

A Flexible Digital-Mode Interface

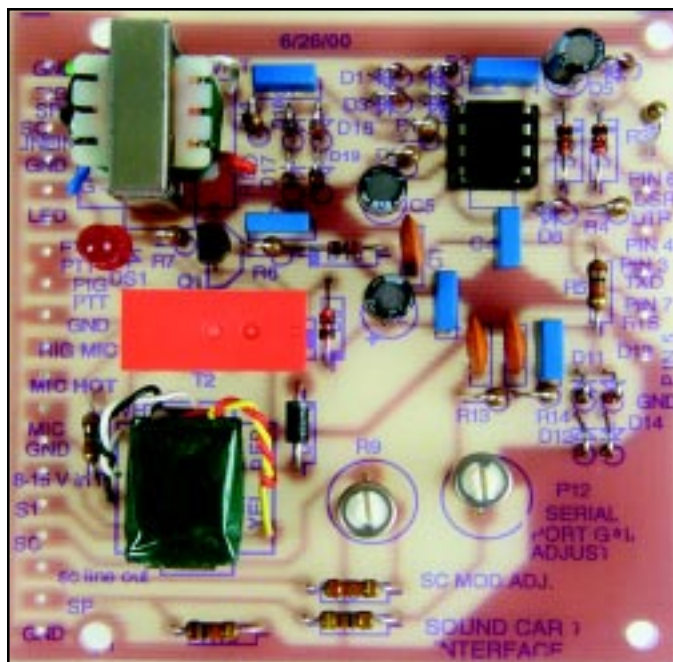
One interface, all the software—here's how to do it simply and inexpensively.

Only a few short years ago, the fax, packet, RTTY and SSTV modes seemed to be reserved for those who possessed the means to purchase and operate sometimes large—and nearly always expensive—equipment. This began to change in the early '90s when software written for home computers began to replace the expensive hardware. Programs such as *HamComm*¹ allow operation of CW, RTTY and some 'TOR modes requiring only a few “junk-box” components to fabricate a simple comparator modem. *JV-FAX*² uses the same modem to give us SSTV with amazing results. These early DOS-based programs were followed by variations on the same theme, but eventually gave way to *Windows*-based software.

Programmers writing software for *Windows* didn't want to continue with the sometimes-inconsistent performance of the simple comparator interfaces, so they looked to using the sound cards with which most computers are equipped these days. A sound card can do most of the signal encoding and decoding required for these modes. Not only does the sound card do a fine job in the DSP department, it eliminates the need for some hardware. All that's necessary now is to deliver the transceiver audio to the sound card's input and send the sound card's output back to the rig's mic or accessory input. A means of keying the rig helps, too.³

Initially, I hesitated to try any of the newer SSTV programs because I didn't want to tear apart my reliable comparator-modem setup to reconfigure the audio I/Os to my computer's sound card. I wanted to continue to use the DOS-based programs, but also wanted to enjoy the new modes

¹Notes appear on page 42.



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such as PSK31⁴ and MT63⁵ with software running under *Windows*. Soon I tired of manually connecting and disconnecting wires to the rig. I realized then that I needed an interface that would allow me to use the comparator modem for DOS applications and use the same I/Os for the sound card programs.

Circuit Description

The interface I designed is shown in Figure 1. The comparator section employs a dual op amp (U1) operating as a limiting amplifier with full free-run amplification. This creates the required rectangular waves at an RS-232-compatible level necessary to run the DOS-based SSTV and FAX programs. The four diodes (D1-D4) in the feedback loop of U1A soft-limit the waveform, delivering a relatively symmetrical rectangular wave with rounded tops and bottoms limiting at about ± 2.8 V. U1B is another maximum-gain stage that ensures correct amplitude and rectangular waveform symmetry are presented to the serial port at J1. Open-loop gain in this stage eliminates the effects of the soft limiting at U1A. Op-amp operating voltage is supplied by the computer's serial port via the DTR and RTS lines. Diode matrix D5-D8 (a bridge circuit) ensures proper voltage polarity at the

appropriate op-amp pins regardless of how the RTS and DTR lines are defined by the various programs.

