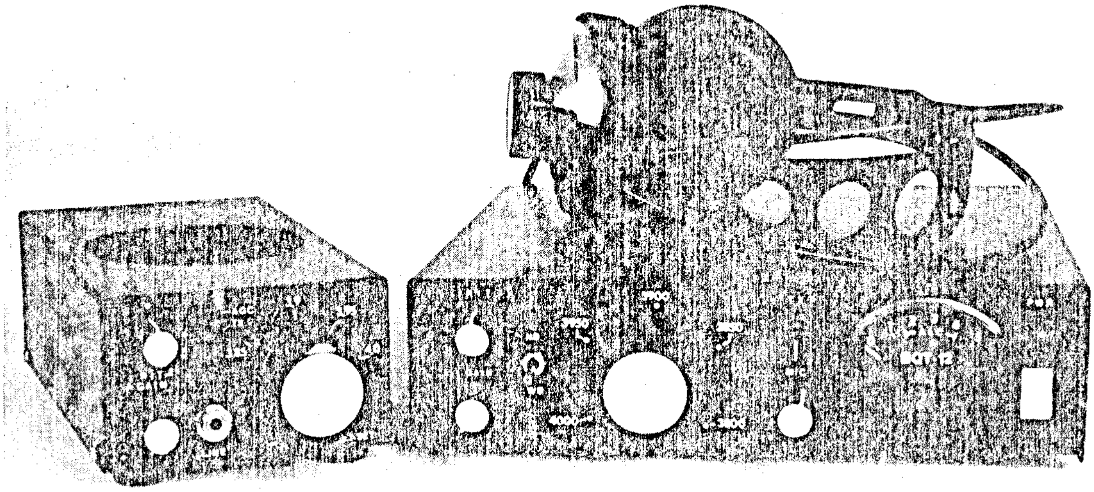
Construct an Audio Amplifier with Agc for Your Simple Receiver



Tired of using headphones with that bare-bones receiver? This module is an inexpensive way to make your little homemade project sound grown up!

By Rick Littlefield,* K1BQT

Many excellent articles describing simple receivers have appeared in amateur magazines. In many respects these receivers perform as well as their commercial counterparts. Most of the designs lack an automatic gain control circuit, however, and this can mean a lot of annoyance and knob twisting while monitoring nets or tuning the band. Some designs do not have the capability of operating with a speaker. In this article I offer one approach to making your next home-built receiver act like a store-bought radio. The module could also be retrofitted to an existing receiver in need of improved audio characteristics.

There are several ICs on the market that satisfy amateur receiver audio requirements. The LM-386, available at Radio Shack stores for about a dollar, is well suited for amateur use. This chip features low distortion, plenty of gain (up to 200), low current drain and high stability. With a 9-V supply it delivers 200 mW of audio power, more than sufficient to drive a speaker.

Automatic Gain Control

Several agc approaches are possible. The one I prefer rectifies a sample of the i-f signal to control the bias of one or more preceding stages. Deriving a control signal from the i-f stage may not be practical in simple designs in which the i-f signal levels are low and BFO leakage is common. Audio-derived agc is usually a safer choice. But deriving audio from a receiver that employs a single high-gain audio chip can also present a problem. The only voltage-sampling point before the volume control is at the output of the product detector, where the voltage level is very low. Thus, a fully functional agc circuit would require the addition of high-gain circuitry to develop a usable control voltage.

The simplest alternative is to derive the control voltage at the audio-amplifier output, where the signal level is high. The agc circuit then keeps the amplifier from being driven past a predetermined output level. Limiting is set somewhere below the maximum undistorted output level of the audio amplifier at a comfortable "maximum" volume level for the radio. A drawback to this approach is that agc action does not occur at very low gain settings. This should not be a problem in quiet listening environments, however, since the human ear can adapt easily to changes of 20 dB or more in normal conversation. In noisy environments the radio would be operated at a higher volume level, and heavy agc action would keep the output more constant. This is a compromise compared to a 90-dB agc system operating independently of the audio gain control; but it meets my design objective without adding much to the complexity of the receiver circuit.

