QEX 79

$1.75

SEPTEMBER 1988

ARRL Experimenters' Exchange and AMSAT Satellite Journal

EX: The ARRL
xperimenters' Exchange
merican Radio Relay League
25 Main Street
ewington, CT USA 06111

Non-Profit Org.
US Postage
PAID
Hartford, CT
Permit No. 2929

QEX (ISSN: 0886-8093) is published monthly by the American Radio Relay League, Newington, CT USA.

Offices

225 Main St, Newington, CT 06111 USA
Telephone: 203-666-1541
Telex: 650215-5052 MCI
Electronic Mail: MCI MAIL ID:215-5052
(user name ARRL)

Subscription rate for 12 issues:
In the US by Third Class Mail:
ARRL/AMSAT Member $10, nonmember $20;

US, Canada and Mexico by First Class Mail:
ARRL/AMSAT Member $18, nonmember $28;

Elsewhere by Airmail:
ARRL/AMSAT Member $38, nonmember $48.

QEX subscription orders, changes of address, and reports of missing or damaged copies may be marked: *QEX* Circulation.

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ABOUT THE COVER

Here's a project that should whet the appetites of the growing number of WEFAXers. No more boxes to clutter your operating desk; this interface hides in your PC!

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio field
3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT 06111 USA. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in recent editions of *The ARRL Handbook*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Any opinions expressed in *QEX* are those of the authors, not necessarily those of the editor or the League. While we attempt to ensure that all articles are technically valid, authors are expected to defend their own material. Products mentioned in the text are included for your information; no endorsement is implied. The information is believed to be correct, but readers are cautioned to verify availability of the product before sending money to the vendor.

Empirically Speaking. . .

AMSAT Announces PACSAT Project

The wraps are off the uSAT (microsatellite) project. AMSAT-NA President Vern Riportella (WA2LQQ) announced plans to launch *four* uSATs from a single European Space Agency Ariane launch vehicle presently scheduled for sometime in 1989. The name uSAT derives from their size: a 23-cm (9-inch) cube of less than 10 kg (22 lb) mass.

The first two are to be store-and-forward packet satellites (PACSATs)—one to be operated by AMSAT-NA, the other by AMSAT-LU. The third is a special-purpose amateur satellite sponsored by Brazil AMSAT (BRAMSAT), and will carry Project DOVE (Digital Orbiting Voice Encoder). This satellite will carry a synthesized voice transmitter. The fourth satellite will carry a low-resolution camera and is sponsored by the Center for Aerospace Technology (CAST) at Weber State College, of Ogden, Utah.

Tucson Amateur Packet Radio (TAPR) is providing some initial funding, and ARRL is assisting with design and construction of the satellites.

FCC Allocates the 220-222 MHz Band to Land Mobile

This is being written on August 5—the day after the FCC Commissioners voted to reallocate the 220 to 222-MHz band to private land mobile use. As the news came just one day after *QST* was shipped to the printer in Kentucky, we were able to get a news flash inserted in the poly bag so that *QST* readers in the United States would know what happened. Also, within a hour of the Commissioners' decision, W1AW transmitted a bulletin that has been relayed across the country by packet-radio bulletin boards and other means. There hasn't been enough time to assess the full reaction, but the first-day reading is outrage and disbelief among US amateurs.

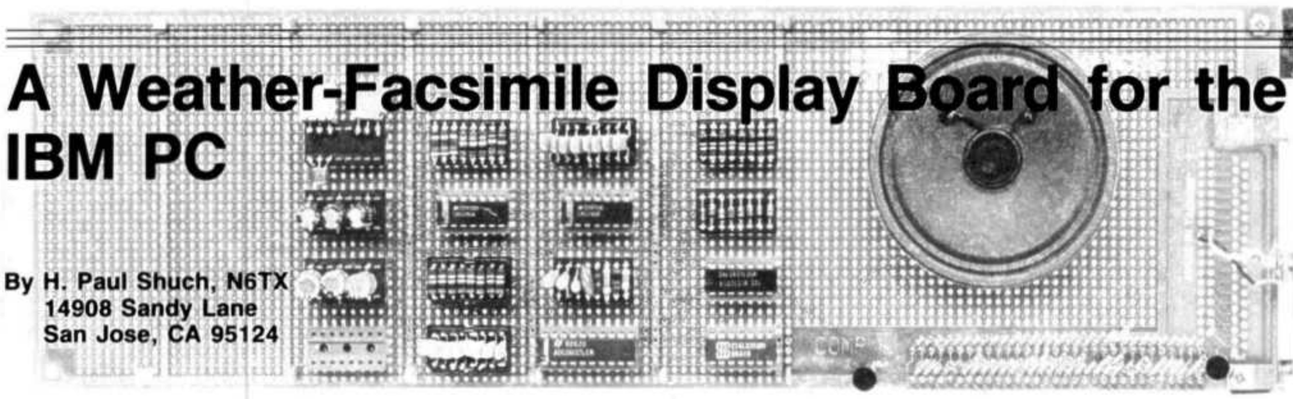
Despite FCC's mistaken belief that Amateur Radio operations in the 220 to 222-MHz segment could easily be reaccommodated elsewhere in amateur bands, a computer printout run on August 4 at ARRL HQ shows a sizable problem. In fact, it's a problem that has grown since the ARRL provided a similar printout to the FCC. There are more 220-MHz repeaters, packet links and other coordinated users than a year ago, especially in the 220.5 to 222-MHz range. Moreover, the activity listings are only the tip of the iceberg. For reasons of system integrity, many control links and some other uses in the 220-222 MHz segment are known only to the users or local coordinators. Only some of these listings are known to the ARRL, even on a confidential basis. We faithfully respected the confidentiality requested and reported only the amount and type of activity to the FCC on a national basis, while not revealing the identities and locations. The bottom line is that the FCC had only the listed uses of the 220 to 222-MHz segment, had some statistical information about the unlisted uses, and did not appreciate that the occupancy of the entire 220 to 225-MHz band has grown at a healthy rate since the public comment period closed.

Particularly hard hit was the packet community as the first 56-kbaud links based on the WA4DSY modem just went on the air in the 220 to 222-MHz segment with others soon to follow. It's an easy thing for the FCC to say that the amateur operations can be reaccommodated elsewhere, but a different matter to (a) find room in the 222 to 225-MHz segment (with wall-to-wall voice FM repeaters) or (b) trash the 220-MHz (special) RF equipment, go to another band and find room there.

Since the 222 to 225-MHz segment is heavily used for voice repeaters and most other users of the band are in the 220 to 222-MHz segment, a serious crunch is anticipated if this FCC decision is not reversed. In these days of "win-win" negotiation strategies, the Commission has created a "lose-lose" situation for amateurs in the 220-MHz band. Those in the 220 to 222-MHz segment lose their bandwidth and have to either discontinue their operation or try to crowd into the 222 to 225-MHz segment. Those in the upper 60% of the band are forced to consider sharing space with the 40% who have been discommoded, and lose their protection ratios carefully crafted by frequency coordinators.

In theory, the FCC's case is based on the expected spectrum efficiency of so-called narrowband modulation systems—usually that is a euphemism for ACSSB. The theory goes on to say that there is no room in the existing land-mobile bands for ACSSB, even on a drop-in basis (put them between FM channels). Further, the proponents contend that ACSSB needs "virgin spectrum"—think about it! The problem with ACSSB is that it sounds fine to say that it needs only 5 kHz per channel and FM needs 15 kHz. On the surface that would appear to be a 3:1 advantage in spectrum efficiency. Unfortunately, the advantage is only illusory. Recent years of theoretical and empirical work have shown that the overall spectrum efficiencies of ACSSB and narrowband FM (say 12.5- or 15-kHz spacing) are about comparable, depending on the situation. To make a long story short, the latest engineering thinking says that some spectrum efficiency can be gained by using ACSSB in special circumstances (earth-space and terrestrial applications with unusual geographical disposition of stations), but that FM appears to be more efficient in a cellular geographical environment, such as for land mobile. It gets complex, but the key is frequency reuse, ie, how far apart stations need to be to provide the required protection ratios.

The answer does not lie in hams rushing into turf warfare over the upper three megahertz of the the 220-MHz band. It is clear that we must use every resource at our disposal to reverse this unfortunate FCC decision. The ARRL has mounted a sustained effort, throughout the proceeding of Docket 87-14, to retain the entire 220 to 225-MHz band. Individual amateurs have sent thousands of well-thought-out letters to the Commission. Have you let your Congressional representatives know how you feel about the FCC's action? Even postcards (QSL cards!) will get the message across. —*W4RI*



A Weather-Facsimile Display Board for the IBM PC

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About fifteen years ago, when I first became involved in the fascinating process of receiving pictures of the Earth from weather satellites,[1] several image-display options existed. Like most experimenters, I tried them all. Although electrostatic printers, rotating-drum facsimile machines, slow-scan TV monitors, storage oscilloscopes, and Polaroid time exposures from CRT displays all produced usable and exciting pictures, I longed for an easier way. I wanted a display with no moving mechanical parts, no messy chemicals, no fumes from sparking Teledeltos paper, and no chance variations in contrast and density from one picture to the next. I reasoned (as did many other radio amateurs at the time) that the ultimate display would involve digitizing an image and storing it in computer memory for manipulation, enhancement, and ultimate display on a video screen.

Unfortunately, technical and financial realities put such a display totally out of reach for the growing community of WEFAX experimenters. Well before the personal-computer revolution, the few of us who had access to our own computers were limited by the memory they contained. Sixteen or 32 kbytes of memory was considered all one would *ever* need for even the most demanding applications(!). Magnetic-core memory was the rage then, and at about one cent per "donut," the half-megabyte or so necessary to store one frame of satellite imagery cost about $40,000! If that wasn't enough to discourage an experimenter, the size and slothfulness of the pre-microprocessor computer usually was!

Computer Evolution

Although the 6502, 8080 and Z80® -based computers of the late '70s were manageable in terms of size and speed, and solid-state memory was fast becoming affordable, these 8-bit machines could directly address only 64 kbytes of memory. A few experimenters managed to digitize small portions of a WEFAX frame, for limited-resolution display. But computer display of the full frame of satellite imagery—in all its glory—still eluded us . . . until recently.

I've never been a great fan of the MS-DOS® operating system. Still, the IBM® PC (and its imitators), with its 16-bit internal architecture and ability to address 640 kbytes of memory, finally made WEFAX digital display practical. And, with bipolar RAM below $100 per Mbyte, the ubiquitous PC clone has fast become the computer of choice for weather-satellite enthusiasts.

