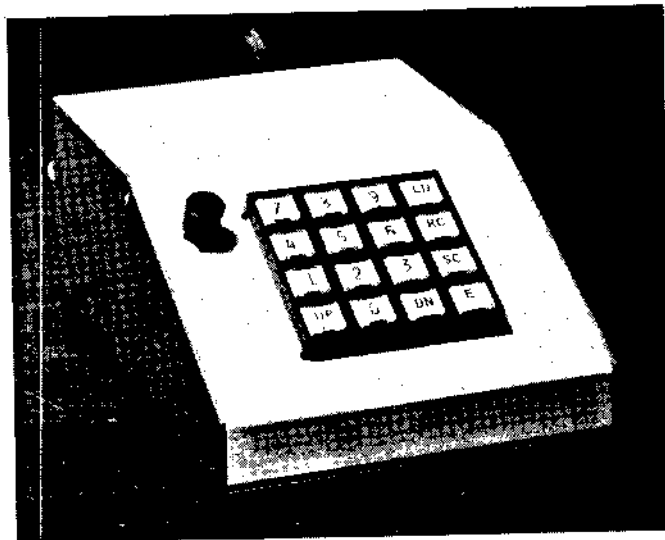


A Three-Chip Microcomputer for Your Station



Been thinking of computer-controlling your synthesized radio equipment? Here's a microcomputer you can build — and the three ICs cost less than \$20!

By Glenn Willman,* N2GW

Up till now, most microprocessor-oriented articles have shown how to interface various commercially available mini/microcomputers to certain pieces of amateur equipment. This is great if you happen to have purchased that particular system. The material may be fun to read and dream about, but how long will it be before you own your own computer system?

A microprocessor (μ P)-based controller in the shack has a variety of uses. Fig. 1 shows one possible configuration: an interface to a synthesized vhf/uhf radio. The 16-key pad can control frequency selection and up to five other programmable functions. Provision can also be made, for example, to handle scan interrupt on busy or clear channels.

Assume that you need to control the MHz units, and 10s and 100s of kHz selection, of a synthesized vhf/uhf radio (the 0/5-kHz switch could be used as is). Four

output lines for the BCD code and three lines for the counter latch control are required. To expand this to a synthesized hf radio, an additional line would be used so that four inputs to the synthesizer could be had: units, 10s and 100s of kHz, and 100s of Hz, with the MHz decision being determined by the band-switch circuit.

System Configuration

The Micro-3 is designed around a 6802 8-bit μ P. This μ P is identical to the 6800 with respect to the instruction set, but advantageously has 128 bytes of on-chip RAM, and a clock generator, requiring only the addition of an external crystal (4 MHz maximum) and a power supply for operation. System program memory is in EPROM for design flexibility. A 2516/2716 (single-voltage supply $2K \times 8$) EPROM is used, which most likely will provide more program memory than required. A single-voltage supply 2508/2708 ($1K \times 8$) could be used, but the 2516 is now cheaper and more readily available than almost all other EPROMs.

The I/O functions are handled by a 6821 PIA (peripheral interface adapter). This IC is identical to the older 6820 PIA, but has TTL interface capability on both A and B registers, and is also more readily

available. A block diagram of the system is shown in Fig. 2.

Micro-3 has memory partitioned as follows: RAM is fixed and must be located at 0000 to 007F; program instructions are written in EPROM starting from 1000. Address decoding for the EPROM is simplified by doing this, since address line A12 can then be used to chip select (CS) the EPROM. The VMA (valid memory address) line from the 6802 is NAND'ed with line A12 to ensure correct timing of the EPROM enable. One NAND gate is required for this, and two other NAND gates are used to debounce the reset line for the 6802 and 6821. The I/O PIA is located at 8000 to 8003; therefore, no decoding is necessary for PIA chip select, since address line A15 is connected to the PIA CS input and address line A12 is connected to the \overline{CS} input.

Assembling the Micro-3

The Micro-3 was built initially on a small wire-wrap pc board, allowing generous foil areas for ground and power connections and thus permitting future changes or additions. The data and address lines were wire wrapped. This method works well and has the advantage of flexibility.

*612 Auth Ave., Ocean, NJ 07712

Once the circuit was debugged, a pc board was designed. No special provisions are necessary, but the more grounding, shielding and bypassing you include the less the potential for EMI. With both the wire-wrap and pc-board versions, there has been minimal EMI generated and the unit is not sensitive to rf energy. The system requires a regulated 0.4-A, 5-V supply. A 5.6-V Zener diode across the supply line helps protect against power supply transients during on/off switching.

The IC-701 Micro-3 System

The IC-701 synthesizer and control cir-

cuity accept a modified BCD code input and perform data latching, so only six output lines are required to load four frequency selection units. Two other PIA output lines are used to control up/down tuning, since inputs for these signals are already located on the '701 accessory connector.

The required frequency input data format consists of a load bit followed by five parallel input data bits for each of the four digits to be entered. The digital data must be entered sequentially, starting with the 100s kHz position and ending with the 100s Hz position. This format is shown in

Fig. 3. Each channel or frequency consists of five time slots with each data bit being approximately 350 μ s long and having an off time of approximately 350 μ s between data bits.

Fig. 4 shows all the interconnections between the μ P, the EPROM and the PIA. The 6821 PIA A register is programmed as the output register (pins 2 to 9), and the B register (pins 10 to 17), programmed as the input register, acts as a keyboard interface. The interface to the A and B registers of the PIA is shown in Fig. 5. Those resistors on each of the B register lines are terminations used to eliminate in-

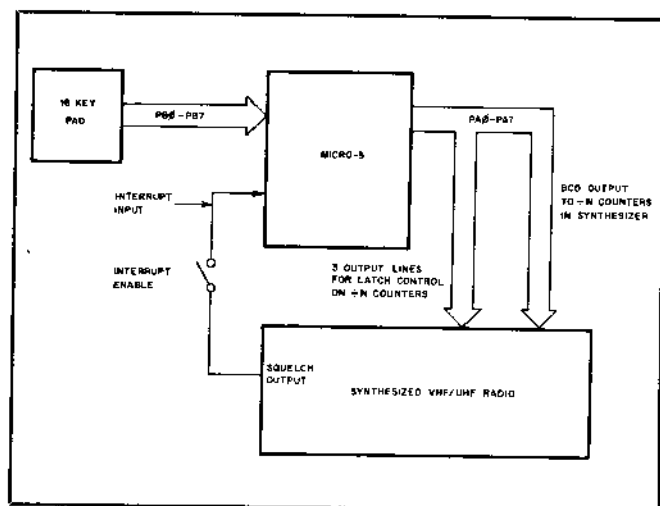


Fig. 1 — A microprocessor-based controller may be used as an interface to a synthesized radio.

