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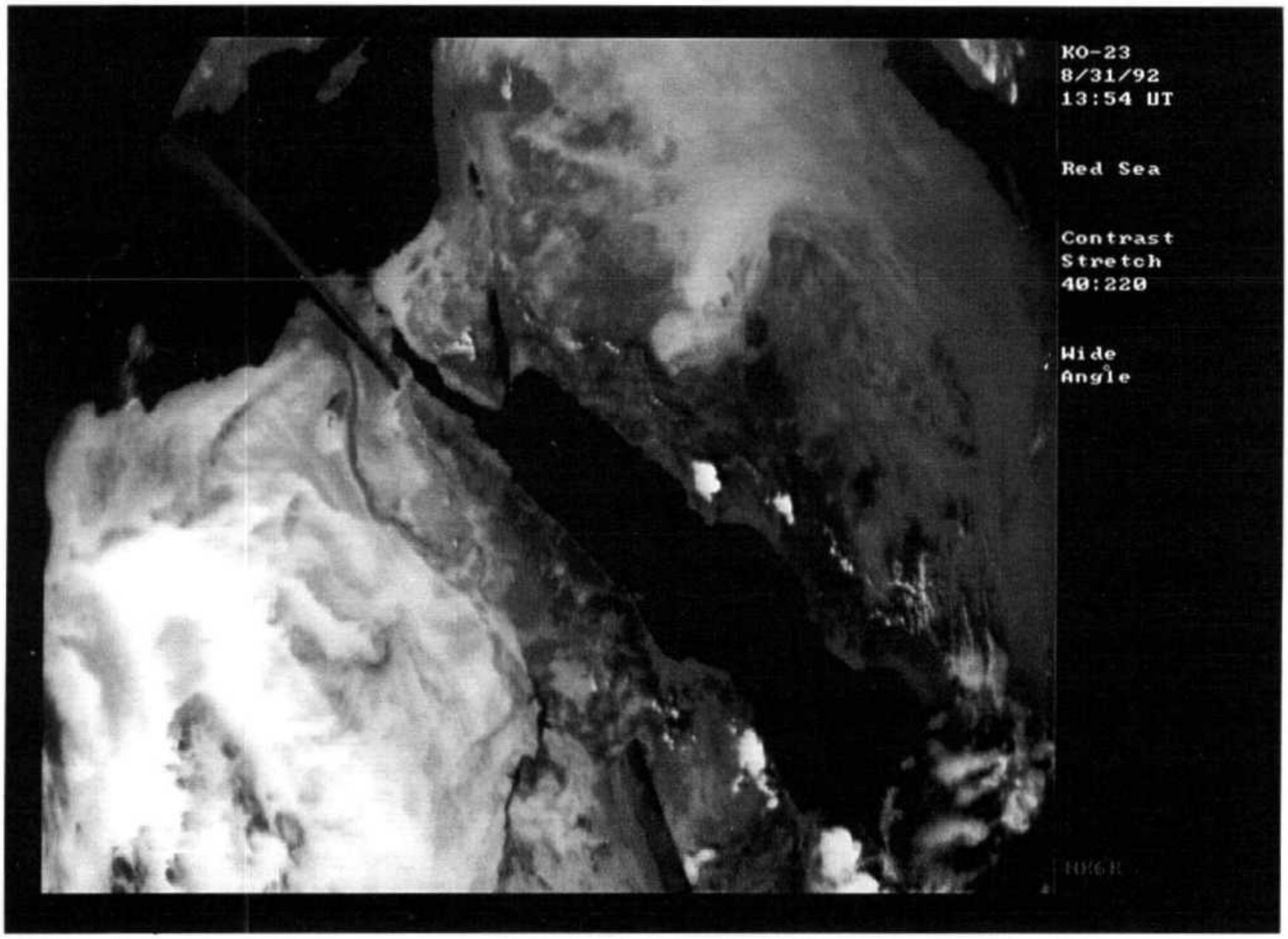
ARRL Experimenters' Exchange

OCTOBER 1992



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THE AMERICAN RADIO RELAY LEAGUE

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Purpose 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 doubled 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*.

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Empirically Speaking...

Algorithms

More and more development in communications technology—including Amateur Radio—is based on the implementation of algorithms. We usually think of algorithms in the context of computer programs. Indeed, computer programs are one of the principal means of implementing algorithms with current technology. There are other means, though, such as digital state machines or even combinatorial logic. A successful project results from the proper implementation of a proper algorithm. But often we hands-on experimenter types concentrate too much on the implementation and not enough on the algorithm! This is perhaps not surprising, since algorithm development is generally a theoretical exercise that often doesn't interest the experimenter or is beyond his or her capacity to do. Unfortunately, the result of using a poorly chosen algorithm is all too often a Rube Goldberg "solution" to the original problem.

Still, there is much room for useful work at the implementation level. What is needed, therefore, is a place where one can go to find solid, well-thought-out algorithms to implement. Suppose, for example, that you want to develop a microprocessor-based WEFAX receiving system. Such a system has been designed before, but you want to use the latest single-chip micro which will allow you to cut the cost in half. If you can't find algorithms to use to do the demodulation and decoding process, you'll have to invent them from scratch. This is called reinventing the wheel, and there should be no need for it!

Another prominent example is the myriad number of DSP algorithms. As DSP hardware gets ever more capable, programmers will want to implement common functions, such as different modem standards, using newer DSP architectures. Why should they have to dig into engineering texts to redevelop algorithms that have been implemented before? Can we not document the way processes work so that they can be easily regenerated when technology advances occur?

And of course, a documented algorithm can become fine tuned as multiple experimenters work on it. A given short cut to implementation may become so well used that it becomes part of the algorithm of choice itself. (The fast Fourier transform is an example of this effect.)

The proposal, then, is to use *QEX* as a medium for documenting algorithms. One instance where we have done this is in last month's article on the LMS noise-reduction algorithm. While the algorithm was developed in the context of a particular TMS320-based DSP design, the information presented is general enough to allow the reader to implement the design on any capable DSP engine. Let's have more such articles! What algorithms have *you* implemented lately? Care to tell us about them?

This month in *QEX*

Continuing our coverage of the DSP25 plug-in DSP board introduced in January, 1992 *QEX*, John Albert, WA9FVP, and Will Torgrim, N9PEA, give us "Developing Software for DSP." This article looks at some of the design considerations that go into making a flexible, practical, DSP-based packet system.

In "Lightning—Your Home and Ham Gear," Stu Gurske, K9EYY, shows us one route to protecting ourselves from the dreaded effects of lightning strikes. It can be done!

Ken Wickwire, KB1JY, wraps up his four-part series, "The Status and Future of High Frequency Digital Communication," with a look at where we go from here.

Zack Lau's "RF" column looks at some portable microwave station design considerations, and Geoff Krauss chimes in with some devices suitable for portable—and other—"VHF+" uses. This month's "Gateway" includes a brief report on KITSAT, the most recent addition to the amateur space program. That it is a valuable addition is demonstrated by the KITSAT image reproduced on this month's cover!

—KE3Z, email: jbloom@arrl.org (Internet)

Developing Software for DSP

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and

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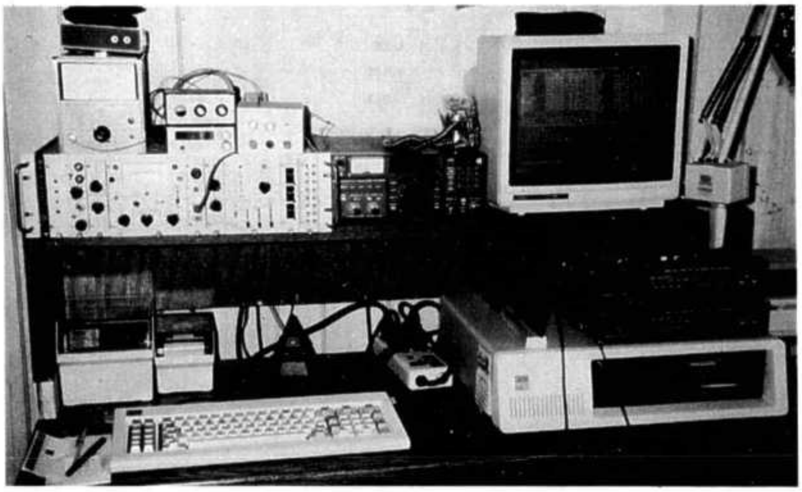
If you read my article in the January 1992 issue of *QEX*, you probably realize that digital signaling processing is indeed an advanced technology. DSP-based TNCs have the capability of uploading modems from a PC. The user can store a library of modems on a floppy disk or hard drive and load them on command. The modems are actually DSP filter programs that use mathematics to convert an FSK signal to a serial digital bit stream. The serial bits are then processed by the TNC's microprocessor, converted into ASCII characters and sent to the PC.



Here's a photograph of the DSP lab (in Jack's basement) where most of the development was done.

The PC, in turn, can send ASCII characters back to the TNC during transmit mode or it can send TAPR commands to change the configuration. The serial port is the link between the computer and the TNC's microprocessor. But where is the link between the computer and the DSP? Can the PC send commands to the DSP in order to change configurations in the modem?

The most important feature of the DSP25 is its ability to receive microcommands and parameters from a PC. The system allows the user to configurate the modem by using a command structure to change parameters.

The DSP25 is a printed circuit board that plugs into the expansion port of an IBM or compatible computer. It replaces the analog filter and FSK decoder circuitry and it has audio and digital ports that are accessed at the rear of the PC for interfacing to a TNC. We are also planning an outboard version that will connect to the PC's serial port and it will run on its own power with the same audio and digital ports for interfacing to a TNC. The whole concept of the project was to develop a DSP that would provide an inexpensive alternative for interfacing the new technology to present equipment.

TAPR Versus DSP Commands

The Packet Radio command structure was first developed by the Tucson Amateur Packet Radio Corporation (TAPR) and has since become the standard for Amateur Radio. Various packet protocols and configurations can be changed in the TNC. That's why we decided to adopt our own set of commands. The user can modify timings, gain, and other filter parameters in the modem to compensate for changing band conditions.

Disclaimer

To help you understand the microcommand structure for the DSP and how parameters are passed, I will attempt to describe some of the basics. I will also try to explain how the host interface can be used to control and change parameters in a DSP system. Because the microcommands are proprietary, I will not cover them in detail. I will, however, give an overview and explain some of the features that we included in our software.

Host Mode

Several TNCs such as the Kantronics KAM or the AEA PK-232 have host mode capability. It allows the PC to send microcommands to the TNC. Unlike the TAPR commands microcommands are simple one or two byte hexadecimal codes that are recognized by the TNC and they allow the parameters to be passed more efficiently via the serial port.

The PC is called the host computer because it runs user-friendly interactive software that sends the microcommands. unlike the TAPR commands, the host software commands are not compatible with all TNCs. Most manufacturers set up their own command structure and the host software will only talk to their product.

DSP/Host Protocol

Because the DSP is a microprocessor it can also pass parameters and microcommands. The question is: What commands are needed, what parameters should be passed and what features would be the most useful to hams? Modems such as the PKTA and PKTB, that we developed for the DSP25, employ a command structure. The PC software communicates to the DSP software using the host interface as the link. (See Fig 1)

Before we started the software, we decided to implement a microcommand structure. The modems and filters that we are dealing with are very complex, and we needed a way to test the performance and to change certain parameters. We also needed a diagnostic tool to help us determine the best filter combination and to obtain the best error performance. I wanted the capability of modifying modem parameters to compensate for changing band conditions and in the future we will implement adaptive filtering.

We started out by developing the band-pass filter software. The mark/space tone filters and postfilters were added later. Each time we developed a new segment, the code was tested and simulated for maximum performance. We then added the microcommands which allowed us to control and generate various signals such as a software driven pseudorandom noise and an FSK generator (the FSK generator was able to send the Quick Brown Fox message which was loaded into the DSP RAM from the PC).

Test Generators

The one thing that DSPs do the best is signal processing or signal generation. The DSP's audio output was looped to the audio input by using a command that placed the analog interface (AI) chip in a loop mode. By using a sort of DSP multitasking software, we were able to generate the FSK signal with noise, feed it back to the DSP for FSK detection in real-time and sent the decoded signal to the data port or display it on the PC screen.

The whole project was conducted without the use of any external signal or noise generator or any other test equipment. In fact, we could probably write software that will simulate the HF environment and conduct a simulated on-the-air test without using a transceiver.

