QEX 27 May 1984 $1

The ARRL Experimenters' Exchange

Third Packet Conference

The Third ARRL Amateur Radio Computer Networking Conference was held on April 15, with 100 packeteers in attendance. Printed copies of the conference proceedings are available via mail from ARRL Hq. for $10 each (10 to 49 copies at $7.75 each, over 50 copies, $7 each). It contains 124 pages of papers on various uses for packet radio as a hobby or as an emergency communications system. Also included is a complete copy of the CCIR Recommendation 476-3, which is the basic specification for AMTOR.

Here is a listing of the papers:

Title	Page no.
"Networking Considerations for the Amateur Packet Network," J. Gordon Beattie Jr., N2DSY	1
"The Eastnet Network Controller," David W. Borden, K8MMO	4
"HF Packets: Modems and Gateways," Robert E. Bruninga, WB4APR	6
"Eastnet: An East Coast Packet Radio Network," Robert E. Bruninga, WB4APR	8
"The Racing Problem: A Packet Solution," Robert E. Bruninga, WB4APR	12
"ISO Reference Model Review," Terry Fox, WB4JFI	16
"AX.25 Network Sublayer Protocol Recommendation," Terry Fox, WB4JFI	23
"Packet Formats of AX.25 Level 3 Protocol," Terry Fox, WB4JFI	30
"Optional Facilities for AX.25 Level 3 Protocol," Terry Fox, WB4JFI	38
"Annex A Through F for AX.25 Level 3 Protocol," Terry Fox, WB4JFI	44
"An Enchanced Terminal Node Controller," Lyle Johnson, WA7GXD	56
"Some Thoughts on AX.25 Level Two," Lyle Johnson, WA7GXD	61
"The OSCAR-II Packet Experiment," Lyle Johnson, WA7GXD	64
"A New Vancouver Protocol," Lyle Johnson, WA7GXD	68
"Working "Packet" on OSCAR 10," H. S. Magnuski, KA6M	77
"A Packet Radio Emergency Communications System," Bob Neben, K9BL	79
"An Application Note Describing A Low Power RS-232 Like Interface," Paul Newland, AD7I	83
"Q-Call," Paul Newland, AD7I	85
"Packet Radio Software Approach -- 1984 Onwards," Robert M. Richardson, W4UCH	88
"Packet Radio -- The 3rd Generation Software Approach AX.25 Protocol," Robert M. Richardson, W4UCH	90
"A Mini-Sized Bulletin Board System Possible Standard for Packet Radio," Robert M. Richardson, W4UCH	109
"Keyboard Input Message With Automatic Switching in Connected Mode and Return for Packet Radio Using Software Approach," Robert M. Richardson, W4UCH	119
"Adding Multiple Repeater Capability to Packet Radio Using the Software Approach AX.25 Vol. 2," Robert M. Richardson, W4UCH	122
Appendix	
"Direct-Printing Telegraph Equipment in the Maritime Mobile Service," CCIR Recommendation 476-3	125

Correspondence

An Optional Program Change for the Sinclair BASIC Program for Pi-L Networks

One note about my program appearing in the March 1984 issue of QEX (no. 25): Once this program is entered into the computer, it will run properly. However, purists will insist that line 125 should read, "GOTO 280." - R. W Knaack, Jr., W7FGQ, 11415-28th S.W., Seattle, WA 98146.

Satisfied Customer

I have just returned from Japan where I purchased a Sony ICF-7600D. According to a San Diego distributor, this model is identical to the Sony 2002. As you have commented in QEX, it is a good receiver with many possibilities.

Thank you for the reference in the February QEX on the schematic. I look forward to seeing any articles on the 2002 used in Amateur Radio applications. If I develop any unique modifications or uses, I will pass them along. - Richard W. Doering, WA6CFM, 1037 Cornish Dr., San Diego, CA 92107.

M²I²UC Membership Expands

I just read of KB2M joining the M²I²UC, (Sony ICF-2002 Users' Cult) February 1984 QEX, (no. 24), and I am happy to say that I will qualify for membership soon! I'm looking forward to it.

The Sony 2002 looks like a great set from what I've seen. I have also viewed the ICF-2001 and can't imagine the new one! Keep up the good work. - Hank L. Schultz, Jr., KA3GXP, 610 Young Rd., Apt. 1, Erie, PA 16509.

A Time-Stretcher for the Handicapped

Here is a "time-stretcher" circuit that I use for helping handicapped students. A slight switch operation is expanded to provide a "bio-feedback" response.

The relay used is a Radio Shack SPDT sensitive mini relay. Test results are:

Battery(V)	C(uF)	R(Ω)	RY(Ω)	Time Hold(s)
9	2000	0	500	4
9	470	0	500	1
9	1000	0	500	2
9	4700	0	500	7
9	4700	150	500	7
18	4700	150	500	12
18	4700	0	500	10
18	4700	0	1200	13+
18	4700	15	1200	13

The use of a relay/condenser arrangement is compact, and battery operation poses no electrical hazard. (Of course, the battery needs to be checked periodically.) The relay contacts of the Radio Shack #275-004 relay is one amp which seems adequate for small battery operated toys.

Perhaps this circuit is useful in amateur rig switching applications, such as to enable a handicapped person to activate the PTT line without having to hold it. - Charles Wilson, W7NLX, W 3819 Weile Ave., Spokane, WA 99208.

(This circuit is shown in Fig. A on page 3).

Notes on the IBM MINIMUF Program

Thank you for the IBM MINIMUF Program (Nov. 1983, no. 21). I would like to suggest a few changes that will enable the program to run a bit smoother. In lines 47 and 48 on page 11, East and West should be switched. On page 14, line 281, the values for L2 and W2 should be positive (a value of +6 for L2 is more accurate).

Any future updates would be welcome. I find the program useful and interesting. - Ken Bursell Jr., K9AH, RR 1, Box 197, Sparland, IL 61565.

In This Issue

May QEX contains two modification articles. The first focuses on improving the turnstile antenna design that was popular during Owen Garriott's, W5LFL, flight on the Space Shuttle Columbia (November 28 to December 8, 1983). The other summarizes a modification to correct oscillator pulling in the popular Sony ICF-2002 receiver. This promised article was mentioned in March 1984 QEX.

Part 1 of a two-part article that had originally appeared in the October and November 1983 RADio COMmunication, is also featured in this issue. Better known as RADCOM, the Radio Society of Great Britain's monthly Amateur Radio journal is sent to the ARRL on a monthly basis -- the RSGB is a member of the International Amateur Radio Union. Correspondence concerning the distribution of the journal should be addressed to: RSGB Headquarters, Alma House, Cranborne Road, Potters Bar, Herts EN6 3JW. The article entitled, "The GB3US Mk2: A Microprocessor Repeater Logic System," can be found starting on page 6.