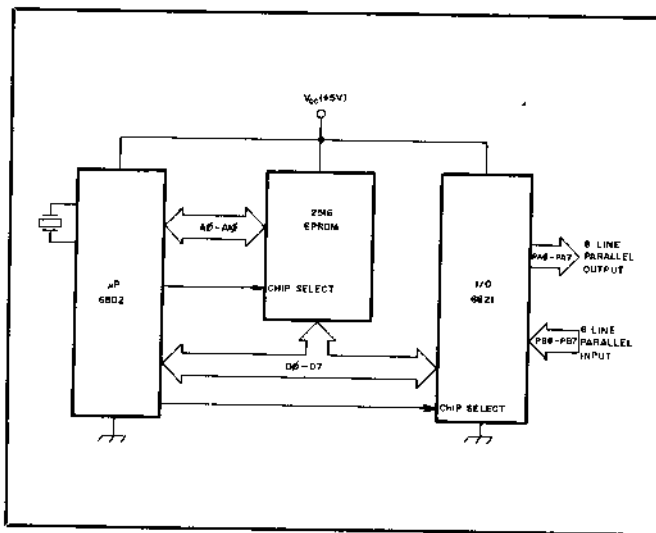


Fig. 2 — Block diagram of the Micro-3 system.

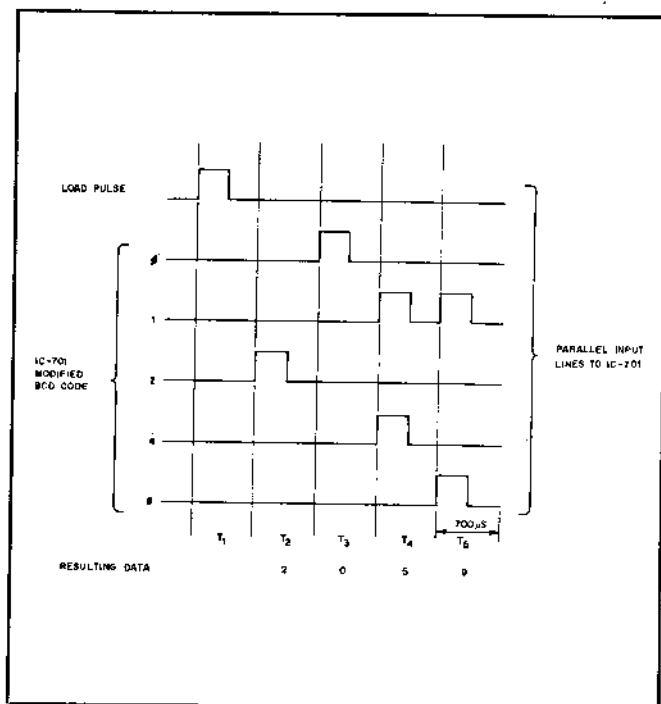
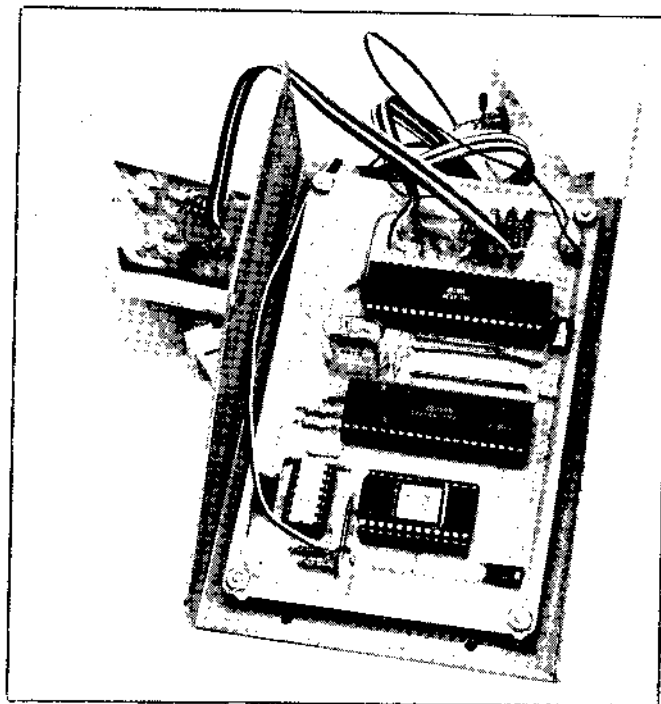
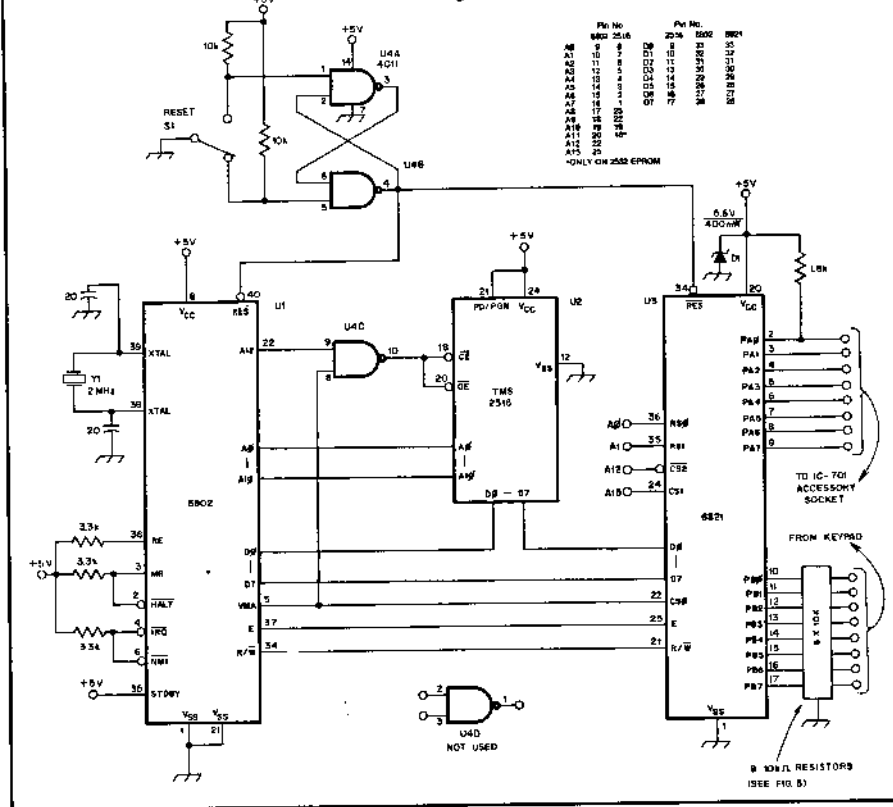


Fig. 3 — Frequency input data format used with the Micro-3 and an ICOM IC-701 transceiver.



