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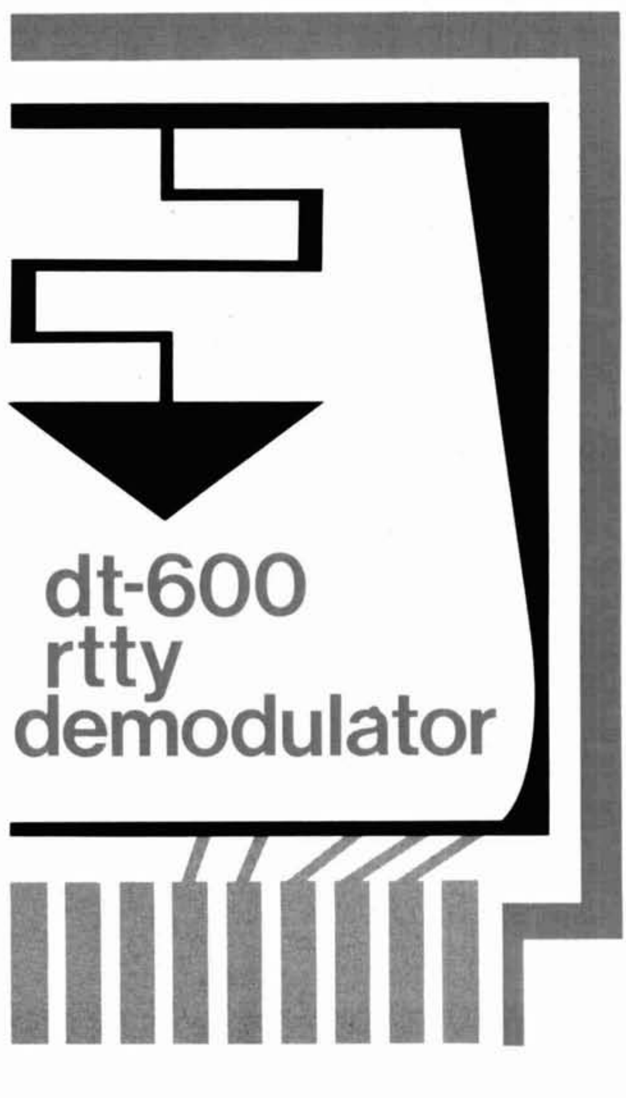
ham radio magazine

FEBRUARY 1976



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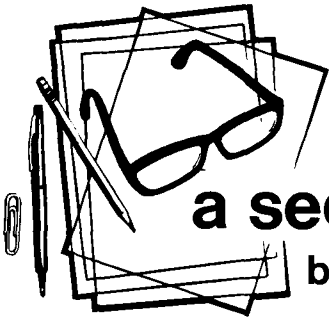

a second look

by Jim Fisk

With **AMSAT-OSCAR 7** now well into its second year of continuous operation, it's becoming more and more apparent that an increasing number of amateur stations using mode B (the 432 to 144 MHz repeater) are using much more power than the recommended 100 watts *effective radiated power* (erp). When more than the recommended power is used, it swamps the agc circuit in the transponder, resulting in an excessive amount of current being drawn from the on-board power source.

In maximum sunlight the solar panel on the spacecraft can supply approximately 1 ampere of current; if more than 1 ampere is required to power the repeater it must be supplied by the on-board battery. However, the red-line limit on battery discharge current is about 1.2 ampere, and when amateurs using mode B run excessive power, the current drawn from the battery often *exceeds 2 amperes* when OSCAR 7 is in sunlight, and more than *3 amperes* when the satellite is in darkness.

At times this heavy current drain on the battery has caused the battery voltage to drop to the point where the under-voltage protection circuits have taken over. These circuits were designed to place the spacecraft in mode D (the discharge mode, both transponders turned off) when the battery voltage drops to 12.1 volts. The spacecraft systems have already switched to mode D a number of times, and some unexpected switches to mode A (the 144 to 29 MHz repeater) have also occurred.

Amateurs who are running more than the recommended 100 watts erp are conspicuous because their signals are much louder than the rest of the stations on the channel. If you tune across the mode B passband and note that certain stations in your local area are consistently much louder than others in the passband, please contact them directly, explain the adverse effects of excessive erp, and ask them to reduce power.

If they indicate that they're only running 100 watts *output,* ask them what they're using for an antenna – one-hundred watts of rf into a *single* KLM, Tilton, K2RIW or WØEYE Yagi produces an effective radiated power of 2000 to 3000 watts! Stations running 100 watts rf output into multiple Yagi arrays may have effective radiated powers of 8 kW or more. Some of the worse offenders appear to be a few 432-MHz EME operators who are not using 100 watts, but their kilowatt finals, and not with a single no-gain antenna but with their multiple Yagi arrays which have gains of 20 dBd or more, for an effective radiated power greater than 60 kilowatts. Their signals are brutally loud, but you can tell when they're on the air by simply monitoring telemetry channel 2B.

Since there may be some amateurs who don't understand the meaning of effective radiated power, following is a list of popular 432-MHz Yagis, and the rf power input for 100-watts effective radiated power for single, double and quadruple Yagi arrays:

antenna type	approx gain	single antenna	double array	quadruple array
KLM	15 dBd	3.2 W	1.6 W	0.9 W
Tilton	13 dBd	5.0 W	2.5 W	1.4 W
K2RIW	15 dBd	3.2 W	1.6 W	0.9 W
WØEYE	14 dBd	4.0 W	2.0 W	1.1 W

The approximate gain is that for a single antenna. A 3 dB increase in gain is assumed for a double array, and a 5.5 dB increase for a quadruple array. Note that 10 watts input to any of these antennas results in more than the recommended 100 watts erp – 10 watts into four properly phased Yagis produces an erp of 1000 watts or more.

These facts must be brought to the attention of mode B users who are abusing the recommended maximum 100-watt limit. Any assistance you can provide in reducing what has become a serious problem will be appreciated by other mode B users and AMSAT alike – continued abuse of the 100-watt power limit will most certainly shorten the useful life of the satellite.

Jim Fisk, W1DTY
editor-in-chief

presstop

AN ARRL OFFER to carry the brunt of the Amateur Radio WARC preparation effort was enthusiastically received at the December 12 meeting of the entire Working Group in Washington. League support outlined by ARRL General Manager, Dick Baldwin, will even extend to participation in various contributory activities such as CCIR meetings.
Overall WARC Timetable was reviewed by Chairman John Johnston and despite the apparent remoteness of 1979, it was obvious that the task of coordinating all services' frequency needs for the next two decades will require every bit of that time.
Amateur Frequencies Proposed by the various task forces include 160-200 kHz, 1715-2000 kHz, 3.5-4 MHz, 7-7.5 MHz, 10.1-10.6 MHz, 14-14.5 MHz, 18.1-18.6 MHz, 21-21.5 MHz, 24-24.5 MHz and 28-29.7 MHz in the HF spectrum, all on an exclusive basis. VHF frequency requests include 50-54, 144-148, 220-225, 420-450, and at least a portion of 890-942 MHz. Basic microwave allocations proposed don't differ much from present U.S. Amateur assignments, though a number of sub bands for satellite and experimental work were incorporated. How likely we are to get any of the proposed new bands or what problems we'll have in keeping or expanding those we have was debated at some length — though some services presently using a lot of the HF spectrum are planning to move to satellites, other services are eager to move into their slots, while pressures on VHF Amateur bands are well known and increasing.

HOAX DISTRESS SIGNAL showed up on 3804 kHz Christmas afternoon and tied up many Amateurs and Coast Guard people through the following afternoon. "WN8HOM" (a call unassigned by the FCC) claimed to be stranded on a 25 foot boat with 10 people on board that was disabled by engine failure near Pelee Island in western Lake Erie. WB9BWU called the Coast Guard in Detroit and the 170-foot Cutter "Mariposa" was dispatched to search for the lost vessel while a growing number of listeners throughout the U.S. monitored the frequency. WB9BWU and W8LIO became the relay stations between the "vessel in distress" and the "Mariposa" and Coast Guard land stations, all operating on 3804.
Possibility Of A Hoax was suspected fairly early in the adventure, but Coast Guard's philosophy is that all distress calls are genuine until proven otherwise. FCC monitors reported that WN8HOM's sporadic signals looked to them to originate from near Zanesville, Ohio, and listeners as far away as Florida reported them to be over S9 — certainly suspect for a Novice rig working from a small boat with failing batteries. Still the drama continued, complete with helicopter after improving weather permitted, until a Zanesville area Amateur reported the signals steady at S9+ from his location and then put his signals on 75 to let the FCC DFers confirm their earlier determination that the Zanesville area was the source. A few minutes later — at 2215 Z Friday afternoon — the Coast Guard called off the search.

AN AMATEUR'S ORIGINAL LICENSE — not a photocopy — will have to be submitted with his application for renewal under the terms of Docket 20672 released by the FCC in mid December. All Comments on the Notice of Proposed Rule Making must be filed by January 22, and Reply Comments are due February 2. This proposal apparently resulted from the discovery of a number of recent applications that included photocopies of licenses showing class not in agreement with FCC file information.
License Renewal Requirements for operating time and code proficiency were dropped in a "Christmas present" Report and Order adopted by the FCC. The relaxation, which became effective December 24, is a logical one since the requirements were essentially unenforceable.
Docket Proposing that volunteer examiners be required to submit photocopies of their licenses with request for examinations has been released. Docket 20679, released December 22, was proposed to help establish the qualifications of volunteer examiners. Due date for Comments is February 2 and for Reply Comments February 12.
Applicants For An Extra Class License will no longer be required to have at least a year as a General or higher class licensee as a result of a Report adopted by the Commissioners this week. Effective date of the change was not available at press time.

AUTOMOTIVE IGNITION NOISE limits are being studied by FCC in an inquiry released by the Commissioners December 10. Docket 20654 relates results of an FCC-funded Stanford Research Institute study on low cost techniques for reducing impulse noise radiation from automobiles (FCC Report RS75-03, available from National Technical Information Service, Springfield, Virginia — order number PS239-471).
Comments On Effects of ignition noise on communications and other radio services as well as feasibility of radiation reduction are being sought by the Commission. Comment due date for Docket 20654 is March 19, 1976; Reply Comments are due May 4.

INSURANCE PROTECTION for mobile rigs may shortly become much stickier as thefts from autos skyrocket. Since January 1 all auto insurance policies in Texas will have endorsement A927 attached to them which states: "The insurance does not apply to loss of or damage to any device or instrument or a combination of devices or instruments designed as a Citizens Band radio, two way mobile radio or telephone, including its accessories, equipment or antennas." Though this limitation as yet applies only to Texas, the Insurance Services Office is reported to be seriously considering introduction of a similar exclusion nationally.

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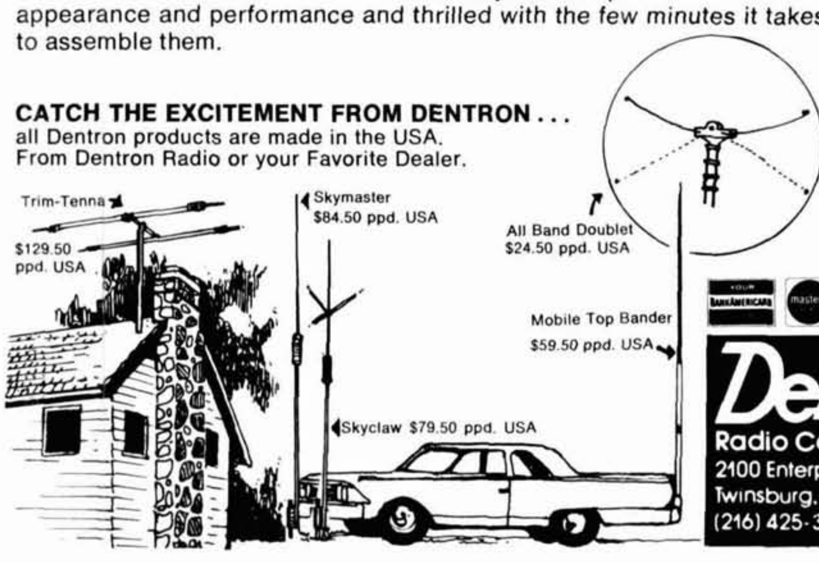

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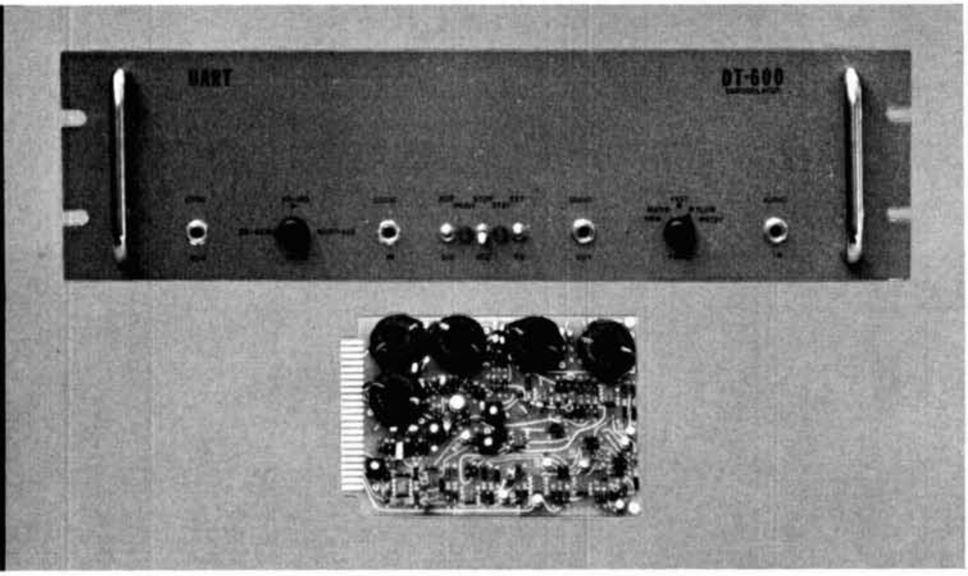

DT-600 RTTY demodulator

An advanced RTTY TU design with the most-wanted features — all on a single PC board

Amateurs have had much experience using IC RTTY demodulators but have found that certain optional circuits are difficult to add. Also, a number of options previously considered important were found to be no longer necessary. The ideas of active RTTY enthusiasts have been included in the DT-600 demodulator design described here.

Amateur RTTY has made significant progress since 1956. Only 850-Hz shift had been allowed until 1956, when the FCC revised regulations to allow any shift up to 900 Hz. It was found that properly designed and adjusted narrow shift (170 Hz) systems were superior to those with wide shift (850 Hz) in terms of adjacent signal rejection, weak-signal detection, selective fading, and noise immunity. The small group that began using narrow shift has grown to the point that wide-shift fsk is seldom heard in the high-frequency amateur bands so it may be assumed to be nonexistent for practical purposes. For this reason it's no longer necessary to provide the option of both narrow and wide shift in an RTTY demodulator. Thus requirements are eased for a sophisticated demodulator, with a resulting decrease in size, cost, and construction time.

It is also no longer considered necessary to provide an option for receiving inverted shift, as standards for direction of shift are well established (fsk *space* below *mark*), and upside down keying is seldom encountered. However, as current operating practice has simplified certain aspects of the RTTY demodulator, it has complicated others. The problem most experimenters face today is

By Robert C. Clark, K9HVW, Garey K. Barrell, K4OAH and Archie C. Lamb, WB4KUR

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modifying the demodulator to interface with external equipment such as the SELCAL,[1,2] a regenerator,[3,4,5] a speed converter,[3,6] a video monitor, or even a computer. This problem has usually meant ending up with scorched boards with lifted foil and components dangling in the air to make modifications to the existing board. The DT-600 provides TTL compatible DATA (mark/space) and AUTOPRINT (print/nonprint) outputs as well as provisions for remote motor control relay.

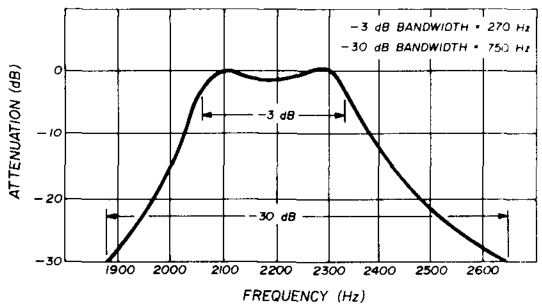


fig. 1. Bandpass filter response for narrow shift.

If you don't need the interface capability the interface components may be omitted, as the DT-600 will stand alone. If you wish, the high-voltage loop keyer, high-voltage loop supply, and motor relay may be mounted in the teleprinter and driven from the interface outputs. This option is particularly important when a number of machines at the operating location must be shifted from one loop to another. Keying and motor control can be easily controlled by a simple matrix switcher. Furthermore, if the high-voltage loop is completely contained within the teleprinter, there is much less likelihood of noise disturbing other equipment.

The DT-600 is an adaptation of the popular and reliable ST-6 demodulator,[7] incorporating the philosophy mentioned above. Other modifications have been made to reduce size, cost, and construction time of the DT-600. Additional design standards and philosophies of the CATC project, described below, have been incorporated. To meet the requirements of both amateur RTTY operators and the CATC project, the following features have been included in the DT-600:

1. Single-board construction
2. Single shift (may be either standard narrow 2125/2295 Hz or wide 2125/2975 Hz).
3. Optional interface connections.
4. Reduction of discrete components.
5. Choice of components to reduce size and cost.
6. A minimum of panel controls.

This article describes the DT-600, a single-board adaptation of the popular ST-6 demodulator introduced by Irv Hoff, W6FFC, in the January, 1971, issue of ham radio. The DT-600 will either stand alone or can be interfaced with a variety of other options. Its design results in a significant decrease in size, cost, and construction time with no decrease in performance. A future article will contain a brief description of the simplified but similar DT-500 vhf demodulator with examples of how to interface both units with external equipment. ***editor***

For single shift, DT-600 performance is equivalent to that of the ST-6 but with the advantages described above.

The CATC group is charged with developing Computer-Automated Teletype Control for the Navy-Marine Corps MARS Teletypewriter Relay System. Its goal is to develop an automatic store and forward message system. The CATC group is using a systems approach for the development of receivers, demodulators, fsk and afsk generators, and control devices. The DT-600 is the first of a series of such devices to be described in coming months. It should be noted that designs described in this and future articles were by amateur radio operators (but professionals in electronics) on their own time. For this portion of the effort the CATC project provides only direction.

Much thought from CATC group members has been incorporated into the CATC system philosophy. Standards have been established for interface between equipment (TTL logic family compatibility), connections to card connectors, card configuration, and power supplies to allow for many options and ease of interconnection. The CATC philosophy allows the user to integrate system components (or self-designed equipment) into a working system with minimum cost, effort, and size, while allowing versatility, presently unavailable, for

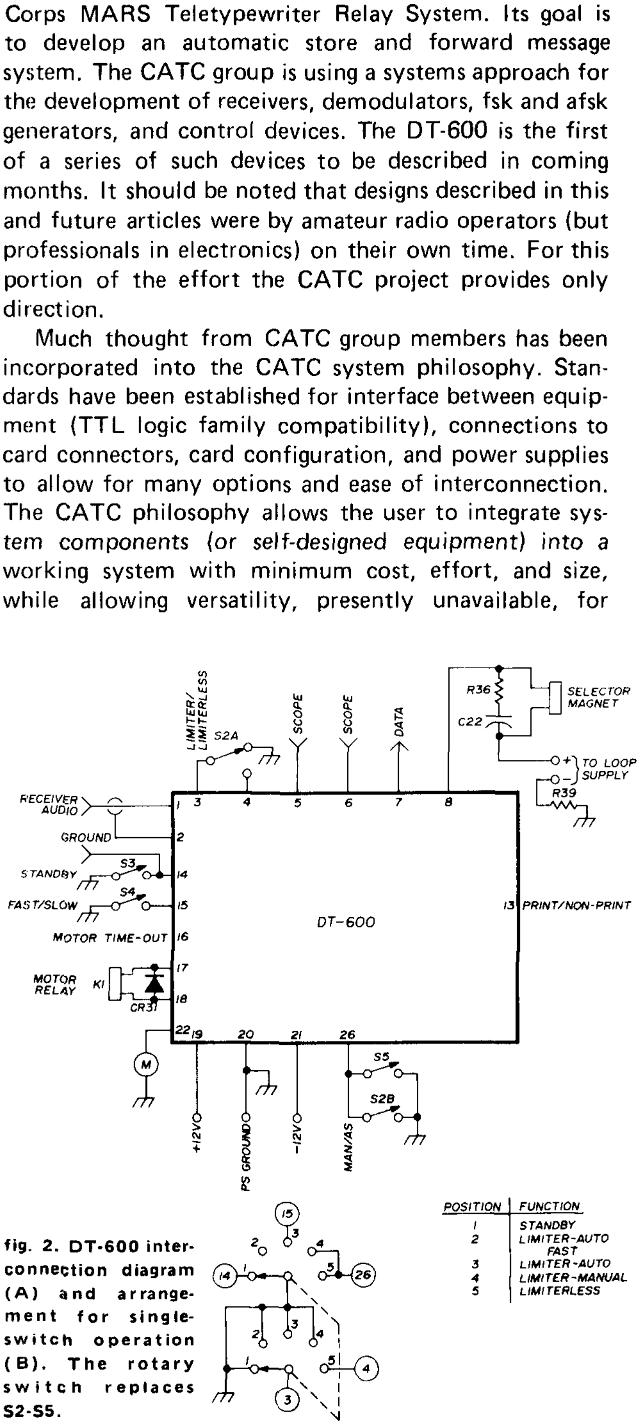
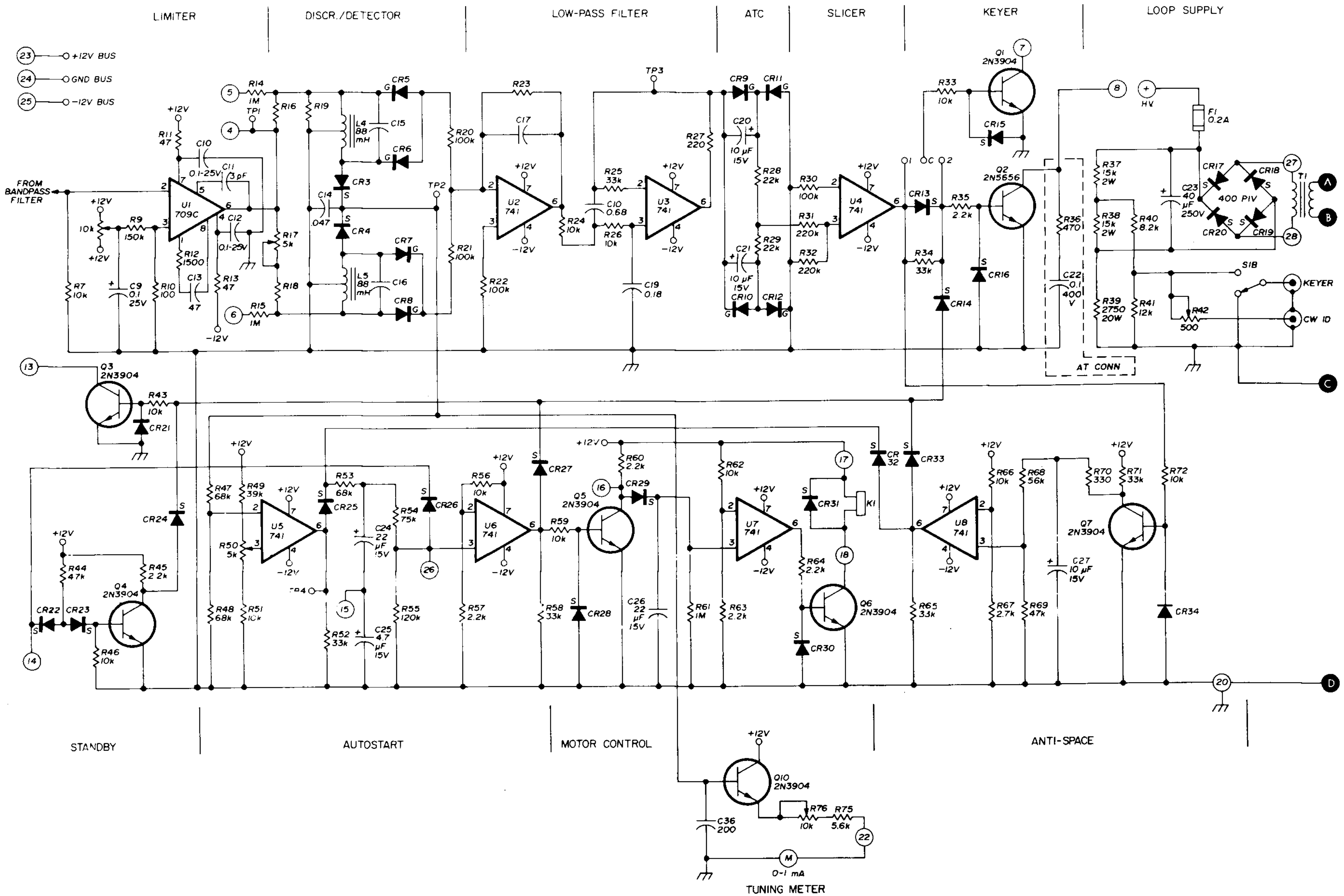


fig. 2. DT-600 interconnection diagram (A) and arrangement for single-switch operation (B). The rotary switch replaces S2-S5.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TP2
TP3
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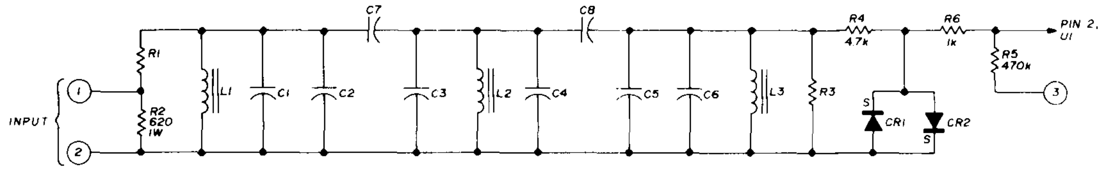
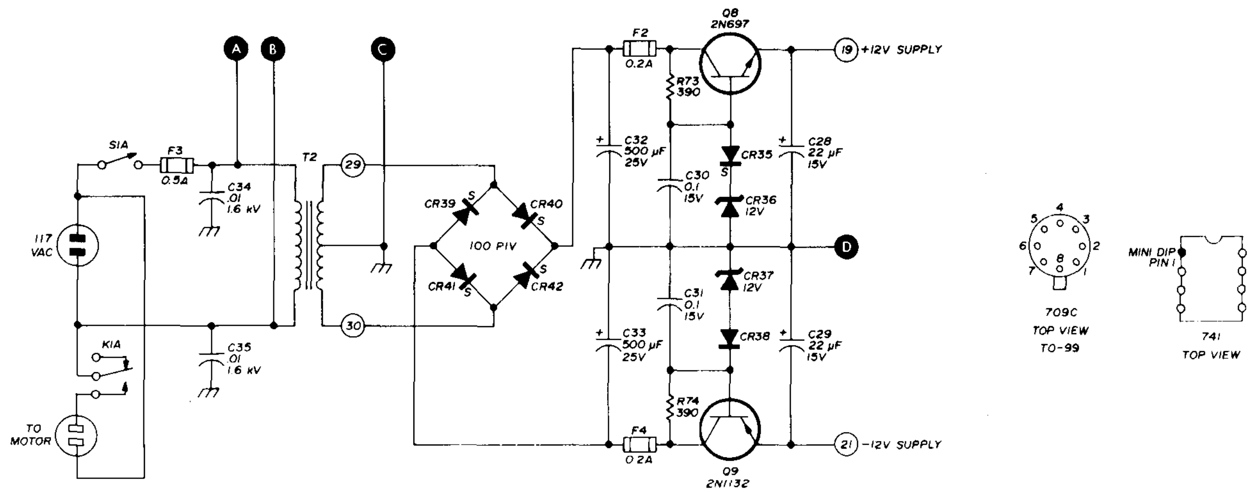


			bandpass filter values										tuning frequencies		
mark	space	shift	C1	C2	C3	C4	C5	C6	C7	C8	L1,2,3	R1	R3	sec 1	sec 2	sec 3
2125	2295	170	0.15	.056	.18	--	.15	.056	.022	.022	22 mH	1.6k	2.2k	2195	2195	2195
2125	2975	850	.015	.018	.015	.01	.015	.018	.015	.015	88 mH	2.7k	3.3k	2400	2500	2400



discriminator values

	2125/2295	2125/2975
R16	6.8k	4.7k
R18	6.8k	6.8k
R19	100k	33k
R23	270k	180k
C15	.068	.068
C16	.056	.033
C17	.012	.018

fig. 3. Schematic diagram of the advanced DT-600 RTTY demodulator. All diodes marked G are Germanium 1N270; diodes marked S are silicon 50 PIV unless noted. All resistors are 1/4 watt. Transformer T1 is an Essex PA8421; T2 is a Triad F-40X or Essex P8180.

system expansion and modification. A simplified vhf demodulator (DT-500) will be described later.

The SELCOM (an advanced yet simplified multifunction version of the SELCAL) will be described in a future article. The SELCOM also functions as a regenerator and speed converter. A simplified mini-SELCOM, which provides the same features except for a limited number of functions, will also be described.

circuit description

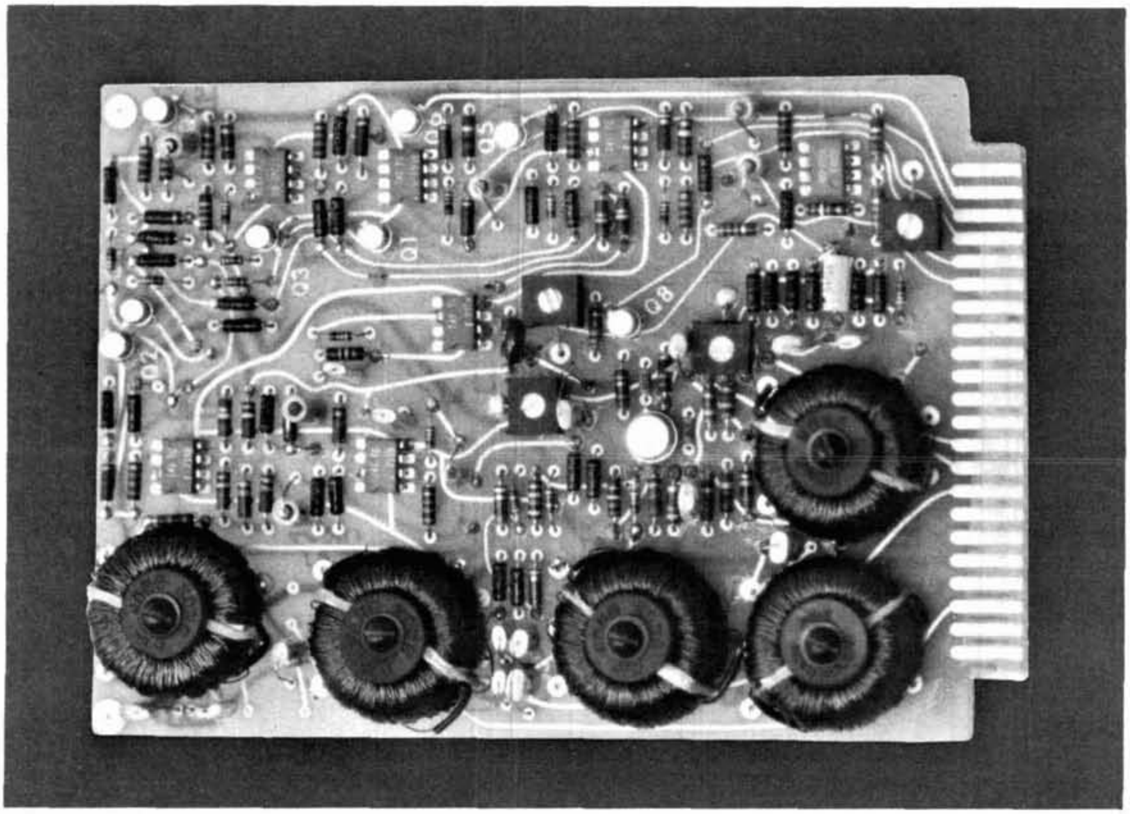
The audio from the station receiver is introduced into the DT-600 through a three-pole Butterworth bandpass filter, **fig. 3**. This filter may be used for either wide shift (2125/2975 Hz) or narrow shift (2125/2295 Hz). The wide-shift bandpass filter is about 1 kHz wide at the −3 dB points, and the narrow-shift filter is about 270 Hz wide (**fig. 1**). This filter provides additional immunity to noise and adjacent signals even when the receiver has good selectivity. Also the bandpass filter significantly reduces any hum that may appear on the receiver audio, protects the first amplifier stage from being damaged by excessive audio input, and provides an impedance match between the receiver 600-ohm output and the high impedance of the first amplifier stage. CR1 and CR2 are ordinary silicon diodes that limit the audio at the junction of R4, R5, and R6 to 0.7 volt.

limiter

Audio from the bandpass filter is amplified by U1, a 709 operational amplifier in the open-loop configuration. U1 functions as an amplifier and hard limits the signal to ±10 volts (at the output). Output from pin 6 is a square wave as long as the input signal exceeds the extremely low limiting threshold (about 1 mV). Thus, very large changes in the rf or audio signal levels may be tolerated. R8 establishes the balance for U1 to provide for minimum threshold and symmetrical output. R12, C13, C11 provide frequency compensation, while R11, R13, C10, C12 decouple U1 from the dc supply lines. Limiterless operation is available by connecting point 3 to point 4. In this configuration U1 limits only on signal peaks. Note that autoprint operation would be unreliable in this mode, so the motor and print control sections are forced on (**fig. 2**) by a parallel switch section.

discriminator/detector

The square wave output of U1 is coupled to the discriminator via R16, R17, R18. R17 is set to equalize the voltage levels of both mark and space signals in the discriminator. L4, L5, C15, C16 form a linear discriminator. Its narrow-shift response is shown in **fig. 4**, with peaks about 100 Hz wide at the −3 dB points. L4, C15 form a parallel-tuned circuit at 2125 Hz (mark). L5, C16 are tuned for the space frequency (2295 Hz for narrow shift or 2975 Hz for wide shift). Since the same inductance is used for both mark and space frequencies, the filter Q would be different, which in turn would cause unequal bandwidth for the two filters (equal bandwidth is particularly important for limiterless copy). R19 damps the Q of the L4, C15 combination to match the Q and bandwidth of the L5, C16 tuned circuit. CR5, CR6, CR7 and CR8 (1N270 germanium) form full-wave detectors for minimum ripple. CR3 and CR4 form an OR gate so that a positive voltage appears across C14 if either mark or space tones are present. This voltage is used to control the demodulator autoprint section and may also be used to drive a tuning meter. Scope connections are through one-megohm resistors to eliminate loading the discriminator.



Complete DT-600 RTTY demodulator is built on one plug-in printed-circuit board. The five 88-mH toroids used in the filter circuits are mounted along the lower edge of the board. Double-sided circuit boards with plated-through holes are available from Data Technology Associates (see footnote on page 14).

low-pass filter

The two-stage (741 op amps) active low-pass filter is designed for 100 wpm operation. Degradation of 60 wpm performance is so slight with the filter set for 100 wpm (**fig. 5**) that the additional complexity of switching filter characteristics to optimize response for 60 wpm is not considered worthwhile. If only 60 wpm is to be used, R24, R26 may be changed to 16k, and C17 to 0.02 μF for narrow shift and 0.03 μF for wide shift.

ATC and slicer

During selective fading the automatic threshold corrector provides the symmetry necessary for the slicer, another 741 op amp. Action is shown in **fig. 6** for selective fading on the space channel. Without the ATC action selective fading would bias the signal. The symmetrical ATC output is fed to U4 which is set for maximum gain to provide uniform keying from the varying, but symmetrical, ATC output. This high gain allows just 1 or 2 mV over offset to trigger the output and allows copy during deep selective fading and incorrect (straddle-tuned) shift.

keyer

Strapping options are available on the board so that slicer output may be fed directly to the base of Q1 (jumper from 1 to C), an open-collector output stage.

Output from Q1 does not respond to the mark hold provided by the standby line, autoprint section, or anti-space. Q1's output may be used to provide data to external equipment, such as the SELCOM, where the autoprint attack time delay is not desired. CR15 prevents the negative portion of U4's output from reaching the transistor.

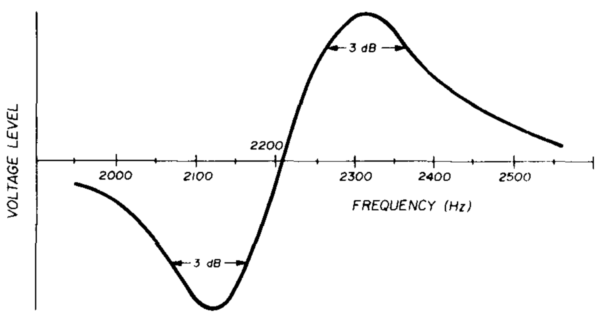


fig. 4. Discriminator response for narrow shift.

By strapping 2 to C, Q1 may be inhibited by the standby line, the autoprint section, and the anti-space section. Q2 is the high-voltage keyer. It is always inhibited, as described for the second option on Q1. For a simple selector magnet keyer stage, the importance of a high-voltage supply and keyer can't be over emphasized.[8] Several designs are based on the fact that only 12 volts are necessary to maintain a 60-mA selector-magnet current but completely overlooked is the behavior of a large inductance (selector magnet) in an ac (switched) circuit. Results from such low-voltage keyers are very poor, even with no distortion on the received signal. Their operation deteriorates rapidly with distortion. Q2 may be omitted and Q1 used to drive a remote keyer within the teleprinter, as mentioned earlier. (A simple circuit to control the loop keyer and motor relay through logic levels will be described in the future article which features the simplified DT-500 demodulator.)

