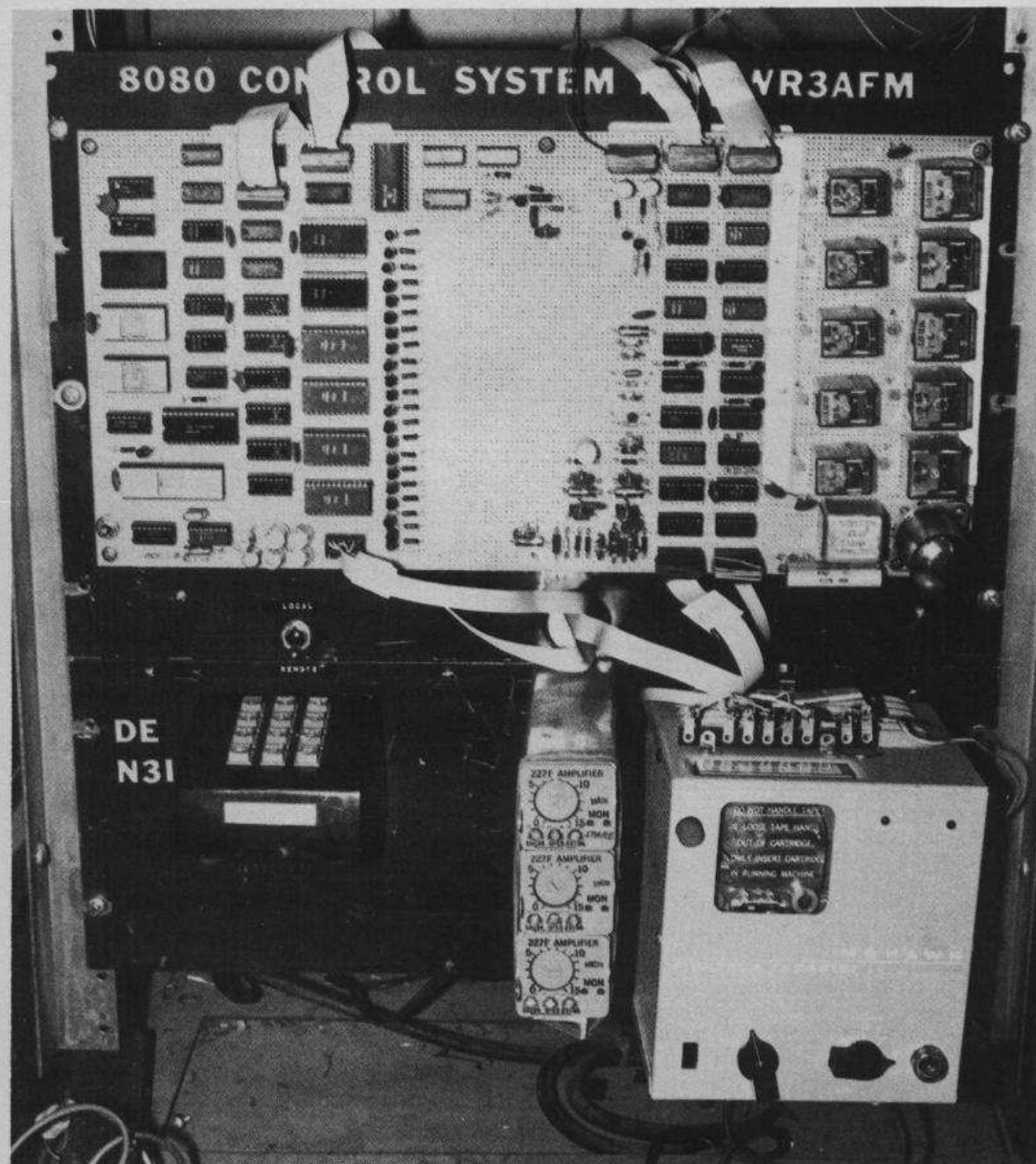


most six functions. We required several dozen functions, and simple expansion of the relay system would have made the repeater look and sound like a telephone company central office. After the new system was finished, the simple output functions took a back seat to the innovations which were not possible before.

In order to understand what the 8080 control system does, a brief description of the Baltimore Amateur Radio Club's repeater (WR3AFM) is necessary. Fig. 1 shows a block diagram of the repeater. There are actually two repeaters: a two meter repeater and a 440 MHz repeater. The 440 repeater is a simple duplexed one. It has an autopatch independent of the rest of the system. The two meter repeater is a multiple split site repeater. The two meter transmitter is located at the site of the 440 repeater. Spread around the city are up to six receive sites. Each receive site receives signals on the two meter input frequency and retransmits them on a 440 link frequency to the transmitter site. At the transmit site, signals are received from each of the links. Each link receiver feeds a voting selector, which continuously evaluates the signal-to-noise ratio of each signal and passes the best one on to the transmitter. The two meter repeater also has an autopatch. The repeaters can be controlled via the two meter repeater autopatch telephone line or a 440 receiver reserved for control. All told, there are eight 440 receivers; off the receive port of the 440 duplexer is a 440 multicoupler which splits and boosts the signals received from the 440 repeater antenna. As can be seen, we obtain maximum utilization (eight



Control system connected to repeater.

receivers and one transmitter) from the 440 antenna on the top of the tower (400 feet high)!

The voting selector can be directed to pass only one of its inputs to the transmitter, or to ignore some of its input receivers. This is a major function of the control system. As our repeater gradually expanded, it became more difficult to diagnose problems. A week would go by before we even realized that one of the receive sites was inoperative. With the new system, it is easy to check all sites by commanding the voter to pass each receiver one at a time. During the summer

months, we are plagued with skip signals from users of the two nearest repeaters on the same frequency: Hazelton PA and Trenton NJ. At times, our repeater is unusable due to constantly timing out from the extraneous signals. We can now command the voter to ignore our northeastern receiver, from which most of the interference arrives. These two basic functions provided the impetus for the construction of the 8080 system.