Software

Now, what about software? Elmer Schwittek, K2LAF, made a significant contribution with his programs REALTIME.BAS and MAGNIFY.BAS,[2] WXFAX.BAS,[3] MULTIFAX.EXE, and the most recent versions of Multifax,® MF2.1 and MF3.0.[4] Which version of the program you should use depends on the equipment at hand. If you have a color-graphics adapter (CGA), use MF2.1. MF3.0 can be used *only* with an enhanced-graphics adapter (EGA). You *can't* use a monochrome display adapter (MDA) or Hercules graphics adapter (HGA); they are *not* compatible with the Multifax programs!

I designed the latest version of the FaxBoard—an all-inclusive interface between the audio output of a WEFAX receiver and the I/O bus of the IBM PC—around Elmer's MF3.0 software. However, the FaxBoard is compatible with *all* versions of the software. The FaxBoard is not available as a commercial product; you'll have to build your own. But then, that's what Amateur Radio is all about!

Interface Hardware Requirements

A weather-satellite receiver produces as its output an audio tone (typically 2.4 kHz), the amplitude of which varies as a function of video intensity (brightness). To display the image on a computer's video monitor, it is necessary to both demodulate the instantaneous amplitude of the audio subcarrier, and to periodically digitize that amplitude for storage and display. The FaxBoard performs these two functions, and a few others, as shown in the block diagram of Fig 1. The schematic diagram of the board is shown in Figs 2-4; a parts list appears in Table 1.

Audio output from the receiver is first applied to a high-pass filter (U1A) to strip off any hum and low-frequency noise that might be present. An audio AGC stage (U1B and associated components) maintains a constant video level, but in the process may generate distortion products, which are removed in an active bandpass filter (U1C). Contrast amplifier U1D establishes the appropriate drive level to U2A and U2B, a full-wave audio-subcarrier demodulator. The signal is next filtered in an active low-pass filter (U1C), to remove any vestiges of the original subcarrier from the video waveform that is sampled and displayed. Buffer U2D represents the final analog gain stage, establishing the appropriate drive level for the analog-to-digital (A/D) converter.

Digitization is accomplished in U3, an internally clocked CMOS A/D converter, the Tri-State® parallel outputs of which are enabled by the address decoder circuitry (to be described), providing an 8-bit digital word. Note that MF2.1 supports only the *two most significant bits* of this signal, thus can display an image in up to four colors (or video levels). MF3.0, the EGA version of K2LAF's program, supports two, three or four bits, for significantly more shades/colors. Future software products may permit the use of even more bits per pixel. Currently, FaxBoard 3 provides an 8-bit (256-level) capability, in anticipation of future software enhancements. Low-resolution-display software uses fewer of these bits.

[1]Notes appear on page 15.

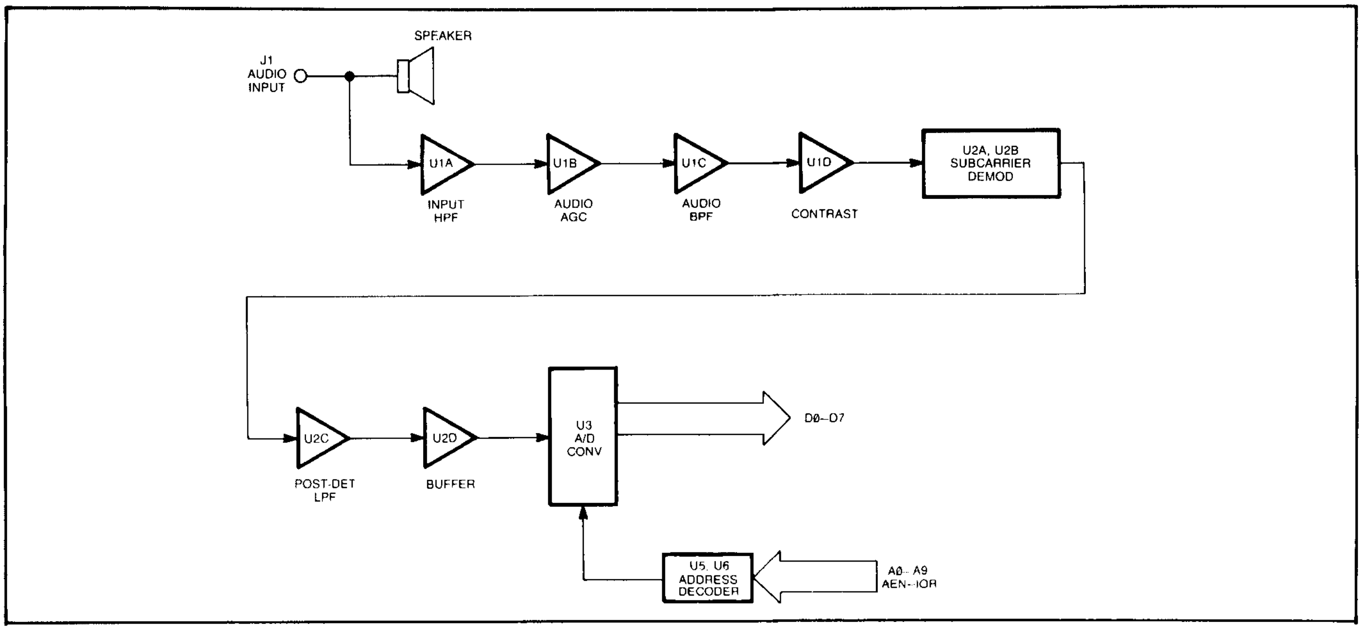

Fig 1—A block diagram of the FaxBoard.

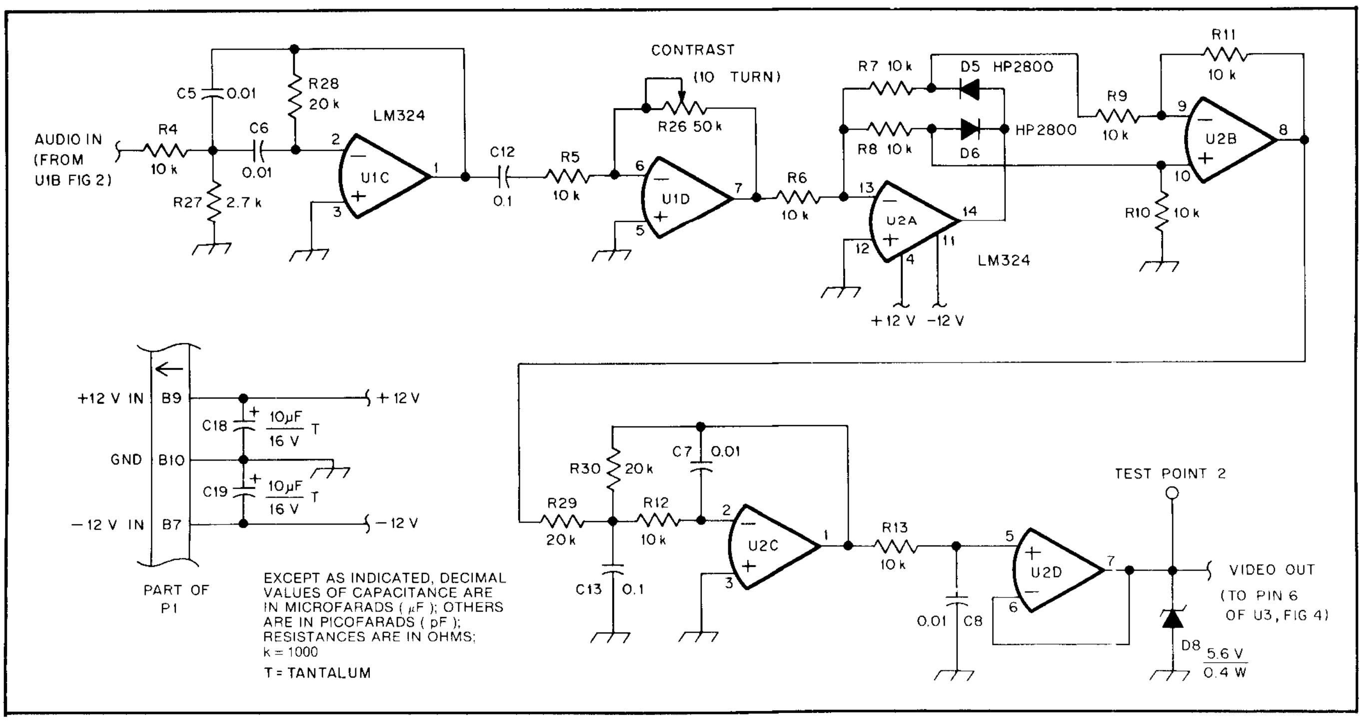

Fig 3—Active audio-bandpass filter (U1C), contrast amplifier (U1D), full-wave audio-subcarrier demodulator (U2A and U2B) and active audio low-pass filter (U1C) stages of the FaxBoard. U2D, the final analog gain stage and buffer, establishes the appropriate drive level to the A/D converter of Fig 4. With no input signal applied, and having properly adjusted the AGC CALIB control (see Fig 2), adjust the CONTRAST control for a 5-V P-P reading at test point 2.