R36 and C22 suppress keying transients, and CR16 prevents the negative-going pulses from the selector-magnet field decay from being propagated back through preceding stages. It's possible through the options provided on the board to take the data signal from Q1, process it in external equipment, then reintroduce the processed signal to the loop keyer. (This feature will be used with the DU-200 regenerator and speed converter to be described as the basis for the SELCOM in a future article.)

autoprint

CR3 and CR4 form an OR gate as mentioned earlier. If either mark or space tones are present, a positive voltage will appear across C14. U5 threshold is set (by R50) so that with no signal present its output is positive. This positive voltage locks the keyer stage (through CR27) in mark hold. When a signal appears on either mark or space frequencies, the OR gate output forces U5 to reverse state so that its output is negative. This action stops the charge on C24, C25, which begin to discharge through R54, R55. When the voltage at point 26 has decreased to a level determined by R56, R57 (time constant is such that it takes about 1.3 seconds to reach this level with C24, C25 in series and about 7.4 seconds with point 15 shorted to ground), U6 pin 6 is forced negative, the standby line is released; Q5 is biased off charging C26; U7 output is forced positive; and Q6 conducts, pulling in motor relay K1. If the signal disappears, or if (as in CW) the duty cycle drops below 25%, then C24, C25 begin to charge, eventually returning to mark hold. However, C26 must discharge below the voltage on U7 pin 2 before the motor relay is released. This delay gives about 38 seconds after loss of signal before motor shut down, which is desirable to keep the motor from turning on and off between transmissions or when the signal fades into the noise. Shorter turn-on and turn-off times may be had by making C24 and C26 each 18 μF.

anti-space

In the mark condition, the positive output of U4 (pin 6) forward biases Q7, preventing C27 from charging. On space, Q7 is shut off and C27 begins to charge. The time constant is such that C27 will charge above the threshold set for U8 in slightly over 132 ms (132 ms is the longest steady space expected from valid RTTY, a blank at 60 wpm). Thus, U8 will not trigger with normal RTTY where C27 is quickly discharged by each mark signal through Q7. Should a space exceed the time constant, U8 output becomes positive, and the positive voltage is applied through CR33 to the mark hold line. The positive output of U8 is also applied through CR32 to C24, C25, starting the motor time-out sequence. Thus a steady space will a) not turn the machine on, b) immediately clamp the printer in mark hold if it is already on, and c) begin the time-out sequence.

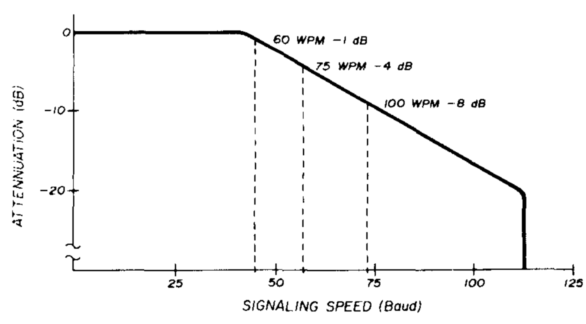


fig. 5. 74.18 baud low-pass filter response.

standby

When the standby line (14) is grounded, Q4 forward bias is removed, placing a positive voltage on the mark hold line through CR24. Also U6 pin 3 is pulled low, starting the motor, as described previously. (The only time the standby feature is regularly used is during transmit and, hence, holds the motor on during a long transmission.) Note that the mark hold line is positive when no signal is present, the standby line is grounded, a steady space is present, or a signal is present (CW or other non-RTTY) that doesn't switch U5. All these situations occur on nonprint. The mark hold line positive voltage forward biases Q3, which may be used to indicate to external equipment that no valid RTTY signal is present. When a valid RTTY signal does appear, Q3 forward bias is removed.

tuning meter

The CR3, CR4 OR gate output is also coupled to the base of Q10, a meter amplifier. When the RTTY signal is properly tuned, a positive bias is applied to Q10 base if the signal is either mark or space. The tuning meter reading will be proportional to the signal level of mark (or space) at the discriminator. In operation the receiver is tuned for the highest steady meter reading. For tuning incorrect shift the meter tuning indicator is superior to an oscilloscope, as a proper meter reading will closely indicate balanced output from the discriminator to the low-pass filter.

loop power supply

A full-wave 170-volt supply provides the required loop current (60 mA). Note that loop-current limiting resistor R39 is in the negative supply lead. This is the floating loop introduced by Hoff and included in the ST-6.[7] By allowing the supply to float, a polar output (mark negative, space positive) is available at point 11 to key either an afsk or fsk oscillator. Grounding point 12 gives less than full saturation current through a shifter diode, yielding narrow-shift CW identification.

components

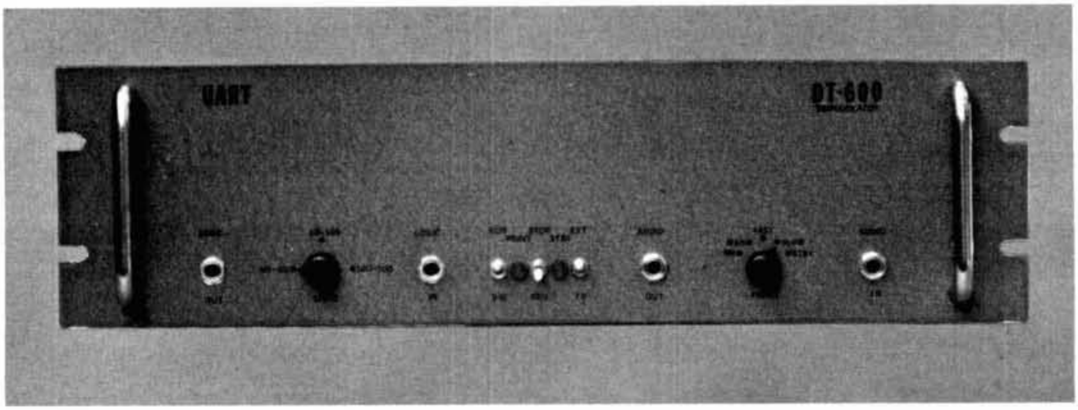
The DT-600 is constructed on a single 4½ by 6 inch (11 by 15cm) board, which includes all parts except the switches and power supplies (a single ±12 volt supply may power several DT-600s).* A 22-pin edge connector is provided at the board edge.

The capacitors that tune the bandpass and discriminator filters should be of high quality and have high Q. Sprague *Orange Drops* or Mallory polystyrenes are generally available and recommended. Tantalum capacitors are recommended for C20, C21, C24, C26, and C27. All resistors are ¼ watt unless otherwise indicated. Diodes CR5 to CR12 are germanium 1N270s. All other diodes may be 1N914 or equivalent (note: larger diodes will not fit the available space on the circuit board). CR17 to CR20 are 400 PIV 1 amp, and C39 to C41 are 100 PIV, 1 amp. U1 is a 709 op amp (must be in TO-99 package), but all the others are 741s (8 pin mini-dip). Substitutions should not be made. Transistors are specified, but only Q2 is critical. Nearly any transistor that meets the specifications will do (2N3904: npn silicon switch V_{ce} = 40 V at 200 mA; 2N5656: npn silicon switch V_{ce} = 300 V at 500 mA). The loop supply transformer is an Essex PA-8421, which provides 125 Vac at 50 mA, but since the filament winding isn't used the transformer is well within rating, supplying 60 mA to the loop.

Relay K1 should have a 12-volt coil and the contacts should be rated at 10 amps for long life, such as the P&B KA11DG. Trimmers R8, R17, R50, R76 are PC-board mounts, such as TRW X201. A single two-pole, five-position rotary switch can handle all the switching functions (**fig. 3B**), or miniature toggle switches may be used. M1 is any inexpensive 0-1 mA meter. Dale EBT156 22-pin connectors may be used for the edge of the card.

construction

Consult the parts layout sheet provided with the circuit board and mount all parts on the board except for components for the bandpass input filter and discriminator. These tuned circuits must be adjusted to the proper frequency before they are permanently mounted on the board. The tuned circuits are adjusted with an audio



The DT-600 RTTY demodulator described in this article is only part of the overall CATC system of RTTY modules. Others will be described in future articles.

*A double-sided printed-circuit board with plated-through holes for the DT-600 is available from Data Technology Associates, Inc., Post Office Box 1912, Miami, Florida 33143. The price is $12.50, postpaid.

oscillator and a frequency counter coupled to the tuned circuit through a high-resistance (100k) to eliminate loading of the tuned circuit (**fig. 7**). Audio voltage across the tuned circuit is monitored by a vtvm. The audio generator is adjusted to obtain the peak. If the frequency is lower than desired, reduce the inductance to increase resonant frequency. If the frequency is higher than desired, capacitance may be added. Note that the inductors for the narrow-shift bandpass filter are 22 mH. These may be formed by placing the two windings of an 88-mH toroid in parallel.

filter tuning

The procedure for tuning the narrow-shift bandpass filter is to mount all capacitors on the board, but omit R1, R2, R3, and R4 at this time. Each of the three sections is, in turn, tuned to 2195 Hz. Short the toroid in the center section and tune the first and third sections to the desired frequency. Then remove the short from the center section, short the toroids in the first and third sections, and tune the center section to the desired frequency. Remove all shorts and place R1, R2, R3, R4 in their respective positions on the board. The discriminator filters are best tuned on the board, supplying either mark or space tones through the input filter. Use care in tuning all filters, as performance will be seriously degraded if filters are not resonant at the proper frequencies. No instructions are provided for tuning the wide-shift input filter, as it is sufficiently noncritical with the specified capacitors that tuning is not required.

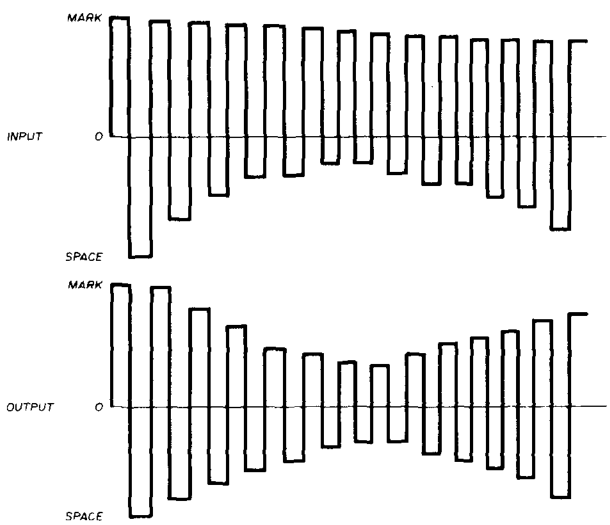


fig. 6. Automatic threshold corrector action for selective fading on space.

adjustments

After the board has been completed and filters tuned, the unit may be adjusted. Short the audio input and adjust R9 until the voltage at TP1 is zero. Remove the short from the audio input and apply a mark tone. Note the reading at TP2. Adjust the audio oscillator for the space frequency (depends on choice of shift), and adjust R17 for the same reading at TP2 as obtained with the mark signal. Repeat the procedure until the readings are identical for both mark and space. R50 determines the bandpass for autoprint (i.e., how far off frequency a station can be and still hold in the autoprint). Set the audio oscillator about 50 Hz below the mark frequency and adjust R50 so that the voltage at TP4 fluctuates near zero (both positive and negative excursions). R76 should be set for a maximum meter reading of 70% of full scale for either mark or space.

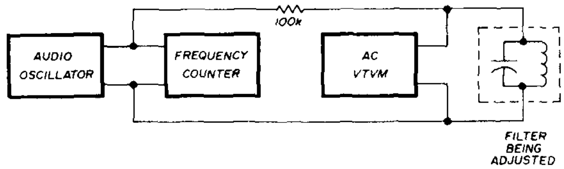


fig. 7. Instrumentation for filter tuning.

With all adjustments completed you are now ready to operate the DT-600. In normal operation nothing is done to the DT-600 except to ground the standby line during transmit. For very weak signals you may prefer to switch to limiterless and manual print control. Sometimes it's a bit frustrating to think that there's no way to adjust things to improve the print. However, with the exception noted above, you can be sure the DT-600 is providing the best print available for the price, and only slight improvement is available even at the higher prices. Interface connections will be discussed in a future article.

acknowledgements

We wish to thank Werner Fehlauer, KL7HKB, for constructive comment on early designs; Ronald C. Viets for parts layout and PC artwork changes; James E. Scalf, K4TKU, for drawings (and their many revisions); Fred R. Scalf, Jr., K4EID, for CATC systems interface compatibility and project coordination.

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ham radio

a new look at solid-state amplifiers

Techniques for joining unipolar and bipolar transistors to exploit the features of each

This article reveals no technological breakthroughs, nor will it lead you through the intricacies of a construction project. Rather, it suggests that amateurs and experimenters have overlooked a useful and versatile cricuit technique – the marrying of unipolar and bipolar transistors to produce an amplifying module with the desirable features of each solid-state device. In the following paragraphs arguments in behalf of the union of these devices are developed. I hope these discussions will stimulate the interest of those who enjoy designing and building their own equipment.

When bipolar transistors first became commercially available, it became obvious that this device had a serious shortcoming compared with the vacuum tube: the current hungry base-emitter junction was recognized as a sorry trade for the voltage-actuated input circuit of the tube. Because of the many advantages of the transistor (no heater, no microphonics, negligible aging, small size and cost) we learned to live with its low-impedance, power-consuming input.

fet transistor

Technological evolution produced the unipolar, or field-effect transistor, known as the fet. Logic can be presented to show that the fet should have chased the bipolar transistor right off the market. Some of the reasons why such a displacement did not occur are:

1. Fets tended to lag behind bipolars in gain-bandwidth product.

2. Fets acquired a reputation for being limited in power-handling capability, even for the needs of low-level circuitry.

3. Fets have never been cost competitive with bipolar transistors.

4. At least until recently, fets have not been hot performers – transconductance tended to be low – in the several hundred to several thousand micromho range.

5. The electronics fraternity has been in need of articles such as this to illustrate the benefits of beefing up fet performance with the bipolar transistor.

operational amplifier

What about the operational amplifier? Surely, the monolithic op amp *must* be the ultimate amplifying device. Not necessarily! From the viewpoint of the experimenter, the op amp has the following disadvantages:

1. It is far from easy to work with unless your eyes, nerves, and fingers were predestined for the jewelry trade.

2. During experimentation, it is vulnerable to catastrophic damage.

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3. Dual-polarity dc supplies are required.

4. The cheapies — the ones amateurs can afford — are notorious for performance kinks such as latch-up from overdrive and a propensity for oscillation.

5. The op amp is a bargain, it's true, in terms of the perhaps several-dozen discrete devices displaced. But a great number of amplifying tasks don't require differential input, dc response, or accurate operational functions. As a more mundane gain-producing device the op amp often is less than a good buy.

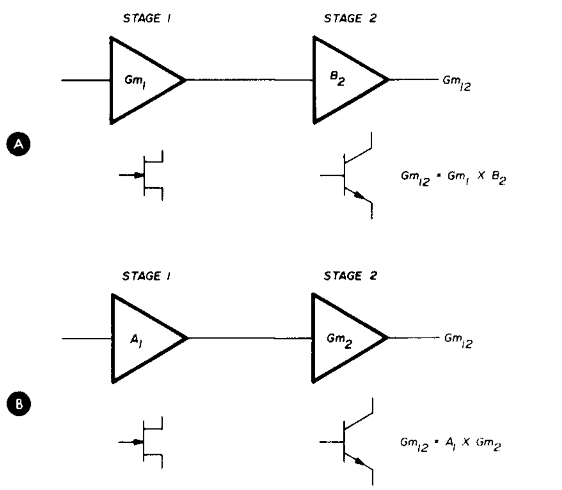

fig. 1. Transconductance amplification in a two-stage amplifier. G_m is increased by the current gain of a following stage, A, and by the voltage gain of a preceding stage, B.

We could deal similarly with the merits and shortcomings of other amplifiers; for example the tube, magnetic amplifier, and tunnel diode. All have problems for general experimental use. An amplifying module with the high-impedance input of tubes and the output characteristics of bipolar transistors would be a major step in the right direction.

the transconductance problem

One of the salient features of the bipolar -- and one not generally appreciated — is its inordinately high transconductance, which can range from several hundred thousand to millions of micromhos. Think of a tube or fet with such a characteristic! The reason that little awareness of this feature exists is that the healthy transconductance loses much of its significance when we have to supply power to the input circuit. Now the concept of driving a bipolar with an fet should begin to make sense. With such a combination we can achieve both high input impedance and high transconductance.

In the amplifier cascade of **fig. 1A** assume that the transconductance of stage 1, the fet, is Gm_1, and that the current gain of stage 2, the bipolar, is B_2. The *overall* transconductance of the cascade is given by $Gm_1 \times B_2$. Expressed in words, the transconductance of a stage is increased by the current gain of a *subsequent* stage. (Keep in mind the concept of transconductance as the figure of merit of amplifying capability.)

Let's now deal with the amplifying cascade depicted in **fig. 1B**. This time, the voltage gain of stage 1 is known and is represented by A_1. The transconductance of stage 2 is represented by Gm_2. The overall transconductance of the amplifying cascade is given by $A_1 \times Gm_2$. In words, the transconductance of a stage is increased by the voltage gain of a *preceding* stage. Assuming that the same amplifying cascade is represented by the block diagrams of **A** and **B** in **fig. 1**, some meaningful insights can now be attained.

We have seen that two products are both equal to a common quantity: overall transconductance, or Gm_{12}. We can therefore write:

$$Gm_1 \times B_2 = Gm_{12} = A_1 \times Gm_2 \qquad \textbf{(1)}$$

or simply

$$Gm_1 \times B_2 = A_1 \times Gm_2 \qquad \textbf{(2)}$$

We can make any of four algebraic transpositions; that is, **eq. 1** can be manipulated to facilitate the solution of any of its four terms. For our investigations, a particularly interesting transposition focuses on Gm_2, the transconductance of the bipolar transistor. Thus, we have:

$$Gm_2 = \frac{Gm_1 \times B_2}{A_1} \qquad \textbf{(3)}$$

practical example using a fet and a bipolar

When we consult manufacturer's spec sheets, we generally find the transconductance of fets and the current gain of bipolars. (We seldom find the transconductance of bipolars.) Let's deal with the type 2N5438 n-channel fet and the 2N3565 npn bipolar transistor. The fet can have a nominal transconductance of 4000 micromhos, and the bipolar can have a nominal current gain of, say, 300. (The parameter tolerances of both devices are, to say the least, sloppy.) Suppose that the fet is used as a common-source voltage amplifier and that its voltage gain is four. It is thus employed to drive the bipolar. With a bit of crank-grinding, we can use these numbers to compute Gm_2, thus:

$$Gm_2 = \frac{4000 \times 300}{4} = 300{,}000 \text{ micromhos}$$

transconductance for the 2N3565 transistor

Note, too, that the overall transconductance, Gm_{12}, of the amplifier cascade calculates to a whopping 1,200,000 micromhos! (Both $Gm_1 \times A_1$, and $A_1 \times Gm_2$ confirm this result.) Whether a single device or a module with more than one active device, an amplifier that develops over a million micromhos and extracts no power from the signal source has to be what the doctor ordered. Also to be considered is the fact that voltage gain is available from the bipolar. If we insert a 1k load resistor in the bipolar transistor collector circuit, the circuit will develop a voltage gain of 300 (from voltage gain $= Gm \times R_L = 0.3 \times 1000 = 300$, where Gm is expressed in mhos). The overall voltage gain of the amplifier cascade is then the product of the voltage gains of stages one and two, or 4 X 300 = 1200. This is confirmed by multiplying the overall transconductance, Gm_{12}, by the output load resistance, or 1.2 X 1000 = 1200. This calculation is made on the premise that a 1,200,000 micromho, or 1.2 mho, amplifier acts upon a 1000-ohm output load resistance. Note that high voltage gain can be produced in the bipolar stage with low load resistances, which implies relatively low degradation of higher frequencies. If you wanted high voltage gain in a single fet, the drain resistor would have to be many tens, perhaps hundreds, of kilohms; and frequency response would peter out pronto.

multipurpose amplifying module

In **fig. 2** we have an amplifier with the described performance characteristics. The −3 dB points are approximately 100 Hz and 0.6 MHz. But this is only a start. The circuit is extremely flexible. The frequency response, voltage gain, power output, and power consumption are easy candidates for selective optimization. Such versatility and noncritical features stem from the use of ac coupling between the stages. Direct coupling can also be used but will, in general, require a bit more patience in satisfying the mutual bias requirements of the two active devices. Direct coupling can lead to more compact packages and is necessary, of course, if dc amplification is needed.

The bipolar load resistor, R_L, is in effect acted upon by an overall transconductance exceeding a million micromhos. At the same time, the input impedance is of the same order of magnitude obtainable from vacuum-tube amplifiers and is limited only by R_G. The dashed enclosure in **fig. 2** facilitates thinking of the cascade as a *single* "amplifying module." Component values are noncritical and can be modified considerably from those indicated to optimize gain, frequency response, power output, or power consumption. Similarly, other than the indicated devices can be used. Not obvious from inspection of **fig. 2** is the fact that the load presented to the fet is primarily the input resistance of the bipolar transistor. This value is in the order of 1000 to 1200 ohms and enables the fet to develop a voltage gain of 4.

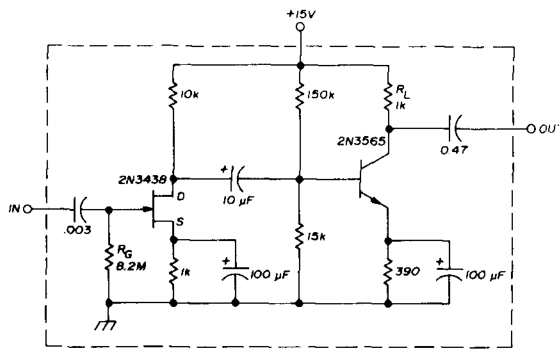

fig. 2. Multipurpose amplifying module using a field-effect transistor to drive a bipolar transistor.

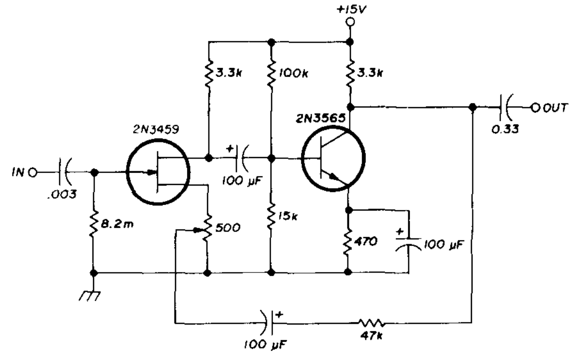

fig. 3. Low-distortion feedback amplifier. Circuit can be optimized for rf as well as audio frequencies by adjusting coupling, feedback, and emitter bypass capacitor values.

feedback amplifier

In **fig. 3** a similar amplifier is shown, but with the addition of an overall feedback path. Depending on how much feedback is used (how much the overall gain is decreased), various circuit attributes are evident. These include distortion reduction, extension of frequency response, and stabilization against gain variations, which otherwise tend to occur from the effects of temperature on both active and passive components and from changes in power-supply voltage. In this circuit, the feedback decreases the amplifier output impedance, which is usually a desirable feature.

This amplifier, like the previous one and the subsequent ones as well, can be optimized for rf as well as audio. In this particular case, you would reduce the size of the coupling, feedback, and emitter bypass capacitors. Or if both low and high frequency response are desired, these capacitors can be paralleled by small ceramic or mylars (electrolytics often don't perform well at higher frequencies). At high frequencies, the amplifier physical layout becomes exceedingly important, and a printed circuit board is probably the best approach.

Other things being equal, the extent of flat frequency response increases with increased feedback. If in addition to these techniques the fet and the bipolar are selected for both high transconductance and gain-bandwidth product, such a feedback amplifier can provide voltage gain by a factor of several tens to a frequency of several or more MHz. (For higher frequency work, the cascade arrangement of **fig. 4D** is best.)

experimental amplifying-module family

Nine other unipolar-bipolar amplifying modules are shown in **fig. 4**. Their names and applications are:

A. Alternative feedback amplifier – audio, general purpose, rf capability at low gain.

B. Audio amplifier with direct coupling – speech amplifier, low-level audio.

C. Audio amplifier for operation from rectified line voltage – audio output.

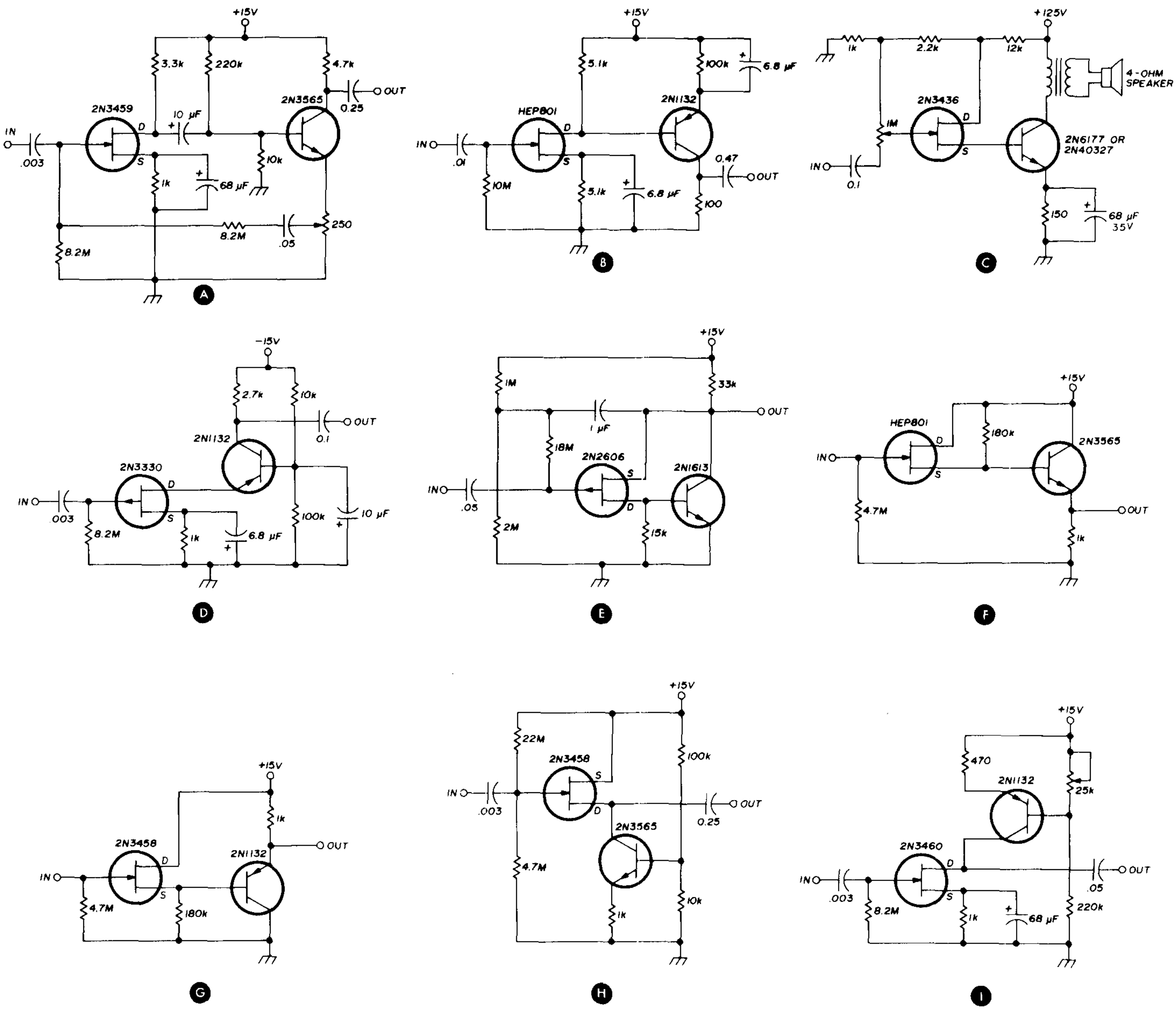

fig. 4. Family of amplifying modules useful for many applications.

D. Cascode amplifier — audio, video, i-f, rf; best arrangement for use with tuned circuits.

E. Ultrahigh input impedance amplifier — active scope probe, electrometer, instrumentation.

F. Darlington amplifier — meter interface, impedance transformer, coax driver, relay actuator.

G. Complementary symmetry Darlington — meter interface, impedance transformer, coax driver.

H. Source follower with constant-current bias supply — used where a source follower with high output-voltage swing and voltage gain close to unity is required.

I. Single-stage amplifier with dynamic load — high voltage gain; can be used with very low supply voltage.

In all instances the designated device types and component values are intended only as a guide. Because of device and component tolerances as well as the specific performance required, various modifications will probably be made. In particular, the empirical determination of bias networks in direct-coupled circuits will usually pay dividends in the attainment of symmetrical voltage swing. Improved performance of these circuits, as well as those in **figs. 2** and **3**, can sometimes be obtained by connecting a high resistance from the fet gate to the ungrounded battery terminal. Several tens of megohms should do the trick.

Why not build a few of these amplifier modules and retain them as convenient building blocks?

ham radio

vestigial sideband microtransmitter for amateur television

Amateur television video bandwidth can be reduced by adapting commercial techniques

To conserve spectrum space commercial television uses a transmission mode known as vestigial sideband. A composite video signal, containing frequency components from dc to 4 MHz, is amplitude modulated onto a carrier. The resulting sum and difference frequencies (sidebands) occupy an 8-MHz bandwidth. Before transmission, the modulated signal is filtered. The upper sideband and carrier are transmitted, but most of the lower sideband is not (see **fig. 1**). Thus the video signal plus its audio can be transmitted in the 6-MHz TV-channel allocation.

As amateur television (ATV) activity expands in the 70-, 23- and 13-cm bands, it will become necessary for amateurs to adopt vestigial sideband as their operating mode to avoid interference with other communications services. A case in point is the possibility of interference with the 435.1-MHz OSCAR satellite telemetry beacon, which would result from the unfiltered lower sideband of an ATV station operating on the 439.25 MHz ATV calling frequency.

In commercial television, the modulated carrier is developed, and filtering performed, at the ultimate transmission frequency (**fig. 2**). A complicating factor, the need for frequency flexibility, makes such a system impractical for ATV. Imagine retuning a stagger-tuned string of over-coupled resonator pairs for sharp skirts and flat response over a 5-MHz band, then retuning it each time you need to shift your operating frequency!

One alternative is to generate a stable, well-filtered vestigial sideband video signal on a fixed frequency in the vhf spectrum, then heterodyne it to the desired uhf in a balanced mixer. The conversion stage local-oscillator chain, if made variable in frequency, will provide the system with the required frequency flexibility. **Fig. 3** is a block diagram of one such system, which I use for ATV transmission in the 70-cm band. The observant reader may note in **fig. 3** a pronounced similarity to the transceive converter for 1296-MHz ssb published in an earlier issue.[1] Obviously, the process of heterodyning a modulated signal into a higher frequency band for transmission is virtually the same, regardless of whether the original signal was modulated with a-m, fm, ssb, CW, or video.

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Many of the blocks in the local oscillator and rf strings of **fig. 3**, as well as the mixer, are either available commercially or may be adapted from equipment designs published previously. This article deals with the design and construction of the microtransmitter and vestigial sideband filter modules of the ATV system in **fig. 3** – *building blocks toward clean, commercial-quality TV transmission.*

microtransmitter chip

The heart of the ATV transmitter is the LP-2000, a miraculous integrated circuit from Lithic Systems Inc., in Saratoga, California.* The outgrowth of a program to develop a microminiature aircraft crash-beacon transmitter, the LP-2000 is a complete transmitter system – oscillator, buffer, driver, power amplifier, modulator, preamplifier and regulator – all in a single 10-lead, TO-100 can. With the addition of a crystal, two tuned circuits, a battery, and a modulation source these ICs can generate as much as 100 mW of CW, or 50 mW of a-m or pulse-modulated output well into the vhf spectrum. **Figs. 4** *and* **5** *indicate the very complex circuitry that can be built into a single monolithic microcircuit.* A complete

Heart of the ATV system is the LP-2000 IC next to the crystal.

circuit description is available from the manufacturer in the form of an application note.[2]

An appealing feature of the LP-2000 is that its modulator transistors (Q14 and Q16 in **fig. 5**) are dc-coupled to both the driver and power amplifier transistors, Q13 and Q15. Additionally, direct coupling is employed between all modulator stages. Thus the circuit lends itself well to video-modulated applications.

frequency selection

The operating frequency chosen for the microtransmitter, 61.25 MHz, corresponds to the assigned video carrier frequency of commercial TV channel 3. This permits the basic microtransmitter module to be used for short-range, closed-circuit TV applications, there being no local channel 3 allocation in my area to interfere with such operation. Similarly, you may wish to select an operating frequency corresponding to the video carrier frequency for a locally unassigned lower vhf-band TV channel.

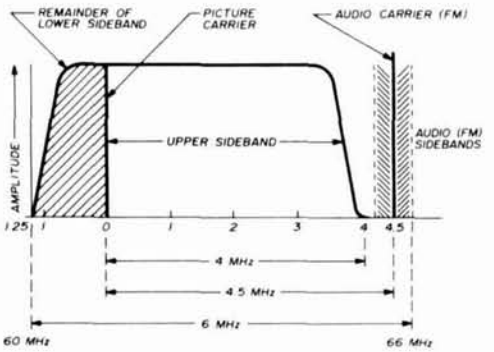


fig. 1. Vestigial sideband transmission on monochrome television signals.

The circuit I used on channel 3 (**fig. 6**) will cover TV *channels 2 through 4 merely by substituting crystals and* retuning the two trimmer capacitors. For operation on channels 5 and 6, it will be necessary to reduce L1 to 6 turns, L2 to 8 turns, and L3 to 2 turns. All other component values remain as in **fig. 6**. Similarly, the vestigial sideband filter shown in **fig. 7** may be tuned to cover TV channels 2 and 3. For operation on channels 4 through 6, L1 and L4 of **fig. 7** must be reduced to 3 turns, and L2 and L3 to 7 turns each. **Table 1** will serve as a guide in selecting crystal frequencies. When the microtransmitter operating frequency is increased, output power will begin to degrade as the upper frequency limit of the integrated circuit is approached.

microtransmitter circuit

The basic circuit for generating 10 mW of stable double-sideband A5 with the LP-2000 microtransmitter

table 1. Video-carrier frequencies of lower vhf television channels.

channel number	video carrier frequency (MHz)
2	55.25
3	61.25
4	67.25
5	77.25
6	83.25

IC is shown in **fig. 6**. The circuit is divided functionally into three sections. J1 is the video input connector, which is driven by the standard composite video output signal from a TV camera or video tape recorder (typically 1 volt peak into a 72-ohm impedance). This video

*An experimenter-grade version of this microcircuit, the NA2000, is available for $9.95 from NASEM, Box AI, Cupertino, California 95014.

drive level is more than adequate to overmodulate the microtransmitter, hence the pad-and-trimpot combination at J1, which simultaneously matches the relatively high video input impedance of the IC to 72 ohms and allows the appropriate video level to be set.

Because of the number of stages employed, the LP-2000 IC provides a considerable amount of rf gain in a rather confined space. Thus the circuit exhibits a strong tendency toward oscillations if precautions are not taken. It is advisable to let the physical arrangement of the schematic dictate the circuit board layout. As with all "hot" vhf circuits, short and direct wiring is a must. No printed-circuit artwork is provided, as the stray coupling between traces in a PC board would most likely lead to instability. I have achieved the greatest success by using a piece of PC stock only as a ground plane, positioning the components in space above it to minimize lead lengths. I call such a configuration a "breadspace," for breadboard suspended in space. (See the accompanying photographs.) This circuit would also lend itself well to isolated-pad construction, as described in recent articles.[3,4]

Parallel resonant circuits C1-L1 and C2-L2 tune the oscillator and amplifier stages respectively. Any coupling between them will obviously result in oscillations, or at least potential instability. Although the toroidal cores on which the inductors are wound tend to minimize stray coupling, the two inductors should nonetheless be

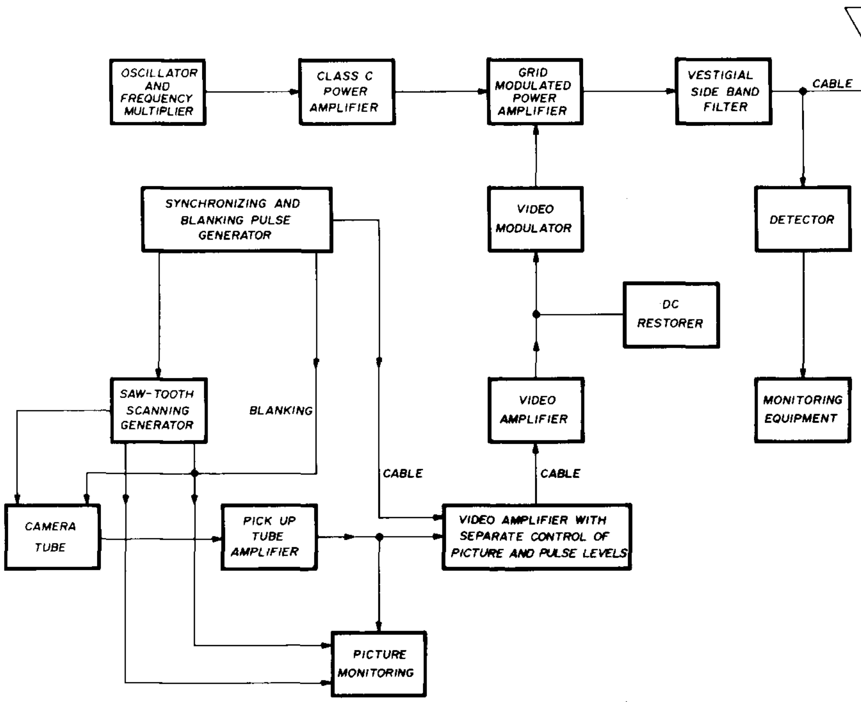


fig. 2. Simplified block diagram of a monochrome TV transmitter.

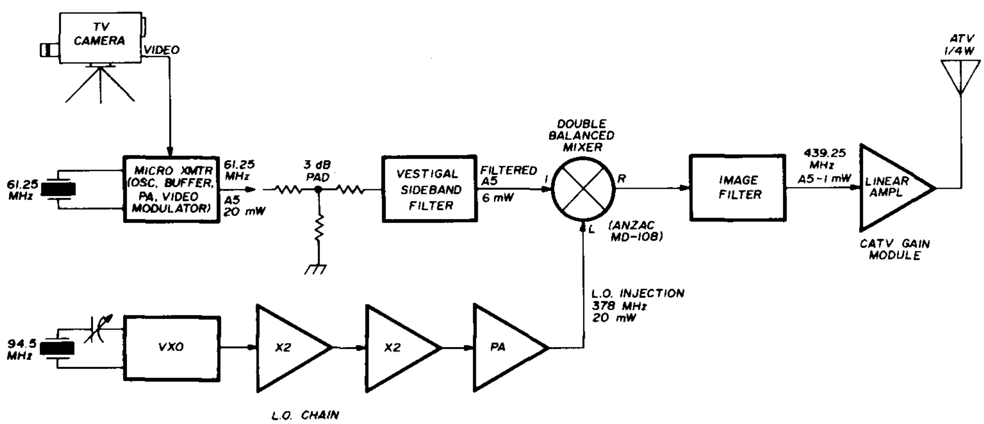


fig. 3. Block diagram of ATV transmitter for use in the 70-cm band.

oriented at right angles to one another as a precaution against oscillations. Although not attempted in the prototype unit, the use of shields positioned as shown by the dotted lines in **fig. 6** is a good idea. The 3-dB T pad between L3 and J2 not only keeps the power level within the requirements of the system but also provides a degree of isolation against instability that may occur from mismatching the output to its load.

microtransmitter tuning

A common amateur practice in tuning transmitting equipment is to adjust all tuned circuits for maximum indicated output power. As this circuit is potentially unstable, such an approach would be disastrous if applied to the microtransmitter. The resulting output signal could well contain a multitude of frequency components. If some of the output energy did indeed fall on the desired video carrier frequency, it would only be by coincidence. The best way to tune this circuit is with a spectrum analyzer. Trimmers C1 and C2 are tuned for maximum output on the desired video carrier frequency consistent with minimum spurious output. Tuning should be accomplished with video input connector J1 terminated into a 75-ohm resistor. Some interaction between the tuning of C1 and C2 will be noticed; repeated adjustments may be necessary.