To perform at their best, SSTV and FAX programs such as *EZ-SSTV*, *JV-FAX*, *MSCAN*⁶ and *EasyFAX*⁷ require only a basic HamComm-style modem. A HamComm modem can be as simple as a single op-amp stage, a decoupling capacitor driving the inverting input and a resistor to ground (see the inset of Figure 1). These programs can use such a modest interface because they determine the audio-input frequency by counting waveform zero crossings. A few other SSTV programs, such as *GSH-PC*,⁸ rely heavily on the symmetry and accuracy of the rectangular wave presented to the serial-port handshake line (DSR) to produce their best picture quality. Waveform asymmetry and inaccuracy can be caused by a number of variables: A computer's DTR and RTS lines are rarely balanced (ie, having equal voltages of opposite polarity) and op amps may exhibit a large dc-offset error. This circuit, however, fulfills the requirements of all the DOS-based programs mentioned here by providing a very symmetrical waveform at proper RS-232 levels.

Q1 is driven by the serial port RTS line via D10 and R6. K1A is energized when Q1 turns on. A PTT switch action is pro-

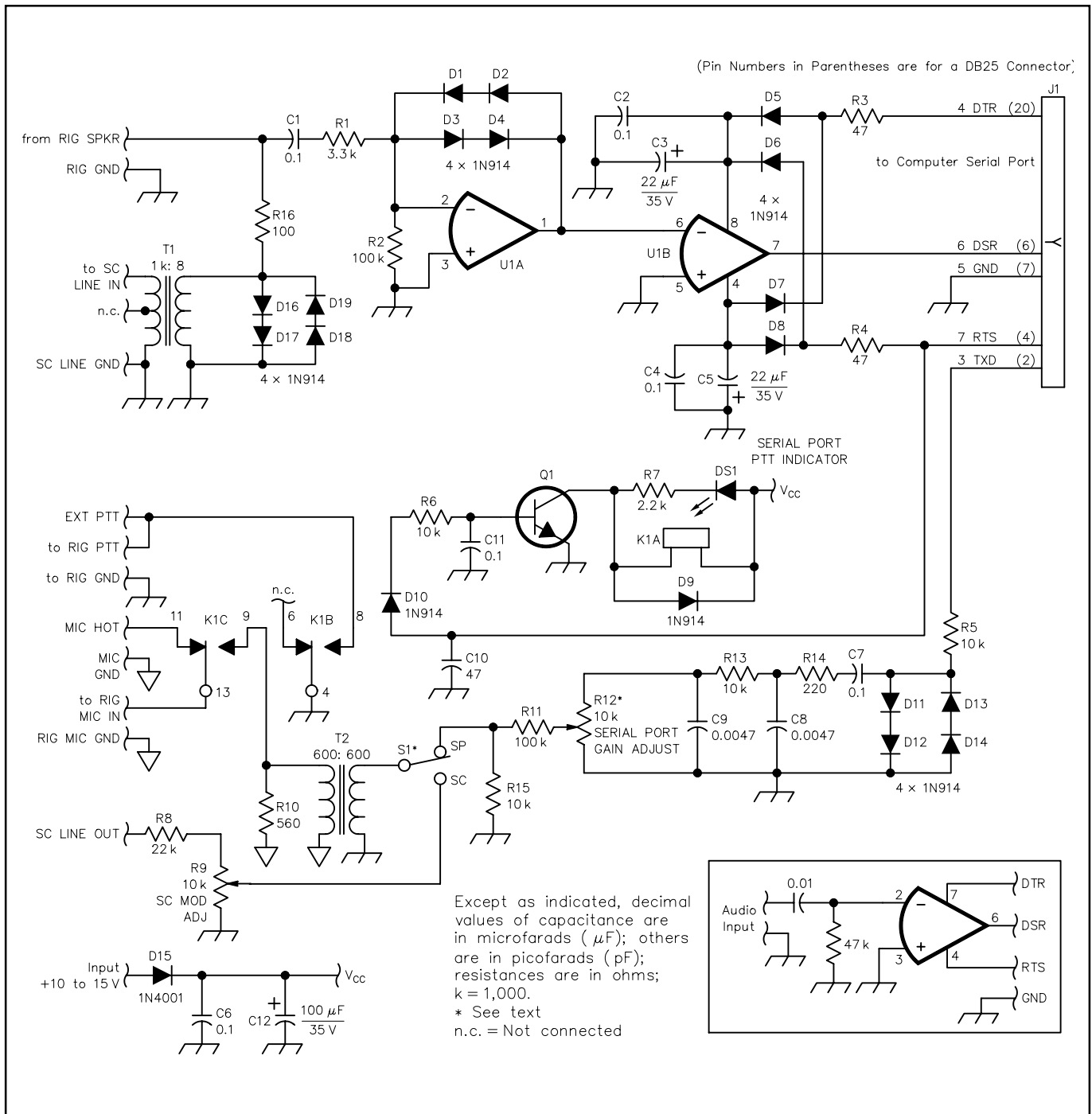


Figure 1—Schematic of the flexible digital-mode interface. Unless otherwise specified, resistors are $\frac{1}{4}$ -W, 5%-tolerance carbon-composition or metal-film units. RS part numbers in parentheses are RadioShack. (Note: All of the resistors used in this project can be found in assortment RS 271-312; specific part numbers are also given.) Equivalent parts can be substituted; n.c. indicates no connection. J1 pin numbers are for a DB9 connector; pin numbers in parentheses apply to a DB25 connector. The inset shows a basic interface referred to in the text. Note that a different ground symbol is used for the connections labeled **MIC HOT**, **MIC GND**, the bottom end of R10 and the primary of T2. These four connections are purposely isolated from the other grounds (see text) and should remain isolated from them and from the enclosure if a metal one is used. The other grounds are connected to a common bus and the FAR Circuits PC-board mounting pads and can be connected to the enclosure.