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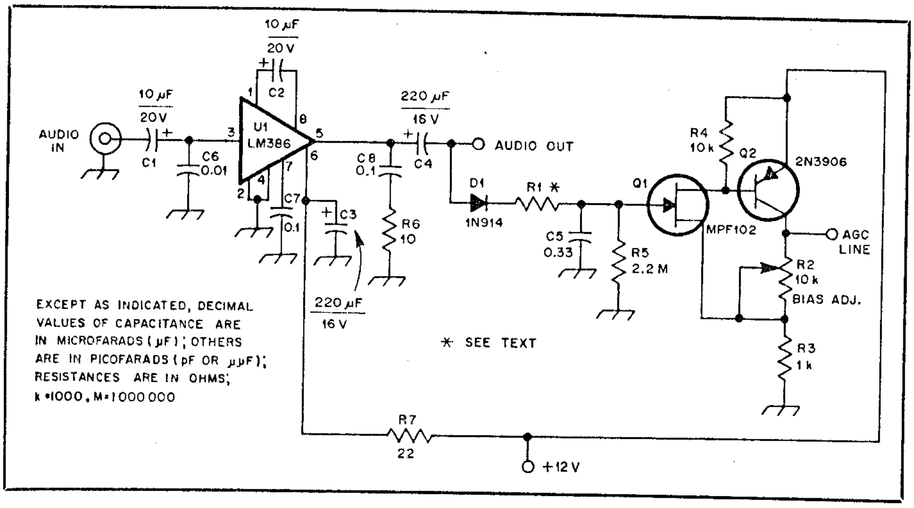


Fig. 1 — Circuit diagram of a simple audio amplifier and agc module for use with homemade receivers.

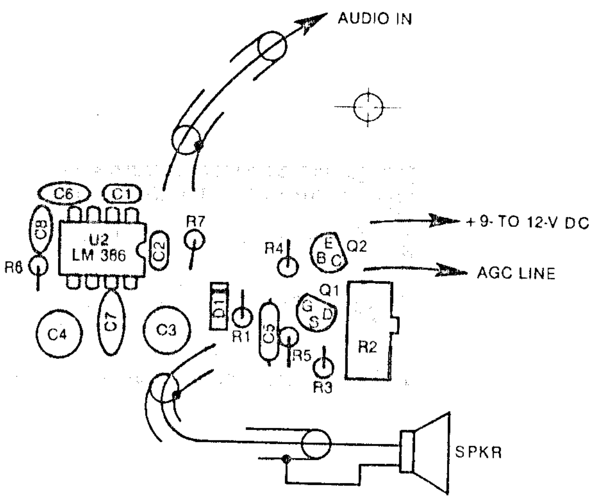
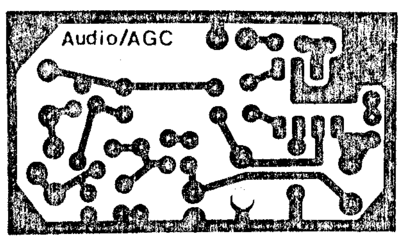


Fig. 2 — Parts-placement guide for the audio module. This view is from the component side of the board. Gray areas represent an X-ray view of the unetched foil. A full-size etching pattern is shown below.



Etching pattern for the audio amplifier and agc module. Black represents unetched copper, viewed from the foil side of the board. Pattern is shown full size. A parts-placement diagram appears in Fig. 2.

Circuit Information

I have used a circuit similar to that shown in Fig. 1 for several small receivers. The LM-386 audio section is compact and stable. Miniature 220-µF, 16-V capacitors (available from Radio Shack) contribute to the small size of the layout (Fig. 2).[1] The circuit is designed to drive an 8-ohm speaker. For the sake of good audio, it should be at least 3 inches in diameter.[2] Operation with headphones is possible by adding a simple attenuator similar to those used in tape recorders and transistor radios. A 10-ohm resistor replaces the speaker, and a 470-ohm series resistor drops the output to a comfortable listening level.

The agc design was borrowed from a more conventional audio-derived configuration and adapted for my application.[3] This circuit has some interesting features that make it universal. First, it samples a wide range of audio levels while remaining virtually "transparent" to the circuit because of the high input impedance. Second, it can be used with either a bipolar or an IC-based i-f section that requires a positive bias-voltage swing, or with MOSFET stages, which employ a negative bias-voltage swing. Since Q1 will respond to either positive or negative voltage, the polarity of D1 determines the direction of the bias-voltage swing. R2 sets the resting-bias level. Adjust this level to the point where agc action begins to lower the receiver background noise on a quiet frequency. R1 is used to adjust the drive. It should be set for smooth response. Overdrive will cause a pronounced overshoot or a cracking sound when strong signals come on. Lack of drive will cause insufficient limiting, and the audio amplifier will be driven into distortion. A substitution box can be used to determine a fixed value for R1 that will work best with your radio. Or, start with a 50-kΩ potentiometer and measure the required resistance.

