By Steve Ford, WB8IMY

# The HF Digital "Tower of Babel"

The world of amateur HF digital communication is growing faster than anyone would have imagined. Let's pause, catch our breath and see where we are today.

*And the Lord came down to see the city and the tower, which the children of men built. And the Lord said, "Behold, the people are one, and they have all one language; and this they begin to do: and now nothing will be restrained from them, which they have imagined to do. Let us go down, and there confound their language, that they may not understand one another's speech." So the Lord scattered them abroad from thence upon the face of all the Earth: and they left off to build the city. Therefore is the name of it called Babel; because the Lord did there confound the language of all the Earth.—Genesis 11:5-9 (King James version)*

Life used to be simple for the HF digital operator. Prior to 1982, you had RTTY—period. Then AMTOR hit the scene, coinciding with the birth of the Computer Age. A few years later we began hearing 300-baud packet on HF.

In early '90s, we saw the emergence of Clover, PACTOR and G-TOR. Finally, hams discovered the amazing abilities of their computer sound cards and new modes began popping up like mushrooms after a steady rain. PSK31 is the most famous of these, making a big splash two years ago. More sound-card-based HF digital modes have arrived in the meantime, and more are on the way.

Like the Genesis story, we began with one language and now we are scattered into many camps. What are we doing with all of these modes? What's hot and what's not? Let's take a guided tour through our own Tower of HF digital Babel.

## RTTY

Radioteletype, better known as *RTTY*, is the granddaddy of HF digital, although its popularity has been seriously undercut by PSK31. RTTY remains, however, the mode of choice for digital contesting and DXing.

RTTY does not use any form of error detection; what you see on the screen is what you get. Even so, with adequate demodulator sensitivity and sharp filtering, it's possible to enjoy excellent copy under poor conditions.

The traditional road to RTTY has been through an external *terminal unit* or *multimode processor* such as those manufactured by Kantronics, MFJ, Timewave, HAL Communications and others. (The HAL ST-8000A, for example, is considered the *crème de la crème* of terminal units, offering extraordinary RTTY performance.) With a computer and an SSB radio, these devices act like "radio modems," converting receive audio to data, and data to transmit audio (see Figure 1).

In recent years, sound card software for RTTY has made substantial inroads. The majority of these programs are intended for "casual operating." That is, they are not designed for competitive RTTY such as DX pileups or contesting. A few programs, such as *RITTY 4.0* by Brian Beezley, K6STI, *are* written to meet exacting performance requirements. Depending on whom you talk to, *RITTY's* performance approaches that of the venerable ST-8000A.

## AMTOR

Amateur Teleprinting Over Radio—AMTOR—enjoyed widespread popularity from about 1983 through 1991. Its distinctive *chirp-chirp* sound was a staple on the HF bands. Hams made ample use of its error-free text capability, even setting up automatic AMTOR mailbox operations (MBOs) where messages could be stored for later retrieval from anywhere in the world. AMTOR has since been superseded by faster, more versa-

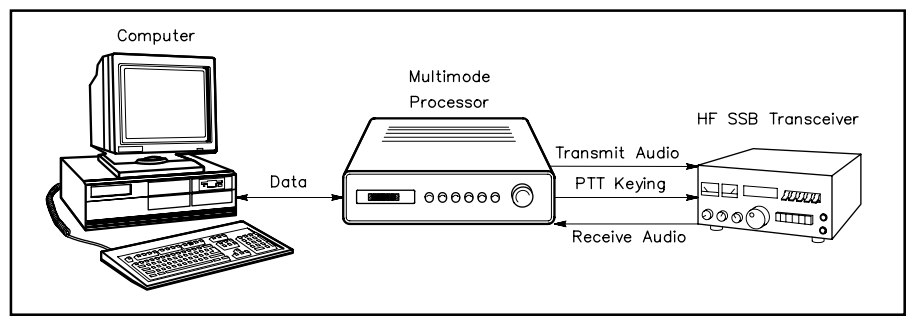


**Figure 1—A typical HF digital station using an external multimode processor.**

### WinLink 2000—Internet E-mail from Anywhere!

The Internet has become the e-mail medium of choice for most hams, but there is a sizeable group of amateurs who often travel beyond the reach of the Internet. This group includes hams at sea, travelers in recreational vehicles (RVs), missionaries, scientists and explorers. No doubt the day will come when wireless, affordable Internet e-mail access will be available from any point on the globe. Until that day arrives, however, Amateur Radio HF digital operators have a very capable substitute!

More than 21 HF digital stations worldwide have formed a remarkably efficient e-mail network known as WinLink 2000. Running *WinLink 2000* software and using primarily PACTOR or PACTOR II, these facilities transfer e-mail between HF stations and the Internet. They also "mirror" (share) messages between themselves using the Internet, allowing amateurs to pick up their e-mail from any WinLink 2000 station.