Reducing the Speed of Internal Cooling Units

In recent Amateur Radio literature, there have been hints on reducing the speed of fans and blowers that are used to cool amplifiers and heat sinks. Most fans and blowers have ac motors designed to operate in a narrow speed range. Quite often, though, a full speed fan is noisy in the ham shack environment and its cooling service is needed only during transmit or intermittent high power periods.

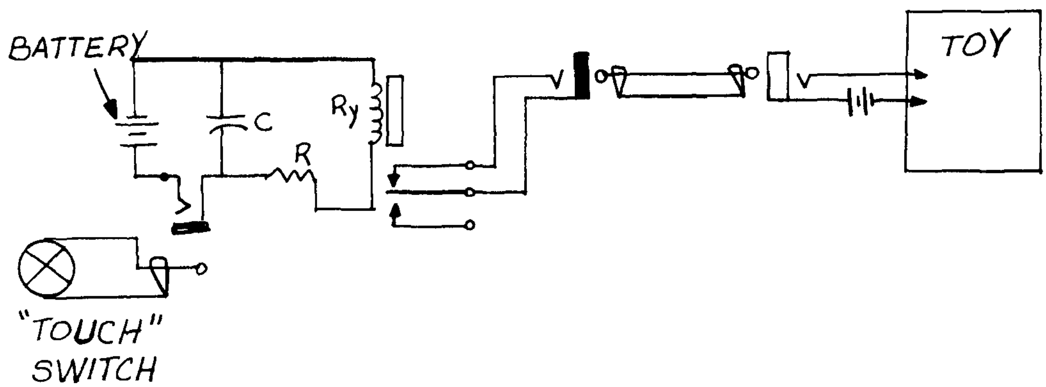
Placing an impedance in series with the fan

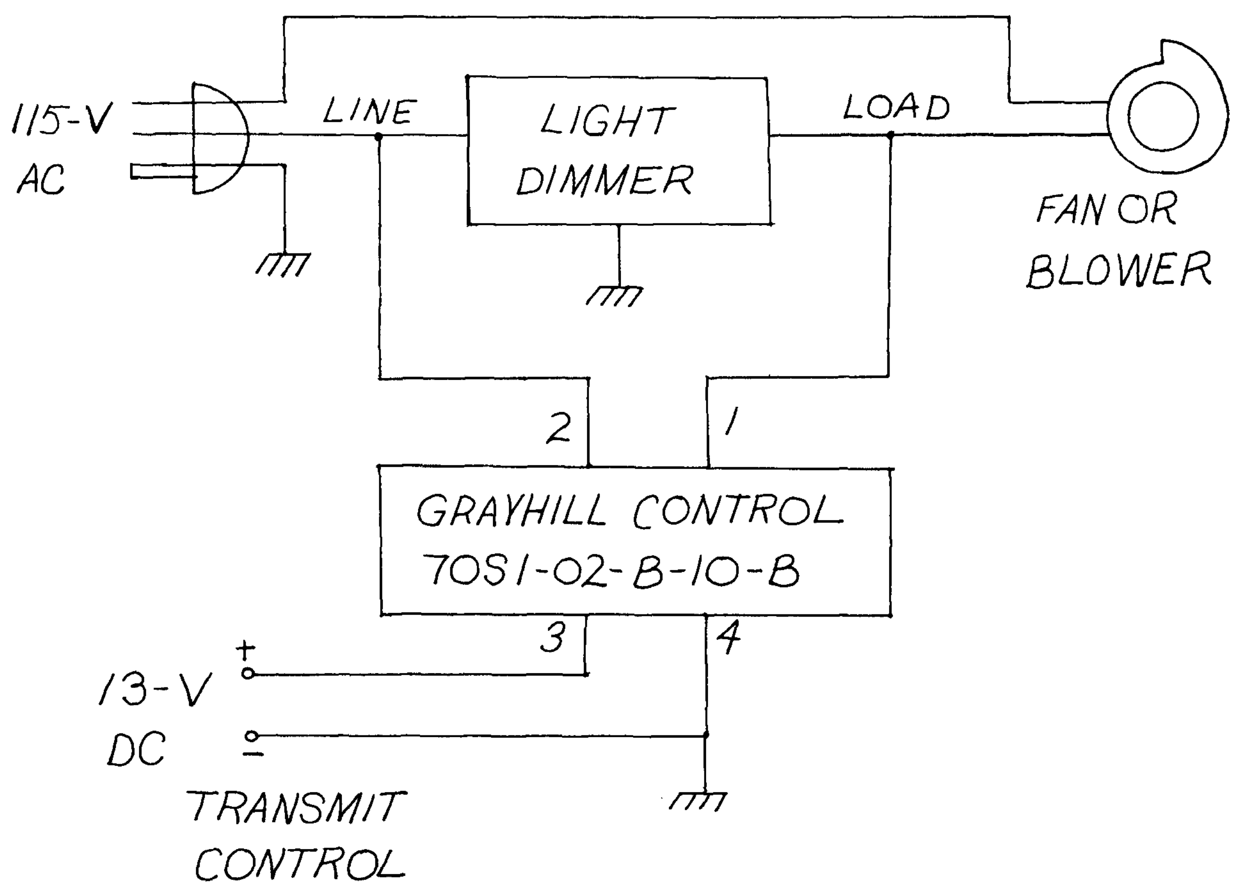
(Correspondence continued)

motor can effectively slow it to the point that the acoustics are not objectionable. Elements for the series impedance can be either resistive (a power resistor) or reactive (an ac capacitor). Both have been used with varying results. In many cases the slowed fan has a sufficient air output to provide the needed cooling.

In cases where a full speed fan is necessary, the operator can switch out the series impedance. A solution to this is shown in Fig. B. It provides a control without conventional relay contacts that might be severely erroded by switching a highly reactive load. This solution also provides the operator with a ready means to adjust the "idle" speed of the fan, a task that is otherwise tedious.

The speed control is a low-cost light dimmer device available at most hardware stores. The solid-state switch is a surplus Grayhill P/N 70S1-02-B-10-B unit that can handle 140-V ac at 10 ampere all with a control of 10- to 30-V dc. Obtaining the needed control voltage should be a minor problem for most amateur transceivers that operate on 13.5-V dc. The switch and control provided an excellent solution to a high-power amplifier problem that had been troublesome. - Dick Jansson, WD4FAB, 1130 Willowbrook Trail, Maitland, FL 32751.