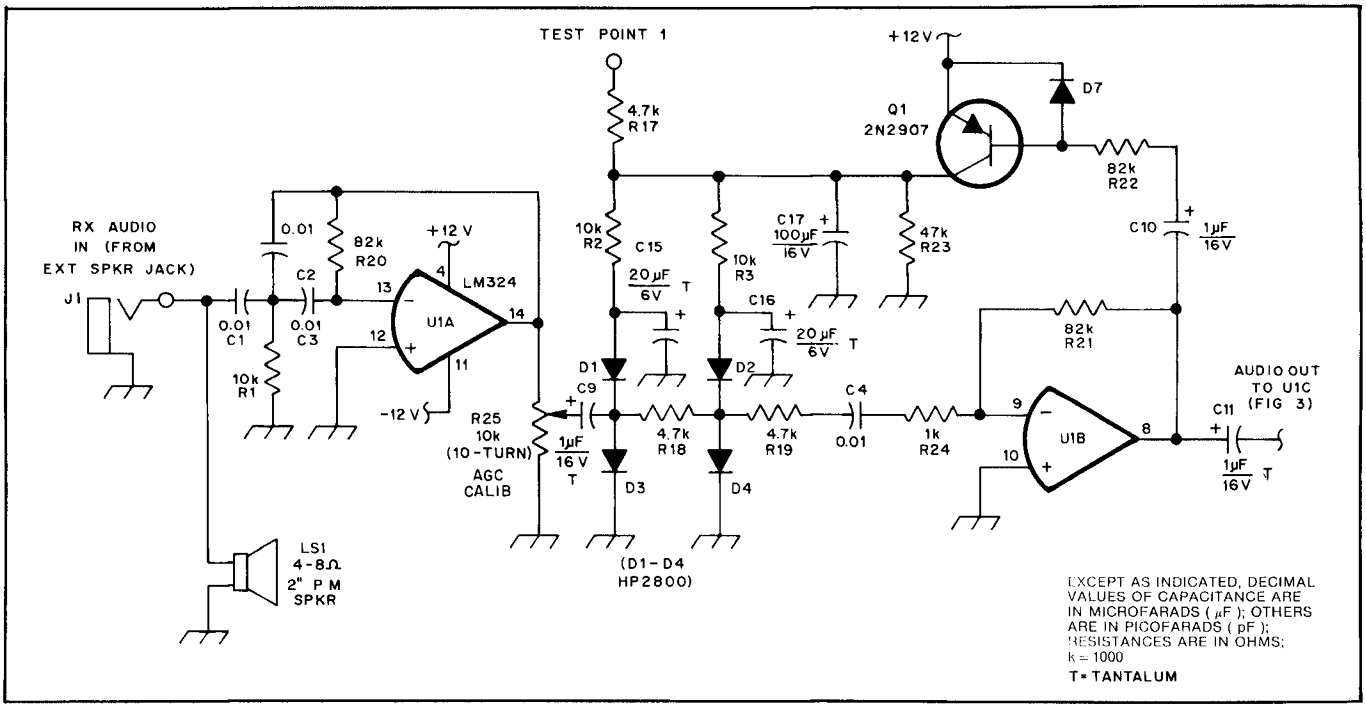

Fig 2—Input, high-pass filter and AGC stages of the FaxBoard. With no input signal applied, adjust the AGC CALIB potentiometer for a 50 µA reading with a microammeter attached to test point 1.

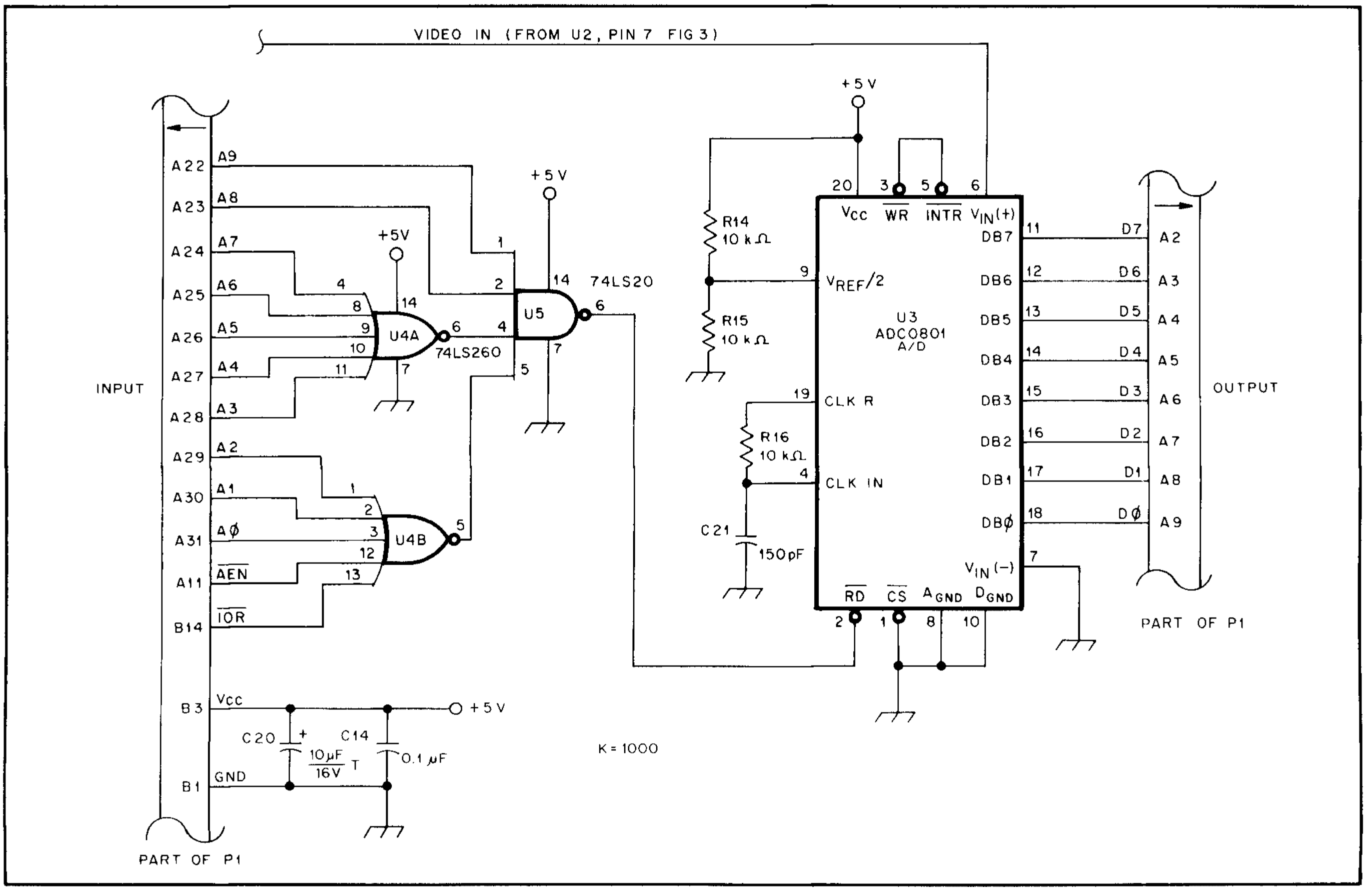

Fig 4—The A/D stage of the FaxBoard. The pin identifiers for P1 of the prototyping board are labeled within the block. The A identifiers refer to pins on the component side of the board; B identifiers refer to the wire-wrap side of the board (see text).

Table 1

Parts List

Unless otherwise specified, all resistors are ¼-W, 5% tolerance carbon-composition units; disc ceramic capacitors are 25-V units.

Part Identifier	*Mount to Header #*	*Part Identifier*	*Mount to Header #*
C1-C8—0.01-μF disc ceramic	1	R17-R19—4.7 kΩ.	9
C9-C11—1-μF/16-V tantalum.	2	R20-R22—82 kΩ.	9
C12-C14—0.1-μF disc ceramic.	2	R23—47 kΩ.	10
C15, C16—20-μF/6-V tantalum.	3	R24—1 kΩ.	10
C17—100 - μF/16-V tantalum.	3	R25, R26—10 kΩ, ⅛-W ten-turn trimmer potentiometer	6
C18-C20—10-μF/16-V tantalum.	4		
C21—150-pF silver mica.	2	R27—2.7 kΩ.	10
D1-D6—HP5082-2800 or equiv (see text).	5	R28-R30—20 kΩ.	10
D7—1N914 silicon diode.	5	SP1—4-8 Ω, 2-in. diam speaker.	
D8—1N752 (5.6-V/400-mW) Zener diode.	5	U1, U2—LM324 quad op amp.	
J1—⅛-in. phone jack.		U3—ADC0801 A/D converter.	
Q1—2N2907 or equiv.		U4—74LS260 dual, low-power Schottky, 5-input NOR gate.	
R1-R16—10 kΩ.	7, 8	U5—74LS20 dual, low-power, Schottky 4-input NAND gate.	

Misc.

JDR wire-wrap prototyping card (JDR-PR1); JDR Microdevices, 110 Knowles Dr, Los Gatos, CA 95030, tel 800-538-5000.
Four 14-pin DIP wire-wrap sockets.
Ten 16-pin DIP wire-wrap sockets.
One 20-pin DIP wire-wrap socket.
Ten 16-pin DIP headers.

Once the digital intensity information is generated, the controlling software needs to sample it periodically for input to memory via the computer's I/O channel. This is done through memory mapping, enabled by an I/O read command, and inhibited during direct-memory-access (DMA) operations with the address-enable signal, as decoded by gates U4 and U5. Please note that the I/O address selected for the FaxBoard is &h300, (the "&h" representing hexadecimal notation) the first address assigned by IBM to their prototyping card. The default address for image input assumed by the Multifax program is &h201, the first game-port address. This address, if used, would create a conflict between the FaxBoard and any device connected to the joy-stick port. Fortunately, in its SETUP option, the Multifax program allows you to specify the I/O address desired. FaxBoard circuit users should remember to set up their software for I/O address &h300.

Receipt of valid address, enable and I/O read commands activates the Tri-State buffers within U3, momentarily transferring the A/D converter output to the computer data bus. From there, each picture element can be stored on disk, or displayed on screen, under software control.

Circuit Credits

The analog and digital circuitry both borrow heavily (and shamelessly) from the works of others.[5-10] I claim no originality here, having merely adapted widely used circuits to a single PC prototyping card.

The material referred to in note 5, the definitive study of digital scan conversion, is a historically significant document. It was published prior to the proliferation of personal computers, and represents the first known attempt to integrate analog signal processing, A/D conversion, and solid-state digital memory into a single package. I highly recommend to all WEFAX experimenters the *Weather Satellite Handbook,* (see note 6) written by Ralph Taggart (WB8DQT). The book is an excellent overview of weather-satellite systems, receive hardware options, and competing display technologies. The digital circuitry design was guided and inspired by the information contained in *Handbook of Software and Hardware Interfacing for IBM PCs,*[11] which I recommend to anyone wanting to understand more about the architecture of the IBM PC bus.

The *Journal of the Environmental Satellite Amateur Users' Group*[12] is a quarterly to which most weather-satellite enthusiasts should subscribe. It periodically carries useful technical articles, which enable WEFAX experimenters to share ideas and accomplishments. At least one computer bulletin board[13] similarly caters to the WEFAX enthusiast.

Fabrication Considerations

One major objective of the FaxBoard project was the integration of all interface circuitry onto a single circuit board, so everything required for WEFAX reception, with the exception of the RF hardware, could disappear into the computer. This was done by constructing all of the circuitry on a single prototyping card,[14] using wire-wrap techniques. Wire-Wrap DIP sockets are installed on the card not only for the ICs, but also for all of the discrete components. The discrete components are mounted on DIP headers that plug into the sockets; this eases the wire-wrapping of all interconnections.

Fig 5 shows how I positioned the various ICs and headers (labeled with H numbers) on my prototyping card. This is merely an example; layout is not critical, nor are lead lengths, with the exception of power-supply-decoupling capacitors. These capacitor's leads should be routed to provide the shortest possible path to ground. Similarly, the power-supply leads for each IC *should not be daisy-chained,* but connected directly to the etched power bus on the board, using a separate wire for each device.