This inside view depicts the neat simplicity of the Three-Chip Microcomputer.

Fig. 4 — Wiring diagram of the Micro-3 system.



put line stray-signal pickup that could be interpreted as keyboard signals. The B register will interface to any 4 × 4 matrix switch arrangement (two of eight connect), and the keyboard routine for the IC-701 program is robust enough to debounce most anything. A 1.8-kΩ pull-up resistor on line PA0 (pin 2) of the PIA is necessary because the internal load in the '701 is slightly more than the drive capability of the PIA.

The IC-701 Program

Since my ICOM IC-701 accepts frequency-control information in a different format than the traditional divide-by-N, multiple-counter type of synthesizer, the software developed initially for the Micro-3 was tailored specifically for that rig.

The program functions are divided into separate subroutines, each responsible for performing a distinct operation. Essentially, the main program waits with a keyboard scanning routine until one of the six function keys is activated. Then it decides which subroutine to access, and the selected subroutine takes over from there. Fig. 6 is a simplified flow chart of the procedure.

Operation of the IC-701/Micro-3 is simple, and the key strokes are explained

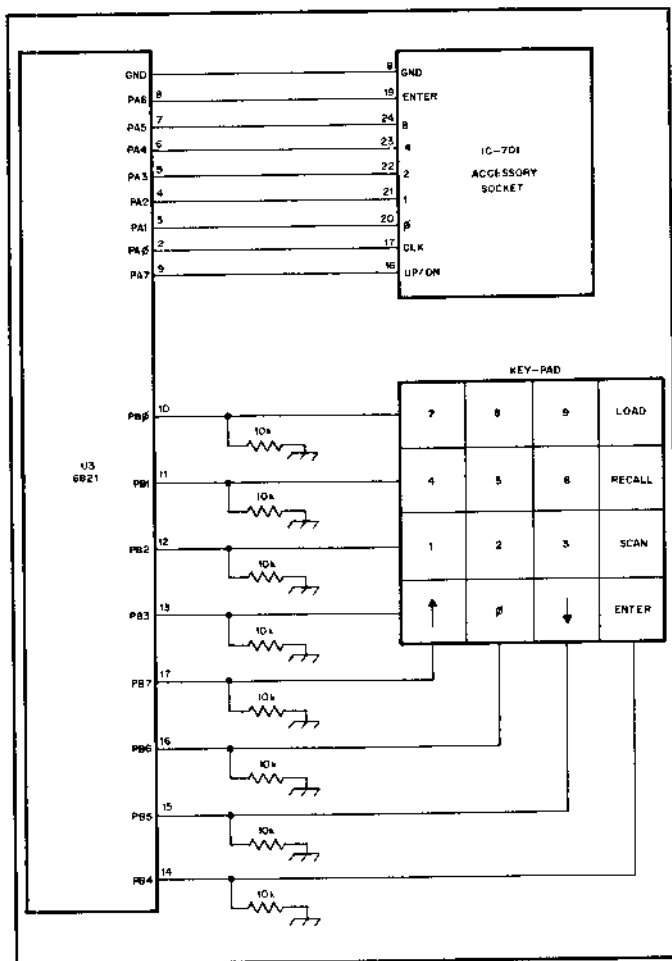


Fig. 5 — PIA A and B register interfacing.

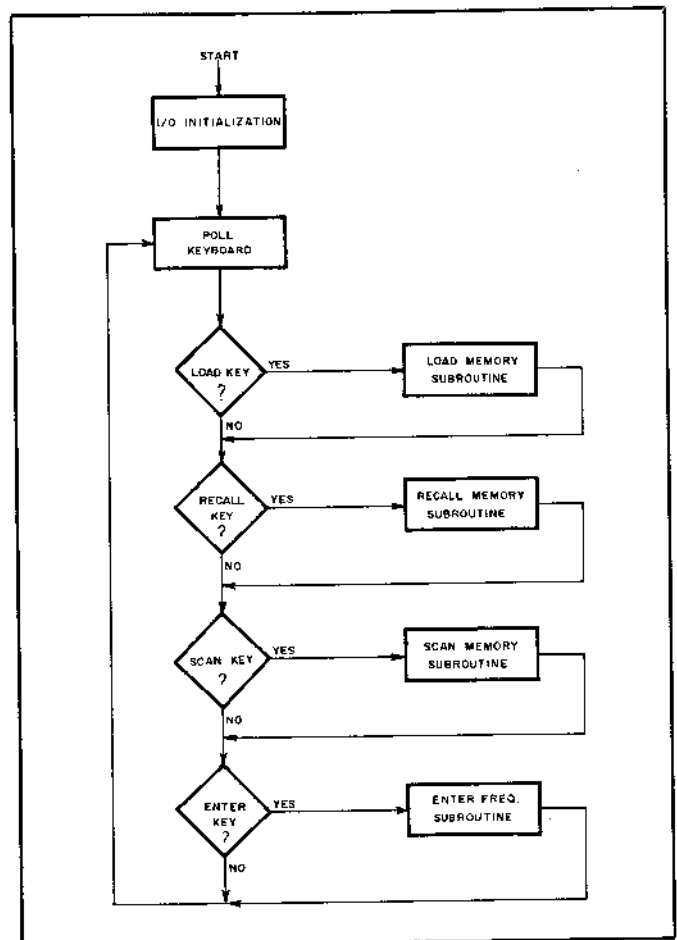


Fig. 6 — Simplified flow chart of the Micro-3 program designed for use with the IC-701 transceiver.

Table 1

Keypad Functions

Key	Operation
LOAD	Used for keying in memory locations and frequency to be stored. LOAD 12049 stores 204.9 kHz in memory 1.
RECALL	Recalls frequency stored in a particular memory. RECALL 5 recalls the frequency stored in memory 5.
SCAN	Used to select memory channels to be scanned. SCAN 15 permits scanning memories 1 through 5, and repeats. The lowest memory number must be entered first. An entry such as SCAN 51 will initiate scanning memories 5 through 9 and proceed into invalid RAM; the RESET key may be used to stop the scan function.
ENTER	Permits direct four-digit frequency input. ENTER 2049 enters 204.9 kHz. Initiates up or down incremental tuning of the radio. Pressing either key again will stop the tuning.
RESET	Used to stop any of the above functions, and does not alter memory information.