[1]Notes appear on page 31.

Receiver Applications

Fig. 3 shows how I used this circuit in conjunction with a receiver that has a 455-kHz i-f and employs a single MOSFET i-f stage. Note that the polarity of D1 is set to provide a negative voltage swing. The agc action is smooth, and the i-f amplifier seems to be resistant to overload when no agc signal is present. Consequently, I did not include an rf or manual i-f gain control.

This receiver was built as a small net monitor for 75 meters. I had doubts about the "audio-derived limiter" approach to agc when I remembered how my old SBE-34 used to snap and crack every time a strong signal appeared. By setting the agc bias at the point of gain reduction and adjusting for the smoothest response, however, I eliminated most of that problem. The scheme worked so well that I decided to try it with a solid-state transceiver, which used an MC-1350P i-f amplifier.

Fig. 4 shows the receiver section of that rig, which uses a 9-MHz i-f stage. The results were good. In practice, I set the gain so that stronger signals activate the agc while weaker ones do not. This provides a reasonable dynamic range while maintaining good audio quality and a low level of background noise.

This receiver does employ a manual i-f gain control, since overload is a problem when signals are strong. Your i-f amplifier is overloading if signals sound distorted at low volume, but seem to clear up at higher levels, when the agc reduces the stage gain. If panel space is not available for the addition of an i-f gain control, a simple attenuator switch using fixed resistors could

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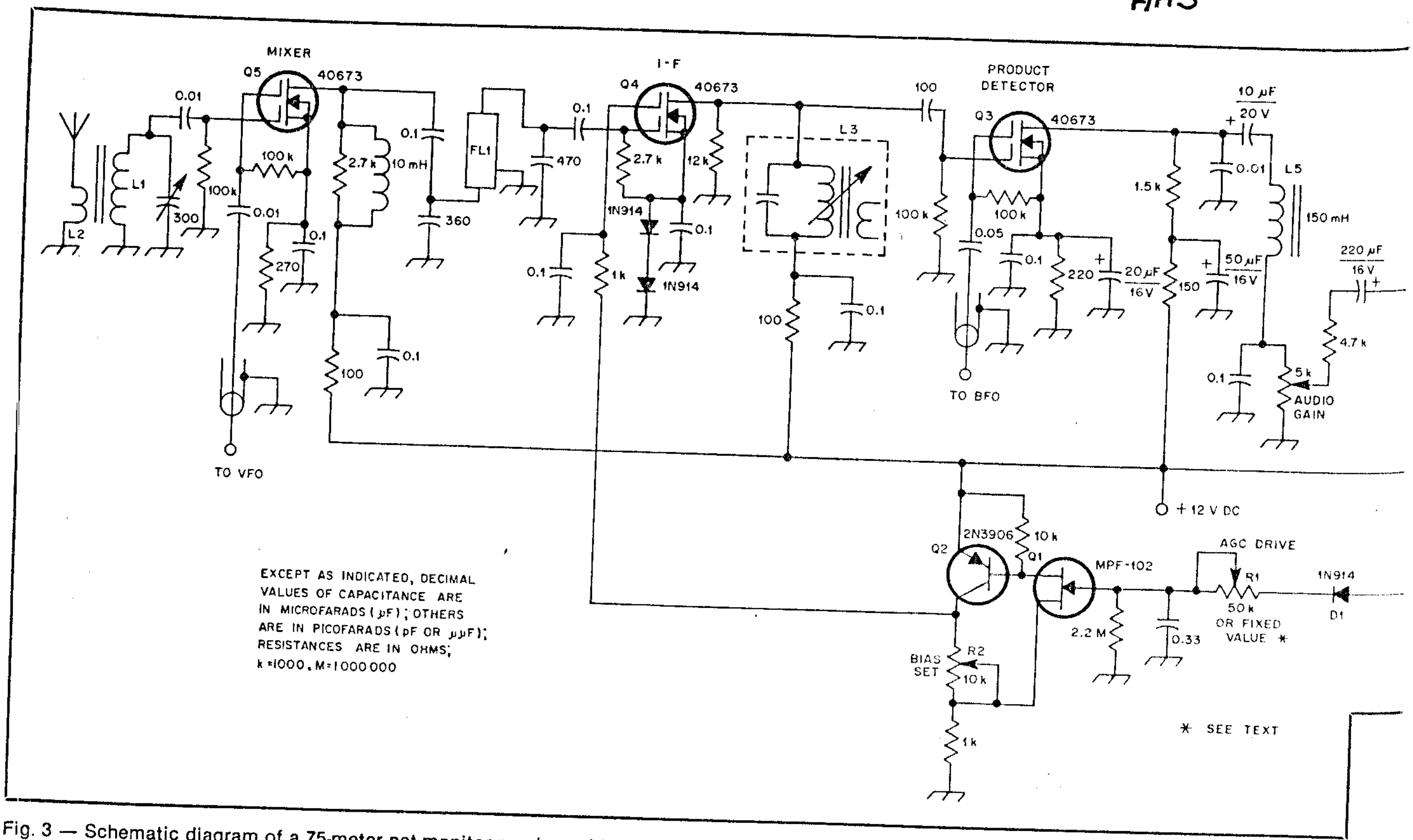