Remember that all input and output signals to the PC bus—as well as all four computer power-supply voltages (+12, −12, +5 and −5)—appear on the 62-pin edge connector (P1) of the prototyping card. Edge-connector pin numbers are shown in the schematic of Fig 4. The A identifiers represent the component side, the B side being the wire-wrap side of the circuit board. Pin numbering starts with 1 at the connector pin nearest the board's mounting bracket. The card I used (and recommend) is silk-screened on both sides with signal names printed near each pin of the edge connector. Check the pin identifiers against those called out in the diagram while you're wiring the FaxBoard. Connections to the individual edge-connector-pin holes are made by means of

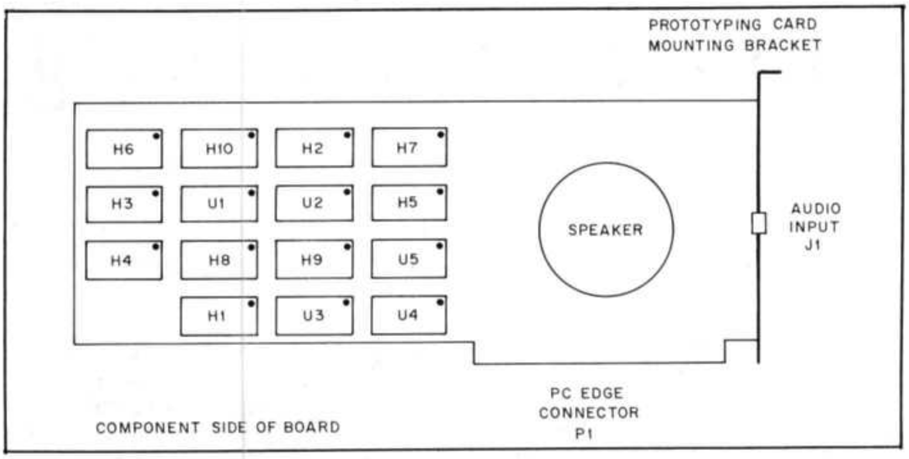

Fig 5—Positions of the ICs and headers (labeled with H numbers) on the prototype FaxBoard.

rows of 0.1-inch-spaced wire-wrap pins.

All components used in the FaxBoard design are common, and should be available from most surplus or mail-order houses. Don't overlook your local Radio Shack® store as a parts source. The digital ICs I used are all low-power Schottky (74LS) devices, although the 7400-series TTL ICs will work just as well. The HP diode types indicated for use in the AGC limiter and subcarrier demodulator circuits are not critical; any reasonably fast hot-carrier diode will suffice. All resistors are ¼-W, 5% carbon composition or metal film; all capacitors should be rated for at least 20 V, unless otherwise specified on the schematic.

Tune-Up and Test

If desired, the digital circuitry (Fig 4) can be built first, and tested with the Multifax software by connecting the VIDEO INPUT (U3, pin 6) to the wiper of a 10-kΩ potentiometer, which is connected between +5 V and ground. Select Option 1 (SET PICTURE memory limits and data port) from the Multifax Main Menu, and enter I/O address &h300 into the program's default file. (Note: The menu options I refer to here are for MF2.1. The MF3.0 menus are slightly different, but are explained in the software manual.) Next, select Main Menu option 2 (RECORD a new PICTURE into memory), and vary the potentiometer to simulate incoming video data. You should see color bars forming on the screen.

Once correct operation of the digital circuitry is verified, the analog circuits should be built and tested. Audio to the FaxBoard comes from the external speaker jack of your VHF or microwave weather-satellite receiver. Because plugging an external speaker into this jack generally disables the internal speaker, I included a small 4-Ω speaker on my board. Being able to hear the signals greatly simplifies antenna aiming and receiver tuning.

With a WEFAX transmission tuned in, adjust your receiver volume for a comfortable listening level using the FaxBoard's speaker. Connect a microammeter to test point 1, and adjust the AGC CALIB trimmer potentiometer for an indication of 50 μA with a clean signal present. Next, hook an oscilloscope to test point 2 (use of a 10:1 probe is recommended) and observe the demodulated video waveform. Adjust the CONTRAST trimmer potentiometer for a 5-V peak-to-peak signal at test point 2.

With the calibration potentiometers set, level optimization is performed with the WEFAX receiver's volume control during the phasing interval at the beginning of an actual picture transmission. Run the Multifax program, and from the Main Menu, select Option 2 (RECORD a new PICTURE in Memory). During the phasing interval, you will need to adjust the receiver volume control for the lowest level that produces white (or whatever color you have assigned to maximum video intensity) on screen. Decrease the receiver volume until the color changes, then increase the volume just to the point at which the desired color is again visible on screen. This verifies that the video amplitude is within the range of the A/D converter, and completes alignment of the FaxBoard.

It's still necessary to optimize the timing loop of the Multifax software to synchronize with your computer's clock rate. Instructions for this process are included in the Multifax manual. Following the procedures outlined, you should soon be observing digitized WEFAX images, in false color, almost in real time. Fig 6 shows a dot-matrix printout of such an

(continued on page 15.)

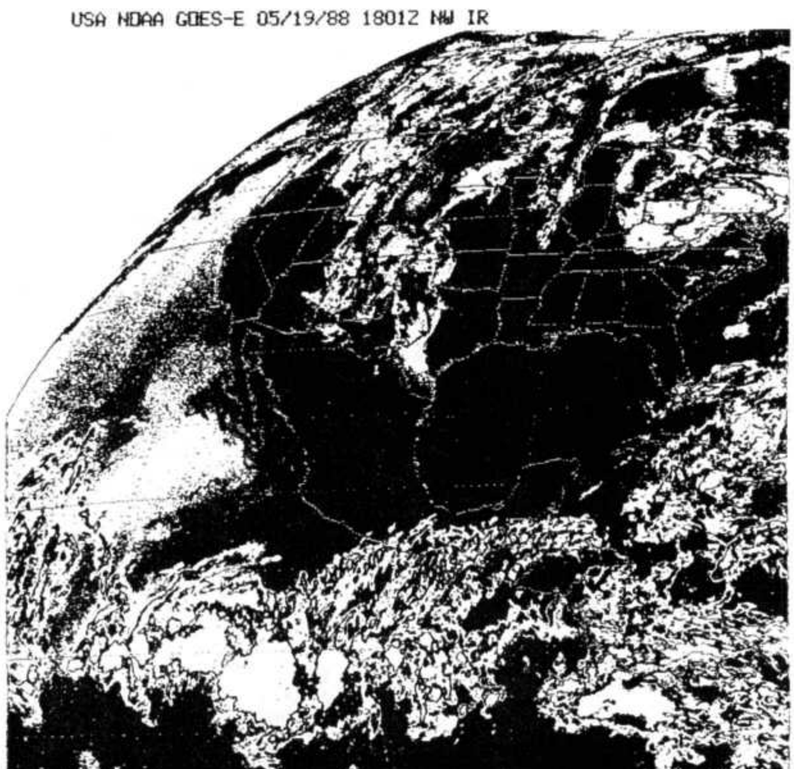

Fig 6—A dot-matrix printout of a WEFAX image, captured using the K2LAF Multifax program. On screen—and in color—your pictures will look even better. ***(Picture courtesy of Elmer Schwittek, K2LAF.)***

Facsimile Over a High-Frequency Radio Link

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In "Just the FAX, Ma'am" (Empirically Speaking, *QEX*, August 1987, page 2), *QEX* editor W4RI called for papers and correspondence relating to this increasingly popular mode. That editorial also discussed CCITT Group 1, 2 and 3 standards for FAX transmission over the public telephone network and mentioned that Japanese experimenters are using CCITT Group 2 machines in Amateur Radio work (see Yoshi Iwasaki, "Facsimile in Japan," *QEX*, February 1988, pages 8 and 9). This month, Canadian engineers describe a CCITT Group 3 system that transmits facsimile imagery to ships at sea over a 2400-baud HF radio link. Based on commercially available FAX modems and ship-to-shore transceivers, the system underwent successful trials during July 1987 over skywave paths several hundred kilometers long.

Most scientific research vessels have slow cruising speeds—typically 10 to 12 knots. This limits their daily distance traveled to between 200 and 300 nautical miles. Oceanographers need an overview of the surface features of the ocean to optimize their sampling patterns and better understand their measurements. This is required because the ocean is dynamic; horizontal and vertical water properties, and the sea life within the water column, are in constant motion.

Recognizing this need, scientists at the Institute of Ocean Sciences (IOS) implemented a weather facsimile relay system to the Canadian West Coast and the Beaufort Sea in 1986, using facilities at the nearby naval base. Despite operational and technical constraints, the system produced usable imagery and was an invaluable research aid. This early work led to the development of a facsimile-over-HF-radio link in 1987.

CCITT Group 3 Facsimile Standard

The CCITT Group 3 facsimile transmission standard is established by international agreement. This standard is primarily intended for the transmission of black-and-white imagery (no gray tones) over the standard public switched telephone network at speeds of 2400, 4800, 7200 and 9600 bit/s, dependent upon line quality. The CCITT Group 3 FAX standard is digital, with a standard resolution of 200 pixels (or dots) per inch horizontally and 100 lines per inch vertically. Thus, an 8½-x-11-inch page potentially consists of approximately four million data bits. The CCITT Group 3 standard also specifies a run-length compression polynomial (Huffman code), which typically reduces telemetry requirements by a factor of 6 (to about 35,000 bytes). Data is compressed for transmission and expanded after reception for display.

No error detection or correction scheme is prescribed in the CCITT Group 3 facsimile standard. Error correction would be necessary if every transmitted bit had to be successfully received for useful facsimile communication. Fortunately, however, the quality of a received FAX image is judged empirically by eye—and the eye is fairly forgiving of random isolated errors and short burst errors. (Such errors appear as occasional black flecks or missed scan lines in the received image.) If the quality of the communication channel is sufficiently poor, the facsimile preamble training session fails, and connection is not established.

An important feature of the CCITT Group 3 facsimile standard is the ability to tolerate transmission-path variations *after* a successful training session. This ability is due to the adaptive equalization and AGC circuitry in FAX modems built to comply with this standard.

Comparison to Packet Radio Transmission

Initially, packet radio seemed desirable as a FAX transmission system. However, packet retransmission requests increase dramatically as channel quality worsens. Also, the fixed packet length used in most packet systems is inconvenient. (A variable packet length can allow optimization of the link. When conditions are excellent, overhead can be reduced by increasing packet length, resulting in a greater net throughput for a given bit rate; when conditions are poor, shorter packets are more likely to get through without errors.)