Table 2

Program Listing (Used with the IC-701)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1000	8E	00	7E	7F	80	81	7F	80	83	86	F8	87	80	82	86	FF
1010	87	80	00	86	84	87	80	81	87	80	83	CE	80	84	DF	00
1020	8D	10	51	96	84	81	11	26	83	BD	10	83	81	12	26	83
1030	BD	10	94	81	14	26	83	BD	11	AA	81	18	26	83	BD	10
1040	A3	81	28	26	83	BD	11	4C	81	88	28	CF	BD	11	46	20
1050	CA	86	10	B7	80	92	CE	84	FF	89	26	FD	F6	88	8A	0F
1060	02	CA	F0	C1	F0	26	87	49	81	80	27	E5	80	E5	8A	0F
1070	97	83	D4	83	DE	80	E7	80	88	DF	80	F8	80	82	D1	82
1080	27	F9	39	CE	80	84	DF	80	BD	10	51	BD	11	DE	DF	80
1090	BD	11	39	39	CE	80	84	DF	80	BD	10	51	BD	11	DE	BD
10A0	10	B4	39	CE	80	84	DF	80	BD	11	30	CE	80	84	DF	80
10B0	8D	10	B4	39	C6	83	86	40	B7	80	80	86	20	4A	26	FD
10C0	86	80	B7	80	80	86	20	4A	26	FD	86	80	80	86	20	4A
10D0	86	80	86	86	20	4A	26	FD	86	80	80	86	80	86	20	4A
10E0	26	FD	C1	80	27	83	5A	20	E1	39	81	48	26	83	86	82
10F0	39	81	84	26	83	86	84	39	81	44	26	83	86	86	39	81
1100	24	26	83	86	8C	39	81	82	26	83	86	19	39	81	42	26
1110	83	86	14	39	81	22	26	83	86	18	39	81	81	26	83	86
1120	1C	39	81	41	26	83	86	20	39	81	21	26	82	86	24	39
1130	4F	97	88	BD	10	51	96	80	4C	97	80	81	84	26	F4	39
1140	86	80	97	80	86	81	97	80	BD	11	58	39	86	80	97	80
1150	86	81	97	80	BD	11	58	39	96	80	87	80	80	BD	11	76
1160	96	8A	87	80	BD	11	76	BD	11	70	C1	88	27	86	C1	87
1170	28	27	82	20	E3	39	CE	86	80	80	26	FD	39	86	10	B7
1180	80	82	CE	83	80	80	26	FD	F6	80	82	CA	F0	C1	F0	26
1190	87	49	81	80	27	13	20	E7	8A	8F	97	83	D4	83	D7	83
11A0	F6	80	82	01	83	27	F9	D6	83	39	CE	80	84	DF	80	BD
11B0	10	51	BD	11	DE	DF	86	CE	80	84	DF	80	BD	10	51	BD
11C0	11	DE	DF	86	DE	86	BD	10	B4	DF	8A	BD	12	2A	DE	8A
11D0	9C	88	27	82	20	F0	BD	10	84	BD	12	2A	20	E6	96	84
11E0	CE	80	8C	81	48	27	42	CE	80	10	81	84	27	38	CE	80
11F0	14	81	44	27	34	CE	80	18	81	24	27	2D	CE	80	1C	81
1200	82	27	26	CE	80	20	81	42	27	1F	CE	80	24	81	22	27
1210	18	CE	80	28	81	81	27	11	CE	80	2C	81	41	27	8A	CE
1220	80	30	81	21	27	83	7E	10	80	39	86	8C	CE	10	80	80
1230	26	FD	4A	26	F7	39	80	80	80	80	80	80	80	80	80	80
13FE	10	80														

