high dynamic range

two-meter converter

Circuit details
for a 2-meter converter
with a +15 dBM
intercept point
and 5 dB noise figure

This two-meter converter is an improved version of an earlier model[1] and is a result of research and development which I did around 1969 at AEG-Telefunken in Ulm, Germany. The German Ministry of Postal Affairs (equivalent to the U. S. FCC) requires that for all approved receivers for commercial and military application, a dynamic adjacent channel measurement must be performed. The result of the test depends upon the third-order intermodulation-distortion characteristic of the input stages.

A Radio Amateur group has used this particular converter circuitry which was later referred to as the "Martin front end."[2] This technique is also successfully used in the Rohde & Schwarz high-frequency Communication Receiver EK47, and was later adopted by Southcom and Atlas. The basic purpose of this circuit is to get the best performance out of a mixer by obtaining the lowest possible noise figure. To achieve this, the i-f output circuit has to be properly terminated over a large frequency range. This feature was previously described in *ham radio*.[2] During the last few months, the third-order intermodulation distortion has been evaluated in several magazines. However, a so-called *second-order* intermodulation distortion problem has received little mention.

A two-tone test is used for both second- and third-order IMD performance measurements. Second-order performance is checked at $f_1 \pm f_2$. Third-order is the performance at $f_1 \pm 2f_2$.[5] To reduce the effects of second-order IMD, it is necessary to use as much selectivity as possible and then compensate for the losses of these filters by using appropriate amplifiers. A suitable low-noise preamplifier with wide-band matching will be discussed later.

The two-meter converter shown in **fig. 1** combines these techniques. It was designed for extreme linearity and selectivity with the added goal of keeping the noise figure below 5 dB.

Many converters with noise figures below 3 dB described in the literature use neutralization. This method has two distinct disadvantages in the way it is currently done:

1. The neutralization can be made only over an extremely narrow frequency range, and

2. Since, in most cases, amateurs do not have ade-

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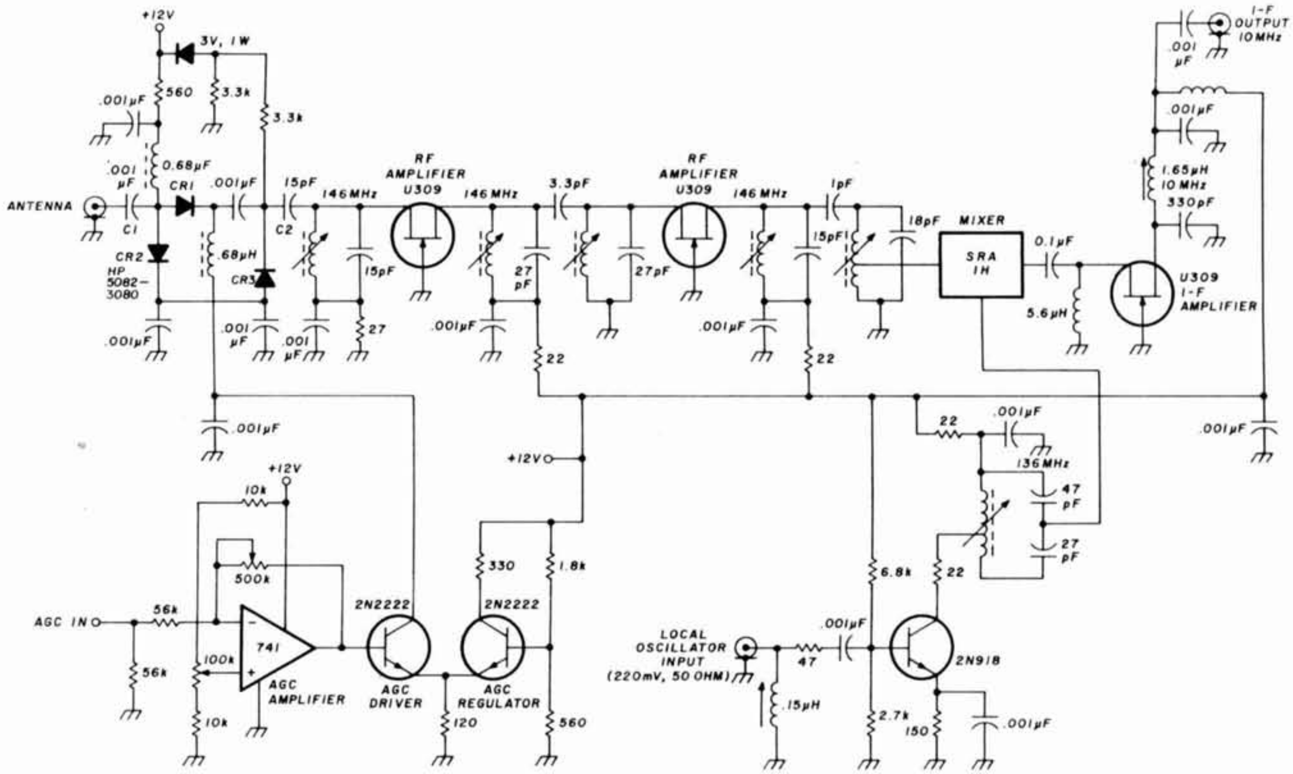