The system has other important functions. It allows the two meter and 440 repeaters to be linked when needed. A prere-

corded tape loop can be activated on request, giving information about the repeater and the club. A feature is provided to test touchtone pads—the repeater tells the user in Morse code what it received. The processor controls the autopatch. Instead of the normal system, it gets the requested telephone number from the user and redials the number into the telephone system. If the proper number of digits is not received, it will not even access the telephone line. Single-digit codes permit dialing of emergency numbers. Non-collect toll calls are impossible. There

Using the System

The following text, after suitable modifications, is intended to be distributed to users of repeater systems using the 8080 control system. Use of the processor functions and the autopatch are described.

WR3AFM is now controlled by an 8080 microprocessor. The processor permits flexibility in the system as well as many functions which could not reasonably be implemented without a processor. There are five CW IDs; four are permanently stored, and one is remotely programmable via a touchtone pad. Any of the five IDs may be selected, or, as is often the case, the different IDs may be made to cycle. The programmable ID allows meeting announcements and anything else that could be useful to be placed on the repeater.

For testing and diagnosis, each of the individual receive sites on 07/67 may be either disabled or forced on through the voting selector. There are several modes of accessing the control system, so it is possible for control stations to work on the system without interfering with repeater users. For most functions, the 8080 responds to correct commands with an "R" in CW, so when "R"s are heard on 67 this means that someone is commanding it. Under such circumstances, be slow to pick up transmissions in case the control operator has any requests; if none are made, feel free to continue using the repeater and ignore the "R"s.

For those interested in the size of the 8080 system, it currently has about 2K of program in ROM, 256 bytes of RAM, seven eight-bit output ports, and three eight-bit input ports. The control program is about 1300 lines long, and the hardware consists of 57 integrated circuits.

The processor makes possible the redialing of telephone numbers, the virtual elimination of incorrect dialing for autopatches, and the prevention of toll-charge telephone calls. In addition to the control functions and the autopatch, the processor has five codes available for general use which are accessible via 146.07. Any ideas for additional functions will certainly be entertained. For each of the codes, it is necessary for the first digit to be held at least one full second. It doesn't hurt to hold any tone longer than required. With this in mind, here are the various codes:

1#1—Links the 146.07/146.67 repeater with the 444.35/449.35 repeater. The repeater answers with an "R" if the function is accepted. The linkup will remain up indefinitely until knocked down with a *. Signals on 146.07 will come out on both repeaters, and signals on 444.35 will come out on both repeaters. When disconnected, the repeater responds with an "R" as well. The intention of this function is for calling someone on the other repeater, not for extended rag chew-

ing on both repeaters simultaneously. When transmitting on 444.35, 1#1 will also link up the repeaters. This function on the 440 end is not controlled by the microprocessor, and it does not acknowledge with an "R". The * on 444.35 will kill the linkup if it was initiated on 444.35; alternatively, on the 440 end the linkup will time out after three minutes. This is only true for linkups made from the 440 repeater. The two linkups are separate; if linked on 146.07 they must be killed on that frequency, and if linked on 444.35 they must be killed on that frequency.

2#2—Initiates a prerecorded tape message giving information about the repeater. The tape will disable itself upon completion.

3#3—Disables the blocking of touchtones. Any tones sent after the 3#3 before the carrier is dropped will not be blocked. Normally, upon recognition of valid tones, the repeater mutes them. This is done to protect the ears of those of us who monitor often. It is done on a tone-by-tone basis to facilitate diagnosing problems, since you can hear a short blip for every digit and can tell how many tones were sent. For those hams with selective call decoders, it is necessary for the tones to pass unimpeded, which is the reason for this function. If only short tones are required, the selective call function need not be used, as the repeater does not initiate tone blocking until a valid tone of about one second is received. This is to prevent blocking of voices.

4#4—Touchtone test. Any digits sent after the 4#4 before the carrier is dropped will be sent in Morse to tell the user what the repeater decoded the digits as. Any sequence up to 24 digits can be accommodated.

5#5—If preceded by a 4#4 test, will repeat what the 4#4 sent. If preceded by an autopatch, the telephone number entered will be sent in Morse. If an autopatch attempt fails, 5#5 will show what the number requested was (if the autopatch code was accepted). If, after making an autopatch, you wish to clear your telephone number from the machine, simply do a 4#4.

NOTE: The functions 1#1 through 5#5 are intended for use by anyone, club member or not. The autopatch is restricted to club members and transients. When performing any of these commands, be certain to identify your station first. The functions are there to be used, but not abused. This is somewhat of an experiment in the hope that our repeater users will use these functions wisely. We hope to be able to continue this free access. Should it become necessary, any of the functions may be disabled by remote control. Please do not force us to deactivate them.

are several different CW identifications which may be selected, and special IDs can be loaded in minutes remotely. For a number of years, we have had a reprogrammable CW identifier (73 Magazine, April, 1976). It was a great success, and the ability to program an ID remotely makes it more useful. Any of the functions can be disabled, and, of course, the repeaters can be turned off if necessary. A complete explanation of the user codes appears elsewhere in this article. A sample of what can be placed on the tape message loop is given. A complete description of

the control functions, "Controlling the System," also appears elsewhere. It is more difficult to control the system than with a simple arrangement, but many times it is not even necessary to enter the control mode and forcefully disable functions. Merely by transmitting on the control frequency, everyone else loses access to the touchtone decoder. This is of great use when some user decides that he will execute some function without identifying himself, as required by FCC regulations. A simple transmission on the control frequency removes his access to the system, and it is not

even obvious to those listening. With any amount of luck, these individuals adjust their touchtone pads attempting to bring up a function and throw their pads away in disgust after being unsuccessful.