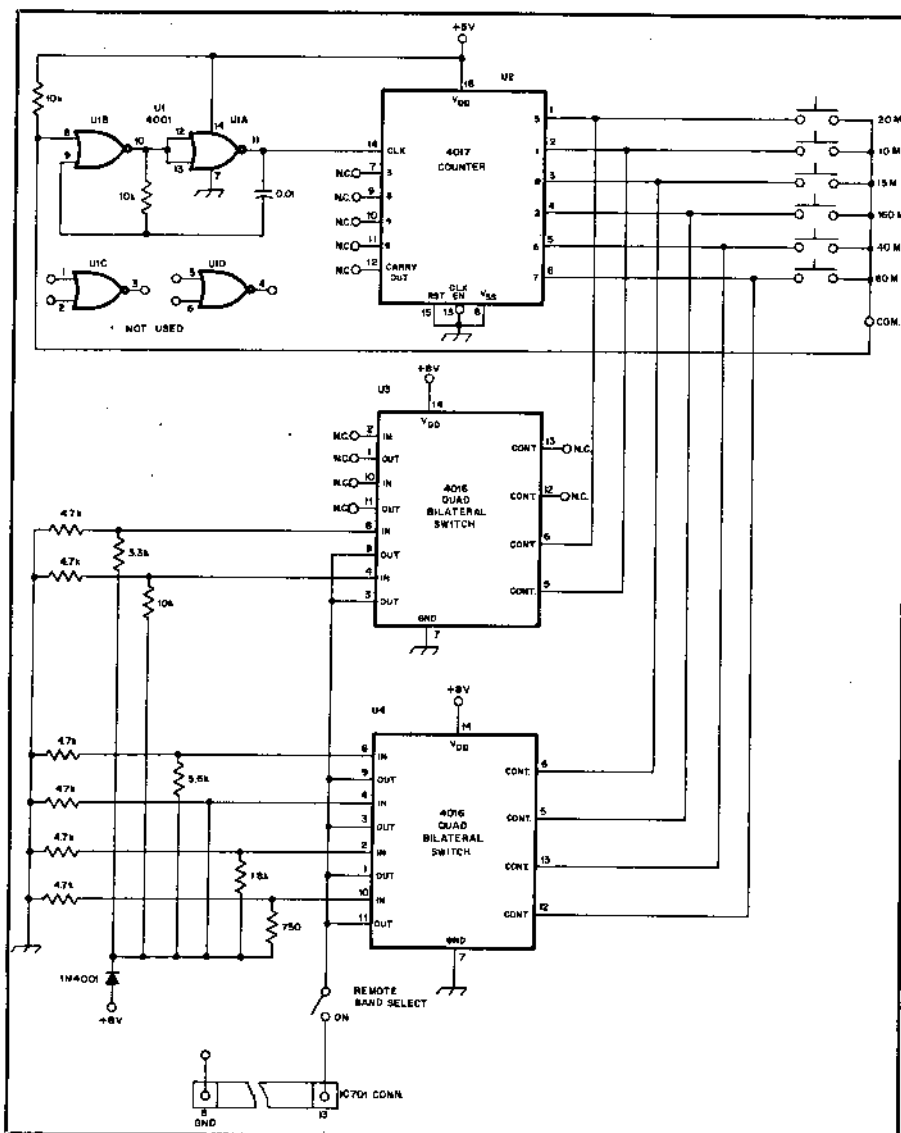


Fig. 7 — Schematic diagram of a push-button band-switching system employed by the author with his IC-701 transceiver. Resistance values are in ohms, k = 1000. Resistors are carbon composition or film, 1/4-W, 5% types.

in Table 1. A program listing is shown in Table 2. Using the LOAD key in sequence with 0 and four digits (i.e., LOAD 01111) will load a time-delay factor used in the scan mode. Using digits from the 9 column will provide about a 1.5-second scan delay; the 8 column, about 3 seconds; and the 7 column, about 6 seconds. Four digits must be entered for the delay factor to be used properly. An entry such as LOAD 09874 is valid, since the first digit (9) determines the scan delay (1.5 seconds).

Summary

I built an earlier version of this controller without the μP , which contained a relatively simple circuit for push-button band switching. This could easily be included for a fully functional digital-control system. The schematic diagram is shown in Fig. 7.

I hope the ideas presented here encourage some experimentation by novice μP users and allow others to use the 6802 system design for their μP -based project that has been waiting on the drawing board. For those interested in using the Micro-3 system described here, a kit is available from the author that includes a drilled and plated pc board, all ICs and sockets, for \$38 postpaid. If you are interested in obtaining the IC-701 program, the same kit with a programmed EPROM is \$43.¹

¹The ARRL and QST in no way warrant this offer.

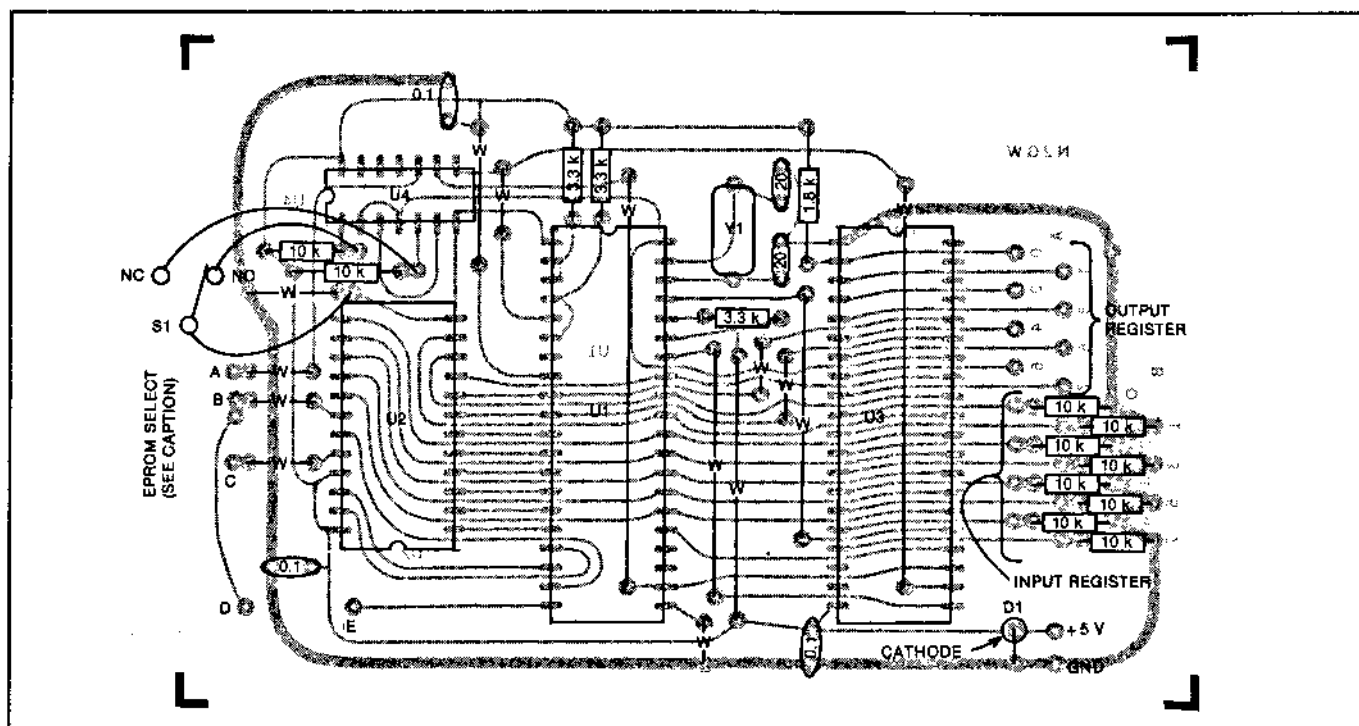


Fig. 8 — Parts-placement guide for the Three-Chip Microcomputer. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. (The etching pattern appears in the Hints and Kinks section of this issue.) Resistances are in ohms; k = 1000. Capacitors with whole-number values are in picofarads. Capacitors with decimal-value numbers are in microfarads. W = wire jumper. With 2508 or 2516 EPROMs, jumper A to B and B to C. For 2532 EPROMs, jumper A to C and D to E.

Strays

ATTENTION AFFILIATED CLUBS

☐ All affiliated clubs who have not filed an annual report between January 1 and June 1, 1982 are delinquent. Contact the Club and Training Department if your club has *not* completed a 1982 form or needs a copy. — Sally O'Dell, KB1O, Club Program Manager, ARRL

WESTLINK EAST

□ The Metroplex Amateur Communications Association of Leonia, New Jersey, is providing the only East Coast telephone outlet for the Westlink Radio Network. To hear the latest news on amateurs' activities, FCC decisions and local antenna rulings, call 212-224-1555. To contribute news to Westlink, call 805-251-7180. — *Hank Goldman, W4ZOVG*

NEW MICROWAVE FET

□ General Electric Company scientists have developed a MESFET field-effect transistor (silicon-on-sapphire metal semiconductor) that provides a 6-dB gain with 50% efficiency. It delivers 0.6 watt at 3 GHz. The manufacturer states that this

transistor has the highest efficiency yet achieved by a silicon device at 3 GHz. The MESFET is intended, apparently, for use in MICs (monolithic microwave ICs).

