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Title: Accessories for Your VFO
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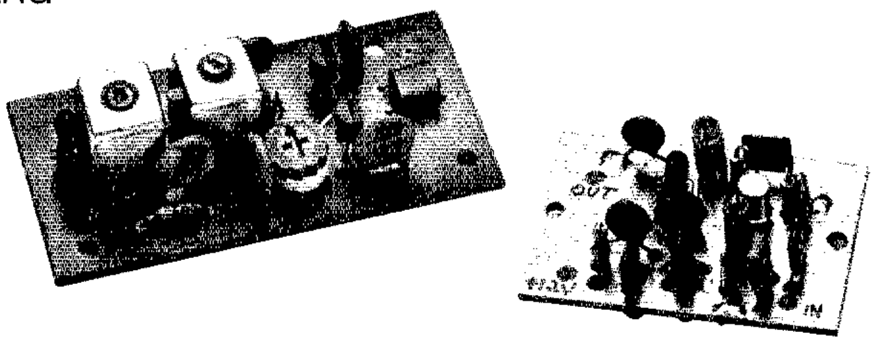
Accessories for Your VFO

Broadband amplifiers and frequency doublers can be used with homemade VFOs to increase the power output and provide two-band operation. Two practical circuits are offered here.



By Doug DeMaw, W1FB
ARRL Contributing Editor
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Have you experienced difficulty with frequency stability when building a VFO for direct use on 20 meters? Or how about learning that your VFO lacks sufficient output power to properly excite the first stage of your transmitter? These are common experiences for most of us who like to build equipment.

Fortunately, some simple circuits can be built to overcome these problems, and we will focus on them in this article. You may wish to construct the broadband, fed-back amplifier described here, or you may prefer to build the push-push doubler module for obtaining 20-meter output from your 40-meter VFO. Both circuits are inexpensive and easy to get operating.

Building a Broadband RF Amplifier

Many of us recall the perennial shortage of grid drive in vacuum tube equipment. Our homemade rigs always seemed to be shy of grid drive to the final amplifier. This was particularly true of rigs built for the upper end of the HF spectrum and at VHF. In some ways, things have not changed with our solid-state home-built gear. In an effort to minimize the number of VFO or transmitter stages, we often end up with too little driving power for some stage in the circuit. Some amateur VFOs have very low output, owing to design deficiencies or lack of foresight during the design exercise.

Whatever the cause of low output power, we can boost the VFO signal by adding a broadband amplifier at the VFO output. Fig 1 shows the schematic diagram of a practical linear amplifier that uses a 2N2222A transistor. The operating potential is 12 V. The amplifier frequency response is relatively flat from 1 to 30 MHz. Output harmonic filtering is included in the interest of providing a clean output voltage. It is desirable to "launder" the VFO output energy to ensure that a sine wave is available for exciting the first stage of a transmitter. If large amounts of harmonic current are present, the stage being excited will amplify the harmonic energy and pass it along to the next stage. Also, unwanted mixing of spurious frequencies can be reduced by delivering a clean waveform to the transmitter input port. This also helps the transmitter to operate more efficiently, and the PA stage output will be much cleaner.

The circuit of Fig 1 is patterned after a design by Wes Hayward, W7ZOI. His circuit uses a 2N5179 CATV transistor with a 1.2-GHz f_T to provide a 65-MHz bandwidth. I find that a 2N2222 or equivalent is suitable in this type of circuit, provided a 30-MHz bandwidth is acceptable.

C4, R2 and R3 of Fig 1 form a shunt feedback network to flatten the amplifier gain and aid stability. Unbypassed resistor R4 provides degenerative feedback, which lowers the input impedance of the amplifier to approximately 50 Ω. The amplifier output impedance is on the order of 200 Ω. T1, a broadband 4:1 transformer, matches the collector of Q1 to the 50-Ω harmonic filter, FL1. Amplifier gain is approximately 10-12 dB from 1 to 30 MHz. FL1 is a simple half-wave filter that provides 30 to 35 dB of attenuation at the second and third harmonics of 7 MHz.

