Getting Started in Digital Communications - Part 4 - AMTOR

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Getting Started in Digital Communications

Part 4—AMTOR. . .and Beyond!

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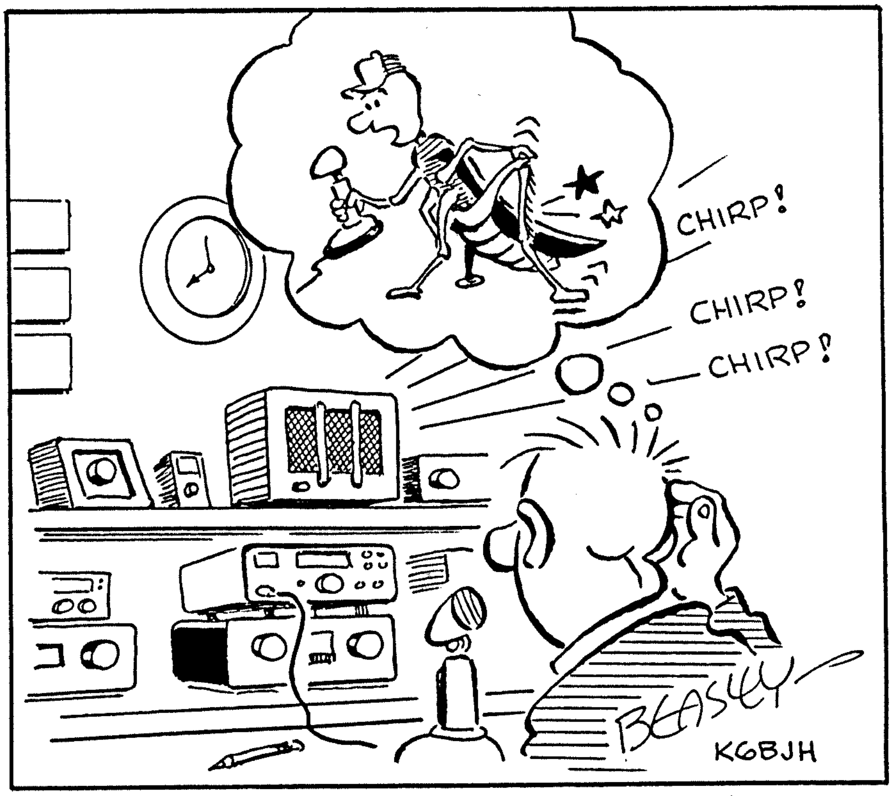

AMTOR is mysterious to many hams. The uninitiated may know it only as odd, cricket-like signals they hear below the HF phone subbands. What do these chirping signals mean? Why do they make those peculiar sounds? If you've asked these questions yourself, you're not alone!

What is AMTOR?

AMTOR is one of the fastest-growing HF digital communications modes in Amateur Radio. It has much in common with RTTY, but includes an error-correcting system similar to packet. Like CW, AMTOR has the ability to maintain communications under marginal conditions. I've seen clean text appearing on my screen when I could barely hear the signal from the other station!

AMTOR is based on an existing radioteletype system designed for maritime communications. The commercial version is often called TOR (Teleprinting Over Radio) or SITOR (Simplex Teleprinting Over Radio). The technical details of AMTOR, TOR, and SITOR can be found in CCIR 476 and CCIR 625.[1] Peter Martinez, G3PLX, is the father of AMTOR as we know it today.[2] He adapted the CCIR definitions for Amateur Radio use and coined the term "AMTOR."

AMTOR has two primary modes—*ARQ* (or Mode A) and *FEC* (or Mode B). ARQ produces the familiar cricket signals. FEC, on the other hand, sounds like high-speed RTTY.

Like RTTY, AMTOR uses FSK (frequency-shift keying) and a 170-Hz shift. (See Part 3 of this series for more information concerning frequency-shift keying.)[3] Lower sideband (LSB) is preferred for amateur transmissions. Commercial SITOR stations commonly use upper sideband (USB).

Setting Up for AMTOR

When it comes to connecting your equipment, there is no difference between AMTOR and RTTY. You can use either AFSK or direct FSK depending on your rig and AMTOR modem or multimode communications processor (MCP). To my knowledge, all AMTOR modems and MCPs include RTTY as well. I strongly suggest that you follow the setup and operating details in Part 3 of this series and become familiar with RTTY *before* you try AMTOR.

AMTOR and Radios

The first question I always hear from newcomers to AMTOR is, "Won't the high-speed transmit/receive switching ruin my rig?" No! I've used AMTOR for ten years with almost every radio I could get my hands on. I have yet to see a modern transceiver that was damaged by frequent AMTOR operating. It's true that some radios work better on AMTOR than others, but it shouldn't damage (or wear out) the equipment.

Caution! The same may *not* be true for linear amplifiers! Unless your amplifier is expressly rated for fast on/off switching (QSK), don't risk it! Besides, 50 or 100 watts of RF output is usually more than enough for AMTOR.

The major concern with using any transceiver on AMTOR is *transmit/receive turnaround time*. Most HF transceivers made in the last 6 to 8 years switch fast enough for AMTOR ARQ operation. However, some of the older-generation equipment may be pretty slow when changing from transmit to receive and back again. This is not always the case, though. I know several fellows who use 20-year-old tube equipment on AMTOR. In addition, many radios can be modified to increase their switching speeds. Radio manufacturers and active AMTOR operators are your best source of data concerning modification of older rigs.

If you have the equipment and like to tinker, Fig 1 shows how to use a triggered-sweep oscilloscope to measure your transceiver's transmit/receive time delay. The shorter the delay, the better. Ten to 20 milliseconds (ms) is good; up to 30 ms is usable.

If you don't have access to the proper

[1]Notes appear on page 45.