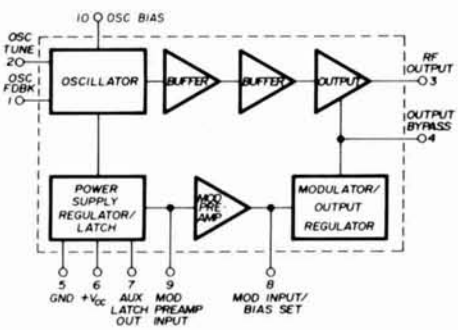
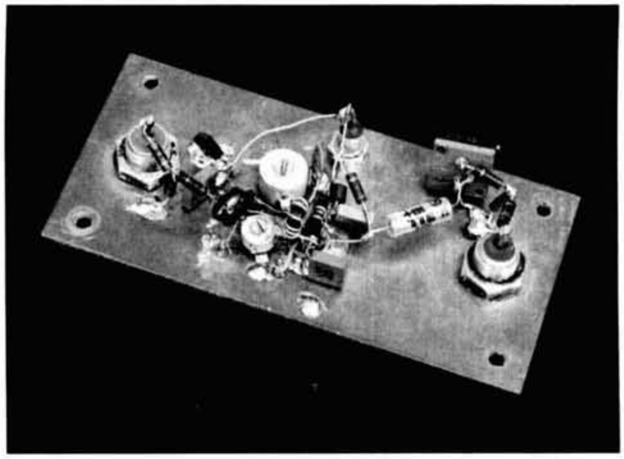


fig. 4. Block diagram of the LP-2000 transmitter IC.



Vestigial ATV system uses point-to-point wiring on PC chassis.

Since few amateurs have access to a spectrum analyzer, two alternative tuning methods are proposed. The first involves the use of a high-selectivity absorption wavemeter (or grid-dip oscillator in the absorption mode), *loosely* coupled to J2. Adjust C1 and C2 repeatedly for maximum indicated output on the desired video carrier frequency, then tune the wavemeter over its *total* frequency excursion to ensure absence of parasitic oscillations.

Those lacking an absorption wavemeter will probably have difficulty in adjusting this circuit. Nonetheless, a "last resort" tuning method may be attempted. Loosely couple J2 output into a TV receiver that is adjusted for reception at the channel for which the microtransmitter was built. Tune C1 and C2 until the resulting video carrier blanks the TV receiver screen. Now tune the receiver to all adjacent channels to detect any parasitic oscilla-

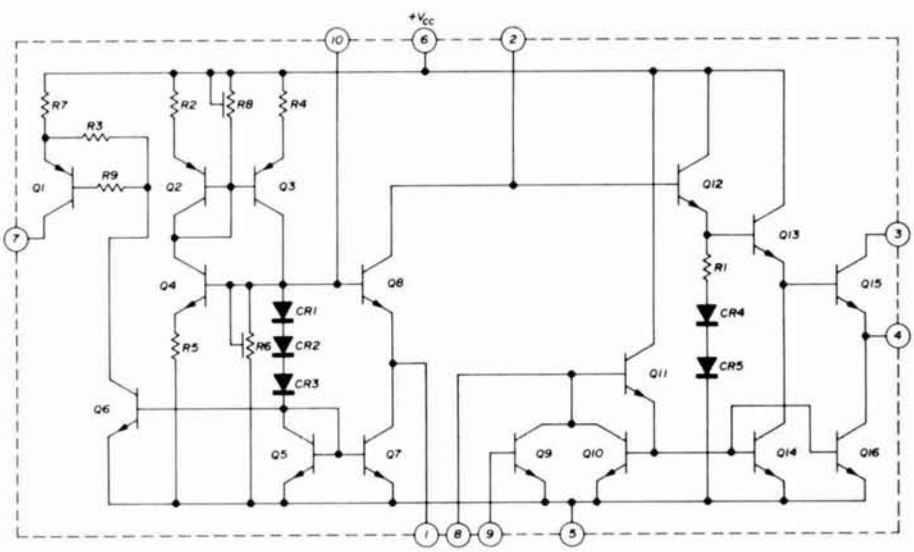


fig. 5. LP-2000 IC schematic.

tion. *If any other channel is blanked, try again until* output is noticed *only* on the desired channel.

The video level setting is best accomplished visually. After the rf adjustments are completed, loosely couple the rf output into a TV receiver. Connect a TV camera to J1 and scan a scene containing bright white level (a test pattern is ideal). Tearing of the horizontal synchronization will occur with the trimpot set for maximum video modulation. Back off on the video level until a stable sync is obtained, which will put the transmitter very close to the standard 12.5% ±2.5% modulation level for bright white. If the camera is properly adjusted, the 75% ±2.5% blanking level will fall into line automatically.

vestigial sideband filter circuit

The filter depicted in **fig. 7**, consisting of two critically coupled parallel resonant circuits with link coupling in and out, is the absolute minimum in circuit complexity considered adequate for amateur vestigial sideband transmission. Attenuation of frequency components 2 MHz below the video carrier frequency, as seen in **fig. 8**, is 11 dB referenced to the passband midpoint. Similarly, the −3 MHz component is attenuated by 13.5 dB. If high-power ATV operation is anticipated, a greater degree of lower-sideband attenuation may be desirable, and two or more sets of resonator pairs may be cascaded. If multiple stages are used, stagger tuning may be necessary to maintain the required passband bandwidth.

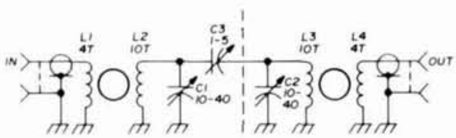
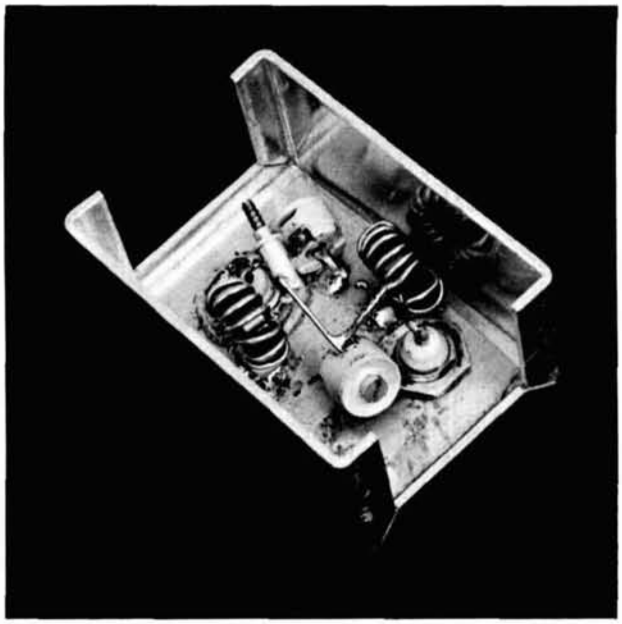


fig. 7. Vestigial sideband filter schematic for TV channels 2-3. All coils are wound with no. 18 (1mm) on Amidon T50-10 toroids. L1 is 4 turns; L2 is 10 turns; L3 is 4 turns; L4 is 4 turns. See text for coil data for channels 4-6.

As mentioned previously, the vestigial sideband filter may be modified for operation at different video carrier frequencies by modifying the number of turns on the toroids. As a general rule, skirt selectivity can be expected to degrade as operating frequency increases (due to a decrease in loaded Q). This suggests that cascaded resonator pairs should be considered for operation at TV channels 5 and 6.



Construction of the vestigial sideband filter. All coils are wound on Amidon T50-10 toroid cores.

Construction of the vestigal sideband filter is far less critical than that of the microtransmitter module. The only precaution to be observed is adequate shielding of the filter assembly to prevent lower video sideband components from leaking around the filter and being radiated into following stages.

vestigial sideband filter tuning

As in the case of adjusting the microtransmitter module for optimum rejection of spurious output, properly tuning the vestigial sideband filter requires equipment not often available to the ATV experimenter. Thus

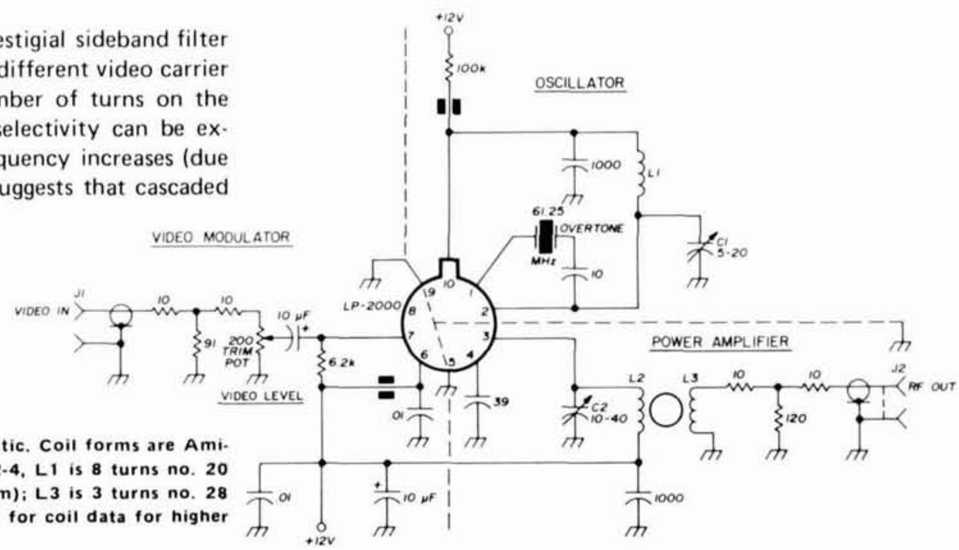


fig. 6. Microtransmitter module schematic. Coil forms are Amidon T25-10 toroids. For TV channels 2-4, L1 is 8 turns no. 20 (0.8mm); L2 is 10 turns no. 28 (0.3mm); L3 is 3 turns no. 28 (0.3mm) wound opposite L2. See text for coil data for higher channels.

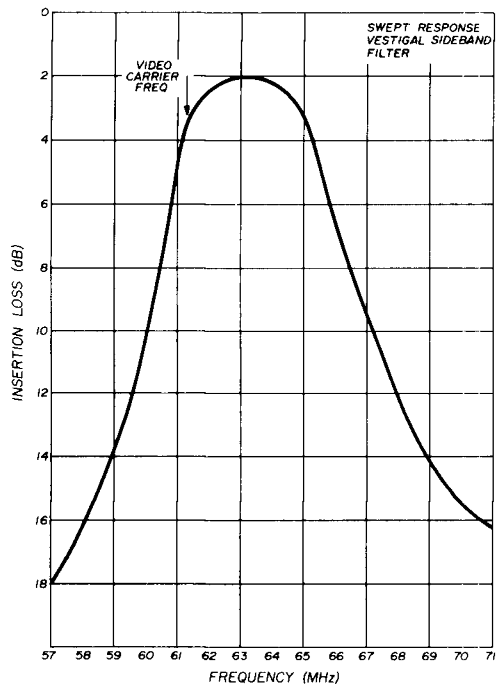


fig. 8. Vestigial sideband filter swept-frequency response.

in addition to the ideal approach, a compromise adjustment method will be outlined. Ideally, the filter should be adjusted on an rf sweep setup, as indicated in **fig. 9.** The procedure consists merely of adjusting C1, C2 and C3 of **fig. 7** repeatedly until the desired frequency response (that of **fig. 8**) is displayed on the CRT. The goals are a 5-MHz bandwidth, minimum passband ripple, and steepest possible lower-skirt selectivity with the video carrier frequency falling just at the knee of the lower-skirt rolloff. An application note from Hewlett-Packard[5] describes swept attenuation measurements in detail.

The filter passband can be adjusted manually using a stable rf signal generator, a vtvm with rf probe, and a 50-ohm coaxial feedthrough. Equipment is connected as in **fig. 10**. The signal generator is adjusted to 2 MHz above the desired video carrier frequency, coupling capacitor C3 adjusted to minimum capacitance, and C1 and C2 adjusted for a maximum indication on the vtvm. The filter will now be adjusted for minimum coupling (thus maximum Q) and will be resonant near the center of its passband. Next readjust the signal generator frequency to coincide with the video carrier frequency. The vtvm indication should drop off markedly because of the high selectivity and narrow bandwidth of the undercoupled resonators. The filter passband will widen if C3 capacitance is increased (because of tighter coupling), which will bring the video carrier within the lower skirt.

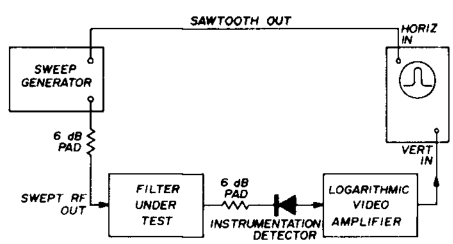


fig. 9. Setup for swept-frequency response measurement of filters.

The carrier-frequency attenuation, relative to midband power level, will be 1 to 2 dB when the voltage produced at the video carrier frequency (measured on the vtvm) equals 80 to 90% of the voltage indicated at mid passband. Acceptable vestigial sideband filtering will result under such conditions. Passband ripple and skirt selectivity can be examined readily by sweeping the signal generator manually in frequency and observing the vtvm.

conclusions

As rf spectrum space becomes increasingly scarce, vestigial sideband transmission will become the standard for ATV. A high degree of frequency flexibility can be maintained by generating a stable vhf television signal, filtering it to roll off the lower sideband, then heterodyning the resulting vestigial sideband signal to the transmission frequency. I hope the equipment described will be the first of numerous approaches to apply commercial standards to amateur television transmission.

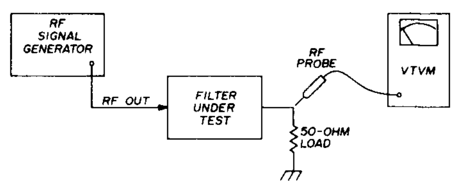


fig. 10. Setup for manual-frequency response measurement of filters.

acknowledgements

I wish to express my appreciation to Bob Hirschfeld, W6DNS, president of Lithic Systems, for his interest in developing amateur applications for his products. Thanks also go to Cliff Buttschardt, W6HDO, for encouraging me to try the LP-2000 even though, in his words, "it's a squirrelly chip." Once tamed, I found the device to be a fine choice indeed.

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3. Ted Swift, W6CMQ, "Low-Cost Instant Printed-Circuit Boards," *ham radio*, August, 1971, page 44.
4. Alfred F. Stahler, W6AGX, "Isolated-Pad Circuit-Board Construction," *QST*, May, 1973, page 44.
5. "Swept Frequency Techniques," Application Note 65, Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, California, August, 1965.

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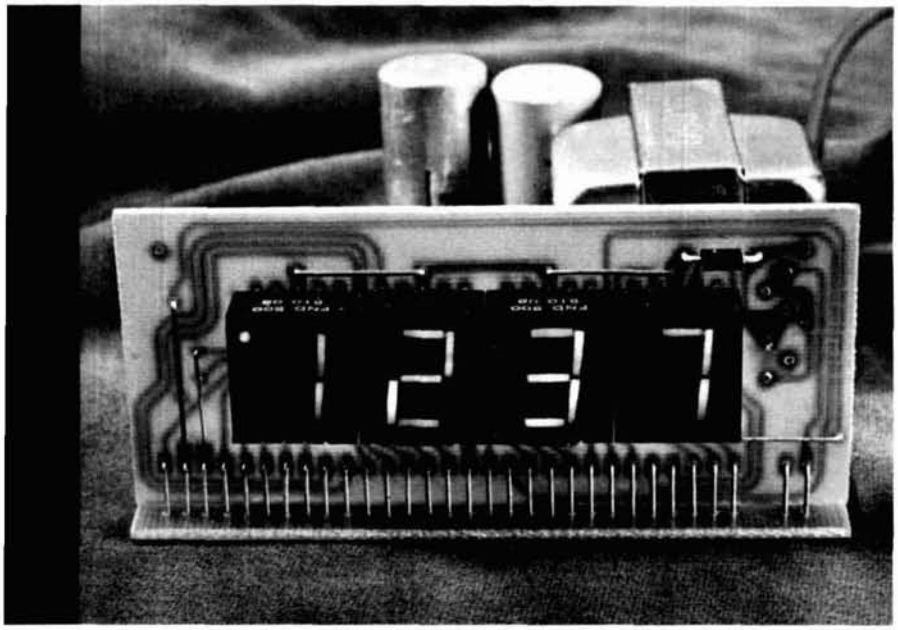

low-cost digital clock

New digital clock IC is designed for alarm clock-radio service and provides display drive, alarm and sleep-to-music in 12- or 24-hour formats

Fairchild Semiconductor has announced the 3817, an mos digital clock IC with full clock radio features. The direct drive offered by the 3817 IC allows the design of a simple, low-cost clock radio without the multiplex noise problem previously associated with mos clock circuits. The design described here capitalizes on this direct-drive capability and features the Fairchild FND500 LED display.

device description

The 3817 digital alarm clock is a monolithic mos IC which uses Isoplanar p-channel processing. The logic density thus achieved allows the incorporation of large output transistors for direct digit drive without making the overall chip size too large for low-cost, high-volume production. The 3817 is micro-programmable at the mask level to allow options such as alarm tone or dc at the alarm output pin without making major changes to the entire mask set. Four display modes are switch selectable (time, seconds, sleep and alarm) allowing the user to build several types of clocks and timers. Either a 50- or 60-Hz input may be used for the clock input, derived from either the power line with the simple RC filter shown or from an external timebase. Time display may be either 12-hour (with AM/PM indication) or 24-hour format. Outputs consist of display drive, alarm, and sleep to music (timed radio turn-off).

The FND500 is a 0.5 inch (13mm) high common-cathode LED display using a single diode per segment with a light pipe for diffusion. The digits may be horizontally stacked on 0.6 inch (15mm) centers for a compact display.

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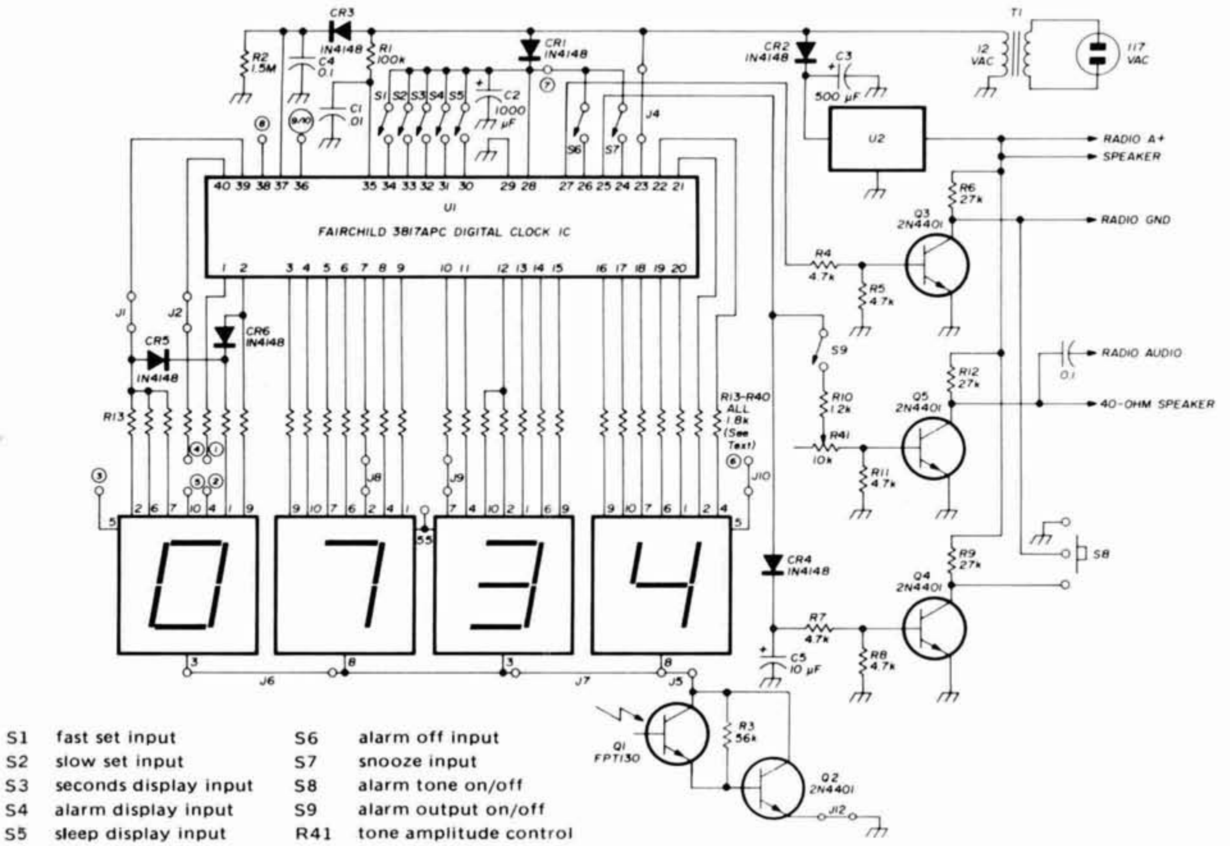


fig. 1. Schematic diagram of the digital clock using the Fairchild 3817 digital clock IC. Circuit may be wired for 12- or 24-hour format, as discussed in the text. Pinouts of the 3817 are shown in fig. 2.

circuit description

Power supply. Three separate power supplies are actually used in the design shown in **fig. 1**. Diode CR1 and capacitor C2 provide V_{ss} and display power; CR2, C3 and U2 provide a regulated A+ for the radio; CR3 and C4 provide a "high" to the display blanking input of the 3817. Should a power failure occur, R2 discharges C4, the display blanking input goes low, and the display is blanked until power is reapplied. With the display blanked, the 3817 requires less than 4 mA to maintain the registers and this is provided by the charge on C2. U2 is a 7800-series IC voltage regulator with the output voltage and current handling capability determined by the requirements of the radio used. R1 and C1 form an RC filter to remove line transients which could cause false counting or device damage. The output of the filter is applied to the C_p input (pin 35) of the 3817, where an internal Schmitt trigger shapes the signal for further use.

Output drive circuits. Transistor Q3 and its associated resistors provide an active low output for timed radio turn-off after a user-selected interval of up to 59 minutes. This portion of the circuitry may be omitted in its entirety if the feature is not desired.

Diode CR4 and C5 rectify the alarm tone output for amplification by Q4, resulting in an active low output for timed radio turn-on when a coincidence is detected by the alarm comparators. Again, this portion may be omitted in its entirety if the feature is not desired.

Transistor Q5 and its associated components provide an alarm tone output at a level sufficient to drive a

Layout of the digital clock PC board. Three-terminal voltage regulator is not installed, nor is the phototransistor display control circuitry.

table 1. Display modes of the Fairchild 3817 digital clock IC.

selected display mode*	digit 1	digit 2	digit 3	digit 4
Time display	10s of hours and AM/PM	hours	10s of minutes	minutes
Seconds display	blanked	minutes	10s of seconds	seconds
Alarm display	10s of hours and AM/PM	hours	10s of minutes	minutes
Sleep display	blanked	blanked	10s of minutes	minutes

*If more than one display mode input is applied, the display priorities are in the order of Sleep (overrides all others), Alarm, Seconds, Time (no other mode selected).

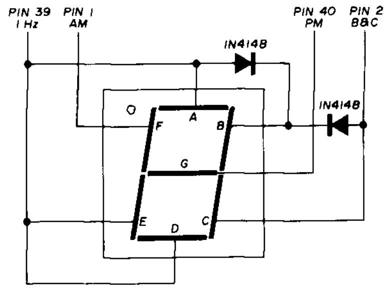


fig. 3. Wiring of the tens of hours digit for the 24-hour format is accomplished on the PC board (fig. 5) by jumpers as discussed in the text.

40-ohm speaker with enough volume to wake even the soundest of sleepers. If a radio is used, this speaker should be omitted and 0.1-μF capacitor from Q5's collector to the radio's audio amplifier input should be installed. S9 is tone on/off and R41 controls the tone amplitude.

Control circuits. All control functions are implemented by applying V_{ss} to the appropriate pin (an internal pull down to V_{dd} through approximately 2 megohms is provided.) Time of day is displayed in the absence of any of the following inputs:

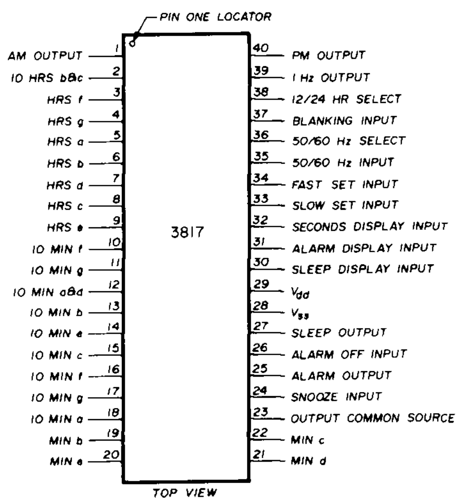


fig. 2. Pinouts of the 3817 digital clock IC.

Fast Set (pin 34) advances hours at a 1-Hz rate; *Slow Set* (pin 33) advances minutes at a 1-Hz rate; *Seconds Display* (pin 32) blanks the tens of hours digit and minutes and seconds are displayed on the remaining digits; simultaneous operation of *Seconds Display* and *Slow Set* displays seconds and holds the time counters (refer to **tables 2** and **3** for a complete explanation of control and display functions).

Alarm Display (pin 31) temporarily defeats time-of-day display and causes the time for which the alarm is currently set to be displayed, along with the appropriate AM or PM indication when in the 12-hour format. *Alarm Set* is accomplished by simultaneous operation of *Alarm Display* and the appropriate setting input; the time-of-day setting is not disturbed by this operation.

Sleep Display (pin 30) blanks the hours digits and displays the minutes remaining until timed radio turn-off occurs. Operation of this input plus a setting input causes the sleep timer to decrement at the same rate at which time of day is set. When this input is activated, *sleep output* (pin 27) goes to V_{ss}; when the counter reaches 00 a latch is reset and the output goes low, Q3's collector goes high, and the radio turns off. The turnoff may also be accomplished at any time in the countdown by momentary operation of the *Snooze* input (pin 24).

Snooze inhibits the alarm output for 9 minutes, after which the alarm again sounds. The input may be used as often as desired during the 59 minutes for which the alarm latch is set.

Alarm Off (pin 26) resets the alarm latch, causing pin 25 to remain low and therefore silence the alarm. This momentary connection to V_{ss} also readies the latch for the next comparator output, causing the alarm to sound again 24 hours later. If no alarm output is desired for more than a day this input should remain at V_{ss}, so a spst toggle was used for this function. S9 is provided to silence the alarm tone while causing the radio to remain on for up to 59 minutes.

Digit drive circuits. Resistors R13 through R40 limit the output current of the 3817 to provide uniform display brightness and to prevent destruction of the output de-

table 2. Setting control functions for the 3817 digital clock IC.

selected display mode	control input	control function
Time*	slow	Minutes advance at 1-Hz rate
	fast	Hours advance at 1-Hz rate
	both	Hours advance at 1-Hz rate
Alarm	slow	Alarm minutes advance at 1-Hz rate
	fast	Alarm hours advance at 1-Hz rate
	both	Alarm resets to 12:00 AM (12-hour format)
	both	Alarm resets to 00:00 (24-hour format)
Seconds	slow	Hold (input to entire time counter is inhibited)
	fast	Seconds and 10s of seconds reset to zero without a carry to minutes
	both	Time resets to 12:00:00 AM (12-hour format)
	both	Time resets to 00:00:00 (24-hour format)
Sleep	slow	Subtracts count at 1 Hz
	fast	Subtracts count at 60 Hz
	both	Subtracts count at 60 Hz

*When setting time, sleep minutes will decrement at rate of time counter until the sleep counter reaches 00 minutes (sleep counter will not recycle).

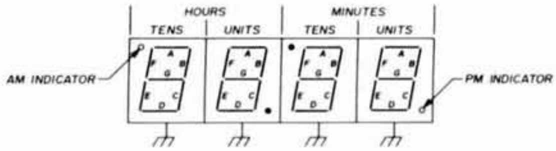


fig. 4. Arrangement of the FND500 common-cathode LED displays showing the AM and PM indicators. Note that the tens of hours and tens of minutes displays are inverted. In the 12-hour format the colon is provided by the unused decimal points included with the digits.

vices. The value of these resistors is determined by the formula

$$R = \frac{V_{ss} - V_f}{I_f}$$

Therefore, with a 12-volt rms transformer, R will be approximately 1800 ohms at 8 mA, as the forward voltage drop of GaAsP is about 1.6 volts and the 1000-μF filter capacitor will charge to the peak ac value.

Wiring for the tens of hours digit in 24-hour time format is shown in **fig. 3** and is accomplished on the PC board **(fig. 5)** by jumper installation as follows:

12-hour operation: jumper points 1 and 3, 4 and 6, and omit J1

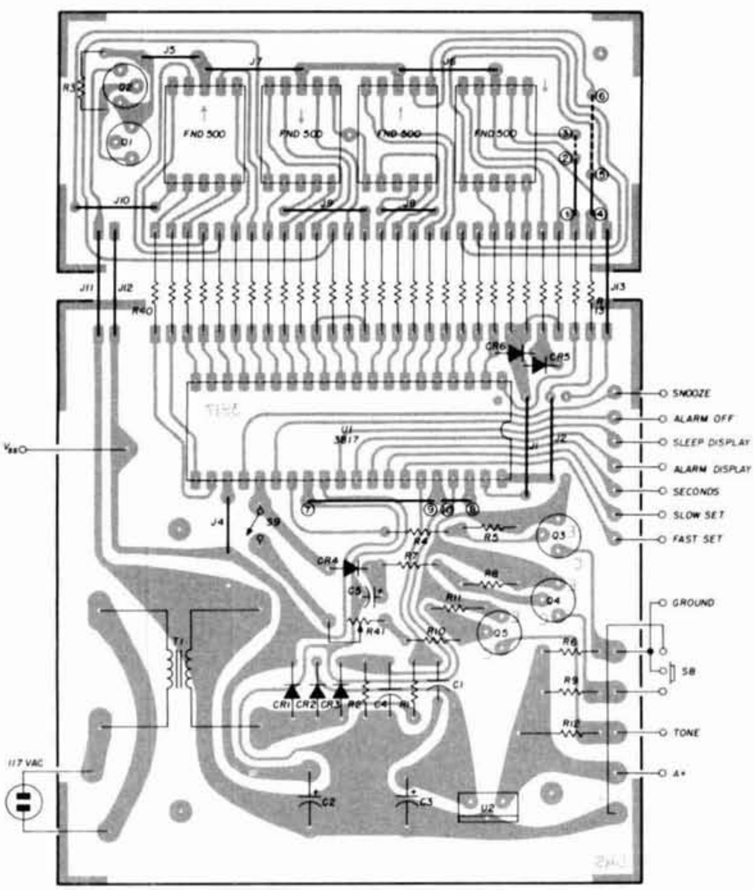
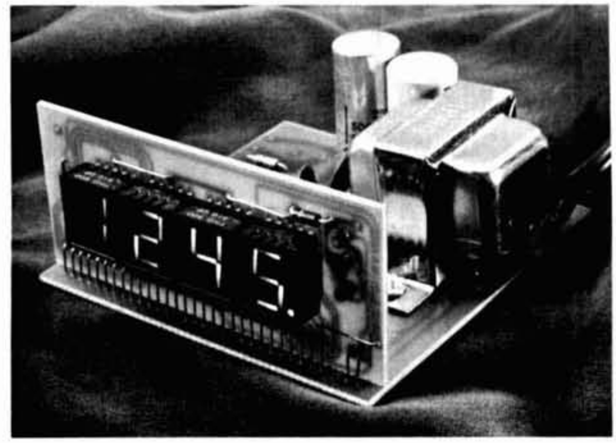


fig. 5. Component placement on the digital-clock PC board. A full-sized printed-circuit layout is shown in fig. 6.

24-hour operation: jumper points 1 and 2, 4 and 5, and 7 and 8

In the 12-hour format, only, resistors R13 thru R40 may be omitted and replaced with jumpers if the following additional changes are made:

1. Replace J5 with a 5.1 volt, 1 watt zener diode with the anode oriented toward Q1 and Q2 collectors.



Front view of the low-cost digital clock shows installation of the separate readout circuit board.

2. Replace diode CR6 with a jumper. This maintains the display V common 5.1 volts above ground and moves a watt of power dissipation to the zener diode.

Display brightness control. Transistor Q1, a phototransistor, and Q2 control the voltage drop between the LED common cathodes and ground. R3 biases Q2 so that the display does not completely blank even in total darkness. 56 kilohms has been used with satisfactory results. Increasing the value will lower the minimum brightness with 100k being about the highest practical value. Q1 may be omitted and a 25k pot installed from V_{ss} to ground with the wiper connected to Q2's base, using the Q1 emitter pad for connection, if manual brightness control is desired. Q1, Q2 and R3 may be omitted and replaced with a jumper from Q2's collector to emitter for fixed maximum brightness.

Display. The tens of hours and tens of minutes digits **(fig. 4)** have been inverted in the display to provide an AM indicator and an acceptable colon from the otherwise unused decimal points included with the digits. This approach eliminates the use of discrete LED lamps for these functions. It should be noted that the manufacturer's designations of segments A thru G must be disregarded when a digit is inverted and the builder should re-define the segments as shown. The colon may be wired to the junction of CR2/C3 through a resistor in either the time display format, or, in 12-hour format only, it may be tied to the 1-Hz output thru a resistor one-half the value of that selected for R13 thru R40. This latter method will pulse the colon at a 1-Hz rate for an activity indicator. An added benefit of this approach is that the colon brightness will then track display brightness since the 1-Hz output transistor is on the output common source bus rather than V_{SS}.

The AM or PM indicators are normally lit constantly (tens of hours digit in the 24-hour format); however, if V_{SS} drops below approximately 8 volts, the indicator will flash at the 1-Hz rate to indicate a potential display error. The indicator returns to a steady state after application of either setting input while in the time-of-day mode.

construction

Construction is very straightforward although normal handling precautions should be applied to the 3817 during construction. Small arrows on the display board foil side indicate the position of the orientation notches of the FND500 LED readouts.*

The single-sided PC board shown in **fig. 3** is cut in two pieces at the dimensioning lines and R13 thru R40 with J11 thru J13 support the display board perpendicular to the main board as shown in the photograph. Operation at 50 Hz is selected by installing a jumper between points 7 and 10.

Table 3, a parts list, is included to provide a starting point for the builder. Few of the components shown are critical; in fact, resistance and capacitance values can be varied by 50% and more with no adverse effects, specified diodes can be replaced with virtually any diode with a minimum of 10:1 front-to-back ratio, and the transistors may be virtually any available npn type.

table 3. Parts list for the digital clock.

qty	part	description
1	C1	0.01 µF, 25 WVdc disc ceramic
1	C2	1000 µF, 25 WVdc electrolytic
1	C3	500 µF, 25 WVdc electrolytic
1	C4	0.1 µF, 25 WVdc disc ceramic
1	C5	10 µF, 25 WVdc electrolytic
6	CR1-CR6	1N4148
1	Q1	FPT130 phototransistor
4	Q2-Q5	2N4401 npn transistor
1	R1	100k, 10%, ¼-watt
1	R2	1.5 megohm, 10%, ¼-watt
1	R3	56k, 10%, ¼-watt
5	R4,R5,R7, R8,R11	4.7k, 10%, ¼-watt
3	R6,R9,R12	27k, 10%, ¼-watt
1	R10	1.2k, 10%, ¼-watt
28	R13-R40	1.8k, 10%, ¼-watt (see text)
1	R41	10k potentiometer
6	S1-S5,S7	spst pushbutton switch
2	S6,S9	spst toggle or slide switch
1	S8	spdt toggle or slide switch
1	T1	12 Vac secondary transformer, rating as required by radio
1	U1	Fairchild 3817APC digital clock IC
1	U2	78Lxx or 78Mxx voltage regulator (voltage and current determined by radio requirements)

*Printed-circuit boards and semiconductors for the digital clock are available from Circuit Specialists Company, Post Office Box 3047, Scottsdale, Arizona 85257: set of two circuit boards, $4.50; Fairchild 3817APC clock IC, $6.50; FND500 LED readouts, $3.50 each; MPSA70 transistor (2N4401 replacement), 32¢ each.