The network evolved in the 1990s from the original AMTOR-based *APLink* system. APLink was a network of stations that relayed messages to and from the VHF packet network. As PCs became more powerful, and as PACTOR and Clover superceded AMTOR, a new software system was needed. That need brought about the debut of *WinLink*, originally authored by Victor D. Poor, W5SSM, with additions from Peter Schultz, TY1PS. *WinLink* itself evolved with substantial enhancements courtesy of Hans Kessler, N8PGR. To bring the Internet into the picture WinLink stations needed an e-mail "agent" to interface with cyberspace. To meet that requirement Jim Jennings, W5EUT, added *NetLink*. The entire system was integrated and overhauled last year to create Winlink 2000.

Thanks to these advancements, an HF digital operator at sea, for example, can now connect to a WinLink 2000 station and exchange Internet e-mail with nonham friends and family.

WinLink stations scan a variety of HF digital frequencies on a regular basis, listening on each frequency for about two seconds. By scanning through frequencies on several bands, the WinLink stations can be accessed on whichever band is appropriate according to your location and the propagation conditions at the time.

You can access Winlink 2000 stations using just a basic PACTOR setup. However, most users also rely on a piece of software known as *Airmail* to handle uploading and downloading automatically. *Airmail* is a 32-bit program that runs under *Windows 95, 98* or *NT 4.0*. *Airmail* supports the SCS PTC-II and IIe PACTOR-2 processors, as well as the Kantronics KAM+ and KAM-98, AEA/Timewave PK-232 and PK-900 modems, and the MFJ 1276 and 1278B. You can download a copy of *Airmail* online at **www.airmail2000.com**. To learn more about WinLink 2000, see K4CJX's Web site at **www.winlink.org/k4cjx/**.

tile modes. It is rarely heard on the ham bands today.

This doesn't mean that you can't operate AMTOR, but you may have a difficult time finding anyone to chat with. For this reason, there hasn't been a stampede among software programmers to write sound-card-based code to do AMTOR. You'll still find AMTOR on most multimode processors, though.

## PACKET

Although packet technology had been in existence since the early '70s, hams embraced it with gusto in the middle '80s. (Personal computers were the driving force.) Packet is an error-detecting mode, which means that it is capable of communicating error-free information, including binary data (for images, software applications, etc). The problem with packet, as far as HF communication is concerned, is that it requires strong, "quiet" signals at both ends of the path to function efficiently. Packet doesn't tolerate signal fading, noise or interference, which makes it a poor choice for the chaotic world of HF.

Despite its poor performance, HF packet remains stubbornly alive. HF packet is still used for long-distance traffic forwarding between some VHF packet networks (although much of this data is now traveling via the Internet). You'll also find HF packet in use as part of the APRS (Automatic Position Reporting System) network. If you hear packet bursts at the upper end of the 30-meter band, it's probably APRS.

## PACTOR

PACTOR strolled onto the telecommunications stage in 1991. It combined the best aspects of packet (the ability to pass binary data, for example) and the robust error-free nature of AMTOR. It was eagerly embraced by HF digital equipment manufacturers and became the most widely used HF digital communication mode in a remarkably short period of time. PACTOR was also widely adopted for mailbox operations and other forms of message handling. Today it still remains the most popular of the error-correcting modes.

Most PACTOR is done using standalone multimode processors like the MFJ, Kantronics, HAL or Timewave products I've already mentioned. When this article went to press, there was only one soundcard program capable of transceive operation in PACTOR. It is part of an earlier version of Brian Beezley's *RITTY* and it is still available directly from Brian at a cost of $150 (see the "Learn More!" sidebar).

PACTOR II debuted in the mid '90s as a rival to Clover (see below), and the two have been doing battle for the hearts, minds and pocketbooks of HF communicators (commercial and amateur) ever since. Like Clover, PACTOR II uses DSP techniques and innovative data coding to achieve extraordinary error-free performance. PACTOR II is only available in multimode processors manufactured or licensed by Special Communications Systems (SCS), and they tend to be expensive ($800). This has slowed PACTOR II's acceptance in the ham community. In 1999, SCS introduced a pared-down processor (the PTC-IIe) that offered the same performance, but at a somewhat lower cost ($650).

## Clover

Clover was unveiled in 1993 by HAL Communications. It was one of the first HF digital modes to use sophisticated data coding, coupled with complex modulation schemes and digital processing technology, in an effort to overcome the vagaries of HF. Clover promised, and delivered, impressive performance even in the face of weak signals and terrible band conditions. This performance initially came at a stiff price—one that few hams could afford. As you'd expect, the high cost of Clover technology dampened enthusiasm in the beginning. Price reductions later in the decade, and the introduction of Clover II, helped the mode retain a small, yet dedicated, following.