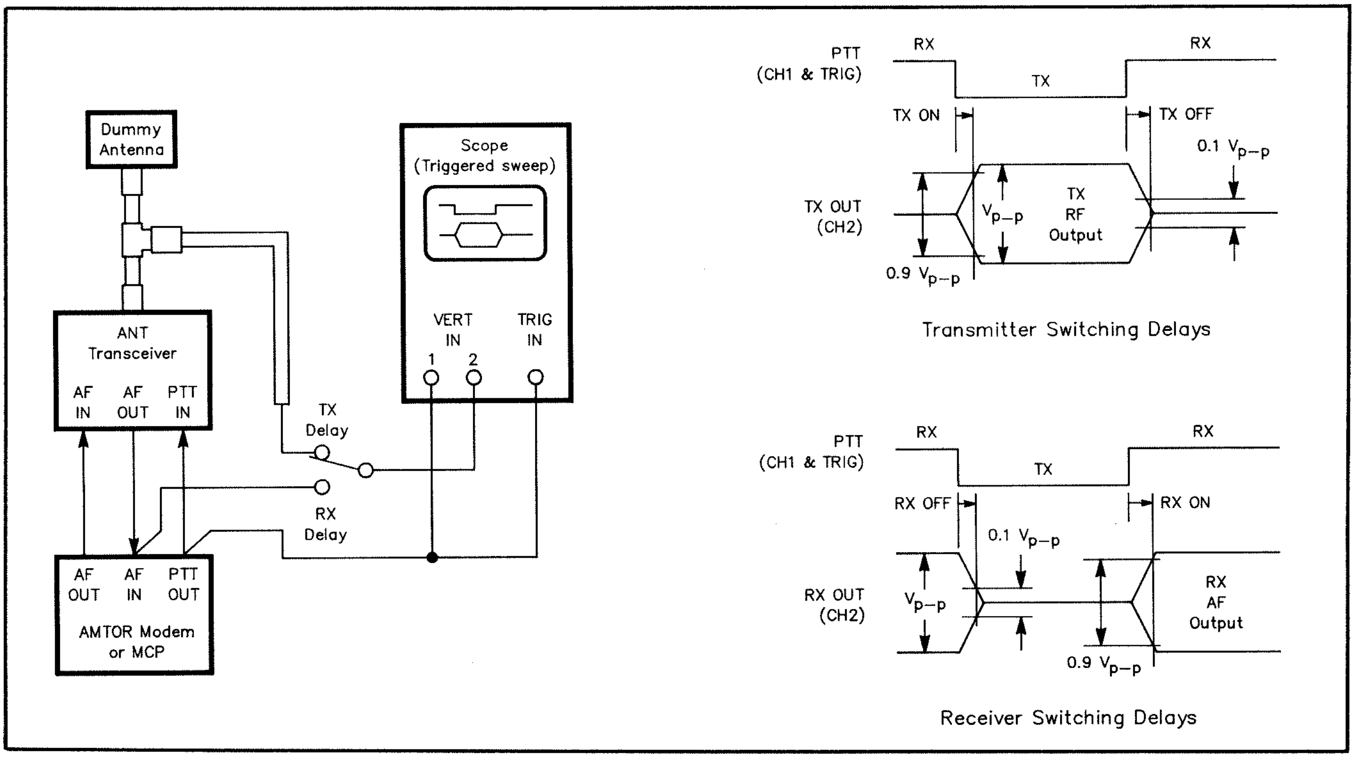

Fig 1—An oscilloscope triggered by the push-to-talk line of your AMTOR modem or MCP can be used to measure transceiver switching delays. Set your transceiver to LSB, switch on your modem/MCP calibrator and tune for the mark signal. Now adjust your transceiver output to a typical operating level. (Be sure to use a 10:1 scope probe when sampling RF at the T connector.) Place your modem/MCP in the ARQ mode and begin calling. Adjust your oscilloscope trigger to produce the display shown above. Adjust your transmitter output and receiver volume as well. Use delayed sweep if available. When you see a display similar to the one shown above, carefully measure the time delays.

measuring equipment, don't worry. Give AMTOR a try anyway. If your rig won't switch fast enough, you'll know right away because you won't be able to connect with other stations. Even then, don't give up hope completely. There are probably a couple of programmable delays in your AMTOR controller or MCP that you can use to skew the odds in your favor. We'll talk about them a little later.

AMTOR Theory and Modes

As we discussed earlier, AMTOR and RTTY have a great deal in common. Unlike RTTY, however, AMTOR has the ability to check for data errors. AMTOR uses a special 7-bit code for each character. There are 4 *mark* and 3 *space* bits in each character sent. The AMTOR receiving modem (or MCP) checks each received character for this 4:3 bit ratio. If the ratio is different, it's assumed that at least one bit of the character was received incorrectly.

ARQ Mode

The primary mode used in AMTOR today is ARQ. ARQ is a generic data term that means *a*utomatic *r*epeat re*q*uest. In ARQ mode, the *information sending station* (ISS) sends three characters and then turns its transmitter off. The *information-receiving station* (IRS) checks each character for the 4:3 ratio and then transmits a single control character. The control character means "Acknowledged. Send the next three," (ACK) or, "Not acknowledged. Repeat the last three" (NAK). The character group is repeated over and over until it's copied error-free. It's this rapid transmission/acknowledgment cycle that creates the *chirp-chirp* signal that's the hallmark of ARQ.

ARQ Timing

AMTOR ARQ is precisely timed so that both stations know exactly when one is transmitting and the other is listening. As you can probably guess, this timing is *very* critical, and it's one of the reasons why an AMTOR controller is more complicated than a RTTY system. It's also the reason why high-speed transmit/receive switching is important. A slow radio may still be switching when it should be listening or transmitting!

A typical ARQ transmission/acknowledgment sequence is illustrated in Fig 2. The example may seem complicated, but bear with me. The concept is far simpler than the diagram!

The ARQ cycle starts when the ARQ link is established. The sending station (ISS) sends three AMTOR characters, which takes 210 ms. After receiving and checking the characters, the receiving station sends its ACK/NAK control signal (CS). The ISS has a 240-ms receive *window*. The CS character must arrive at the ISS before the window "closes," or the ARQ link will eventually fail.

The IRS requires 70 ms to send the CS character. That leaves 170 ms to spare (240 ms − 70 ms = 170 ms). Sounds like we've beaten the clock so far, doesn't it? The catch, however, is that we haven't considered all the possible delays that can take place. After all, even radio waves aren't instantaneous. They travel at the speed of light. The delay they induce is called the *propagation delay*. The propagation delay depends on the distance between the two stations.

Keep in mind that our goal is to communicate over varying distances. The distance may vary from "zero" (two stations a short distance apart) to half-way around the world—about 6300 miles or 10,000 km. (I use 6900 miles [11,000 km] to account for extra travel due to multiple hops). Taking the speed of radio waves into account, it takes about .037 seconds (37 ms) for a signal to travel halfway around the world. Since the ARQ signals must pass *both ways* within each cycle (ISS to IRS and IRS to ISS), we need *twice* that time for the total propagation delay (74 ms). If you subtract 74 ms from 170 ms, we still have 96 ms remaining. That's plenty of time—or is it?

Don't forget that equipment delays take a significant bite out of our spare time. The modems at each station add a *1 bit period* delay. That's 10 ms for each modem, or 20 ms total. If slow-switching (60 ms) transceivers are used at both stations, an additional 120 ms is added to the delay (60 ms $\times$ 2 = 120 ms). Add the 20 ms modem delays and our total equipment delay has now reached 140 ms. We've used all of our spare time with an extra 44 ms for good measure. (96 ms − 140 ms = −44 ms) This AMTOR link is doomed to failure!

If both stations have fast-switching transceivers (30 ms), the total equipment delay can be reduced to 80 ms (60 ms for the rigs and 20 ms for the modems). That leaves sufficient time to spare in our previous example. (96 ms − 80 ms = 16 ms) Fig 3 shows the cumulative effect of equipment and propagation delays.