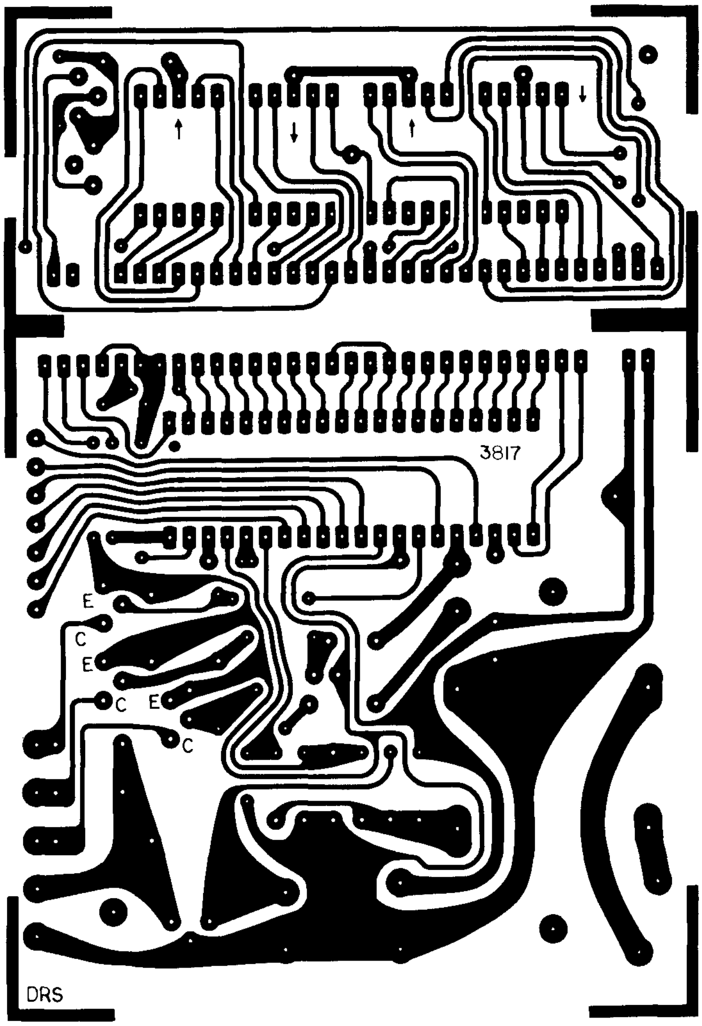


fig. 6. Full-size printed-circuit board for the digital clock.

conclusion

An attempt has been made to illustrate a minimum-cost but full-featured clock radio design which can be scaled down to a simple desk clock if so desired by the builder. The usual multiplexing noise associated with electronic digital clocks is eliminated by the direct drive approach, while overall circuit cost and complexity is reduced. The 3817 IC should find a home in many other applications such as automobile clocks (using a crystal and 12-state cmos divider for time-base generation and the blanking input to kill the display in ignition off conditions). Photography timers, appliance timers, industrial controllers, and digital stopwatches are other potential uses. Other common-cathode displays such as the FND70 may be used in place of the FND500 shown, or liquid crystal, neon, or fluorescent display may be substituted at some cost sacrifices. The 3817, FND500, and related data sheets may be obtained from franchised Fairchild distributors.

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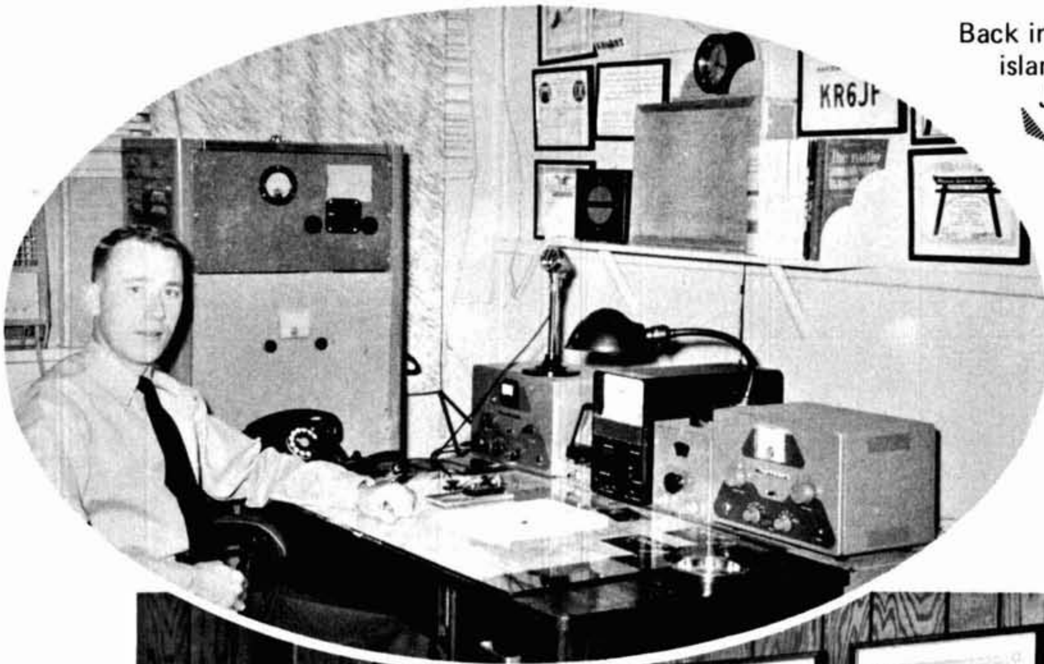

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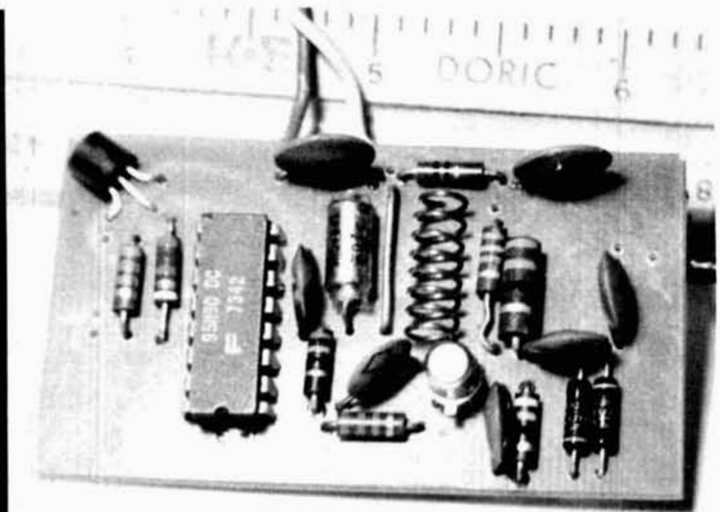


vhf prescaler

for digital frequency counters

A sensitive circuit that will extend your counter's range to 300 MHz

As easy-to-build, high-performance vhf prescaler can be added to a high-frequency digital counter to extend its useful frequency range to 300 MHz. Such a prescaler is described here with my experiences in adding it to a homebrew counter. The prescaler is based on the Fairchild 95H90 and a series of articles by W6PBC.[1,2,3] These articles contain excellent material for those interested in obtaining the ultimate performance from the 95H90 prescaler. The unit described here can be built for around $25.

circuit

The circuit (**fig. 1**) is based on W6PBC's work and information in Fairchild 95H90 data sheets.[4] A low-impedance input amplifier uses a 2N5179 transistor to provide good gain at vhf. Two back-to-back 1N914 diodes protect the input from overload. The 22-ohm resistor and two 0.05-μF capacitors isolate the input amplifier to prevent oscillation. The amplifier is coupled to the 95H90, which also has a low input impedance. The 95H90 operates best with low input impedances hence the 68- and 200-ohm input bias resistors.

Decoupling the 95H90 from the power supply is accomplished with the 0.01 and the 2-20 μF capacitors. A 2N5771 couples the 95H90 output to TTL counter inputs. Most counters with amplified inputs can be

By Marion D. Kitchens, Jr., K4GOK, P.O. Box 183, Haymarket, Virginia 22069

operated by connecting pin 8 of the 95H90 to the counter input through a 0.01-μF capacitor. Both arrangements are shown in the schematic and the parts placement drawing, **fig. 2**. Input sensitivity was not measured but should be around 15 mV at 100 MHz and about 100 mV at 260 MHz, according to W6PBC's data.

construction

Construction is simple. Just mount all parts, except R_x, onto the PC board and solder. (R_x is discussed later.) A few points about construction should be made, however. The 2-20 μF decoupling capacitor should be the smallest physical size you can obtain. The PC board is laid out for ¼-watt resistors, although if you really work at it you can install ½-watters. The ¼-watt resistors are preferred. Note that pin 14 of the 95H90 is floating; no connection should be made to it.

The RG-174 coax is held in place (strain relieved) by placing short loops of wire over the coax and soldering them to the PC board. **Fig. 2** shows component placement. A photo of the circuit board is shown without the heatsink in place and with temporary wiring. The

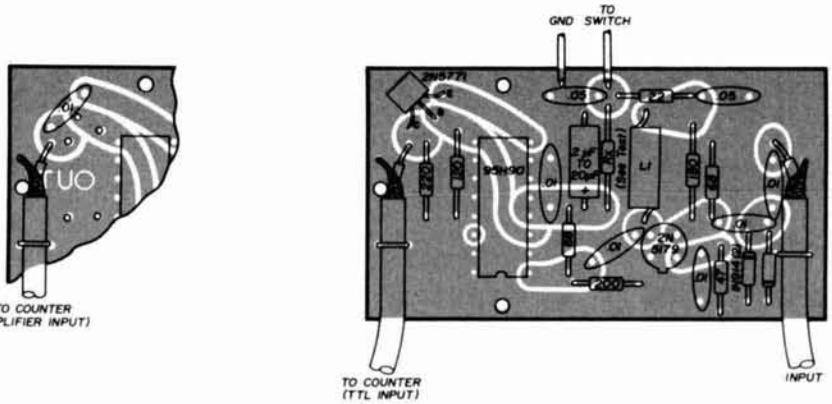
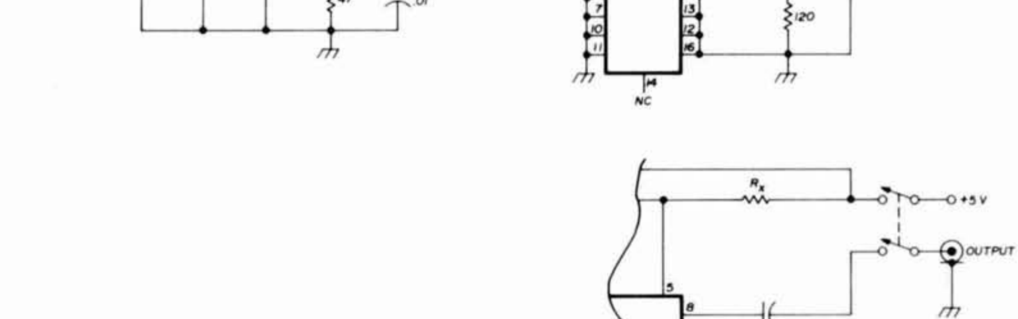


fig. 2. Full-size board showing component placement.



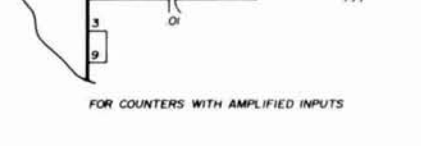


fig. 1. Vhf prescaler schematic using the Fairchild 95H90 (after W6PBC). L1 is 8 turns no. 26 (0.4mm), 5/32" (4mm) diameter, 5/8" (16mm) long.

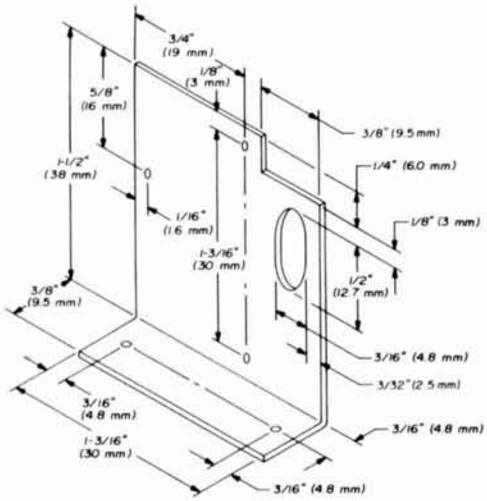


fig. 3. Heatsink is made from 0.03-inch thick (1.0mm) aluminum.

2N5771 should be installed with its flat side down against the PC board so it will clear the aluminum heatsink.

A heatsink (**fig. 3**) is strongly recommended although not absolutely necessary. Fairchild data sheets indicate the 95H90 maximum count frequency depends on the IC's temperature. About 750 kHz is lost for each °C rise in temperature, for near-room temperatures. My prescaler frequency limit was around 270 MHz without the heatsink, but went to 300 MHz with it. The signal source, a grid-dip oscillator, was limited to 300 MHz so I don't know if my prescaler will go higher or not. The heatsink was used to mount the prescaler in the cabinet. **Fig. 4** shows a full-size etched board layout for the prescaler.

Only external evidence of the vhf prescaler in K4GOK's homebrew frequency counter is the separate prescaler input connector and on-off switch on the right side of the front panel.

supply voltage

Individual 95H90s have a "best" supply voltage that results in maximum count frequency. The best voltage for most 95H90s is 4.85 V according to W6PBC's data. My homebrew counter power supply provides 4.85 volts (how lucky can you get?), so when the prescaler was wired directly to the power supply for testing a 300-MHz count frequency was obtained. However, when the permanent installation was made, the maximum count frequency was only 150 MHz. After many hours of searching I found the 95H90 voltage was only 4.60 V. I was surprised to find a 2-amp in-line fuse produced a 0.1-volt drop. The other 0.15-volt drop was across a switch located between the power supply and the counter. This total 0.25 volt drop caused no problems with the basic counter but sure played havoc with the prescaler.

fig. 4. Full-size etched board layout.

The 95H90 draws 100 to 150 mA so a value for R_x in the 1-ohm range will provide 4.85 volts from a 5.0-volt source. Individual 95H90s will draw different currents, so R_x is best determined by trial and error. Tack in a trial resistor and measure the maximum count frequency until you're satisfied.

conclusion

The prescaler was easy to build and operate. It should be useful for vhf enthusiasts since it covers 50, 144 and 220 MHz with good sensitivity. No tricky, fussy or unstable circuits are involved. The vhf prescaler is a very worthwhile addition to all digital counters.

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1. F. E. Emerson, W6PBC, "Advanced Divide-by-Ten Frequency Scaler," *ham radio*, September, 1972, page 41.

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3. F. E. Emerson, W6PBC, "Comments on Frequency Scaler," *ham radio*, November, 1973, page 64.

4. "95H90 Very High Speed Divide by 10/11 Prescaler," Fairchild Characteristics And Applications Data Sheet, Fairchild Semiconductor, July, 1973.

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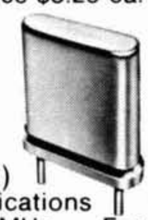

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More Details? CHECK–OFF Page 110

50 years of television

The first public demonstration of television was given fifty years ago although experimenters have been interested in transmitting visual images for more than 100 years

Last year marked approximately the 50th anniversary of television, a media which began amidst an array of flickering neon lamps and a whirling disc in 1925, when C. Francis Jenkins transmitted a live silhouette of a moving windmill from his workshop in Anacostia, Maryland, to the Navy Department in nearby Washington, DC. Later that year Jenkins gave his first public demonstration of the radio transmission of live images (which he called "radiovision") and film ("radiomovies").

In a conference at the Department of Commerce on May 29th, 1925, the authorities decided to allow amateurs to transmit pictures and facsimiles on any wavelengths for which they were licensed,[1] but there is no record of any amateur television transmissions until many years later.

the early years

The transmission of visual images goes back one-hundred years, to 1875, when George Carey in Boston used the system of **fig. 1** to simultaneously transmit each separate picture element by wire. This followed the discovery in 1873 by Lewis May, a British telegrapher, of the photoconductive properties of selenium. The principle of rapidly scanning each picture element in succession, line by line, was proposed in 1880 by Maurice Leblanc of France and led to one of the first television patents which was issued to Paul Nipkow of Germany in 1884. The distinctive feature of the Nipkow system was the use of a spinning disc, with a spiral array of holes near its outer edge, to disassemble the image into a series of dots, and a similar disc at the receiving end to reassemble the picture (**fig. 2**). Until the advent of all-electronic image scanning in the 1930s, all workable television systems depended on some form or variation (mirrored drums, lensed discs, etc.) of the sequential scanning system examplified by the Nipkow disc.

The sequential reproduction of visual images is feasible only because the human visual sense displays a persistance of vision – the brain retains the impression of illumination for about 100 milliseconds after the source of light is removed. If the image-making process occurs within less than 100 milliseconds, the eye is unaware that the picture has been assembled piecemeal, and it appears that the whole viewing screen is continuously illuminated.

Although selenium was used by all the early television experimenters, it had one serious handicap: slow response to changes in light. The discovery of a potassium hydride coated cell in Germany in 1913 improved sensitivity and the ability to follow rapid changes of light,

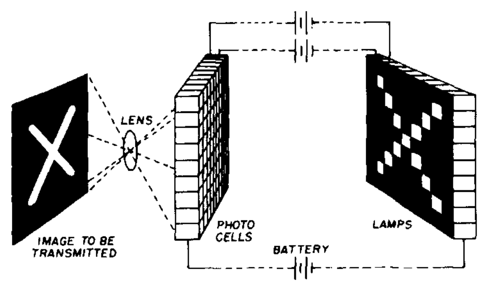


fig. 1. Image transmission system of 1875. At the transmitting end light is converted into electrical energy which is used to energize a lamp at the receiving end. Since the output of each selenium cell must be individually connected to a corresponding lamp at the receiving end, a large number of wires is required.

By Jim Fisk, W1DTY, and Dave Ingram, K4TWJ but experimenters were still limited by the slow response of incandescent lamps. This was solved by the invention of the neon gas-discharge tube by D. M. Moore in 1917.

The application of the cathode-ray tube for television reception was first proposed by Boris Rosing in Petrograd in 1907, but development of his patent was retarded by the lack of suitable photo cells and electronic amplification. However, he did succeed in transmitting and reproducing some crude geometrical patterns. In 1908, Alan Campbell-Swinton, a Scotsman, outlined a method that is the basis of modern television when he proposed the use of a magnetically-deflected CRT at both the camera and receiver. Although his idea couldn't be translated into workable hardware because he lacked suitable amplifiers, his proposed mosaic-screen image pickup tube was remarkably like the iconoscope invented by Vladimir Zworykin some fifteen years later.

Because of the lack of suitable amplifiers, television experimenters continued to work with mechanical television systems and, in 1922, using his own version of Nipkow's disc, C. Francis Jenkins transmitted a still picture from one room to another. The next year he received nation-wide attention when he sent a recognizable picture of President Harding by wireless from Washington to Philadelphia.

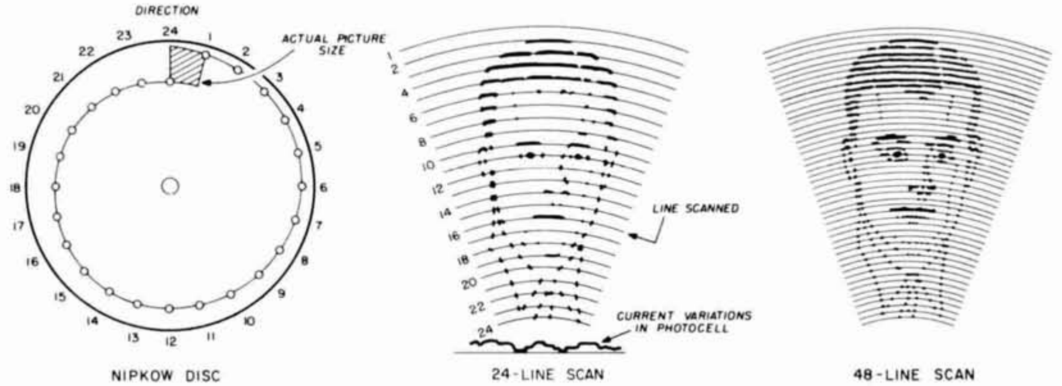
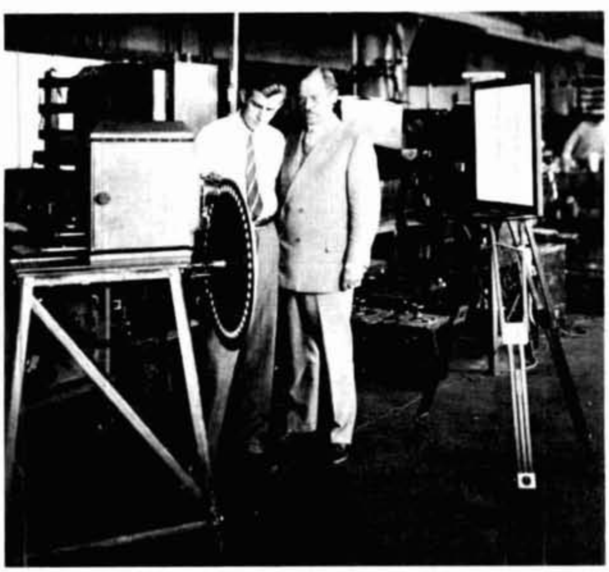


fig. 2. Spiral hole layout in a 24-line Nipkow scanning disc is shown at left. The shaded area represents the size of the reproduced image. Enlarged view of an image produced by the 24-hole scanning disc in center shows poor resolution of 24-line scanning. At right is the same image produced by 48-line scanning disc. Resolution is improved but is still crude compared to modern standards.



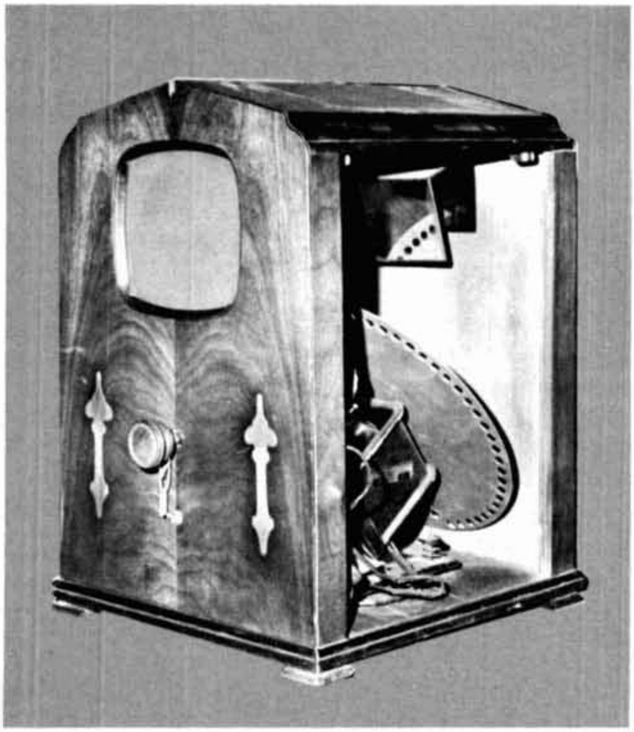
Television pioneers Dr. E.F.W. Alexanderson (right) and Ray D. Kell examine a lensed 48-hole Nipkow disc used in TV experiments in 1927. This disc is now in the collection of the Antique Wireless Association Museum in East Bloomfield, New York. (Photo courtesy RCA)

In the Jenkins system a disc with 24 (later 48) apertures was rotated at 2000 rpm by a motor whose speed was varied until it was synchronized with a similar setup at the transmitting end.[2] A neon tube was positioned behind the receiving disc and connected in place of the receiver's earphones which, in the broadcast sets of the 1920s, were connected between the audio output tube's plate and B+ supply. A piece of ground glass or thin wax paper was placed in front of the neon tube to diffuse the light. Motor speed was difficult to regulate, and since exact synchronism was required for good image reproduction, copying a picture off the air was something of a challenge. The pictures were usually about two inches (51mm) square although many viewers (Jenkins called them "Lookers in") used a magnifying glass to enlarge this area to 5 or 6 inches (13 to 15cm) square.

All of the mechanical systems, however, suffered from poor definition and flickering. Swinton and others had pointed out that at least 100,000 and preferably 200,000 elements were required for good quality and definition on a screen of reasonable size. John Baird of England gave the first true demonstration of television in 1926 by transmitting moving pictures in *halftones* using 30 lines, scanned 10 times per second. However, since the number of elements is approximately equal to the square of the number of lines, Baird's 30-line system was far from adequate – 300 lines being more nearly the minimum.

Far-sighted planners at American Telephone and Telegraph, Westinghouse, RCA and General Electric saw the commercial possibilities of television in the mid-20s, and in April, 1927, AT&T set up the first long-distance telecast in the United States when then Secretary of Commerce Herbert Hoover spoke from a makeshift studio in Washington, DC, and sight and sound were received over five minutes of every hour along with simultaneous sound which was broadcast by another local station.

In September, 1928, General Electric telecast the first *live* video drama from W2XCW in Schenectady, an old play called "The Queen's Messenger," selected primarily because it had only two characters. The accompanying sound was transmitted by WGY, GE's a-m broadcast



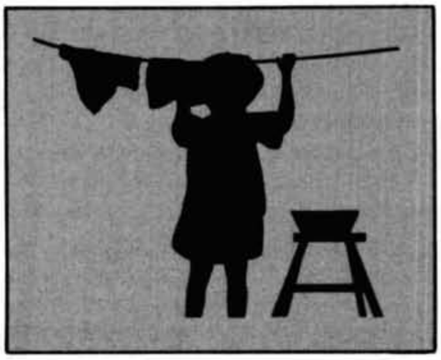

Jenkins Radiovisor from the collection in the AWA Museum. In this set the image was transmitted through a rotating Nipkow disc to a mirror and reflected onto the ground glass viewing screen. (Photographs by W2BWK)

the telephone circuits in New York City, 200 miles away. In the considerable publicity given to the AT&T transmissions the term "television" was used and soon came into widespread use as applying to any form of visual broadcasting. "Television," of course, means transmission over wire, and although you cannot argue with established usage, Jenkins stubbornly continued to call the new medium "radiovision" in his magazine articles and advertising.

In the summer of 1928 the Federal Radio Commission issued experimental television licenses to Jenkins Laboratories in Washington (W3XK) and to the General Electric Company in Schenectady, New York (W2XCW). Jenkins began broadcasting radiomovies on a regular schedule on July 2nd, and a month later he reported that "one hundred or more had finished their receivers and were dependably getting our broadcast pictures . . . " Hugo Gernsback's magazine, *Television*, regularly reported new developments and published construction articles for amateurs eager for information and was packed with advertising for television kits, parts, discs and neon lamps. Gernsback also owned a pioneering radio station in New York, WRNY, which broadcast live pictures for the first

station. This created a lot of excitement in the press, but Dr. Ernst Alexanderson, who directed much of the television development at GE, cautioned that the program was experimental and didn't mean that television was yet ready for public consumption.

Indeed it wasn't. Although *QST* devoted more space to television in 1928 than it did to radiotelephony, amateur interest in the crude radiovision systems of the day waned quickly, and the topic received little coverage in *QST* in 1929. It wasn't until eight years later and the



Silhouette as broadcast by the Jenkins Laboratories in 1928. The image size shown here is the approximate size of the image seen by "lookers in."

development of cathode-ray television systems that *QST* expressed renewed interest in the subject.[3,4]

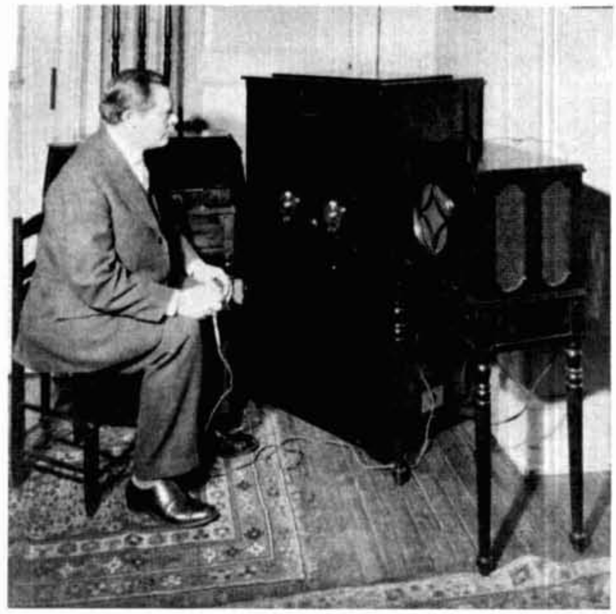
Aside from the very crude pictures of the disc-television systems which made it difficult, in the words of one wit, " . . . to tell the difference between an opera singer and her poodle," the big problem was synchronization. The utility companies tried to maintain 60 Hz, but there were no unified power grids as we know them, so synchronization was always slow and laborious, and often impossible. To quote ARRL's Percy Maxim, W1AW, " . . . for about half a second, I actually had a picture. It flickered and it was fuzzy and foggy, and about the time I was wondering why they picked on a cow to televise, it suddenly dawned on me that it was a man's face I was looking at. Then I lost synchronism and my man disappeared into a maze of badly intoxicated lines . . ."[5]

By 1929 a total of twenty-six television stations were licensed by the Radio Commission, although few of them broadcast with any regularity. Jenkins, however, increased the power of W3XK and started work on a plant in New Jersey to build "radiovisors." In 1930 he petitioned the Radio Commission to commercialize television using his 60-hole disc system, but the request died without action when a Commission engineer said the mechanical system was "an absorbing field for the experimenter but not ready for entertainment." The major corporations – including GE, RCA and Westinghouse – echoed the Commission's view.

The images, as seen in the receiver, were small and extremely crude. In addition, the pickup camera was fixed so the subject had to be brought to it, and the transmission of a person's head and shoulders strained all the resources of the scanner and transmitter. Obviously, a telecast within such technical limitations could have little entertainment value.

Nevertheless, continuing research resulted in increasing the number of scanning lines to about 180 lines per picture, and later, to 240-line images, all generated by mechanical methods. The increased image details forced higher and higher speeds in the mechanical parts, until engineers despaired of ever presenting an image of fine detail by mechanical scanning methods.

By this time news of all-electronic image-scanning systems were beginning to reach the hobby magazines, and the days of the whirling discs were numbered. In 1932 Jenkins terminated his broadcasts and was taken over by the Deforest Radio Company, which itself later drifted into bankruptcy.



The first home television reception took place in 1927 at Dr. Alexanderson's home in Schenectady. A television system developed by Alexanderson and his co-workers was used for public broadcasts in 1928, the year this photo was taken. The television screen is in the small square at eye level. (Photo courtesy GE)

General Electric televised the first remote television broadcast in Albany on August 22, 1928, when Governor Alfred E. Smith accepted the Democratic nomination for President. (Photo courtesy GE)

1925 re-activated

As a nostalgic special interest project, K4TWJ is planning a re-activation of 1925 style television. This will be a project designed so that anyone can join in the fun at minimum expense (less than ten dollars, depending on your junk box). Alan Smith, W8CHK, and Dave Ingram, K4TWJ,* will work together to supply information to interested parties. Alan will have the disc patterns, detailed sketches, and instructions available via mail; Dave will distribute cassette tapes of TV signals (include return postage).

The tapes will be handled on an exchange basis. Originally, a one-time transmission of 1925 TV signals was planned for 20 meters. These TV signals sound a bit like someone tuning up (a 1000 Hz note) and occupy little bandwidth.* Briefly, K4TWJ's request to the FCC was for a one time, three-minute TV transmission which

*Alan Smith, W8CHK, 3213 Barth Street, Flint, Michigan 48504.

Dave Ingram, K4TWJ, Eastwood Village, No. 604N, Rt. 11, Box 499, Birmingham, Alabama 35210.

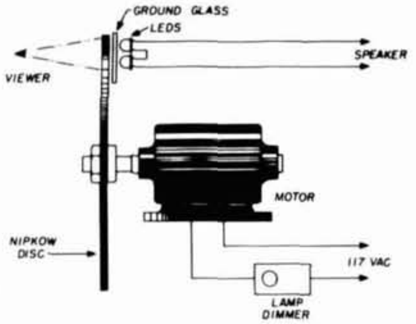


fig. 3. System used by K4TWJ to re-activate 1925-style television.

would be included in a roundtable discussion among interested parties, and would be abandoned if QRM was evident. The FCC turned thumbs down on the request, contending that the mode was outdated, the transmission would create unnecessary interference, and suggested a nationwide telephone hookup. Mailing tapes was the alternative.

Fig. 3 shows K4TWJ's modern day equivalent setup for reproducing 1925 style TV. An ac motor such as an old fan or phono motor is used to rotate the scanning disc. A commercial light dimmer is placed in series with the motor for sync/speed control of disc. The speed will later be adjusted to approximately 1700 rpm. Light-emitting diodes are used to replace the neon glow tube used in the early systems. It is suggested that three or four LEDs be used and positioned to form a square picture area. Wire the LEDs in parallel and connect them to your receiver or tape recorder speaker. A piece of ground glass (grind in a mixture of turpentine and sand) is placed between the LEDs and the disc to produce a picture area. This area will be approximately 1/2 inch (13mm) square, depending on the LED's size.

Harry Mills, K4HU, and Alan Smith, W8CHK, are to be thanked for their assistance with this project. Harry's experiences in actually receiving the original TV transmissions from GE's station in Schenectady was the final push needed to get it going. His assistance in locating information on disc TV systems in old engineering texts was very helpful. Alan, W8CHK, heard of the project and offered to help with copying and mailing. Their assistance is greatly appreciated.

electronic image scanning

In 1923 Dr. Vladimir K. Zworykin, a former student of Boris Rosing in Petrograd, was granted a patent on a system for the "cell storage of light" that was to become the basis of modern television. A year later he demonstrated a crude tube, which he called the *iconoscope*,† that scanned a scene electronically.

*There is a close resemblance between 1925 TV signals and modern slow-scan television. Both signals use audio tones which require minimum rf bandwidth. Slow-scan TV, however, is infinitely more stable and has much higher definition. If 1925 TV sounds interesting, you are invited to investigate sstv. Any active slow-scan operator will be glad to get you started. Also, the weekly SSTV Net which meets on 14.230 MHz on Saturdays at 1800 GMT welcomes inquiries.

†From Greek *icon*, "image," and *scope*, "to observe."

In the iconoscope (**fig. 4**) the external image is focused on a mica plate which is covered on one surface by millions of photosensitive particles, each insulated from the other (called a mosaic plate). The other side of the plate has a thin, deposited metal coating (called the signal plate) so each photosensitive particle forms one plate of a miniature capacitor. When a scene is focused on the mosaic plate, each of the particles develops a positive charge which is proportional to the amount of light falling upon it. When the photosensitive mosaic is scanned by an electron beam, the beam discharges each of the particles, in turn, and creates a small electric current which is picked off the signal plate and amplified.

Although the iconoscope was used in nearly all the early electronic television systems, secondary electron emission generated undesired outputs which had the effect of producing uneven shading. As a result, the reproduced image had large areas with varying brightness levels which were not contained in the original scene. This spurious shading signal is often called *dark-spot* shading because it can be generated when the mosaic plate is not illuminated. The spurious shading signal is inherent in the iconoscope camera tube but is minimized by using low values of beam current (at the expense of camera efficiency).

At about the same time Zworykin was working on his iconoscope, Philo T. Farnsworth was working independently toward an electronic scanning system somewhat along the same lines. However, while the iconoscope is based on electron storage, Farnsworth's *image dissector* camera tube may be considered an instantaneous scanner. The image dissector, shown in **fig. 5**, consists of a flat photosensitive cathode located at one end of the tube. The light from the scene is focused on the cathode, and electrons are emitted in proportion to the amount of light striking it at any one point.

The electrons emitted from the cathode are forced to move down the tube by high positive voltages applied to

K4TWJ and the Nipkow disc he built to reactivate 1925-style TV.

Dr. Vladimir K. Zworykin, inventor of the iconoscope, all-electronic "eye" of the television camera. (Photo courtesy RCA)

attracting electrodes at the opposite end of the tube. A fixed scanning aperture is also located at the anode end of the tube and the electrons from the cathode are magnetically deflected by external coils — as the electrons are moved past the aperture they enter and are amplified by the electron multiplier structure. Therefore, in the image dissector the electronic image is moved while the scanning device is stationary; the opposite is true of the iconoscope.

In 1929 Dr. Zworykin demonstrated a television transmitter based on mechanical scanning with a receiver in which an improved form of cathode-ray tube called the *kinescope*,* was used to reproduce the transmitted 120-line image. In 1931 RCA made experimental television transmissions over station W2XBS in New York City and RCA's president, David L. Sarnoff, predicted that within five years television would become "as much of a part of our life" as radio. As with so many other, similar predictions, however, it proved to be premature. It was to be four more years before Dr. Zworykin had developed the iconoscope to the point where it could be used as the basis of a workable, all-electronic television system.

After several years of experimentation with mechanical scanning systems, RCA built an entirely new television transmitter at the Empire State Building and equipped NBC's nearby broadcasting studios for broad experimentation in all phases of television broadcasting. In the summer of 1936 RCA began extensive field tests from the Empire State Building with electronically-scanned 343-line pictures, 30 frames per second. In January of the following year, however, definition was raised to 441 lines in accordance with the proposed standards of the Radio Manufacturer's Association, a figure which remained until 1941.

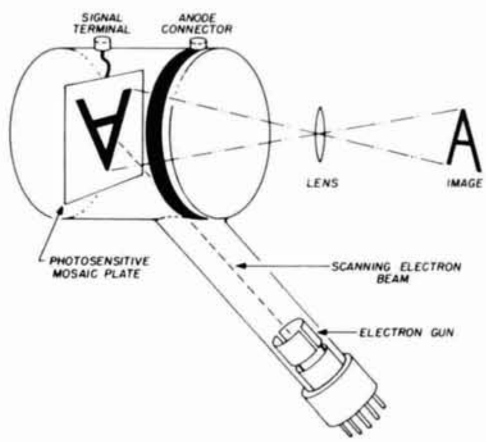


fig. 4. Iconoscope invented by Vladimir Zworykin uses photosensitive mosaic deposited on thin mica plate.

The television art was also advancing in other parts of the world. In England, Electrical and Musical Industries (EMI) set up a TV research group in 1931 under the direction of Isaac Schoenberg. He fostered the evolution of a practical system based on a camera tube known as the Emitron, which was an advanced version of Zworykin's iconoscope, and a CRT for the receiver. Schoenberg saw the need to establish standards that would en-

*From Greek *kine*, "motion," and *scope*, "to observe."

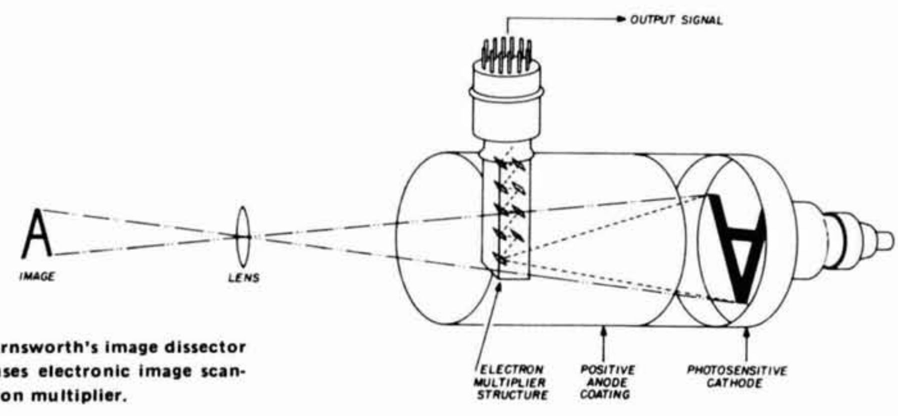


fig. 5. Philo Farnsworth's image dissector camera tube uses electronic image scanning and electron multiplier.

dure for many years and proposed 405-line pictures, 50 frames per second.