If you want to try Clover, you must use a HAL processor; Clover is not available in other units. However, Clover multimode processors are now in the same


**The HAL Communications ST-8000A RTTY terminal unit.**

***DigiPan*—one of the most popular software packages for PSK31.**

price ballpark as other multimode units (less than $400). The only other hardware requirements are a computer and a reasonably stable SSB transceiver.

### G-TOR

G-TOR was the brainchild of Kantronics, a digital communication equipment manufacturer. It is yet another high-performance mode, although not as costly as Clover or PACTOR II. Like both of the former, however, G-TOR is *proprietary*. That means that it is only available in equipment manufactured by Kantronics. Coming several years after the appearance of PACTOR, G-TOR never really captured the attention of HF digital operators. It is somewhat uncommon on the ham bands today as a result.

### PSK31

PSK31 could be viewed as a high-octane cousin of RTTY. It is not an error-free digital mode, but it offers excellent weak-signal performance. Peter Martinez, G3PLX, the same person who brought the commercial SITOR mode to the ham bands as AMTOR, invented PSK31. For a few years, PSK31 languished in obscurity because special DSP hardware was necessary to use it. But in 1999, Peter designed a version of PSK31 that needed nothing more than a common computer sound card. It was a simple piece of software that ran under *Windows* and used the sound card as its interface to the transceiver. Peter made the software available at no cost on the Internet. Announce that you are offering free software to the ham community and the reaction will be predictable—PSK31 took off like gangbusters.

The PSK31 community received another jolt in 2000 with the debut of "panoramic" software such as *DigiPan* and *WinPSK*. Both software packages made it outrageously simple to get on the air with PSK31—all you have to do is hook up the necessary cables, then point and click your mouse.

In a span of just two years, PSK31 has become the *Number One* HF digital mode for casual keyboard-to-keyboard operating. It has also been embraced enthusiastically by the QRP (low power) community—and for good reason. With just a couple of watts and a wire antenna you can work stations throughout the United States, along with a good selection of DX as well. PSK31 is easy to operate and the software is inexpensive (free, in many cases). With most amateurs owning sound-card-equipped computers these days, that's a combination too powerful to resist.

### Hellschreiber

Hellschreiber is not a new mode (it was pioneered in the 1920s and 30s by Rudolf Hell), but a number of hams are beginning to discover its possibilities. Unlike all of the other modes we've discussed so far, Hellschreiber is *visual*. That is to say, the signals "paint" the text on your screen much in the same sense that a television or fax signal paints an image.

One variation of Hellschreiber known as *Feld-Hell* works its magic by keying a CW transmitter ON for every black portion in a text character, and OFF for every white space. Timing is critical. See Figure 2 for an example of Feld-Hell signal reception. Feld-Hell has drawn some interest among low power (QRP) operators because you can operate with simple (but stable) CW transmitters. Most Feld-Hell operation, however, is done using SSB transceivers using on/off tone "keying" to accomplish the same result. Feld-Hell is the most popular of the Hellschreiber modes.

You can also send text imagery by using different *frequencies* (tones) to represent the black and white areas. This version of Hellschreiber is called *Multi-Tone Hell*, or simply MT-Hell. There are several variations of MT-Hell in use.

Once again, Hellschreiber in its various flavors is available through sound-card software. If you are already set up to do PSK31 or RTTY with your sound card, you can try Hellschreiber by

### The Need for Speed

If you are considering any of the so-called "burst" modes such as AMTOR, PACTOR, Clover or G-TOR, it is critical that your HF transceiver be able to switch from transmit to receive very quickly.

Why, you ask?

All of the burst modes use some form of ARQ—automatic repeat request. In the basic system, a chunk of data is sent and then the sending station waits for *a specific amount of time* to hear from the receiving station. Was everything received without errors? If the answer is "yes," the receiving station transmits an acknowledgment signal, or ACK, and the next data chunk is sent. If the answer is "no," a non-acknowledgment, or NAK, is transmitted and the data is repeated. This sets up a kind of ARQ dance where the stations ping-pong back and forth until everything makes it through error free. For the dance to work properly, however, the transmitting station must hear the ACKs and NAKs. If the rig at the transmitting station does not switch fast enough, the ACK or NAK could arrive before the radio is ready to receive. We're talking *milliseconds* of time!

The rule of thumb is to look for a radio that can switch from transmit to receive in less than 30 ms. The lower the number, the better. *QST* "Product Reviews" often measure transmit/receive-switching times for exactly this reason.


