An Introduction to AMTOR

This mode adds space age excitement to RTTY!

By Paul Newland,* AD7I

On January 27, 1983, the FCC approved the error-correcting teleprinter protocol known as AMTOR for use by American radio amateurs. What is AMTOR, anyway?

AMTOR (*Am*ateur *T*eletype *O*ver *R*adio) is an exciting new mode of radioteletype (RTTY). It offers all the utility and enjoyment of conventional RTTY plus one great advantage: AMTOR removes virtually all errors caused by interference, fading or other disruptions. It also has built-in capability for selective calling. If your station is configured for AMTOR, it has the option of not responding to ASCII, Baudot or cw; only AMTOR signals will print on your teleprinter. This new system should prove useful for avid RTTY operators and traffic handlers as well.

I will provide an overview of how AMTOR operates and how amateurs can make use of it. Those interested in more of the technical details of AMTOR are encouraged to read the excellent *QST* article by Peter Martinez, G3PLX.[1]

AMTOR is a derivation of the commercial teleprinter system, SITOR, which stands for *Si*mplex *T*eletype *O*ver *R*adio.[2] SITOR is a commercial hf RTTY error-correction system used by many ships and coastal marine radio stations. SITOR allows a shipboard teleprinter to be connected to the international Telex network via hf radio so ship owners can send messages directly to their ships in real time. In addition to having error-correction capability, SITOR also includes selective calling. With this feature, coastal stations can call any ship that is monitoring, and forward a message to it without error or operator intervention.

AMTOR, in most respects, is the same as SITOR. With an AMTOR code converter, however, it is possible to monitor other stations using either AMTOR or SITOR operating in Mode A. This feature is important for radio amateurs so they can continue to self-police their bands. Most SITOR code converters do not have this capability.

Modes of Operation

AMTOR features four modes of operation.[3] They are: A — Automatic Request for Retransmission (or fills), B — Broadcast, L — Listen, and S — Selective Broadcast. Before discussing the modes in detail, it is useful to define some terms:

Master Station (MS) is the station that starts the communications. It does not show who is sending data at any one time, but only who began the contact. All stations synchronize their transmissions to those of the master station.

Slave Station (SS) is the station that is called by the MS.

Information Sending Station (ISS) is the station that is generating or sending data. I will sometimes use the term *sending station* when I mean, more correctly, ISS.

Information Receiving Station (IRS) is the station that is receiving and printing data. I will sometimes use the term *receiving station* when I mean, more correctly, IRS.

Of all the modes, Mode A is the most immune to errors, but is also the most complex. In Mode A, both the ISS and IRS send bursts of data to each other. This requires both stations to operate in a VOX-like manner. The ISS sends three AMTOR characters in a burst, and the IRS sends one AMTOR character in a burst. After each station sends a burst, it switches to receive so it can detect and decode bursts from the other station. This requires radios capable of switching from transmit to receive or receive to transmit in 10 to 20 ms. Most modern ssb radios meet this requirement.

To begin a QSO in Mode A, the operator tells the AMTOR code converter the selective calling characters of the station to be called.[4] The MS code converter begins to send the selective call characters, using bursts of three characters and switching to receive between the bursts. The gaps between the bursts provide time to listen for the receiving station. The receiving station, when correctly decoding its own selective call characters, will respond with a special AMTOR signal that says, "I hear you and I am ready." When the MS code converter hears that signal, the MS becomes the ISS, and it will alert the operator (usually through the use of LEDs on the code converter) that the IRS is ready to copy. The ISS may now send data to the IRS. During communications, the ISS (either the MS or SS) transmits characters in groups of three and the IRS replies with a one-character AMTOR signal that says either, "I received the last group of three correctly; send the next three," or "I missed that last group; send it again." Because AMTOR enables the ISS to repeat characters until they are received without error, the number of errors actually printed on the teleprinter is reduced drastically in comparison to conventional RTTY.