C1, C2, C4, C6, C7, C11—0.1 μF
(RS 272-135)

C3, C5—22 μF , 35 V electrolytic
(RS 272-1026)

C8, C9—0.0047 μF (RS 272-130)

C10—47 pF (RS 272-121)

C12—100 μF , 35 V (RS 272-1028)

D1-D14, D16-D19—1N914 (RS 276-1122,
package of 10)

D15—1N4001 (RS 276-1101)

DS1—LED from assortment package
(RS 276-1622)

K1—DPDT 12-V dc PC-mount relay
(RS 275-249)

Q1—2N2222 (RS 276-1617)

R1—3.3 k Ω (RS 271-1328)

R2, R11—100 k Ω (RS 271-1347)

R3, R4—47 Ω (RS 271-312)

R5, R6, R13, R15—10 k Ω (RS 271-1335)

R7—2.2 k Ω (RS 271-1325)

R8—22 k Ω (RS 271-1339)

R9, R12—10-k Ω PC-mount pot

(RS 271-282) or use optional 10-k Ω pot
with SPDT switch (RS 271-215); see text.

R10—560 Ω (RS 271-312)

R14—220 Ω (RS 271-1313)

R16—100 Ω (RS 271-1311)

T1—Audio-output transformer

(RS 273-1380)

T2—1:1 isolation transformer

(RS 273-1374)

U1—TL082 dual op amp (RS 276-1715)

vided by K1B when the software signals *transmit* and toggles the RTS line positive. K1C selects the interface's modulating source: the mic, sound card or TxD line of the computer's serial port. When RTS is negative, the mic is selected. When RTS is positive, the PTT line is actuated and either the sound card or serial port is selected. A PTT indicator (optional) is provided by DS1 at the collector of Q1.

The modulating source of the interface is selected by S1. In the **SP** position, that source is the computer's serial port. The **SC** position selects the sound card **LINE** output. R8 and pot R9 (**SC MOD ADJ**) attenuate the sound card's **LINE** output. T2 isolates the interface and computer grounds from the rig's mic ground to minimize RFI problems.

DOS-based digital-mode software provides modulating tones in the form of square waves at the serial port's TxD line. A brute-force low-pass filter comprised of C7, R14, C8, R13 and C9 rolls off much of the square waves to present a waveform more like a sine wave to the rig's modulator; the rig's filtering does the rest of the job. R5 and D11-D14 form a limiter stage that maintains the output of the serial port's TxD line at around ± 3 V. (This circuit is not required for the interface to function, however, and is discussed later.)