Now let's look at the opposite extreme. Consider two AMTOR stations side by side. The propagation delay is effectively zero. Let's also assume that the IRS sends its ACK/NAK control character immediately after receiving the ISS data pulse. If the transmit/receive switching delays at the ISS are too long, ISS equipment will still be switching when it should be receiving the control character. As a consequence, it will never hear the control-character transmissions.

Programmable Delays

The solution to the timing problem is the control delay (CD). This is the delay between the time the IRS receives a data pulse and the time it sends its ACK/NAK character. If both stations are extremely close to each other, the IRS station must lengthen its control delay to allow the ISS station sufficient time to switch back to the receive mode.

Some hams have argued that AMTOR can't be used over short distances—no matter what adjustments are made. Baloney! It can work over zero propagation distance if the IRS control delay is set properly. The total delay is dependent upon the equipment used at both stations. What works for one pair of stations may *not* work for a different pair of stations. With these thoughts in mind, I'd like to suggest several guidelines for setting your control delay:

- There is no universal setting that works for all distances and all stations.
- If you're working a nearby station (2500 miles or less), set your control delay in the range of 30 to 50 ms.
- If you're working a distant station (more than 2500 miles), set your delay to a lower value (10 to 20 ms).
- If you call a station and the station can't seem to maintain the link, try adjusting *your* control delay.
- If another station calls you and *you* can't maintain the link, the calling station must adjust his or her delay.
- There *is* a maximum distance for AMTOR communications that varies with the equipment and delay settings at both ends. With proper adjustments, however, you should be able to work most earth-based stations.

Not all AMTOR modems and multimode communications processors will allow you to adjust the control delay. If this is the case with your equipment, don't let it stop you from trying AMTOR. There are some stations you won't be able to contact, but there are many other stations you *will* be able to contact—depending on propagation and equipment delays.

There is another programmable delay in most AMTOR controllers and MCPs: the *transmit delay* (TD). Take another look at Fig 3. You'll note that the transmitters don't reach full output instantly. Since this is the case, the transmit delay tells the AMTOR controller or MCP to hesitate before sending the data. I find that practically all HF transmitters work correctly if you set TD to 10 ms. If you're in doubt, measure your transmitter delay using an oscilloscope triggered by the push-to-talk line from your AMTOR modem or MCP. After you've determined your transmitter delay, set your TD to match it. This parameter can remain fixed since it will be valid for all AMTOR contacts. Of course, remember that your transmit delay—and the transmit delay used by the other station—will increase the total time delay in the ARQ link.

FEC Mode

AMTOR FEC (forward error correction) does *not* rely on rapid on/off transmitter switching. Instead, the ISS turns its transmitter on, sends the complete text, and then turns its transmitter off. FEC also includes error correction, but not by repeated chirps. FEC sends each character twice, with the repeats delayed by four characters (280 ms). Using the 4:3 ratio test, the FEC

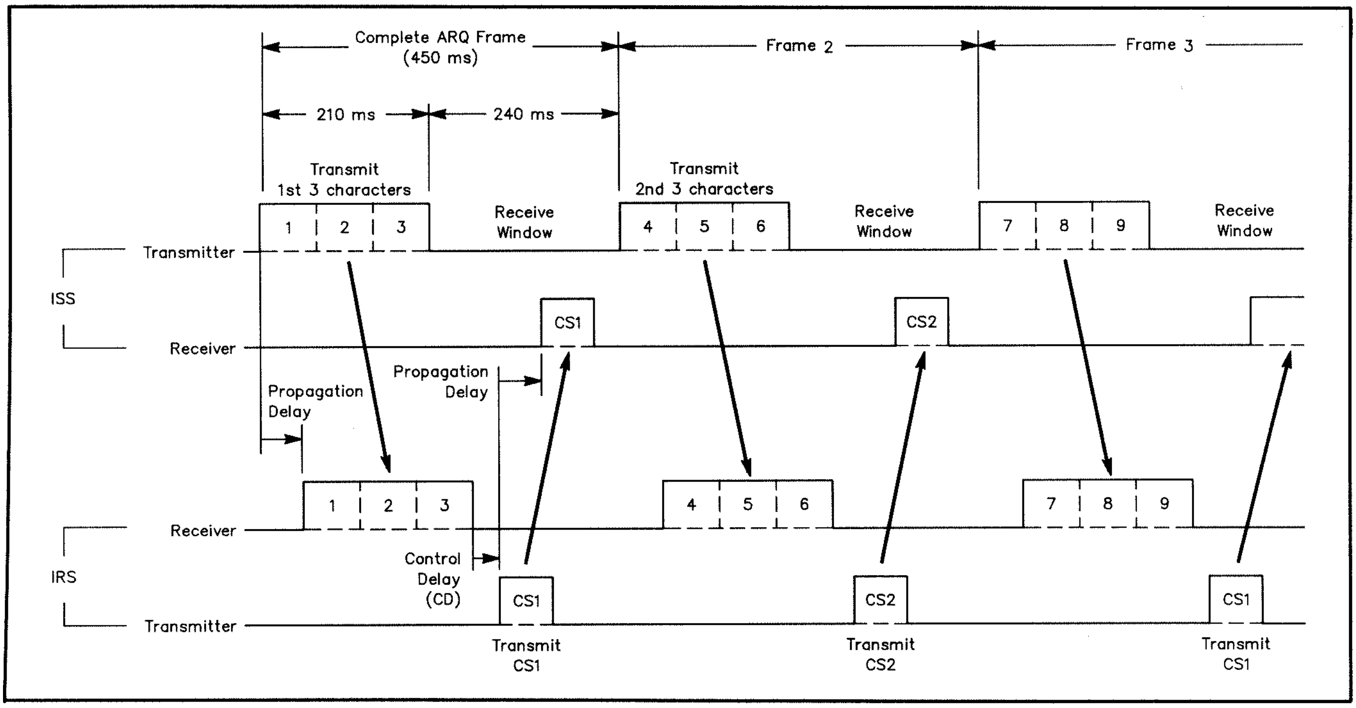

Fig 2—A typical AMTOR timing cycle. The dark arrows indicate the signal path from the transmitting station (ISS) to the receiving station (IRS) and vice versa. Notice how transmitted data does not reach the receiving station instantaneous. This is caused by propagation delays.