The British government authorized the BBC to adopt these standards as well as the complete EMI system, launching the world's first public, high-definition TV service in 1936. These same standards remained in effect until 1964, when they were gradually superseded by a 625-line standard.*

Initially, and for only a short time, the EMI system was under comparison with alternate broadcasts from a 240-line, 25-frame system developed by John Baird. However, the Baird system used mechanical scanning and suffered from poor sensitivity.

electron velocity is required in the neck of the tube, however, because of difficulties in magnetic deflection and focusing with a low-velocity electron beam.

Photoelectrons are emitted from the cathode surface in direct proportion to the light and shade in the scene, converting the optical image into an electron image. The electron image is accelerated toward the target (which is 300 volts positive in respect to the photocathode), and is focused through the screen onto the target plate by a uniform magnetic field in a manner very similar to that used in Farnsworth's image dissector tube. As the electron beams scans the target, a charge distribution corresponding to the picture elements in the light image determines the number of scanning electrons returned to the electron gun.

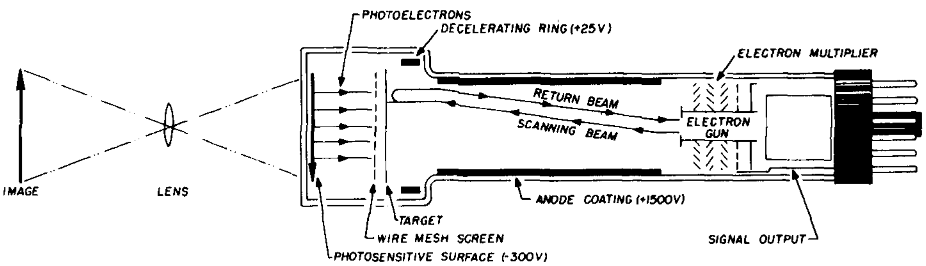


fig. 6. Basic construction of the image orthicon. The external focusing and deflection coils are not shown.

Regular television broadcasts began in Germany in 1935, though with medium definition (180 lines), and in France engineers were working on a high-resolution 1000-line system which eventually resulted in France's 819-line standard.

camera tube development

Later research in television camera tubes resulted in the development of pickup tubes, based on the iconoscope principle, which had greatly increased sensitivity. The first of these was the orthiconoscope or *orthicon* which was developed by Albert Rose and Harley Iams in 1939. Continuing research led to the development of the *image orthicon* by Albert Rose, Paul Weimer and Harold Law of RCA in 1943.

In the image orthicon, **fig. 6**, a glass plate coated on one side with a conducting layer of photoelectric material serves as the photocathode. The semitransparent plate receives the light image on one side while photoelectrons are emitted from the other side, which faces a wire-mesh screen and target, to produce an electron image which corresponds to the scene focused on the front of the glass plate.

The electron gun produces a stream of electrons which is accelerated toward the target by the positively charged anode wall coating. Beam deflection is accomplished with magnetic deflection coils which are mounted externally on the tube. A decelerating ring with a very low positive potential is placed near the target to slow down the electrons so the scanning beam does not have sufficient velocity to produce secondary emission that generates spurious shading signals. High

*There is still one BBC station broadcasting 405-line telecasts. At this time no firm date has been established to convert it to the 625-line standard.

The returning stream of electrons arrives at the gun close to the aperture from which the electron beam emerged. When the returning electrons strike the aperture disc, which covers the gun element and is at a potential of about +200 volts, they produce secondary emission. Therefore, the disc serves as the first stage of a five-stage electron multiplier -- the output current from the final stage varies in magnitude with the light image. A more complete discription of this complex tube is contained in reference 6.

While the image orthicon still plays a dominant role in television broadcasting, the more compact *vidicon*, introduced in the early 1950s, is used in most amateur TV systems. The vidicon, **fig. 7**, makes use of a semiconducting material which is characterized by a resistance that decreases upon exposure to light.[7] The inside surface of the glass faceplate is coated with a very thin layer of photoconductive material; the optical image is focused on the other side of the plate and the photoconductive layer is scanned with an electron beam which deposits just enough electrons on each spot it touches

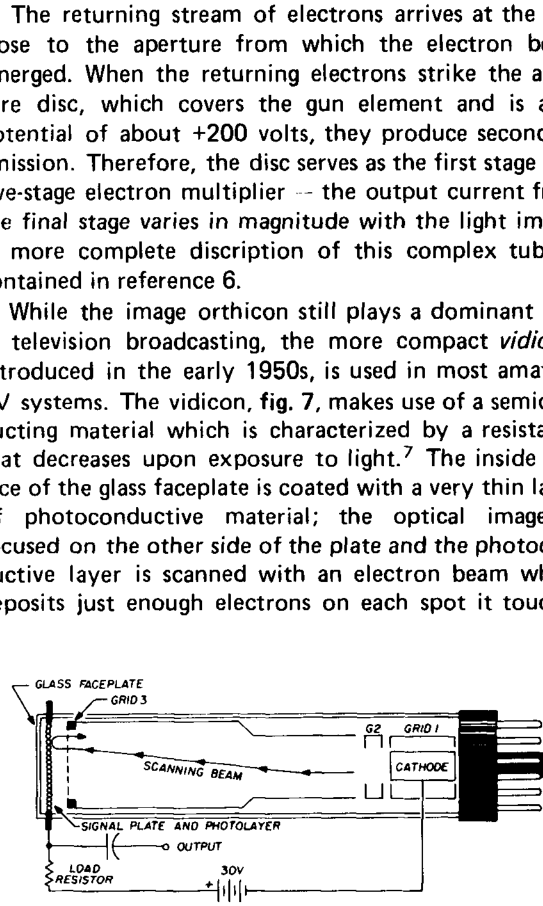


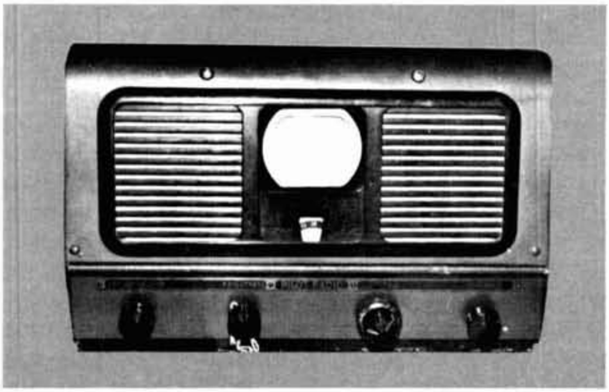
fig. 7. Schematic diagram of the vidicon. External focusing and deflection coils are not shown.

that it reduces the signal plate-to-cathode potential. During the short time between successive scans, charge leaks through the photoconducting material at a rate which is determined by the intensity to which that part of the photoconducting material is subjected. As the electron beam scans the surface of the photoconducting material, the charge it deposits varies in accordance with the variations in the illumination of successive elements of the photoconductor. Therefore, the current through the load resistor, and hence the output voltage, electronically reproduces the light intensity of the scene.

frequency allocations

Late in the fall of 1937 the FCC announced new allocations for the spectrum between 30 and 300 MHz and, much to the delight of amateurs, reaffirmed the 56-60 MHz (5-meter) band as exclusively amateur. The new rules also provided two new exclusive amateur uhf bands: 112-118 MHz (2½ meters) and 224-230 MHz (1¼ meters). One of the big worries at the time was the huge spectrum space demanded by the impending arrival of television, still around several corners but getting closer. In fact, the Commission's press release on the new uhf allocations commented that, "The investigations and determinations of the Commission justify the statement that there does not appear to be an immediate outlook for the recognition of television service on a commercial basis. The Commission believes that the general public is entitled to this information for its own protection . . . "

Nevertheless, the FCC allocated seven main television channels, each 6 MHz wide, between 44 and 108 MHz, and twelve additional channels above 156 MHz. The 50-56 MHz TV channel was of special concern because of possible interference due to its close proximity to the amateur 5-meter band. In New York this channel was assigned to CBS, and in a brief survey their engineers logged scores of amateur stations operating between 54 and 56 MHz, well outside the band. When you consider that modulated oscillators and superregen receivers were the order of the day, this is understandable, but the new TV allocations spelled the end of broad signals from unstable 5-meter transmitters (which were often operated on raw ac). Not unexpectedly, in December, 1938, the FCC required that all 5-meter amateur transmitters meet the same stability requirements as those already imposed on the lower frequencies.



Pilot home television set from the late 1930s, one of the first sets offered to the consumer. From the AWA Museum collection. (Photo by W2BWK)

This television set, first introduced by RCA for public use at the New York World's Fair in 1939, featured a picture reflected from the top of the kinescope to a mirror on the underside of the cabinet's uplifted lid. (Photo courtesy RCA)

modern television

The first regular television schedule in the United States was introduced by NBC's W2XBS in 1939 with a telecast of President Roosevelt opening the World's Fair in New York. RCA announced the new NBC programming in an advertisement for television receivers in *QST* which explained that NBC stations in New York, Schenectady and Los Angeles would begin telecasting two one-hour programs per week, plus special pickups of sports, visiting celebrities, etc.[8] The public, however, didn't respond eagerly to the new medium, and after five months of broadcasting, RCA had sold only 400 television sets. The story was much the same in England where only 3000 receivers had been sold after two years of television broadcasting by the BBC.

The New York World's Fair also marked an important milestone for amateur television. The Managing Director of W2USA at the World's Fair, Art Lynch, W2DKJ (now W4DKJ), after seeing a successful demonstration of amateur television equipment at a radio show in Chicago in June, was convinced that television communications should be added to the station at W2USA, "the most visited amateur station in the world." Since the World's Fair was scheduled to close at the end of October, time was short, but Art lined up the necessary talent, and with some help from industry, the group built two complete television systems in an effort to establish the first *two-way* television contact. Their goal was accomplished on September 27, 1940, when amateurs at W2USA and W2DKJ/2 at the New York Daily News Building in Manhattan began exchanging fair quality television pictures

In the early 1930s, Felix the Cat was the first "star" to appear before RCA-NBC experimental television cameras. Felix whirled around on his phonograph turntable for hours on end while four hot arc lights beat down on him. In those early days the crude TV images of Felix looked like he was being viewed through a venetian blind. (Photo courtesy RCA)

on the amateur 112-MHz band.[9] Accompanying sound was transmitted on 56 MHz. Distance between the two stations was about eight miles.

The television equipment at each end of the circuit consisted of a camera-modulator unit, a receiver and a transmitter which were duplicates of equipment described earlier in *QST*.[10-12] The system used 30-Hz vertical scanning, 3600-Hz horizontal scanning and a 120-line raster. Considering that the pictures were viewed on a CRT with a P1 phosphor, the results were quite gratifying. Each station boasted the very latest in electronic equipment including electro-magnetically-deflected cathode-ray tubes, free-running sweep circuits synced by external pulses and iconoscope camera tubes. The equipment was donated by RCA, National, Hallicrafters, Hammarlund, Thordarson and Kenyon. The station at W2USA used a single 1000-watt lamp for subject illumination while W2DKJ/2 had a battery of smaller lights with reflectors.

A number of amateurs in the vicinity of New York were working on their own television receivers and on October 15th, W2AOE put on a demonstration for members of the Northern Nassau Radio Association by receiving TV signals from the 20-watt station at W2DKJ/2, 17 miles away, using an improved version of the receiver described by J. B. Sherman in *QST*.[9] The range was increased to 29 miles on October 19th when good quality TV signals from W2DKJ/2 were received at W3FRE in Denville, New Jersey.

On July 1st, 1941, NBC's New York station, called WNBT, and CBS's station, WCBW, were licensed as the first commercial television stations in the United States. The FCC authorization provided for an upgrading in picture definition by adopting a 525-line standard, and fm for the audio portion of the telecasts (replacing a-m). However, the outbreak of the war in December brought television broadcasting to a standstill, and as critical materials and manpower were channeled into the war effort, television broadcasting ceased.

The FCC was carefully studying spectrum allocations during the last few years of the war, in anticipation of the armistice, and in March, 1945, they announced the new vhf allocations above 108 MHz and below 44 MHz. The spectrum between 44 and 108 MHz was to be allocated later, after running fm transmission tests during the summer. Since the release of raw materials was not imminent, this didn't appear to pose any problem. However, after VE day cutbacks and labor layoffs commenced in industry and it appeared that needed raw materials would soon be available – on June 27th the FCC announced the allocations between 44 and 108 MHz without running their planned tests. Under the new plan amateurs would get 50-54 and 144-148 MHz, fm broadcasting would move to 88-106 MHz (106-108 MHz was reserved for facsimile broadcasting), and television received channels 1 through 13. Channel 1, originally slated for the 44-50 MHz slot, was later deleted.

By 1948 there were 36 television stations on the air, 70 more were under construction, an estimated one-million television sets were in use by the public, and interference problems began to appear. In September, 1948, the FCC put a freeze on licensing any new TV stations in order to study the frequency allocations and to consider the problems posed by color television (more about that later). This situation continued for three years, prolonged by the Korean War and a consequent shortage of critical materials. Finally, in April, 1952, the FCC lifted the freeze with a document that supplemented the twelve existing vhf channels with 70 new uhf

Here's how Felix the Cat looked on the screens of experimental black-and-white TV sets in the early 1930s. The picture was transmitted by RCA-NBC cameras from a studio in New York City, and was received as far away as Kansas. There, and at points in between, it was picked up by video buffs on their primitive 60-line viewers. (Photo courtesy RCA)

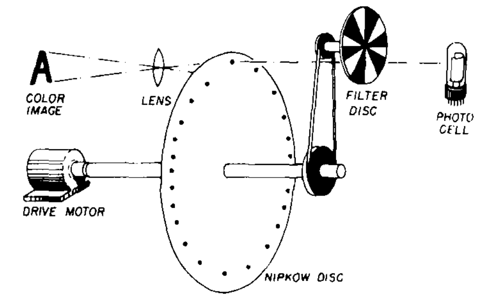


fig. 8. Color television system of the late 1920s. Light from the image is concentrated by lenses on the main scanning disc, but reaches photocell only when the proper color filter is presented by the second rotating disc, which revolves faster than the scanner. Similar setup was used at the receiver.

channels. Within a few months they had processed a backlog of 700 applications for new stations and had granted 175 new licenses. Within a year there were 377 stations on the air, and by 1955 about 95 per cent of the country had television coverage. Today there are 919 television stations (590 on vhf, 329 on uhf) throughout the United States and there are few places in the world that don't have television service.

color television

Although color television is generally accepted as a product of the past 25 years, it is nearly as old as television itself. One of the earliest proposals was patented in Germany in 1904, and the same Dr. Zworykin who invented the iconoscope filed a patent disclosure for an electronic color TV system in 1925.

John Baird demonstrated the first practical color television system in 1928 which used a Nipkow disc with three spirals of 30 apertures, one spiral for each primary color. The light source at the receiver used two gas-discharge tubes: one of mercury vapor and helium for the green and blue colors, and a neon tube for red.

In 1929 Herbert Ives and his colleagues at Bell Laboratories transmitted 50-line color images between New York and Washington, DC. This was also a mechanical system, but one that simultaneously sent the three primary color signals over three separate circuits.

In 1940 both NBC and CBS gave public demonstrations of color television which used 441-line scanning. Numerous demonstrations were also given after the war, including one by RCA in 1946 in which a stereoscopic system was used to present a three-dimensional representation of the image. In all of these demonstrations, however, color filter discs (or drums) rotated in synchronism in front of the camera tube and receiver.

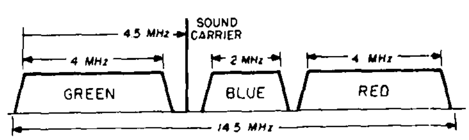


fig. 9. Transmission channel for RCA's experimental simultaneous color television picture signal required 14.5-MHz bandwidth. Monochrome receivers were tuned to the green carrier. Detail capable of being resolved in a blue image is much less than in a green, red or white image so bandwidth of blue video signal can be reduced substantially without affecting the quality of the color picture.

At the receiver the color images were presented sequentially (field-sequential system) so the red, green and blue components of the scene were viewed one after the other. Because of the persistance of vision the viewer perceived a full-color image; however, if he moved his head or scanned the picture rapidly, the image suffered from "color break-up." The rotating mechanical discs were also a drawback, and as black-and-white TV sets became widely distributed in the late 1940s, the inability of unmodified monochrome receivers to reproduce a color program made color television broadcasting, on this basis, economically impractical.

These difficulties were solved by a simultaneous three-channel color system introduced by RCA in 1946 in which the three component images (red, green and blue) were separately transmitted and projected on a screen or presented on three separate CRTs which were viewed through a system of beam-splitting dichroic mirrors. RCA even developed a projection CRT for this purpose which they called the *trinoscope*. Monochrome receivers were simply tuned to the green channel (**fig. 9**).

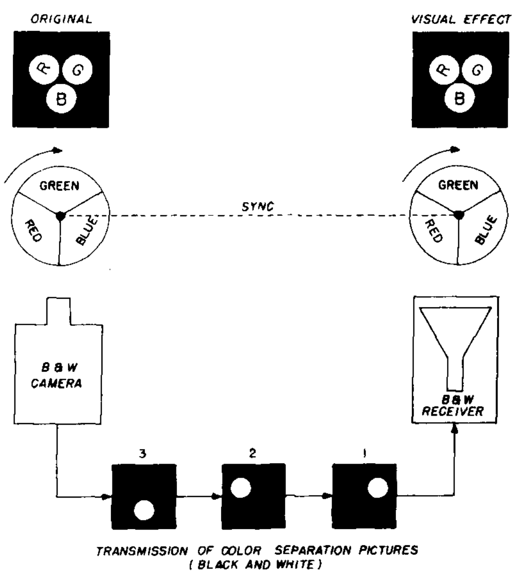


fig. 10. Basic system for field-sequential transmission of color television images.

However, both the field-sequential and simultaneous three-channel color systems required, for equal picture definition and freedom from flicker, much greater bandwidth than the 6-MHz channels already allocated to black-and-white TV. In view of the great pressure for frequency allocations in the vhf spectrum, it was generally agreed that color television should be accommodated within the existing 6-MHz channels. By reducing both the color frequency and the number of lines, the field-sequential color system could be transmitted within a 6-MHz bandwidth, but only with poor resolution and increased flicker.

Slow-scan setup used by Don Miller, W9NTP, in 1969. Equipment was very up to date at the time, included a sampling slow-scan camera (left), a shuttered camera (upper right) and both slow- and fast-scan monitors. Don's sampling camera was one of the first of its type and was widely duplicated by amateurs.

Investigators at RCA (1949) found it was possible to retain full resolution, freedom from flicker, *and* monochrome compatibility with a simultaneous system that used a monochrome picture signal with a phase and amplitude-modulated subcarrier which carried the color or chroma information. The chromatic subcarrier, approximately 3.58 MHz above the picture carrier, was selected so it had no visible effect on the picture reproduced by a monochrome receiver. In a color receiver the subcarrier was used to distribute picture brightness between the three primary colors to produce a natural color rendition of the original scene.

Nevertheless, in October, 1950, after a lengthy series of hearings, the FCC adopted the incompatible field-sequential color system as the standard for the United States. However, in December, 1953, the Commission rescinded its earlier ruling and issued a new set of specifications which had been submitted by RCA and the National Television System Committee (NTSC). These corresponded to the compatible color system developed earlier by RCA – this same basic color system is still used throughout North and South America, Japan, Korea, and parts of Europe.

slow-scan television

No history of television would be complete without some mention of slow-scan television, and the important role that amateurs played in its development. Copthorne MacDonald, W4ZII (now WØORX), introduced slow-scan television to amateurs in a 1958 *QST* article[13] which described a simple system, using a flying-spot scanner, to transmit photo transparencies. Initial on-the-air tests were conducted on 11-meter a-m between W4JP at the University of Kentucky and K4KYY. MacDonald also tried to run tests with PJ2AO in Curacao, but band conditions were too poor for satisfactory picture reception.

The slow-scan system, which requires no more bandwidth than an audio signal, was originally conceived as a facsimile system and it was a number of years before the medium was used to transmit live images. Since 11 meters was the only high-frequency band where facsimile transmission was permitted, most sstv activity ceased when amateurs lost 11 meters to the Citizens Radio Service. Eventually, however, the FCC granted special permission to conduct sstv tests on 10 meters and, later, 20 meters. The sstv standards which are used today were developed during these early tests. Since August, 1968, slow-scan television (designated narrow-band A5 and F5 emission) has been permitted on portions of all the high-frequency bands plus most of vhf.*

*Complete bibliographies of slow- and fast-scan television articles which have appeared in *QST* are available from ARRL, 225 Main Street, Newington, Connecticut 06111. Send a stamped, self-addressed, business-size envelope.

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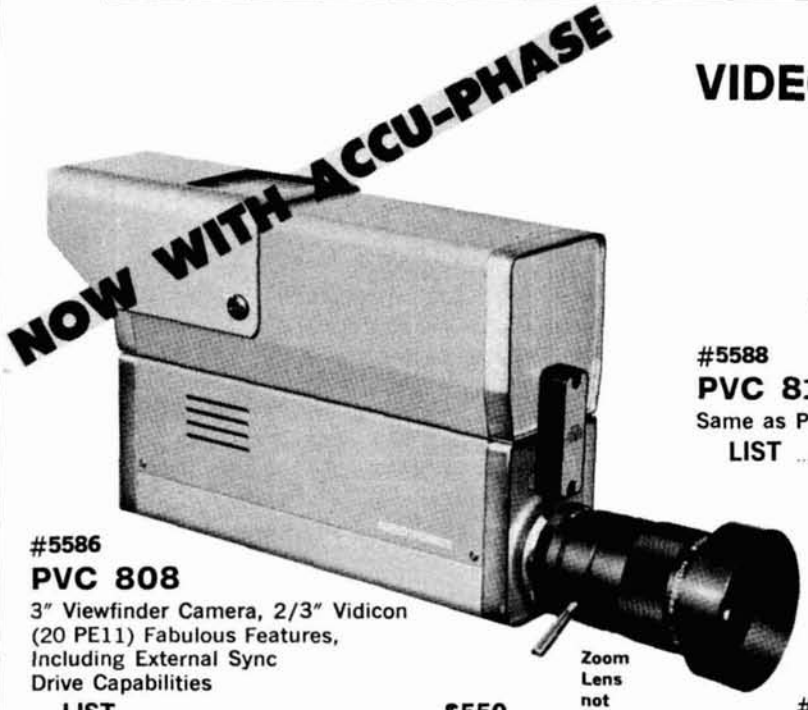
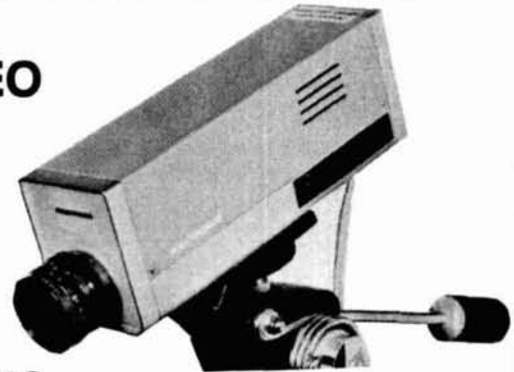
ham radio

AUDIOTRONICS CAMERAS:

VIDEO





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Model PVC-808 7½"H x 4"W x 10⅛"D. Wt. 9.5 lbs. Model PVC-818 3⅝"H x 3"W x 10⅛" D. Wt. 5.5 lbs.

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More Details? CHECK—OFF Page 110

the 1979 World Administrative Radio Conference

and what it means to you

What, me worry? Yes, you worry – about an increasingly important four-letter word – WARC.

What's a WARC? A WARC is a World Administrative Radio Conference – a gathering of all the ITU member nations to examine and decide upon basic questions of mutual interest. The first WARC was in Berlin in 1903, the most recent in 1959, and the next has been scheduled for sometime in the second half of 1979, in Geneva, Switzerland.

Okay, that's a WARC – so what? The "What" of the WARC is *what* is going to be discussed in 1979 – namely, frequency allocation, or perhaps more properly, *re*-allocation, that's "what."

On an international basis the radio spectrum from 10 kHz to 47 GHz has already been allocated. There are no unallocated segments of the spectrum within those limits. Therefore, if some user of that part of the spectrum needs additional frequencies, it must come from someone else's *present* allocation (*ah* – the light dawns!). Yes, even from the hitherto sacrosanct domain of the amateur bands if the justification for such a request is strong enough. And there is the secret word – justification! Say it correctly, and the duck will bring you 200 kHz (sorry, Groucho).

Seriously, though, justification is not the numbers game – just the number of licensees alone in a given radio service will not be adequate justification for getting new frequencies, much less keeping those already allocated. Sure, the Amateur Radio Service has grown from 46,000 in 1934, to 185,000 in 1959, to 275,000 today, with basically the same allocated spectrum – give or take a hundred kHz. Crowded? Sure. QRM – you bet! But can you imagine what it would be like if we still used only double-sideband-with carrier? Absolute chaos!

The Amateur Radio Service responded to increased band crowding in its historical manner – ingenious adaptations of, and subsequent improvements upon, commercial techniques to relieve congestion. (Sounds like a nasal spray commercial but it sure worked – remember the disparaging remarks about the "Donald Duckers," and when SSB was known as SSSC?)

Well, if numbers aren't the answer, then what is? Simple, and like many other things, money included, it's not how much you have, but what you do with what you have. How *does* Amateur Radio use its allocated spectrum? Is it being used wisely for the benefit of the public at large and in keeping with the Service's Basis and Purpose as outlined in Part 97.1 of the FCC Rocks and Shoals? Or, is it being used for the personal amusement and satisfaction of a miniscule percentage of the U.S. citizenry? What are the trends in the Amateur Radio Service? Where will it be in the year 2000? How will, or can, WARC influence this?

These and similar questions, plus those dealing with the Amateur frequency needs now and up to the year 2000, are being discussed by members of eight task forces set up by the FCC in what's called the "Amateur Working Group." This group, numbering about forty, has been given the job of developing recommendations for the United States Amateur Radio Service position in the next WARC – including the justifications needed to keep the frequencies it presently has, plus – maybe – getting some new ones. There's plenty of time 'till 1979, right? *Wrong*!

The lead-time of a bureaucratic, international operation like a WARC boggles the mind! What with the need to coordinate, review, correlate, adjust, modify, etc., both within the FCC and between various parts of our government, coordinate unofficially with other ITU member governments, and so forth, it's not surprising that the preliminary Amateur Radio Service frequency allocation request has to be in the FCC's hands by the time you read this! And there are only a few more months in which to come up with the most persuasive justification possible for the continuation of the Amateur Radio Service as we now know it, and would like it to be. This "Amateur Radio Service position paper," as it is being called, has to be submitted to the FCC for its consideration no later than June of this year – *this* year, not 1979!

In the meantime, if you're now concerned, re-read Stu Cowan's excellent article in the April, 1965, issue of *QST*.*

What, me worry . . . you bet!

By Pete Hoover, W6APW, 1520 Circle Drive, San Marino, California 91108

*Stuart D. Cowan, W1RST, "The Death – or Survival – of Amateur Radio," *QST*, April, 1965, page 80.

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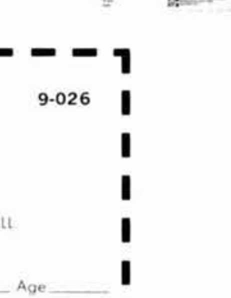

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More Details? CHECK—OFF Page 110

MICROPROCESSORS

What is a microcomputer input/output device?

In the discussion of the anatomy of a microcomputer last month, we described the various data paths in a microcomputer, including data input, data output, external device addressing, in and out function pulses, and interrupt signals. These are the vital lines of communication between the microcomputer and the "outside world," i.e., those signal lines that are necessary to interface the microprocessing unit (MPU) to the input/output, or I/O devices that you would like to control.

What, exactly, is an I/O device? Some useful definitions include the following:

input/output General term for the equipment used to communicate with a computer and the data involved in the communication.[1]

I/O Abbreviation for input-output.[2]

I/O device Input/output device. Any digital device, including a single integrated-circuit, that transmits data to or receives data or strobe pulses from a computer. The in and out functions are always referenced to the computer.[3]

The traditional view of an I/O device is that it is somewhat large or complex. Card readers, magnetic tape units, CRT displays, and teleprinters certainly fit such a description. However, a single integrated-circuit chip, such as a latch, shift register, counter, or small memory can also be considered to be an I/O device to a computer.

Another important point is that several device-select pulses may be required to interface a single I/O device. For example, a 74198 shift register has a pair of control inputs that determine whether the register shifts left, shifts right, or parallel loads eight bits of data. This chip also has a clock input and a clear input. Thus, a single 74198 chip, when serving as an output device, may require up to four device-select lines from the microcomputer. Therefore, the fact that we can generate 256 different input and 256 different output device select pulses does not necessarily mean that we can address 512 different "devices." A more reasonable number is of the order of 50 to 100 different devices.

Device-select pulses are inexpensive and easy to implement. We encourage you to use them as often as possible as you attempt to substitute computer software, (microcomputer programs) for integrated-circuit chip hardware. We shall repeat this theme often: software vs hardware. There is a tradeoff between the two, but your main objective in using microcomputers will usually be to substitute software for hardware. When you do so, the only penalty that you may pay is time because it takes time to execute computer instructions. If you can accept the delays inherent in computer programs, then you can vastly simplify the circuitry required to accomplish a specific interfacing task.

By Peter R. Rony, David G. Larsen, WB4HYJ, and Johathan A. Titus.

Mr. Larsen, Department of Chemistry, and Dr. Rony, Department of Chemical Engineering, are with the Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Mr. Jonathan Titus is President of Tychon, Inc., Blacksburg, Virginia.

what is interfacing?

Interfacing can be defined as the joining of members of a group (such as people, instruments, etc.) in such a way that they are able to function in a compatible and coordinated fashion.* By "compatible and coordinated fashion," we usually mean synchronized. Some important definitions include the following:

Synchronous In step or in phase, as applied to two devices or machines. A term applied to a computer in which the performance of a sequence of operations is controlled by equally spaced clock signals or pulses.[2] At the same time.

Synchronous computer A digital computer in which all ordinary operations are controlled by equally spaced signals from a master clock.[2]

Synchronous operation Operation of a system under the control of clock pulses.[3]

To synchronize To lock one element of a system into step with another.[2]

Synchronization pulses Pulses originated by the transmitting equipment and introduced into the receiving equipment to keep the equipment at both locations operating in step.[2]

We can thus define *computer interfacing* as "The synchronization of digital data transmission between a computer and one or more external input/output devices."[3]

Although the details of computer interfacing vary with the type of computer employed, the general principles of interfacing apply to a wide variety of computers. Such principles include the following:

The digital data that are transmitted between a computer and an I/O device are either individual clock pulses or else full data words.

The computer and the input/output device are both clocked devices. At the very least the I/O device has a single flip-flop that is set or reset by the computer. All data transmission operations are synchronized to the internal clock of the computer.

The computer sends synchronization pulses, called device-select pulses, to the I/O device. These pulses are generated by the computer program i.e., they are software generated, and are usually quite short (for an 8080 microcomputer operating at 2 MHz, they last only 500 nsec). *They synchronize and select at the same instant of time.*

Individual device-select pulses are sent to individual input or output devices. This is called *external device addressing*. The pulses are used for latching data output and strobing data input.

Computer program operation can be interrupted by the transmission of a clock pulse from an I/O device to a special input line to the computer. This is called *interrupt generation*. Upon being interrupted by an external I/O device, the computer goes to a computer subroutine that responds to, or *services*, the interrupt.

Full data words can be output from, or input into, the accumulator register. For the 8080 microcomputer, a full data word contains eight bits. Output data from the accumulator is available for only a very short period of time, and usually must be latched. Input data into the accumulator is acquired over a very short period of time, and usually must be strobed into the accumulator.

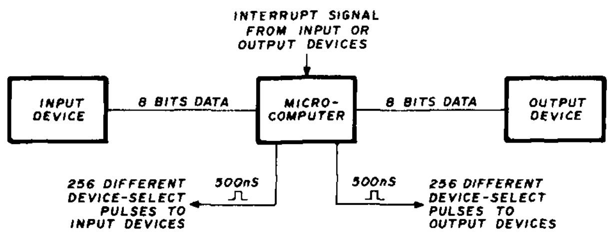

fig. 1. The I/O and control data paths in an 8080 microcomputer.

As shown in **fig. 1**, which summarizes the above comments, interfacing basically consists of the synchronization of parallel input or output data via the use of the 512 device-select pulses.

Hardware is required to tie the MPU to the external device and is just as important as the microcomputer software. We shall tackle both of these facets of microcomputer interfacing in detail in subsequent columns. In the next column we will discuss the output instruction for the 8080 microprocessor chip, which has at least four sources of supply. This is more than for any other MPU. It is clear that the 8080 MPU is destined to become a widely used microprocessor.

*Charles L. Garfinkel of Keithley Instruments, Inc. is the originator of this definition.

references

1. Microdata Corporation, *Microprogramming Handbook*, Santa Ana, California, 1971.
2. Rudolf F. Graf, *Modern Dictionary of Electronics*, Howard W. Sams & Company, Inc., Indianapolis, 1972.
3. Peter Rony and David Larsen, *Bugbook III. Microcomputer Interfacing, Experiments using the Mark 80, an 8080 System* E&L Instruments, Derby, Connecticut, 1975. ($14.95 from Ham Radio Books, Greenville, New Hampshire 03048.)

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More Details? CHECK—OFF Page 110

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Software. Altair 4K BASIC leaves approximately 725 bytes in a 4K Altair for programming which can be increased by deleting the math functions (SIN, SQR, RND). This powerful BASIC has 16 statements (IF . . . THEN, GOTO, GOSUB, RETURN, FOR, NEXT, READ, INPUT, END, DATA, LET, DIM, REM, RESTORE, PRINT, and STOP) in addition to 4 commands (LIST, RUN, CLEAR, NEW) and 6 functions (RND, SQR, SIN, ABS, INT, TAB, and SGN). Other features include: direct execution of any statement except INPUT: an "@" symbol that deletes a whole line and a "←" that deletes the last character; two-character error code and line number printed when error occurs; Control C which is used to interrupt a program; maximum line number of 65,529; and all results calculated to seven decimal digits of precision. *Altair 4K BASIC is regularly priced at $60 for purchasers of an Altair 8800, 4K of Altair memory, and an Altair I/O board. Please specify paper tape or cassette tape when ordering.*

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More Details? CHECK–OFF Page 110

horizontal-antenna gain

at selected vertical radiation angles

Graphical aids for choosing antenna height to optimize near- or far-field gain

In a previous article, I gave the gain for certain vertical-plane radiation angles for horizontal antennas at certain antenna heights.[1] Since then I've had requests for data on what height to use for optimizing gain at a certain radiation angle. Suppose you'd like to work DX on 20 meters and your beam is on a 40-foot (12m) tower. You may find in this case that you hear stations about 900 miles (1440km) away much louder than the DX stations, which are perhaps over 2000 miles (3200km) away. Would it help, and if so, how much, to use a higher tower? The answer to these questions are in this article. The data is useful in selecting heights for horizontal dipoles for 40 and 80 meters as well as tower heights for beams at 10, 15 and 20 meters. Most of this article and examples, however, cover the latter case.

antenna height for several radiation angles

The answers to the question of what height to use to optimize gain at certain radiation angles is given in **fig. 1**, in which relative antenna gain is on the vertical scale and antenna height in wavelengths is on the horizontal scale. Curves are given for several radiation angles, α. Reference gain is 1.0 (the gain of a half-wave antenna in free space for all radiation angles). This is just a convenience, as all the gains are relative. If an antenna is higher than a half-wavelength, multiple lobes occur in the vertical plane; this data is shown in detail in the ARRL *Antenna Handbook*.[2] Similar data is also shown in **fig. 1** especially for $\alpha = 30°$, which shows peaks near $h/\lambda = 0.5$ and 1.5, with nulls at $h/\lambda = 1.0$ and 2.0.

Fig. 1 shows that for $\alpha = 5°$, the higher the tower the better, as the peak in the gain curve doesn't occur until the antenna height is almost three wavelengths ($h/\lambda = 3.0$). As a convenience **table 1** is included, which gives h/λ for tower height for the 10-, 15- and 20-meter bands. Thus, only at 10 meters with a 100-foot (30m) tower is $h/\lambda = 3.0$, where maximum gain is achieved at $\alpha = 5°$. **Table 2** shows the relationship between radiation angle, α, and distance for F_2-layer one-hop signals. **Fig. 1** also shows that for radiation straight up ($\alpha = 90°$), a very low antenna ($h/\lambda = 0.1$) is sufficient; for $\alpha = 10°$, an $h/\lambda = 1.2$ is best; and for $\alpha = 15°$, a first plateau in gain is reached at $h/\lambda = 0.6$, with maximum gain at $h/\lambda = 1.1$.

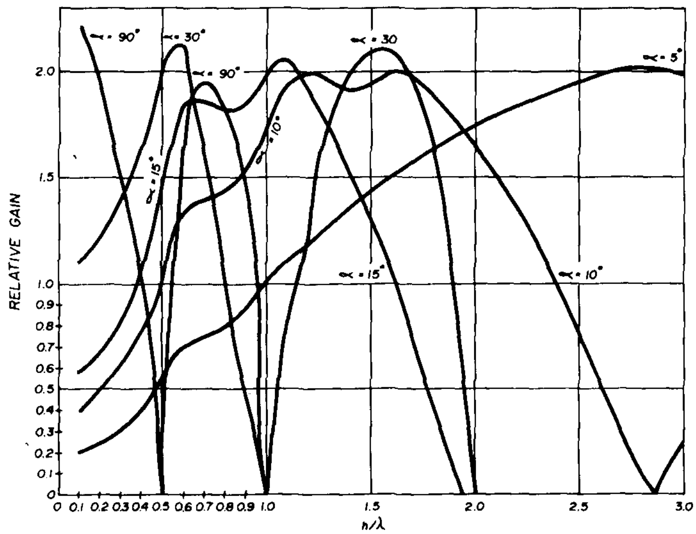

fig. 1. Horizontal-antenna gain as a function of height, h/λ, for several vertical-plane radiation angles, α

The graph would become pretty messy if more α values were plotted. (I have data for other α values, which I'd be happy to send on request.) The curves shown should cover most situations since there's not as much need to optimize antennas for vertical-plane radiation angles above 15° or for distances less than 1200 miles (1920 km) as there is for DX work.

other examples

It's also useful to plot gain versus tower height, either

By **Robert E. Leo, W7LR,** Electronics Research Laboratory, Montana State University.