**The MFJ 1278B multimode processor.**


**Figure 2—Reception of a Feld-Hell signal.**

**Brian Beezley's *RITTY* software in action.**

**Throb is a 9-tone MFSK digital mode. As with so many new HF digital modes, it has been implemented with sound-card-based software. You can learn more about Throb on the Web at www.lsear.freeserve.co.uk/index.html.**

simply loading and running the software.

### MT-63

Pawel Jalocha, SP9VRC, invented MT-63. It is a keyboard-to-keyboard "live" mode operationally similar to RTTY and PSK31. With MT-63, however, the data components are spread over 64 different tones! This allows a tremendous amount of redundancy, assuring good reception even when as much as 25% of the data has been obliterated by noise, fading or interference. Thanks to its modulation structure, MT-63 offers excellent performance under poor conditions, even rivaling Clover and PACTOR II.

There is a certain amount of controversy surrounding MT-63 in the amateur community. In the most robust form of MT-63, the signal is quite wide (1 kHz). With crowded conditions in the HF digital subbands today, the movement has been toward narrow signals. PSK31, for example, is only about 31 Hz wide. MT-63 seems to run counter to this trend. Finally, there are legal issues involving the complex MT-63 modulation scheme. As this article was written, the Federal Communications Commission had not declared MT-63 to be a legal mode for US-licensed amateurs.

## Learn More!

Forgive the shameless plug, but if you want to learn more about HF digital operating, I recommend that you pick up a copy of my book, *The ARRL HF Digital Handbook*. No, I won't receive a royalty from your purchase, only a bit of ego gratification! See the ARRL Publications section in this issue, or call 888-277-5289.

**Multimode Communication Processors**

Kantronics, 1202 East 23rd St, Lawrence, KS 66046; tel 785-842-7745; **www.kantronics.com**

MFJ Enterprises, PO Box 494, Mississippi State, MS 39762; tel 601-323-5869; **www.mfjenterprises.com/**

HAL Communications, 1201 W Kenyon Rd, Urbana, IL 61801-0365; tel 217-367-7373; **www.halcomm.com/**

Timewave Technology Inc, 58 Plato Blvd E, St Paul, MN 55107; 651-222-4858 **www.timewave.com/**

SCS, Roentgenstr 36, D-63454 Hanau, Germany; **www.scs-ptc.com/**

**Sound Card Software**

*BlasterTeletype* (RTTY)
**www.geocities.com/SiliconValley/Heights/4477/**

*DigiPan* (PSK31)
**members.home.com/hteller/digipan/**

*DSP-CW* (CW and RTTY)
**www.zicom.se/dsp/index.html**

*IZ8BLY Hellschreiber* (Hellschrieber)
**iz8bly.sysonline.it/**. Also, **members.xoom.com/ZL1BPU/software.html**

*MMTTY* (RTTY)
**www.geocities.com/mmtty_rtty)**

*Mix32W* (RTTY and PSK31)
**tav.kiev.ua/~nick/my_ham_soft.htm**

*Multimode* (RTTY and PSK31 for Macintosh computers. PowerPCs recommended.)
**www.blackcatsystems.com/software/multimode.php3**

*PSK31* (for Linux)
**aintel.bi.ehu.es/psk31.html**

*RITTY* (RTTY)
Brian Beezley, K6STI, 3532 Linda Vista Dr, San Marcos, CA 92069; **k6sti@n2.net**. $100 with delivery via e-mail, $5 additional for postal delivery. Check or money order only.

*Stream* (MFSK16 and other modes)
**iz8bly.sysonline.it/**

*TrueTTY* (RTTY)
**www.dxsoft.com/**

*WinPSK* (PSK31)
**www.winpskse.com/**

### MFSK16

MFSK16 is among the newest of the amateur HF digital modes. By using multiple audio tones to send data, MFSK16 offers outstanding weak-signal performance. Many say that it exceeds the performance of PSK31. The most popular MFSK16 software is the *Stream* package by Nino Porcino, IZ8BLY. It is entirely sound card based and is shareware. For a thorough overview of MFSK16, see the article by Murray Greenman, ZL1BPU, in this issue.

### The Future?

You don't need a crystal ball to predict that HF digital modes will continue to proliferate. Already we're hearing new modes such as Piccolo 2000, Throb, Mosaic II and others.

My guess is that we will see sound card software becoming the preferred platform for new modes in the years to come. There are several reasons for this:

- Computers and sound cards are becoming increasingly powerful while costs continue to drop.
- The majority of amateurs who own computers also own sound cards.
- The Internet offers a highly efficient means to distribute new software and updates. Most amateurs now have some form of Internet access.
- Once a sound card is successfully connected to a transceiver, the same system can be used for several modes—it's just a matter of booting up a different piece of software.

One thing is certain, if you're into HF digital hamming, there are exciting times ahead! QST