The Next Few Paragraphs will Refer to Fig 1

I would like you to note that some blocks in Fig 1 such as the host interface or I/O port are electronic circuits. Others are hypothetical and are actually software programs. The distinction between the two is irrelevant but keep in mind that the signals are digital and are passed from the DSP register to the host interface or AI chip in the same manner. I show the software as an electronic block diagram so that you can understand how it works. In order to reduce the clutter, the AI chip isn't shown.

The microcommand list started out with only a few commands that controlled a tone and noise generation. We now have the capability of probing the various sections of the modem software. In Fig 1 the software switch is controlled by the microcommands which are sent via the host interface from the computer. The switch is actually an instruction that redirects the math to the AI chip. By the way, the math is used to calculate the filters, the AGC level, the limiter and post detection routines.

In the analog world, an electronic technician uses a procedure to troubleshoot audio circuits using a piece of test equipment called a "signal tracer." But you can't probe a DSP modem with the same equipment because it's stored in a memory chip as instructions or software! You need a test plan that uses microcommands to change how the modem outputs a signal to the analog port. You also need a menu-driven program that runs on your PC and allows you to change the modem using a simple keyboard selection.

Monitor Modes

The DSP outputs audio via the digital-to-analog converter (DAC) which is built into the AI chip. The PC control panel software can instruct the DSP to change the position of the software switch. It can, for example, select the audio input from the AI chip thus bypassing the modem completely (in Fig 1) the software switch would be pointing to the "audio in" line). This mode can be used to monitor the receiver's audio at the DSP's audio output using an external speaker/amplifier.

We decided to add three more monitor test points. This allows the user to monitor the audio at the modem's prefilter output. The third allows the monitoring of a second prefilter which has sharper skirts and the fourth mode passes the discriminator's output to the analog output port. Mode four allows the user to connect the DSP's analog out port to an EIA-232 compatible serial port. This is a requirement to hook-up some public domain software

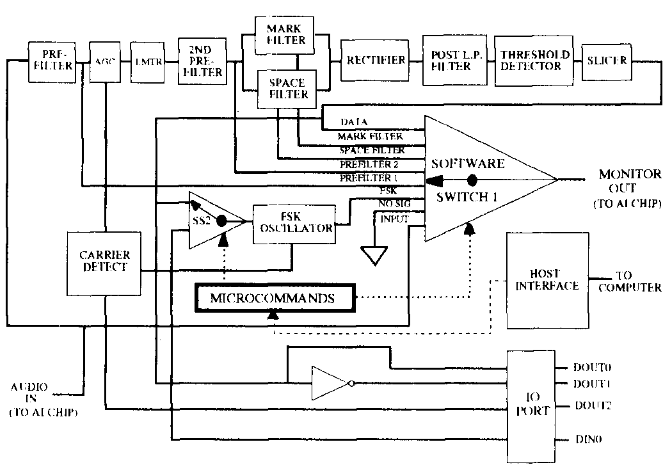


Fig 1—Microcommands are used to control software switchers in the PKT modems.

such as HamCom II. The DOUT0 and DOUT1 provides the same signal at a TTL level.

Controlling the Carrier Detect

The PKT modems have carrier detect routines that are similar to the analog carrier detect circuits in a TNC. There are microcommands that allow the PC software to control the threshold and even tune the filter's center frequency using the + and – keys on the PC's keyboard. We're also planning a feature that will allow the user to change the nose and hang timings of the CD routine. The same routine will be used in a Morse code regenerator software.

A PC Oscilloscope

Snapshot is another feature that exercises the microcommands. The PC can capture 4 traces and display them on the monitor. The PC can even send the snapshot to a printer using the DOS GRAPHICS.COM utility. The 4 traces are similar to the display on a digital storage oscilloscope and they can be changed to view various signals inside the modem.

You can display, for example, the input signal, the AGC, prefilters 1 and 2, the discriminator, the mark/space tone filter outputs and the FSK generator. You can even change the amplitude and timebase of the display. While the DSP is sampling the audio input, it stores the data in the DSP RAM. Then the DSP sends about 4 kbytes of the snapshot data from the DSP RAM to the PC. The process takes several seconds to write the traces on an IBM XT but that's no problem! The slow oscilloscope function is serviced, without interruption, even during the detection of packets. On a 486 computer, the snapshot feature runs at lightening speeds.

Fig 2 is an actual printout of an RTTY signal copied on 20 meters. CH1 is the audio input to the DSP (mostly noise), CH2 is the recovered tone from the mark filter and CH 3 is the space filter. CH4 is the recovered data. The number under the channel designation is a microcommand code that is passed to the PC from the DSP. We display it for the purpose of debugging the software. Fig 3 is a snapshot of the PKTA modem using a signal-to-noise test. The signal is 300-baud FSK sending a continuous 101010 pattern. The noise is 11 dB greater than the signal. As you can see on CH4, the data is copied with 1 error out or 16 bits. The modem can actually copy no errors at –10 dB S/N.

In Fig 1, when the signal changes from a mark to a space, notice that the sine wave output of either tone filter almost drops to zero while the output of the other is at a maximum level. The filters in the PKTA or PKTB modem use the bowtie filter to improve the tone separation and the tuning accuracy using an "X/Y" oscilloscope. I developed the bowtie technique in the mid '70s and improved on it in the mid '80s using switched capacitance filters. We decided to implement the technique in the software. The snapshot feature allowed us to tweak the filters for the best performance and then display it on the PC.

Similar routines that are used in snapshot will be added to the digital voice recording software. The user will be able to record short audio samples and save them to a floppy disk. The maximum recording time (which is determined by the amount of memory in the PC) will be approximately one minute. This will be handy for saving and replaying digital audio recordings such as packets, voice messages, or even short RTTY samples. Because the recording is done digitally, the playback will be perfect without the "wow" and "flutter" that is normally a problem in tape recorders.

Conclusion

The advantage of using the microcommands in a

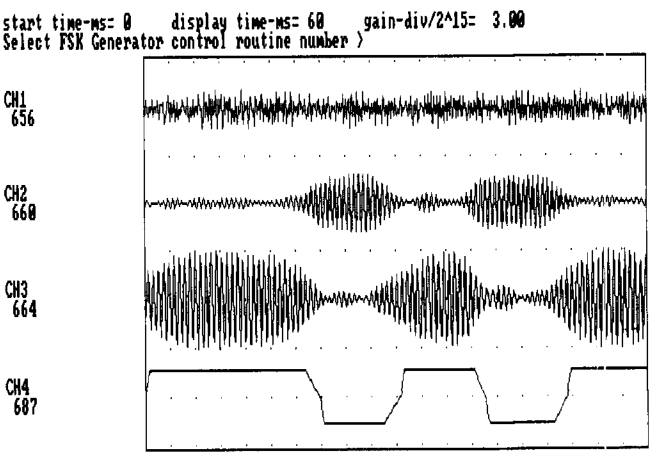


Fig 2

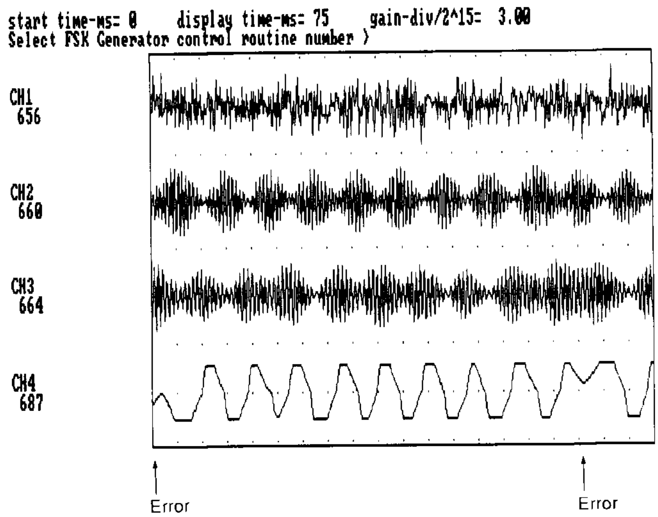


Fig 3

DSP modem is obvious. You won't have to reload the modem if you want to change something. Without it, you'll have to wait for the manufacturer or a users group to change a parameter in the software in order to improve the modem's performance. With smart modems, parameters can be stored in a configuration file and when the "control panel" software is loaded, it reads the file and changes the modem. When you modify a parameter the control panel software will update the configuration file.

Modem reconfiguring was too costly in the analog world because it required complex filters and microprocessor-controlled tuning circuitry. In order to maintain quality control, expensive precision components were required.

In the digital world, every modem offers the same performance, and the filters aren't affected by component tolerances or temperature changes. Features such as filter tuning or timing control take only a few lines of code to implement in the software and it can be offered without adding expensive circuitry. With a DSP you can simply reload a new modem or change a parameter.

The technologies that I mentioned are only the tip of the iceberg. The DSP hardware is the easy part, it's the DSP programmers that will open new horizons to digital communications.

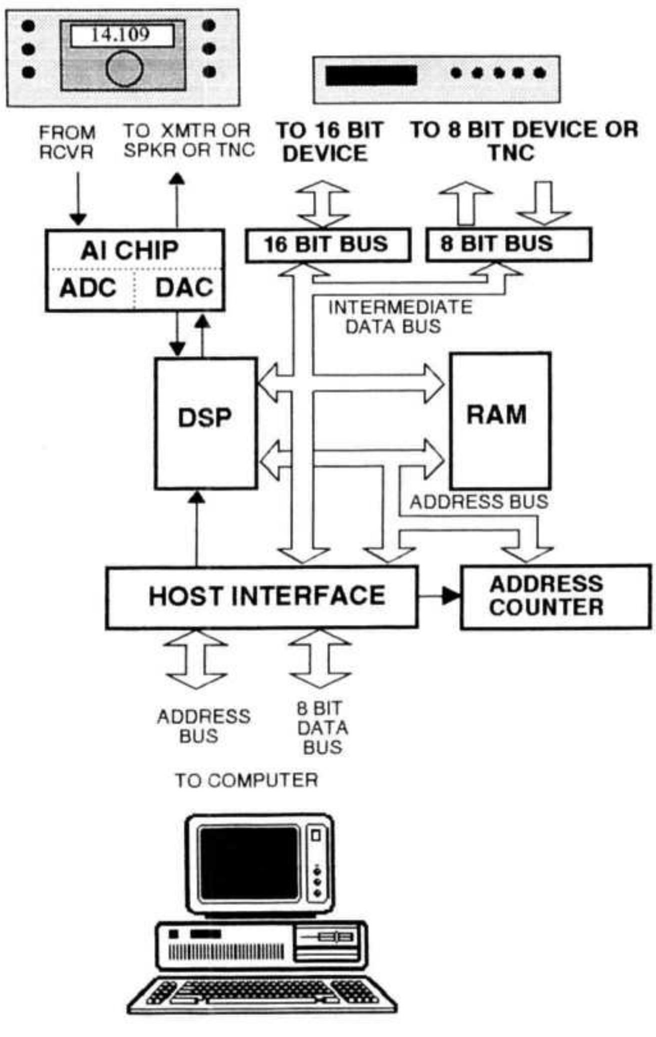


Fig A—The DSP hardware configuration.

```
     *******MAIN MENU*********

 1    Transmit Setup
 2    Receive Setup
 3    A/I Chip Setup
 4    Oscilloscope Mode
 5    Reset Modem Parameters
 6    Special Functions
ESC   Exit to DOS

ENTER NUMBER -->_

HERE'S AN EXAMPLE OF THE CONTROL PANEL MAIN MENU
```

Fig B

```
    ******RECEIVE SETUP*******

 1    Data Output to Port 2        DISABLED
 2    Audio Input Select           AUDIO IN
 3    Regenerator Keying           ENABLED
 4    Audio Monitor                ENABLED
 5    Adjust Carrier Detect
 6    Tune Filters
 7    Adjust Output Level
ESC    Exit To Main Menu

ENTER NUMBER -->_

 HERE'S AN EXAMPLE OF THE RECEIVER SETUP MENU
```