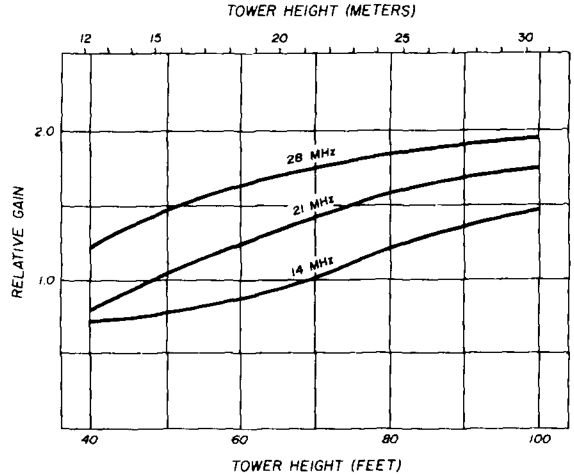

fig. 2. Horizontal-antenna gain as a function of height for the 10-, 15-, and 20-meter bands, $\alpha = 5°$.

for one radiation angle or for one band (**figs. 2 and 3**). **Fig. 2** shows that for $\alpha = 5°$ (2000 mile or 3200 km one-hop F_2-layer DX), the higher the tower the better for all three bands (10, 15 and 20). Now consider **fig. 3**.

table 1. Horizontal-antenna height in terms of wavelength for the 10, 15 and 20-meter bands.

height feet	(meters)	height, wavelengths 10	15	20
10	(3)	0.3	0.20	0.15
20	(6)	0.6	0.40	0.30
30	(9)	1.0	0.6	0.45
40	(12)	1.2	0.8	0.60
50	(15)	1.5	1.0	0.75
60	(18)	1.8	1.2	0.9
70	(21)	2.1	1.4	1.1
80	(24)	2.4	1.6	1.2
90	(27)	2.7	1.8	1.4
100	(30)	3.0	2.0	1.5

If you have a 40-foot (12m) tower, the gain for DX signals ($\alpha = 5°$) is about 0.75, while for signals 900 miles (1440 km) away ($\alpha = 25°$), the gain is 2.25. This ratio is 0.75/2.25 or 3 to 1 against you. This is why those W9s sound so loud and the DX so weak!

If you had an 80-foot (24m) tower, the DX/W9 ratio at $\alpha = 5°$, say, would be 1.26/0.16 = 7.88, which is a lot better (24 times better) than with the 40-foot (12m) tower. The whole business is, however, not too simple as even at 80 feet (24m), the gain for *1200-1500-mile* (1920-2400 km) ($\alpha = 15°$ to $10°$) signals is much greater than for 2000-mile (3200 km) distant DX signals; and if you go to a 100-foot (30m) tower, the 900-mile (1440 km) signals are strong and the 1000-mile (1600 km) signals weak! Data is given in **table 3** so that you can plot graphs similar to **figs. 2** and **3** for other angles or other bands.

table 2. Vertical-plane radiation angle for horizontal antennas for various distances using F2 layer, one-hop propagation.

radiation angle, α (degrees)	distance miles	(kilometers)
2	2600	(4160)
5	2000	(3200)
10	1500	(2400)
15	1200	(1920)
20	1000	(1600)
25	900	(1440)

table 3. Horizontal-antenna gain, height and vertical-plane radiation angle for the 10-, 15- and 20-meter bands.

	40-foot (12m) tower			80-foot (24m) tower		
α	G_{10}	G_{15}	G_{20}	G_{10}	G_{15}	G_{20}
5	1.22	0.80	0.72	1.85	1.6	1.22
10	2.0	1.45	1.36	0.96	2.0	2.0
15	1.9	1.83	1.86	1.32	1.05	1.9
20	1.11	1.88	2.15	1.75	0.65	1.11
25	0.13	1.62	2.25	0.10	1.90	0.13

	60-foot (18m) tower			100-foot (30m) tower		
α	G_{10}	G_{15}	G_{20}	G_{10}	G_{15}	G_{20}
5	1.65	1.22	0.88	1.98	1.78	1.45
10	1.80	2.0	1.57	0.26	1.64	1.98
15	0.40	1.9	1.86	1.97	0.21	1.29
20	1.28	1.11	1.74	0.34	1.84	0.16
25	1.95	0.13	1.28	1.96	1.66	1.49

While there's no simple answer of what tower height to use, it's evident that one at 80 feet (24m) is much more desirable than one at 40 feet (12m) for 20-meter operation to improve the DX/W9 signal ratio. Graphs such as that in **fig. 3** for 10 and 15 meters are even more complex, so practical and economic factors may dictate which height to use.

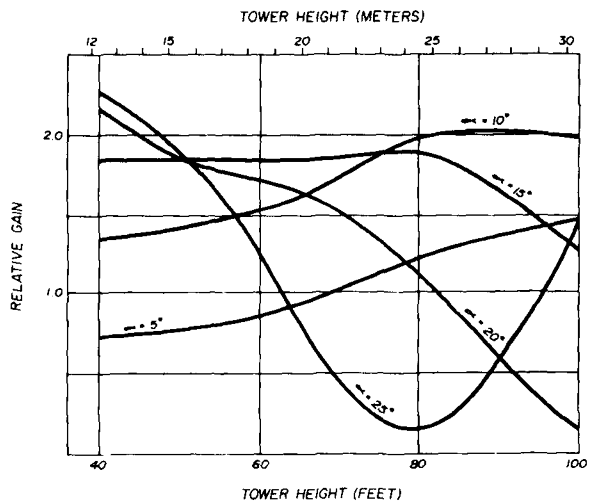

fig. 3. Horizontal-antenna gain as a function of height for the 20-meter band, α = 5, 10, 15, 20, and 25 degrees.

references

1. Robert E. Leo, W7LR, "Optimum Height for Horizontal Antennas," *ham radio*, June, 1974, page 40.
2. *ARRL Antenna Handbook*, ARRL, Newington, Connecticut, 13th edition, 1975, pp. 55-56.

ham radio

TS-520 Specifications

MODES: USB, LSB, CW
POWER: 250 watts PEP input on SSB, 160 watts DC input on CW
ANTENNA IMPEDANCE: 50-75 Ohms, unbalanced
CARRIER SUPPRESSION: Better than -45 dB
UNWANTED SIDEBAND SUPPRESSION: Better than -40 dB
HARMONIC RADIATION: Better than -40 dB
AF RESPONSE: 400 to 2600 Hz (-6 dB)
AUDIO INPUT SENSITIVITY: 0.25μV for 10 dB (S+N)/N
SELECTIVITY: SSB 2.4 kHz (-6 dB), 4.4 kHz (-60 dB). CW 0.5 kHz (-6 dB), 1.5 kHz (-60 dB) (with accessory filter)
FREQUENCY STABILITY: 100 Hz per 30 minutes after warmup
IMAGE RATIO: Better than 50 dB
IF REJECTION: Better than 50 dB
TUBE & SEMICONDUCTOR COMPLEMENT: 3 tubes (2 x 6146B, 12BY7A), 1 IC, 18 FET, 44 transistors, 84 diodes
DIMENSIONS: 13.1" W x 5.9" H x 13.2" D
WEIGHT: 35.2 lbs.
SUGGESTED PRICE: $629.00

VFO-520

Provides high stability with precision gearing. Function switch provides any combination with the TS-520. Both are equipped with VFO indicators showing at a glance which VFO is being used. Connects with a single cable and obtains its power from the TS-520. Suggested price: $115.00.

SP-520

Although the TS-520 has a built-in speaker, the addition of the SP-520 provides improved tonal quality. A perfect match in both design and performance. Suggested price: $22.95.

So much for only $629!

Kenwood's TS-520 is a solidly built, superbly designed SSB transceiver that has literally taken the amateur world by storm. The value of its features and specifications are obvious. Less obvious, but just as important, is the kind of quality that Kenwood builds in. Hundreds of testimonials, in writing and on the air, attest to its performance and dependability. You probably have heard some of the same glowing praise.

The TS-520 operates SSB and CW on 80 through 10 meters and features built-in AC and 12VDC power supply. VOX, RIT, noise blanker, 2-position ALC, and double split frequency controlled operation are only some of its fine features.

Kenwood offers accessories guaranteed to add to the pleasure of owning the TS-520. The TV-502 transverter puts you on 2-meters the easy way. (It's completely compatible with the TS-520.) Simply plug it in and you're on the air. Two more units designed to match the TS-520 are the VFO-520 external VFO and the model SP-520 external speaker. All with Kenwood quality built in.

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116 East Alondra / Gardena, California 90248

TV-502

TRANSMITTING/RECEIVING FREQUENCY: 144-145.7 MHz. 145.0-146.0 MHz (option).
INPUT/OUTPUT IF FREQUENCY: 28.0-29.7 MHz
TYPE OF EMISSION: SSB (A3J), CW (A1)
RATED OUTPUT: 8W (AC operation)
ANTENNA INPUT/OUTPUT IMPEDANCE: 50Ω
UNWANTED RADIATION: Less than -60 dB
RECEIVING SENSITIVITY: More than 1μV at S/N 10 dB
IMAGE RATIO: More than 60 dB
IF REJECTION: More than 60 dB
FREQUENCY STABILITY: Less than ±2.5 kHz during 1-60 min after power switch is ON and within 150 Hz (per 30 min) thereafter.
POWER CONSUMPTION: AC 220/120V, Transmission 50W max., Reception 12W max. DC 13.8V, Transmission 2A max., Reception 0.4A max.
POWER REQUIREMENT: AC 220/120V, DC 12-16V (standard voltage 13.8V)
SEMI-CONDUCTOR: FET 5, Transistor 15, Diode 10.
DIMENSIONS: 6⅝" W x 6" H x 13¼" D
WEIGHT: 11.5 lbs.
SUGGESTED PRICE: $249.00

CW-520
500 Hz CW Crystal Filter: $45.00

Prices subject to change without notice

When you get tired of compromises...

TS-700A Specifications

TRANSMIT/RECEIVE FREQUENCY RANGE: 144-148 MHz
MODE: SSB, FM, CW, AM
RF OUTPUT: CW, FM: more than 10W output. AM: more than 3W output. SSB: more than 20W DC input.
ANTENNA IMPEDANCE: 50Ω (unbalanced)
CARRIER SUPPRESSION: Better than 40 dB
SIDE-BAND SUPPRESSION: Better than 40 dB
SPURIOUS RADIATION: Less than –60 db
MAX. FREQUENCY DEVIATION (FM): ±5 kHz
REPEATER FREQUENCY SHIFT WIDTH: 600 kHz
TONE BURST TIME: 0.5-1.0 sec.
MODULATION: Balanced modulation for SSB. Variable reactance frequency shift for FM. Low power modulation for AM.
MICROPHONE: Dynamic microphone, 500Ω
AUDIO FREQUENCY RESPONSE: 400-2600 Hz, within –9 db
RECEIVING SYSTEM: SSB, CW, AM: Single-superheterodyne. FM: Double-superheterodyne.
INTERMEDIATE FREQUENCY: SSB, CW, AM: 10.7 MHz. FM: 1st IF: . . . 10.7 MHz. 2nd IF: . . . 455 kHz.
RECEIVING SENSITIVITY: SSB, CW: S/N = 10 dB or better at 0.25μV. 20 dB noise quieting = Less than 0.4μV. AM: S/N = 10 dB or better at 1μV.
IMAGE RATIO: Better than 60 dB
IF REJECTION: Better than 60dB
PASS-BANDWIDTH: SSB, CW, AM: More than 2.4 kHz at –6 dB. FM: More than 12 kHz at –6 dB.
RECEIVER SELECTIVITY: SSB, CW, AM: Less than 4.8 kHz at –60 dB. FM: Less than 24 kHz at –60 dB.
SQUELCH SENSITIVITY: 0.25μV
AUDIO OUTPUT: More than 2W at 8Ω load (10% distortion)
RECEIVER LOAD IMPEDANCE: 8Ω
FREQUENCY STABILITY: Within ±2 kHz during one hour after one minute of warm-up, and within 150 Hz during any 30 minute period thereafter.
POWER CONSUMPTION: Transmit mode: 95W (AC 120/220V), 4A (DC 13.8V), max. Receive mode (no signal): 45W (AC 120/220V), 0.8A (DC 13.8V).
POWER REQUIREMENTS: AC 120/220V, 50/60 Hz. DC 12-16V (13.8V as reference).
DIMENSIONS: 278 (W) x 124 (H) x 320 (D) mm
WEIGHT: 11 kg
SUGGESTED PRICE: $700.00

Prices subject to change without notice

KENWOOD'S TS-700A finally fulfills the promise of 2-meters...more channels, more versatility, tunable VFO, SSB-CW and, best of all, the type of quality that has placed the Kenwood name out front.

- Operates all modes: SSB (upper & lower), FM, AM, and CW
- Completely solid state circuitry provides stable, long lasting, trouble-free operation
- AC and DC capability. Can operate from your car, boat, or as a base station through its built-in power supply
- 4 MHz band coverage (144 to 148 MHz) instead of the usual 2
- Automatically switches transmit frequency 600 KHz for repeater operation. Just dial in your receive frequency and the radio does the rest . . . Simplex repeater reverse
- Or do the same thing by plugging a single crystal into one of the 11 crystal positions for your favorite channel
- Outstanding frequency stability provided through the use of FET-VFO
- Zero center discriminator meter
- Transmit/Receive cabability on 44 channels with 11 crystals
- Complete with microphone and built-in speaker
- The TS-700A has been thoroughly field-tested. Thousands of units are in operation throughout Japan and Europe

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the UAR/T and how it works

Versatility plus on a 40-pin TTL-compatible chip — useful for many data transmission and receiving applications

One of the largest LSI devices found in recent construction projects and commercial data communications equipment is the UAR/T or universal asynchronous receiver/transmitter. It is also one of the most interesting and versatile chips now available, yet very few people understand its operation. The UAR/T receives and transmits digital information. It acts as a pair of shift registers, the transmitter converting parallel input data to serial output data and the receiver converting serial data bits back to a parallel word. We could easily use an SN74165 as the transmitter (parallel-to-serial) and an SN74164 as the receiver (serial-to-parallel). Data present at the SN74165 is serialized and transmitted to the SN74164 where it is reconstructed again in parallel form.

You could actually perform this experiment, but you would quickly find that a common clock is needed for both shift registers, and the receiver must be synchronized to receive the data as you start to transmit it. If a large number of digital words are being sent between the shift registers, you must have some way to distinguish the end of one word and the start of the next. This requires a great deal of extra synchronizing logic and control lines between the two shift registers.

You probably know that some tricks are used in data communication between terminals and computers, since the data generally flows over one or two pairs of wires and no additional connections are available for clocks or logic control. One of the tricks, using the UAR/T, is to start each data word, generally eight binary bits long, with a START bit and to end each data word with two STOP bits, as shown in **fig. 1**. Now, whenever the receiver is waiting for a new word and it senses the negative edge of the START bit, it resets itself internally and starts shifting in the serial word.

When the two STOP bits are sensed, the data word transfer is complete, and the reconstructed paralleled data is available. Since there are no common clocks, the receiver and transmitter operate out of sync, or asynchronously. The clocks at both ends of the transmission circuit are set very closely but are not exact. The UAR/T makes up for this by sensing input data in the middle of each bit position. If the bits are not exactly aligned they are still sensed correctly, somewhere close to the middle of each bit, as shown in **fig. 1**.

The clock, supplied externally to the UAR/T by a crystal or R/C TTL oscillator, is set at a frequency 16 times the desired bit rate, which allows the internal logic to perform control and sensing functions. Clock inputs for the receiver and transmitter sections of the UAR/T chip are independent and may be set at different bit rates if needed.

By Jonathan A. Titus, Tychon, Incorporated, P.O. Box 242, Blacksburg, Virginia 24060

functional description

A block diagram of the UAR/T is shown in **fig. 2**. This 40-pin chip has many functions that control the sending and receiving of data and allow programming the UAR/T for certain functions. The number of data bits per word is programmed from five to eight, the number of STOP bits may be selected as one or two, and odd or even parity may be selected or parity may be eliminated from the data word. Five input lines allow the user to program the format of the data sent and received by the UAR/T (**table 1**). The receiver and transmitter are programmed at the same time, so the format of transmitted and received data must be the same. For convenience the *Control Strobe* signal may be left at logic 1 rather than being strobed, which assures that the programming information is always input. In the following examples, pins 34-39 of the transmitter control are programmed at logic 1 giving an eight-bit data word, no parity, and two STOP bits. Active signals are followed by their abbreviation and pin number.

Eight bits of parallel data are entered on the eight transmitter input lines. It is important to note that this

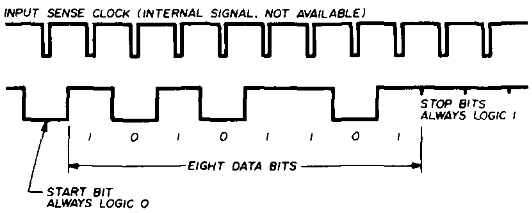

fig. 1. UAR/T data transmission and bit sensing timing.

data may have any format: two BCD digits, an ASCII character, or any random data. Once the eight bits are ready, the Data Strobe (DS/23) is pulsed with a logic 0, and the data is transmitted in serial form. The *Serial Output* (SO/25) is a TTL-compatible output that is at a logic 1 when no data is being sent. A *Transmitter Buffer Empty* flag (TBMT/22) is available to indicate that the next eight bits of parallel data may be entered to the UAR/T. The UAR/T is double-buffered, having a holding register as well as the transmitter register. This buffering allows the next data word to be entered and stored while the UAR/T is still transmitting the previous word. The stored word is then automatically placed in the transmitter register and sent.

ASCII keyboard input

A typical UAR/T application is shown in **fig. 3** in which an ASCII keyboard supplies the data. The transmitter clock is set at a bit transmission rate 16 times the actual output rate. In the keyboard example there are 11 bits since the START and STOP bits must also be counted. A common telecommunication speed is 110 bits per second, or 110 baud. The clock rate must be 16 times this rate or 1760 Hz, which may be supplied from an NE555 oscillator circuit or other source. Although not used in this example, the TBMT output could signal for the next ASCII character. The TBMT output is often

table 1. Input lines for transmitter control.

	control signal	symbol	function
35	No parity	NP	0 = no parity entered 1 = parity entered
36	STOP bits	SB	0 = stop bit 1 = 2 stop bits
37-38	Bits per word	NB2,NB1	NB2 NB1 data bits 0 0 5 0 1 6 1 0 7 1 1 8
39	Parity select	PS	0 = odd parity 1 = even parity
34	Control strobe	CS	enters the above control bits to the UAR/T

used when data is stored in a buffer or computer and you want to send one word right after another to use the data communication lines efficiently. Whenever TBMT goes to logic 1, the next eight-bit data word is entered to the UAR/T buffer register.

The serial output from the UAR/T can go to an fsk generator to store the data on tape, to a modem, or even to another UAR/T. Although you may not have recognized it, **fig. 1** represents the transmission of an ASCII 5 or octal 265. (Remember that the least-significant bit, DB1, is sent first, right after the START bit.) The UAR/T receiver section must be programmed to receive data in the same format as it was sent. The receiver acts as your serial-in, parallel-out shift register, reforming the data into a parallel data word. When the receiver senses a negative transition at the edge of a START bit, it resets to receive a new serial data word. The receiver waits eight clock pulses then starts to sample the serial input bits. This initial offset of eight clock pulses positions the sensing pulse in the middle of each serial data bit, which makes up for the asychronous clocks. The clock difference may be about ±5%.

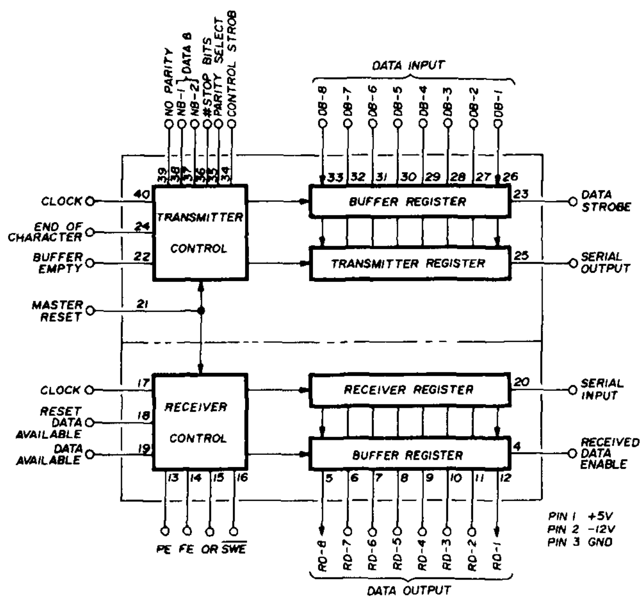

fig. 2. Functional block diagram. Five input lines allow programming of transmitted and received data.

Besides the eight output data lines, the receiver also has some error and flag outputs. The error signals are not frequently used in small systems, but they can serve a useful purpose in debugging systems that use serial data transmission. The *Parity Error* (PE/13) indicates that the parity programmed in the UAR/T and the parity of the received word don't match. The *Framing Error* (FE/14) indicates that the received word doesn't have valid STOP bits, and the *Overrun* (OR/15) indicates that we haven't read the current word and a new word just took its place on the eight output lines. A logic 1 on any of these lines signals an error.

remote data transmission

A *Data Available* flag (DAV/19) goes to a logic 1 to signal that a complete character has been received and may be read at the eight output lines. The data may be read by a terminal (TV typewriter), a computer (Mark-

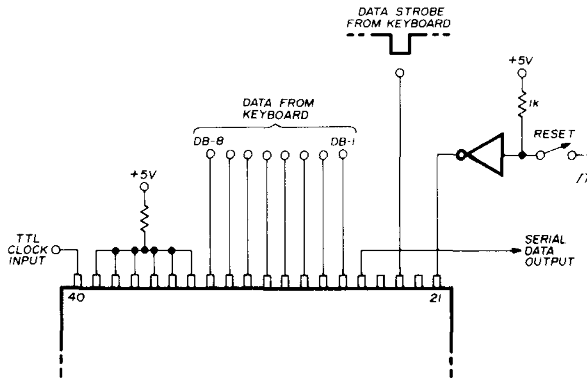

fig. 3. Typical UAR/T application using keyboard input for eight-bit words.

8), or other data storage or output device. After the word is read, the Data Available flag must be reset or it will not indicate when the next word has arrived. Pulsing the Reset Data Available line (RDAV/18) with a logic 0 resets the flag. If the flag is not reset, the next word received will generate an overrun error.

The receiver's data, error, and flag outputs are all tri-state so that a number of UAR/Ts could be used on a bus input scheme. The Receiver Data Enable (RDE/4) and the Status Word Enable (SWE/16) enable the data and flag outputs so that we can read the data. For general, non-bus applications, both these enable lines may be connected to ground. If the UAR/T is to be used on an input bus to a computer or terminal, the tri-state outputs are enabled at the correct time by pulsing RDE and SWE with logic zeros. In the Mark-8 this is done with input instructions.[1]

Fig. 4 shows how a UAR/T could be connected to the TV typewriter to provide the ASCII input from a remote location, possibly from the keyboard shown in **fig. 3.** In this example, the data-available flag triggers an SN74121 monostable to provide the key-pressed pulse to the TV typewriter, and this pulse is also used to clear the data available flag.

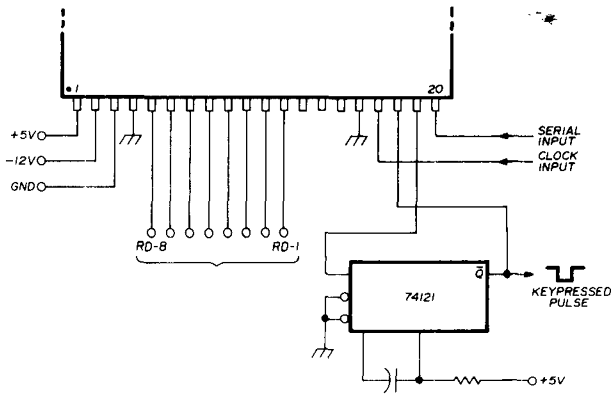

fig. 4. Remote UAR/T receiver for display terminal.

remote data acquisition

Having a receiver and transmitter available in a standard 40-pin package represents a considerable package count, cost, and power saving over a discrete or SSI (small-scale integration) version of this circuit. UAR/Ts have many other applications besides transmitting data back and forth to terminals and computers, so they become useful tools for remote data acquisition and remote control. For example, BCD data could be stored temporarily in a shift register then shifted, one BCD character at a time, to the UAR/T to be transmitted to a terminal or printer. By connecting DB5, DB6, and DB8 to logic 1 and DB7 to ground, octal 260 is inserted into the transmitted data, converting it directly to ASCII. Decimal 3 becomes 263, the ASCII code for 3. The source of the BCD data could be a digital meter, pressure indicator or position encoder -- multiple digits are sent over a pair of wires!

The acquisition and transmission of the data can be controlled by using the receiver section and two SN7485 digital comparators (**fig. 5**). You can compare an output character from the receiver to a preset eight-bit data word. When the two are equal, a monostable starts the data acquisition/transmission sequence and resets the data-available flag. Using a dozen or so 7400-series chips

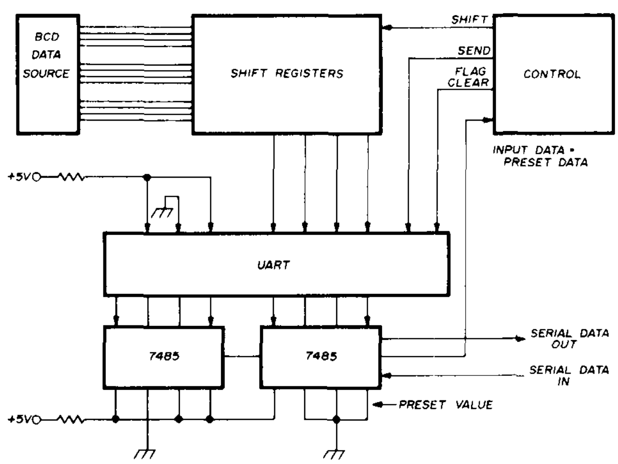

fig. 5. UAR/T used for remote data acquisition. Data output starts when the 7485s find an input equal to the preset value.

and a UAR/T, you now have a four-wire remote data station.

The UAR/T data inputs don't have to be limited to encoded data. They can also be used to monitor limit switches on equipment or even burglar alarm switches or fire sensors. **Fig. 6** shows how two UAR/Ts can be used to indicate remote switch positions. Open and closed switches enter logic 1s or zeros to the UAR/T, and this data lights the corresponding LEDs at the receiver. Data is continuously transmitted by deriving the $\overline{DS}$ pulse from the clock input.

The remote UAR/T receiver section can also be used for housekeeping control at the area being checked. Two SN74154 decoders are connected to the receiver output lines. You can now decode up to 256 possible combinations; and using some NOR gates, you can generate a positive output for each combination. Only one of the 256 combinations may be active at any time. You could also have used eight relay drivers connected to the eight receiver output lines, which would allow independent control of eight devices. The keyboard located at the monitoring station is used to control the receiver outputs. Complete connections in these examples have not been shown for clarity.

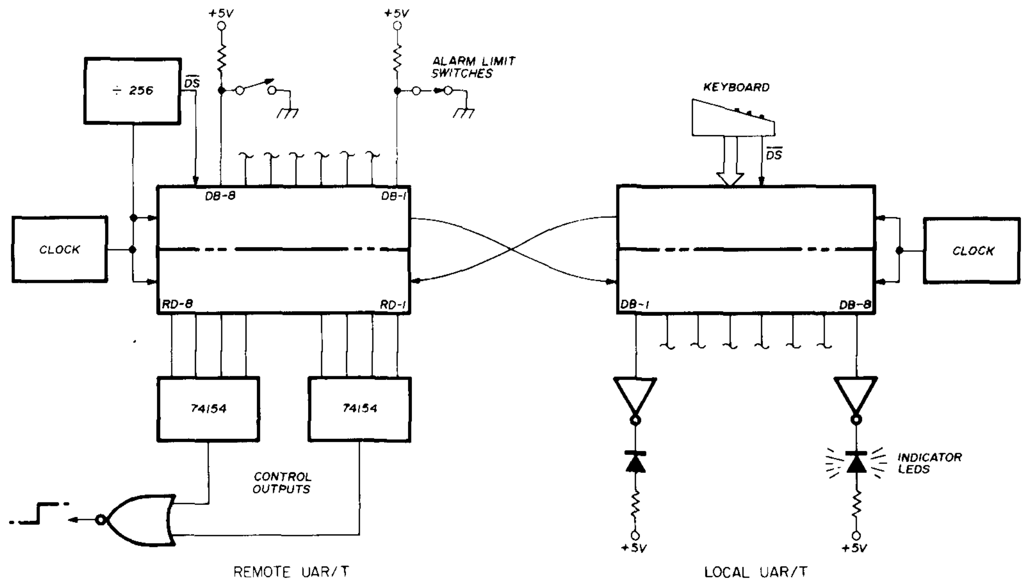

fig. 6. UAR/T used for remote sensing of eight inputs and for remote control.

The serial output from the UAR/T should not be used to drive lines longer than about six feet (1.8m). If longer lines are required, line drivers and receivers such as the DM8820 and DM8830 should be used. Each of the UAR/T outputs has a TTL fan-out of one load; and although the UAR/T is a mos device, it doesn't require pull-up or pull-down resistors.

availability

If you want to experiment with UAR/Ts for data communication or remote control, you may find it difficult to insert the 40-pin chips in breadboard sockets such as those available from E&L Instruments, Continental Specialties, and AP, Inc. To make UAR/T experimenting easy, a special breadboard* has been developed that brings all the connections to 16-pin IC sockets for easy connections with jumpers, and the most important connections are brought to the front of the breadboard to small pins. The complete breadboard plugs into an E&L Instruments SK-10 socket or an AP, Inc. Superstrip socket, leaving plenty of extra room for other chips and connections. Pins on the UAR/T board pick up 5 volts and ground from the power buses. The −12 volts must be supplied with a jumper. All connections are labeled by function and pin number. UAR/Ts available from various manufacturers are generally pin-for-pin compatible, but data sheets should be thoroughly checked before use. The UAR/Ts listed below are compatible.

source	part no.
General Instruments, Inc. 600 West John Street Hicksville, New York 11802	AY-5-1012
Western Digital Corp. 3128 Red Hill Avenue Newport Beach, California 92663	TR1602A & TR1402A
Texas Instruments, Inc. P. O. Box 5012 Dallas, Texas 75222	TMS-6011-NC
American Microsystems, Inc. 3800 Homestead Road Santa Clara, California 95051	S-1883

*The UAR/T breadboard is available from E&L Instruments, 61 First Street, Derby, Connecticut 06418 as part no. LR-21.

reference

1. Jonathon Titus, "Computer!" *Radio Electronics*, July, 1974, page 29; "Computer Modifications," *Radio-Electronics*, December, 1974, page 43.

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15. NBFM - 15 KHz Channel Separation
16. External Speaker Jack
17. Built-in Speaker
18. Dynamic Microphone Included
19. Mobile Mounting Bracket Included
20. Frequency Range 144-148
21. 6½"W x 2½"H x 9½"D
22. Weight: 5½ lbs.
23. Power Requirements:
    Source: 13.5 VDC ± 10%
    Receive: .45A
    Transmit: 2.6A (10W), .7A (1W)

WILSON announces the addition of the 220 and the 450

2202 SM

FREQUENCY RANGE 220 - 225 MHz

- 6 Channel Operation
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- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 and 455 KC IF
- .3 Microvolt Sensitivity for 20 Db Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 2.5 Watts Output @ 12 VDC
- Current Drain: RX 14 MA TX 500 MA
- Microswitch Mike Button
- Unbreakable Lexan® Case

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2. Antenna
3. Ni-Cad Batteries
4. Leather Case
5. 223.50 Simplex Installed

4502 SM

FREQUENCY RANGE 420 - 450 MHz

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- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 and 455 KC IF
- .3 Microvolt Sensitivity for 20 Db Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 1.8 Watts Output @ 12 VDC
- Current Drain: RX 14 MA TX 500 MA
- Microswitch Mike Button
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5. 446.00 Simplex Installed

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BC1 - BATTERY CHARGER	$36.95
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LC1 - 1402 LEATHER CASE	14.00
LC2 - LEATHER CASE FOR 1405, 2202, 4502	14.00
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TE1 - SUB-AUDIBLE TONE ENCODER INSTALLED	39.95
TTP - TOUCH TONE PAD INSTALLED	$59.95
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CRYSTALS: TX OR RX (Common Freq. Only)	4.50

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More Details? CHECK—OFF Page 110

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1402SM HAND HELD 2.5 WATT TRANSCEIVER
144-148 MHz

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FEATURES

1402 SM
- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In.
- 12 KHz Ceramic Filter
- 10.7 IF and 455 KC IF
- .3 Microvolt
- Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- S-Meter/Battery Indicator
- Size: 8 7/8 x 1 7/8 x 2 7/8
- 2.5 Watts Minimum Output @ 12 VDC
- Current Drain RX 14 MA TX 500 MA
- Microswitch Mike Button

1405 SM
- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 and 455 KC IF
- .3 Microvolt Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 5 Watts Minimum Output @ 12 VDC
- Current Drain: RX 14 MA TX 400 MA (lw) 900 MA (5W)
- Microswitch Mike Button
- Unbreakable Lexan® Case

1405SM HAND HELD 5 WATT TRANSCEIVER
144-148 MHz

$279.95

SPECIAL ON EACH RADIO INCLUDES:

1. Antenna
2. Case
3. Ni-Cad Batteries
4. 52/52 Xtal
5. Your Choice of 2 TX/RX Crystals (Common Repeater Frequency Only)

OPTIONAL TOUCH-TONE PAD SHOWN

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More Details? CHECK—OFF Page 110

repair bench

Michael James

voltage troubleshooting

Most successful electronic technicians combine a number of different troubleshooting techniques when tracking down a circuit problem, including signal tracing, resistance measurements and oscilloscope checks, but voltage measurements are probably the most popular. They go hand in hand with resistance measurements so you can't understand one without understanding the other, but since resistance measurements are often the next logical step after detecting an incorrect voltage, troubleshooting with an ohmmeter will be discussed next month.

Although voltage troubleshooting is probably the best known, it isn't always the best choice – logic dictates that you should first isolate the problem to one section or stage in the equipment. If your test equipment is limited to a voltmeter you can use voltage measurements to pinpoint a problem area, but other techniques are usually faster. Nevertheless, once you know which circuit to look in, voltage troubleshooting is a quick way of finding the faulty part.

Most modern instruction books and schematics include voltages at each transistor or IC terminal, and some include dc voltages and signal levels at various points in the circuit. To troubleshoot the circuit you start by measuring each dc voltage in the suspected circuit and compare it to the correct voltage on the schematic. When you find a voltage that is much higher or lower than it should be, you have to figure out what could cause it. If you know Ohm's law for voltage, current and resistance, it's not too hard to decide what's causing the undesired voltage change.

When comparing the measured voltages with those given in the instruction book, don't be lead astray by the fact that the instruction book values are "nominal" values – the actual, measured voltages may be 10 per cent higher or lower. This isn't usually a problem in solid-state circuits because the measured voltages should be within 1 or 2 volts of that specified, but in vacuum-tube equipment the measured voltages may be as much as 30 or 40 volts off and still be within the "nominal" range. In a transmitter stage with a "nominal" 800-volt plate supply the actual circuit voltages could fall in the range from 700 to 900 volts and still be okay. The clue here is the actual dc supply voltage, so the first thing to check is the dc supply voltage at the output of the last power supply filter. If it's 10 per cent higher than that noted on the schematic, you can expect other unregulated voltages in the set to be 10 per cent higher.

voltage dividers

We'll discuss series and parallel resistance circuits in more detail next month when we get into troubleshooting by resistance measurement, but in the meantime let's look at a typical series circuit and see what happens when one of the resistors in the string changes value for some reason. Consider the simple series cricuit in **fig. 1**. Since the resistors are connected in series, the same current flows through them all and the resistors divide the voltage in direct proportion to their resistance values. In the circuit of **fig. 1** the resistance ratios are 8:4:3:1. The R1-R2 voltage is 24 volts below the supply voltage, the R2-R3 junction is 12 volts below R1-R2, the R3-R4 junction is 9 volts below R2-R3, and 3 volts are developed across R4. The 8:4:3:1 ratio is maintained. (Although circuit voltages are measured in reference to ground unless otherwise specified, you can directly measure the voltage drop across a resistor by placing the voltmeter probes on each lead of the resistor. Be sure the negative voltmeter lead is placed at the lower voltage end of the resistor.)

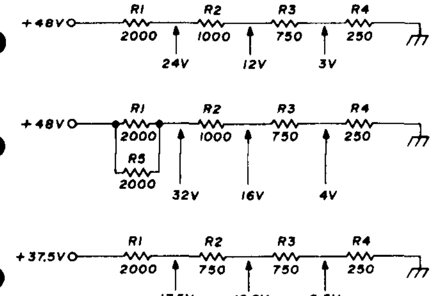


fig. 1. Typical series voltage dividers, showing how the resistance and voltage- dividing ratios are maintained even when a resistor or supply voltage changes value.

Now consider what happens when you change one of the resistance values as in **fig. 1B**. A 2000 ohm resistor has been added in parallel with R1, lowering its effective resistance to 1000 ohms. This changes the resistance ratio of the divider chain to 4:4:3:1, and the voltage divides accordingly. R1 (with R5) drops 16 volts, R2 drops 16 volts, R3 drops 12 volts and R4 drops 4 volts, maintaining the 4:4:3:1 voltage ratio.

If you forget R1 (and R5) for a moment, note that the ratios of R2, R3 and R4 are 4:3:1 for both circuits. This is important because it illustrates the fact that if one resistor in a series voltage divider changes value, the ratio of the other resistors in the divider remains the same. As a further example of this consider **fig. 1C** where the value of R2 has been reduced to 750 ohms and the supply voltage lowered to 37.5 volts. The voltage and resistance ratios are 8:3:3:1 with the ratios between R1, R3 and R4 the same as in **fig. 1A**.

As an example of voltage troubleshooting, consider the simple voltage divider circuit of **fig. 2**. This is the type of circuit that might be used to provide different operating voltages to various transistor circuits in a set. The bypass capacitors provide necessary circuit decoupling. The circuit of **fig. 2A** shows the normal dc voltages (usually called operating voltages) while **fig. 2B** shows the voltages which you might measure in the circuit when you start troubleshooting.