The smaller of the two PC-board modules in the title photo is the broadband

BROADBAND AMPLIFIER

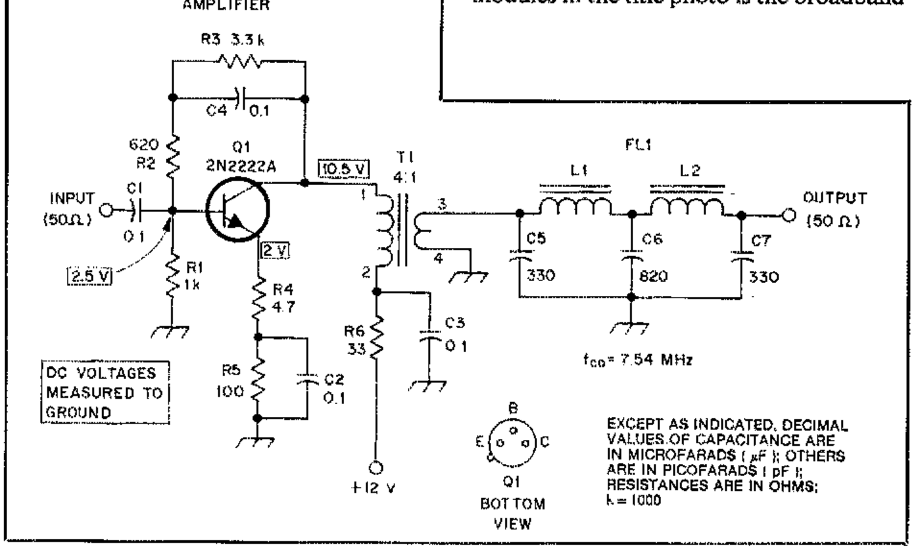

Fig 1—Schematic diagram of the class-A broadband RF amplifier. Capacitors are disc ceramic except for C5, C6 and C7, which may be disc ceramic, silver mica or polystyrene. Resistors are ½-W carbon composition. L1 and L2 are 1.45 μH. Use 20 turns of no. 30 enam wire on an Amidon Assoc T-25-2 toroid core. T1 has 15 turns of no. 30 enam wire on an Amidon FT-23-43 ferrite toroid. The secondary winding has 7 turns of no. 30 enam wire.

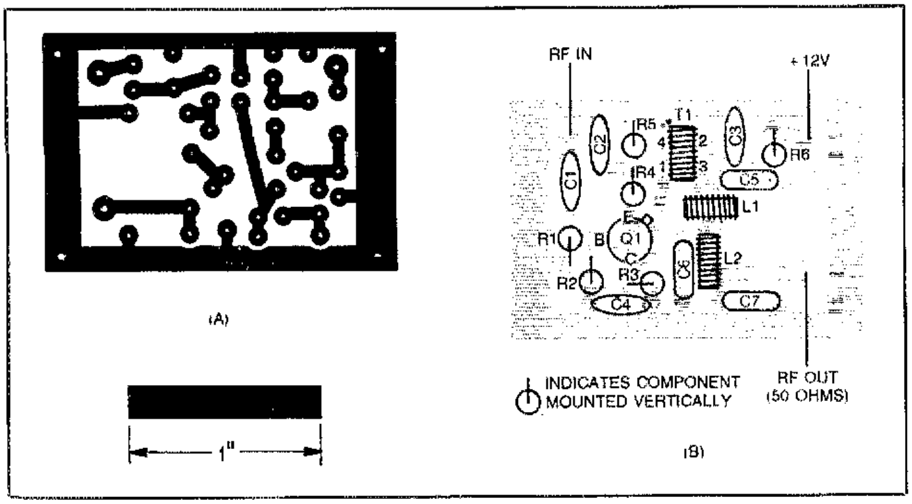

Fig 2—At A, the circuit-board etching pattern for the broadband amplifier. The pattern is shown full size from the foil side of the board. Black areas represent unetched copper foil. The component (nonpattern) side of the board has unetched copper which serves as a ground plane. Clearance holes are provided in the ground plane where component leads pass through the board. At B, a parts-placement guide. The shaded area represents an X-ray view of the copper pattern.

amplifier. A scale etching template and parts-placement guide are provided in Fig 2.