C6 and C12 filter the external dc source. D15 protects the circuit from an incorrectly polarized power-supply input. R16 and D16 through D19 act as a limiting stage to protect the sound card input from excessively high audio input.

Construction

Component values and types are such that a single trip to RadioShack should be all that's necessary if you can't find the parts you need in your junk-box or that of a friend. The FAR Circuits PC board⁹ makes building this project easy. Duplicate holes are provided on the PC board for various connections. **EXT PTT** can be used if an additional PTT line output is needed.

Using a PC-mounted control at R12 to adjust the serial-port modulation level is adequate. Once this level is set, there is seldom any need for readjustment. On the other hand, the sound card line output might require more frequent adjustment if multiple *Windows*-based sound card programs are used; level requirements might vary from one program to another. Adjusting the sound card's mixer panel **.WAV** output is usually an acceptable means to ensure proper modulation level from the sound card's **LINE** output. This could be a minor inconvenience, but I found an excellent resolution to this dilemma in a normally stocked item at RadioShack: a panel-mounted 10-k Ω control with a SPDT switch (RS 271-215). Using this control for R12 instead of a PC-mount pot

allows not only line-output adjustment, but doubles as the modulation-source selection switch (S1). Rotating the control fully counterclockwise to the **OFF** position selects the serial port (**SP**) as the modulating source. Rotating the control clockwise and turning the switch to its **ON** position selects the sound card's **LINE** output (**SC**) as the modulation source. If frequent sound card **LINE** output-level adjustment is not necessary, the PC-board-mounted control should be adequate for your application.

An external 10 to 15-V dc source applied via D15 is required to power the relay and the optional serial port PTT LED, DS1. If the optional PTT indicator circuit is not required, omit R7 and DS1.

Component-Value Considerations

A few component values might have to be changed to accommodate your equipment's level requirements. The TxD data-leveling circuitry (R5, D11-D14) in conjunction with the insertion losses of the low-pass filter (C7, C8, C9, R13, R14) and the attenuation provided by R11, R12 and R15 sufficiently reduce the amplitude of the TxD output to microphone level. This level reduction might be excessive for some applications. If you find that your rig can't be modulated adequately, remove D11 through D14 and replace R5 with a wire jumper. Adjust R12 to see if the level has increased sufficiently to properly modulate your rig. If the level is still not high enough, you can reduce the value of R11, but not below a value of 1 k Ω . Similarly, R8's value may need altering to ensure proper modulation when the computer's sound card is used as the modulation source. R8 is the *only* component in this part of the circuit whose value can be modified, as your computer's audio-mixer controls should be used to set these levels.

Alignment

With all components interconnected and a dummy load attached to your rig, rotate S1 to the **SP** position. Ensure R12 is fully counterclockwise (minimum resistance). Set your rig's microphone-level control as you normally would. Select a DOS-based SSTV program and load a picture. From within the program, select transmit. The rig should key, but should *not* be modulating. Slowly adjust R12 clockwise until the modulation peaks just enter the ALC region of your rig's meter. If the modulation level is high as you start to open R12, additional attenuation is required. Select a value for R11 that allows full modulation at about mid-rotation of R12. If R12 is full clockwise (minimum resistance) and your rig lacks full modulation, try one of the steps mentioned earlier to increase the level through the TxD low-pass filter to your rig's modulating point. Unkey the transmitter.

A similar procedure is used to adjust R9. Place S1 in the **SC** position to select the sound card as the modulating source. Use the sound card mixer panel to adjust the **.WAV** output level. Set R9 fully counterclockwise (minimum). Select a sound card program and set it up to transmit. If you choose an SSTV program for this adjustment, load a picture. From within the program, select transmit. The rig should key, but should not be modulated. Slowly rotate R9 clockwise and note how the rig begins to modulate. If the modulation level is high as you start to open R9, increase the value of R8 or decrease the sound card's **.WAV** output level. Select R8's value such that full modulation is realized somewhere around midposition of R9. On the other hand, if the incoming audio level is insufficient to properly modulate the rig with R9 at minimum resistance, decrease the value of R8. You should easily find a value for R8 that, in conjunction with adjustment of the **.WAV** output of your computer's sound card mixer panel, results in proper modulation.