Modification for the Turnstile Antenna

By Joseph D. Dvorsky,* WA3KOF

The following comments on the turnstile antenna design (Sept. 1983 QEX, no. 19), are offered so that further experimentation can take place. With improvements to the antenna, more amateurs will be able to successfully contact future space expeditions. I heard W5LFL on three separate occasions, and experienced great satisfaction with my design changes.

Most coaxial cable available on the market today is made of foam dielectric. It is easier to find this type of coax than the standard dielectric kind, but because the velocity factor for foam is 0.79, (0.66 for standard), the quarter-wave Q match and quarter-phasing section may require modification.

Eq. 1 shows the formula used for a quarter wave in a vacuum.

$$c = f\lambda; \text{ and } \lambda = \frac{c}{f} \qquad \text{(Eq. 1)}$$

where,

$f = 144.910$ MHz
$c = 299.7925 \times 10^{6}$ m/s
$\lambda = 2.06881858$ m
$\lambda/4 = 0.517$ m
$= 1.696$ ft (1 ft = .3048 m)
$\lambda/4 = 20.362$ in
$= 51.72$ cm

For a velocity factor of 0.66 (RG58/U, RG58A/U and RG59/U), the quarter wave formula becomes:

$$\lambda/4 \times 0.66 = 13.439 \text{ in} = 34.136 \text{ cm} \qquad \text{(Eq. 2)}$$

For a velocity factor of 0.79 (RG58/U and RG59/U foam), the equation is:

$$\lambda/4 \times 0.79 = 16.089 \text{ in} = 40.859 \text{ cm} \qquad \text{(Eq. 3)}$$

Foam coax has lower loss and is readily available. The chart below shows losses at 155 MHz per 100 ft.

Coax Type	Loss (dB)
RG58/U	6
RG58A/U	6.7
RG59/U	----
RG58/U foam	4.6
RG59/U foam	3.4
RG8/U foam	2.0

Design details such as those for the Q-match quarter-wave transformer could have been included.

$$Z_Q = \sqrt{Z_1 Z_a} \qquad \text{(Eq. 3)}$$

where,

Z_Q = Q-match impedance
Z_1 = feedline
Z_a = antenna (load) impedance

The design specifies Z_Q as RG58/U, with an impedance of 53.5 Ω. If the transmission (feed)line is RG59/U, and its impedance is 73 Ω, rearranging Eq. 3 gives us:

$$\frac{Z_Q^2}{Z_1} = Z_a \qquad \text{(Eq. 4)}$$

Therefore,

$$Z_a = \frac{53.5^2}{73} = 39.2089\ \Omega$$

Parallel air insulated line, $Z_{min.} = 83\ \Omega$.

The impedance of the first dipole is 70 to 75 Ω, and the antenna should be resonant at the transmitting frequency. The phasing-line impedance must be 73 Ω with the same argument applied to calculate its length.

The second delayed dipole may be considered a matched 73-Ω system taken together with the phasing line. The Q-match section at 53 Ω is to work approximately 39 Ω. Therefore, the addition of the first dipole must reduce the impedance of the second matched system to 39 Ω. It appears as two 73-Ω systems in parallel.

I constructed my turnstile using furring strips as suggested in the article, but I used 6-in steel angles and 5/16-in bolts at each of the 8 cones for strength. A dual furring strip was placed at the center of the mast for support, with 3-in, 5/16-in bolts. These strips split easily and I preferred drilling holes for bolts rather than using wood screws.

Window screening was used for the reflector ground plane because it has better reflection

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(continued on next page)

(Turnstile Modifications continued)

qualities compared with hardware cloth. Icing is not a problem in my area (Los Angeles, CA), and my antenna is mounted on a flat, non-metallic roof. I also applied several coats of spar varnish as it rains a lot here during the winter months.

The aluminum window screen was attached to the top side of the furring strips with no. 6 carpet tacks. I found staples an inconvenience to work with. I used a 1 X 3 for the mast (antenna weight does not have to be supported by it), and the dipoles were placed 20.3 in above the reflector surface to give a full balloon-type pattern for initial experiments. The dipoles were made of brass rod material that is moderately ductile and can be bent only a few times.

An etched piece of G-10 printed circuit board (3 in X 4 in), was bolted to the top of the mast. The dipole elements were, in turn, bolted to the pc board using no. 10 hardware. The ends of all coaxial connections were fastened with crimp connectors. These provide strong connections.

I used RG58/U foam for the Q-match with a velocity factor equal to 79 and an impedance of 53.5. RG59/U was used for the phasing section and its velocity factor is 79 with an impedance of 75 Ω. The Q-match, therefore, would like to see:

$$\frac{53.5^2}{75} = Z_a = 38.163\ \Omega \qquad \text{(Eq. 5)}$$

The antenna load is less than 50 Ω.

An AT-200 2-meter Antenna Tuner designed by Barker and Williamson is available for those wishing to use 50-Ω hardline or 50-Ω as a feedline. Its purpose is to match a 50-Ω transceiver to a lower z or RG8/U foam automobile antenna. A 50-Ω hardline could be substituted for the 73-Ω feedline, and this device mounted at the antenna. One advantage to this set up is its adjustability for peak output power.

Pi-type networks are also used to transform a high impedance to a lower one, and might be placed at the phasing line rather than using a quarter-wave section. The quarter-wave section seems the simplest and it is a reliable design when working with 73.5-Ω line because it has less loss. It is preferred for use as a feedline. I suggest, however, using foam low-loss coax and correcting the lengths as previously explained.

$$\text{phase} = \frac{1}{\sqrt{K}} \qquad \text{(Eq. 6)}$$

where,

K = dielectric constant

vacuum = 1,000

air = 1.00054

The gain of a turnstile antenna over an isotropic radiator is 1.15 with approximately +0.6 dB as compared with a dipole that is 2.15 dB at 1.64. To determine the flux density of the spacecraft, Eq. 7 might be used.

$$P_R = \frac{P_T G_T}{4\pi R^2} \; G_R \frac{\lambda^2}{4\pi} \qquad \text{(Eq. 7)}$$

where,

P_R = received power in watts

P_T = transmitted power in watts

R = distance in meters

G_R = gain over isotropic for receiver

G_T = gain over isotropic for transmit antenna

λ = wavelength in meters

$R_{min.}$ is approximately equal to 159 miles or 250 km.

The G_R of a helix antenna depends on the length of the helix. Using values for a Kenwood TR2400 and G_R = Ø dB, 0.2 V for 10 dB SINAD = -120.97 dBm, and 1 μV for 30 dB S/N = -106.9897 dBm. At 159 miles, the received power is -79.85 dBm or 22.75 μV into 50 ohm. This is +41 dB over the threshold of -120.97 ohm. Atmospheric attenuation was neglected because of oxygen absorption (.1279 dB, .0008 dB/mile).