You may use the amplifier to boost your VFO output power, or you can use it as an instrument amplifier, such as between a low-level signal source and a scope or frequency counter. It is not recommended as an RF amplifier for a receiver; the noise figure is too high for weak-signal reception above 40 meters.

Push-Push Frequency Doubler

You can use your 40-meter VFO for 20-meter operation by adding a frequency doubler at the VFO output port. The advantage of doubling from 7 to 14 MHz for VFO operation is that (1) the oscillator is less prone to drift at 7 MHz, and (2) the 7-MHz VFO has greater isolation from its load (the first stage of the 14-MHz transmitter). Chirp is less likely to be experienced when a VFO is operated at half the transmitter frequency.

A single-ended (one transistor) doubler is not suitable for this purpose unless band-pass filtering is used after the doubler. This is because the fundamental energy (7 MHz in this case) will feed through the doubler and appear at the output. A good band-pass filter will attenuate the 7-MHz energy, but it is easier to use a push-push doubler of the type shown in Fig 3. This type of doubler cancels the 7-MHz driving frequency and produces 14-MHz energy at the output. It is possible to obtain up to 40 dB of 7-MHz rejection if the doubler is well balanced. Furthermore, a push-push doubler operates as efficiently as a straight class-C amplifier—a bonus feature.

You must provide ample power to drive Q1 and Q2 into conduction. They are biased for class-C operation, which requires at least 1 volt RMS of excitation between the 2N2222 bases and emitters. I used the broadband amplifier of Fig 1 and this doubler with the experimental VFO circuit described later. The broadband amplifier was needed between the VFO and the doubler to ensure sufficient driving power for the doubler. Without the amplifier there was no output from the doubler.

Refer to Fig 3. T1 is a broadband transformer that applies push-pull input to Q1 and Q2. The transistor collectors are connected in parallel. R1 provides emitter bias for class-C operation. It also permits the circuit to be balanced in the event Q1 and Q2 are not closely matched dynamically. R1 may be adjusted for a dip in Q1, Q2 collector current. Alternatively, you may adjust R1 while observing the 14-MHz output on a scope. Set R1 for the best waveform (least distortion). This will coincide with the dip in collector current. If R1 is adjusted to either extreme (zero resistance from one of the emitters to ground), the circuit may break into self-oscillation. That is not uncommon for push-push doublers of this variety.

L1 is adjusted for resonance at 14 MHz, and should be tweaked for the purest 14-MHz waveform obtainable. If you do not have a scope, sample the energy at the output of L2 and route it to your receiver. Tune to the VFO driving frequency (7 MHz) and adjust L1 for minimum signal.

L2 with C6 forms a 7-MHz parallel trap. L2 is also adjusted for minimum 7-MHz energy as noted on your scope or receiver S meter. The 14-MHz waveform is quite pure without L2. You may eliminate the 7-MHz trap if you are not seeking an extra clean 14-MHz waveform.