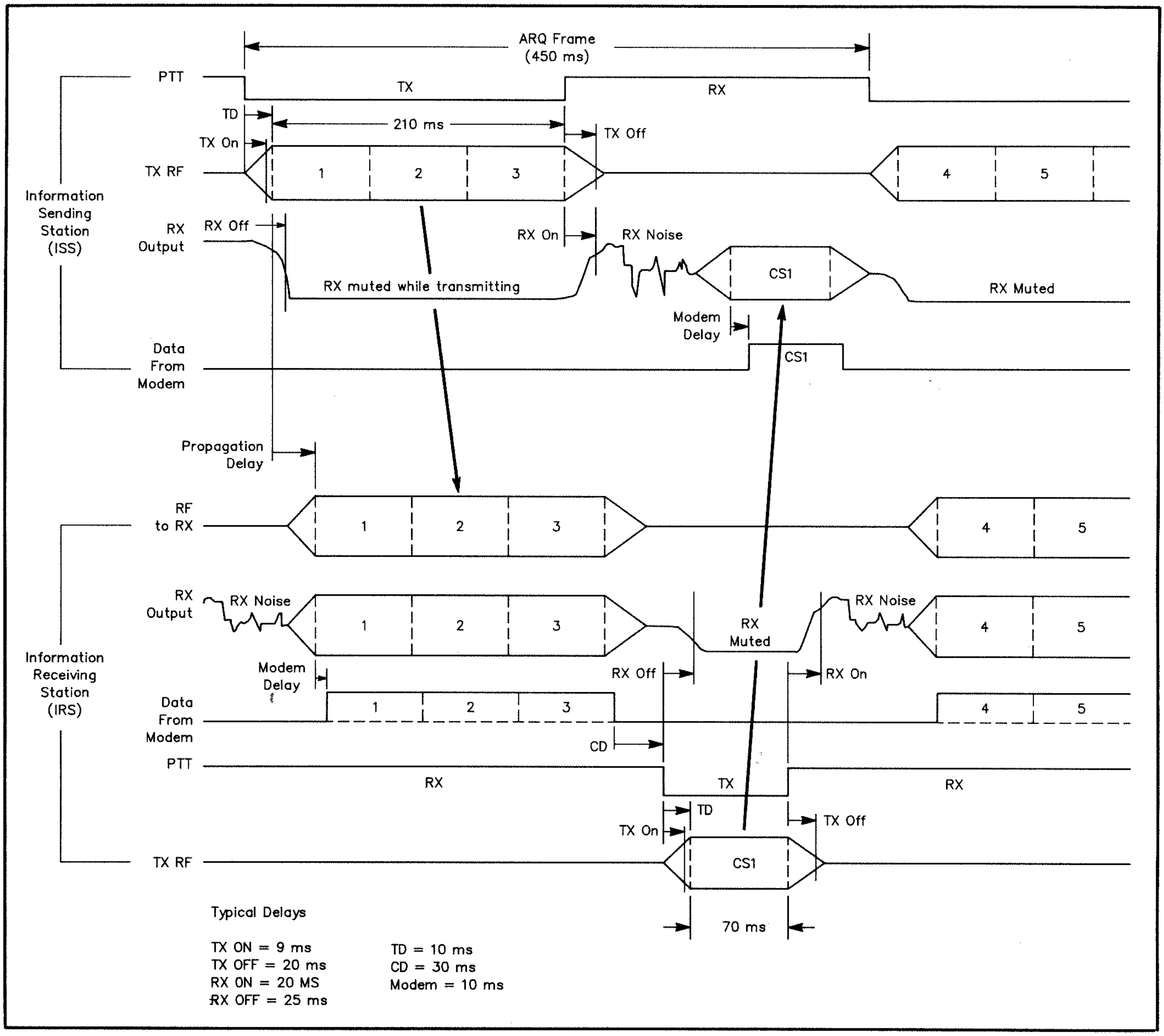

Fig 3—One ARQ cycle with all delays—equipment and propagation—included. The ISS sends a 210-ms burst of data after its TD expires. After a propagation delay, the signal arrives at the IRS and is decoded, with the modem adding its own delay to the process. By the time the IRS control character (CS1) is transmitted and received at the ISS, the ISS receive window (RX) is about to close!

receiving station checks the first reception of each character and prints it if it's correct. If the first test fails, the second transmission is examined. If both transmissions fail the test, a blank space or underline character is printed (this varies with AMTOR controllers and MCPs).

In commercial SITOR operation, FEC is used to send broadcast messages from one station to several others (weather bulletins to ships, for example). Commercial FEC is also called Collective Broadcast Mode.

Amateurs use FEC primarily to call CQ, but it's also used for round-table QSOs with more than two stations. FEC is used by W1AW to send bulletins via AMTOR.

SELFEC Mode

Selective FEC (SELFEC) is used commercially to make limited broadcast transmissions to a specific group of stations (from company headquarters to company-owned ships, for example). SELFEC has its own group call (GC) code that all stations must recognize before they can copy the message. While SELFEC is a valid AMTOR mode—and it is included in some AMTOR controllers and MCPs—few amateurs use it.

Listen Mode

Listen mode is unique to AMTOR and is usually not included in commercial SITOR controllers. Listen mode allows AMTOR stations to tune to an ARQ QSO in progress and print the text *without* being part of the link. You need a bit of patience when using listen mode since it doesn't include the error-correcting feature you get when stations are linked. You'll no doubt see some errors, and it may take a while for the controller to synchronize to the signal.

Listen mode also works differently depending on the AMTOR controller or MCP you're using. The listen mode in some controllers automatically senses and switches to ARQ, FEC or SELFEC mode, copying any signals that match these modes. Other units monitor only ARQ transmissions in the listen mode and must be manually switched to the standby mode to monitor FEC or SELFEC signals.

Standby Mode

Most AMTOR controllers have a standby mode. (In some MCPs, entering the ARQ mode places the unit in the standby state.) If your controller is in standby mode and you tune in an FEC signal, it automatically switches to FEC and prints the received signal. Also, if a station calls you in ARQ mode (using your SELCAL code), the controller will automatically switch to ARQ and attempt to establish a link.

Tuning AMTOR Signals

Tuning AMTOR takes practice. If you're a long-time RTTY operator (as I am), it may be difficult to break some old habits. RTTY operators tend to tweak the knob while they're receiving, watching both the indicator and the printed output. While this technique is fine for RTTY, it can be deadly to AMTOR!

When tuning AMTOR, keep your eyes on the modem or MCP tuning indicator. Tune slowly until your indicator tells you that the signal is tuned correctly. Once you've got the signal locked in, don't touch the tuning knob! Even a slight frequency change can disrupt the link. Also, do not expect characters to instantly appear on the screen. An AMTOR controller must receive several ARQ characters, or as much as one FEC line, before it can synchronize to the received signal. Have faith and believe your indicator!

Eavesdropping on AMTOR

Set your receiver to LSB and your AMTOR controller or MCP to the *listen* or *monitor* mode. Now hunt for a chirping ARQ signal. I suggest that you look for a strong signal between 14.070 and 14.080 MHz. (Twenty meters isn't the only band with AMTOR activity, but it's one of the most popular.) When you've tuned the signal correctly, you should see characters within 15 to 20 seconds. If not, try another signal. On some controllers, you may have to reset the listen mode to restart the synchronizing process. With practice, you should be able to copy an ARQ signal with ease. The listen mode drops out of sync at times, especially when one station ends its transmission and switches from ISS to IRS. This is normal since the listen mode can only synchronize to one station at a time.