At 1 μV, (-106.99 dBm), with no atmospheric oxygen attenuation, the distance is 5820 km = 3617 miles, but the absorption is 2.9 dB. Therefore, the distance becomes greater than or equal to 4168 km or 2590 miles. For example, at 30 dB quieting, the spacecraft distance could be 2590 to 3617 miles.

FLIGHT OF COLUMBIA
STS-9/Spacelab-1

Launched on November 28, 1983
and after 247 hrs, 47 min
landed at Edwards A.F.B. on December 8, 1983

- First launch of Spacelab (provided by the European Space Agency)
- Longest Orbiter flight to date
- First European crewmember
- First 'Payload Specialists' (non-career astronauts)
- First six-person spaceflight

★ First Amateur Radio station in space
W5LFL

Transceiver: modified Motorola MX-300 2-meter FM transceiver, hand-built by the Motorola Amateur Radio Club in Florida.
Antenna: directional ring radiator with cavity, designed to fit in the upper window of the spacecraft; built for NASA by volunteer employees of Lockheed.
Power: 4.5 watts
Mode: FM, CW (by keying carrier) All transmit and receive audio were tape recorded, which constitutes the station log.
Operating orbits: 40D, 56D, 62A, 71D, 91A, 96A, 97A&D, 110D, 111A&D, 112A, 113A, 129A, 130A, 134A, 134D, 135A&D, 144A&D, 145A&D, 146A, 149D and 150D.
Stations, 2-way contact: over 350
SWL: approximately 10,000 cards received
Countries: 23
Total operating time: about 4 hrs, 30 mins.

The W5LFL QSL card. It is being sent to over 12,000 radio amateurs who have heard Owen Garriott aboard the Space Shuttle Columbia. The next possible space mission carrying Amateur Radio will occur in March of 1985 with astronaut Tony England, WØORE.

Dual-Gate Mixer for the Sony ICF 2002

By Jonathan Towle,* WB1DNL

The Sony ICF-2002 receiver audio output changes when strong signals are received. It is manifested by chirping on CW and instability on SSB. This problem is not a result of poor regulation or inadequate buffering of the BFO. It is caused by loading on the second VCXO by the AM second mixer, Q11.

To correct the problem, we decided to decouple the two circuits by replacing Q11 with a 40673 dual-gate mixer. This solution greatly reduced the interaction between the two circuits and shows little or no loss in conversion gain.

Although the modification is relatively simple, you should not attempt the procedure unless you feel comfortable working on small circuits and have the proper tools. Remember, making modifications to your unit will void the warranty! Before you do anything, please get a service manual from Sony. The parts placements and circuit are not reprinted here.

Figure 1 shows the circuit after modification. Changes were made simply by replacing the existing components. No changes are necessary to the circuit board foil pattern. The only difficulty lies with the 40673. First, its metal case must not contact any other component. Second, the source and drain lead must be crossed to match the foil pattern. This requires you to insulate one or the other of the two leads.

Begin by removing the circuit board from the case. This is done by removing the back cover and then the front cover. A ribbon cable connects the keypad and synthesizer board to the receiver board. To separate the two units, lift up on the outer portion of the black connector on the receiver board until the ribbon cable slips out. This connector does not come apart, it simply grabs on to the ribbon cable.

The receiver board can now be removed from the plastic frame. First, remove the black tape from the component side of the board. Then remove the screws and lift the plastic fingers that hold the board in place.

Remove the following components from the receiver board. R64 (22 k Ω), R65 (180 k Ω), R77 (100 ohm) and Q11. Next, replace R66 (3.9 k Ω) with R64 and R67 (1.5 k Ω) with a 270-ohm resistor. Insert the 40673 as shown in Fig. 2. Make sure the case does not contact XF1.

Place a 560-ohm resistor by passed with a 0.005-uF capacitor from the source lead of the 40673 to ground where R65 was removed. Finally, add a 180-k Ω resistor from gate 2 to the high side of C64. See Fig. 2.

Check the AM IF alignment as described in the Sony manual and reassemble. Your radio should now sound more stable when listening to SSB or CW.

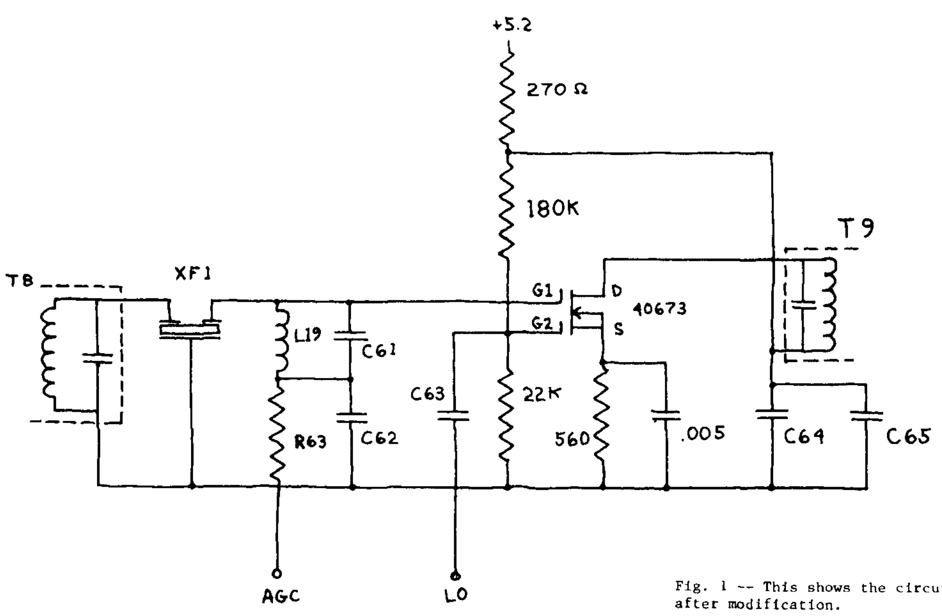


Fig. 1 -- This shows the circuit after modification.