The assembled doubler is the larger of the two PC boards pictured in the title

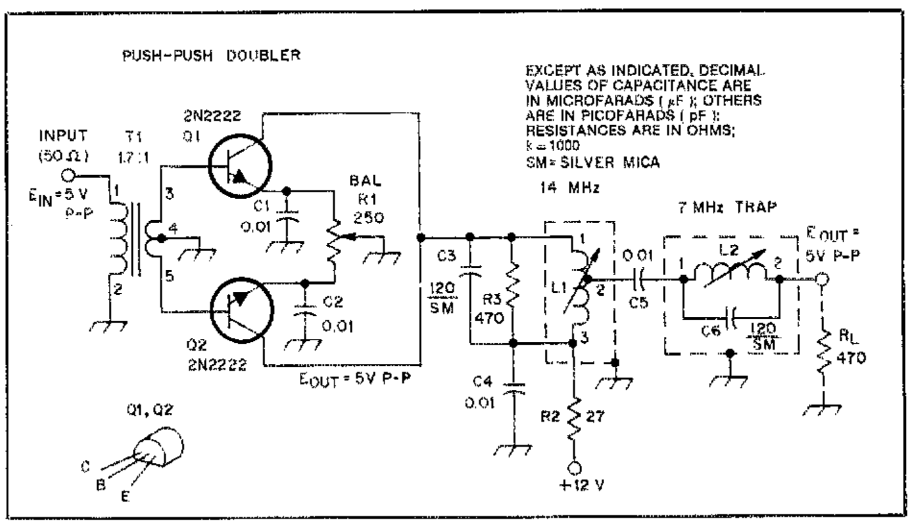

Fig 3—Schematic diagram of the push-push doubler. Capacitors are disc ceramic except for C3 and C6, which are silver mica. Fixed-value resistors are ½-W carbon composition.

L1—Shielded inductor, 1 µH. Use 11 turns of no. 30 enam wire on the bobbin of an Amidon L-43-6 assembly. Tap winding at 6 turns above C4 end.

L2—Shielded inductor, 4.3 µH. Use 22 turns of no. 30 enam wire on bobbin of an L-43-6 assembly. A toroid coil and a trimmer capacitor may be substituted for C3-L1 and C6-L2. The L2 bobbin winding may have to be stack wound to accommodate all of the turns.

R1—Trimmer control, 250 Ω, carbon composition.

T1—Broadband transformer. Use 4 primary turns of no. 30 enam wire through an Amidon BN-61-2402 balun core. Secondary has 3 turns, center tapped, of no. 30 enam wire. You may substitute two rows of three Amidon FT-23-43 toroids, side by side, to form a balun core. Glue toroids with epoxy cement. Use the same number of turns specified for the BN-61-2402.

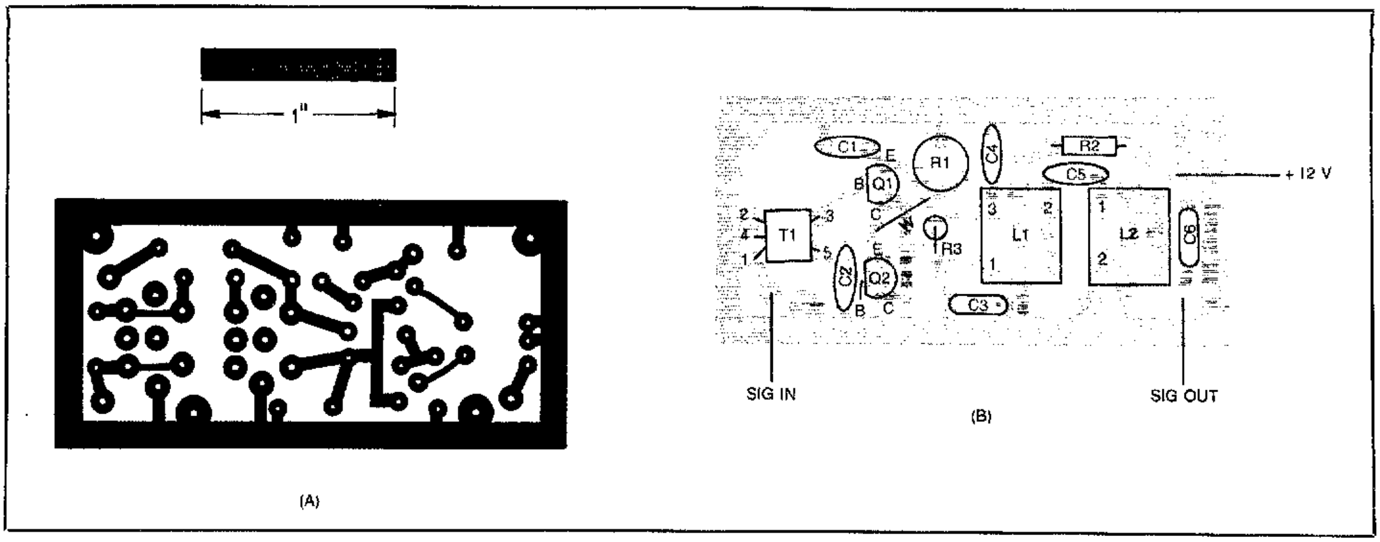

Fig 4—Circuit-board etching pattern (A) and parts-placement guide (B) for the push-push doubler. The pattern is shown full-size from the foil side of the board. Black areas represent unetched copper foil. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. W = wire jumper.