When the ISS wants to let the other stations send data, it sends the three characters, FIGS Z B.[5] This sequence of three characters is the AMTOR "over" signal for Mode A. Now, the IRS becomes the ISS, and vice-versa. Similarly, when the

[1]Notes appear on page 13.
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new ISS wants to convert back to an IRS, the operator types in the characters FIGS Z B. In addition, the IRS station is able to break into the ISS transmission at any time. To do this, the IRS operator presses the OVER button on the code converter. Instead of the IRS sending the usual "send it again" or "give me the next block of data" bursts, it responds with another special one-character message that says, "I want to send you some data; let's exchange places." When the ISS receives this message, the exchange is made and the ISS may begin sending data.

When the ISS wants to close the QSO, the operator presses the QRT button on the code converter, causing both converters to "handshake" and go off the air. If the IRS wants to close the contact before the ISS is finished, the IRS can "break" into the ISS and exchange places. The operator may then press the QRT button to close the contact.

Mode B

Mode B is useful for broadcasts when the sending station wants to reach more than one station simultaneously, or when the IRS cannot send acknowledgements to the ISS. Examples of this type operation are W1AW bulletins or net operations.

In Mode B, the transmitter is on continuously, unlike Mode A, in which the data is sent in bursts. The sending station AMTOR converter sends each teleprinter character twice, with the second transmission of a character delayed from the first by 280 ms. These transmissions are made synchronously, as opposed to conventional RTTY, which uses start and stop signals before and after each character. In synchronous communications, all data characters are sent one after the other, without start and stop signals, and at a rate that is controlled by an accurate time base, such as a crystal oscillator. When there are no characters from the teleprinter to send, the code converter fills this "dead time" with AMTOR idle characters. These characters are used to fill the periods of time when the sending teleprinter is not generating data, but they do not print on the receiving teleprinter; they are like a conventional RTTY "diddle."

The advantage of Mode B, compared with conventional RTTY, is that the teleprinter only receives data from the code converter when there are valid AMTOR signals present. Because the characters are transmitted in pairs, AMTOR B stores the first character in memory and waits for the second. When it receives the second character, it checks both in the pair for errors. If one of the two characters has been received correctly, it is printed. If both are in error, a space will be printed to mark the error. This space is easy for the operator to spot and provides a place on the hard copy for a manual fill to be made.

Listen for AMTOR over W1AW

If you can receive AMTOR, try listening for W1AW AMTOR transmissions, Mode B, following the 11 A.M. EST/EDST (presently 1500 UTC) RTTY/ASCII transmissions Monday through Thursday on 14.095 MHz. W1AW has been transmitting AMTOR bulletins since February 8, first under an STA (Special Temporary Authority granted by the FCC) and continuing after the Commission authorized AMTOR for general use in the Amateur Radio Service. The W1AW AMTOR schedule will soon expand; watch the W1AW schedule, published in alternate issues of *QST*, for full details.

W1AW has also made several two-way contacts using Mode A, mostly with stations in Europe, where AMTOR has been popular for some time. It's still a thrill to have a DX station say, "Please QSL — you're my first U.S. QSO on AMTOR!" — *Chuck Bender, W1WPR, Chief Operator, W1AW*

Mode S

Mode S is just like Mode B, except that it includes selective calling. It is rarely used today, although it probably will be used often in the future. Mode S is useful if you are unable to operate in Mode A and only want to receive messages that are specifically intended for you. Teleprinter paper can be used up at a fast pace if you are on a channel that is active with Mode B traffic!

Mode L

Mode L is useful for monitoring two stations that are using Mode A to communicate. Of course, since the sending station is not getting acknowledgments from the Mode L station, but instead from the other Mode A station, the Mode L station will not obtain the benefits of error correction. This is hardly a problem, because the only purpose of this mode is to allow for monitoring, not error-free communications.

Which Mode?

It is important to understand that for all modes except L an AMTOR controller that is monitoring a channel will automatically switch to the proper mode when it is called by an MS. When someone calls your station, you don't have to be concerned with which mode is being used. The AMTOR controller will determine whether the call is in Mode A, B or S, and will adapt to that mode immediately. Only when a station *places* a call does the operator choose what mode to use.