Fig C

```
    ****OSCILLOSCOPE MODE*******

 1    Take a Snapshot
 2    Display Next Screen
 3    Display Previous Screen
 4    Modify Display Parameters
 5    Select Waveform
 6    Show Selected Parameters and Waveforms
ESC   Exit To Main Menu

ENTER NUMBER -->_

 HERE'S AN EXAMPLE OF THE OSCILLOSCOPE SETUP MENU
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Fig D

Lightning—Your Home and Ham Gear

By J. S. "Stu" Gurske, K9EYY
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Lodi, WI 53555

It takes only one hit from a lightning-filled sky to make one a believer in lightning protection. It took a hit on the K9EYY repeater located near our house to make me realize I don't want that kind of damage again. The repeater was completely destroyed as was the antenna and feed line. Every electric wire, and even the phone line, was destroyed. The back-up batteries (deep-cycle, lead-acid types) actually exploded. The case of one battery was driven into the ceiling of the repeater hut and remains there to this day as a reminder of what can happen.

I know of a case in our area where lightning hit a ham's tower and then jumped to a propane tank located some 100 feet away causing a fire which almost destroyed his home.

This article is written to chronicle how my present lightning protection evolved. While I don't think anything can protect home and equipment completely when a direct hit occurs, I do believe one can take precautions which will afford a great deal of protection and minimize the destruction of a direct hit and give good protection against near hits.

Fire is often caused by lightning raising the potential of a metallic object to a high level and then jumping to another metallic object of different (lower) potential. The arc thus created becomes the vehicle which causes a fire. This then, would suggest that everything of metal in the home should be bonded together to keep everything at the same potential when a near or direct hit occurs. Bond together all heating ducts, water heaters, copper pipes, water wells, if any, propane tanks, gas heaters, eave troughs, power company ground (as it enters your home), towers and other items. If you have driven several ground rods into the earth in various places, be sure they are all connected together by some kind of heavy braid, wire or straps.

MOVs (Metal Oxide Varistors) are very effective and should be attached to the electric mains inside the service entrance box in your home. MOVs should also be attached to water well wires and other electronic equipment. Telephones are a special case. Most phone companies do not like to have anything attached to their wires. They use gas discharge tubes in their entrance boxes to ground transient voltage spikes.

Your ham gear is a special case, however, and if you have a tower you should take special precautions with it and with the antennas and rotators which are attached to it.

We are all familiar with "spark gap" types of devices which are inserted in the coax line and then grounded. They were okay when we had nothing else. Unfortunately, these devices require several hundred volts before they arc (spark) and they take a relatively long time to react. Modern transistor rigs are often destroyed by the time these units fire. Today we have gas discharge tubes for lightning protection. They react much faster and at a very low voltage.

The Alpha Delta company manufactures just such a device.[1] It is known as a Transi-Trap. The regular model is built for coax cable and the model CLP is for control cables. They are available at ham radio stores and other outlets. I contacted the company for technical details and they were very happy to supply the data I needed.

I found the gas discharge tube they use consists of two electrodes which are placed in a hermetically sealed "gas chamber." The gas and the electrode spacing are designed to trigger on the leading edge of a lightning surge voltage pulse. When a voltage is present, the gas ionizes and creates a path between the electrodes. One electrode is connected to the antenna circuit and the other is connected to a ground wire. The surge spike is therefore "crow-barred" or shorted to ground. After the pulse passes, the gas tube cartridge automatically resets itself for the next pulse. The response time to crow-bar to ground is less than 100 nanoseconds. If can withstand a 5000-volt, 20,000-ampere surge without failing, and the clamping action occurs at less than 16 volts. The tube is transparent to RF signals and presents less than 0.8 pf of capacitance across the electrodes. The above characteristics were quite impressive to me and, since I did not find any other device which equaled these criteria, I decided to use the Transi-Traps.

The Transi-Traps designed for coax use a single gas discharge tube for the center conductor of the coax. The CLP model is designed for individual wires such as those found in rotator cables. Some manufacturers of these devices use one tube to serve several wires. The Transi-Trap CLP uses a gas discharge tube for each wire. The

[1]Alpha Delta Communications, Inc, PO Box 51117, Phoenix, AZ, tel: 601 966-2200.

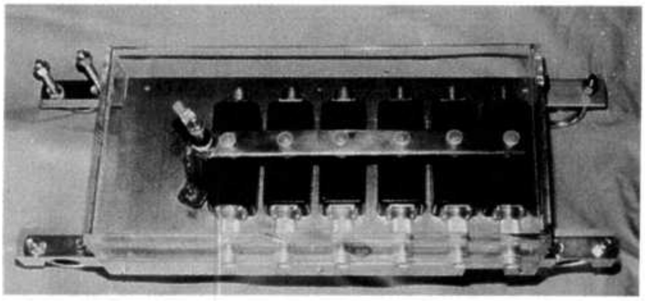

Fig 1—Photo showing 6 Transi-Traps mounted on double-sided printed-circuit-board material. The plastic cover is in place. The coax cables from 6 antennas connect to the top of these assemblies. Coax is then connected to the bottom of these units and is routed into the house.

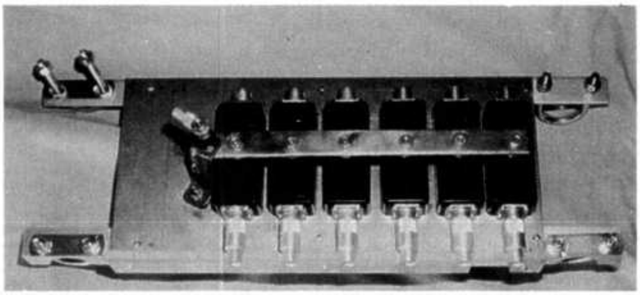

Fig 2—Coax Transi-Trap assembly with plastic cover removed.

device can accommodate 8 wires. Connections are easily made because of the special connector inside the case. First, remove a small amount of insulation from the end of the wire. Second, use a small screw driver to unscrew the captured screws. A slot is exposed to insert the bare ends of the wires (Fig 6). The screw is then tightened and the slot closes to securely capture the ends of the wires. I connected my rotator wires with no difficulty even though I used large diameter wires. I used three CLP devices, one for each rotator cable and one for the wind-speed indicator.

When using Transi-Traps in coax lines, remember the protection of the gas discharge tube is afforded to the center conductor of the coax only. It does not protect a surge on the outside of the coax (the braid). To protect the outside of the coax, be sure to ground the case of the Transi-Trap so the braid is grounded. Or ground the shield of the coax directly. I have six runs of coax plus azimuth and elevation rotator cables and a six-conductor wire for my wind speed and direction unit located on the tower.

Here is how I chose to use the Transi-Traps:

Figs 1 and 2 show how the six Transi-Traps are mounted on double-sided printed-circuit-board material. Note how the aluminum angle and flat bar stock are used to mount the entire assembly to the tower by using "U" bolts at the four corners. Fig 3 shows how all of the

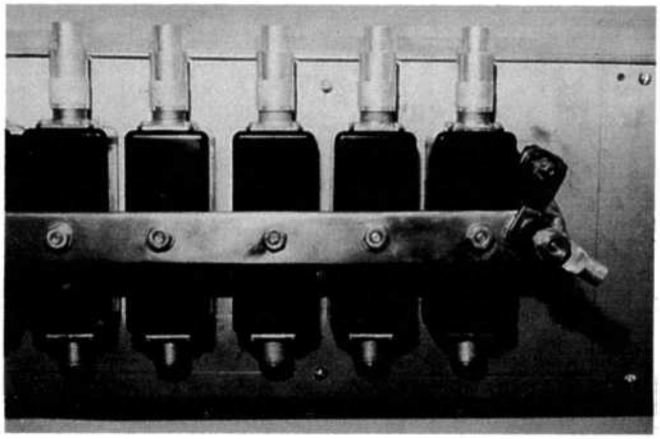

Fig 3—Close-up showing the heavy strap connecting the Transi-Traps together and the connector to which heavy braid is connected and routed directly to the ground rod located at the base of the tower (approximately 2 feet away). Note how the straps are all bolted with brass bolts and are soldered together where they connect to the copper base plate.

Transi-Traps are tied together with heavy copper straps. I removed the back plates from the Transi-Traps and mounted them directly to the copper board. I also applied some conductive grease to the cases where they contact the copper board to reduce corrosion and improve conductivity between the pot-metal cases and the board. Brass screws, nuts and bolts are used throughout for connections to reduce corrosion.

The large brass (1/4-20) bolt which grounds the entire assembly is soldered to both sides of the copper board. A large connector is mounted to this bolt and a heavy braid is connected directly to this assembly. It is run to an 8-foot ground rod which is located at the base of the tower. The assembly is located near the base of the tower. I have room for 6 runs of coax on this device. Each run of coax connects to an individual Transi-Trap. At the bottom of each Transi-Trap another coax connector is attached and this coax then leads into the house through an underground conduit. I then enclosed the entire assembly by building a plastic cover (Fig 1). I left the bottom of the cover open so that I can reach up and remove any or all of the coax connectors which run to the house.

Figs 4-6 show how the rotator and wind-speed indicator wires are connected to the model CLP Transi-Traps. Note how essentially the same building techniques are used as previously. Fig 4 shows a rectangular cut out in the aluminum angle located near the left edge of the board. It accommodates the diagonal cross brace of the tower and results in a neat flat mounting. Here again I removed the paint from the bottoms of the cases and used conductive grease between the cases and the copper-clad board. The large brass bolt is connected directly to the 8-foot ground rod at the base

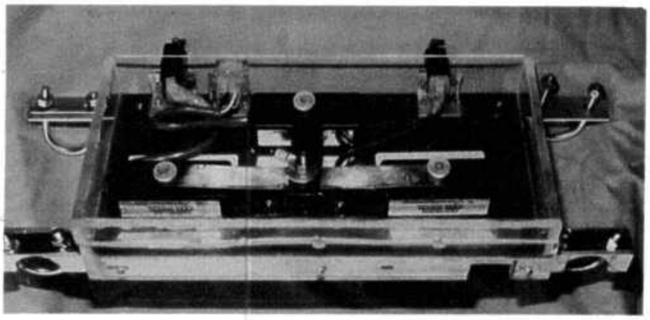

Fig 4—Three Transi-Trap CLP units mounted on their copper board. The plastic cover is in place.

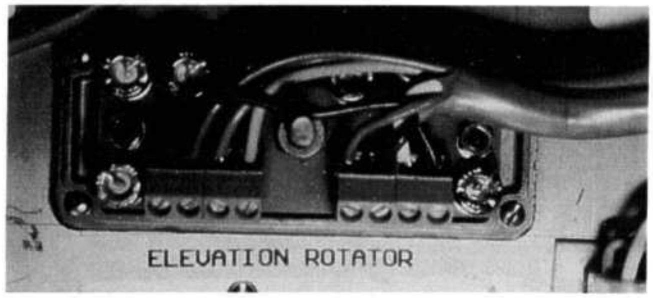

Fig 6—The cover is removed from a CLP unit showing how the rotator wires are connected to the eight separate gas discharge tubes. Four of the tubes are visible. Note how the terminal strip holds the wires. For clarity, I have only shown one wire in each terminal slot, actually two wires are connected (ie, one coming from the rotator and one going on into the house).

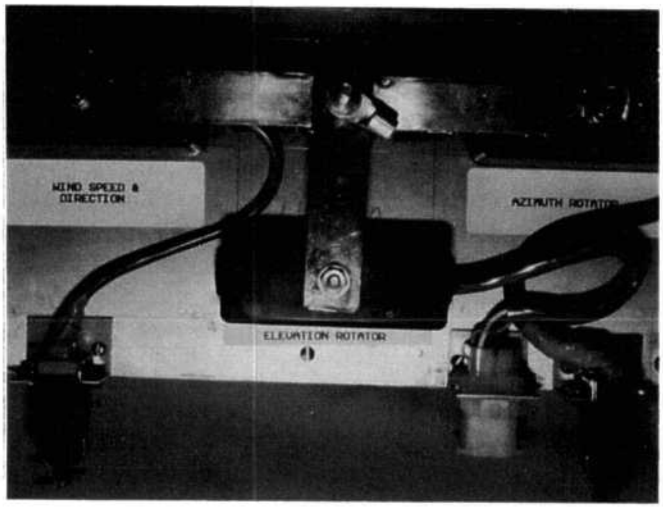

Fig 5—CLP units showing the heavy strap connecting the 3 units together and the connector which receives the heavy braid which is routed directly to the ground rod. Note the three plugs at the bottom of the assembly. These plugs make it possible to disconnect each unit if necessary without having to disassemble the entire assembly.

of the tower. This ground rod is located about 2 feet from the Transi-Trap assembly. I attached plugs and sockets at the bottom of this board so that each of the units can be disconnected at this point if necessary.

All wires are run from these devices to the house in an underground conduit. As the wires (coax and control cables) go to the house, they are accompanied by a length of grounded wire braid which goes into the house and is routed directly to the power company ground on the other side of the basement. This completes the connection so the antenna grounds are connected to the other grounds (ie, water well, heat ducts etc).

Some of the older texts recommend a grounded metal object, sharpened to a point, be mounted at the highest point on the tower. The implication is that this is all you need. While the pointed rod may help some, don't rely on it alone to give you the protection you need. Believe me, I know!

[ARRL Technical Advisor John Stanley, K4ERO, suggests that a sheet of copper or aluminum, if available, would be preferable to the use of copper-clad circuit board for mounting. He also advises the use of two or three ground rods for grounding the tower so as to achieve the lowest possible resistance to ground. And he reminds us that it's still a good idea to disconnect from the power line—possibly via a master disconnect plug, not a switch—whenever possible since this is the most likely entry point for damaging voltages.—Ed.]

The Status and Future of High Frequency Digital Communication

Part IV: Where is HF Digital Networking and Where is it Going?

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1. Introduction

In this last part of the series I'll discuss the status of actual networks, with emphasis on both commercial and amateur developments. Since no modern communications network can be discussed nowadays without reference to *standards and interoperability*, I'll first outline the so-called OSI Model of data networks and view HF digital networking from the OSI and standards perspectives. Next I'll summarize the current activity in HF networking among government, commercial and amateur experimenters. Following this comes a discussion of some aspects of adaptive control of an HF network, including the choice of a channel access protocol. Part IV will conclude with some predictions and final remarks on the role amateurs can play in further developments of digital HF.

2. Standards for Commercial and Government Networks

This section deals with the regulation of HF digital networking. The purpose of regulation is to ensure that networks set up by different organizations can operate together in a useful way. Regulation is achieved by the promulgation of mandatory and voluntary *standards* for automatic radio operation on individual links and in networks.

2.1. The OSI Model

Let's start with the *OSI Model*, which is a classification system for network functions that has become the customary framework for discussion of communications networks. Since the OSI model was initially set up with reference to computer (and not shortwave or other radio) networks, it will be necessary to treat HF digital networking from the standpoint of how well it fits into the OSI framework.

The OSI Model was written by the International Organization for Standardization (ISO), and was adopted in 1983 as a standard for data communications. OSI stands for *Open Systems Interconnection*, the idea behind it being that it should help to make various networks "open" to operation with other ones.

Motivation for the OSI Model was a concern similar to that felt about ten years ago by designers of HF modems: that use of diverse commercial products developed to aid in the operation of data networks that can be connected ("open systems") would make those networks so incompatible that they would become "closed" to each other. This would lead to confusion or even collapse of international communication and commerce. The OSI Model was proposed in part to prevent such a disaster. Because of its generality, the OSI Model, or "architecture," is probably best viewed as an aid to discussion rather than as a set of strict requirements for network design.