No provisions have been made to adjust the rig's audio-output level at the interface. The input of the comparator (U1A and U1B) can handle speaker audio levels ranging from barely audible to full-room volume. If a fixed audio-level point (such as the output at an accessory connector) is connected to this point, that should do. Use the sound card mixer **LINE INPUT** control to control the audio level fed to the sound card. Some SSTV programs provide a control for this audio source also.

PC-Board Pin-Out IDs

Most of the connections to the PC board are obvious, but I thought it might be a good idea to identify them here as well. The labels near the PC-board interconnection pads identify lines *from* the off-board source.

- **RIG SPKR**—Connection your rig's **SPEAKER** or **LINE** output (high side) to this pad.
- **SC LINE IN**—Connects to the computer's sound card **LINE INPUT** jack (high side).
- **RIG GND**, **SC LINE GND** and **PTT GND**—Electrically, these are all the same point on the interface. These points connect from the interface to the rig or the sound card as indicated in the labeling.
- **EXT PTT**—This pad is connected in parallel with the relay PTT contacts. This is convenient if you have a secondary PTT actuator such as a foot switch or a grounding switch on the microphone.
- **MIC HOT**—If you're using the rig's mic input as the modulating point for the interface *and* the microphone, connect your mic to this pad and the mic ground to **MIC GND** on the interface.
- **RIG MIC IN**—From the rig's modulating input point; either the mic connector, or the

accessory jack **LINE** input. If you're using your rig's accessory connector as the modulation input to your transceiver, connecting a microphone to the interface's **MIC HOT** pad (as described earlier) isn't necessary as the mic is likely connected directly to the rig's mic connector.

- **SC LINE OUT**—Input from the sound card **LINE OUTPUT** jack (high side).
- **+10 to +15V**—External power-supply connection.

Serial-port connection labels are on the component side of the PC board opposite the rig and sound card I/Os. Pin numbers indicated are those for a 9-pin (DB9) connector at J1. If you have a 25-pin serial port connection, use the pin numbers enclosed in parentheses in Figure 1.

Summary

Now you have no excuse for not trying AMTOR, FAX, Hellschreiber, MT63, PACTOR, PSK31, RTTY and SSTV. With this interface, you can operate most of the modes by simply running the appropriate software (much of which is *free*) and se-

lecting the proper interface. You're sure to have fun!

Notes

¹K7SZL's *Unofficial HamComm* home page (<http://home.att.net/~k7szl>) contains information on nearly every aspect of the popular *HamComm* program.

²The *JV-FAX/JV-Comm32* site is <http://www.jvcomm.de>.

³Most sound card SSTV and other digital-mode software can be found at <http://www.muenster.de/~welp/sb.htm>.

⁴For PSK31 information and software, visit the "Official" PSK31 Homepage at <http://aintel.bi.ehu.es/psk31.html>.

⁵Information on the MT63 experimental mode and software can be found at <http://members.xoom.com/ZL1BPU/MT63/MT63.html>.


⁶All of these DOS SSTV programs (*EZ-SSTV*, *GSH-PC*, *JV-FAX*, and *MSCAN*) in addition to most sound card SSTV software can be obtained from <http://www.ultranet.com/~sstv/index.html>. The *EZ-SSTV* site is <http://www.ultranet.com/~sstv/ezsstv.html>. *MSCAN* is available from <http://www.mscan.com>.

⁷You can download *EasyFAX* V1.10 from ftp://ftp.funet.fi/pub/ham/fax_sstv/ef110.exe.

⁸*GSH-PC* is available at <http://ourworld.com>.

compuserve.com/homepages/dl4saw and <http://www.pervisell.com/ham/gs1.htm>.

⁹PC boards are available from Far Circuits, 18N640 Field Ct, Dundee, IL 60118-9269; tel 847-836-9148 (voice and fax); <http://www.cl.ais.net/farcir/>. PC Board only, \$5 plus \$1.50 shipping for up to four boards. Visa and MasterCard accepted with a \$3 service charge.