We have been quite pleased with the overall operation of the control system. The user codes have given the repeater users some involvement with the repeater, and, after the initial adaptation period, general user sentiment has been quite positive. Although the control system is fairly complex, the reliability so far has been good. In the first two months of operation,

the system crashed twice. In the software world, a computer "crash" refers to the occurrence of some error which causes a computer to ignore operator commands, necessitating a hardware restart. I added an error detection/recovery routine to the system, and there have been no crashes since. There have been no hardware failures.

In the following sections, I will show how you can duplicate the system, how the hardware and software functions are distributed, what the hardware components are, and provide explanations of how to use and control the

Autopatch Access Procedure

The following procedure is recommended for accessing the autopatch.

- 1) "N3ABC autopatch"
- 2) Send the autopatch code and the telephone number in one transmission. Remember to hold the first tone one second. It is imperative that the carrier continue throughout the entire operation of all ten digits. Upon the release of carrier, the repeater will determine if your number is valid. The number is valid if any one of the following conditions is met: exactly one digit which corresponds to a single digit emergency number; exactly seven digits, the first digit not a 1; exactly eight digits, the first number a 0; exactly eleven digits, the first number a 0. If the number is invalid, nothing will happen. It will act as though no autopatch code had been entered, and it is not necessary to send the knockdown digit. If the number is valid, the repeater will bring up the telephone line and redial your number.
- 3) After the number has been dialed, and the line has clicked over, "N3ABC".
- 4) Conversation
- 5) "N3ABC clear with John Doe at 12:37 PM on August 12."
- 6) Knockdown code. If the "beep" is heard, the patch has been killed.
- 7) "WR3AFM this is N3ABC clear."

If you have problems, remember the 5#5 code.

The repeater now has several single-digit special numbers. Make a note of these special codes:

- 2—Baltimore City Police
- 3—Baltimore City Transit and Traffic
- 4—Maryland State Police
- 5—Harbor Tunnel Information
- 6—Anne Arundel County Police
- 7—Coast Guard Search and Rescue
- 8—Baltimore County Police
- 9—Howard County Police

To use the single digit codes, send the autopatch code followed immediately by the single digit. The repeater will dial the proper number for you.

Half Duplex

The autopatch is half-duplex. This means that the audio from the telephone line is switched off when you push the PTT. This feature can be used to block obscene language, business communication, or whatever, if the called party gets carried away. However, "skip" or interfering signals also have the same effect. Therefore, it is not wise to initiate an autopatch under such conditions. If this problem occurs, remember that the party on the telephone can hear you perfectly—it is just that you cannot hear him whenever any signal is present on 146.07, be it yours or something else.

Autopatch Timer

The autopatch is to be used for short traffic only. A timer will automatically terminate the patch after three minutes. Once activated, the patch will stay up until terminated by the timer or the knockdown code. No kerchunking is needed to keep it up. Three minutes is more than adequate for most autopatches. However, sometimes when in communication with police regarding an emergency it is desirable to continue the autopatch past the three-minute limit. Because of this, the timer is automatically deactivated when a *single digit* emergency number is used. The patch will not time out for these calls. For normal calls, it is not possible to extend the three-minute limit. For all calls, think of what to say before calling.

system. The method of construction, a detailed circuit and program analysis, and some principles I learned in developing the project will be presented in subsequent parts.

Duplication

The 8080 control system can be duplicated for your repeater with few modifications. The control system supports some features of WR3AFM which may not be of use on

Tape Message Text (Time: 2 minutes, 50 seconds)

Welcome to the Baltimore Amateur Radio Club's 07/67 repeater, WR3AFM. The transmitter is located at the old WBAL tower on Park Heights Ave., and drives a 250-Watt amplifier, though only a portion of that power reaches the antenna through about 500 feet of feedline. The repeater has receivers north of the beltway on Old Harford Road, at the WRBS tower near I-95 south and the beltway, downtown at 4000 North Charles Street, and at the QTH of K3VC and N3JC at the top of the Jones Falls Expressway. Each of these receivers drives a 440-MHz link transmitter. At the transmit site, there is a link receiver for each receive site. Each signal is fed to a voting selector, which continuously evaluates the signal-to-noise ratio of each receiver, the best of which goes to the transmitter. All of the repeater equipment is of the General Electric MASTR make.

At the transmit site, there is also a duplexed 440-MHz repeater, 444.35 in and 449.35 out.

You will note that a short click is heard after releasing your carrier. This signifies that the repeater timer has been reset, and leaves time for breakers. It is not necessary to let the repeater carrier drop. 07/67 has an autopatch, limited to travelers and club members, but open to anyone for emergency traffic.

The repeater is set up to block touchtone signals. After a long first tone of about one second, any further tones will be blocked from repeating, and only a short blip will be heard. There are several codes that anyone is welcome to use. One pound one links the 67 machine with the 440 repeater. To acknowledge that function, the repeater sends an "R" in Morse. The repeaters remain linked until a star is sent, again acknowledged with an "R". We do not desire to use this function for more than a calling mode. Two pound two gives this recorded message. Three pound three will disable the repeater's blocking function until the carrier is dropped, permitting the tones to be repeated. Any touchtone digits sent after four pound four will be verified in Morse after the carrier drop. Five pound five will repeat what was sent during a four pound four operation or the telephone number dialed during an autopatch, whichever was last.