Error Detection

AMTOR is able to process data without error because it rejects data that it believes is incorrect. How does AMTOR know when the data is wrong? It converts each five-unit Baudot character to a seven-unit character that always has four 1s and three 0s before transmission. At the receiving station, AMTOR checks each received character to see if it meets the 4/3 criterion. If it does, the code converter assumes that the data is correct.[6] If it does not, the character is assumed to be in error.

Even though this method of error detection may appear to be overly simplistic, it provides adequate performance for "outwitting" the error-causing phenomena found on hf radio circuits.

How to Hook It All Up

AMTOR equipment is available for moderate cost and is *simple* to hook up. Those totally unfamiliar with RTTY might want to review the information on this mode found in the ARRL *Handbook*. The basic equipment used for AMTOR is the same as that used for normal RTTY, with the addition of an AMTOR code converter between the terminal unit (modem) and the teleprinter. As an added plus, with AMTOR you don't need a terminal unit with auto-start, mark hold, and so on. The AMTOR code converter provides all those features for you.

Where and When

Most AMTOR operation is centered around 14,075 and 3637.5 kHz. These two frequencies are typically used for calling. After contact is established, and if both operators are present(!), they will usually move the QSO to another frequency.

Some stations have their radios configured for scanner operation. They will tell other AMTOR operators the frequencies they scan and what their hours of operation are. When someone wants to contact them, they locate a frequency that the other station is known to scan, make sure it is inactive, and then begin a Mode A call. Usually, if the "receiving" station is not in a QSO on another channel, it will respond to the Mode A call within 40 seconds and the QSO can proceed. If stations are using scanners, there is no need to move off channel because the QSO can begin on a *working* channel, instead of a calling channel.

Some stations, such as G3PLX and HB9AK, monitor 14,075 kHz continuously and have computers attached to their AMTOR systems. The computers can be used to store or retrieve messages intended for their station or others. Some AMTOR computer systems can also act as store-and-forward repeaters. When you call these systems, you can request that your message be relayed to another station on completion of your QSO.

As an example of this capability, G3PLX and I were trying to pass some information on 20 meters, and the path between us was just not there; we found that by relaying messages from G3PLX to A4XFW in Oman, to HB9AK, to AD7I near New York City and back again, we could communicate. It is noteworthy that there were *no* operators at HB9AK or A4XFW during these relays. [This type of unattended

transmitting is not presently allowed under FCC rules without special authorization. — Ed.] Everything at these two stations was under computer control. Now *that* has to be a new form of long path!

Simple, But Robust

I have been involved with AMTOR for some time now and I continue to be impressed with its robust capabilities, while maintaining simplicity. It has proved to be a simple and inexpensive addition to any amateur RTTY station. Finally, the most compelling reason I can offer for becoming active with AMTOR is that RTTY is more fun without errors!

Readers' comments and suggestions are always welcome. I would like to hear from anyone interested in getting involved with AMTOR. Please include an s.a.s.e. with your correspondence.

Notes

[1]J. Martinez, "AMTOR, an Improved Error-Free RTTY System," *QST*, June 1981, pp. 25-27.

[2]The exact specifications of SITOR are outlined in CCIR (International Radio Consultative Committee) Recommendation 476-2.

[3]Not all controllers include all modes. If you consider building or purchasing a code converter, you should know which capabilities you want. In addition, if you purchase a commercial AMTOR code converter, make certain the unit meets or exceeds all specifications outlined in CCIR Recommendation 476-2 for the modes you want to use.

[4]AMTOR uses four-letter combinations for selective calling. With a 26-letter alphabet, this provides for 456,976 unique calls. Although it might be desirable to have more calls available, this is all the internationally agreed upon standard allows. Most amateur stations use the first letter and last three letters of their call sign for the selective calling characters. Using this algorithm, the calling characters for W1AW would be WWAW.