One of the three main ideas behind the OSI Model is that the operation of any data network using any communications medium can—and should—be broken down into separate functions that are carried out at one of up to seven "layers." These start at the bottom with the "physical layer," at which bits are moved from keyboards to modems, and end at the top in the "application layer." At the application layer, a "user," commonly a person at a computer terminal, performs some job (say transferring a file, sending a command, forwarding electronic mail, or making a move in a worldwide chess match) involving data processing and communication of data. In principle, each layer is supposed to add to the capabilities of the layer below it.

The second idea behind the OSI Model is that data communication should happen in such a way that the user is not aware of any communications errors having been committed or any routing decisions having been made; that is, all the networking operations that occur in the layers below the applications layer should be "transparent" to the user. It is the ultimate goal of networking that the operations of each layer should be transparent to the layer above it. That is, each layer should perform its functions (error or flow control, routing, connecting to other networks, etc.) in such a way that the layer above it does not have to concern itself with anything that goes on below it: If an error occurs in the operations below, the layers below will detect and correct it; if a routing decision needs to be made in the layer below, the layer above not only assumes that the decision will be made, but need not even be aware that such a decision had to be made.

The third big idea behind OSI is that if everybody organizes his network according to the standard, then all open networks of the future will be compatible. While this must be viewed as a doubtful (and perhaps not even a desirable) proposition, it is nevertheless true that the publication of the OSI Model has provided a powerful aid to clear thinking, and has also made it possible—with some additional work—to connect networks that without the model would have had to work independently, or with laborious and slow interconnection. Before we turn to the effect on HF networking of the OSI Model, let me list the model's seven layers and some of what goes on in them. This is done in the table below.

Examples of functions in an HF network carried out at the physical layer are: matching terminals to modems with an RS-232C interface, and those functions performed by an HF modem *without* FEC or ARQ (for example, A/D conversion and FSK tone-encoding of data).

Table 1

Layer	*Main functions of the layer*
Physical (bottom layer)	Makes electrical connections, passes bits between connected machines and radios
Data Link	Chooses frequencies and sets up connections between pairs of network nodes, puts bits into frames, synchronizes and sends frames; may detect or correct errors made on links
Network	Routes and relays packets or messages, manages message queues, divides messages into packets or frames and recombines them into messages at the receiver
Transport	Connects and routes across sub-networks, performs end-to-end error and flow control
Session	Sets up smooth dialogue between application users
Presentation	Converts "syntax" of incoming data into a form the application can "understand" (including translation from a foreign language), encrypts and decrypts data if required
Application (top layer)	Delivers and sends data in a way transparent to the application's users

Data link layer functions are performed by an HF modem that *has* FEC or ARQ. For example, the FED-STD-1045 ALE modems described in Part II carry out functions in the physical and data link layers: in the data link layer, Golay coding, three-fold repetition and interleaving occur in what might be called the *FEC sublayer*, the ALE handshake occurs in what we might call the *ALE sublayer.*

Network layer functions are performed by the AX.25, IP and NET/ROM protocols used in amateur packet radio (see below). In a network, a node control computer will be responsible for operations in the network layer and above.

The transport layer in an HF network is where end-to-end delivery of messages is assured. This layer "finishes the work" of the network layer. The transport layer usually works exclusively with messages (rather than with bits or frames) and is responsible for end-to-end acknowledgment and flow control when they are needed.

The rest of the layers have not yet been studied in any detail for HF applications.

A look at this table makes it clear that the OSI model was not developed with HF networks in mind. It is also true that HF modem and networking standards—at least until recently—have not been developed with the OSI model in mind. In the OSI model, which was developed for computer communications over reliable, high speed links, the emphasis is on smooth ("transparent") operation of applications at the *top* layer.

In HF digital networking, on the other hand, the only "application" has so far been fairly simple: getting short messages received accurately in a reasonable amount of time. To achieve this, the emphasis is placed on successfully adapting link and routing performance to the difficult HF channel, and most of the techniques for doing this are applied at various places in the *bottom three* OSI layers. It is worth noting that the functions of a pure relay (without storage and forwarding of messages) are all performed at the lowest three OSI layers.

2.2 The New US Federal Standards for HF Networks

About five years ago, when it became clear in the US that HF radio was experiencing a rapid and somewhat unexpected rebirth, the American government appointed a working group to draft a framework for the systematic organization of new developments. Without such a framework, manufacturers of HF equipment in the US were producing (and planning to produce) sets of equipment that could not interoperate; in particular, data modems with different modulations and error control, and ALE modems with different linking protocols.

The working group proposed a stepwise approach to creation of a framework. The steps would start with relatively simple operations like ALE and move then to more complicated ones like exchange of channel quality information, adaptive routing and operation of networks with more than one medium (for example, HF and VHF). Each step was to involve proposal of a draft standard followed by extensive testing, comments from manufacturers and governmental users, and finally an official *Federal Standard* that governmental (and many commercial) users would have to follow in buying equipment and setting up networks.

The first steps in standards development dealt with **Automatic Link Establishment** and **data transfer,** which I treated in Part II.

Following their initial work on modems, the standards developers turned to **sounding** and **polling,** which are needed to provide network nodes with the information required to adaptively control their modems and determine message routing. Polling is being covered by Federal Standard 1046, and standards with higher numbers will treat other aspects of network operation at various OSI levels. For example, standards for **exchange of connectivity information** and for **measurement of channel quality** are now also in the drafting stage. Fig 4-1 illustrates schematically the main aspects of sounding, polling, connectivity exchange and channel quality measurement.

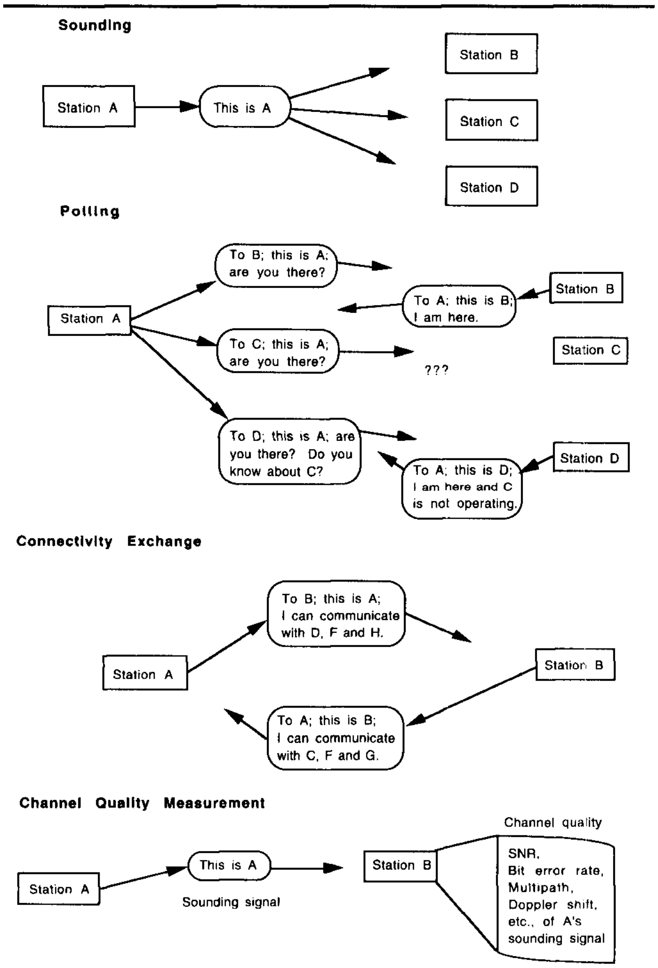

Fig 4-1 Sounding, Polling, Connectivity Exchange and Channel Quality Measurement

The table below gives an idea of the correspondence between the functions carried out in an automatic HF network, the new HF Federal Standards and the layers of the OSI Model. The overlapping of OSI layers and contents of Federal Standards will be evident.

Although it is beyond the scope of these articles to give a detailed discussion of how well the new HF standards fit into the OSI model, or how the OSI model might be expanded at its lower layers to accommodate adaptive HF networking more systematically, it will be noted that several of the operations covered by the new HF standards take place at more than one of the lowest three OSI layers. For example, both ALE and data transfer involve functions that belong to all three of the bottom three OSI layers. Making sure that data networks that communicate over HF channels work well with each other and with "conventional" wideband data networks that must deliver reliable service to applications poses challenging problems to both network designers and standards developers. Each group must keep abreast of what the other is doing and show a willingness to account for unusual ways of thinking.

2.3. Some Actual Shortwave Digital Networks.

Several shortwave digital networks have been operated in the US, and several are presently operating. One of the earliest was set up in 1986 for use by the Alaskan Air Command of the US Air Force. The network was created for experimental study of automatic networking techniques in a region affected by a *disturbed ionosphere* (namely, the auroral ionosphere, where the presence of the highly ionized auroral curtain and polar cap events cause rapid fading and other communications difficulties). This network operated for about three years and is now inactive.

All stations in the Alaskan network used (nonstandard) ALE techniques and passed data with fairly simple BFSK modems. The modems and ALE devices were combined into the same piece of commercially available equipment from the Harris Corporation. These modems sent data at 50 bits per second and controlled errors with an extended (24, 12) Golay code that can correct up to three random bit errors (see Part II) in a codeword. The modem did not use interleaving. Output power of the radios in the network was 500 or 1000 watts. It was radiated by broadband antennas that did not require tuning as the ALE modems switched between the assigned frequencies looking for the best one.

The Alaskan network (which had eight stations located across all of Alaska) was fully automatic. Control software for each node was run by IBM-compatible personal computers with hard disks for storage of data on network performance. The node-control software was organized and written in conformity with the physical, link, network, transport and application layers of the OSI Reference Model. Data on link quality were collected actively according to regularly scheduled sounding and *group LQA calls.*

The network used distributed routing with fairly sophisticated automatic routing protocols. The protocols chose relays with automatic storage and forwarding to route messages around disturbed regions or places where the ionized auroral curtain restricted long-distance communications. Routing decisions were made on the basis of the scheduled soundings of assigned channels, whose quality was measured in terms of received SNRs. Digital test messages of fixed, known content were generated automatically, with randomly chosen destinations (about one message per station per hour around the clock), and detailed statistics on network performance (eg, percent of messages delivered) were collected and delivered to a central point for further analysis.

Average throughput in the Alaskan network was fairly low (usually no more than about 25 bps) because of the difficult channel conditions in the region. Since the network (with its customized control software) did not carry out ALE in accordance with FED-STD-1045 (which had become the primary interest), it was closed down in 1990. It nevertheless provided designers with a great deal of information on the quirks of network operation that they could not have gained from theoretical analyses or even a simulation.

Another network (set up in mid-1990 and still operating) involves about eight stations spread across the US. The purpose of this network is mainly the testing of the new ALE standard 1045. The network uses ALE modems from six different US manufacturers whose equipment is being tested (among other reasons) for *interoperability;* that is, to make sure that modems that are supposed to be built according to the standard can *actually* communicate with each other. This network does not yet route messages automatically (there is not yet any routing software that is publicly available and compatible with all of the computers used in the network). Digital messages can be sent automatically or manually from the computer key-

Table 2
HF Networking Functions, Standards and the OSI Model

Level of Interoperability of Radios in an HF Digital Network	Existing or Planned Federal Standard	OSI Layer
Entry and Exit of stations from a network	FED-STDs-1045 and 1046	Data Link, Network, Application
ALE (with scanning receivers)	FED-STD-1045	Data Link
Sounding	FED-STD-1045	Data Link, Network
Polling	FED-STD-1046	Data Link, Network
Link Quality Assessment and Exchange of Connectivity and Traffic Data	FED-STDs-1045 and 1046	Data Link, Network
Data Transfer:		
—Without FEC or ARQ	Various Modem Standards and Recommendations	Physical
—With FEC or ARQ	Various Modem Standards and Recommendations	Data Link
Formation and Reassembling of Packets or Frames	FED-STD-1047	Data Link, Network
Automatic Routing (including Storage and Forwarding of Messages)	FED-STD-1047	Network
End-to-end Acknowledgment and Flow Control	FED-STD-1047	Transport
Network Control	FED-STD-1047	Network, Transport
Connection with Other Networks (VHF Packet, Telephone System, etc.)	FED-STD-1048	Transport
Protection of Links from Unauthorized Interception	FED-STD-1049	Presentation

boards of each station (at rates between 60 and 160 bit/s).