Design Approach

The system to be desribed was designed with a "try it and see" attitude. The audio bandwidth of the HF transceiver chosen appeared to be adequate for the 2400 bit/s FAX data, which is encoded as 1200-Hz quadrature phase-shift-keying modulation of an 1800-Hz carrier. Nevertheless, expert opinion indicated that inherent channel problems, such as multipath and fading, would render the system useless for other than line-of-sight paths. The throughput required was only one or two images per day, however, and time and transmission frequency could be selected for the best propagation. These factors made our facsimile approach feasible.

System Components

Modem

Three Gammafax facsimile boards (designed to be installed in an IBM® PC and compatibles) were purchased from Gammalink[1] in the spring of 1987. These boards and the accompanying software essentially turn the computer into a fully compatible CCITT Group 3 facsimile modem, with the exception that FAX images are stored as files and can be viewed on a monitor or sent to a printer.

Another advantage of the computer-based approach is that the facsimile images—which may consist of text—can be translated from the facsimile file format to ASCII, and vice versa. (This feature was not used, but its potential is obvious.)

HF Radio System

Fully frequency-synthesized transceivers capable of tuning the HF range in 1-Hz steps were used at both ends of the FAX link. Short-range transmission tests had revealed that a very fast (10-ms) TR turnaround time was necessary for success of the link. If the transceiver response was too slow, the training session at the beginning of the transmission would fail, resulting in a disconnect. (Few of the transceivers evaluated could meet this 10-ms turnaround-time requirement, but it has since been relaxed somewhat, as will be explained later.)

The Canadian Department of Com-

[1]Gammafax boards are available from Gammalink, 2452 Embarcadero Way, Palo Alto, CA 94303, tel 415-856-7421. Price class: $1000.

munications [now Communications Canada—Ed.] was very cooperative when informed of the experiment. They supplied a list of frequencies that could be tried; one or two of these frequencies seemed quiet enough for the test.

VOX Interface

The FAX board's modem was initially connected to a transceiver via a commercial VOX unit for on-site testing. The VOX was necessary to provide the two- to four-wire interface and activate the transceiver PTT switch.

Tests Results

Preliminary Test

A preliminary trial of the system was performed on the CSS *Parizeau* in June 1987 over a mixed land and sea path 50 km long. The tests were conducted in the early morning, when electrical noise and traffic on the communication channel were relatively low. The results were much better than expected: The quality of the image varied from virtually perfect to a disconnect. It was obvious that performance was limited by static crashes (about which little could be done) and by the VOX (which was critical to good reception). Surprisingly, multipath distortion (intersymbol interference) did not seem to be a problem; one transmission was received as an error-filled but usable image, even though significant fading had been present on the received signal.

Scientific Test

Before the final test, a custom VOX was designed and built. This solved the dropout-during-large-fades problem experienced with the previous VOX. At the same time, an analog delay was built into the transmit path to ease the TR turnaround constraint.

The facsimile-over-HF system went to sea on the CSS *Parizeau* in July 1987. Good images were obtained every day for a week as the *Parizeau* circumnavigated Vancouver Island. Mixed land and sea paths of up to 300 km seemed to have negligible effect on reception quality. Fig 1 shows a transmitted image (A) and received image (B) in a typical case.

The scientists were ecstatic that a tool was now available that permitted them to dynamically alter their sampling program in response to surficial ocean temperature observations. Suddenly, their results made much more sense, and the sampling program could be more effective.

Penultimate Development

The "final" work on the system occurred in the fall of 1987. Gammalink Corporation modified their hardware and software to virtually eliminate the requirement for a VOX interface between the FAX modem and radio transceiver. Revised software was received that permitted an operator-selected delay between signal reception and subsequent transmission. This meant that transceiver TR time was no longer critical, allowing almost any transceiver to be used. Further, the revised Gammalink software uses a spare connector pin to provide a PTT output. Thus, by adding a transistor and a BNC jack, the custom VOX was replaced by a three-resistor pad. Like its predecessor, the revised Gammalink board is compatible with other CCITT Group 3 facsimile boards and systems.

Future Work

Development of this facsimile system continues. The Gammalink board uses a switched-capacitor filter; this may allow the improvement of signal quality by changing a few components for an improved match between the output of FAX modem and the audio response of the radio system. (A FAX modem modified in this way would be incompatible with other CCITT Group 3 systems, however.)

A second line of research is directed

(continued on page 13.)

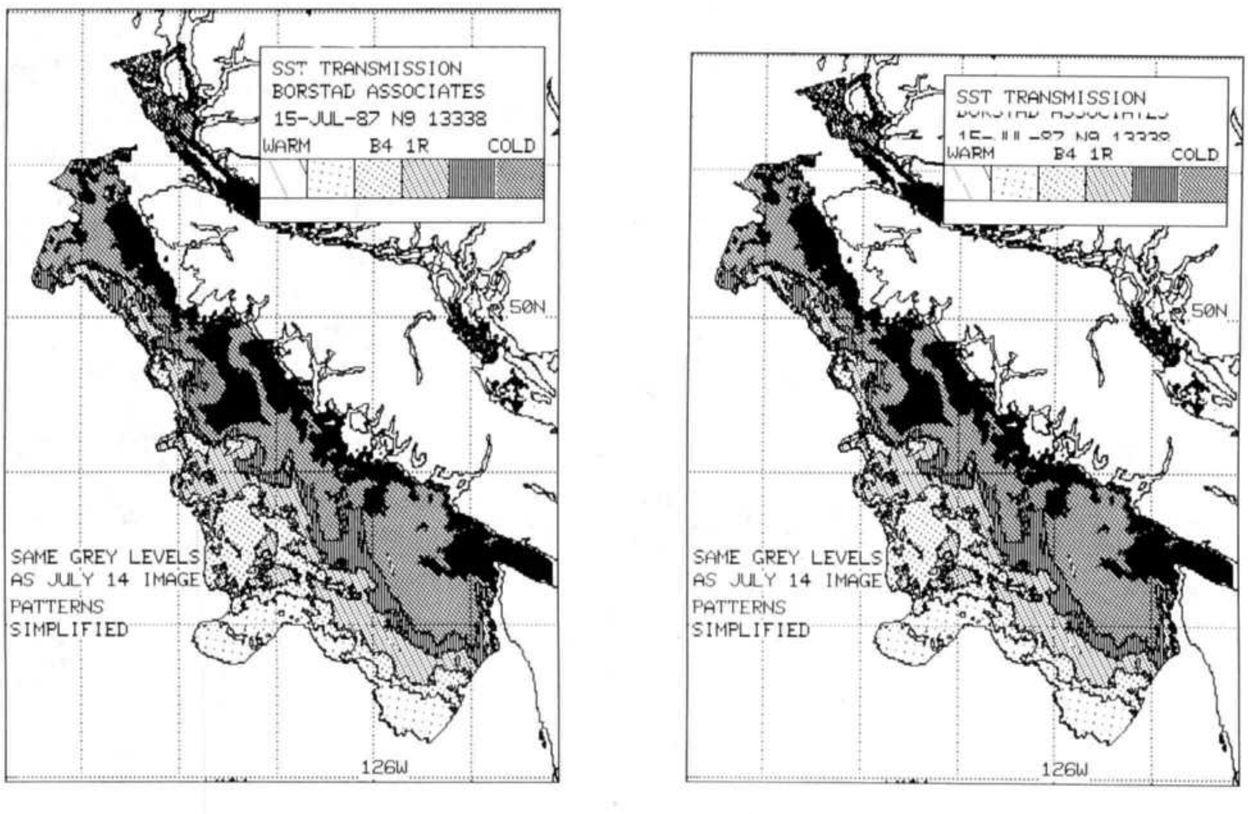

Fig 1—CCITT Group 3 facsimile can provide images of excellent quality over an HF radio link over distances as great as 300 km. At A, a transmitted image; at B, the received facsimile.

A Tuning Aid for Packet Radio, RTTY and SSTV

By Massimo Biolcati, I4YH

(This article originally appeared in the November 1987 issue of the Italian publication, RadioRevista, *pages 36-37. The translation was provided by Louis Mallozzi.)*

Shortly after I started using packet radio on the HF bands, I realized the need for a more effective tuning indicator. Many TNCs presently in use have only one LED for signal tuning—a very ineffective approach. Other TNCs use LED bar graph displays, but even these didn't satisfy me. No sooner did I have my hands on a discarded old oscilloscope, than the idea for a more effective tuning indicator came to me. I decided to modify the scope by installing active filters for the audio tones commonly used in packet radio, RTTY and SSTV. Naturally, it's possible to change or add shift frequencies as you desire by changing or adding a minimum of components.

The additions to the original oscilloscope are shown in Fig 1. These additions —everything to the left of the HORIZONTAL and VERTICAL amplifier gain controls— include a power supply for the ICs. All of the added circuitry can be placed in a small box within the host oscilloscope.

Receiver output is fed to the input of U1, which amplifies and clips the signal. Eliminate the 680-ohm resistor across the