Now, find an FEC signal. At first, FEC may be hard to differentiate from RTTY. Set the controller to the standby mode and tune-in the FEC signal. An FEC transmission includes special synchronizing characters, but the CCIR specifications only require that they be sent once per line of text. It can take 10 seconds or more to receive these synchronizing characters—longer if you miss them or get a noise burst when they're sent. Some AMTOR modems and MCPs send extra FEC synchronizing signals and these signals will be easier to receive. Practice tuning FEC before you attempt your first AMTOR QSO.

Loading Your SELCAL

To use the ARQ mode, you must first load your own selective call identifier, or SELCAL. When AMTOR stations wish to communicate in ARQ, this is the code that must be used to establish the link. The SELCAL code uses *only* letters, and we choose letters that match at least part of our call signs. Some examples are:

Call Sign	*CCIR-476 SELCAL*	*CCIR-625 SELCAL*
K9GWT	KGWT	KIGWTXX
W6IWO	WIWO	WFIWOXX
KS9I	KKSI	KSIIXXX
WA9YLB	WYLB	WAIYLBX
W1AW	WWAW	WAAWXXX
WB8IMY	WIMY	WBHIMYX

SELCAL codes for both CCIR-476 and CCIR-625 are shown above. Most amateurs use only the CCIR-476 configuration. Also, the letter combinations shown for CCIR-625 are strictly my own choice—you can use others. In our QSO examples, we'll use only CCIR-476 SELCAL codes.

But What is CCIR-625?

CCIR-625 is the new AMTOR/SITOR international standard. It was devised to address two problems: (1) the four-character CCIR-476 code was too limited to provide different SELCALs to all stations, and (2) under some circumstances, a CCIR-476 station could re-link with an incorrect station if the original link failed. CCIR-625 allows *seven* characters in its SELCAL, automatically identifies both stations at link-up, and also tightens the specifications for FEC synchronization.

Newer AMTOR controllers include both modes, but CCIR-476 is compatible with both new and old equipment. A discussion of the differences between the two modes requires more space than this article permits. You may want to do a bit of reading and research on your own.[4] It would be time well spent! In a few years, CCIR-625 may become the dominant Amateur Radio AMTOR format.

Let's Call CQ!

Switch your controller/MCP to the FEC mode to call CQ. (Some controllers and MCPs permit you to send FEC while in the ARQ mode.) An AMTOR CQ should include both your call sign *and* your SELCAL code. The format I prefer is:

[Transmitter ON]
[blank line]

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT)

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT)

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT) K

[Return to standby mode]

The last step is *very* important! Your AMTOR controller must return to standby to be ready to receive an ARQ call. Most AMTOR controllers have two different ways to end an FEC transmission; one command returns the controller to the standby mode and another returns to the FEC mode. Be sure to check your manual!

If someone copied your FEC CQ, they'll call you in ARQ mode using the SELCAL code specified (KGWT in our example). If you don't get an answer, try another call. Keep your calls short—don't get fancy or long-winded!

Under no circumstances should you ever start an FEC transmission with the "RYRYRY..." sequence. In FEC AMTOR, the "RYRYRY..." string thoroughly confuses the other fellow's controller, preventing it from synchronizing to your transmission. Using "RYRYRY..." in FEC is a good way to guarantee that your CQ will *not* be answered!

More AMTOR-Speak

Before we go further, we need to learn some more AMTOR terminology, or "AMTOR-speak." For example, the calling station sets-up the ARQ link. For the duration of the QSO, this station is the *master* and the station called is the *slave*. All timing for the ARQ QSO is set by the master station; the slave synchronizes its timing to the master. This has *nothing* to do with which station is sending or receiving (ISS or IRS). When a station responds to your FEC CQ, it's the calling station and therefore becomes the master; your station is the slave.

Over Commands

The *over* command allows the stations to trade places from ISS to IRS. When you finish typing your comments, for example, you must turn the link over so that the other station can reply.

There are two over commands that can be used. The normal procedure is to type +? at the end of your transmission. (Depending on the terminal software and the AMTOR modem or MCP you're using, the +? can be sent by tapping a single key.) This automatically sends a control code that says, "Let's turn the link around. You're the ISS now." When the link switches, you'll hear the difference immediately.

Recognizing that there are times when the IRS operator (receiving station) would like to immediately break in and make a comment, most AMTOR controllers also include a *forced over* command. A forced over causes an immediate link reversal, even if the ISS operator is still typing or has text in his transmit buffer. The exact command used to cause a forced over varies between controllers. Again, read your manual. Use the forced over sparingly; it's rarely needed, but very handy at times.

End Command

An ARQ link will continue indefinitely unless one station or the other sends the *end* command. Again, the code used to send the command varies with the controller or MCP. With HAL units, for example, you'd type ZZZZ when you wanted to *down the link*.

An Anatomy of an AMTOR QSO

Let's take a look at a typical AMTOR QSO. Notice how each command is used.

[My station in FEC mode]:
[K9GWT transmitter ON]

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT)

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT)

CQ CQ CQ DE K9GWT K9GWT K9GWT (KGWT KGWT KGWT) K
ZZZZ

[K9GWT returns to the standby mode]

[W6IWO loads "KGWT" into his controller and answers in ARQ Mode]

KGWT KGWT KGWT [W6IWO sends my SELCAL code. This not printed.]

[The ARQ link is established; W6IWO is master and ISS]

K9GWT DE W6IWO GOOD AFTERNOON OM. NAME HERE IS DALE, QTH IS FOUNTAIN VALLEY, CA. YOU ARE 10 OVER NINE. IT'S SUNNY AND 75 DEGREES HERE. HOW COPY?
+? [W6IWO sends the *over* command]

[K9GWT becomes ISS, W6IWO changes to IRS]

W6IWO DE K9GWT

GOOD AFTERNOON TO YOU DALE. MY NAME IS BILL AND QTH IS URBANA, IL. YOU ARE REALLY BOOMING-IN AT 20 OVER! I ENVY YOUR WX. SNOW IS A FOOT DEEP AND STILL FALLING. IT SURE IS NICE TO BE INSIDE. I'M TRYING A NEW RIG HERE. HOW'S IT SOUND TO YOU? +?

[K9GWT sends the *over* command]

[W6IWO becomes ISS, K9GWT changes to IRS]

The QSO continues between W6IWO and K9GWT. We discuss all kinds of important things and solve most of the world's problems. Eventually, the QSO ends:

[K9GWT is ISS, W6IWO is IRS]

W6IWO DE K9GWT

FINE DALE. IT'S BEEN NICE TALKING WITH YOU. SNOW HAS STOPPED FALLING AND I'D BETTER GO FIND A SHOVEL. 73 FOR NOW. +?