The control system for the repeaters is an 8080-based microprocessor, which performs the various functions including multiple identifications, as well as redials telephone numbers for the autopatch.

The Baltimore Amateur Radio Club has another two meter repeater, 34/94, which is a duplexed repeater in the Towson area. We hope you enjoy the use of our repeaters, and would like to see you at our meetings on the first and third Wednesdays of the month at the Ames Methodist Church in Pikesville at 8:00 pm. Listen for interesting bulletins weekdays on 67 at 7:30 am and rebroadcast on 94 at 6:00 pm. Code practice can be heard Mondays at 9:00 pm on 34/94. Should you desire to contact the club, write the Baltimore Amateur Radio Club, PO Box 5344, Baltimore MD 21209.

an average repeater. If nothing but the basic user codes, the multiple IDs, the autopatch functions, and on/off control for a simple repeater is needed, the 8080 control system would still be worthwhile to construct. If the system is totally duplicated, and portions are left unconnected (due to having no voter, 440 repeater, etc.), the system will operate and leave room for expansion. Alternatively, the appropriate pieces could be left out easily. In either case,

the program would remain the same. It may have codes which do nothing or do something different, but the program is the major work and is already done for you. If no changes are contemplated for the program, then it is not necessary to understand how it works. It is always informative to do so, but don't worry about it too much if you are not familiar with 8080 machine language. For those who wish to personalize the software, it can certainly

Controlling the System

The following text is intended for distribution to control operators of repeater systems utilizing the 8080 control system. The necessary codes will have to be changed.

The microprocessor control system is a complex but flexible and powerful system. It is of utmost importance to completely understand its operation before attempting to utilize it. Although at first the system may seem to be overly complicated, the structure of the control codes makes it easier to use than a first glance might show.

Basically, the system reads the output of the touchtone decoder to decipher the codes, and has 56 output lines which may be controlled by the proper input combinations. External to the processor itself is additional circuitry to perform the necessary functions, i.e., autopatch, remote base, control frequency repeat, and phone line control. User codes all operate on the outputs indirectly. The proper bits are set and reset to perform the desired function, but control codes are all direct changes of output lines which are assigned to control the various functions.

The basic decoding method used decodes three-digit codes. The first digit of the code must be held down for one second, or nothing will happen. After the release of the first digit, if three seconds elapse before another digit is received, the code will be canceled where it stands. After the release of the second tone, three seconds is likewise allowed to enter the third digit. During the time that the first tone exceeds the one second time period, and until the end of the digit sequence, the blocking relay will follow any valid touchtone signal. During an autopatch or remote base function, the blocking relay will follow the tones as well. At all other times the blocking relay is not activated. Due to this arrangement, in order to have voice signals blocked, the voice must be a valid touchtone signal for one second—certainly a rare if not impossible situation.

be done. If you do not have any support for the 8080, or for some other reason cannot program 2708 ROMs, I will provide the two ROMs for a cost of \$50. Specify your choice for the following codes: 67#, 2*2, 9#5, 6*#, #*6, #48. The knockdown digit will be * unless requested otherwise. Codes may not start

with whatever digit is chosen as the knockdown digit. Also specify the four IDs and the telephone numbers for the single-digit dialing. For obvious reasons, the above codes must be changed for each repeater.

This project is by no means a simple one, and it is not suitable for the

Telephone and Control Receiver Access

There are two modes for each of these devices: control and talk. The normal mode for both is control. For the control receiver, this means that the signal is not repeated on 67 but the control receiver grabs the touchtone decoder. The control receiver has highest priority, unless the control receiver touchtone bit is set, which effectively removes the control receiver from the system. If, while transmitting on the control frequency, a # is entered for five seconds, then the control receiver talk mode is entered. While in this mode, the control receiver is repeated on 67. The only way to exit this mode is to send a one-second * while on the control frequency. As long as the control receiver bit is not set, the control receiver always has the decoder. When in the non-talk mode, this allows control of repeater functions without bothering users of the repeater, except that they will not be able to access the touchtone decoder to make autopatches. For the telephone line, when a call-in is made, the mode is set to telephone control. You cannot hear anything. However, the touchtone decoder is listening only to the telephone line. In this manner, control can be exerted in the same way as with the control receiver. If you wish to hear the repeater on the phone line, a five-second # on the line will switch you out of the phone control mode, and the voter audio will be sent down the phone line when an incoming carrier is present. When a signal is present, it has the decoder, not the phone line. Otherwise, the phone line has the decoder. To return to the phone control mode, a * while on the telephone will do so, as will hanging up and redialing. If the telephone touchtone disable bit is set, it will be impossible to enter the phone control mode, and any touchtones received from the phone will be rejected.

Note that any of the three modes of control may be disabled: 150 input, control receiver, and telephone. Beware: If all bits are set, you go to the repeater and push the reset button (or wait for a power failure to reset it automatically). Naturally, it would be inconceivable to lock out all modes of control accidentally.

beginner. Construction experience with integrated circuits and a basic understanding of the system are required. It is not an extremely difficult project as long as care is taken during assembly. Probably the most difficult

part will be deciding how to interface a particular repeater to the system. The entire system can be constructed in one week (full-time) by a proficient builder. Do not shy away from the project if you have no prior experience with microprocessors. The "black box" approach is utilized, and detailed knowledge of the inner workings of microprocessors is not required. Total cost for the system is dependent upon how much peripheral equipment is available. The control system cost us about \$225, exclusive of the touchtone decoder and pad, amplifiers, and tape loop.