*ARRL Laboratory

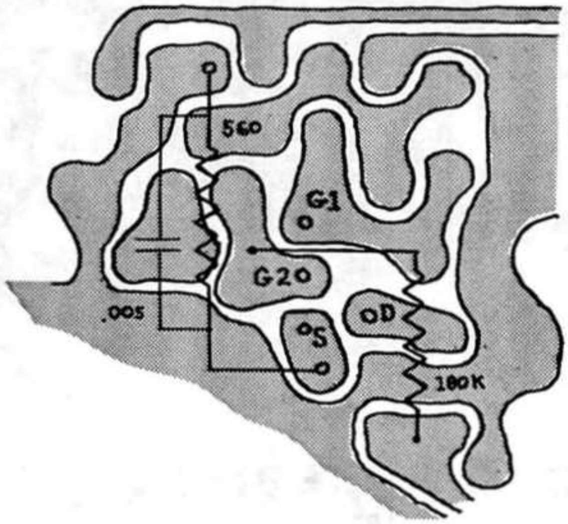
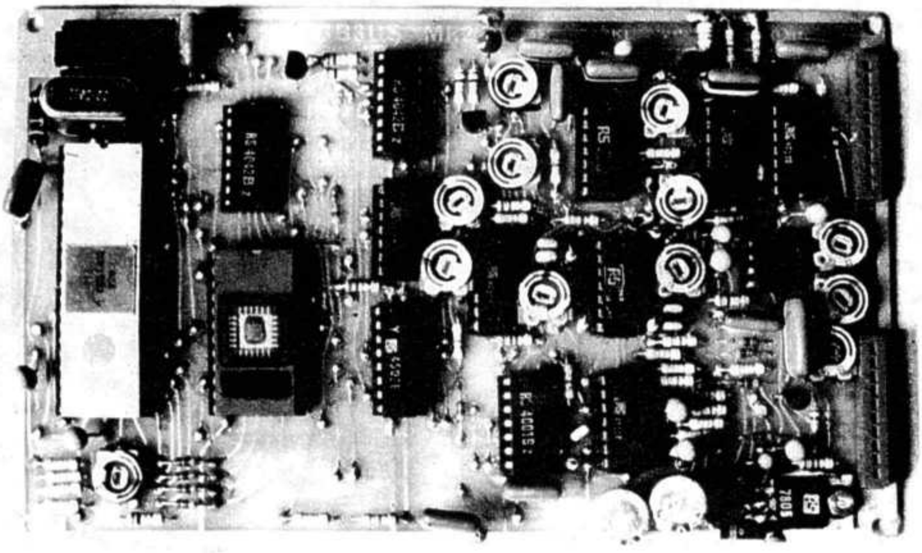


Fig. 2 -- Foil side of the board where the modifications occur.

THE GB3US Mk2



A microprocessor repeater logic system

PART 1

by A. J. T. Whitaker, G3RKL*

Tony Whitaker obtained both his BEng and PhD in the Department of Electronic and Electrical Engineering at the University of Sheffield during the 'sixties. After several years as a research assistant, he took up his present post as a senior experimental officer in 1976, and is concerned with a wide variety of projects involving microwaves, ultrasonics, computing and electronic circuitry.

Licensed while still at school, operation was mainly confined to top band, but interest in vhf was kindled with the acquisition (and necessary modification) of a B44 for 70MHz. This led to the setting up in 1969 of the 70MHz beacon GB3SU (now GB3BUX), initially in Sheffield, before moving to its present site at the department's microwave antenna test range near Buxton. With the introduction of repeaters in the early 'seventies, the associated technical challenge resulted in GB3HH (R4, 1976) and GB3US (RB0, 1978), with particular emphasis on the control logic. Present activity is almost entirely devoted to the building of the first pssb repeater, GB3SF, which should be operational around the end of 1983.

G3RKL was a member of the Repeater Working Group during its early years, and now serves as a corresponding member of the VHF Committee, concerned with GB3SF.

Introduction

All repeaters need some form of automatic control, which determines when the through-audio is relayed, identification made, and other features entered such as timeout, overdeviation indication etc. As long as this control complies with the requirements of the licensing authority, the complexity of the system is at the discretion of the repeater group concerned. Most control systems to date are purely hardware devices; that is, the required features have been permanently built-in, with very little or no capability of change. The microprocessor, however, offers the opportunity of producing a unit with a great deal of flexibility since, providing the relevant hardware exists, the operation of the repeater can be made solely dependent on software, ie the program which controls it. This article describes the hardware design and construction of a simple, low-cost, micro-based system, which is a direct replacement for the GB3US Mk1. A machine code listing of the original GB3US program is also included, which, when copied with a few appropriate changes, will produce a working unit. To help people develop their own software, a full listing of this program can be obtained from the author by sending a self-addressed 8 by 12in envelope stamped with either a 30p (1st class) or 21p (2nd class) stamp to him at the address below.

Design considerations

Since many GB3US Mk1 control logics [1], some with the filter/timeout addition [2], are now in use, it was decided to make the Mk2 printed circuit board of the same physical size, with identical connector pin designations, so that one board could just replace the other. As with the Mk1, low power consumption was necessary, so the RCA cmos CDP1802C, eight-bit microprocessor was chosen, together with standard cmos logic ics. A memory size of 2k bytes ($1k = 1{,}024 = 2^{10}$, 1 byte = one eight-bit word) is sufficient to hold even a complex program, for which the popular TMS 2516JL (single rail 2716–5V) erasable programmable read only memory (eprom) is ideally suited. The micro should also have sufficient input/output lines to respond/talk to the outside world, the number depending to some extent on the degree of control required. Because of space considerations, the conventional input/output system of the 1802 was not used, an effective memory map being employed instead, giving six input and four output lines. The crystal clock was chosen as 1,792kHz, giving a machine cycle time of 4·5μs and, using a single CD4020BE 14-stage binary divider, outputs of 1,750, 875 and 109Hz were available, the latter being used to drive the interrupt line.

The main hardware features are thus as follows:

(a) A completely self-contained unit on one double-sided printed circuit board, 6·5 by 4in (same size as the GB3US Mk1).

(b) Low impedance audio output up to several volts peak-to-peak. Transmit key output will drive a small low-voltage relay (same as Mk1).

(c) Remote closedown, eg an externally-located key switch, which prevents the transmitter from being keyed but leaves the rest of the station unaltered (same as Mk1).

(d) Low power consumption, +13·5V, ±1·5V at approximately 70mA, mainly determined by the eprom current.

(e) Two independently-keyed sine-wave tones, 1,750 and 875Hz, with shaped envelopes.

(f) High/low amplitude level control of keyed tones.

(g) Software generated output tone, square or rectangular wave, from the Q output.

(h) High/low input frequency indication from the receiver (two lines).

(i) Mains/battery operation indication line.

(j) Self-tuning 1,750Hz notch filter (as per filter addition to the Mk1).

(k) One general input line, eg manually-operated mode switch.

(l) Four auxiliary input lines, eg digital signal strength, overdeviation, dtmf (touchtone) etc.

*University of Sheffield, Department of Electronic & Electrical Engineering, Mappin Street, Sheffield S1 3JD.