Jim Mitrenga, N9ART, received his Technician class license in March of 1979; he upgraded to Amateur Extra class in 1981. Jim's wife, Sandy, is KB9MXF. Jim and Sandy are active on VHF and UHF FM for family communication. HF CW is Jim's favorite mode, but he's active on AM, FM, SSB, SSTV, PSK31, RTTY and packet, and enjoys Amateur Radio electronics design. Jim's other interests include fishing, hiking, bicycling, gardening, computers, audio recording and broadcast engineering. Jim is employed as a program manager at Motorola, Inc, in Schaumburg, Illinois, where he started as an RF design engineer in 1979. Currently he concentrates on digital communications audio quality. You can contact Jim at 1013 Chippewa Dr, Elgin, IL 60120; ssstv@hotmail.com and n9art@arrl.net 

NEW BOOKS

THE ELECTRONICS OF RADIO

By David B. Rutledge, KN6EK

Published by Cambridge University Press, 40 West 20th Street, New York NY 10011-4211; tel 212-924-3900; fax 212-691-3239; <http://www.cup.org>. First edition, 1999, 431 pages including the index, paperback 10 × 6⁷/₈ inches, B&W illustrations, 3¹/₂-inch disk included. ISBN 0521646456. \$44.95.

Reviewed by TA Paul Danzer, N111
ARRL Technical Advisor

◊ *The Electronics of Radio* is a college-level textbook, and the author is a professor of electrical engineering at the California Institute of Technology. There is a good deal of mathematics in many of the chapters, and knowledge of basic first-year calculus would be helpful to understand some of the material.

This being the case, why would this book be of interest to many hams? Because there are some real goodies between the soft covers of an attractive, well-written text using the NorCal 40A QRP rig as its example.

The first chapter is a summary of radio—from the *Titanic* through basic electrical laws, receiver and transmitter components and stages, up to the NorCal rig. From this point onward the following chapters are more conventional—components, transmission lines, filters, amplifiers and so on. But included in here are any number of interesting sidelights and approaches. As an example of acoustics, in Chapter 7 there is

a problem (or exercise for the student) using a resonate tube to change the response of a loud speaker. Anyone remember some of the old "Hints And Kinks?"

The oscillator chapter of *The Electronics of Radio* contains a very nice explanation of RIT, the NorCal circuit that generated this function, and a drawing of the components on the board to show how it is actually built. For those who like to see actual hardware along with theory, KN6EK often obliges.

Chapter 12 is devoted to mixers, and there is a bit of math used. However, for anyone who is tired of long and inconclusive discussions of mixers, spurious products and receiver problems, the material in this chapter is very much worth reading. Included is a very precise explanation of key clicks using a power spectrum expression—but with it is a filter and an explanation of the way the filter works.

The noise chapter a mathematically based explanation of what goes on in a receiver. Like it or not, this is an area where the math is needed to explain the operation. Although some calculus is used, unless you are an engineering student, you probably won't miss much by just passing over the calculus equations.

Chapter 15, Antennas And Propagation, contains a very nice section concerning the Friis Formula. Many technical people will recognize most of it as the radar range equation, used to predict how far a radar system can see a target. Along with it is an expla-

nation of how to calculate line-of-sight for VHF, UHF and microwave is an explanation of why the Earth's radius is multiplied by 4/3 for calculating line-of-sight.

There are several appendices included. Appendix B goes through Fourier Series. But unlike the treatment in most math handbooks, this one is directed and limited to radio and electronics applications. The examples worked out in detail are for a square wave, rectified cosine (or sine) wave and narrow pulses.

Another appendix explains the use of *Puff 2.1* and the disk accompanying the book. *Puff 2.1* is a circuit simulator for linear circuits that also makes microstrip and stripline layouts. I did not attempt to use the software.

The final appendix is a very nice feature I appreciated both as a reader and teacher—a set of data sheets for the critical components used in *The Electronics of Radio*, as well as the Web addresses of many of the suppliers. Often you see a transistor or integrated circuit used in a technical discussion and you have no clue as to its characteristics. The appendix thankfully cures this problem.

In summary, *The Electronics of Radio* uses the novel approach of making a real ham rig as the subject of most of its examples. As a textbook, it is not general light reading for everyone, but it has a number of goodies in it, and if you want to see a slightly different approach to electronics, take a look at *The Electronics of Radio*. 