A third network was set up at the beginning of 1991 to analyze link quality assessment, advanced ALE techniques, sounding, polling, and other aspects of the HF standards that are now being worked on by various government agencies. This network has a central data-collecting node near Washington, DC, and about twelve other stations. Links in the network range from those involving near-vertical-incidence skywave (NVIS) on the east coast of the United States to very long, trans-equatorial links between the US and Australia. Some of the stations in the network are at governmental installations and others are at plants belonging to modem manufacturers. All of the ALE modems in this network conform to FED-STD-1045, but transmitters, receivers and amplifiers are of various modern types. The main purpose of the network is analysis and comparison of data from individual links; automatic routing and storage and forwarding of messages (at data rates between 60 and 160 bit/s) may be added later. Several amateurs are involved professionally with these tests, and it is expected that some authorized work with the ALE modems in the amateur bands can also be done.

Several large US manufacturers of HF equipment (for example, Rockwell International Corporation and the Harris Corporation) have their own shortwave digital networks, on which various experiments involving modem and radio performance, and networking techniques (including automatic routing and storage and forwarding of messages) are carried out. A lot of this work is *proprietary* (not made public for commercial reasons), so it is not always easy to get a clear or complete picture of it.

3. Amateur Networks

Amateur modes of digital HF radio operation include manual and automatic Morse code, traditional radioteletype (in which characters are coded using the Baudot or ASCII source codes, and are sent as soon as they are typed), AMTOR radioteletype and packet radio. With the exception of Morse code, all of these modes use BFSK modulation.

AMTOR is an improved teletype system that uses simple FEC and ARQ to control errors. It is still widely used to pass long-distance text traffic at slow speeds (around 100 bit/s), and is probably the most popular means of shortwave digital communication at this time. The signaling format is a slightly modified version of a commercial radioteletype protocol that has been used by sea-going ships for many years. The AMTOR system employs a source code that is an extension to seven bits of the five-bit Baudot source code; the code produces symbols that always contain *three ones and four zeros.*

Both error control modes in AMTOR use time diversity. These modes require synchronization of the transmitter and receiver. In the FEC mode ("mode B"), each block of three telegraph characters is sent twice, giving the receiving station two chances to receive characters correctly. Characters are assumed to be correct if the ratio of ones to zeros in them is found to be three to four. In the ARQ mode ("mode A"), the transmitter sends a block of three characters and waits for a one-character ACK or NACK from the receiver, which tests each character for the 3:4 ratio of ones to zeros. The transmitter continues sending each block of three characters until it gets an ACK. AMTOR operation has recently been enhanced by CCIR Recommendation 625 for maritime telex, which allows for longer calling addresses and automatic identification of calling stations.

AMTOR is of interest to amateurs looking to the future of HF digital signaling because of its modern error control features. However, neither AMTOR nor standard radioteletype provides the flexibility and adaptability needed to take full advantage of the emerging power of digital signal processing. The first clear look into those capabilities is provided by packet radio.

3.1. AX.25 and Amateur HF

The greatest amount of amateur activity in digital communication as a whole occurs in packet radio. Most of the packet work in the shortwave band is still over point-to-point links at about 300 data bits per second, but the networking advances in VHF packet, and the imminent availability of modems designed for HF use should soon lead to networking activity over long-distance links, and at higher speeds.

The source code for packet information is ASCII. The source-coded data in amateur packets are organized in most modern systems according to the AX.25 (the A stands for "amateur") framing format and signaling protocol, which is a modification for amateur use of the bit-oriented HDLC protocol described above. (HDLC is the link-level protocol of a more comprehensive digital protocol called X.25.) The main modifications of HDLC in AX.25 are an extension of the address field to include up to ten amateur call signs, and the inclusion of unnumbered information frames, which are used to send information without first establishing a connection with a receiving station (see Fig 2-9 in Part II). The supervisory frames in AX.25 serve a subset of the purposes served by supervisory frames in HDLC: declaring the receiver ready or not ready to accept information, and asking for retransmission of frames received out of order.

In shortwave operations with AX.25 it is customary to send one unacknowledged frame at a time (the ARQ window size is one) and a CRC is used to detect errors. If an error is detected, the frame is not acknowledged by the receiver, and the transmitter concludes from the lack of an acknowledgment that it should send the frame again unless the time-out for retries has been exceeded. Thus, AX.25 uses Stop and Wait ARQ at HF. No FEC is used in packet radio, but this should change soon with the availability of more advanced HF modems (see Part II).

3.2. Amateur Packet Networking

As mentioned above, almost all HF packet activity is over point-to-point links; no significant amount of automatic HF relaying takes place yet. Some rudimentary forms of relaying do, however, take place in the VHF (and UHF) networks that operate through "dual ports" at the ends ("entry points") of HF links. It is worthwhile to outline this activity briefly here, as it points the way to more advanced and effective means of true (relay-assisted) networking.

3.2.1. Networking With Digipeaters

The extended address field provided by AX.25 allows for **fixed routing via digipeaters**. A digipeater is an amateur packet radio station that can automatically relay a received packet to a station whose address is listed in the AX.25 address field. Any of the commercially available packet node controllers listed in Part II can be operated in the digipeater mode. In this fixed routing technique (routing is treated in Part III), the initiating station puts into the packet address subframe the addresses of all the relay stations it wants the packet to use on its way to the destination, and the order in which the relays are to be used. In the digipeater mode of packet operation, packet acknowledgment is from end to end: when a packet arrives correctly at its final destination, an ACK message is sent along the entire digipeater path to the sender. If an ACK is not received by a given time, the initiator must send the packet again.

It can be seen that routing by digipeaters is not a technique that can work well at HF: The changing HF channel requires that instead of allowing the *initiator* to set a packet's route, the relays should decide the route according to their assessment of channel quality and network status (message queues, etc). Furthermore, the use of end-to-end acknowledgments in digipeating wastes too much capacity when the channels are poor. The use of digipeaters—even at VHF and UHF—is in fact likely to be phased out sooner or later in favor of more effective networking techniques.

3.2.2. Skipnet

The next step toward true networking for amateurs is embodied in **Skipnet,** which is a system of HF gateway stations that have been given special authorization by the FCC to operate unattended in the HF band. These stations are linked through "dual ports" to local networks operating at VHF or UHF. This is a simple form of *hierarchical routing* according to the classification in Part III. Skipnet gateways and those similar to them have been used to provide national and international packet radio communications. Since the Skipnet relays are generally chosen on a fixed basis, this system, while it does provide long-distance packet connections, is also unable to provide true HF networking.

3.2.3. NET/ROM

The NET/ROM system, used primarily for VHF packet radio at this time, is the first real implementation of networking in digital Amateur Radio. This commercial system (used mainly by amateurs) was developed by Ron Raikes, WA8DED, and Mike Busch, W6IXU, who introduced it in 1987. NET/ROM gets its name from the fact that it provides packet radio with NETworking software that is programmed into a ROM chip. The chip replaces the usual EPROM chip in packet terminal node controllers (TNCs) and turns a TNC station into a NET/ROM station. A NET/ROM station performs two main functions using most of the AX.25 link-level signaling protocol. First, it connects and delivers packets to normal (TNC-equipped) packet stations and digipeaters using the fixed routing described above. Second, it can connect and deliver packets to other NET/ROM stations.

At first glance, this seems like no more than a renaming of stations, but it is more, because in connection with performing these functions NET/ROM stations can store and update information on the quality of digipeater routes to other NET/ROM stations. This information is relatively simple compared with that being studied for use in governmental HF networks—route quality depends mainly on how much time has elapsed since the route was last used successfully. Nevertheless, NET/ROM route quality assessment has attributes many workers in the field consider essential in a truly adaptive HF network: route quality is frequently updated, it is frequently shared by NET/ROM nodes, and it is made available to network users on request. This allows users (including NET/ROM nodes themselves) to choose routes using recent measurements of channel quality—the essence of adaptive networking.

Another important distinction between NET/ROM routing and fixed, digipeater routing is that NET/ROM uses point-to-point acknowledgments. This is more efficient in terms of bandwidth usage than end-to-end acknowledgment, especially in poor channels.

The fact that NET/ROM performs automatic routing means that it can operate at the network layer of the OSI Model. NET/ROM nodes also provide flow control (discussed in Part III) to assure that automatically chosen NET/ROM relay nodes share the message traffic in an efficient manner. Flow control is needed in HF networks to ensure that bottlenecks do not occur at relay stations using poor channels or loaded with unexpected surges of traffic. This is a function assigned to the transport layer of the OSI Model, the layer above the network layer.

The Kantronics KA-node function offers a partial implementation of NET/ROM capabilities: It carries out node-to-node acknowledgments. It does not perform automatic routing, which can only be achieved by acquiring the NET/ROM chip.

3.2.4. Other Amateur Networking Projects

In this section are listed some other amateur projects that may lead to improvements in amateur digital HF.

- *TexNet.*

A high speed (1200 to 9600 bit/s) VHF and UHF packet network set up by the Texas Packet Radio Society. TexNet provides node-to-node acknowledgments, digipeater routing and round-table conferencing. While TexNet does not use fully adaptive route selection, it does provide on command extensive statistics about network performance.

- *The Radio Amateur Telecommunications Society Open System Environment (ROSE) network.*

An addressing and routing scheme developed by amateurs in New Jersey that uses *connected routing*: before data packets are sent, a "call setup" packet is sent across the network to establish a usable route. Once a usable route is found, all data packets take that route. Although this system reduces message overhead by doing away with the list of digipeater or other call signs in the packet address field, it is probably not flexible enough for regular HF work.

- *Karn's TCP/IP protocol implementation.*

In 1985 Phil Karn, KA9Q, proposed (and made available for operation on DOS-equipped PCs) the use by amateurs of two protocols that had previously been employed mainly in governmental computer networks. These are the Defense Research Projects Agency (DARPA) *Internet Protocol* (IP) and the *Transmission Control Protocol* (TCP). The IP is a network layer protocol in the OSI Model, and TCP is a transport layer protocol. (Karn's proposal actually involved several other protocols employed at other OSI layers, but we won't go into all the details in this general account.)

Both IP and TCP handle messages on the *datagram* principle. A datagram is a message frame that carries in its header and control field all the information needed to route it from its sender to its destination. Handling messages as datagrams via some method of non-fixed or "connectionless" routing is to be contrasted with handling them in a *virtual circuit;* that is, using connected routing, as in the ROSE network described above. Because of its greater flexibility, datagram handling, or "datagram service," as it is sometimes called, is better suited to operation in the HF channel than "virtual service."

Message delivery by means of TCP and IP, which is now used in various parts of the world for line-of-sight packet radio, and is second in popularity to NET/ROM for packet networking, is of interest in further developments of digital HF networking for three reasons. The first is the use in connection with IP of what might be called *broadcast polling* to ascertain the ability of the destination or a relay to accept a message: when an IP node receives a datagram, it broadcasts a "polling message" to all the IP nodes in its network. If the network is operating properly, the destination node responds to the polling message by sending back its (the destination's) call sign; a connection is then established, and the message is sent to the destination. This procedure may be an effective way of delivering messages to sub-network nodes and relays in a hierarchical HF network.

The second aspect of TCP/IP networking of interest in HF applications is the system's use of automatic storage and forwarding of messages. This function, which may be viewed as an aspect of message routing, involves holding on to a received message until a connection is established (using a three-way handshake) with the next node to which it is to be sent. This requires buffering and some sort of filing system to keep track of which message goes to whom. It is more sophisticated than digipeating, which tries stubbornly to get rid of messages as fast as possible.