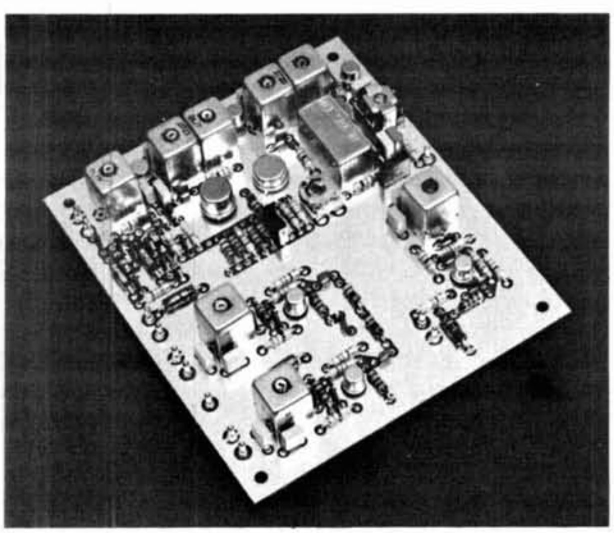
fig. 1. A two-meter converter with +15 dBm intercept point, 16 dB power gain, and less than 5 dB noise figure.

quate test instruments, an exact adjustment is seldom achieved, which degrades the two-tone IMD performance.

This converter has five tuned circuits at the input frequency which results in an overall bandwidth of barely 4 MHz. Proper tuning of this converter can best be achieved by the use of a suitable sweep generator.

These five tuned circuits provide an image suppression of 60 dB for an i-f of 10 MHz, or more than 80 dB for an i-f around 30 MHz. To simplify the circuit, U-309 fets are used which should have an $I_{DSS} = 20\ mA$. The third-order IMD of these transistors can be neglected as compared to the performance of the SRA-1H mixer. The overall gain between the antenna termination and the mixer input is about 10 dB. Therefore, the overall intercept point of the converter is +15 dBm with a noise figure of slightly less than 5 dB. Part of the fairly high noise figure is due to the 1-dB loss in the pin-diode attenuator.

This converter uses the ground-gate field-effect transistor circuit as described in reference 2. However, in the original version,[1] a special bipolar transistor in grounded-base configuration was used and provided a suitable wideband match for the mixer. This converter is shown in **fig. 2** as part of a transceiver that uses a frequency-locking system to stabilize the free-running oscillator in increments of 6.25 Hz (semi-synthesized).



Photograph of the converter board. Two additional output stages have been added.

unconditionally stable low-noise input stage

The low-noise preamplifier shown in **fig. 3** is based upon a circuit suggested by AEG-Telefunken in the 1950s and first published by me in English.[3,4] It was used to achieve extremely low-noise input stages with triodes while avoiding neutralizing circuits with

fig. 2. Photograph of a semi-synthesized 2-meter transceiver using the converter shown in fig. 1.

their inherent mass production problems. The same feedback arrangement not only avoids all instability problems but also improves the dynamic range. With practically all other neutralizing circuits a certain degree of performance reduction is observed.

The amplifier shown in **fig. 3** is a mixture between a grounded-gate and a grounded-source circuit. It is a bridge arrangement which neutralizes the feedback

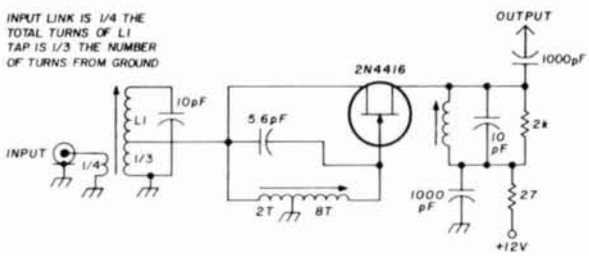


Fig. 3. Low-noise pre-amplifier with rf feedback to provide unconditional stability and low distortion.

capacitance between gate and drain. In addition, the input impedance $(1/S)$ is transformed in parallel between the gate and ground and provides the necessary wideband characteristic. A noise figure of between 1 and 2 dB, using the inexpensive 2N4416, can be easily achieved and the gain is roughly 15 dB. The circuit is unconditionally stable. This is the only circuit known to me which combines optimum matching for best noise, lowest input swr, and best matching for high power gain.

references

1. Rohde, "Zur Optimalen Dimensionierung von UKW Eingangsteilen", *Internationale Elektr. Rundschau*, May, 1973, page 103.
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4. Rohde, "The Field-Effect Transistor at VHF", *Wireless World*, January, 1966, page 1.
5. Rohde, "Eight Ways to Better Receiver Design", *Electronics*, February 20, 1975, page 87.

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