Fig. 3 — Schematic diagram of a 75-meter net-monitor receiver with a MOSFET i-f stage. The audio amplifier/agc module is used as the audio stage in this receiver.

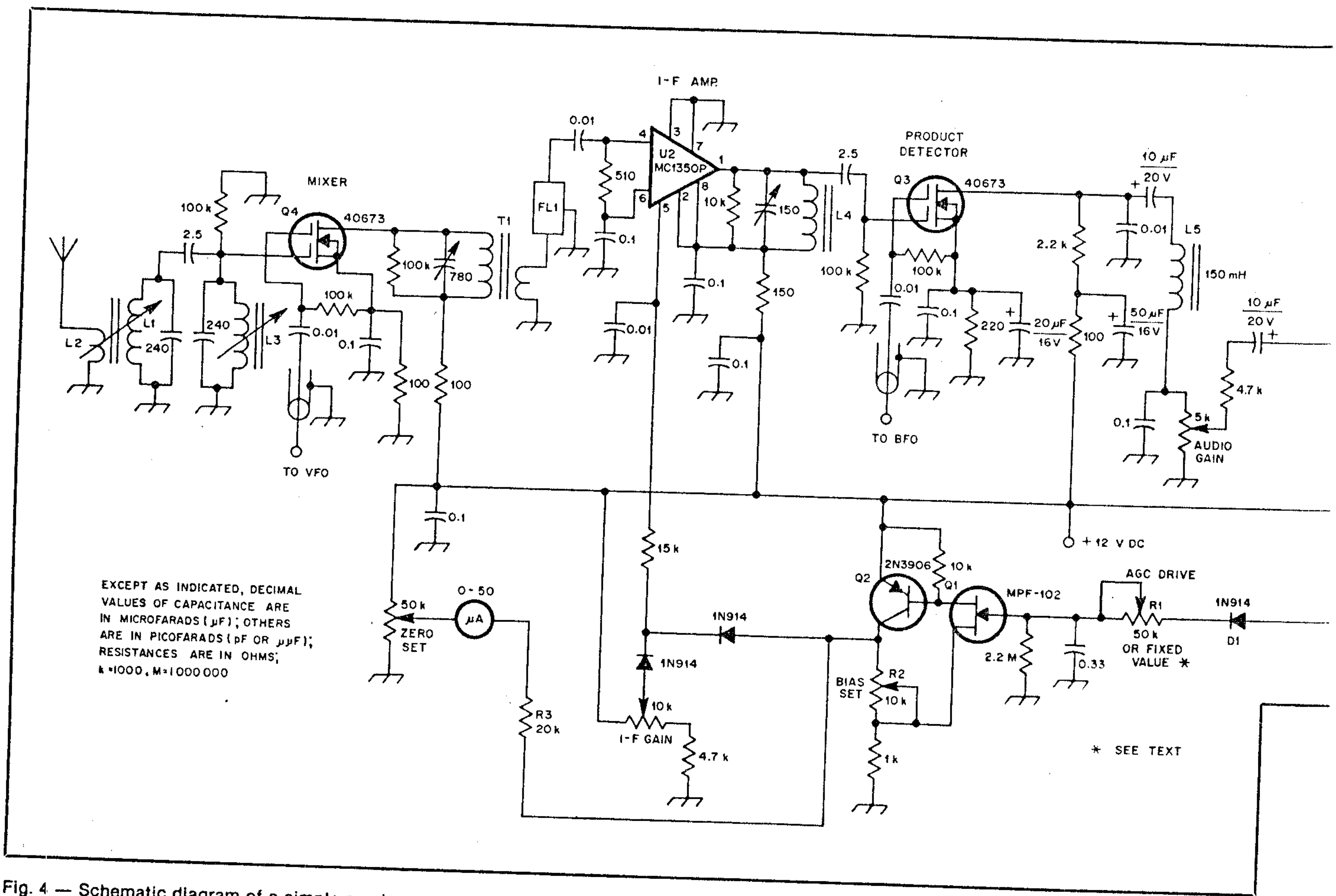

Fig. 4 — Schematic diagram of a simple receiver employing a 9-MHz i-f. The audio amplifier/agc module comprises the audio section of this receiver.