Hardware/Software Balance

Some of the control functions are implemented in software and some are implemented in special

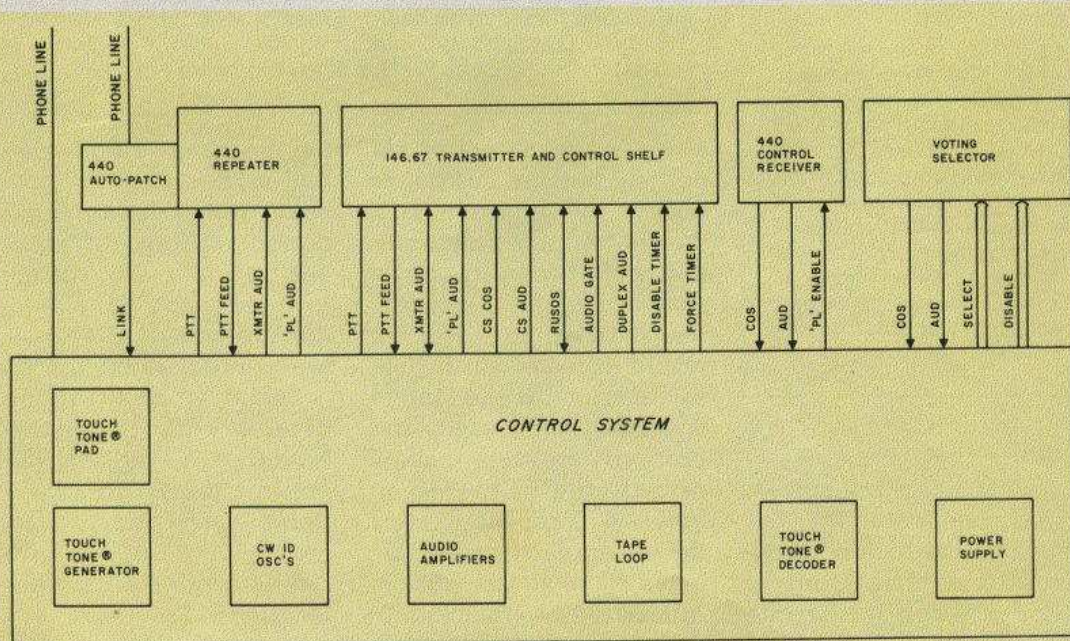


Fig. 2. Repeater/control system interface.

hardware. Deciding where to draw the line is an interesting problem. There are trade-offs which must be made. The major advantage of using a microprocessor is replacing hardware with software, so at first glance it may seem that everything that can be placed into software should be. However, I would rather add one flip-flop than add several hundred extra lines of program. Four years ago, I made the mistake of taking all possible hardware out of a system. My first attempt at computerizing WR3AFM started at that time when I constructed a system based on the 4004 CPU, a 4-bit machine. I designed the hardware, giving the software total control over the hardware. Everything was done with the software. At that time, being hardware oriented, I built the thing first and assumed that I would then write the program. The hardware functioned perfectly—unfortunately, I could not write the program. It could be done, but it was so complicated that it would have taken me several months of concentrated effort to accomplish the task. I effectively junked the project and am still trying to think up some possible use for the thing.

This time around I did not make the same mistake. There are four state flip-flops in the external hardware. These keep track of the autopatch, remote base, control receiver talk, and telephone control states. The processor does not know or need to know the current state to execute its functions. It basically acts as a CW identifier and a multiple digit decoder. It does keep track of many internal states, but these states are not needed until a function is called which needs them. The extra dozen ICs greatly simplify the soft-

ware, and I believe that the hardware/software balance of this system is near optimal.