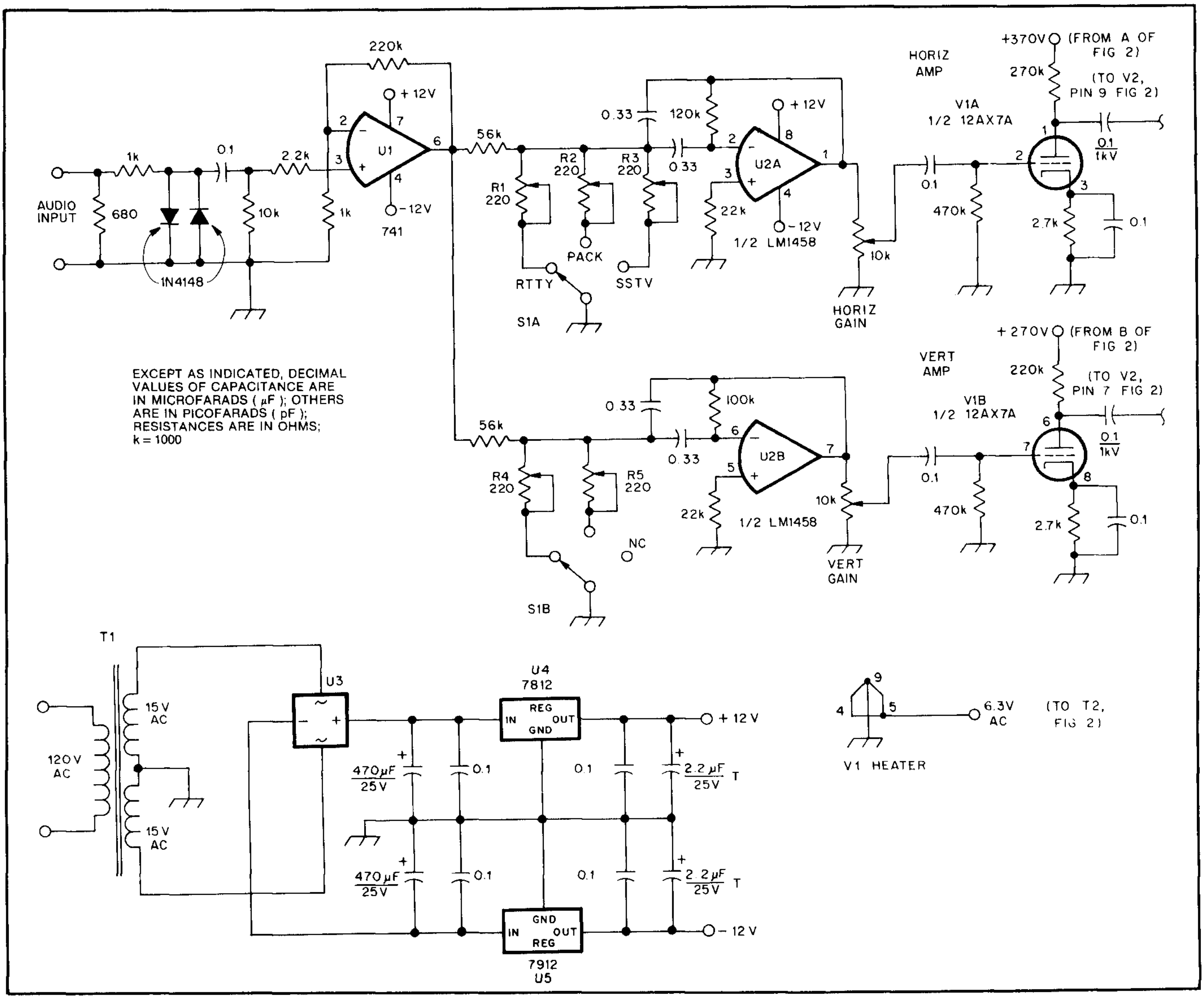

Fig 1—Additions made to an discarded scope by I4YH turn it into a useful tuning indicator. The additions include a low-voltage power supply and the circuitry to the left of the HORIZONTAL and VERTICAL gain controls.

T1—120-V pri; 30-V CT sec.

U3—100-PIV, 1.5-A bridge rectifier.

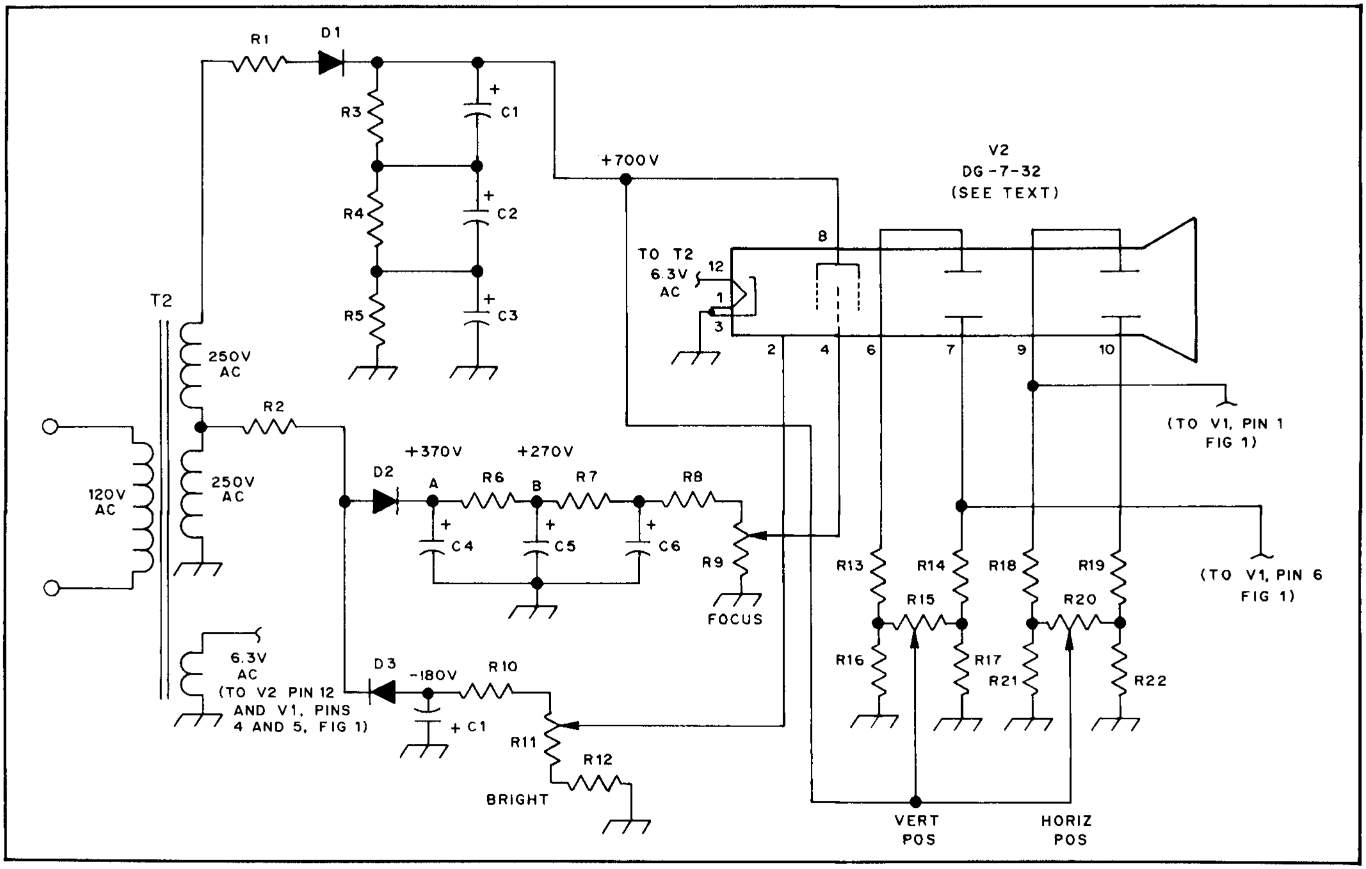

Fig 2—Schematic diagram of the CRT, high-voltage and heater supply circuits for the tuning indicator.

C1-C3—33-μF, 350-V electrolytic.
C4—50-μF, 500-V electrolytic.
C5, C6—22-μF, 350-V electrolytic.
C7—16-μF, 500-V electrolytic.
D1-D3—1N4007.
R1, R2—10 Ω, 1W.
R3-R5—1 MΩ, ½W.
R6—15 kΩ, 2W.
R7—22 kΩ, 2W.
R8—22 kΩ, ½W.
R9—47 kΩ potentiometer.
R10—82 kΩ, ½W.
R11—100-kΩ potentiomter.
R12—10 kΩ, ½W.
R13, R14, R18, R19—1 MΩ, ½W.
R15, R20—220-kΩ potentiometer.
R16, R17, R21, R22—2.2 MΩ, ½W.
V2—DG-7-32, 2AP1 or other CRT (see text).

input to the scope if you're using a transceiver that has a high audio output impedance (such as the Kenwood TS-440 transceiver's FSK OUT circuit).

U1 drives two active filters (U2A and U2B), which are tuned to the mark and space signals of the mode being received. Table 1 provides a list of the modes, filter frequencies and controls used to adjust the filters.) For RTTY, I elected to use the high-frequency tones because the majority of HF transceivers use this combination. By using a switch at S1 that has more than the three positions shown, you can add other tone selections. For instance, you might want to add the low RTTY (1275/1445 Hz) and packet-radio (1200/2200 Hz) tones and possibly CW (750-800 Hz in most transceivers).

The outputs of these filters are coupled to the horizontal and vertical amplifiers that feed the CRT shown in Fig 2. The horizontal and vertical amplifiers are each one-half of a 12AX7A (ECC83) dual triode. These tube sections furnish about 160 V P-P to their respective pins on the CRT. Admittedly, the tube is being pushed over its rated limits, but continues to operate without trouble.

The use of a tube for the horizontal and vertical amplifiers was dictated by the fact that the plate and heater voltages were already available in the old scope. The difference in the values of the plate resistors of the two amplifier stages is related to the different amplifier gains required to properly drive the CRT's horizontal and vertical deflection plates. (The horizontal deflection circuit requires more drive than the vertical.)

Although the CRT of my oscilloscope is a DG-7-32, the basic circuit of Fig 2 is similar in most old scopes. With some circuit modifications—and paying proper attention to the pin numbers—you can use other CRTs (such as a 2AP1), which are usually easy to obtain surplus or at flea markets.[1]

Table 1

Modes, Tones and Controls

Mode	*Frequency (Hz) and Control*	*Frequency (Hz) and Control*	*Shift (Hz)*
RTTY	2125 R1	2295 R4	170
Packet Radio	1650 R2	1850 R5	200
SSTV	1500 R3		(Sync signal)

Note

[1]A basic circuit for a modulation-monitoring oscilloscope appears in *The 1988 ARRL Handbook*. Specifications and pin-outs for CRTs can be found in older editions of the *Handbook* (those prior to 1979). —Ed.

Correspondence

Tactical LF Transmitting Antenna Test

The Space and Naval Warfare Systems Command (SPAWAR), under contract with Astron Corporation, will conduct tests on an experimental low-frequency antenna to determine its electrical performance characteristics and to evaluate its potential for various applications including tactical use aboard naval combatant ships. This antenna is being developed under the Small Business Innovative Research program contracted to Astron Corporation, Herndon, Virginia. Radio amateurs working on this project include Frank Gentges (AK4R), Steve Shengold (N4QYC), Chris O'Toole (N4SBY), Ed Rathbun (W4ZW) and Ed Ray (W4NEZ).

Testing will be conducted on a sporadic basis from August to October 1988 from test sites at Bumpass, Virginia, and Carroll Island, Maryland. Transmitter output power will be 1 kW. The antenna is a loop design in the shape of a triangle, 65 feet high at the apex and extending 400 feet along the base. The wire is no. 0 Litz cable, and the loop is tuned with a combination of fixed and variable capacitance.

As part of the test process, listening reports from longwave listeners are requested. This reception data will augment field-strength data taken by project personnel. The objective is to determine the potential coverage of a low-frequency system using this type antenna in a naval battle group. The primary operating frequency will be 185 kHz; 175 kHz will be used as a secondary frequency.

The test signal will consist of alternate periods of steady carrier and on/off keyed, 10-WPM International Morse Code using the call sign NWA, and the word TEST followed by a single alpha character related to the current test conditions. Other information related to the test may also be included in the transmission sequence.