In **fig. 2A** the +12 volts appears at the junction of R2-R3 because of the 6 volt drop across R1 and R2. A further voltage drop across R3 causes +6 volts at the junction R3-R4. When analyzing the incorrect voltages in **fig. 2B** note that two of the voltages have changed. Since the voltages have changed, it follows that the resistance ratios have changed.

The first step in troubleshooting this circuit, therefore, is to determine what the new resistance ratios are. If you consider only the +4 volts at the R2-R3 junction,

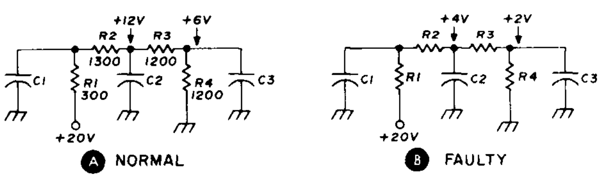


fig. 2. Voltage divider which might be used in solid-state electronic equipment to provide operating voltages to different stages. The incorrect voltages in (B) are easily analyzed with voltage ratios to determine the bad component.

there are two possibilities: R1 and R2 have higher resistance than normal, resulting in a larger voltage drop, or R3 and R4 have lower resistance with a lower than normal voltage developed across them. Which is it? The clue lies in the fact that the ratio between the voltages at R2-R3 and R3-R4 is the same in both circuits, 12:6 = 4.2, or 2:1. Therefore the trouble is more likely in either R1 or R2; one of them has probably increased in value.

You might be inclined at this point to disconnect the two resistors from the circuit and measure them with an ohmmeter. However, further voltage measurements will indicate that one retains its ratio to R3-R4 while the other does not. Even though the voltage isn't shown for the R1-R2 junction, you can quickly calculate it with Ohm's law. Since 6 volts appears across R 4, a 1200 ohm resistor, the current through the circuit is 5 mA. Therefore, the voltage at the R1-R2 junction should be 1.5 volt, a ratio of 1:8 when compared to the voltage at R2-R3.

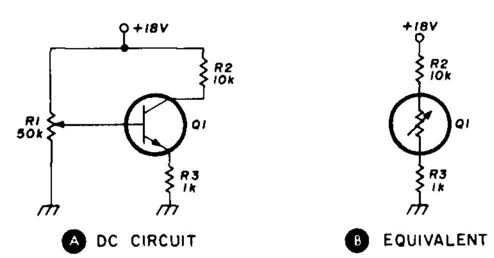


fig. 3. Basic transistor circuit and its equivalent circuit when the transistor is considered to be a variable resistance. Equivalent is complicated because resistance is a function of the base bias which is set by R1.

If the voltage at R1-R2 is 0.5 volt in the faulty circuit, it has the correct ratio to the 4 volts at R2-R3 and resistor R1 is the culprit. On the other hand, if you measure 1.5 volt at R1-R2 in the faulty circuit, R2 has increased in value and should be replaced.

The same type of reasoning is the basis for analyzing all dc voltages in series circuits. First look at the ratio of resistances, compare the voltage ratios, and then figure out what's causing the problem.

transistor and tube circuits

Thinking in terms of resistance and voltage is simple so long as the resistances are simple, and with a little experience you'll be able to estimate voltage ratios close enough to give you a clue to which resistance has changed. Transistor and IC (and vacuum tube) circuits, however, are different because the dc operation of the device changes as you alter the bias and/or supply voltages. In the circuit of **fig. 3A**, for example, the current through the transistor (and the voltage drop from collector to emitter) is determined by the base bias which is set by R1. Increasing the base bias (base-to-emitter voltage) increases the base current which is multiplied by the current gain of the transistor. This increased emitter current increases the voltage drop across the emitter resistor which affects bias, which affects base current, which affects emitter current, and so on.

The same sort or thing occurs in the vacuum-tube circuit in **fig. 4**. Here the grid bias is picked off the cathode resistor R1. Since the current through the tube is a function of grid bias, any changes in plate current are reflected throughout the series circuit, which affects bias, which affects plate current, etc.

Although the transistor and vacuum tube can be rather loosely represented by an equivalent variable resistance, the interdependency of bias and emitter or plate current make it difficult to treat active devices as simple ratio dividers. There are some circuit difficulties that can be tracked down with voltage ratios, but you have to be very careful to distinguish between cause and effect. In many cases it is practically impossible to separate the two without resorting to another troubleshooting technique. But don't feel too badly if you get caught in this trap -- more than one technician has chased his tail around a circuit only to discover that what he thought was the cause was really the effect, and vice versa.

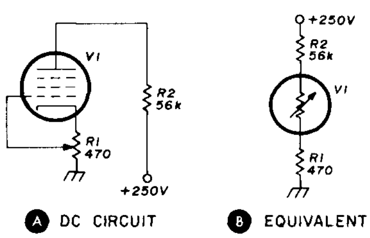


fig. 4. Basic vacuum-tube circuit and its basic series resistance equivalent. Plate resistance is a function of grid bias which is set by the cathode resistor R1. This complicates the analysis as discussed in the text.

Consider the transistor amplifier circuit shown in **fig. 5A** and its resistive equivalent in **fig. 5B**. Voltages are shown for each point in the circuit so you can calculate the voltage and resistance ratios. There is a 9 volt drop across R2, a 6 volt drop across Q1 and a 3 volt drop across R1 so the ratio is 3:2:1. Now assume that something goes wrong with the circuit and you measure the voltages shown in **fig. 5C**. With 4.2 volts across R1, 1.2 volts across Q1 and 12.6 volts across R2 you have a voltage ratio of 3:0.29:1. Since the ratios of R1 and R2 remain the same, it's a good guess that they're okay, but the resistance of Q1 has changed, upsetting the voltages in the circuit. However this doesn't necessarily mean the transistor is bad. It's very likely that something in the circuitry at the base of the transistor (not shown) is causing the problem.

To get an idea of how complex these relationships can get, look at the transistor audio amplifier shown in **fig. 6A**. Shown in **fig. 6B** is the equivalent diagram of the collector circuit ($Q1_C$ is the collector-emitter junction); **fig. 6C** shows the equivalent circuit for the base circuit and includes the bias network (R1 and R2) and the path through the base-emitter junction ($Q1_B$). Note that the emitter resistor R4 is in this path, too, so a current change in either circuit affects the voltage drop across that resistor.

Fig. 6D shows the combined dc paths through the transistor. Figuring out the voltage ratios in this circuit would be difficult even if the resistances were simple, whole numbers, which they aren't, but the circuit is complicated by the fact that the value of $Q1_C$ is controlled by $Q1_B$. However, as will be seen later, there are some rules of thumb that remove some of the apparent complexity and allow you to successfully use voltage ratios to troubleshoot circuits of this type.

We will study transistor circuits in greater detail in a future column, but there are several important facts about transistor circuits that are particularly helpful in understanding the operating voltages of the stage. In a transistor amplifier, for example, the base-emitter junction is always forward biased and the base-collector junction is always reverse biased.* That is, the base terminal is always at a higher dc potential with respect to the emitter, and the collector is always at a higher potential than the base. In npn transistors the collector is positive with respect to the emitter, and in pnp transistor circuits the collector is negative with respect to the emitter. Furthermore, there's an approximately 0.7 volt voltage drop from base to emitter in silicon transistors, and about 0.2 volt base-emitter voltage drop for germanium transistors. In **fig. 6A**, for example, there's a 0.7 volt difference between the base and emitter terminals so Q1 is a silicon transistor.

It's also important when analyzing transistor stages to remember that the base current is a small fraction of the collector or emitter current, typically 1 per cent or less (for a collector current of 25 mA, typical base current is about 250 μA). Therefore, the fact that R4 in **fig. 6D** is common to both the base and collector equivalent circuits is of little consequence because base current contributes only about 11 mV to the voltage drop across R4.

Since the base-emitter voltage remains relatively constant throughout the operating range of the transistor, this can complicate troubleshooting because if the emitter voltage increases for some reason, the base voltage will follow right along behind it. On the other hand, if the base bias voltage increases, this increases the base current slightly, increases the emitter current greatly, and increases the voltage measured at the emitter terminal. The measured voltages may be the same in both cases but the causes are different.

*Forward biased for class-A stages. Class-AB stages are slightly forward biased while class-C stages are operated at zero bias.

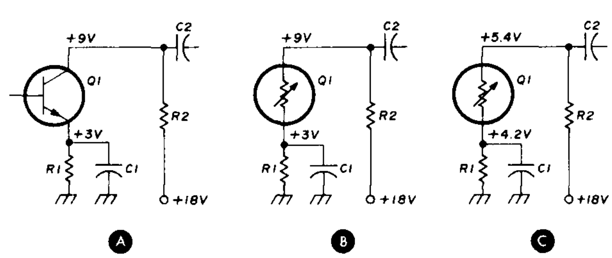


fig. 5. Simple transistor circuit (A), the dc equivalent of the collector circuit (B), and incorrect voltages which can be analyzed using voltage ratios. Troubleshooting cannot be completed however, without considering the base circuit as shown in fig. 6.

The circuits of **fig. 7** are the same as those of **fig. 6A** except that the operating voltages have changed, indicating trouble. Note in both cases that the emitter voltage has increased. In **fig. 7A** the emitter voltage has increased to 1.6 volt while the collector voltage has dropped to 5.4 volts. In **fig. 6A** the ratio of the voltage drops across R3 and R4 is approximately 8:1. In **fig. 7A** the R3 and R4 voltage drops are 12.6 and 1.6 volts respectively, a ratio of about 8:1. Therefore, the difficulty is the base bias network (the value of R1 has probably decreased, increasing the current flow through R1-R2 and increasing the base bias voltage).

In **fig. 7B** the emitter voltage has also increased, but note that the ratio of the voltage drop across R3 (15.6 volts) to that across R4 (1.3 volts) is now 12:1. Further checking will reveal that the value of the emitter resistor has decreased to about 100 ohms, nearly doubling collector and emitter current.

The i-f amplifier in **fig. 8** is typical of the type you might find in a modern communications receiver. Assume you have tracked a receiver problem to this stage and measure the transistor voltages shown in **fig. 8B**. The collector voltage is very low, indicating either higher than normal current through the transistor or that R4 has increased in value. The base voltage is a little low, but it has changed little with respect to the emitter voltage. If you study the circuit you quickly decide that the bypass capacitor C3 has shorted. With 1 volt of forward bias the transistor conducts heavily, dramatically lowering collector voltage.

There are countless transistor and IC supply circuits which you can analyze in this same way. First, pick out the voltage that is the most wrong and find out what caused it. Concentrate on one supply path at a time and try to ignore the effects of other circuits. When you decide what happened in one circuit, then decide whether another circuit could possibly be causing the incorrect voltages in the circuit. The component that is common to all symptoms is usually the culprit. Each symptom leads to another, and ultimately to the defective component.

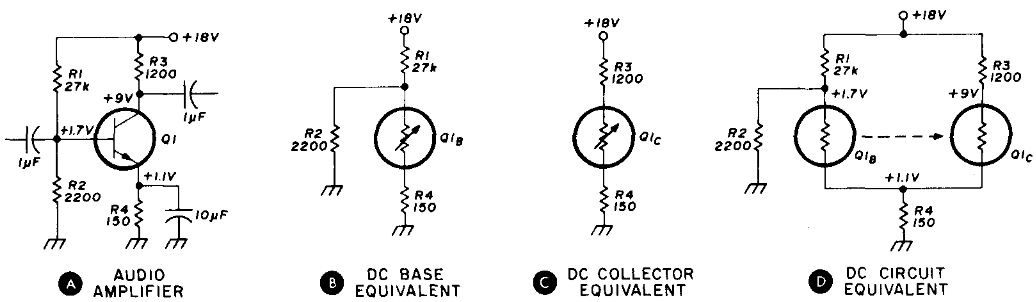


fig. 6. Transistor audio amplifier (A), dc equivalent of the base circuit (B), dc equivalent of the collector circuit (C), and the complete equivalent including collector current dependence upon base current (D).

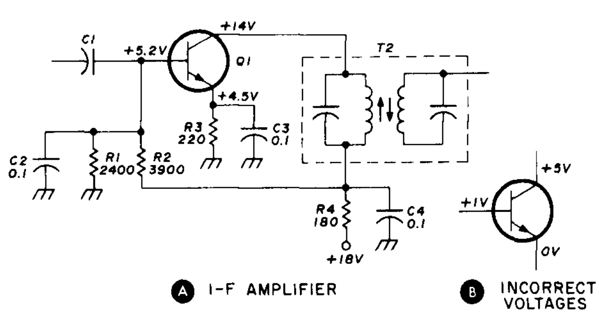


fig. 8. Transistor i-f amplifier with correct operating voltages is shown in (A). Incorrect operating voltages in (B) are analyzed in text.

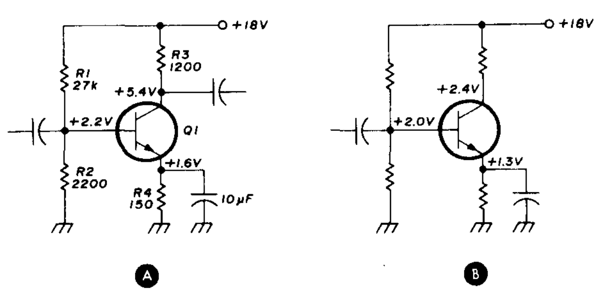


fig. 7. Transistor audio amplifier circuit of fig. 5 with incorrect operating voltages. Although the emitter voltage has increased in both of these circuits, the cause is different in each case as discussed in the text.

Collins paint

Although not directly in the area of troubleshooting, maintaining the appearance of your amateur equipment is also important. Not generally known is the fact that Collins Radio stocks spray cans of paint for both the S-line and the older 75A4/KWS line. The S-line color scheme is actually in three different hues: 180 Gray for the cabinet (Collins part number 097-6161-000), 250 Gray for the panel (Collins part number 097-6162-000) and 126 Medium Gray for the ring (Collins part number 097-6163-000). The spray paint for the 75A4/KWS line is St. James Gray (Collins part number 097-6164-000). Spray cans may be ordered through your local Collins dealer.

ham radio

More Details? CHECK—OFF Page 110

More Details? CHECK—OFF Page 110

the ham notebook

high power calibration for the Heath HM2102 vhf wattmeter

The great crowds of two-meter fm enthusiasts will no doubt provide the Heath Company with a continuing market for their HM2102 vhf watt meter. This dandy piece of equipment provides two switch-selectable power ranges of 25 and 250 watts full scale, in the 50 to 160 MHz range, and also includes a built-in swr bridge.

In checking out my wattmeter I found that everything worked fine with the exception of a noticeable discrepancy in the accuracy of the high power (250 watt) range. Checking further, I found that the problem was due to the fact that R8, a 68k resistor which is used as a meter multiplier in the 250 watt range, was out of tolerance. The problem could have been cured by replacing R8 with a new resistor, but it occurred to me that even greater accuracy could be obtained by replacing R8 with a variable 100k resistor to allow separate calibration of the high power range.

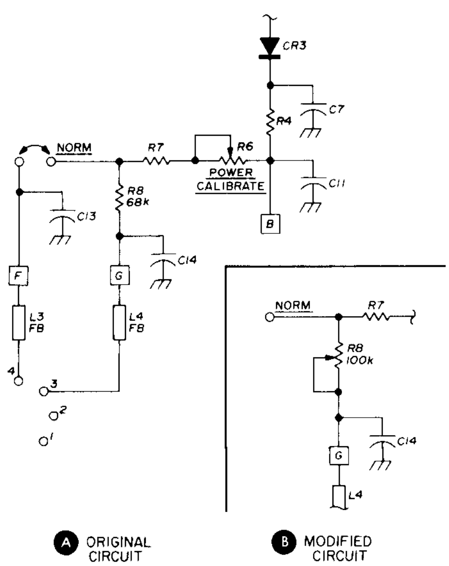


fig. 1. The high-power range of the Heath HM2102 vhf wattmeter can be calibrated by replacing R8 with a 100k potentiometer such as the Allen-Bradley ZV1041 or Bournes 3389P. Calibration procedure is discussed in the text.

This modification is easily done and works out very nicely. The small trimpot may be supported by using short pieces of solid hookup wire inserted in the PC board holes formerly occupied by R8. The adjusting slot should face upward in the same direction as potentiometer R6. A hole in the cover plate allows access to R8 when the cover is in place. This access hole can be labeled high for high power adjust, and the hole already in the plate for R6 can be labeled *low.*

The original calibration procedure calls for adjusting R6, a 50k pot, in the low power position, which also affects the high power calibration. With the addition of a 100k pot for resistor R8, the new calibration procedure is as follows:

1. Using a known power source in the 10 to 25 watt range, and/or comparing with another wattmeter of known accuracy, adjust R6 for the correct meter indication in the 25 watt range.

2. Switch to the 250 watt range, and again using a transmitter with known output, and/or a comparison wattmeter, adjust R8 for correct meter indication.

Both ranges are now individually calibrated. Any further adjustment of R6 will require readjustment of R8.

Robert H. Johnson, W9TKR

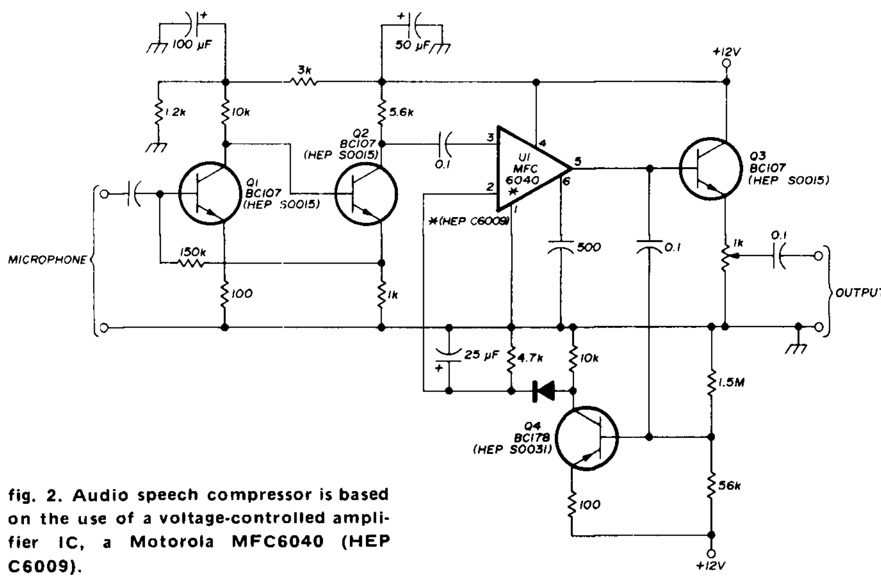


fig. 2. Audio speech compressor is based on the use of a voltage-controlled amplifier IC, a Motorola MFC6040 (HEP C6009).

speech compressor

I wanted to improve the efficiency of my homebrew ssb transmitter, so I decided to build an audio speech compressor. The circuit in **fig. 2** uses a Motorola MFC6040 voltage-controlled amplifier IC which has 13 dB gain and 90 dB (maximum) gain reduction. Maximum input is specified at 5 mV rms. In this circuit transistors Q1 and Q2 are a microphone preamplifier. Transistor Q4, which is connected to the output through a 0.1 µF capacitor, is the agc detector/amplifier for U1, the voltage-controlled gain stage. Q3 is the output buffer.

At my station I use a 500-ohm dynamic microphone with this circuit and the output remains constant at 1.8 volts rms. The performance of the unit could be further improved by adding a 300-3000 Hz filter at the output.

L. Novotny

goral oscillator notes

The Goral crystal oscillator circuit described by Don Stoner in *ham radio** appears to be excellent in many respects. I have found, however, that the proper value of C2 in **fig. 4** of the original article is a critical function of the capacitance for which the crystal is calibrated. Crystals for the GE Progress Line, for example, are ground to operate into a 10-pF load and will not oscillate on their proper frequency using 20 pF as the value of C2. Data on two different crystals for a GE Progress Line receiver are shown in **fig. 1**. A value of 12 pF for C2 is more suitable as it allows the crystal to be netted using an 8-pF trimmer capacitor at C1. The data also illustrate the wide frequency range over which the oscillator will operate when different values of C1 and C2 are used.

Robert E. Cowan, K5QIN

nicad battery care

Most pocket computers are powered by rechargeable nicad batteries. These are good batteries, but they must be treated with care. If you run the batteries, or even one cell, much below 0.7 volt, there seems to be the danger of the weakest cell reversing its polarity and chemically burning itself out. If one cell does go dead, it is suggested you replace the

*Donald L. Stoner, W6TNS, "High-Stability Crystal Oscillator," *ham radio*, October, 1974, page 36.

whole string in series, or you may have further problems with cells burning out. If you can get a rundown battery to recharge a little, you may be able to cycle the battery back to health by recurrent discharging and recharging. It appears these cells may also remember how you treat them. Treat them ruggedly, and they will be rugged; treat them kindly, and they wilt away.

monitor receiver modification

I would like to elaborate on the W3WTO article in the January, 1975, issue of *ham radio*.* In this unit the local oscillator is 10.7 MHz *below* the 162 MHz received frequency, at about 151 MHz. By slightly spreading the turns of the oscillator coil, it can be moved to the range of 156 to 159 MHz, 10.7 MHz *above* the two-meter band. The present tuning arrangement covers about 3 MHz, or 145 to 148 MHz if the coil is carefully adjusted.

Weather Monitor tunes from 145 to 148 MHz.

Since the rf coils were previously peaked at 162 MHz, sensitivity on two meters can be substantially improved by *replacing* the rf coils using the same size wire and coil diameter. L1 and L2 should have one additional turn and L3 should have two additional turns. Carefully adjust the length of the new coils for optimum sensitivity.

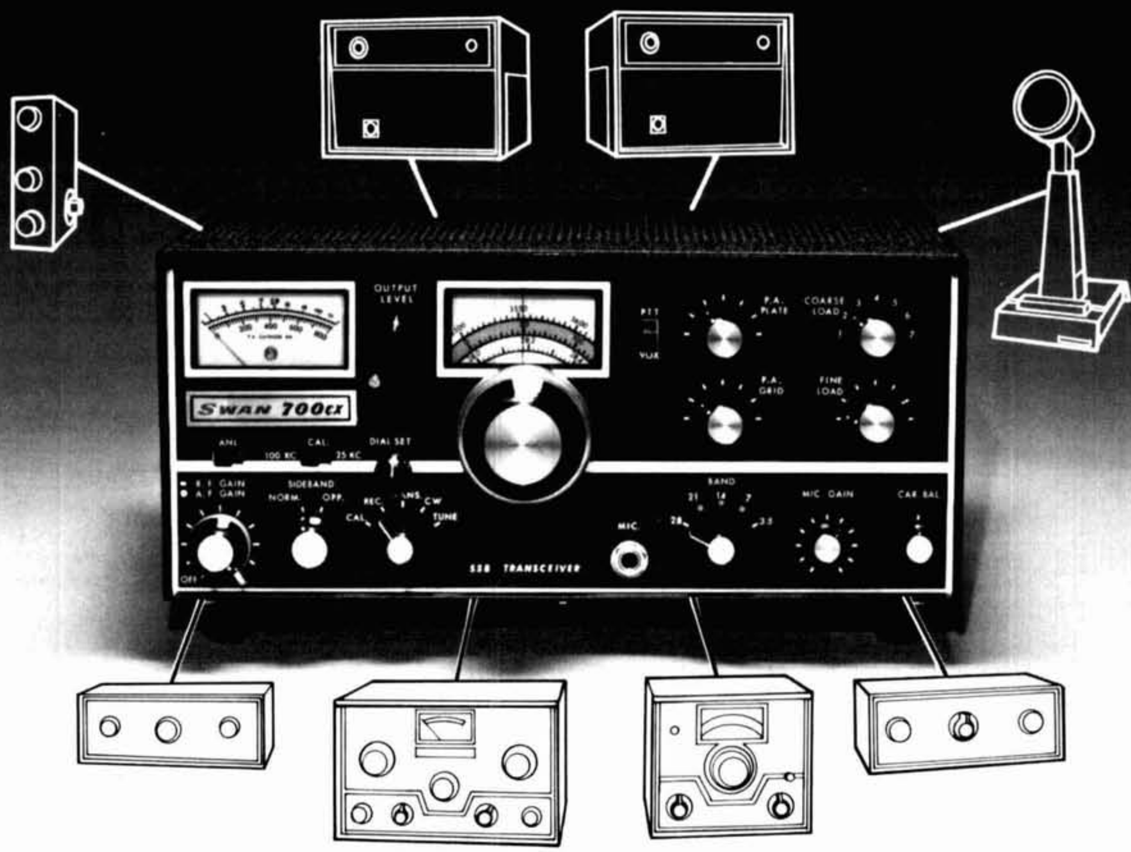
While the unit works well with its self-contained antenna, I added a phono jack for convenient connection to an external antenna.

It really gives quite good performance for a tunable, $15 two-meter receiver.

Lowell White, W2CNQ

*Kent Mitchell, W3WTO, "Return Weather Monitor Receiver for Two-Meter FM," *ham radio*, January, 1975, page 56.

Swan 700CX transceiver.



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More Details? CHECK—OFF Page 110

NEW products

general coverage receiver

The SSR-1 receiver is a new addition to R. L. Drake Company's family of communications equipment. Several design features make it a good candidate for portable work, general-purpose shortwave listening, emergency use, or as a standby receiver. The SSR-1 is frequency synthesized and covers 500 kHz to 30 MHz, providing reception in the a-m, CW, and ssb modes, with selectable upper or lower sidebands.

The SSR-1 is completely self contained including built-in speaker, removable telescoping antenna, 117/234 Vac 50 to 60 Hz power supply, and provision for eight D-cell batteries. With batteries installed, the SSR-1 switches automatically to battery operation if ac power fails. To conserve battery power, the SSR-1 features a front-panel push-button switch that must be depressed to illuminate dial lights.

More information may be obtained by writing to the R. L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342, or use *check-off* on page 110.

up/down counters

ESE is now producing the ES-301 and ES-302 digital up/down counters. Both are four-digit, 100-minute timers featuring four gas-discharge displays for display up to 99:59. Six separate controls count up, count down, stop, minutes advance, seconds advance and reset. The controls are momentary push-button switches. When the stop control is pressed, the display is automatically held at the precise second. Both the ES-301 and the ES-302 may be preset to a desired number for a specific count, and timing can be activated from that point, up or down. Desired numbers on the ES-301 can be preset by advancing the minutes and seconds simultaneously or independently. Lever wheel type switches instantly preset the number on the ES-302.

Depressing the reset button on both units returns the numbers to 00:00 from which they will continue counting up or down, unless the stop button is pushed. Both units may be equipped with an option that returns the number to the preset digits when the reset is activated. Counting direction (up or down) on both units can be reversed or reset to 00:00 without stopping the count.

Both the ES-301 and ES-302 come in an etched aluminum case with simulated walnut sides and top. Power for both is 7 watts maximum, 117 Vac at 60 Hz. The ES-301 and ES-302 are efficiently designed for constant, daily use, utilizing solid state reliability, silence, easy operation, high accuracy, long life, low initial cost and operation.

For detailed catalog sheets contact ESE, 505½ Centinela Avenue, Inglewood, California 90302 or use *check-off* on page 110.

wideband rf transformers

Communications Power is offering a complete line of wideband rf transformers designed specifically for impedance matching in high-power solid-state amplifiers. The transformers cover 1.8 to 30 MHz and are rated at 150 watts. Extremely rugged construction assures reliability in any environment. Applications include marine as well as military and amateur radio communications equipment.

High-volume manufacture means lowest prices. The following example is representative of CPI wideband rf transformers available for immediate delivery. These units all have turns ratios of 1:3, 4, 5, or 6 and cover 1.8 through 30 MHz:

series	power rating (watts)	price (1 - 4 pieces)
RF1000	150	$5.00
RF800	100	4.00
RF600	50	3.50
RF400	25	2.50

Information on other types is available on request. Write Communications Power, Incorporated, 2407 Charleston Road, Mountain View, California 94043, or use *check-off* on page 110.

fm signal generator

The Edison Electronics division of McGraw-Edison Company has developed a solid-state fm signal generator that covers all the mobile communications frequency bands allocated by the FCC. Four models are offered, designed to your specific carrier-frequency needs. Each model has six frequency bands. The model 800A covers 25 to 960 MHz; model 801A, 25 to 470 MHz; model 802A, 25 to 175 MHz; and the model 803A, 25 to 520 MHz. Any desired frequency can be quickly obtained by first selecting one of the six frequency bands, then tuning the coarse tuning control until the desired frequency appears on the hand-calibrated tuning dial. Finally, narrowband adjustments may be made with either an electronic fine tuning control or incremental frequency controls.

Output voltages are provided with accuracy traceable to NBS. Output is continuously variable between 0.1 microvolt and 0.1 volt. A temperature-compensated bolometer circuit maintains output voltages automatically. Accurate receiver sensitivity measurements can be made to 0.1 microvolt.

The Measurements Model 800A series fm signal generators feature internal modulators that provide fm at 1000-Hz

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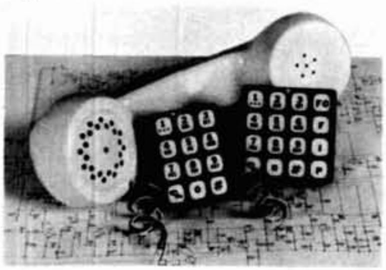
sine waves or 20-Hz sawtooth waves. External modulation between dc and 30 kHz may be applied through binding posts on the panel. Sync output and sync phase are available for external modulation up to ±32 kHz peak deviation so that dual-trace sweep alignment may be used.

All four models are available at $992,00 FOB Manchester, New Hampshire. For a brochure providing more technical details write Edison Electronics, Grenier Field, Manchester, New Hampshire 03103 or use *check-off* on page 110.

tone encoding keyboards



Four new tone encoding keyboards have been introduced by Electrografix for vhf/uhf installations where access is required to amateur autopatch repeaters. Designated TEK-125, -165, -225, and -265, the series incorporates the cmos IC developed by Motorola: the MC14410 digital tone encoder.

The pads provide a compact, accurate, low-power, digital tone encoding system with a full 2-of-7 or 2-of-8 encoding format from a basic 1-MHz crystal oscillator. A unique key pad switch complements the anti-falsing lockout feature of the Motorola IC.

The two smaller pads, TEK-125 12 button and TEK-165 16 button, are for use with hand-held transceivers or other small units. TEK-225 and TEK-265 are much larger and are intended for installation in remote-control panels, repeater sites, or on vehicle dash panels. All units are 0.40 inch (10.2mm) thick. External dimensions are: TEK-125, 1.58x2.08 inches (40x52.8mm); TEK-165, 2.08x2.08 inches (52.8x52.8mm); TEK-225, 2.05x2.70 inches (52x68.6mm); TEK-265, 2.70x2.70 inches (68.6x68.6mm).

Also featured are a glow-in-the dark keyboard face and a LED in the bezel

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face to indicate when a tone has been generated. The LED also functions as a battery-level indicator. The keyboard face is nonradioactive, and when exposed to normal sunlight or other similar light, it will glow up to eight hours. The phosphor green color is highly visible and legible under all lighting conditions, from bright sunlight to total darkness. Other colors are available in quantity purchases.

The TEK series tone-encoding keyboards have gold-plated circuit boards, single-unit molded ABS plastic bezels and cases, and an externally adjustable level control. Combined operating current for the tone generator and LED indicator is less than 13 mA. When operating as a battery-level indicator, the LED current drain is less than 8 mA at the rated input of 6 to 16 Vdc. Output level is a 0 to 600 mV p-p composite waveform, which will modulate any transmitter. The TEK-165 weighs less than 0.9 ounce (27g).

The TEK keyboards are complete and ready to go. Only three electrical connections are needed at the transmitter: audio, B+, and ground. Mechanical installation is simple – either by self-tapping screws or adhesive strips provided with each unit.

The single-unit list price for TEK-125 is $57.50; for TEK-165 it is $65.00. The TEK-225 and 265 prices are available on request. For additional information, write Electrografix, Inc., P.O. Box 869, Chino, California 91710, or use *check-off* on page 110.

semiconductor replacement guide

This book is designed to fill a gap in the information available to amateurs and electronics technicians. It provides general-purpose replacements for manufacturers' semiconductor parts numbers. Over 15,000 semiconductors used in entertainment-type electronic equipment are cross-referenced to the universal replacements produced by General Electric, International Rectifier, Mallory, Motorola, RCA, Sprague and Sylvania. Included are bipolar and field-effect transistors, diodes, rectifiers, and integrated circuits. 256 pages, softbound, $3.95 from Ham Radio Books, Greenville, New Hampshire 03048.

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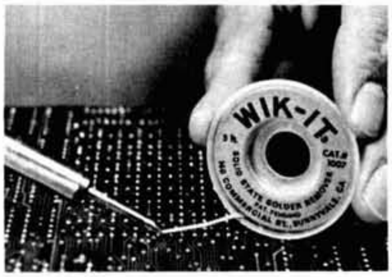
solder remover



You can de-solder any soldered joint merely by placing your iron atop a special braid, called *Wik-It*, which in turn is laid on the soldered joint. In a second or two the solder simply disappears into the special braid. The soldered joint is now clean and free of solder, ready for the next operation.

Wik-It is a patented solder remover developed by the Wik-It Electronics Corporation. Because of special chemical treatment of the braid, the solder to be removed is drawn into the braid through capillary action. When the solder has been removed from the joint, the user just snips off about a half-inch of *Wik-It* which is then ready to be used again.

Because the solder removal occurs so quickly, little heat is transferred to the surrounding material, whether it be mounting board or wire insulation. As a result, *Wik-It* eliminates delamination. lifted pads, and measling which are all too often seen with de-soldering attempts. Flux contamination and component damage are also eliminated by the quickness of the *Wik-It* method.

Wik-It has been thoroughly tested for over two years in manufacturing companies and is approved for use in military and aerospace work since it meets specification MIL-F-14256C Type W and Type A.

Wik-It is available in different sizes to suit small transistor and IC applications as well as larger tube and heavier-size wire work. *Wik-It* comes in various lengths from 5 to 100 feet. The price of a 5-foot roll of *Wik-It* is from $1.59 to $1.79, depending on width, and is available in electronics supply stores or from the manufacturer. Free samples are available upon request.

For more information, contact *Wik-It* Electronics Corporation, 140 Commercial Street, Sunnyvale, California 94086, or use *check-off* on page 110.

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5 WAYS TO STOP WASTING TIME IN ELECTRONICS.

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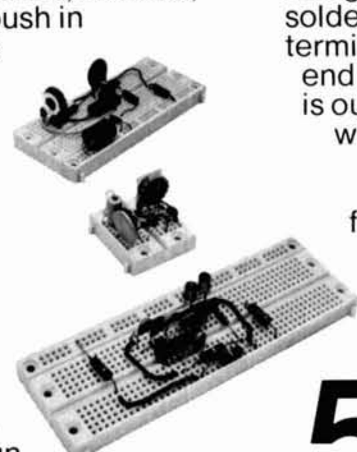

2. Stop wasting your time designing circuits. Design Mate™ 1 will help, by providing you with QT hookup versatility (see above), a continuously-variable 5-15V, 600mA 1%-regulated supply, and a voltmeter to monitor supply or circuit. Plug it in, turn it on and start designing more by soldering less. At $49.95* you can afford to.

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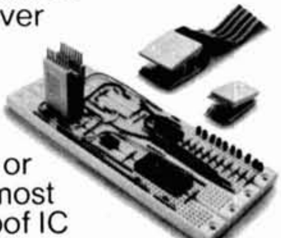

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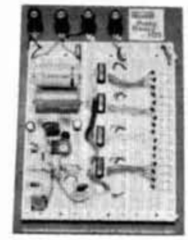
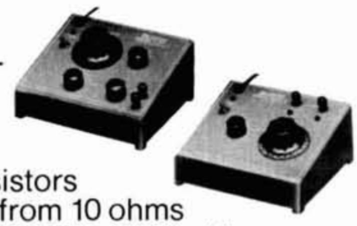


5. Stop wasting your time testing. You can own the test gear you need at economical prices. Our Design Mate 2, for instance, gives you a 3-waveform function generator— sine, square and triangle—from 1 Hz to 100 kHz...for just $64.95* Design Mate 3 R/C bridge provides 5%-accurate measurements of unknown resistors and capacitors from 10 ohms to 10 meg and 10 pF to 1 uF, with built-in LED null indication. Price is a "micro" $54.95* And as you're reading this, we're busy adding new low-priced, high-quality Design Mates.



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*Manufacturer's recommended retail.

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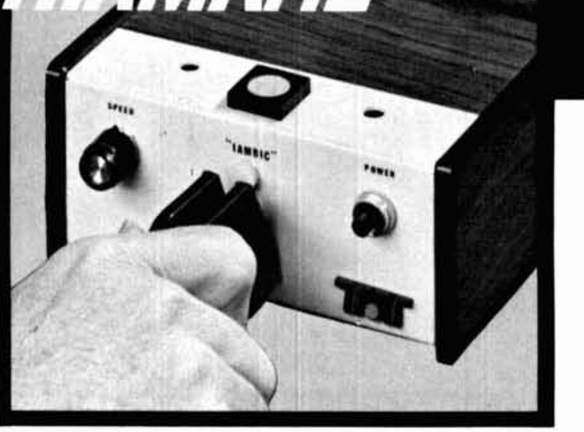

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- SUPERLATIVE "FEEL" 5-50 GRMS PADDLE FORCE
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The KR50 is versatile. Dit and dah memories are provided for full iambic (squeeze) keying. Either dit or dah, or both, may be turned off for operation as a conventional type keyer. Self-completing characters at all times.

A convenient "Straight key" is built-in for QRS sending or tune-up. Also an internal side-tone and 115VAC/12VDC operation is provided.

The KR50 is designed to have a permanent place in your shack for the years, perhaps decades, ahead. An investment in the enjoyment of CW.

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KR20-A

Paddle has unique principle with excellent feel for rhythmic CW. Characters are self-completing. Bit weighting is optimized for normal speeds. Manual key button conveniently located for hand sending. Side tone signal. Reed relay. Plug-in circuit boards. 115VAC or 6 to 14 VDC. HWD 2½" X 4½" X 8¼", Wt. 2½ lbs.

PRICE $67.50

KR1-A

This is the paddle mechanism used in the KR50. Requires 6-14 VDC for adjustable electromagnetic paddle return force. Adjustable contact spacing. For iambic or conventional keyers. "Straight key" button. Housed in an attractive metal case with cream front panel, walnut vinyl top. Size: 2" X 4" X 6", Wt. 1½ lbs.

PRICE $25.00

KR5-A

Similar to the KR20A but without monitor signal and AC power supply. A great value. For 6-14 VDC operation. Size HWD 2" X 4" X 6". Weight: 1½ lbs.