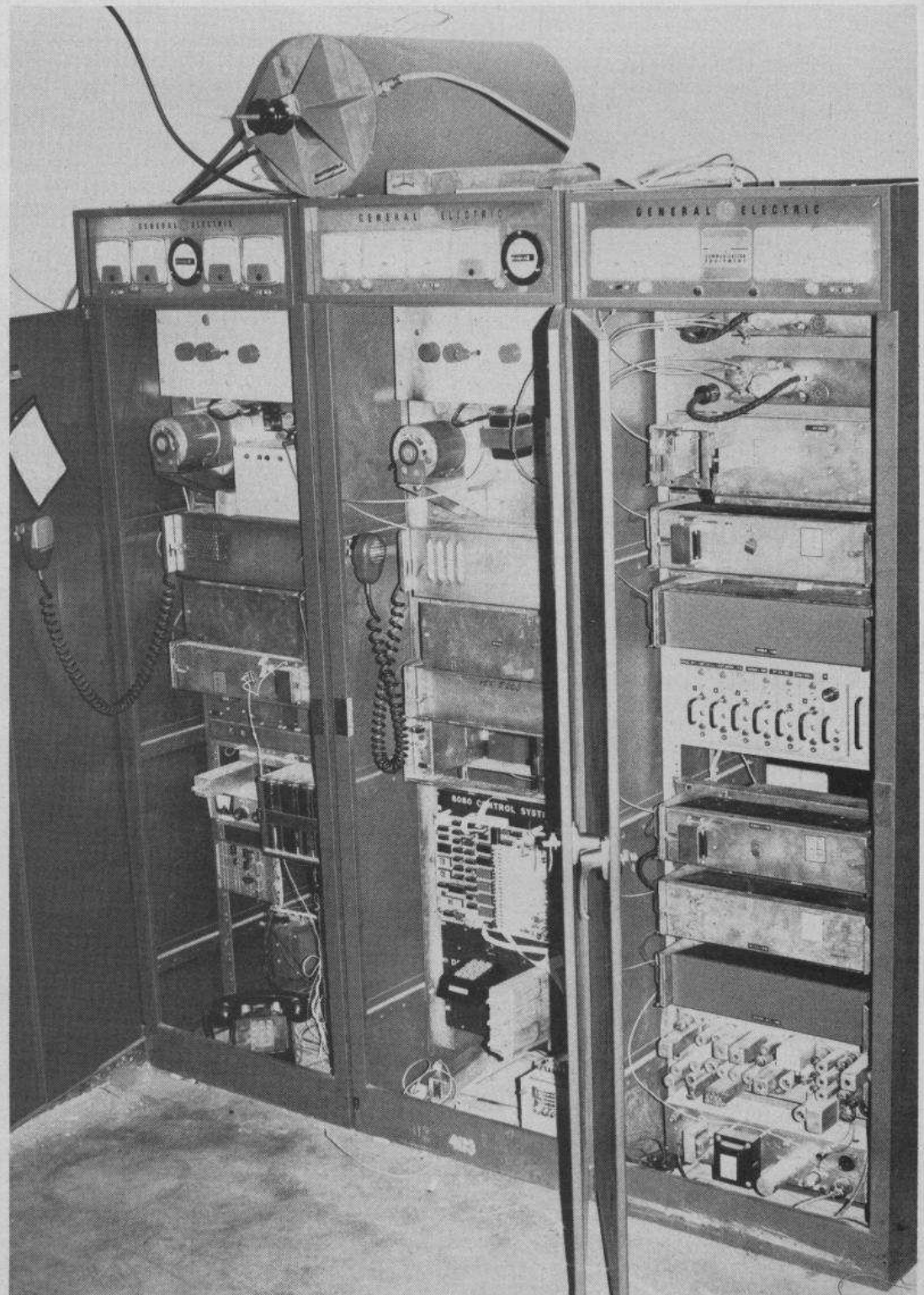
Hardware Description

The repeater block diagram shown in Fig. 1

was previously discussed. Fig. 2 shows how the control system interfaces with the repeater. Surely, each repeater will have to be reckoned with on an individual basis. Understanding how WR3AFM works

should demonstrate how to interface the control system with any repeater.

The 146.07/146.67 MHz repeater is referred to as 150 and the 444.35/449.35 MHz repeater is referred to as either 440 or 450. The



WR3AFM. Left cabinet—444.35/449.35 repeater. Top to bottom: power amplifier, transmitter, receiver, control panel, autopatch circuitry. Center cabinet—146.67. Top to bottom: power amplifier, transmitter, control receiver, control shelf, 8080 control system. Right cabinet—link cabinet. Top to bottom: 440 multicouplers, power supply for receiver #6, 5 link receivers, voting selector. Tube receiver on bottom no longer in use. 146.67 pass cavity on top. 440 duplexer out of view in left cabinet.

User Codes

There are eight user codes. 1#1 links 67 and 449.35. The two repeaters remain linked until they are unlinked by a single *. The proper output line is automatically set and reset for the link and unlink commands. To tell the user that the link or unlink has been established, the repeater acknowledges with an "R" in Morse.

2#2 plays the prerecorded tape loop. Once it is started, there is no way to stop it short of shutting down the repeater.

3#3 is the disable blocking or selective call code. The blocking is disabled after the second three is received until the incoming carrier is dropped.

4#4 is the touchtone test function. Any tones up to a maximum of 24 will be played back on CW after carrier drop if preceded with the 4#4 code.

5#5 will repeat what was sent during a 4#4, or the telephone number requested in an autopatch, whichever was last.

67# is the autopatch code. In one transmission, the code plus the telephone number must be sent. The processor will not access the telephone line unless a valid telephone number is received. Normally this consists of exactly 7 digits, the first digit not a 1. Other valid numbers are 8 or 11 digits, with the first digit a 0 and the single digit codes. If the single digit code is correct, the proper emergency number will be found and sent. If an invalid number is attempted, nothing happens, exactly as if no autopatch attempt had been made. For valid numbers, the repeater will bring up the telephone line and redial the stored telephone number. This system prevents incorrect calls due to signal chopping which cause shotgunning of the touchtones (which result in more than 7 digits). When a single digit code is used, the three-minute timer is defeated automatically. If the 67# is sent by itself and the direct autopatch bit is set, then the repeater will bring up the telephone line and permit the user direct access to the telephone dialing system. This is not normally done, as it is not needed.

9#5 is the remote base code. The normal method is to use this by calling in on the phone line. However, nothing prevents its use on the air. All it does is connect the repeater to the phone lines, but it will not initiate a call. This is not strictly a user code, as the users should not know it, but there is no technical distinction between it and the other user codes. If the repeater times out during an autopatch or a remote base function, those functions will be canceled.

2*2 also performs the tape function. There is no distinction between this and the 2#2 except that the 2*2 is for control stations only. The two codes may be disabled separately. By using the 2*2 function, if it becomes necessary to disable 2#2, control operators may activate the tape upon request without needing to get into command mode and enable the 2#2 function.

In order to exert command on the repeater, it is necessary to enter the command mode. 6*# initiates the request. After entering this code, the carrier must be dropped. If the command is from the telephone line, the procedure may continue immediately. A confirmation code must be entered next. The confirm code is #*6. *Important:* Once the command code is issued, the system will wait for the confirm code forever. If no tone is given, the system will not be reset until it receives another touchtone. After the confirm code is entered, the carrier must be dropped again. Next, a single digit code is entered. If the single digit is a valid command, then the repeater will acknowledge with an "R". With the exception of three special single digit commands, the command mode is automatically left, and operation is again normal. A description of the single digit codes follows.