The third aspect is the function of TCP that it shares with all other transport layer protocols: It provides end-to-end error and flow control for messages that go across different subnetworks. That is, the combination of TCP and IP can supply source-to-destination acknowledgment (or ARQ) of messages in a hierarchical routing scheme (even with subnetworks that use different media), and it can also prevent bottlenecks (congestion at overloaded or malfunctioning nodes) by redirecting or slowing down message traffic. It does this by telling senders how many bytes they may send beyond the last acknowledged byte.

Unfortunately, the use of these protocols (which were designed to handle computer traffic over reliable lines) requires the addition of a large number of overhead bits (at least 320 in the current versions). This high overhead—which is more than the information content of some messages sent over HF channels—coupled with the otherwise desirable provision of end-to-end error control (by means of ARQ), exposes message packets for long periods to the fading and interference we know to prevail in the shortwave channel. It is therefore likely that despite its advanced and useful functions, the TCP/IP combination is not suitable for HF work with the modems currently available to amateurs. (It is possible that this prognosis will change with the coming of modems that can deal with the burst errors encountered in the HF channel.)

Nevertheless, the TCP/IP combination represents a powerful addition to the "service" provided by digipeaters, and with the proper modifications and simplifications (for example, compression of headers), it can bring amateur HF communication closer to effective networking than it is now.

3.3 Some Predictions

The publication of the new federal and military standards for ALE and data modem operation occurred only about a year before the establishment of the codeless amateur license class in the US. Since that time the equipment that performs these advanced functions has fallen in price (it is still too expensive for widespread amateur use) and has begun to be manufactured by at least six companies. It is probable that amateur groups interested in experimentation will soon request permission from the FCC to use the ALE and advanced data waveforms in amateur tests.

Since some of the personnel working on the new HF standards are also amateurs, it is likely that the first amateur experiments with the new digital HF equipment will occur in that quarter, but there is no reason why the new equipment should not also be used widely by other hams (and several reasons why it should) when its price falls. Experience with the spread of other digital techniques through the amateur world gives grounds for optimism that we will soon be in the forefront of advanced HF experiment and development.

4. Adaptive HF Network Operation

I'll end the series with a sketch of some aspects of the most important part of HF networking: the adapting of a network's operation to changes of the channel and the traffic pattern. I'll cover as important examples access protocols, link control and adaptive routing.

4.1 Access Protocols

Whenever a communications channel must be shared by users, the need for an *access protocol* arises. An access protocol is a set of rules stations must follow to assure that limited channel resources are used in a fair and orderly way. In the OSI scheme, access is controlled at the link level.

Access to the HF channel is made difficult by contention and by the unpredictability of link quality caused by changing signal strength and noise. These changes mean that the most effective access schemes must be adaptive: When the channel is crowded, or poor, or both, the access scheme must limit access; when the channel improves or the number or contenders falls, greater access should be allowed. A further problem with HF operation that makes many of the usual access techniques unsuitable is that the length of the backoff after an access failure must depend on whether the failure was caused by noise or contention. (The backoff should be short after a noise burst and long after contention.)

Access protocols may be divided into three classes: *fixed* assignment schemes, *random access* schemes and *reservation* schemes. (Reservation schemes, which require centralized network control, are probably not suitable for HF networks.) In fixed assignment, the channel is allocated to users in a fixed way, independently of how their requirements change. In a random scheme, the entire channel is available to all users, who attempt to use it in random fashion (usually on a first-come-first-served basis); if there is contention, some sort of backoff procedure is followed. An example of a fixed scheme is *time division multiple access* (TDMA), in which time slots are reserved for each station, whether it needs them at a particular time or not. The best known random access scheme is called *ALOHA* (so named because it was first studied at the University of Hawaii), in which stations contend completely randomly for use of the channel, trying again and again after backoffs if contention makes it necessary.

In networks where the amount of traffic and the channel quality change frequently, fixed access protocols are generally inefficient. Random access usually copes better with the randomly changing channel. A protocol that has already been used in an experimental HF network, and which shows promise of future usefulness is called *carrier sense multiple access* (CSMA), which is also the access protocol of VHF packet radio. In the simplest form of CSMA, a station that wants to use the channel listens to determine if the channel is already in use (that is, it tries to "sense a carrier"). If it decides the channel is unoccupied (in particular, if it is occupied by a transmitter that can't be heard), it begins to transmit. If it senses that the channel is in use, it waits a random time and tries again, and so on. Generally, the more times it senses the channel is occupied, the longer it waits between tries. (Contention with unheard transmissions can be resolved with an ARQ technique.)

The CSMA protocol is best suited to networks in which the time it takes a signal to travel from transmitter to receiver is a small fraction of the time it takes to send a message frame, which is the case with HF and VHF packet radio. While it is possible to derive mathematically the maximum throughput achievable by CSMA and several other access schemes for channels that don't change, this is very difficult for the randomly changing HF channel. A further impediment to analysis is the fact that use of ALE protocols leads to *changing numbers of stations seeking access* to a particular channel (frequency). The only way to measure the throughput achieved by CSMA in realistic HF conditions is to use a simulation.

There are several ways to make access to the HF channel adaptive. All approaches require that stations gather (and in some cases exchange) information on their success with ALE attempts; if many attempts are made before each success because of contention or poor channel conditions, stations should increase the time between access attempts. This is called *retransmission control.* Another approach is to divide the set of assigned frequencies into subsets that are assigned for access by particular stations; the number of frequencies assigned to a station can be varied as the demand for access changes. A third approach is to use one access protocol (say CSMA) for some frequencies and another one (say TDMA) for others, changing the mixture as conditions change. In hierarchical networks, one or more frequencies can be assigned for exclusive use in *intergateway* communications, and other frequencies for *intranetwork* access by means of TDMA or CSMA.

4.2. Adaptive Link Control

Control of a link involves two steps: collection (directly or from other stations) of data on channel quality, followed by adjustment of one or more "transmission parameters" to raise throughput or lower the error rate on the link. Among the data that describe link quality are the interference pattern or noise level, the SNR, the Doppler shift and spread ("fading rate"), the multipath delay ("multipath spread"), the number of NACKs in an ARQ scheme, and so on. Among the parameters that can be adjusted to raise throughput or lower the BER using these data are the power (often not desirable!), the bit rate, packet and packet window lengths, retry backoff time, and the error detection and correction abilities (including interleaver depth) of an error control code. Several experimental links have been set up in the last five years to study the adaptive control of HF links of various lengths, and the field is the subject of active study.

4.3. Adaptive Routing

The approach to routing is similar to that of link control: stations gather and exchange data on network performance, such as lists of stations that can be reached ("connectivity") and the number of relays needed to reach them, quality of links to third stations, message backlogs, changes in network membership, local propagation anomalies, etc. In a network with distributed control, which is probably best suited to HF operation (see Part III), each station uses the information it collects to choose relays. How well they are chosen by a particular technique is generally decided by the resulting probability of correct message delivery and average delivery time. The best way to measure the performance of an adaptive routing technique at this time is by means of a Monte Carlo simulation. However, when advances in DSP cause ALE and data modem prices to fall far enough and amateurs get authorization to experiment with the new digital modes, HF routing studies should move rapidly from the computer to the vast experimental test bed amateurs are already providing for VHF packet radio development.

5. Concluding Remarks

In this series of articles I have demonstrated that the coincidence of two events—the rising cost and vulnerability of military satellites, and the falling prices of powerful digital signal processing hardware—has brought renewed governmental (and hence commercial) interest to digital communications in the shortwave band. The standardization in the US of protocols for the operation of HF automatic link establishment and data modems that has followed these events has recently led to the availability of commercial products that carry out the standardized functions. The field is now ready for widespread theoretical *and experimental* work on difficult but rewarding adaptive techniques for effectively operating shortwave networks. With the inevitable spread of commercial products will come their availability at reasonable prices for amateur use. The outlook is therefore good for greatly increased activity in digital HF experimentation by amateurs, which will benefit not just the hobby but—as has happened so often before—communications in general.

Notes to Part IV

A clear explanation of the OSI Model and some of the difficulties of applying it to radio networking applications can be found in *Computer Networks* by A. S. Tanenbaum (Prentice Hall, Englewood Cliffs, NJ, 1981). This is the standard work on digital networks. Also useful is *Telecommunications: Protocols and Design* by J. D. Spragins et al. (Addison-Wesley, Reading, MA, 1991).

The current version of the OSI Model was written with connected networks in mind; that is networks with fixed routing. A version of the OSI Model for *unconnected* networks, which is probably better suited to HF operations, is currently under development.

A comprehensive discussion of the current state of amateur VHF, UHF and HF packet radio activity is contained in *Your Gateway to Packet Radio* by Stan Horzepa, WA1LOU, (ARRL, Newington, CT, 1989).

Long-distance HF packet radio with amateur equipment can work surprisingly well on channels that are not affected by contention (interference from other shortwave stations), which is usually one of the main HF channel disturbances. During the recent war in the Persian Gulf, an HF packet radio link was operated successfully between the Eastern United States and Saudi Arabia for 41 days in a row. (AMTOR links with various places were also set up by amateurs in the Gulf region during the war.) Since the modems used for these packet communications had no means of error control other than Stop and Wait ARQ, the packet link could be maintained for only about an hour around noon (UTC) each day before multipath made it unusable.

Amateur experiments coordinated by the ARRL are now underway to study the possible use in AMTOR of an adaptive ARQ scheme developed by the maritime administration of the former Soviet Union. The scheme involves the choice, following a handshake, of sending either the customary three characters of an AMTOR ARQ block, or (if the channel is good enough) a block of *nine* characters. Proper use of the technique is said to raise throughput by as much as 20% if conditions are right.

Versions of Karn's TCP/IP protocol software are now available for Macintosh and other personal computers.

Details of the new federal standards for HF ALE radios can be found in a recent series of articles by Adair and Bodson in *QST*. The first article is in the May 1992 issue.

RF

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Portable Microwave System Design

A common complaint about microwave operation is that it just isn't feasible to work VUCC from one's home location. This is especially true here in Connecticut, where big and successful HF contest stations actually have their HF antennas below the tree tops!

The most popular solution is to operate portable, taking advantage of scenic spots with distant horizons. Not only is the propagation great, but you often get to promote ham radio by showing off your equipment to other people taking advantage of the great view. I always prefer to demonstrate stuff that works, so this column discusses portable design issues.