Signal-reception logs covering more than one signal report, along with comments concerning observed signal anomalies will be particularly appreciated. Individual spot reports will also be valuable. All reception reports should include the following:

1—Time and Date.
2—Receiver location.
3—Description of antenna and receiver.
4—Signal frequency.
5—Signal quality (RST).
6—Test condition alphabetic character.

Current information on the test times and frequencies are provided by a prerecorded message available by calling 703-471-1539. Reception reports will be verified with a special QSL card available only to participants in this test. All reception reports should be sent to: SPAWAR, NWA Test, Washington, DC 20363-5100. *—Tom Francis, NM1Q, ARRL HQ*

Impedance Measuring—Redux

I have received several interesting responses to my solutions to the analytic problems presented in the Peter Dodd, Tom Lloyd antenna impedance article.[1] The reactive ambiguity, and its resolution, received the most discussion, particularly from those individuals using the graphical solution.

Analyzing the resulting measurements given by an impedance bridge circuit like the one described in the original *QST* article[2] and the subsequent Dodd/Lloyd article[3] presents a problem: not knowing which of the experimental values are the "best" ones to use. The impedance diagram in May 1988 *QEX*[4] shows that several equations can be written describing the two unknown variables from the five known variables. There are 12 possible equations, some of which reduce to the same form, four that are fourth-order equations.

A second problem is that the resolution of the reactance ambiguity is not straightforward. An equation that results in either a square or fourth-order root produces two answers that are sign ambiguous; the third (*j*X3) results only in magnitude. In my May 1988 *QEX*[5] letter, the form for Eq 5 changed the sign of EC to keep the results comparable to the original Dodd/Lloyd article.[6] In the new code, Fig 1, the capacitance value is changed to negative, (in keeping with accepted convention), even though the data is read in as a positive value. This method produces a clear reactance value.

Convergence was another concern when using the graphical method because the data scatter does not allow vector triangle closure. The new computer code averages the three derived reactance values, calculates a standard deviation for the three values, and identifies the sign of the reactance.

In addition to the above code changes, I added one of the quadratic solutions and calculated a mean value for the reactance as well as the standard deviation of the calculated values for the selected roots. I also added a second quadratic and a second linear solution for the reactance, and deleted the reactance calculation that produced only magnitude (old *j*X3). See Fig 2.

Where there are two positive values of calculated resistance, I use the values with the smallest dispersion. (For some sets of data, the order of the roots will reverse where the reactance sign changes. Some of this data will have no convergence at all.)

Another graphical approach that can produce answers using several of the new expressions is shown in Fig 3. Close examination of this data will show why it is generally not easy to obtain answers to a complex problem using simple means. *—Don Jenkins, WA6OGH, 5945 Donna Ave., Tarzana, CA 91356.*

Notes

[1]P. Dodd, T. Lloyd, "Measurement of Antenna Impedance," *QEX* Nov 1987, pp 6-9.
[2]D. Strandlund, "Amateur Measurement of R + *j*X," *QST*, Jun 1965, p 24.
[3]See note 1.
[4]D. Jenkins, Correspondence, *QEX*, May 1988, pp 3-5.
[5]See note 4.
[6]See note 1.

```
2 LPRINT"Antenna Bridge Parameters"
5 LPRINT"Freq (ID)","Rx","Jx"
10 LPRINT
15 er=50
20 FOR x=1 TO 22
25 READ f,ea,ecz,ec,ez
30 ec=-ec
35 rx=(ea^2-ecz^2-er^2)/(2*er)
40 jx=(ecz^2-ez^2-ec^2)/(2*ec)
45 sum=(rx^2+ec^2-ecz^2)*4
50 IF sum > (2*ec)^2 THEN 300
55 sum1=SQR((2*ec)^2-sum)
60 jx1=(-2*ec+sum1)/2
65 jx2=(-2*ec-sum1)/2
75 rx1=SQR(ecz^2-ec^2-2*jx1*ec-jx1^2)
80 rx2=SQR(ecz^2-ec^2-2*jx2*ec-jx2^2)
85 h=ea^2-ez^2-er^2-ec^2
90 a=1+(er/ec)^2
95 b=-h*er/ec^2
100 c=(h/2/ec)^2-ez^2
105 IF b^2 < 4*a*c THEN 300
110 rx3=(-b-SQR(b^2-4*a*c))/(2*a)
115 rx4=(-b+SQR(b^2-4*a*c))/(2*a)
120 jx3=h/(2*ec)-rx3*er/ec
125 jx4=h/(2*ec)-rx4*er/ec
130 jrr=jx3
135 IF SGN(jx)=1 THEN jrr=jx4
140 sumj=ABS(jx)+ABS(jx2)+ABS(jrr)
145 avgj=sumj/3
150 stnd=jx^2+jx2^2+jrr^2
155 stnd=stnd-(sumj)^2/3
160 IF stnd < 0 THEN 170
165 stnd=SQR(stnd/2)
170 a$="capacitive"
175 IF SGN(jx)=1 THEN a$="inductive"
180 LPRINT f;;x
185 LPRINT "original",rx,jx
190 LPRINT "jx1",rx1,jx1
195 LPRINT "jx2",rx2,jx2
200 LPRINT "jx3",rx3,jx3
205 LPRINT "jx4",rx4,jx4
210 LPRINT "average jx for selected roots  ohms ",avgj;a$
215 LPRINT "standard deviation of jx  ohms ";stnd
220 LPRINT
225 NEXT x
230 END
300 LPRINT f;;x
302 LPRINT "original",rx,jx
304 LPRINT "negative
      discriminant"
305 LPRINT
GOTO 225
DATA 3.55,120,105,52,53
DATA 3.56,115,98,52,47
DATA 3.57,109,90,52,40
DATA 3.58,102,80,51,31
DATA 3.59,95,70,51,24
DATA 3.60,89,57,51,22
DATA 3.61,87,45,52,34
DATA 3.62,94,53,51,61
DATA 3.63,118,70,50,102
DATA 14,183,161,47,117
DATA 14.05,169,145,47,71
DATA 14.1,137,113,47,63
DATA 14.13,129,99,47,63
DATA 14.15,128,90,48,60
DATA 14.17,135,90,48,79
DATA 14.2,188,141,48,149
DATA 14,119,101,70,34
DATA 14.04,114,93,71,28
DATA 14.1,109,82,70,28
DATA 14.13,110,77,71,38
DATA 14.15,113,75,71,50
DATA 14.2,159,110,71,106
```

Fig 1—Revised BASIC code listing for calculating antenna feed-line impedance.

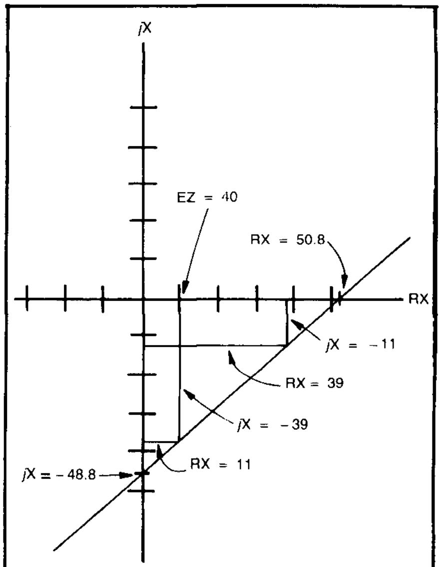

Fig 3—Alternate impedance graphical method. See text.

1—Draw a circle of the radius EZ (item 1, Fig 2).

2—From items 8 and 9 of Fig 2, find the intercepts of jX and RX, Set jX = Q and RX = Q.

Example:

For RX = Q jX = EA² − EZ² − ER² − EC²-/2EC = 5077/-1 − 4 = −48.8

RX = 5077/100 = 50.8

The resulting run record will show that the calculated roots of this construction are RX3 = 10.7 − jX3 = 38.5, RX4 = 38.1 jX4 = −12.2. Which is the correct value?

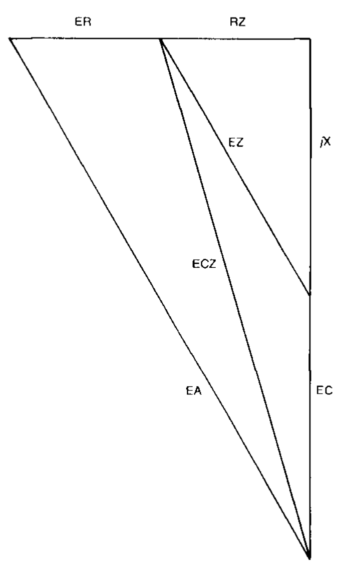

Fig 2—BASIC code change and additions. See text.

June 1988 Revised BASIC code

1—$RZ^2 + jX^2 = EZ^2$

2—$RZ^2 + (jX + EC)^2 = ECZ^2$

3—$(RZ^2 + ER)^2 + (jX + EC)^2 = EA^2$

May 1988 BASIC code

4—$RZ = EA^2 - ECZ^2 - ER^2/2 \times ER$

5—$jX = ECZ^2 - EZ^2 - EC^2/-2 \times EC$

Added quadratics:

Use the value RZ from item 4 in item 3.

6—$jX^2 + 2 \times EC \times jX + (RZ^2 + EC^2 - ECZ^2) = 0$

This is solution jX1 and jX2 in the June 1988 code.

7—$2 \times ER \times RZ + ER^2 + 2 \times jX \times EC + EC^2 = EA^2 - EZ^2$

8—$jX = EA^2 - EZ^2 - ER^2 - EC^2/2 \times EC - ER/EC \times RZ$

9—$RX = EA^2 - EZ^2 - ER^2 - EC^2/2 \times ER - EC/ER \times jX$.

Substitute the value of jX from item 8 to item 1. This results in RX3 and RX4 which will produce jX3 and jX4 in item 8.

Facsimile Over a High-Frequency Radio Link

Continued from page 9.

at generating a halftone image. (Some standard FAX machines already perform this function.) This capability would allow clearer transmission of gray-scale imagery.

Finally, a small effort is being directed at using the Rockwell R24MFX FAX-modem IC to transmit digital information directly. This requires the application of a forward-error-correction polynomial to minimize or obviate the need for retransmission.

Acknowledgments

The success of a development project is due to many people. Ken Denman at IOS provided much of the scientific impetus. Jim Galloway alerted the authors to the potential of facsimile technology. Hank Magnuski of Gammalink took an obvious interest in the project and provided much assistance. Larry Dorosh provided crucial technical support. G. A. Borstad and Associates processed the Advanced Very High Resolution Radio-meter (AVHRR) satellite imagery and provided operational support.