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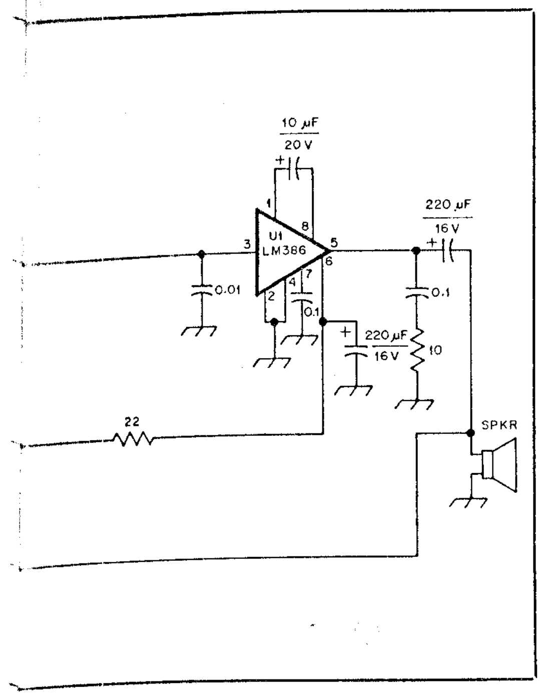
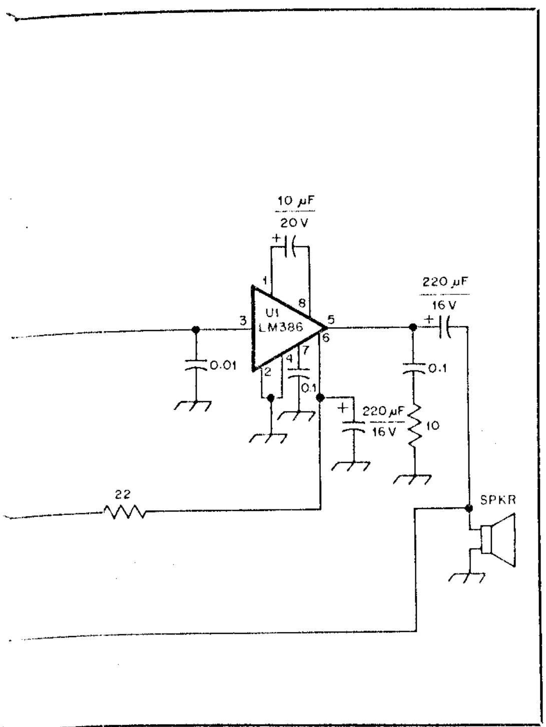


FL1 — 2.1-kHz bandwidth i-f filter. The one used by the author is a Kokusai unit purchased from MHZ Electronics.
L1 — 40 turns no. 24 enam. wire on an Amidon or Palomar T68-6 toroid core.
L2 — Two turns no. 24 enam. wire over ground end of L1.
L3 — Primary of a 455-kHz i-f transformer.