[K9GWT sends the *over* command]
[W6IWO is ISS, K9GWT is IRS]

K9GWT DE W6IWO OK BILL. HAVE FUN IN THE SNOW AND DON'T OVERDO IT. 73. ZZZZ

[W6IWO sends the *end* command and ARQ link is broken]

Answering an AMTOR CQ

As you can see from the example, W6IWO heard my FEC CQ and then called me in ARQ. To answer an FEC CQ, we must first load the *other station's* SELCAL code. Be careful not to change your own SELCAL code in the process! Obviously, there are two SELCAL codes involved: your SELCAL and the SELCAL of the other station. To help keep this straight, AMTOR controllers and MCPs label your SELCAL as *MYCALL*, *MYA*, *MYSEL* or *LOCAL CALL* (LC).

When you want to answer a CQ in the ARQ mode, most controllers will prompt you to enter the SELCAL of the other station:

SELCAL?

Other controllers (such as the HAL PCI-3000) include a call directory that lists several calls in a menu format. Still other controllers label the SELCAL to be sent as the *remote call* (RC), or sometimes *HISCALL*. Consult your manual to determine the correct label and the proper procedure to enter the other station's SELCAL.

WRU Answer-Back

Most AMTOR controllers and all commercial SITOR controllers include an automatic station identification feature called "Who Are You" (WRU). This feature dates back to mechanical Teletype machines. The concept involves another station sending a special character code that triggers an automatic response from your station—usually your call sign. If the station doesn't know your call sign, it's literally asking, "Who are you?"

AMTOR WRU works like this:

- My WRU feature is on and I have text in my *ANSWERBACK* storage (my call sign).
- Your station is the ISS and you send the WRU code.
- My AMTOR controller responds with a *forced over*.
- My station then sends the preprogrammed ANSWERBACK text.
- Finally, my station sends *over* (+?).

Note that it should be the station called (mine in this example) that forces the first *over*. If your controller or MCP doesn't handle the exchange in this manner, using your WRU feature can create some *very* confusing situations! For this reason, you may not care to use the WRU function unless you are also using APLink.

> **Upper-/Lowercase AMTOR**
>
> AMTOR evolved from commercial TOR and SITOR, which in turn evolved from Baudot radioteletype. One of the handicaps of this evolution was that AMTOR could only send uppercase letters and limited punctuation. Peter Martinez, G3PLX, and Victor Poor, W5SMM, have recently created an extension of AMTOR, using the *null* code as an upper-/lowercase shift signal for receiving stations. The null code was assigned in CCIR-476 and CCIR-625, but was previously unused.
>
> By using upper-/lowercase AMTOR, additional punctuation symbols can be transmitted as well. In fact, the W5SMM version of APLink includes all of the standard punctuation symbols. For this reason, some operators refer to mixed-case AMTOR as *ASCII AMTOR*. It really isn't full ASCII, but it's close. When an APLink BBS uses this modified software, there is no discernible difference between the received text passed via AMTOR or packet.
>
> At the time this article went to press, only the AEA PK-232 and the HAL PCI-3000 and AMT series controllers supported upper-/lowercase AMTOR. No doubt other manufacturers will incorporate this modification as it becomes more popular. Stations using upper-/lowercase AMTOR—including APLink BBSs—are fully compatible with uppercase-only users.—*K9GWT*

APLink

APLink is a BBS program designed by Vic Poor, W5SMM, to provide message store-and-forward capability for AMTOR users. APLink allows stored messages to be shared between two computer ports—one port for an HF AMTOR controller and another for a VHF packet TNC. Messages can be read or stored by an AMTOR station on HF, or by a packet station on VHF. As a result, APLink provides a connection (no pun intended!) between AMTOR operators and the VHF packet network.

The use of APLink has renewed interest in AMTOR. Prior to the advent of APLink, there were a few hundred dedicated AMTOR operators in the US. Since APLink became popular, that number has swelled to over 5000!

APLink uses the WRU function if it's available. Just make sure your ANSWERBACK message is in the expected format.

The APLink Scanning BBS

Frequency-scanning AMTOR BBS stations first appeared in Europe as the brainchild of G3PLX. They're now common in the United States and they are spreading worldwide.

A scanning APLink BBS uses the programmable memories and scanning options of newer HF transceivers. When the BBS is not in use, its receiver continuously scans the programmed frequencies. A BBS station often scans four or five bands and two or three different frequencies within each band. A complete scan can take 15 to 30 seconds.

The scan pauses for 2 to 5 seconds on each frequency. If the BBS station hears its own SELCAL being sent by a potential user, scanning ceases and an ARQ link is established. If the frequency is busy, or the BBS SELCAL is not heard, the BBS resumes scanning.

This frequency-scanning technique allows one BBS to serve stations at varying distances—regardless of propagation conditions. If you can't connect to an APLink BBS on 20 meters, for example, try again on another band. Eventually you'll find a band that offers a good path between you and the APLink BBS. It's a very clever way to make the best use of our

The AMTOR-Speak Dictionary

ACK (Acknowledge): the ARQ mode **IRS** response that tells the **ISS**, "The last three characters were received correctly, please send next three characters."

AMTOR: AMateur Teleprinting Over Radio. An adaptation of commercial ship-to-shore SITOR (CCIR-476) by Peter Martinez, G3PLX.

ANSWERBACK: The programmable message that responds when **WRU** is enabled and the IRS receives the WRU signal.

APLink: A radio bulletin board station (BBS) program created by Vic Poor, W5SMM. Messages and files may be accessed by either HF AMTOR or VHF packet-radio stations.

ARQ: Automatic repeat request. This is the error correcting mode of AMTOR. ARQ signals are easily recognized by their *chirp-chirp* sound. An ARQ link can be established only between two stations.

CCIR-476: The international recommendation that gives the technical specifications for AMTOR and SITOR.

CCIR-625: The newer international definition for AMTOR and SITOR. Compared to CCIR-476, CCIR-625 expands the ARQ **SELCAL,** clarifies ARQ mode re-linking and defines **FEC** mode synchronization. CCIR-625 controllers are compatible with CCIR-476 operation.

CD: Control delay. A programmable AMTOR controller time delay inserted by the **slave IRS** between the end of its reception of the **ISS** data "chirp" and the transmission of its control signal.

CLOVER: A new modulation and data protocol created by Ray Petit, W7GHM. CLOVER uses PSK and ASK modulation on a pulsed tone sequence. CLOVER modulation levels are adaptive and data may be sent at throughput rates 10 to 100 times faster than HF AMTOR or HF packet radio. The CLOVER signal bandwidth (500 Hz at −50 dB) requires half the equivalent spectrum of AMTOR and a quarter that of HF packet radio.