Researchers are striving to develop devices with greater gate lengths (the present unit has a gate length of 1 μm). This should make it possible to produce several watts of power at 50% efficiency. GE contemplates expanding the use of silicon devices to 4 GHz. These developments offer promise to amateurs who are involved with microwave circuit design and communications. The principal scientists in this technological advance are Dr. John Eshbach and Dr. Se Puan Yu. — *Doug DeMaw, W1FB*

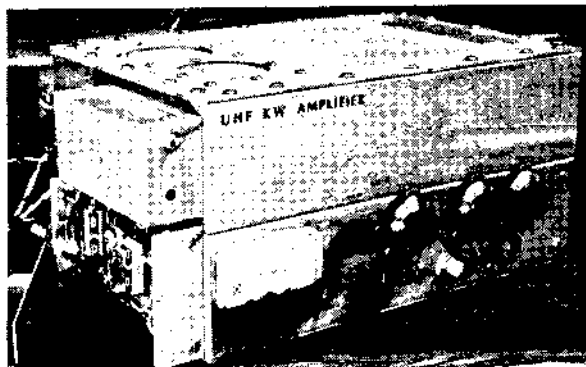
ELMER OF THE YEAR NOMINEES SOUGHT

□ Nominations are being accepted for the 1982 Northern New Jersey Elmer of the Year award. Sponsored by the Northern New Jersey chapter of the Quarter Century Wireless Association, the award is given each year to the radio amateur who is judged to have done the most to help others become Amateur Radio operators. Nominations must be received on or before September 1, 1982. For more information, write to or call Carl Felt, N2XJ, 8 Charles Place, Chatham, NJ 07928. tel. 201-635-7686.



Members of the Radio Society of Great Britain soon will be able to "visit" ARRL/RSGB Headquarters, thanks to the efforts of RSGB General Manager David Evans, G3OUF. David carried a complete videorecorder system "across the pond" in late April to chronicle his trip to the Dayton Hamvention and to Newington. Unfortunately, we weren't able to preview the tapes, because European and American television standards are different and the RSGB equipment is, of course, made to the European standard!

The Care and Feeding of Linear Amplifiers for ATV



Your amplifier doesn't like to be fed ATV signals? Careful grooming will give it a healthy appetite for this delectable mode!

By Tom O'Hara,* W6ORG

The increased availability and affordability of video equipment has helped account for the growing number of fast-scan ATVers. Microcomputers, video cassette recorders, color cameras, and video Teletype and cw converters have encouraged hams to want broadcast-quality, real-time pictures. Just receiving a snowy, black-and-white call-letter plate from 40 or more miles away is "old hat." Emphasis today is on getting good-color, snow-free pictures with which to play computer games, coordinate public-service events, or show the latest home movies or videotapes.

Once your 10-watt ATV station is working well, and all the antenna and tower height the wife and neighbors will allow have been put up, thoughts turn to more power. This article covers trade-offs between transistor- and tube-type amplifiers, gives test results of three popular transistor amplifiers, and discusses system considerations to enable you to decide which suits your needs best.

Tubes vs. Transistors

What is the difference between a tube amplifier and a transistor amplifier? Watts are watts, aren't they? Well, if you are using fm or cw, it may not matter. With ATV you need to reproduce the video without degrading the linearity, video-to-sync ratio, or bandwidth (to the point of poor contrast), tearing or jittering, or lack of sound and color. With a-m, the choice of amplifying device must

be made with these characteristics in mind, or results can be disappointing.

Let's consider bandwidth first. Uhf power transistors are low-impedance devices (input and output impedances are often around 1 ohm), while tubes have much higher impedances, in the thousands of ohms. This high impedance dictates input and output loaded Qs that limit bandwidth. It also determines the level of sound and color subcarriers, and resolution. Transistor loaded Qs are often below 10 because of the relatively high resistive- to reactive-component ratios. These values determine the matching-circuit strip-line dimensions. Tubes, on the other hand, usually have high grid capacitance and lead inductance — the limiting factor in the values used to make a resonant circuit at 400 MHz. Grid Qs can end up being more than 75 in tubes, such as the 4X150, with all the matching tricks normally employed. In tube amplifiers of this kind, the grid is the major killer of resolution, color and sound. For this reason, many hams end up using their 10-W ATV rig as an rf driver and adding a high-power video modulator.

Linearity is a factor that enables tubes to fare better than transistors, so a trade-off is often considered between bandwidth, (favoring transistors) and linearity (favoring tubes). Tubes are linear up to the abrupt point of limiting in Class C operation, so you can expect good gray scale and little reduction of sync. With transistors, input-to-output gain varies greatly, depending on the power-output level. Generally, the last 3 dB of output

increase takes more than 6 dB of input increase. Many hams like this characteristic for ssb because the soft limiting effect gives a higher average power, termed "talk power." Voice recognition suffers little from the peak distortion, and it does improve the signal-to-noise ratio. With video, you must have the sync to enable the TV set to sweep correctly and give a stable picture. Since the sync tip is transmitted at peak envelope power, a transistor power amplifier can compress the sync amplitude to half or less, giving a jittery, torn or rolling picture in the TV. A rule of thumb for using power transistors in the linear mode is to set the peak envelope power at half the manufacturer's rating. For instance, a Motorola MRF648 is rated at 60 W and should be run at 30-W PEP for ATV.