The system has five different messages. Four are permanently stored in the ROM. They are presently (1) "DE WR3AFM BARC," (2) "DE WR3AFM BALTIMORE," (3) "73 DE WR3AFM," and (4) "DE WR3AFM BALTO ARC." In addition to these four, there is a fifth which may be programmed through another command.

Commands one through five select that number ID to be used always. Command six rotates through 1,2,3,4,1,2,3,4, etc., each time the repeater identifies. Command seven rotates through all five IDs.

Command nine resets all functions to the normal state. Normal is both repeaters enabled, ID #1 selected, and all other outputs ungrounded. This is the same thing as pushing the reset button on the control system.

Command * resets the ID timer. The next time one of the repeaters is kerchunked, that repeater will identify. A word here about the timing of IDs is in order. In the rest mode, as after the * command, the first repeater used identifies. If, in the subsequent three minutes, one or both of the repeaters is used, then one or both of the repeaters will identify three minutes later. In this manner, the repeater is a "tail-end," and always gets in the last word (something that is very difficult for one of us mortals to do on the repeater).

Commands 8, 0, and # are the commands which do not exit the command mode immediately. Command eight is the ID load command. This loads ID #5 into memory. It does not change the specification of which ID is to be used. After entering the eight, and dropping carrier to hear the "R", the load program is waiting for further instructions. The ID is loaded in a character-by-character fashion. Dits are zero, dahs are one. The characters are loaded in the same as they are in Morse. For instance, take the letter "F". This is di-di-dah-dit, corresponding to 0,0,1,0. To enter "F", then the sequence should be 0,0,1,0. When the letter is entered, enter a 2 to signify that that letter is done. Continue loading characters in this manner. A 2 entered with no zeroes or ones will automatically be translated into a space. When the entire message has been entered, a 3 signifies that you are

equipment is General Electric MASTR. This includes the voting selector, receivers, transmitters, and control shelves. The voter has two outputs: the COS line and the audio output. The COS (carrier operated switch) is low when an incoming signal is present. This is at a transistor level, and, actually, we added single transistor inverters in several places throughout the system to interface the various components exclusive of the control system. All audio lines in the system are balanced. The control system is

designed for balanced lines; therefore, it will work with both balanced and unbalanced lines. If you use unbalanced lines, be certain to keep track of the hot and cold ends so that they match up. There are select and disable lines driving the voter. These lines are active low. The control system provides a ground when commanded; otherwise, the select and disable lines are open.

The 440 control receiver has the COS and audio lines the same as the voter. Additionally, Private Line™ or Channel Guard™ subau-

dible tones may be required to unscquelch it. This "PL" enable line requires a ground when it is desired to place the receiver into the PL mode.

The two meter repeater is connected to its control shelf (standard MASTR equipment) in the ordinary fashion. The PTT (push-to-talk) line is just that. The PTT interfaces with the rest of the system only through the control system. It is used for two purposes: to keep the transmitter on the air during IDs and to see if

the repeater has timed out. The control shelf provides the three-minute timer and drop delay timer. The PTT line is disconnected from its normal feed. During normal operation, the control system reconnects the PTT and feed. The transmitter audio pair is the audio input to the transmitter. This is shorted out to block repeating of touchtones and is shorted with the same lines from the 440 transmitter for linkups. The "PL" audio input is any audio input

Command Codes

done. The repeater acknowledges this with an "R", and the ID load and command commands are exited. Normally, place a space at the beginning and at the end to make the IDs uniform. Always be certain that the ID load mode is left, or the controller will be waiting to receive a "3" before it resumes its normal functions. After loading a message, you should select ID #5 and either wait to hear it or reset the ID timer to hear it to verify that it received what you think it did. After loading and verification, the desired ID mode can be set (either 5 or 7).

Command zero is the most powerful command, and it is through it that positive control is established. After releasing carrier and hearing the "R", the output mode is entered. In this mode, the repeater is waiting for three digit codes specifying which output bit to change. There are 64 bits arranged as eight eight-bit ports. Port 0 is a dummy port; it has no output lines and is used to disable the user functions. Port #1 is used by the indirect commands and is not normally used in the output mode. Ports #2 and #3 are enable functions. Port #4 is completely spare, port #5 is voter receiver disable, port #6 is voter receiver enable, and port #7 controls the touchtone generator. For ports #5 and #6, the bit number is the receiver number. This leaves room for eight receivers with no changes necessary. The normal configuration is all ports zero. This gives an ungrounded condition on the voter and spare ports. The three digit sequence for the output mode is XYZ, where X is the port number, Y is the bit number, and Z is either 0 (normal) or 1 (asserted). After each output sequence, the output routine acknowledges with an "R" if the command is valid. Invalid commands would be 831, 690, 300, 236, for obvious reasons. After each sequence, the output routine waits for further commands until a * is sent. The repeater sends an "R" to this and output and command modes are exited. For example, to turn off 67: enter command mode (6*#, #*6), 0, (output mode), 281 (turn it off), * (exit command).

Command # permits loading of the telephone number stored for the single digit #1. Simply send the telephone number followed by a *. An "R" acknowledges loading and exits command mode.

Always be sure that you have left the ID load, output, and load telephone number modes. If the repeater IDs, you have. This is true for all commands. A useful command to execute before ending a control session is the reset timer command, to hear the ID which guarantees that all is OK.