Control Signal: The single character sent by the **IRS** to acknowledge (ACK) or not-acknowledge (NAK) the data sent by the **ISS**. The ISS repeats characters when a NAK (or no response) is received from the IRS.

Down the link: Terminating an AMTOR QSO by sending the **end** command. As in, "I'll let you down the link."

DSP: Digital signal processing. A technique that uses specialized, high-speed microprocessors to process signals.

End: The control command sent by an AMTOR station to end an ARQ link.

FEC: Forward error correction. An AMTOR mode that may be used to send a message to more than one receiving station. Each character is sent twice to provide error correction. FEC is also called "Collective Broadcast" mode in commercial usage.

Forced Over: An over command that can be initiated by the **IRS** to force a change in the channel direction (**IRS** to **ISS** and vice-versa). The command used to cause a forced over varies with the AMTOR controller or MCP.

GC: Group call. The special letter (or number) sequence sent at the beginning of an AMTOR **SELFEC** transmission. The transmission will be printed only by stations who have programmed the same GC in their controllers.

ISS: Information-sending station. The station that is sending information on the ARQ link. The ISS may be either the **master** or **slave** station.

IRS: Information-receiving station. The station that is receiving information on the ARQ link. The IRS may be either the **master** or **slave** station.

Listen: The mode of an AMTOR controller that allows it to monitor ongoing ARQ (and FEC and SELCAL) transmissions. Listen mode does not include error correction when receiving an ARQ QSO. Listen mode is generally not included in commercial SITOR controllers.

Master: The station that establishes the ARQ link. The master station designation remains fixed for the duration of the ARQ QSO, regardless of which station is sending information. The master station sets the timing for both stations in an ARQ link.

NAK: Not-acknowledge. The IRS response that tells the ISS station, "The last three characters were not received correctly, please repeat last three characters."

Over: The control command that switches the roles of the two ARQ stations—IRS becomes ISS and ISS becomes IRS. Over is signaled by typing +?.

PACTOR: A modification of AMTOR and packet radio developed by DL6MAA and DF4KV. PACTOR uses the ASCII character code and adaptive data speed control to provide two to four times faster data throughput than HF AMTOR or HF packet radio.

RX Off: The delay between switching the push-to-talk (PTT) line from receive to transmit and the receiver audio falling to 10% of its full output.

RX On: The delay between switching the push-to-talk (PTT) line from transmit to receive and the receiver audio reaching 90% of its selected output.

SELCAL: Selective call. The special letter (or number) sequence sent at the beginning of an AMTOR call in ARQ mode. An ARQ link will be established only when the transmitted SELCAL letters match those programmed at the desired station. Amateurs create a SELCAL code as a contraction of their amateur call signs; commercial ARQ stations are assigned numerical codes. CCIR-476 provides a four-letter SELCAL code and CCIR-625 provides seven letters. FCC Amateur Rules and Regulations (Part 97) do not define how amateur SELCAL codes are constructed.

SELFEC: Selective FEC. An AMTOR mode that may be used to send a message to multiple selected stations. It is an FEC mode that includes a group call (GC) that all receiving stations must use. SELFEC is also called "Selective Broadcast" in commercial usage. SELFEC is permitted for US Amateur use.

SITOR: Simplex Teleprinting Over Radio. A commercial name for CCIR-476 ARQ ship-to-shore communications.

Slave: The ARQ station that is called in an ARQ link. The slave designation remains fixed for the duration of the ARQ QSO. The slave always synchronizes its timing to that of the **master** station.

Standby: The resting state of an AMTOR controller. When the programmed **SELCAL** is received, the AMTOR controller automatically switches to ARQ mode and establishes the link. When called in **FEC** mode, the controller automatically switches to FEC mode and prints the message.

Switching Delays: The delays associated with changing a transceiver or transmitter/receiver system from transmit to receive and back again. These delays are usually called **TX On, TX Off, RX On,** and **RX Off.**

TD: Transmit delay. A programmable AMTOR controller time delay that blocks data transmission until the transmitter RF envelope has reached full power.

Throughput: A measure of the effectiveness of a data system. The throughput rate is the number of data elements per unit time (characters, bytes, or bits) that can be passed from one station to another without error. The throughput of AMTOR under ideal conditions is 6.67 characters per second (cps).

TOR: Teleprinting over radio. A commercial name for CCIR-476 ARQ ship-to-shore communications.

TX OFF: The time delay between switching the push-to-talk (PTT) line from transmit to receive and the time it takes for the transmitted RF envelope to fall to 10% of full output.

TX ON: The time delay between switching the push-to-talk (PTT) line from receive to transmit and the time it takes for the transmitted RF envelope to reach 90% of full output.

WRU: Who Are You? A signaling system that lets one AMTOR controller automatically obtain identification from the other station. When enabled, reception of the FIGS-D ($) AMTOR code reverses the channel direction (over), sends text stored in the Answerback message, and restores channel direction (second over). WRU is often used by APlink.

Table 1

APLink Operating Summary

Here's a brief operating summary for APLink. It provides only a quick reference to APLink operation. You are strongly encouraged to obtain a user's manual from your APLink SYSOP.

There are a few points to keep in mind when using APLink.

• Commands to APLink on its AMTOR port should always be on a new line and end with a carriage return.

• The user should avoid transmitting the "+?" sequence. APLink knows when it is its turn to send. APLink will change the link direction, as needed.

• Arguments shown in square brackets [like this] are optional. Arguments shown in point brackets <like this> are not optional and must be included.

A—Abort the current output; GA+? prompt
CANCEL <num>—Cancels message <num> if originated by you
F—Abort the current msg; GA+? prompt
LOGIN <call>—Logs you in if you are registered
LOGOFF—Same as LOGOUT
LOGON <call>—Same as LOGIN
LOGOUT—Logs you off
H—Send the help file
L—List all non-bulletin, non-private messages
L [number]—List all non-bulletin, non-private messages equal to or greater than (number)
LTO or *LM*—List all messages to you
LTO [call]—List all messages to <call>
LFM—List all messages from you
LFM [call]—List all messages from <call>
LB—List new general interest bulletins
LB [number]—List general interest bulletins from [number] and higher
LT—List all NTS messages
NTS—List all unforwarded NTS messages (may be restricted)
LU—List all registered users
LR—List all stations that have logged on during last 24 hours
RN or *RM*—Read all new messages addressed to you
R [number]—Read message [number]
RH [number]—Read message [number] including routing headers
RI—Read the Intercept File (for forwarding to home BBS)
RF— Read the Auto-Fwd File (to see how AMTOR routing is done)
SP <call>—Send a private message to <call>, end with NNNN
SP <call1> AT <call2>—Send a private message to <call1> to be forwarded by packet to BBS with call sign of <call2>
ST <zip>AT NTS<st>—Enter (Send) an NTS message
SB [name]—Enter (Send) a bulletin to "name"; End with NNNN
SB [name1] AT [name2]—Enter a bulletin to be forwarded; End with NNNN
T—Talk to the SYSOP
V—Read version number
/// Anywhere on a command line cancels the command

available HF spectrum and propagation!