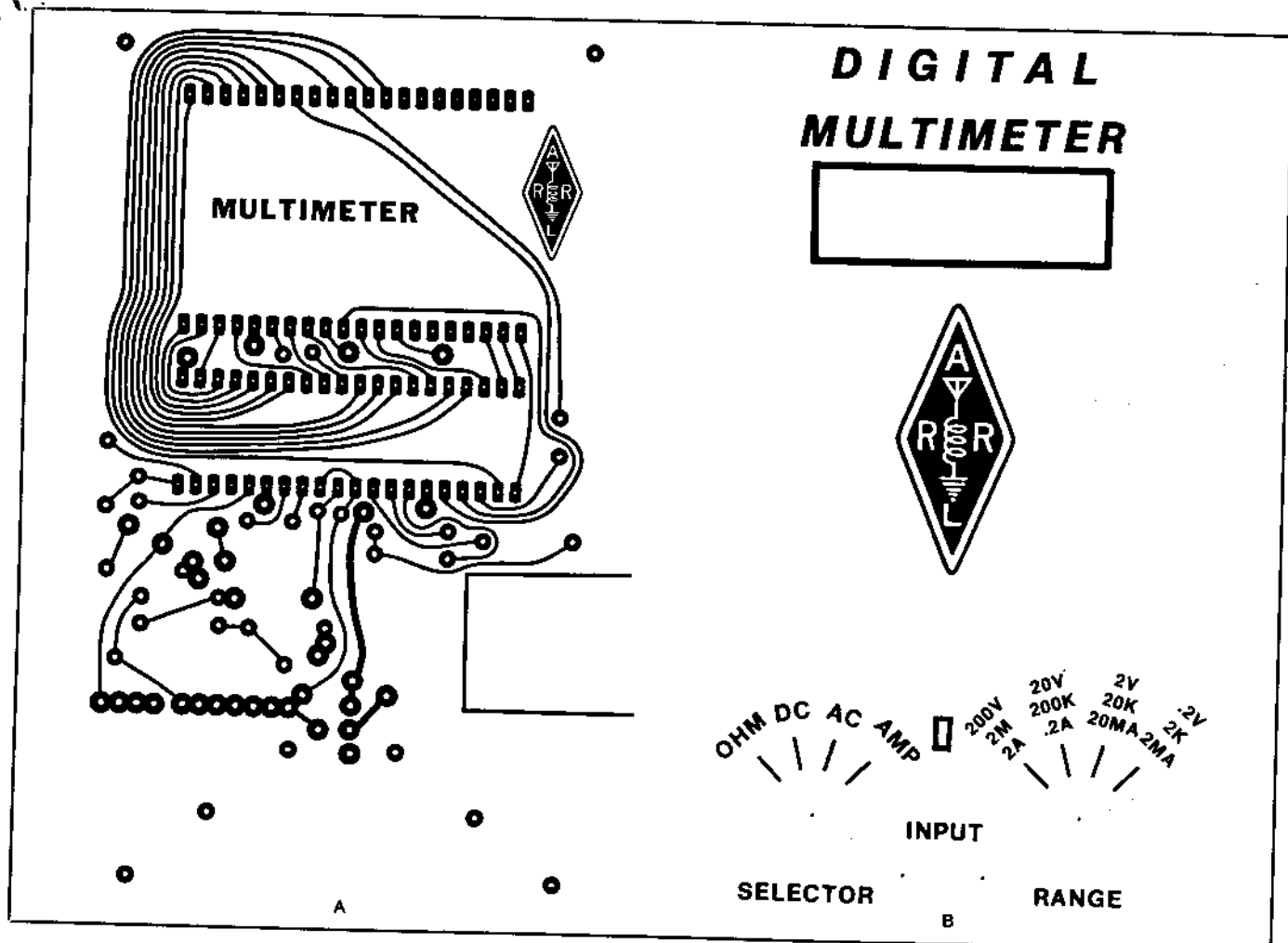
I ran tests using a video-processor amplifier, which enables setting the sync-to-video ratio at any level. Among six TV sets tested, all would lock up with the sync level cut in half. So, as a minimum, set 50% sync compression as the worst case, or 20 IEEE units out of 40. This varies with each TV model and assumes the camera is properly set with 40 IEEE units of sync and 100 units of video. More than 50% of rated PEP can be obtained by use of sync expansion, but more on that later.

Kilowatt ATV

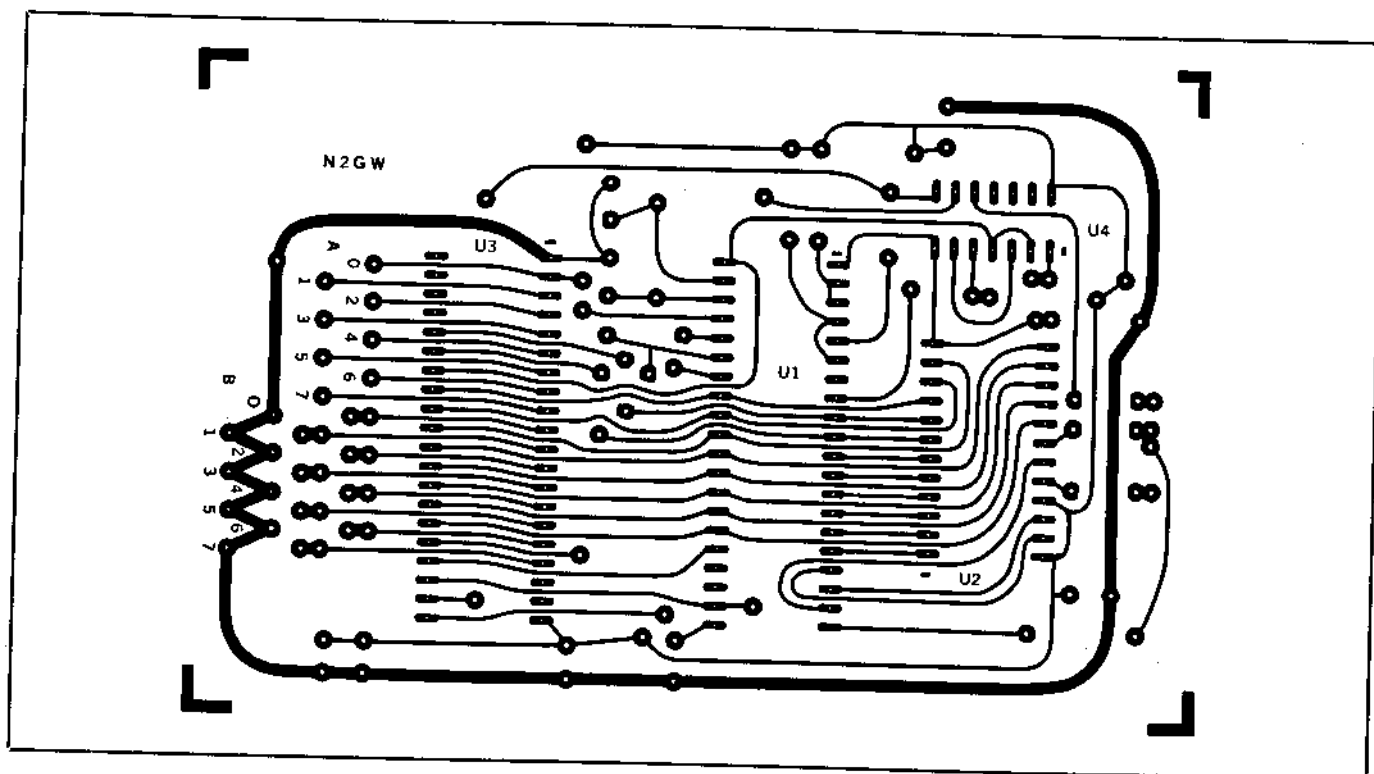
Before we turn to the three tested transistor amplifiers, a discussion of one of the popular tube amplifiers is in order. The K2RIW KW amplifier¹ is available in

*ARRL TA, Fast Scan ATV, 2522 Paxson La., Arcadia, CA 91006

¹Notes appear on page 28.