1#1 - 150/450 link
2#2 - Tape loop
3#3 - Disable blocking until carrier drop
4#4 - Touch Tone (R) Test
5#5 - Repeat 4#4 or autopatch number
67# - Autopatch

2*2 - Tape
9#5 - Remote base

6*# - Command mode
#*6 - Confirm command mode

After in command mode:

1 - Select ID #1: " DE WR3AFM BARC "
2 - Select ID #2: " DE WR3AFM BALTIMORE "
3 - Select ID #3: " 73 DE WR3AFM "
4 - Select ID #4: " DE WR3AFM BALTO ARC "
5 - Select ID #5: programmable through command 8
6 - Rotate through IDs 1 through 4
7 - Rotate through IDs 1 through 5
8 - Load ID #5:
0 - Dit
1 - Dah
2 - End character
3 - End load mode
9 - Reset all outputs and modes to normal operation
0 - Output mode:
XYZ - Port X, Bit Y, Output Z (exit output mode with *)
* - Reset ID timer (first repeater up IDs)
- Load single digit #1 telephone number (exit with a *)

Output Ports:

Port #0
1 - 1#1 disable
2 - 2#2 disable
3 - Direct autopatch enable
4 - 4#4 disable
5 - 5#5 disable
6 -
7 -
8 - 2*2 disable

Port #1 - DO NOT USE

Port #2

1 - Beep disable
2 - Control receiver PL enable
3 - 150 Touch Tone (R) disable
4 - Telephone Touch Tone (R) disable
5 - Control Touch Tone (R) disable (when absolutely necessary)
6 - Autopatch disable
7 - 450 Repeater disable
8 - 150 Repeater disable

Port #3

1 -
2 -
3 -
4 -
5 - DO NOT USE
6 - Timer disable
7 - DO NOT USE
8 - DO NOT USE

Port #4

1 -
2 -
3 -
4 -
5 -
6 -
7 -
8 -

Port #5 - Voter disable

1 - Receiver #1 (Charles Street)
2 - Receiver #2 (Cub Hill)
3 - Receiver #3 (K3VC)
4 - Receiver #4 (WRBS)
5 - Receiver #5
6 - Receiver #6
7 - Receiver #7
8 - Receiver #8

Port #6 - Voter select, bits same as port #5

Port #7 - DO NOT USE

which is not affected by the normal talk audio. It is used for the CW ID tone. The CS COS (control shelf COS) will key the transmitter when grounded. This goes through the two timers in the control shelf and drives the PTT feed. The CS AUD (control shelf audio) pair goes through line amplifiers and compressors to drive the transmitter. This is normally connected to the voter audio output. The RUSOS lead is a lead which, when grounded, keeps the

transmitter on through the timers. A ground on the RUSOS lead will not feed back on the CS COS lead. The RUSOS lead is grounded for autopatches. The DUPLEX AUD is a bidirectional audio path. It is labeled "AUD" on the rear of the control shelf. When the CS COS is low, audio exits from the DUPLEX AUD lead. If +10 volts is placed on the AUDIO GATE line, audio placed on the DUPLEX AUD pair will be fed to the transmitter. This is used to place

telephone line audio on the air. When the DISABLE TIMER lead is grounded, the three-minute time-out timer is bypassed and the repeater will not time out. This is used during emergency telephone calls. The time-out timer is on the input, not the output of the repeater. Between each transmission, the timer resets. It is not necessary to let the repeater carrier drop. However, when the "beep" is active, a fraction of a second after the input signal disappears, the

repeater will beep. The FORCE TIMER line, when grounded, makes the control shelf believe that a signal is present even if it is not. This is used so that when the "beeper" is enabled, not waiting for the beep will not reset the time-out timer.

The connections for the 440 repeater use the same definitions as the 150 repeater. There is a separate interface for that repeater which provides an autopatch on a second telephone line. That is not

—Correction—

Yaesu FT-227RA

The product review of the Yaesu FT-227RA in the January issue of 73 incorrectly states that a conversion kit is available through Yaesu. There is no conversion kit available.

of importance when interfacing with the control system, except that the autopatch logic includes a 1#1 output function so that when that code is sent, the LINK line is grounded. This permits linking up the repeaters from the 440 end.

The telephone line interfaces with the control system and is switched properly by it. In this system, the telephone company interface device is at a member's house. There is a

dedicated line from his house to the repeater site. The audio and a reversing dc voltage are on the single pair, and its operation will be described later. If the telephone company interface device is to be located at the repeater, all of the necessary signals are present in the control system to handle it and it would be simpler than our arrangement. There is a tape recorder connected to the line during autopatches, and the recorder is located at the member's house rather than at the repeater. This allows changing tape easily.

There are various subassemblies in the control system. Rather than building everything from scratch, we used good quality commercial units where possible. There are three audio amplifiers. Two are used for the telephone line and one for

driving the touchtone decoder. The amplifiers are IT&T K227s. They are balanced input/output, 600 Ohm. The gain is variable from -5 to +36 dB, and they each draw 18 mA from a 16- to 24-volt supply. Similar amplifiers should not be too difficult to find, or a few op amps should do the trick nicely. The touchtone decoder is an IT&T K-247-B. It is normally 600 Ohms and is modified for 10k audio input impedance. The digit lockup is disabled. The decoder has 13 outputs: one for each of the 12 digits and one which detects any valid touchtone (VTT). Each of these lines is normally open and goes low when active. Any decoder may be used which follows these conventions, but beware of 567-type decoders which do not employ high/low audio group filtering. I en-

courage the use of commercial decoders. Lacking that, be sure to test homemade ones extensively. While the microprocessor is the brain of the system, the decoder is the heart of the system.

A standard touchtone pad is included to facilitate controlling the repeater when at the repeater site.

The tape loop is a Mohawk Message Repeater. This is an antique vacuum tube device which could certainly be replaced with a newer piece of equipment. When one pair of wires is shorted, it activates the tape. While the tape is running, an output pair is shorted. Any cartridge-type machine should be suitable, and a standard 8-track player could be modified for this use. The tape must turn itself off when completed. ■

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