If you want to connect to a scanning APLink BBS, you must: (1) know the exact frequencies the BBS is scanning, and (2) be able to accurately set your transmitter to those frequencies. My comments in Part 3 of this series concerning dial readings and what they mean for RTTY (and AMTOR) are especially important in this case. Scanning BBS stations have files that list the exact frequencies they monitor. When you first connect to an APLink BBS, download its frequency list so you'll know where to find it the next time.

Before attempting to use an APLink station, I suggest you listen to several of the listed frequencies and see if you can hear the BBS communicating with other stations. This will tell you whether the BBS is busy (calling it will do no good if it is), and the quality of the BBS station's signal at your QTH. When you finally call the BBS, choose a frequency where its signal is strong and stable.

Most APLink operating commands will be familiar to packet users. As is the case with many packet BBS systems these days, APLink stations have disabled their command list response. This means that you may only see GA +? when you initially establish the link.

Sending a private message via APLink is very similar to packet, but AT is used in place of @. For example, on an APLink BBS you'd enter: SP WB8ISZ AT WA8ZWJ rather than SP WB8ISZ @ WA8ZWJ. (Even this is changing with the advent of upper-/lower-case AMTOR. These APLink stations *do* use @ in their message format—just like packet.) See Table 1 for a list of common APLink commands.

Future Digital Modes

There are two new digital modes about to hit the HF bands—*PACTOR* and *CLOVER*. Our series wouldn't be complete without a few words about each one.

PACTOR

PACTOR was designed by Peter Helfert, DL6MAA, and Ulrich Strate, DF4KV.[5] At this writing, a few PACTOR units are on the air and the final details are being worked out. PACTOR addresses two major limitations of AMTOR: (1) AMTOR uses a limited Baudot-type character set rather than ASCII; (2) AMTOR is basically a *slow* mode, even when propagation is superb.

PACTOR includes an adaptive scheme that doubles the data rate from 100 to 200 baud when link conditions are very good. If you are sending text only, PACTOR features a data-compression mode that can double the speed again to nearly 400 baud. PACTOR promises to double—or even quadruple—the data rate currently employed by AMTOR. Like all other data modes previously described, PACTOR uses FSK modulation.

CLOVER

CLOVER was invented by Ray Petit, W7GHM, and is under development in a cooperative effort with HAL Communications.[6] CLOVER uses a form of modulation that is completely different from any data mode yet described. CLOVER modulation utilizes phase-shift keying (PSK) and amplitude-shift keying (ASK). CLOVER also sends a sequence of *four* tone pulses rather than two (as used in packet, RTTY and AMTOR).

The time-versus-amplitude shape of each CLOVER tone pulse is carefully controlled to reduce bandwidth. The total bandwidth of a CLOVER signal (at −50 dB) is just 500 Hz. This compares very favorably to the bandwidth required for AMTOR (as much as 1 kHz) or HF packet (as much as 2 kHz).

When operating in the ARQ mode, CLOVER includes an error-correction code which allows the receiving station to fix errors *without* requesting repeat transmissions. This greatly enhances the efficiency of HF digital communications. Like PACTOR, CLOVER ARQ is adaptive. CLOVER can chose from a total of 128 different modulation, code, and block formats to automatically select the optimum parameters to match existing propagation conditions.

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Getting Started in Digital Communications

(continued from page 41)

CLOVER is still under development, but recent tests have proven that CLOVER modems pass HF data at least ten times faster than AMTOR or HF packet under typical band conditions. When conditions are especially good, CLOVER can be even faster! CLOVER uses digital signal processing (DSP) technology to achieve this level of performance.

Food for Thought

AMTOR is really not as hard to use or understand as it may appear. In fact, it takes longer to read this article than it takes to get on AMTOR and work someone! By taking the plunge into AMTOR, you'll enjoy one of the most fascinating HF digital modes available—and you'll be taking your first steps into the future of Amateur Radio!

Within the next few years, technological innovations like CLOVER will allow us to communicate with ever-increasing speed on the HF bands. Similar advances will offer ultra-high-speed amateur communications on VHF and UHF as well. As Steve Ford, WB8IMY, suggested in the first part of our series, it won't be long before hams begin to digitize speech itself. The data will be sent through high-speed modems and processed by specialized software at the receiving stations. Noise and interference will be discarded, resulting in clear, natural-sounding voices. Commercial telephone companies and the military are far ahead of us in this area, but their systems are extremely complicated and expensive. It's up to hams to find a way to make it cheaper and simpler!

Just as spark yielded to CW in recognition of its inherent superiority, I believe analog communications must eventually yield to digital. As amateurs we have an obligation to explore every possible avenue that may lead to an improvement in our ability to communicate. Digital technology is a tool we can use to make a gigantic leap forward!

I hope you've enjoyed our digital communications series, and I strongly encourage you to try packet, RTTY or AMTOR. No matter how old you may be, these modes will rekindle your child-like sense of awe and wonder. Put aside your microphone or key this weekend and try something different. There's no better time than now to "think digital!"

Notes

[1]CCIR Recommendation 476-4 (1986), "Direct-Printing Telegraph Equipment in the Maritime Mobile Service", *Recommendations and Reports of the CCIR, 1986*, Volume VIII-2, Maritime Mobile Service, Geneva; International Telecommunications Union, pp 60-69.

CCIR Recommendation 625 (1986), "Direct-Printing Telegraph Equipment Employing Automatic Identification in the Maritime Mobile Service", *Recommendations and Reports of the CCIR, 1986*, Volume VIII-2, Maritime Mobile Service, Geneva; International Telecommunications Union, pp 5-59.

[2]P. Martinez, "AMTOR, an Improved Error-Free RTTY System," *QST*, Jun 1981, pp 25-27. For more information about AMTOR, also see: P. Newland, "An Introduction to AMTOR," *QST*, Jul 1983, pp 11-13, and P. Newland, "A User's Guide to AMTOR," *QST*, Oct 1985, pp 31-34.

[3]B. Henry, "Getting Started in Digital Communications—*Part 3*," *QST*, May 1992, pp 41-47.

[4]B. Henry, "New AMTOR Mode," *CQ*, Nov 1989, pp 36-40.

[5]H. P. Helfert and U. Strate, "PACTOR—Radioteletype with Memory ARQ and Data Compression," *QEX*, Oct 1991, pp 3-6.

[6]R. Petit, "CLOVER-II: A Technical Overview," *ARRL Amateur Radio 10th Computer Networking Conference Proceedings (1991)*, (Newington: ARRL, 1991), pp 125-129.