PRICE $38.50

KR2-A

The paddle used in the KR20A. Single paddle for non-iambic keyers. "Straight key" button conveniently located, cream aluminum case with walnut vinyl top. Size: 2" X 4" X 6", Weight: 1½ lb.

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Special Requested Items

RC4194	Dual Track V reg	$ 5.95	N8T97	$ 3.00	MK50C7	$10.95	MC4044	4.50
RC4195	± 15V Track Reg	3.25	4024P	2.25	8263	5.95	LM3909	2.25
F9368	Decoder	3.95	2513	11.00	8267	2.75	MM5320	19.95
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15	74279	.90
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00	4072AE	.45
MC1408L7	A/D	9.95	2525	6.00	8880	1.35	4511AE	2.50
F3341	FIFO	8.95	2527	5.00	7497	5.00	4136	2.50

WE'LL BE HAPPY TO QUOTE ON YOUR SPECIAL PARTS —

OPTO ELECTRONICS

XCITON
LITRONIX
MONSANTO

DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

.125" dia.		.185" dia.		.190" dia.	
XC209R	5/$1	XC526R	5/$1	XC111R	5/$1
XC209G	4/$1	XC526G	4/$1	XC111G	4/$1
XC209Y	4/$1	XC526Y	4/$1	XC111Y	4/$1
XC209O	4/$1	XC526O	4/$1	XC111O	4/$1

.200" dia.		.200" dia.		.085" dia.	
XC22R	5/$1	XC556R	5/$1	MV50	
XC22G	4/$1	XC556G	4/$1	.085" dia. Micro	
XC22Y	4/$1	XC556Y	4/$1	red led	
XC22O	4/$1	XC556O	4/$1		6/$1

DISPLAY LEDS

FND70 DL707 MAN2 MAN3 MAN7 DL747 DL33B

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	.270	$1.95	MAN 74	COMMON CATHODE	.300	$1.50
MAN 2	5 x 7 DOT MATRIX	.300	3.95	DL707	COMMON ANODE	.300	$1.50
MAN 3	COMMON CATHODE	.125	.29	DL747	COMMON ANODE*	.600	1.95
MAN 4	COMMON CATHODE	.187	2.50	DL750	COMMON CATHODE	.600	2.49
MAN 7	COMMON ANODE	.300	1.50	DL33B	COMMON CATHODE	.110	1.95
MAN 7G	COMMON ANODE-GREEN	.300	2.50	FND70	COMMON CATHODE	.250	.50
MAN 7Y	COMMON ANODE-YELLOW	.300	2.50	FND503	COMMON CATHODE	.500	1.75
MAN 72	COMMON ANODE	.300	1.50	FND507	COMMON ANODE	.500	1.75

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$ .17	.16	.15	24 pin	$ .38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$ .27	.25	.24	28 pin	$ .99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$ .30	.27	.24	24 pin	$ .70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
				40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$ .45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5% = 50 PCS.
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5% = 50 PCS.
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5% = 50 PCS.
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5% = 50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5% = 50 PCS.
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5% = 50 PCS.
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5% = 50 PCS.

ALL OTHER RESISTORS FROM 2.2 OHMS - 5.6M AVAILABLE IN MULTIPLES OF 5 ea
5-25 PCS: .05 ea 30-95 PCS: .04 ea. 100-495 PCS: .03 ea. 500-995: .027 ea.

14 PCS POTENTIOMETER ASSORTMENTS

ASST. A 2 ea. 10 OHM 20 OHM 50 OHM 100 OHM 200 OHM 250 OHM 500 OHM
ASST. B 2 ea. 1K 2K 2.5K 10K 20K 25K 50K
ASST. C 2 ea. 50K 100K 200K 250K 500K 1M 2M

$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities $.99 ea.

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST. 8	7 ea.	SN7400 SN7410	7401 7430	7402 7438	7403 7440	7404 7472	SSI TTL	$5.95 ASST
ASST. 9	7 ea.	SN7473 SN7475	7474 7476	7490 7480	7491 7486	74121 74193	MSI TTL	$9.95 ASST
ASST. 10	7 ea.	CD4001 CD4011	4002 4012	4011 4016	4012 4023	4013 4030	CMOS	$7.95 ASST
ASST. 11	7 ea.	LM741C LM7...	301N ...	307N ...	307 ...	709K ...	LINEAR	$10.95 ASST

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Write for FREE 1976 Catalog — Data Sheets .25¢ each

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74LS00 TTL

74LS00	.39	74LS55	.39	74LS151	1.55
74LS02	.39	74LS73	.65	74LS153	1.89
74LS03	.39	74LS74	.65	74LS157	1.55
74LS04	.45	74LS75	.79	74LS162	2.25
74LS05	.45	74LS76	.65	74LS163	2.25
74LS08	.39	74LS83	2.19	74LS164	2.25
74LS10	.39	74LS86	.65	74LS181	3.69
74LS13	.79	74LS90	1.25	74LS190	2.85
74LS14	2.19	74LS92	1.25	74LS191	2.85
74LS20	.39	74LS93	1.25	74LS192	2.85
74LS26	.49	74LS95	2.19	74LS193	2.85
74LS27	.45	74LS96	1.89	74LS194	2.25
74LS28	.49	74LS107	.65	74LS195	2.25
74LS30	.39	74LS112	.65	74LS257	1.89
74LS32	.45	74LS132	1.55	74LS260	.55
74LS40	.49	74LS136	.65	74LS279	.79
74LS51	.39	74LS138	1.89	74LS670	5.95

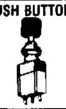
DPST
C & K ROCKER SWITCH
Dim: 1"x1"x¼"

They are rated at 125 Vac @ 5A. They are excellent in applications such as Microcomputer Panel Switches $.69

MINATURE TOGGLE

DPDT				JMT	1	2-9	10-29	30-99
	ON	OFF	ON	221	3.05	2.85	1.97	1.78
	ON	NONE	ON	223	2.85	2.25	1.68	1.61
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

PUSH BUTTON



SPDT - SERIES PB, PB1	Model Number	1 Each	Quanity net prices 2-9	10-29	30-99
Maintained Action Switch — Push to Make Contact And Push Again to Reserve Action	PB-123	$2.35	$1.95	$1.47	$1.30
Momentary Action Switch — Normally Open or Normally Closed (For N C circuit use terminals 2 & 1, for N O, 2 & 3, for N C and N O, 1, 2 & 3)	PB-126	$2.35	$1.95	$1.47	$1.30

5 AMP RATINGS

THUMBWHEEL SWITCHES

Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SERIES SF Front Mount Assembly ($11.70) — SERIES SR Rear Mount Assembly ($13.70)

ACCESSORIES Part No.	Description	Price	ACCESSORIES Part No.	Description	Price
SF EP	End Plate (Pair)	$.50	SR EP	End Plates (pair)	$.50
SF DP	Divider Plate (each)	.40	SR DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40	SR BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40	SR HB	Half Body (each)	.40

8 POSITION ROTARY SWITCH

These switches are a 7 position, one position open, rotary switch enclosed in a TO-5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board. $.99 ea.

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400m	4/1.00	1N4003	200 PIV	1 AMP	12/1.00
1N751A	5.1	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N752	5.6	400m	4/1.00	1N3600	50	200m	6/1.00
1N753	6.2	400m	4/1.00	1N4148	75	10m	15/1.00
1N754	6.8	400m	4/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4734	5.6	1w	.28
1N5232	5.6	500m	.28	1N4735	6.2	1w	.28
1N5234	6.2	500m	.28	1N4736	6.8	1w	.28
1N5235	6.8	500m	.28	1N4738	8.2	1w	.28
1N5236	7.5	500m	.28	1N4742	12	1w	.28
1N456	25	40m	6/1.00	1N4744	15	1w	.28
1N458	150	7m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N485A	180	10m	5/1.00	1N1184	100 PIV	35 AMP	1.70
1N4001	50 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4002	100 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

TRANSISTORS

MPS A05	5/$1.00	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
FN2415	5/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3724	$ .65	2N5087	4/$1.00
2N2906A	4/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3905	4/$1.00	2N5138	5/$1.00
2N3055	$ .89	2N3906	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N4013	3/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N4014	3/$1.00	2N5951	5/$1.00
2N3392	5/$1.00			C106B1SCR	3/$1.00
2N3398	5/$1.00			2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	.05	.04	.03	.001	.05	.04	.035
22pf	.05	.04	.03	.0047	.05	.04	.035
47pf	.05	.04	.03	.01	.05	.04	.035
100pf	.05	.04	.03	.022	.06	.05	.04
220pf	.05	.04	.03	.047	.06	.05	.04
470pf	.05	.04	.035	.1	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1 35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15 35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22 35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33 35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47 35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68 35V	.28	.23	.17	10 25V	.40	.35	.29
1.0 35V	.28	.23	.17	15 25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead					Radial Lead				
.47	50	.15	.13	.10	.47	25	.15	.13	.10
1.0	50	.16	.14	.11	1.0	50	.16	.14	.11
3.3	50	.15	.13	.10	4.7	16	.15	.13	.10
4.7	25	.16	.14	.12	1	25	.16	.14	.11
10	25	.15	.13	.10	1	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.11
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.14	.12	.09
47	50	.25	.21	.19	10	25	.15	.13	.10
100	25	.24	.20	.18	10	50	.16	.15	.12
100	50	.35	.30	.28	47	50	.24	.21	.19
220	25	.32	.28	.25	100	16	.19	.15	.14
220	50	.45	.41	.38	100	25	.24	.20	.18
470	25	.33	.29	.27	100	50	.35	.30	.28
1000	16	.55	.50	.45	220	16	.23	.17	.16
2200	16	.70	.62	.55	470	25	.31	.28	.26

More Details? CHECK—OFF Page 110

More Details? CHECK—OFF Page 110

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Vhf engineering

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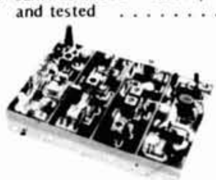
DIVISION OF BROWNIAN ELECTRONICS CORP.

BANKAMERICARD

MINI-CATALOG 1976

THE WORLD'S MOST COMPLETE LINE OF VHF — FM KITS AND EQUIPMENT

TX144B Kit	transmitter exciter — 1 watt — 2 meters	$ 29.95
TX144B W/T	same as above — factory wired and tested	49.95
TX220B Kit	transmitter exciter — 1 watt — 220 MHz	29.95
TX220B W/T	same as above — factory wired and tested	49.95
TX432B Kit	transmitter exciter 432 MHz	39.95
TX432B W/T	same as above — factory wired and tested	59.95



RX50C Kit	30-60 MHz rcvr w/2 pole 10.7 MHz crystal filter	59.95
RX144C Kit	140-170 MHz rcvr w/2 pole 10.7 MHz crystal filter	69.95
RX144C W/T	same as above — factory wired and tested	114.95
RX220C	210-240 MHz rcvr w/2 pole 10.7 MHz crystal filter	69.95
RX432C Kit	432 MHz rcvr w/2 pole 10.7 MHz crystal filter	79.95
RXCF	accessory filter for above receiver kits gives 70DB adjacent channel rejection	8.50

PA2501H Kit	2 meter power amp — kit 1w in — 25w out with solid state switching, case, connectors	59.95
PA2501H W/T	same as above — factory wired and tested	74.95
PA4010H Kit	2 meter power amp — 10w in — 40w out — relay switching	59.95
PA4010H W/T	same as above — factory wired and tested	74.95
PA144/15 Kit	2 meter power amp — 1w in — 15w out — less case, connectors and switching	39.95
PA144/25 Kit	similar to PA144/15 kit except 25w out	49.95
PA220/15 Kit	similar to PA144/15 for 220 MHz	39.95
PA432/10 Kit	power amp — similar to PA144/15 except 10w and 432 MHz	49.95
PA140/10	10w in — 140w out — 2 meter amp — factory wired and tested	179.95
PA140/30	30w in — 140w out — 2 meter amp — factory wired and tested	159.95

HT144B Kit	2 meter — 2w — 4 channel — hand held xcvr with crystals for 146.52 simplex	129.95

RPT144 Kit	repeater — 2 meter — 15w — complete (less crystals)	465.95
RPT220 Kit	repeater — 220 MHz — 15w — complete (less crystals)	465.95
RPT432 Kit	repeater — 10 watt — 432 MHz (less crystals)	515.95
RPT144	repeater — 15 watt — 2 meter — factory wired and tested	695.95
RPT220	repeater — 15 watt — 220 MHz — factory wired and tested	695.95
RPT432	repeater — 10 watt — 432 MHz — factory wired and tested	749.95

PS3 Kit	12 volt — power supply regulator card	8.95
PS15C Kit	NEW — 15 amp — 12 volt regulated power supply w/case, w/fold-back current limiting and overvoltage protection	79.95
PS15C W/T	same as above — factory wired and tested	94.95
PS25C Kit	NEW — 25 amp — 12 volt regulated power supply w/case, w/fold-back current limiting and overvoltage protection	129.95
PS25C W/T	same as above — factory wired and tested	149.95

OTHER PRODUCTS BY VHF ENGINEERING

CD1 Kit	10 channel receive xtal deck w/diode switching	$ 6.95
CD2 Kit	10 channel xmit deck w/switch and trimmers	14.95
COR2 Kit	complete COR with 3 second and 3 minute timers	19.95
SC3 Kit	10 channel auto-scan adapter for RX	19.95
Crystals	we stock most repeater & simplex pairs from 146.0-147.0 (each)	5.00

ORDER FORM

Item	Part No.	Description	Price	Extension

Master Charge or BankAmericard No. ______

Bank No. ______

Expiration Date ______

Name ______ Total ______

Address ______ Shipping ______

City ______ NYS Resident Sales Tax ______

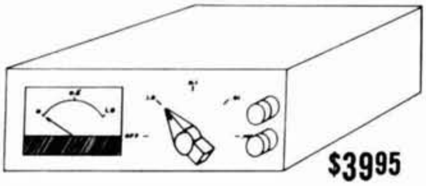
State ______ Zip ______ Total Enclosed ______

SHIPPING INFORMATION: All shipments are F.O.B. Binghamton, N.Y. 13902. Shipments will be made by the most convenient method. Please include sufficient funds to cover shipping and handling. Figure shipping charges on a minimum weight of 2 pounds per unit with the exception of the following: PS15C 13 lbs., PS25C 25 lbs., Repeaters - 25 lbs. Allow 3 to 4 weeks for delivery.

*DPLX-144 and DPLX-220 are shipped freight collect.

TERMS: C.O.D., cash or check with order. We also accept BankAmericard and Master Charge.
CLAIMS: Notify VHF *and* the carrier of damage within seven (7) days of receipt of shipment.
RETURNS: Obtain authorization from VHF before returning *any* merchandise.
PRICES AND SPECIFICATIONS: Subject to change without notice.
Export prices are slightly higher.

More Details? CHECK-OFF Page 110



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C-METER

Direct Reading Capacitance Meter

- Reads from 100 Pf to 1 MFD
- Linear Scale
- Internal 9V battery lasts 1 year
- Fully assembled and tested

$24.95

- 12 HR
- 4 Digit
- Bright ½" Displays
- Fully assembled

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VHF FREQUENCY COUNTER

- 5 DIGIT LED DISPLAY
- 10 Hz TO >230 MHZ
- <200 MV SENSITIVITY
- FACTORY DIRECT SALES
- ASSEMBLED OR KIT

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$195.00
WIRED & TESTED
+ $3.50 POSTAGE
AND HANDLING

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203-853-4716

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Scope Sale

Here's a partial list of our reconditioned and FULLY GUARANTEED scopes. Prices are for Main Frames. See below for partial listing of vertical amps.

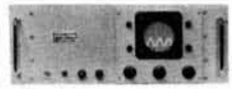
MODEL 531	$395.00
535	$495.00
541	$445.00
551	$595.00
555	$795.00
581	$695.00
585	$895.00

Vertical Amps (purchased with above)

L Plug in	$ 85.00
CA Dual Trace	$145.00
M Four Trace	$295.00
Others	$ 65.00 & up

This Month's Special

DEI Spectral Display Unit, Model TDU-4 — 30 MHz center frequency — Bandwidth is 3 MHz.



New in factory cartons
$295.00

Other Display Units include TDU-3, Nems Clarke/Vitro Model SDU-200, —300 — Center freq. 30 or 21.4 MHz (Specify) — New and Used — Prices range $95 - $295.

CLOSE OUT SPECIAL — $19.95

while they last ppd. USA

ARR-52 SOLID STATE VHF RECEIVER

Easily converted to 2-meter FM. Now set for 163-173 MHz, 16 channels. Includes schematic diagram and conversion details. As described in the Surplus Sidelights Column, (Pg. 58 Oct. CQ).

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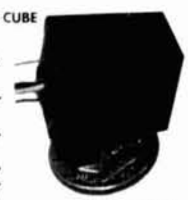

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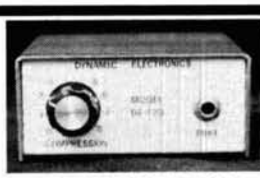

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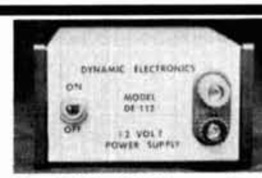

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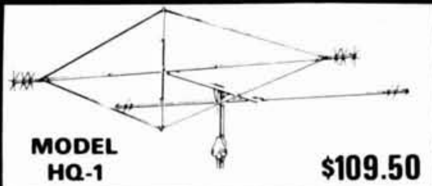

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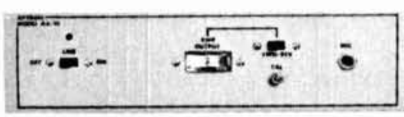

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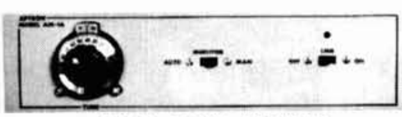

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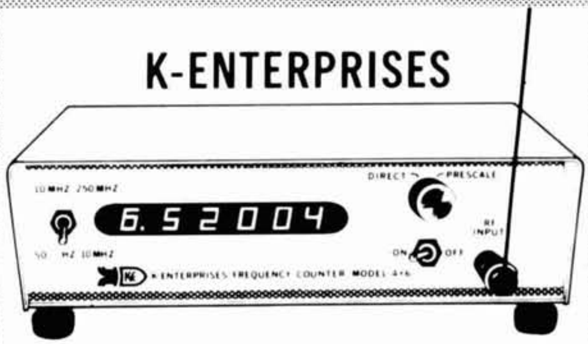

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flea market

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B.A.R.T.G. SPRING RTTY CONTEST — From 0200 GMT March 27th to 0200 GMT March 29th. No more than 30 hours of operation is permitted. Listening counts as operating. Off periods may not be less than 3 hours. Times on and off must be summarized on the log and score sheets. Separate categories for multi operator stations and SWL's. 3.5 thru 28 MHz amateur bands. Stations may only be contacted once on any one band, but additional contacts may be made on other bands. Message exchanged will consist of time, RST and msg. no. Two-way RTTY contacts within one's own country earn Two points. Two-way RTTY contacts outside one's own country will earn Ten points. Stations will receive a Bonus of 200 points per country worked on each band including their own. Two way exchange points times total countries worked plus total country points times bonus points times number of continents worked equal total score. Logs must be received by May 31 by Ted Double, G8CDW, 89 Linden Gardens, Enfield, Middlesex, England EN1 4DX.

MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Hobby Industry, WØJJK, Box H-864, Council Bluffs, Iowa 51501.

STOP don't junk that television set. ASE manufactures the world's most complete line of television picture tubes. Over 1700 types. Most types immediate delivery. Tubes for Old or New TV's, black & white and color. 2 year factory warranty. Lowest prices anywhere. Allied Sales & Engineering, Inc., Dept. 22, Pimento, IN 47866. Telephone 812-495-6555.

SB-104 OWNERS CLUB — Expanding its horizons to include the HW-104 and the new Heath 2 meter equipments. Newsletter, builders guides, modification information and other services on current Heathkit amateur equipments. Send SASE for details to Chuck Harrison, RD 2 Box 1, North Stonington, CT 06359.

INDIANA LAKE COUNTY Amateur Radio Club, Inc., 23rd Annual Banquet, Saturday, February 21, 1976, at 6:30 p.m. CST. Location, Griffith Knights of Columbus Hall, 1400 South Broad Street, Griffith, Indiana. Program includes delicious home-cooked food, entertainment, speeches, gifts, special awards. Come! Bring your friends and enjoy an evening of fellowship. Tickets are $7.50 each, available from Herbert S. Brier, W9EGQ, 409 S. 14th St., Chesterton, Indiana 46304, or from other club members. Positively no tickets sold at the door!

VERY in-ter-est-ing! Next 4 big issues $1. "The Ham Trader," Sycamore, IL 60178.

KLM PRODUCTS, Larsen ants., Icom, police and fire scanners. Send for prices. Not given over phone. Narwid Electronics, 61 Bellot Road, Ringwood, N. J. 07456.

FREE Catalog. LEDS, Microphones, Nicads, IC's, Relays, Ultrasonic Devices, Precision Trimmer Capacitors, Digital Thermometers, Unique Components. Chaney's, Box 15431, Lakewood, Colo. 80215.

LEARN CODE IN A FEW DAYS with audio reflex method of teaching letters, numbers, punctuation. One hour cassette only $7.00. Guardian, 20 E. Main St., Ramsey, N. J. 07446.

MARINE FMH-MC, $299.00. Yaesu FT2 auto scanner xcvr, $289.00. FTDX400, $395.00. FTDX570, $469.00. Herb, Days 213 478-3577, nite 276-8769, 10960 Wilshire, Suite 527, Los Angeles, Calif. 90024.

NOVICE, GENERAL AND CODE COURSES are available at the Harrison, New York School of Continuing Education. 10 two hour sessions one evening a week. Contact George Buchanan WB2FVX, (914) RO-1-4183.

NORTHWESTERN PENNSYLVANIA Swapfest. May 1, Crawford County Fairgrounds, Meadville. Free Admission. $1 to display. Flea market begins at 10:00 a.m. Hourly door prizes; refreshments. Commercial displays welcome. Indoor if rain. Talk-in 146.04/64 and 146.52 MHz. Details, Crawford Amateur Radio Society, Box 653, Meadville, Pa. 16335.

PAYING 5% OVER BEST OFFER for Eimac/Varian tubes, ham and commercial gear, etc. Ted Dames, W2KUW, 308 Hickory St., Arlington, N. J. 07032. (201) 998-4246.

FREE FLYER of electronic parts, printed circuits, kits, photo items, misc. Write to R & L Photo-Electronics Co., Dept. HR, P. O. Box 1432, Reseda, Ca. 91335.

THE 21ST ANNUAL HAM AUCTION. America's Largest. Saturday, March 13, 1976, at Lucas County Recreation Center, Toledo, Ohio. Auction, flea market, commercial displays, prizes. 8:00 a.m. to 5:00 p.m. $1.50 advance, $2.00 after March 1st. Send SASE. Talk-in 146.52. Toledo Mobile Radio Association, Box 273, Toledo, Ohio 43696.

CIRCUIT BOARDS. Artwork, negatives, etchings. SASE for details. Karl Raup, WB4OXG, Box 498, Springfield, Virginia 22150.

RARS 1976 ANNUAL HAMFEST, April 11. For details write: RARS, Box 17124, Raleigh, N. C. 27609.

FACTORY-ALIGNED GLB Channelizer, HW202. WA9QDZ, 2851 Wayside Dr., Evansville, Ind. 47711.

TELEVISION diagnostic repair course prepared by master technicians. Lessons only $6.00 each. Optional matching one hour cassette tape $6.00 each. Send for first lesson and master index. Guardian, 20 E. Main, Ramsey, N. J. 07446.

TECH MANUALS — $6.50 each: SP-600JX, URM-25D, OS-8B/U, BC-348JNQ. Thousands more available. Send 50¢ (coin) for large list. W3IHD, 7218 Roanne Drive, Washington, D. C. 20021.

HOMEBREWERS: Stamp brings list of high quality components. CPO Surplus, Box 189, Braintree, Mass. 02184.

NEW SINGER MODEL RLE-1 low frequency standards receiver — complete with LFA-1 antenna and 100 feet connecting cable ready to go. Make offer. KH6ZT, A. S. Morgan, 4916 Haleilio, Kapaa, Hawaii 96746. 808-822-4726.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send $1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

STERLING ROCK FALLS Amateur Radio Society Hamfest, March 7, 1976. New bigger and better location. Sterling High School Field House, 1608 4th Ave., Sterling, Illinois 61081. Tickets $1.50 advance, $2.00 at door. For info write Don Van Sant, WA9PBS, 1104 5th Avenue, Rock Falls, Illinois 61071. Talk in on 94 Simplex.

ROCHESTER HAMFEST 1976 is Saturday, May 22. Your name added to mailing list or information — write: Rochester Hamfest, Box 1388, Rochester, N. Y. 14603.

TWO HEATHKIT TWOERS — good condition with manual and two crystals. $45 or best offer. WA7EXH, Rt. 1, Box 172-A3, Halsey, Oregon 97348. Ph. 503-491-3591.

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flea market

PC BOARD negatives made photographically from your or magazine's art work. Now obtain professional results quickly, simply. 4 x 5, $3.00 or SASE for information. WA4FRV, 10139 *Apache Road, Richmond, Virginia 23235.* 804-272-8403.

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RTTY — MODEL 15, T.D. unit, converter, manual, $65.00 u-ship. WA5CBF, P. O. Box 143, Tipton, Okla. 73570.

JAPANESE TRANSISTORS — All Transistors original factory made. Over 500 types available. Write for free catalog. West Pacific Electronics, P. O. Box 25837, W. Los Angeles, CA 90025.

DRAKE CC-1, SC-2, SCC-1, CPS-1, $130. Heath scanner #GR110. 146.94 MHz installed, $80.00. Drake R4B, $310. Hallicrafters SR42-A and matching VFO, $115.00. Heath crystal filter #SBA301-1 (AM), $18.00. Crystal pack #SBA401-1, $20.00. Colella, WA2HQD, 105-18 131 St., Richmond Hill, N. Y. *11419.* 212 641-2559.

TRAVEL-PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, N. Y. 12198.

TEKTRONIX SCOPES, Hewlett-Packard audio *& RF generators, and other test or electronic* equipment. Transformers, tubes, amateur supplies, surplus, and scarce parts. Free catalog. Electronic Specialties, 1659 Wetmore, Tucson, AZ 85705. (602) 887-9729.

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UNSCRAMBLE POLICE CODE with decoders. Works on all scanners and receivers. Guaranteed. For prices and brochure write: Don Nobles, Rt. 7, Box 265B, Hot Springs, Ark. 71901. 501-623-6027 (Dealer inquiries invited).

QRP TRANSMATCH for HW7, Ten-Tec, and others. Send stamp for details to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

GREATER BALTIMORE HAMBOREE, Sunday, *April 4th at 9:00 a.m. at Calvert Hall College,* Goucher Blvd. and LaSalle Road, Towson, Maryland 21204. (1 mile south of Exit 28 Beltway - Interstate 695) Prizes, flea market, registration $2. 250 tables inside gym. Over 1000 attended last year. Info: Contact Brother Gerald Malseed, W3WVC at the above address.

ANTENNAS: Dipole, multiple band arrays. 15 thru 75 meters from $59.50. Mobile Antennas — CB, 20M, 40M, and 2M from $19.50. Baluns: 1:1 and 4:1 - $12.95 ea. Data Available. Savoy Electronics, Inc., P. O. Box 5727, Ft. Lauderdale, Fla. 33310.

SIDESWIPER only $13. Airmailed USA. Kungsimport, Box 257, Kungsbacka, Sweden.

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OSCAR SLIDES, set of 5, $1.25. Launch and spacecraft. Proceeds *AMSAT.* K6PGX, P. O. Box 463, Pasadena, CA 91102.

MARYLAND FM ASSOCIATION'S Electronic Swapfest, March 14, 1976 from 0830 to 1530 hours at High Point High School, 3600 Powder Mill Road, Beltsville, Maryland. Open to all *persons interested in electronic and/or radio* communications. Donations $2.00 per person, tables available for $3.00 per table. Anyone wishing advance ticket and/or reserved table send appropriate remittance to David McCrory, WA3TKW/KQI2199, P. O. Box 111, College Park, Maryland 20740. Checks payable to the Maryland FM Association, Inc.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

COMPUTER HOBBYISTS! Bargain hunt or sell via On-Line. 18 issues/year - $3.75. Free sample issue from: On-Line, 24695 Santa Cruz Hwy., Los Gatos, CA 95030.

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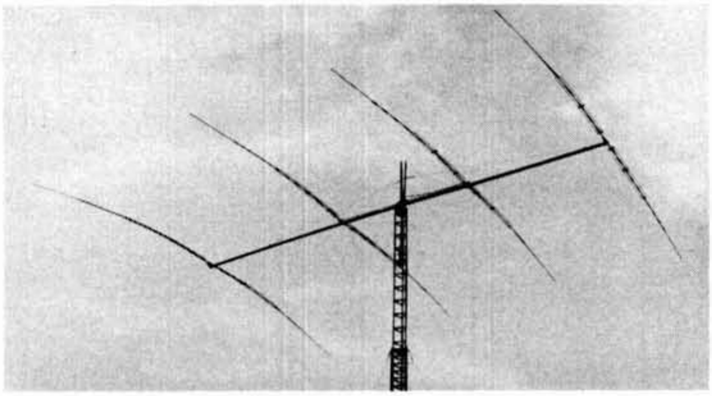
KLM BROADENS ITS BIG STICK LINE OF HIGH FREQUENCY ANTENNAS

4 ELEMENTS 40 METERS



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ELEMENTS: 4, LINEAR LOADED
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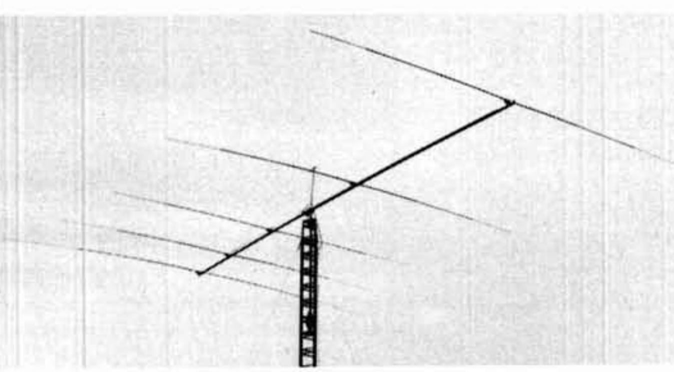
BOOM: 3″ DIA. X 42′ LONG
TURNING RADIUS: 32′
SHIPPING CONTAINER: WOOD CRATE 12′ LONG
125 LBS. TOTAL WEIGHT

GAIN: 7.25 dB/DIPOLE
F/B: 20 dB TYPICAL
FEED IMP.:200 OHMS BALANCED
(50 OHMS WITH OPTIONAL
KLM 5-31 4:1 BALUN — $13.95)
WEIGHT: 85 LBS.
WIND AREA: 10 SQ. FT.

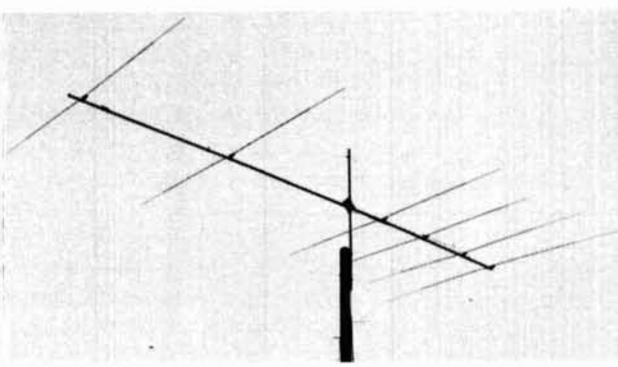
PRICE **$495.00**

20 METER 5 ELEMENT



KLM 13.9-14.4-5 **$249.95**
9.7dBd GAIN 30dB F/B

15 METER 6 ELEMENT



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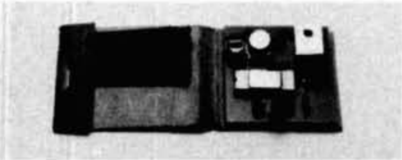

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TTL compatible output $F_{IN}/10$

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100 Volt	.25	400 Volt	.45
200 Volt	.35	600 Volt	.55
2N2222 or 2N2907	.15	2N5496 or 2N6108	.35
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Chart showing uH per 100 turns

CORE SIZE	MIX 2 .5-30MHz u=10	MIX 6 10-90MHz u=8.5	MIX 12 60-200MHz u=4	SIZE OD (in.)	PRICE USA $
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T-106	135			1.06	1.50
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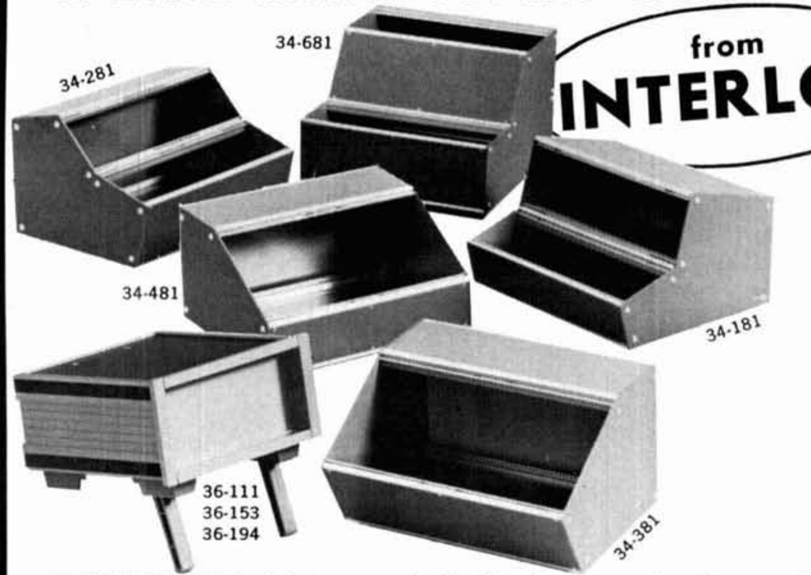

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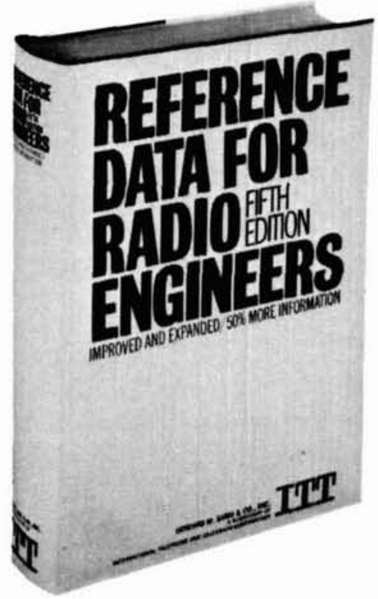

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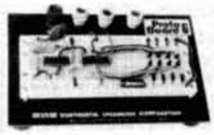

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- **WORKS ANY REPEATER SPLIT**
- **EXTENDED FREQUENCY COVERAGE**

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Frequency Coverage—
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1¼ M; 220.00 MHz to 225.00 MHz

Frequency Resolution— 5 kHz

Frequency Stability— 0.0005%

Power Input— 11 VDC to 15 VDC

Dimensions— 10.5"W x 3.375"H x 10"D

Warranty— 90 days, parts and labor

RECEIVER

Sensitivity—
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AM; 4 dB noise figure, nominal

Squelch Threshold— 0.3 µv

Bandwidth— 13 kHz

Image Rejection— 60 DB minimum

Adjacent Channel Rejection— 80 dB (30 kHz)

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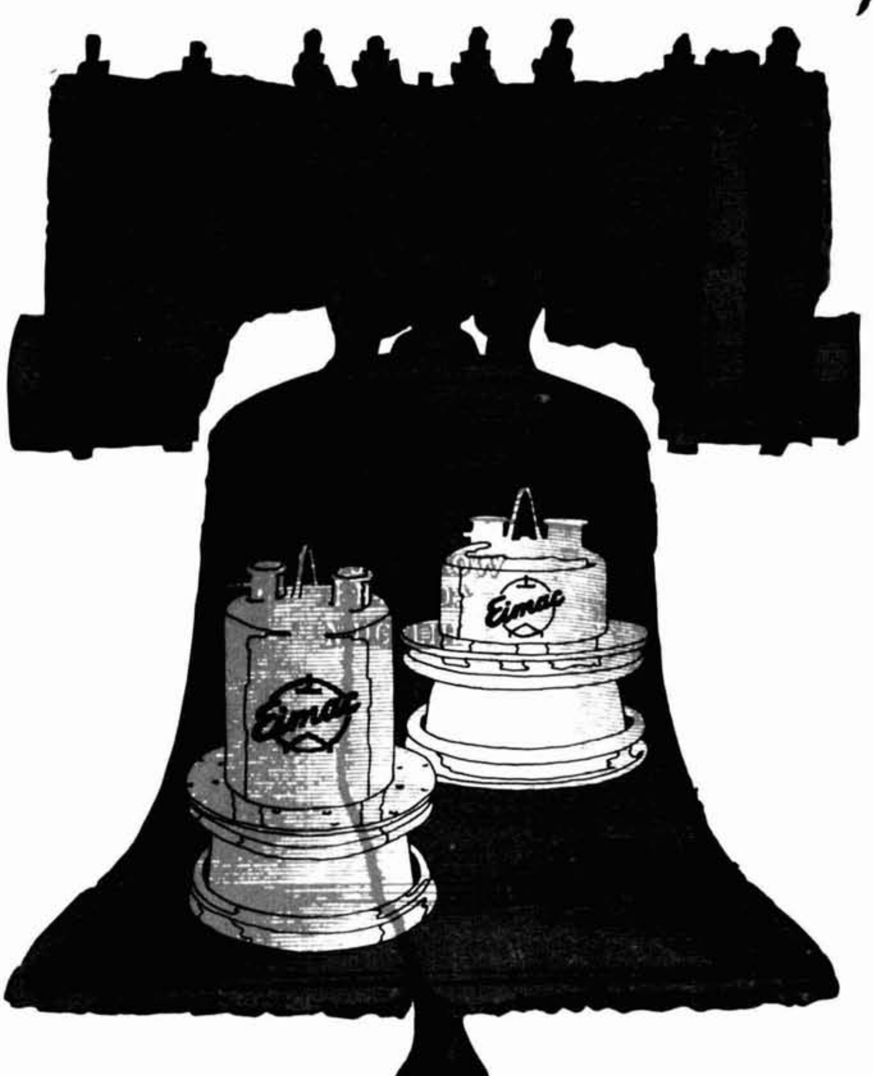

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