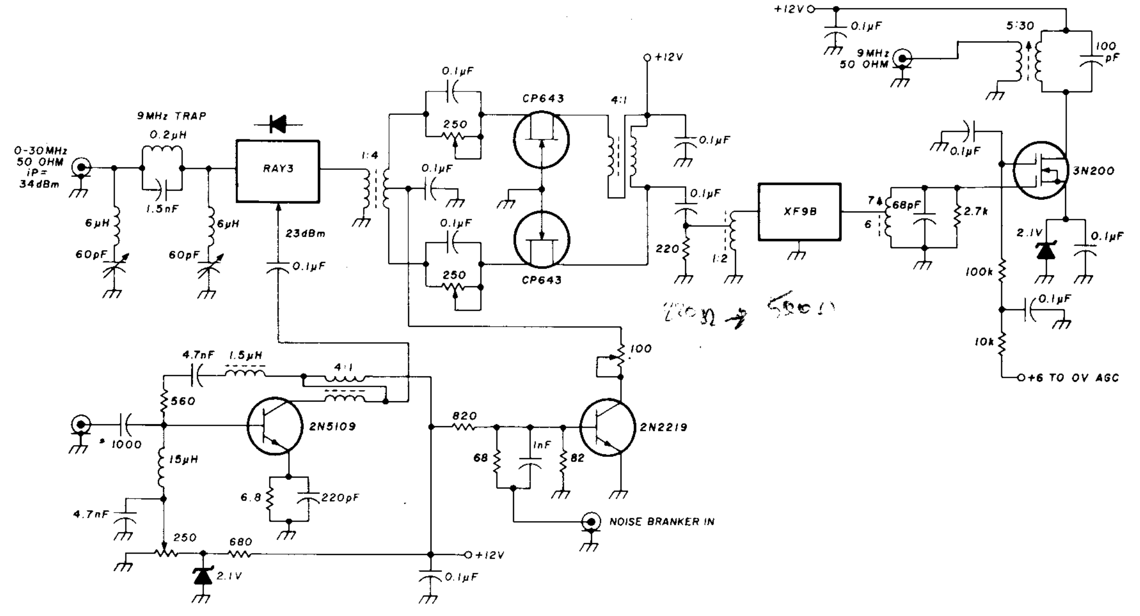

fig. 4. Rf-input stage for a high-performance receiver. Push-pull arrangement accepts blanking pulses without producing the distortion found in most circuits.

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