[5]On CCITT no. 2 coded terminals, FIGS Z B will print as ±?. On terminals commonly used by American radio amateurs FIGS Z B will print as :?.

[6]This leads us to why I must say that AMTOR provides *virtually*, rather than *absolutely*, error-free communication. There is a chance, although small under normal conditions, that some "hits" during transmission will result in a data error that will pass the 4/3 test at the receiving station.

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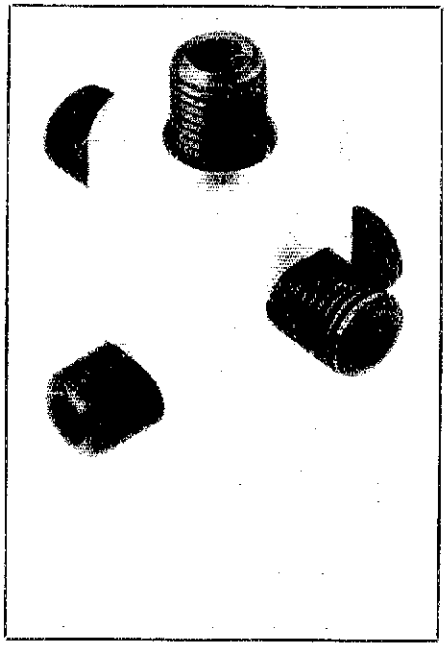
Paul Newland, AD7I, was first licensed in 1971 and is currently active on hf and vhf with new modes such as AMTOR and packet radio. He is presently focusing his Amateur Radio activities on development of hardware and firmware for AMTOR code converters and modems. Professionally, Paul is employed by a major research and development company where he designs microprocessor-based communications interfaces for computers. He received a BSEL degree from California Polytechnic State University in 1979 and a MSEECE from the University of Michigan in 1980. Paul is a member of the ARRL and IEEE.

New Products



In addition to the two basic switches, MEC offers a 10-color variety of keycaps and bezels. Bezels illuminated by LEDs are available, too.

MEC also provides a matrix mounting system (UNIMEC/VARIO-SUPPORT) for their switches. This enables a designer to realize a custom keyboard or switch panel almost instantly. The desired layout and switch functions are determined simply by inserting the appropriate switches into the matrix. According to the manufacturer, this makes panel mounting easy and stops over-pressure as well as flexing of the pc board.

Switches and pricing information are available from Forsbert Sales, Inc., 646 Summer St., Brockton, MA 02402, tel. 617-522-6300, and Switches, Inc., 949 Stierlin Rd., P.O. Box 4248, Mountain View, CA 94040, tel 415-962-8649. — *Paul K. Pagel, N1FB*

X-PANDA-FIVE

☐ A new accessory for the hf mobile enthusiast is available from JL Industries. The X-PANDA-FIVE is an adaptor that permits the installation of up to five resonators on one mobile mast.

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Complete installation and resonator tuning instructions are furnished with the X-PANDA-FIVE. The adaptor is machined from solid aluminum stock and incorporates resonator mounting studs of high-tensile carbide steel. All threads are 3/8" × 24 to accept either Hustler or HyGain resonators and masts. The suggested retail price is $14.95, and the unit is available direct from the manufacturer, JL Industries, P.O. Box 030413, Fort Lauderdale, FL 33303 — *Sandy Gerli, AC1Y*

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☐ A/S MEC-75 of Copenhagen, Denmark, offers a unique modular switch available in two forms: momentary contact and push-push action. Both types provide five different contact configurations. These are determined by selecting the appropriate switch terminals with pc-board traces or hard wiring. Essentially, each switch is a programmable 4pdt type.

Strays

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- "Lowpass Speech Filter Using Surplus Inductors," by Ed Wetherhold, W3NQN.

It also reviewed the Ninth Annual Eastern VHF/UHF Conference and carried a request from Hank Magnuski, KA6M, for information from potential users of the AMSAT OSCAR Phase IIIB AMICON Special Service Channel, which has been designated for packet-radio operations.

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