Some basic properties of the CDP1802

A full description of the CDP1802 can be found in the RCA data sheet [3], but for those not too familiar with the workings of the "all-powerful silicon chip", a few words on its method of operation in this system might prove useful. Fig 1 shows a simple block diagram of the control unit, and it can be seen that attached directly to the micro are the eprom, address latch and input/output interfaces. The program to be obeyed, which is just a sequence of binary encoded instructions, is held in the eprom (and once programmed in, these cannot be erased except by exposure of the chip to ultra-violet light), which is interrogated by the micro via the address bus. The 2516 eprom is capable of holding 2,048, one-byte instructions, in sequential addresses 0000 to 2047, which is 0 to 11111111111 in binary, ie 11 address lines are required to uniquely select any one particular location. For convenience it is usual to refer to such a binary number in hexadecimal, where counting is performed to a base of 16 instead of the more familiar 10, the decimal values 10 to 15 being represented by the letters A to F. Thus an eight-bit byte can be described in two characters, eg 7A (hex) = 01111010 (binary) = 122 (decimal), and so the eprom addresses are 000 to 7FF. Since the address bus from the micro is only eight bits wide, an address "latch" must be used to store the "high" byte of a full two-byte address, the three least significant bits (lsbs) of this high byte being applied to the eprom as the three most significant bits (msbs) of its 11-bit address. It can be seen that a 16-bit (two-byte) address is generated in this manner, designated memory address lines MA0 to MA15, giving the capability of addressing 64k bytes of memory. However, the 2k eprom only requires MA0 to MA10, and so would respond if any of the higher MA lines (11 to 15) were set as well. This is of no consequence in the control unit, as no other memory is used, except that the input/output interfaces are addressed at 4000, so MA14 is used to enable the input/output and, at the same time, disable the eprom.

The 1802 has 16 internal registers, referred to as R(0) to R(F), each 16-bits long, which can be used for either general workspace/counters, the data register (X) or the program counter (P), which holds the address of the next instruction to be obeyed. All input/output data, including the program instructions, is passed to the micro via the eight-line bi-directional data bus, lines D0 to D7, the actual direction being indicated by a zero level on *MRD* for read, or *MWR* for write. Since many output ports could be connected in parallel on the bus, but only one can be active at any one time, tri-state devices (outputs capable of being set to an open circuit) must be used to "switch off" the others not selected, and the eprom and input interface (CD4502BE) are such devices.

Components list

R1	10MΩ
R2, 3, 4, 5, 12, 18, 20, 22, 26, 27, 28, 30, 31, 35, 36, 40, 42	470kΩ
R6, 7, 8, 9, 24, 38, 47, 48	10kΩ
R10, 21, 25, 29, 32, 33, 34, 37, 43, 44	4·7kΩ
R11, 39, 41	150kΩ
R13	68Ω
R14, 15	6·8kΩ
R16, 51	47kΩ
R17, 19	33kΩ
R23, 45, 49	2·2kΩ
R46, 50	22kΩ
All resistors, except R1 which is 0·5W, are 0·25W high stability carbon film, 5%	
RV1, 7, 8	220Ω
RV2, 9, 12	10kΩ
RV3	22kΩ
RV4, 6	1kΩ
RV5	4·7kΩ
RV10, 11	100kΩ
All min horizontal presets	
D1-13	1N4148
ZD1	1N5339B (5V6, 5W)
RG1	7805
RG2	78L05
TR1, 2, 3	BC184L
TR4	2N3819
X1	1,792kHz (HC33/u)

C1, 8, 11, 12, 18, 34, 35, 36	0·1µF 250V polyester
C2, 3	0·22µF 35V tantalum
C4, 5	470µF 16V radial pc
C6, 7, 14	0·01µF 250V polyester
C9, 10, 21	0·001µF 100V monolithic ceramic
C13, 19	4·7µF 35V tantalum
C15	0·22µF 250 polyester
C16, 27, 31, 32, 33	10µF 16V tantalum
C17, 20, 28	2·2µF 35V tantalum
C22, 23, 24	0·01µF 100V monolithic ceramic
C25, 26	0·022µF monolithic ceramic
C29	0·0022µF monolithic ceramic
C30	10µF 25V tube
IC1	CDP1802CD or CE
IC2	TMS2516 JL (single rail 2716)
IC3	CD4020BE
IC4, 6	CD4042BE
IC5	CD4502BE
IC7, 10, 14	CD4011BE
IC8	NE567V
IC9	CD4001BE
IC11	CD4016BE
IC12, 13	348 (Quad 741) TL064, 074, 084 CN
IC15	CD4013BE
SK1,2	10-way pc connector (RS 488-359)

The whole sequence of events within the micro is controlled by the clock, which can be either applied from an external source, or internally generated using the on-board crystal oscillator circuitry. Each machine cycle, except initialization, takes eight clock cycles, and instructions take two or three machine cycles depending on their type. Thus it is possible to derive