FL1 — Mechanical i-f filter. The author used a McCoy 9-MHz crystal filter.
L1, L3 — Approximately 7 µH, wound on a slug-tuned core.
L2 — Two-turn link wound on ground end of L1.
L4 — 24 turns no. 24 enam. wire on T37-2 toroidal core.
T1 — Primary, 25 turns no. 24 enam. wire on T37-2 core. Secondary, 6 turns no. 24 enam. wire.

be substituted. A 20-dB attenuation level should be about right.

Notice that both receivers employ a single-ended MOSFET product detector. This is a reasonable choice since the circuit is simple and provides some gain. An optional low-pass filter on the detector output reduces high-frequency audio interference. Inductor L5 consists of a 0.6-inch single-bobbin pot core wound to capacity with no. 36 wire. The inductance should be about 150 mH.

My transceiver contained a panel-mounted meter, so I included the meter circuit shown in Fig. 4 for the receiver section. Monitoring the agc voltage does not provide true signal-strength readings, but it does give an indication of agc action. This particular meter has a 50-µA movement, but less sensitive meters can be used with adjustments of R3. The comparative readings obtained with this meter make it a worthwhile addition to the project.

Conclusion

Employing an audio chip that is capable of driving a speaker, and adding a simple agc circuit, can eliminate two drawbacks to building your own "bare bones" receiver. This agc circuit may also adapt to existing projects, including direct-conversion receivers with rf amplifiers. Give it a try. The parts are inexpensive and the results are good.

[Editor's Note: This audio/agc circuit was installed in the W1FB "Bare-Bones CW 'Superhet,' " described in June 1982 *QST*. Few circuit changes were required to replace the original audio circuit. The agc bias voltage was connected directly to Q2 gate 1 through a pair of series-connected 1N914 diodes and a 1-kΩ resistor. The diodes were needed to provide the proper bias voltage range for the i-f amplifier. With no signal present, R2 was adjusted to provide +4 V on gate 1. When the receiver was tuned to a strong signal, agc action reduced this to less than 1 V, decreasing the i-f gain. More or fewer diodes may be needed with other receiver circuits.] QST

Rick Littlefield received his General class amateur license in 1957, at the age of 13. He holds a BA degree in communications and an MEd in education counseling from the University of New Hampshire. He is employed by the University of New Hampshire in the Department of Media Services. His main duties include writing and producing educational programming and providing consultation for University-affiliated projects, along with some teaching assignments. Rick also owns and operates Lakeshore Media, a small consulting and production company in Barrington, New Hampshire. Rick's other interests include playing several musical instruments and singing. He has stage and recording experience, is a professional narrator, a nationally published cartoonist, illustrator and author, has a Private Pilot rating, and enjoys sailing and cross-country skiing.

Notes

[1] Etched circuit boards, parts and parts kits for the audio amplifier/agc circuit are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002, and from RADIOKIT, Box 411, Greenville, NH 03048.

[2] mm = in. × 25.4.

[3] W. Hayward and D. DeMaw, *Solid State Design for the Radio Amateur* (Newington: ARRL, 1977), pp. 103-106.

Strays

TA PROFILES

On November 20, 1981, we had the good fortune of adding David A. Zinder, W7PMD, to our team of ARRL Technical Advisors. Because of his more than 24 years experience in engineering and designing electric power control systems, we named him our expert on power supplies and ac power systems. He has been registered as a professional engineer in Wisconsin and Arizona.

Dave received his first Amateur Radio license in 1951, and currently holds an Advanced class license. He resides in Phoenix, Arizona, and is active on 2 meters. If you are in the area, I'm sure you will hear Dave talking to his son (N7DZF) on 2-meter fm.

Dave received his BSEE degree from the University of Arizona. He is employed as the principal engineer for Sperry Flight Systems. He is also the power-supply designer and test engineer for the F-16 cockpit CRT display system. Dave has authored more than 22 technical papers, many of which were published in engineering technical magazines. One of his articles, "SCR Power Control Fundamentals," was selected as the best paper of the year in 1968 by *Appliance Engineer Magazine*.

After retiring as Scout Master, following eight years of service, Dave is still active in the local scout council and is the committee chairman. Many of his evenings are devoted to teaching "Intro to Electronics" at Phoenix College. When time allows, he enjoys hiking, camping and fishing. — *Marian Anderson, WB1FSB*

TA Dave Zinder, W7PMD