VHF+ Technology

By Geoff Krauss, WA2GFP
16 Riviera Drive
Latham, NY 12110

State of the Art: 430 MHz

If you have been following my analyses of the states of the arts on our VHF+ bands, you have probably noticed the basic sameness of those states for the three VHF bands (50, 144 and 220 MHz). The VHF bands share propagation characteristics, such as the possibility of E_s, meteor scatter, aurora, other back- and forward-scatter modes, and so on. The VHF bands also share many equipment characteristics: a large number of CW/SSB and FM rigs, including at least some hand-held units, are available for each band; several tubes are available for full-legal-output power amplification; many types of solid-state devices are available for class-C and linear amplification at power levels below the legal limit; receiving equipment with noise figures much lower than typical ambient band noise are available. The VHF bands are also characterized by the wide availability (and almost universal use) of one type of antenna: the Yagi beam. No other type of antenna provides the same gain, directivity and relative ease of aiming of the major beam lobe at these frequencies.

The stable of commercially-available equipment for the amateur 70-cm band is smaller than that for 2 meters, although the variety of mobile and hand-held rigs for 440-MHz FM appears to be larger than for 50 or 220 MHz. One mode, wide-band TV, is available on this (and higher) bands, but not on the VHF bands. The broad bandwidth required for ATV results in increased total noise power encountered by the receiver, and the high peak power associated with transmission of TV sync pulses reduces average transmitter output. These factors seriously limit the practical communications range of 440-MHz ATV. There are, nevertheless, a growing number of ATV enthusiasts. Several ATV nets are held around the country, and video equipment is becoming more widely available and inexpensive (due, in no small part, to the home video/VCR revolution). A number of small companies sell ATV transmitting and receiving equipment.

At wavelengths below one meter, station-planning considerations are not the same as at VHF. More types of antennas are practical at UHF, and antennas are physically smaller for a given gain (although less tolerant of dimensional and aiming inaccuracies), than their VHF counterparts. At UHF, there are fewer ways of developing legal-limit output power, and frequency stability requirements are more stringent. Designing UHF receiving systems that can obtain maximum sensitivity (with external noise approaching a minimum value), and having enough dynamic range to cope with signals from nearby high-power stations is not easy. The design of a complete communications system thus becomes incrementally more difficult as we consider each area of a state-of-the-art 432-MHz weak-signal station.

Antennas

Unlike the VHF bands, we are presented with a choice between two distinct antenna types for realizing high antenna gains at 430 MHz. One type uses a set of individually-formed elements, such as those used in linear, quad and loop Yagis, collinear arrays, and the like. Because the gain-producing narrowing of the radiated beam results from the phasing of the driven element with the parasitic elements (directors and reflectors), this type of antenna exhibits high gain and low SWR only over a relatively narrow frequency range. The second type of antenna uses distributed parasitic element(s) (generally parabolic reflectors), which act in one similar manner over a broad range of frequencies, and have performance limited only by the frequency response of the driven element used to launch RF energy from the transmission line toward the reflector(s).

Linear-Element Antennas

Linear-element antennas for 70 cm are found in very diverse form; the most prevalent form is the Yagi beam with single driven element, a single reflector and several (typically 3 to 33) directors. Versions with multiple driven elements, square- or rectangular-loop driven elements and reflectors, and multiple linear-element reflectors are also common. There are also types with a single driven loop and quasi-X-shaped directors (to simulate a quad), as found in at least one British design. The number of possible configurations for linear-element antennas at 432 MHz (and the number of proponents of each type) has reached epic proportions.

Yagi antenna designs have come a long way in the past 10 or 15 years: The empirical designs of the late 1960s and early 1970s have been replaced by those that follow stricter theoretical design rules. A computer program called MiniNEC has further encouraged antenna-design improvements by allowing the skilled antenna designer to simulate virtually any configuration of elements and accurately predict performance—all without cutting a single piece of aluminum tubing! Although a number of 432-MHz weak-signal specialists have worked with this program, probably the best known is Steve Powlishen, K1FO, who regularly publishes his findings in *The VHF/UHF and ABOVE Information Exchange.*[1] A recent two-part *QST* series also documented his research.[2] Steve's designs are used by many 432-MHz enthusiasts. Several K1FO antennas (such as versions with 22 elements and a 14-foot boom, 25 elements and a 17-foot boom, 33 elements and a 24+ -foot boom), as well as Yagis designed by K2RIW and W1JR, are available from Rutland Arrays, 1703 Warren St, New Cumberland, PA 17070.

There are a number of other suppliers of beams, power dividers, stacking frames and similar items necessary to assemble a high-gain, multiple-antenna array for EME or terrestrial use. These arrays typically have 2^n (2, 4, 8, 16, and so on) beams. Truly monstrous arrays (such as 24-beam and larger arrays found mostly in the Western US) may depart from this "rule" because the next increment up, at 32 beams, is just too big and cumbersome to position practically, with the accuracy and smoothness necessary to track a point in space with the narrow beamwidths of such arrays.

Parabolic Dish Antennas

The number of amateur stations using dish antennas has markedly increased in the last decade or two. This is significant, because these dishes are, with very few exceptions, homemade. Although there are many commercially available dishes for satellite reception, thay are generally of the 6- to 12-foot-diameter variety. A ballpark figure for minimum usable diameter is about seven wavelengths, which is about 16 feet at 432 MHz, so the common commercial TVRO dishes aren't suitable for amateur use at 432 MHz. The diameter of most home-brew dishes is between 20 and 32 feet. The gain of a dish reflector antenna is:

$$G = 7.5 + 20 (\log f + \log D) \quad \text{(Eq 1)}$$

where
G = gain in dB
f = frequency in GHz
D = diameter in feet

This equation assumes feed efficiency and illumination factors of about 0.5, which is practical for most home-built units. Thus, a 20-foot-diameter dish, if built with a mesh surface having a sufficiently close weave, will have a gain of about 26 dB. The same dish (with the appropriate feed systems) should give gains of about 33 dB at 902 MHz and 36 dB at 1296 MHz, if the screen mesh is fine enough.

Energy must be directed to and from the *focus* or *focal point* of a dish to realize the maximum gain of the dish (see Fig 1). There are a number of methods of placing feed elements for more than one band at the focus of a dish. The focal length (f) of a dish is related to the dish diameter (D) and physical center depth (C) by

$$f = D^2/16C \quad \text{(Eq 2)}$$

The equation governing the parabolic shape is

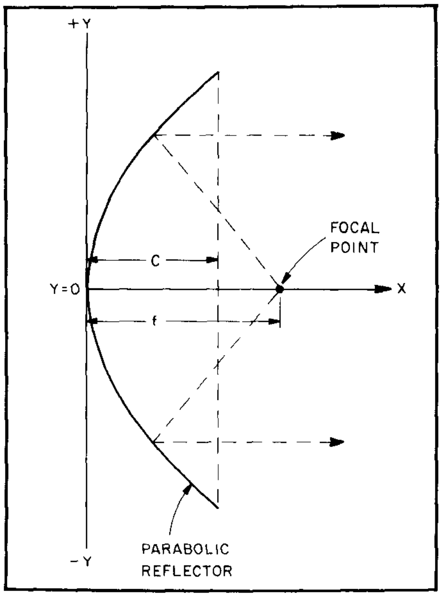

Fig 1—Cross section of the center of a parabolic dish, showing the physical center depth (C), focal length, and location of the focus (f). A dish feed must be placed at f for optimum antenna performance, which makes multiband use of a single dish challenging.

$$y^2 = 4fX \quad \text{(Eq 3)}$$

In designing a parabolic dish, Eq 3 is more useful in the form

$$y^2 = 4D (f/D)X \quad \text{(Eq 4)}$$

Eq 4 emphasizes that the focal-length-to-diameter ratio f/D, generally set by the illumination factor of the dish feed, is the most important consideration in dish design. Typical dish feeds work best with f/D ratios between about 0.3 and 0.5. For our 20-foot-diameter dish example, this gives focal lengths of 6 to 10 feet, and center depths of 4 feet 2 in. to 2 feet 6 in., respectively. Details on building dishes can be found in many VHF/UHF manuals. Next month, I'll continue the discussion of the state-of-the-art 432-MHz station.

Notes

[1]For information, write Harold W. ("Rusty") Landes, Jr, KAØHPK, PO Box 126, St Mary of the Woods, IN 47876.

[2]S. Powlishen, "An Optimum Design for 432-MHz Yagis," *QST*, Dec 1987, pp 20-24, and *QST*, Jan 1988, pp 24-30.

A Weather-Facsimile Display Board for the IBM PC

Continued from page 7.

image, using circuitry similar to that described here, and the K2LAF Multifax program. On screen—and in color—your pictures should look even better. Enjoy your FaxBoard!

Notes

[1]H. P. Shuch, "A Cost-Effective Modular Downconverter for S-Band WEFAX Reception," IEEE Transactions on Microwave Theory and Techniques, Dec 1977, p 1127.

[2]E. Schwittek, "WEFAX Pictures on Your IBM PC," *QST*, Jun 1985, pp 14-18.

[3]E. Schwittek, "HF WEFAX on the IBM PC," *QST*, Dec 1986, pp 46-47.

[4]Multifax 2.1 and 3.0 are available from Elmer Schwittek, K2LAF, 2347 Coach House Lane, Naples, FL 33942; price $49 each.

[5]C. Vermillion, and J. Kamowski, "Weather Satellite Picture Receiving Stations, APT Digital Scan Converter" *NASA Technical Note D-7994*, NASA Goddard Space Flight Center, Greenbelt, MD, May 1975.

[6]The third edition of the *Weather Satellite Handbook* is available from R. Taggart, 602 S Jefferson, Mason, MI 48854; price $12.50, postpaid in the US.

[7]G. Zehr, "The VIP: A VIC Image Processor," *QST*, Aug 1985, pp 25-31.

[8]R. Cawthon, "Attention, Weather Watchers!", *73 Magazine*, Oct 1978, pp 218-223.

[9]K. Sueker, "Real-Time HF WEFAX Maps on a Dot-Matrix Printer," *QST*, Mar 1986, pp 15-20; Feedback, *QST*, Jul 1986, p 43.

[10]M. Goodman, "Weather . . . Or Not?", The Rainbow, Feb 1985, p 42.

[11]J. Royer, *Handbook of Software and Hardware Interfacing for IBM PCs* (Englewood Cliffs: Prentice-Hall, 1987).

[12]The *Journal of the Environmental Satellite Amateur Users' Group* is edited by G. Mengell, 2685 Ellenbrook, Rancho Cordova, CA 95670. Subscription rate is $12/yr.

[13]DataLink RBBS, Dr Jeff Wallach (N5ITU), sysop, tel 214-394-7438.

[14]The IBM-PR1 wire-wrap prototype card is available from JDR Microdevices, 110 Knowles Drive, Los Gatos, CA 95030, tel 800-538-5000; price $27.95 plus shipping.