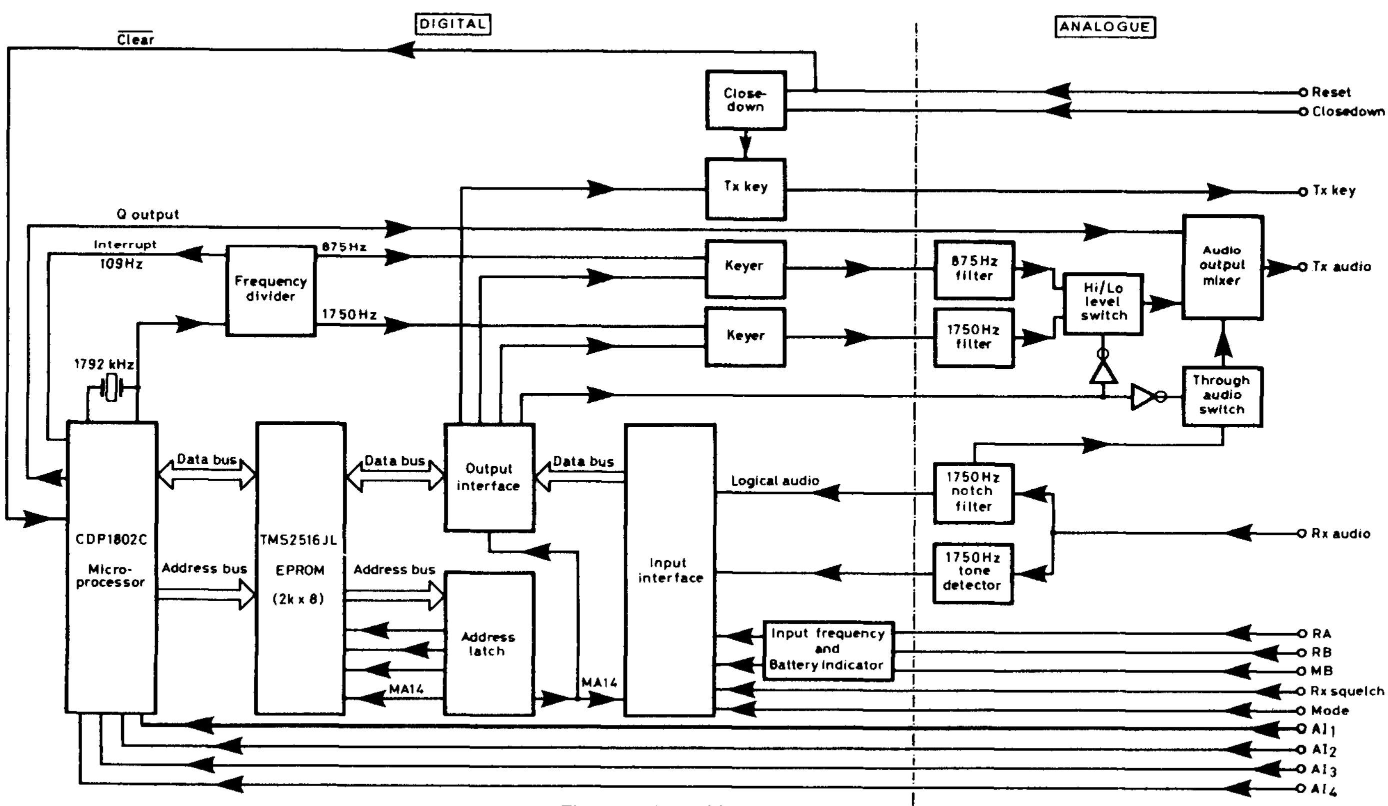


Fig 1. Hardware block diagram

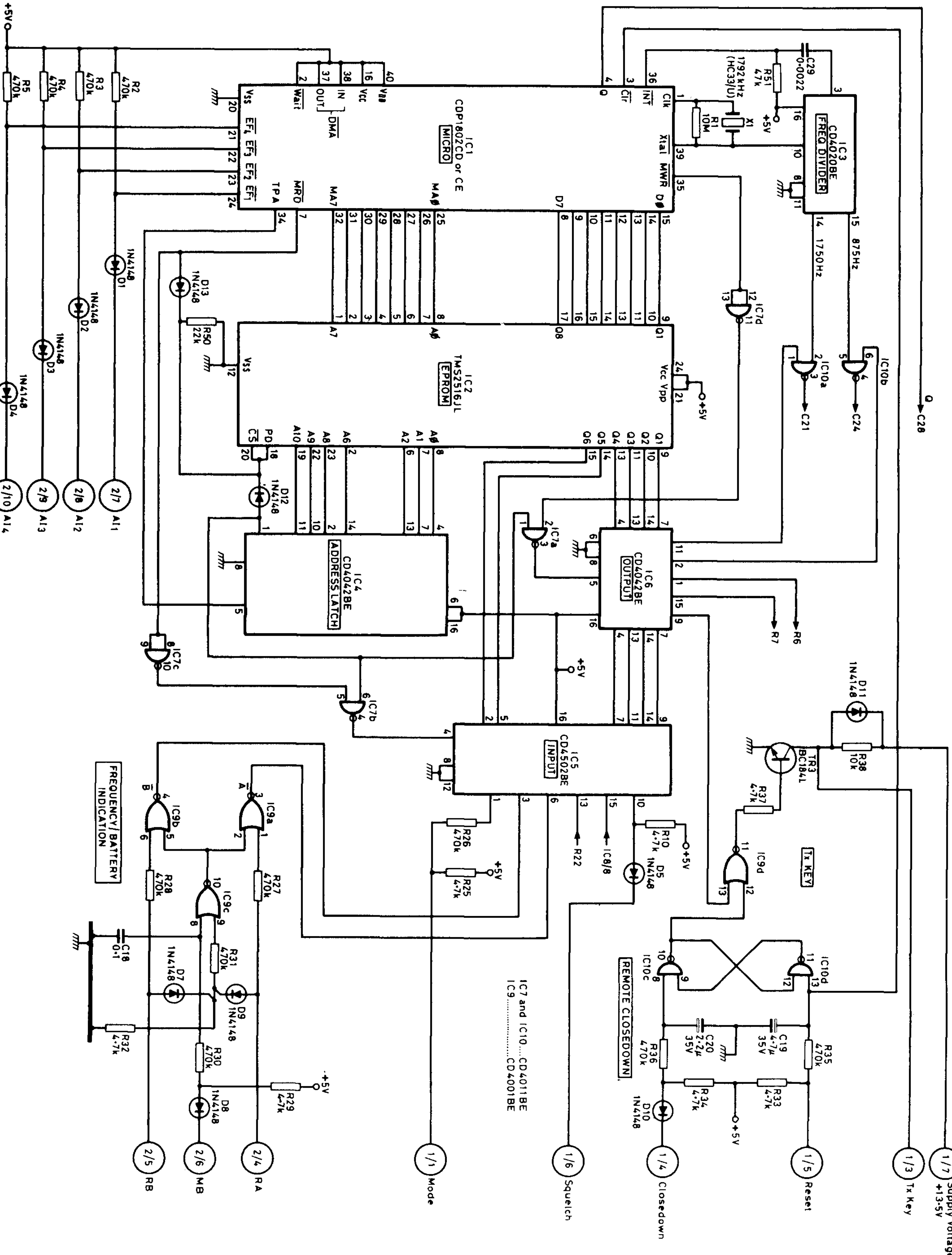


Fig 2. Digital circuitry

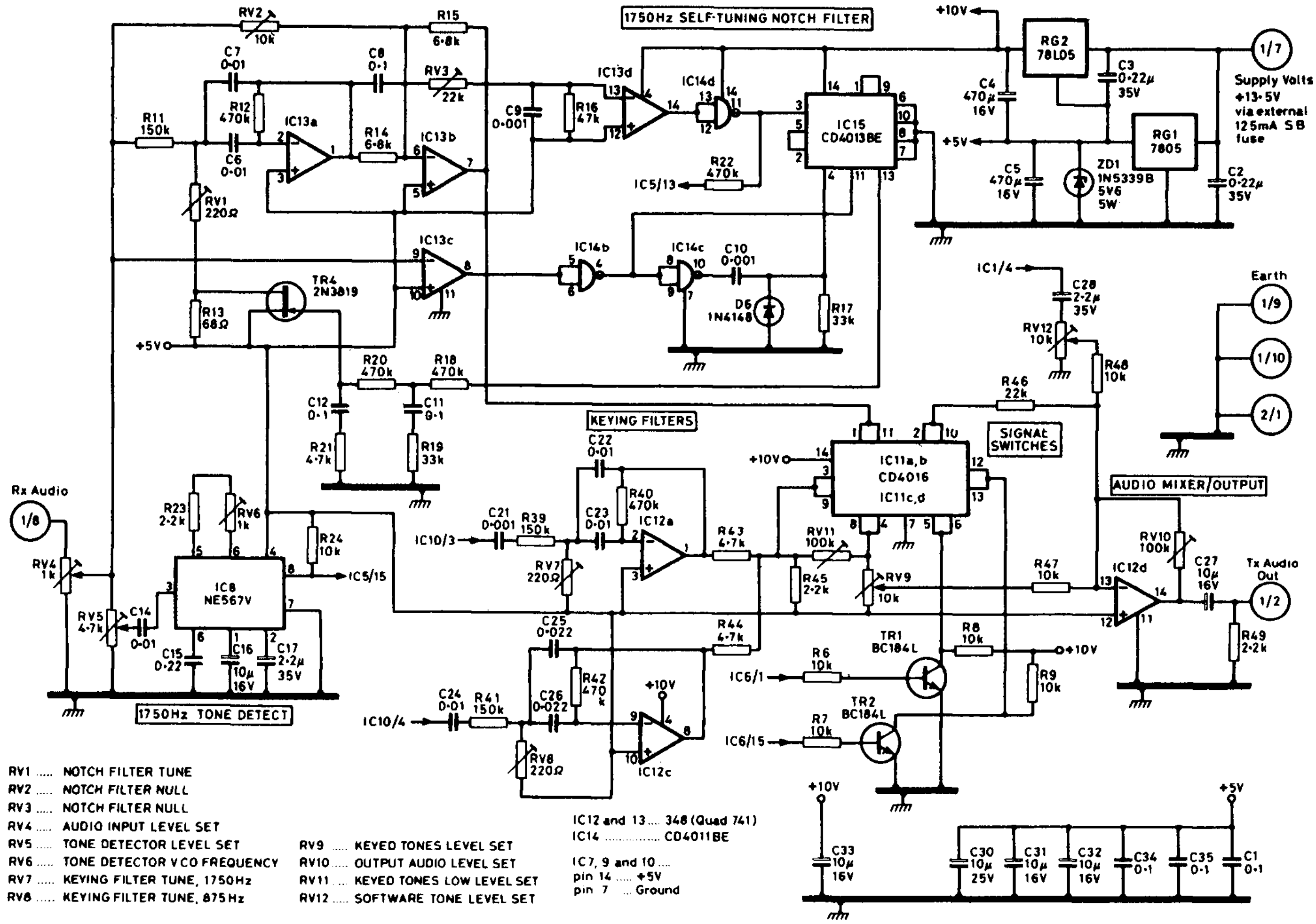


Fig 3. Analogue circuitry

accurate timings by counting instructions obeyed, although in this unit most timing operations are achieved using the interrupt, which functions as follows. When enabled, a zero level on the interrupt line (pin 36) will force the micro to adopt R(1) as its program counter. Thus, by setting R(1) to the address of the interrupt service routine (the piece of program that should be obeyed on interrupt) before the interrupt occurs, when it does, the micro will jump to that predetermined location and continue from there.

Digital circuitry

Fig 2 shows the circuit schematic for the digital side of the system. As mentioned previously, only high address lines MA8, MA9, MA10 and MA14 need to be latched, and these are held in IC4. MA14 is applied to the eprom's select and power-down inputs, OR'd with *MRD* via D12 and D13, to inhibit it during input/output. The six input lines are connected to the data bus (D0 to D5) via IC5, a hex tri-state buffer, enabled by MA14 AND'd with *MRD*, while the four output lines (D0 to D3) are latched into IC6 by the trailing edge of *MWR*, AND'd with MA14. The four auxiliary inputs are connected directly to the E Flags via pull-up circuitry, and the Q bit goes via the level setting control, RV12, to the audio output mixer IC12c.

The 1,792kHz clock is generated by the on-chip oscillator, which also drives the 14 stage binary divider IC3. The Q10 and Q11 outputs are 1,750 and 875Hz square waves respectively, which are keyed by gates IC10a and b, while the Q14 output (109Hz) generates a short negative pulse through C29, R51, which is applied to the micro interrupt line. The transmitter is keyed by TR3, via IC9d, which is controlled by the remote close-down flip-flop IC10c, d. The reset input of this flip-flop (pin 13) is also connected to the *CLEAR* line of the micro (pin 3), such that when power is applied, the time constant of C19, R33, R35, exceeds that of C20, R34, R36, ensuring that the program starts at memory location 000 with the close-down reset.