Etching patterns for the Digital Multimeter circuit board (A) and case front panel (B). At A the black areas represent unetched copper, viewed from the etched side of the board. At B the black areas represent etched copper. A parts-placement diagram appears on p. 33.



Circuit-board etching pattern for the Three-Chip Microcomputer (see the parts layout of Fig. 8, p. 23 of this issue). Black represents copper. The pattern is shown at actual size from the foil side of the circuit board.

Product Review

Conducted By Paul K. Pagel,* N1FB

ICOM IC-720A HF Transceiver

□ A compact, full-featured hf transceiver, the ICOM IC-720A covers all amateur bands from 1.8 through 30 MHz, including the 10-, 18- and 24-MHz WARC frequencies. It incorporates a general-coverage receiver tuning 0.1 through 30 MHz in 1-MHz segments. Cw, usb, lsb, a-m or RTTY (fsk) operation is selectable by front-panel push-button controls. The matching IC-PS15 ac-operated power supply provides 13.8 V dc at 20 A, and is connected to the transceiver by a 2-1/2 foot cable. The power supply is switched by the transceiver.

The review unit included the optional SM5 electret-condenser desk microphone with a built-in preamplifier (powered by the transceiver) and the optional FL-32 500-Hz cw filter. Other options available include the SP3 external speaker (the '720 has a built-in 2-1/2 inch round speaker), HP1 headphones, an MB5 mobile mounting bracket, a BC-10A memory backup power supply and an FL-34 a-m filter.

Among the features standard on the '720 are a digital readout, an rf speech processor, a VSWR indicator, receiver incremental tuning, a noise blanker, band-pass tuning, an rf attenuator, VOX with separate cw and ssb delays, a selectable tuning rate and two built-in VFOs.

Frequency Control

The IC-720A operating frequency is determined by a microprocessor-controlled phase-locked-loop (PLL) local oscillator. Tuning is available in 10-, 100- and 1000-Hz steps, selectable from the front panel. Tuning in the 10-Hz-per-step mode is a bit slow (1 kHz per knob revolution), but it gets around the very noticeable frequency changes found in the 100-Hz-per-step mode. During normal operation, either the 10- or the 100-Hz setting is used, while a touch of the TS (tuning speed) button switches to 1-kHz steps for making larger frequency excursions. A dial-lock control locks the VFO at the displayed frequency, preventing unwanted frequency change through accidental operation of the tuning knob. Red LEDs indicate when the TS and the dial lock functions are in use.

One feature not found on most radios is the method of band selection. Instead of a conventional band switch, the '720A employs a multisection, motorized rotary switch controlled by front-panel push buttons. The band switch control circuit can be accessed remotely through a rear-panel connector. When power is first applied to the transceiver, the band switch steps around to 7.100 MHz (15.000 MHz in the general-coverage mode) from wherever it was when the rig was last turned off. The UP control will move the operating frequency to the next higher amateur band (10 MHz), while the DOWN button will move the frequency to the next lower band (3.5 MHz). In the general-coverage mode, the controls move the receiver frequency to the next higher (or lower) 1-MHz segment. Whenever the band is changed in the

HAM mode, the transceiver will always arrive 100 kHz up from the bottom of the selected band (3.600, 7.100, 14.100 MHz, etc.). In the GENERAL-COVERAGE mode, the frequency will move up or down exactly 1 MHz; for example, if you are listening on 16.372 MHz, a touch of the UP button will change the frequency to 17.372 MHz. The motorized switch is loud enough to wake family members sleeping in the next room, so beware of the late-night DX chasing!

The '720A incorporates two separate built-in VFOs, both controlled by the main tuning knob. Through proper operation of the front-panel push-button controls, the following arrangements are possible: transceive on VFO A; transceive on VFO B; receive on A, transmit on B; receive on B, transmit on A. The VFOs may be set to frequencies on different bands, but split operation (selected by the SIMPLEX/DUPLEX push button) is available only on the same band; the rig will not transmit on one band and receive on another. Another push button will automatically set both VFOs to exactly the same frequency, eliminating much knob-twirling when split operation is needed in a hurry, as when you stumble across that rare DX station who has just announced that he's listening "up 5."

The RIT control, activated by a front-panel push-on, push-off switch, will vary the received frequency ± 800 Hz. A red LED above the frequency display indicates when the RIT is activated. As the rig comes from the factory, the RIT will pulse off each time the main tuning knob is moved, but this feature can be de-

activated by an internal switch. Any receiver frequency change made with the RIT is *not* indicated on the display.

The displayed frequency does not change during transmit. In addition, indicators on the left-hand side of the display indicate which mode and which VFO (A or B) is in use. A thorough reading of the operating manual is encouraged because, in the GENERAL-COVERAGE mode and on the 28-MHz amateur band, the displayed frequency and actual operating frequencies are different at the band edges. For example, at the lower edge of the 15-MHz general-coverage segment, the display will read 15.000.8 in the lsb or cw mode, but the actual operating frequency will be 16.000.8 because of the way the frequency "rolls over" from 15.999.99 MHz at the high end and returns to 15.000.00 MHz on the display. By the same token, on the 28-MHz ham band, for a displayed frequency of 28.000.8 on cw, the transceiver is actually operating on 29.000.8. Don't be surprised if you hear ssb signals when tuning around the low end of 10 meters; they're perfectly legal ssbs operating around 29 MHz.

Receiver

The '720A uses a dual-conversion superheterodyne receiver with the first i-f at 39.7315 MHz and the second i-f at 9.0115 MHz. There are separate RF and AF GAIN controls. The PBT (passband tuning) control is moderately effective in eliminating adjacent-channel interference. Agc operation is selectable from the front panel. The slow or "normal" setting is intended for ssb operation, and features a



*Assistant Technical Editor