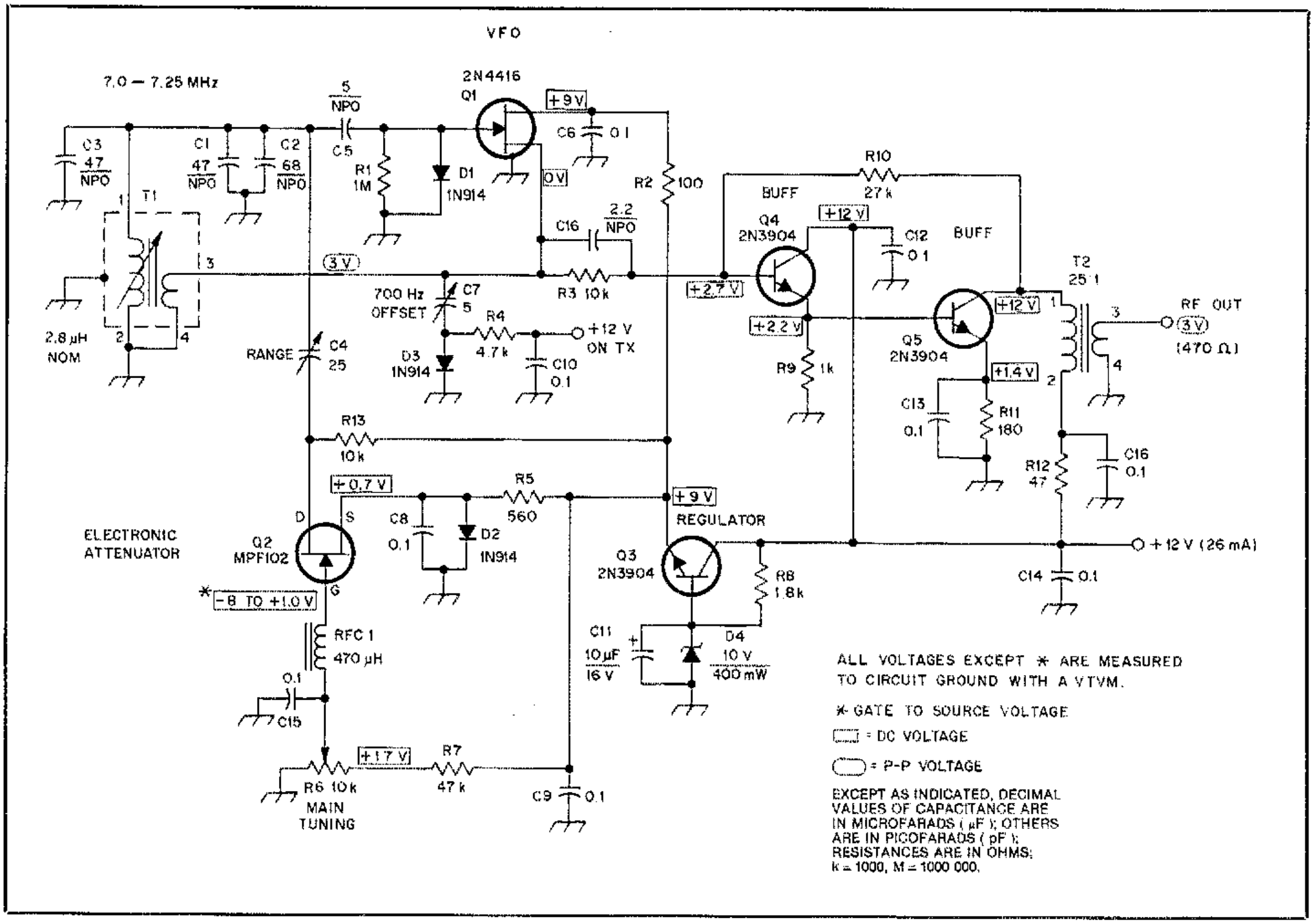

Fig 5—Schematic diagram of the experimental 40-meter VFO. Fixed-value capacitors are disc ceramic except for those with polarity marked, which are tantalum or electrolytic. Fixed-value resistors are ½-W carbon composition. This diagram is presented to illustrate the Q1-Q2 circuit.