For the receiver input frequency and battery operation indications, IC9a, b, c combine the three inputs RA, RB and MB according to the truth table shown in Table 1. With no input at SK2, MB, RA and RB default to 1, 0 and 0 respectively, giving a permanent "OK with mains power" indication. The squelch and general inputs go directly to IC5 via pull-up components, the squelch sense being determined in software rather than by a link as in the Mk1.

Table 1

Input			Output		Indication	
MB	RA	RB	$\bar{A}$	$\bar{B}$	Frequency	Power
1	0	0	1	1	OK	Mains
X	1	0	0	1	Low	Either
X	0	1	1	0	High	Either
0	0	0	0	0	OK	Battery

Analogue circuitry

Fig 3 shows the analogue circuitry, much of which is similar to the Mk1 and filter/timeout addition. Receiver audio passes through the self-tuning 1,750Hz notch, ICs 13, 14 and 15, through the on/off switch IC11a, b, and finally into the output mixer IC12c. The notch circuit also provides logical audio on micro input line 3, which can be used, for example, by an audio detect routine. A conventional 567 phase lock loop, IC8, detects the presence of a 1,750Hz tone, giving a logical signal on input line 2. The two keyed square wave tones, at 1,750 and 875Hz, pass through high Q active filters IC12a, b, which not only convert them to sine waves, but also "ring" slightly to give an excellent keying envelope. These outputs are mixed in R43, R44 and R45, pass through the high/low level switch IC11c, d, and into the output mixer IC12c. The control of the analogue switches (IC11) requires a level shift, which is accomplished by TR1 and TR2.

The stabilized +5V supply is provided by RG1, a 1A regulator deliberately under-run for reliability, with a 5·6V power zener diode, Z1, for circuit protection should it fail. A 100mA regulator, RG2, gives an additional +5V stabilized line (+10V with respect to earth), mainly for the operational amplifiers, where the +5V line acts as the ac ground.

(To be concluded)

(in the next issue of QEX)

QEX: The ARRL Experimenters' Exchange is published by the

American Radio Relay League
225 Main Street
Newington, CT 06111 USA
telephone 203-666-1541

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