The Weather

While it's more important that *you* survive the weather, so should your radio equipment. The nastiest weather problem might be categorized as "electrical precipitation"—static discharges and lightning. I'd recommend you leave if you encounter this stuff. In some places, they make you leave whether you want to or not. However, so you don't have to fix your gear when you get home, you might design your equipment to deal with unwanted static electricity whenever possible, usually by providing dc return paths to bleed off charge.

Almost as annoying is the normal precipitation—rain, snow, and heavy mist that gets your gear wet. This problem tends to dictate the use of low-voltage, low-impedance designs. At a minimum, the equipment should be covered to keep the water out. Note that I said covered, and not sealed. Unless you intend to fill something with dry nitrogen and hermetically seal it, sealing often does more harm than good, as condensation causes internal moisture build-up and subsequent water damage. Containers with drain holes at the bottom work very well. Perhaps someone would like to comment on how they keep their high-voltage amplifiers running in the rain?

Another important consideration is the wind. Vic, W2VC, reports that he almost missed out on making long distance 10-GHz QSOs until Karen, KA1JVU unexpectedly showed up on Mt Wachusett to help steady his dish in the wind! While popular, camera tripods really aren't designed for holding big dishes steady in the wind. I've had much better luck with 3-foot Radio Shack TV tripods and a 5-foot mast. For a really deluxe setup, I drill two quarter-inch holes in the mast—one for the direction-setting circle that sits on the folding bottom supports of the mast and another as a key that sits on a rotating table made out of plywood. Two bearings are used, a plastic one to protect the setting circle and a wooden one to protect the bottom of the table. I really haven't found an easy way to cut a 1.25-inch hole in the center of a 2-foot square of half-inch plywood, though it is possible to use a Greenlee punch on quarter-inch plywood.

Finally, there is the temperature to deal with. Even in the hot summer months, it gets cold on mountaintops; it was probably in the vicinity of 45° F on Mt Greylock during most of the August 10-GHz contest. And in the January contest, those of us out portable/roving had 10-degree temperatures to deal with. (I've been assured by those further north that the temperatures do not get cool enough to significantly improve the noise figure of preamps!) On the other hand, those at the beach looking for coastal tropo openings are likely to get temperatures as high as 100° F. This means that the ideal all-purpose radio would operate between 10° and 100° Fahrenheit.

To me, this means that you have to use active bias circuits to compensate for the fluctuations in device characteristics as the temperature changes. Setting gate voltages with potentiometers may work in the shack, but it doesn't work reliably outdoors where the temperature varies. While it may be overkill, I have been known to bias MMICs with LM317L-based current sources instead of the recommended carbon-composition resistors.

The bias current is usually a bit more critical if you are using the MMIC as a high-order multiplier instead of an ordinary amplifier. I've had pretty good success with high-order multipliers, particularly when the MMIC is feeding a bandpass filter with a tapped input inductor or a transmission line that is grounded. I suspect that shorting out the fundamental signal tends to improve multiplier efficiency.

Finally, everyone knows that oscillators drift with temperature—most of them. The design in the Rick Campbell local oscillator ("A Clean, Low-Cost Microwave Local Oscillator," *QST,* July 1989, pp 15-21) works well, though I've been able to improve its stability roughly tenfold by building the circuit over a ground plane and using a high quality air-variable trimmer capacitor. As builders of HF VFOs have found out, capacitors made out of Fiberglas circuit board are pretty lousy in terms of temperature stability. A common technique that I *don't* recommend is to buy crystals and age them a few years on the shelf. But it certainly does help to encase your oscillator in styrofoam to shield it from the environment, though this does raise the operating temperature of the circuit.

Powering the Equipment

How your equipment is powered depends on how portable it has to be. I've defined three categories of portability. Equipment in the first category is really portable—you can take it anywhere you can go. For me, the limit is a few miles up a hiking trail. The second category comprises equipment just portable enough to get from the parking lot to a nice spot a few hundred feet away. Finally, we have equipment that has to be next to an automobile or gas generator.

Really portable operation implies batteries. At the moment there seem to be four options: alkaline cells, NiCds, gel cells, and nickel-hydride batteries. If you need the maximum performance per pound, nothing competes with alkaline cells or other primary batteries. You will typically get at least 3 or 4 times the energy from an alkaline cell as from a rechargeable or secondary cell. But using alkalines can be pretty expensive, though they do go on sale at discount prices regularly.

Despite all the hype, nickel-hydride batteries don't seem to offer that much of an improvement over NiCds or gel cells, especially if you are looking for 3 to 4 amp hours of capacity (considering amp hours/pound, rather than environmental issues). In fact, they are all pretty close. A microwave station will typically draw at least an amp, so a set of AA cells in series is really pretty useless unless you know you can complete that schedule in 20 minutes (those of us who make lots of microwave contacts know better).

For the RF designer, NiCds work well. The flat discharge curve of voltage vs capacity remaining makes it easy to design circuits, since the input voltage is nearly constant. One has to be careful with homemade battery packs, though. I recently discovered that the steel clips used in my cheap battery holders were adding 0.5 Ω to my 12.5-volt battery pack—not negligible if you are drawing an amp or two! Cells with solder tabs are definitely recommended, though the first pack I built using clips didn't have anywhere near as much loss (which is why I didn't check the second one until I realized it didn't work as well).

If you intend to run several watts of power, big NiCds become prohibitively expensive. Gel cells are probably the way to go if you have power FETs that draw amps of current. A caveat with gel cells is that they actually dry out and become useless if floated with the normal charging voltage. A June 1987 *QST* article by Warren Dion, N1BBH, ("A New Chip For Charging Gelled-Electrolyte Batteries") points out that there are really two voltages that should be used for charging gel cells: one for actual charging to full capacity and another for maintaining the charge. Unfortunately, gel cells vary considerably in voltage during discharge—from 14.4 volts after being freshly charged to around 10 volts at full discharge. As a result, it is often desirable to have a radio that isn't fussy about the power source. I often like to have transverters that run between 10.5 and 15 volts, but this isn't always easy to design. GaAs FETs lend themselves to low voltage designs, since they typically work just fine off of 5 volts, while power devices are often designed to work off 6 or 9 volts.

While silicon MMICs have their advantages, battery operation isn't one of them. For instance, Rick Campbell's 903 transverter ("A Single-Board, No-Tune 902-MHz Transverter," *QST*, July 1991, pp 25-29) has the MMICs biased for operation at 13.5 volts. While the transverter sort of works at 12 volts, the local oscillator drive to the SBL-1X mixers can become disturbingly low. I've changed the bias resistors on mine to accommodate 12-volt operation. I used 430 Ω for the MAR-6s, 220 Ω for the MAR-3s, and 120 Ω for the MAV-11s. Even so, I certainly wouldn't want to run the circuit from a 14.4-volt supply without some sort of low-dropout regulator. Unfortunately, the LM2941 regulator IC is apparently not available anymore, leaving just the low power (100 mA) LM2931CT.

If you need a table of MMIC bias resistor values, you might get a copy of Steve Kostro's microwave kits and parts price sheet—the back features not only the table, but physical information on MMIC packages. Contact Steve at:

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Box 341A, RD1
Frenchtown NJ 08825
tel: Work: 908 834-1304 (9 AM to 7 PM)
Home: 908 996-3584

Using batteries offers an advantage not found with generators—there usually aren't any nasty voltage spikes to deal with, unless your circuit generates them. Two big offenders are inductive/transformer based switching supplies and relays. And perhaps someone would like to comment on all the nasty stuff modern automobiles generate on the power bus? Taking advantage of the big lead-acid car battery as a power conditioner makes sense, except that people get lazy and want to use existing wiring in the automobile, rather than running their own wires straight to the battery.

VHF+ TECHNOLOGY

By Geoff Krauss, WA2GFP
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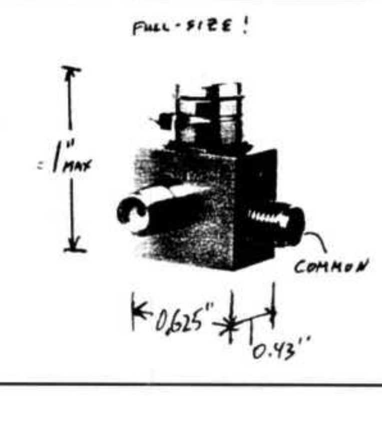
New Goodies to Try

Everyone, I hope, knows enough about communications system design to know that there are three major portions of any station: signal source (transmitter), signal detector (receiver), and some means (antenna) to couple them, generally one at a time, to the transmission medium (in our case, free space). We spend lots of time considering how to get the best specs for each of these portions, especially on the VHF+ bands where we often have to build at least part of the equipment ourself. There is one part of our station that even the most buildingest VHF+er will not want to homebrew—the one-at-a-time coupler, usually an antenna relay. While there are basically two types of RF relays, it is the electromechanical relay that finds the most use in higher-performance VHF+ stations. It has less loss in the connected path and greater isolation in the unconnected path than the fully electronic relay (which may use one or more MMICs, PIN diodes, etc). It is not that coaxial electromechanical RF relays are particularly complicated, as far as the number and type of internal components are concerned; many amateurs in other countries routinely design and build simple units—some are good enough for their designers to go into business selling units to other amateurs who would be unable to afford *any* commercial unit. We in North America are relatively lucky. There are reasonably priced commercial RF relays and even cheaper military-surplus units in abundance; there may be readers with a fully homebrew coaxial RF relay in their VHF+ stations, but I personally have never met one.

With that background, I was really intrigued when I saw an ad for the TOH-55 model coaxial RF relay from Dynatech Microwave Technology, Inc (26677 W Agoura Rd, Calabasas, CA 91302-1921, tel 818 880-6100 [thanks to Sandy Smith, Sales Administrator, for a sample]). I saw this *little* relay, only 1-inch long in the body/coil dimension (see figure); certainly small enough to fit into most portable UHF rigs (Gee, no more rover station T/R switching by swapping cables). I wondered what its RF performance would be like, so I tested my sample. Wanting a really meaningful comparison, I used the same setup to test a GaAs switch MMIC (by ANZAC) that I "liberated" from a client at work and to which I attached SMA connectors via a microstrip test board, as well as a typical full-size SMA relay (by Dow-Key) and a top-of-the-line EME-standard Transco RF switch with N connectors:



Relay	GaAs MMIC	TOH-55	Dow-Key	Transco
	Insertion Loss/Isolation (dB)			
0.005 GHz	0.35/76	<0.05/64	<0.05/89	<0.05/>100
0.5 GHz	0.57/58	0.05/52	<0.05/87	<0.05/>100
1.0 GHz	0.79/46	0.08/46	0.06/85	0.05/>100
1.5 GHz	0.92/40	0.11/43	0.11/83	0.08/94
2.0 GHz	1.03/34	0.15/41	0.13/80	0.11/88
Approx Cost	$25 new	$75 new	$75 used	$125 used
Size cu ins	0.01	0.27	2.8	8.0
Rated RF Power	IP3+1 W	20 W	100 W	AmMax to 1 GHz
Switch Time	<1 μSec	15 mSec	20 mSec	33 mSec

Size is given without connectors. Note that the test equipment I used did not give an insertion loss reading much under 0.05 dB and lost the isolation readings above 100 dB, which is more than most stations need in any legal power situation. It seems obvious that one has to give up some isolation in a relay with small dimensions as the center pin of the switched-off connector and associated structure probably forms some undesired coupling to the very close mechanism of the switched-on connector. Nevertheless, the lower power handling capability of the smaller relays offsets the lower isolation so that the maximum leakage power is still small enough to be adequately handled by even the most delicate silicon devices in the receiver front-end (GaAsFET devices are *more* hardy!). Additional benefits can be obtained in certain situations (eg, UHF and microwave portable/mobile) if one considers the cost and switching power of the four units. The MMIC uses 5 V at <100 mA, while the relays are available with a choice of coil voltage, ac or dc. The tested TOH-55 used 12 V at 230 mA; the Dow-Key, 28 V at 450 mA, and the Transco, 28 V at about ¾ A (and you don't want to know the new cost, either!). Because of its low weight, I would consider use of this small relay for T/R switching in 902/1296/2304 mobile rigs and main-pack rover stations, especially the kind that now use manual cable switching!

ROHM Electronics (3034 Owen Dr, Antioch, TN 37013) has been advertising HyperFETs, heterojunction FETs made from indium gallium arsenide (InGaAs), with some interesting characteristics, especially price. The RHF-1204 with a 12-GHz NF of 0.8 dB and the RHF-1205 with a NF of 0.7 dB, each with typical Ga of 10.5 dB, carry large quantity (>10000 pcs) prices of $4.85 and $5.25, respectively. I checked the curves of the RHF-1204 and it appears able (at 2-V dc, 10-mA I_d) to provide:

Freq	1296	2304	3456	5760	10368
NF dB	0.30	0.36	0.41	0.50	0.70
Ga dB	20	18	17	14	11.5

All this in a ceramic package (at these low prices?). The data sheets give S parameters *and* optimum noise parameters (NFmin, Ga, Gamma-opt and Rn) every GHz from 2 to 18 GHz.

The really intriguing part is the note that small, prototype quantities can be purchased directly from either Garrett/IEU in California (805 922-0594) or Nμ Horizons in New York (516 226-6000) "at a slightly higher price/unit." I am attempting to verify specs and small-quantity pricing and availability, but would be happy to hear from anyone who may already have this information to pass on to the rest of us. (This is one of the biggest problem areas in using SOTA low-noise receiving devices—the lack of small quantity sources for most GaAsFETs, HEMTs and pHEMTs—so any source information should be welcomed by all VHF+ers.)

Another interesting semiconductive component, albeit for not-much-lower frequencies up to about 5000 MHz in the VHF+ range, is the newest Avantek IAM-81008 MagIC low-noise active mixer in a SO-8 plastic surface-mount package. This 8-pin double-balanced mixer is many times smaller than the ubiquitous metal-can DBMs, yet costs only about $6.95 each and still has RF and LO ranges of up to 5 GHz and an IF range of up to 1 GHz with conversion gain for an LO power input of +5 dBm. Okay, it does need some dc power (+5 V dc at 13 mA, typical), which a diode-ring DBM does not. But unlike passive DBMs, there is gain, and its operation is of the load-insensitive type, ie, typical conversion gain of 8.5 dB and with characteristics that do not vary with changing load. Yes, it does have a much higher NF (17 dB) than the 8-dB typical NF of a passive DBM, but the noise added by subsequent circuitry is reduced because of the conversion gain. Remember that passive DBMs have a typical conversion loss of about 7 dB. And yes, IP3, the output IF third-order intercept point is very low, at +3 dBm, but this probably does not matter for many amateur uses below 500 MHz and almost all uses above that frequency. RF, LO and IP port isolations are about the same as the isolations obtainable with no. 7 passive DBMs. The output power at the 1-dB compression point is only –6 dBm, leading to a dynamic range of medium standards, but good enough for most 902-and-up receiving down-converter applications. One important factor is that the mixer works well with only –5 dBm of LO drive, which makes it easy to obtain injection at lower microwave frequencies (say, from a simple diode harmonic generator).

If the low IP3 is not good enough for transmission up-converters, try the IAM-82000 series mixer with its higher intercept point. A 1-dB compression output power of +8 dBm and 15-dB conversion gain, balanced by operation at 10 V dc and 50 mA, make a better (and more expensive) device. Even the IF range gets better with higher bias—it goes up to 2 GHz!

One use that I personally have for one of each mixer is some low-cost HF to 2-m transversion, such as might be used to kick a QRP 14-MHz SSB transceiver (say an older Ten-Tec 509) up to 144 MHz to use with all those nice no-tune microwave units for 902, 1296, 2304 and 3456 (all of which use the common 2-m IF). I do not have a spare 2-m SSB rig and would rather not spend into the four-figure range to get an extra. I figure a pair of IAMO with power splitter, and some TOKO helical resonator filters should do the trick. Anyone have some other good uses for these active mixers?

Gateway

Conducted by: Stan Horzepa, WA1LOU
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Wolcott, CT 06716-2755
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or 70645,247 (CompuServe)

ARRL BOARD TO RECONSIDER HF PACKET PROPOSAL

The ARRL Executive Committee has set a tentative timetable for further consideration of the matter of HF packet. At their meeting in Los Angeles on August 22, the committee voted to resume deliberations on their recommendations concerning unattended HF packet and, in particular, the writing of a draft Notice of Proposed Rule Making for consideration by the entire ARRL Board.

The Committee will request that the board's Digital Committee meet with a "representative group" of five participants in the ARRL's Special Temporary Authorization for unattended HF packet operation. The Digital Com-mittee will report to the Executive Committee by October 5 and the Executive Committee will consider the matter again at its November 14 meeting.

KITSAT-OSCAR-23 IS BORN!

With a picture perfect launch from the Kourou, French Guyana spaceport and a flawless separation from the third stage of an Ariane rocket, KITSAT-OSCAR-23 (KO-23) was born shortly before midnight UTC on August 11. KO-23, a joint effort of the University of Surrey and the Korean Advanced Institute of Technology, joins a proud family of OSCARs that provide packet store-and-forward capability. In addition, KO-23 goes one step further than its predecessors. It contains two built-in charged coupled device (CCD) cameras capable of providing either 4-km resolution or 400-meter resolution pictures. Another exciting aspect that sets KO-23 apart from the other PACSATs is its Digital Signal Processing Experi-ment (DSPE). Many OSCAR users have encountered the power of Digital Signal Processing (DSP) whenever they use AO-21's FM transponder. Still, others have heard AO-21's digital voice synthesizer speaking foreign languages. KO-23 will take DSP one step further by allowing the user to leave voice mail. Store-and-forward voice messages may become common-place.

The first pictures taken by KO-23's CCD cameras were of the Antarctic and the tip of Patagonia on August 19. The image was excellent, displaying cloud formations with spectacular lighting effects due to the low sun angle. Since that first picture, others have been taken earning the praise of all who have processed them. Because KO-23 has a high-resolution camera lens, it is referred to as the narrow-field-of-view (FOV) lens. The low-resolution lens is called the wide-angle lens. Be aware of this, because the name of the image files stored aboard KO-23 follow this convention: files named KAINxxxx are the high-resolution, narrow-FOV pictures; those named KAIWxxxx are for the low-resolution, wide-angle lens *[See the cover photo for an example wide-angle image—Ed.]*. With the successful testing of the CCD cameras, all are invited to download the image files stored aboard KO-23. The KITSAT Ground Controllers ask that those within the footprint of HLENJ to please not QRM the uplink when you observe the "NO -1" message on the downlink. This indicates that the HLENJ needs a clear channel because it is uploading software.

Look for KO-23's downlink signal at 435.175 MHz. When KO-23 becomes operational, users can access the 9600-baud FSK BBS on the uplink frequencies of 145.850 or 145.900 MHz.

—from AMSAT News Service

THE COHERENT-PACKET-INTERNET-UUCP LINK

Coherent Software (a UNIX clone) by Mark Williams Company can provide an easy link to Internet email and provide packet-radio users with a connection to an expanding package of UNIX tools. It is possible to connect a PK-88 (and I assume other TNCs) set in Transparent Mode to a computer running Coherent Software. When connected to the TNC, the user will receive the Log-in prompt and be able to enter their own account or the Guest account. The open-system feel of UNIX is suitable for packet radio and, if the UUCP features of the Coherent package are utilized via a modem to a host, packet users will have open access to the UUCP tools. These tools can provide email and file-transfer access as well the standard Coherent tools. Making C compilers, editors, grep commands and on-line manuals available to the local user can certainly spark some interest in the ho-hum world of packet radio.

I am running a 25-MHz 486 linked to a PK-88 and a modem. Both links utilize full hardware handshaking and are easy to configure. The TNC and the modem need to be made silent (so the computer doesn't see such things as *cmd:* or *RING RING* as attempts to log into an account and get forever stuck in a loop).

The PK-88 commands include:

CONMode T	Echo OFF	Flow OFF	Monitor 0
NEwmode OFF	NOmode ON	TXFlow OFF	XFlow OFF

UBit 5 ON [new command (8/91) forces PK-88 to stay in transparent mode upon power-up]

That may be overkill on the flow commands but it works! On the computer end, I have modified the standard .login file for packet users to include:

TERM=vt100   PAGER=scat   stty -echo

This gives a good interface for the packet user. It allows 24 lines at a time, then press return to get another 24 lines. The configurations for Coherent are extremely stable and allow for several typical terminals in case the user wishes to match some local option.

Extensive testing is not complete, but the system has been up for weeks and will completely reset itself [see UBit] upon a power failure (which are rather common in this part of the world).

Full hardware handshaking means you need more than three wires in your cable between the TNC and the computer. My eyes and hands have long since been unable to cope with all those little pins so I just buy the 25-pin wired versions from Radio Shack or WalMart and plug them in. Don't ask me what is supposed to be connected (the Coherent manual is good for that) but it works! I even have a switch box between the TNC and the computer so I can use a mouse when I run Windows (seldom these days).

If you are in the area, feel free to connect to KB8AOB (perhaps via the UPSHUR node) and log in with the account name of Guest (UNIX is fussy about upper and lower case, that is, upper case *G* and lower case *uest*).

—from Richard Clemens
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NEW MICROSAT EXPECTED THIS YEAR!

UNAMSAT-1, the first Mexican amateur satellite, is being built at the Autonomous University of Mexico (UNAM) under project manager David Liberman, XE1TU. UNAMSAT-1 is another of the MicroSat series and will have five modules (as the earlier MicroSats did). Each module is about 20 cm on a side. Four of the five modules are updated clones of existing MicroSat hardware and software, that is, dual 70-cm PSK transmitters (by YT3MV), V40 CPU (by WA7GXD and others from TAPR with modifications by I2KBD and ITAMSAT), power system with BCR (by KE3Z) and batteries, five-channel 2-meter FSK receiver (by W3IWI), software similar to other MicroSats (by NK6K and GØ/K8KA) and AART Bus architecture (by W3IWI and N5BRG).

The main differences from the other MicroSat configurations are that the V40 CPU will have 4 Mbytes of bulk RAM (versus 8 Mbytes) and UNAMSAT-1 will be equipped with gallium arsenide solar panels (versus BSFR technology).

The new addition is the on-board experiment in the fifth "This Space For Rent" (TSFR) module. UNAMSAT-1's primary mission is to act as a meteor sounder. It will contain a 40.097-MHz transmitter that will output 60 watts during pulses which can be varied from 1 to 10 ms in duration and with a pulse repetition rate of 1 to 10 seconds. The meteor echoes will be detected on a receiver at the same frequency that is designed to detect the returned echo and measure its Doppler shift. The use of the meteor sounder is to obtain research data on the full-sky spatial and velocity distribution of meteors with the focus on a search for high-velocity meteors originating outside our solar system.

When UNAMSAT-1 is not involved in meteor research, it can be turned into a standard PACSAT message store-and-forward satellite. The selection of the 2-meter uplink and 70-cm downlink amateur frequencies are not finalized at this time.

XE1TU has been responsible for technical development of UNAMSAT-1 along with the team of hams (XE1MGI, XE1XUS, XE1YLS) and students at UNAM. Scientific direction for the project has been provided by UNAM Professor of Astronomy Arcadio Poveda. AMSAT-NA provided technical details of its MicroSat satellites to UNAM and, during the development of UNAMSAT-1, technical assistance from AMSAT-NA has been provided by W3GEY, N4HY, NK6K, W3IWI and WD4FAB. ITAMSAT assistance was coordinated through I2KBD.

The UNAMSAT-1 launch will be the beginning of a new era. Along with a larger meteorological satellite, it will be launched by the Russian Space Agency and by the Russian Academy of Sciences on a decommissioned SS-18 ICBM into an orbit about 1000-km high. The launch is scheduled for the first week of December. Details are being worked out now.

—*from AMSAT News Service*

GATEWAY CONTRIBUTIONS

Submissions for publication in Gateway are welcome. You may submit material via the US mail to 75 Kreger Dr, Wolcott, CT 06716-2755, or electronically, via CompuServe to user ID 70645,247, or via Internet to horzepa@evax.gdc.com. Via telephone, your editor can be reached on evenings and weekends at 203 879-1348 and he can switch a modem on line to receive text at 300, 1200 or 2400 bit/s. (Personal messages may be sent to your Gateway editor via packet radio to WA1LOU@N4GAA or IP address 44.88.0.14.)

The deadline for each installment of Gateway is the first day of the month preceding the issue date of *QEX*.

Bits

11th Networking Conference and DSP Course

The 11th ARRL Amateur Radio Computer Networking Conference will be held November 7, 1992, at Fairleigh Dickinson University in Teaneck, New Jersey. Along with an all-day technical paper presentation session, the schedule includes morning introductory and how-to seminars and evening poster-board sessions and vendor presentations. For registration and accommodation information, contact this year's sponsors, The Radio Amateur Telecommunications Society (RATS), PO Box 93, Park Ridge, NJ 07656-0093, or phone 201-387-8896.

In conjunction with the 11th Networking Conference, the ARRL is sponsoring an all-day course on digital signal processing, to be held November 6 at the Best Western Oritani in Hackensack, New Jersey. ARRL Senior Engineer Jon Bloom, KE3Z, will conduct the course, which includes what's available in hardware and software, articles and trade literature, current projects, resources, and programming concepts. For more information, contact the ARRL Educational Activities Department at ARRL HQ.