C4—Small plastic or ceramic trimmer.

C7—Small 5-pF ceramic trimmer (CW offset control).

R6—Linear taper carbon composition control or 10-turn potentiometer with dial mechanism (see text).

RFC1—Miniature 470-µH RF choke.

T1—Shielded RF transformer. Primary is 2.8 µH. Use 16 turns of no. 28 enam wire on bobbin of an Amidon L-57-6 transformer assembly. Secondary has 4 turns of no. 28 enam wire. Glue winding with polystyrene Q Dope® by General Cement Co.

T2—Broadband transformer. Primary has 15 turns of no. 28 enam wire on an Amidon FT-37-72 toroid core. Secondary has 3 turns of no. 28 enam wire. Impedance ratio is 25:1.

(continued on page 46)

(continued from page 33)
photo. A scale etching template and a parts-placement guide is presented in Fig 4.

Experimental VFO

I developed the amplifier and doubler modules in this article after I completed my experiments with the VFO in Fig 5. Generally speaking, there is nothing unique about the major part of the VFO, but the tuning method has not, to my knowledge, been described before. I developed the electronic tuning technique when I wanted to improve upon an earlier innovation I tried. The first circuit used a 500-Ω linear taper potentiometer in series with a trimmer capacitor (C4 of Fig 5). The carbon control was used to change the VFO frequency. Performance was acceptable, but the VFO output level varied with the resistance of the control. Also, one end of the control range yielded little change in VFO frequency, causing nonlinear operation.

I decided to try a JFET as an electronic attenuator. Q2 of Fig 5 serves this purpose. R6 varies the gate bias of Q2, and this causes the junction resistance of Q2 to change. The change in resistance increases or decreases the effective capacitance of trimmer C4. D2 regulates the potential on the source of Q2, which aids the overall VFO stability. RFC1 provides RF isolation for Q2 from R6 and the associated wiring. A 10-turn potentiometer is used for R6 to provide bandspread when tuning the VFO. The frequency range covered by adjusting R6 is determined by the setting of C4. You may tune all of the 40-meter band, or only a few kHz of the band.

Frequency stability is excellent with this circuit. I observed 60 Hz of drift from a cold start to full stability 10 minutes later. Tests were performed at a room temperature of 72°F. The short-term drift was dreadful (some 300 Hz) until I added R13 to apply drain bias to Q2. I find this circuit more desirable than similar ones I have developed with tuning diodes (VVC diodes). The stability of the circuit in Fig 5 is much better than that of my VVC-tuned VFOs.

The use of NP0 ceramic capacitors in the VFO circuit is very important in the interest of minimum frequency drift. Also, a 2N4416 FET is better for VFO service than an MPF102, owing to the better pinch-off characteristics of the 2N4416 family of FETs. The higher pinch-off voltage rating permits greater VFO output voltage. A comparison between an MPF102 and a 2N4416 in the circuit of Fig 5 showed 2 volts P-P output at the source of Q1 with the MPF102. The 2N4416, on the other hand, produces 3.5 volts P-P at the Q1 source. The buffer section of this VFO (Q4 and Q5) is a design by Roy Lewallen, W7EL, that he uses in a 40-meter QRP transceiver.[1] Output from the overall circuit of Fig 5 is 3 volts P-P across a 470-Ω load. This is approximately the input impedance of a class-A, low level stage in a solid-state transmitter. Performance is good, despite the mismatch, when connecting this VFO to the input of the class-A broadband amplifier of Fig 1.

Closing Remarks

There is no reason why you can't develop a push-push doubler for use on other amateur frequencies. L1 and L2 of Fig 3 will need to be modified for the new frequency of operation. No other changes are required. Certainly the two practical modules in this article will be useful to you for a variety of applications. For example, the amplifier may be used to boost local oscillator output to a suitable level for injecting a diode ring, doubly balanced mixer or modulator (+7 dBm normally required). The doubler can be used to develop a two-band VFO, and the list goes on. If nothing more, these projects are ideal for a weekend of workshop activity!

[1]Lewallen, R.W., Feedback, *QST*, Nov 1980, p 53.

New Books

THE PACKET RADIO HANDBOOK

By Jonathan L. Mayo, KR3T. Published by TAB Books Inc, Blue Ridge Summit, PA 17214. First edition, first printing, 1987. Soft cover, 5½ × 8 inches, 217 pages, $14.95.

So you've read all the magazine articles, and you're interested in packet radio, but you're not sure what to do next? Maybe you've been operating packet radio for a few months, and you're interested in how packet *really* works? Perhaps you'd just like to read and find out more about this modern communications mode? *The Packet Radio Handbook* might be what you're looking for.

Jonathan Mayo, KR3T, has done a good job of collecting a lot of information into a small book. The first four chapters of the book might be called the "theory" section. Chapter 1, entitled "What is Packet Radio," is a good introduction for someone who is curious about packet. Chapter 2, "The History of Amateur Packet Radio," covers packet-radio history in detail. Chapter 3 covers packet hardware and modulation techniques, and Chapter 4 discusses protocols and networking.

The second half of the book is the "practical" section. Chapter 5 is called "Setting Up an Amateur Packet Radio Station." This chapter gives information on selecting a terminal, a TNC and a radio for an amateur packet station. Chapter 6 covers operating procedures, and Chapter 7 details the packet equipment that was available in 1986, when the book was written. In Chapter 8, Mayo talks about the future of amateur packet radio. The five appendices cover the ASCII code; the RS-232 standard; addresses of manufacturers, packet clubs and organizations, and other suppliers of packet information; suggested operating frequencies; and an introduction to Amateur Radio for readers who may not be familiar with the hobby. A bibliography, glossary and index round out the end of the book.

Even though the book was published in 1987, the information about TNCs and networking is already a bit dated. New TNCs appear almost daily, and any book showing the available TNCs will be dated almost before it is published! Networking is right on the edge of the changing packet scene as well. The book does provide plenty of useful information in its other chapters, however. The author writes well, the book is easy to read, and there are plenty of graphics and photographs.—*Bruce S. Hale, KB1MW*

CONTEMPORARY ELECTRONICS CIRCUITS DESKBOOK

By Harry L. Helms. Published by McGraw Hill, New York, NY. First edition, 1986. Hard-cover, 8½ × 11 inches, 253 pages.

The assignment: Collect six or seven hundred useful circuits from electronics magazines, manufacturers' data sheets and applications notes. Arrange them in 28 logical chapters. Add an index, a list of abbreviations and the addresses of all the publications where the original circuits can be found. That's what Harry Helms has done to create the *Contemporary Electronics Circuits Deskbook.*

This is an essential book for someone who does not want to reinvent the wheel. Each page of this large hard-cover book shows at least one circuit, with a short description and an original source reference. A partial list of the chapters includes circuits for active filters, amplifiers, frequency synthesis, LEDs and optoelectronics, Morse code, power supplies, single-sideband, repeaters, test equipment, transmitters and voltage regulators.

Each circuit is shown schematically. This is primarily an *idea* book—no construction details are given, and there are no photos of completed units. Helms gives references for each circuit to make it easy to find the original article if more information is required.

As the author states in his preface: "I hope this compilation saves you hours of searching through the literature to locate a specific circuit application. This book can also serve as a useful starting point for your own circuit designs. One of the most interesting points about this book is the number of circuit designs created by Amateur Radio operators; many of them meet the most exacting professional standards. Such resourcefulness and creativity is one reason why I am proud to be a part of the worldwide hobby of Amateur Radio."—*Bruce S. Hale, KB1MW*