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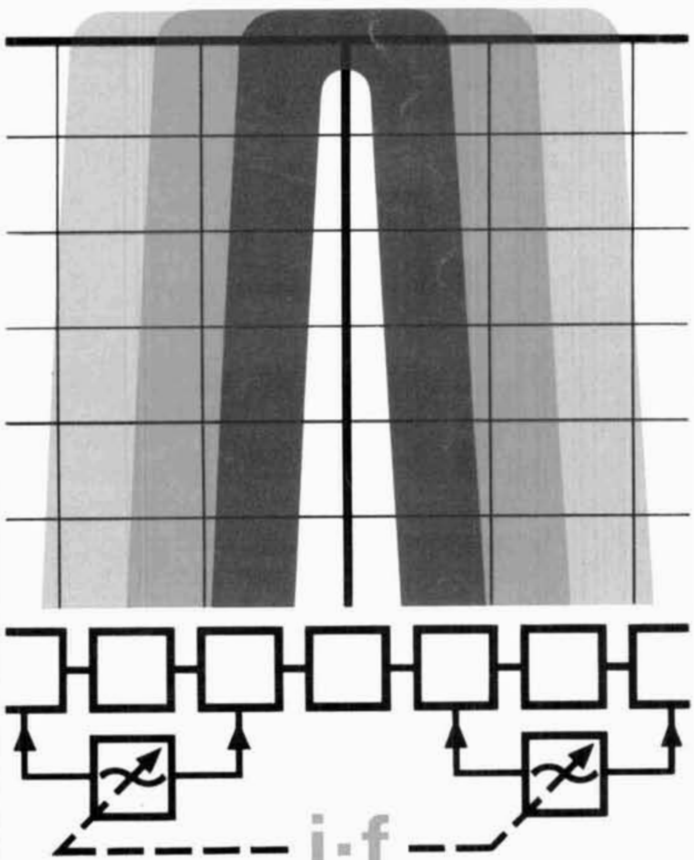

amplifier design

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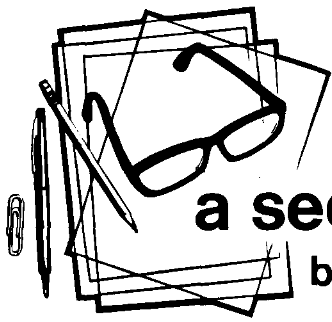

a second look

by Jim Fisk

This year marks the 40th anniversary of the invention of the klystron in a basement laboratory at Stanford University in California — an event that marked the beginning of the practical use of microwaves. Feeble amounts of microwave power had been generated in the laboratory in the 1920s, but long-range microwave communications systems and radar required much more. By 1935 radar was already installed on naval vessels, and the Signal Corps was developing the 270 system which detected the Japanese attack force at Pearl Harbor in 1941, but the equipment was range limited and suffered from poor resolution. Microwaves seemed to be the answer, but how to produce them was a question which remained to be answered.

Russell Varian conceived the klystron — the first practical microwave generator. Dr. William Hansen, a physics professor at Stanford who was working on an oscillator for a linear accelerator, calculated the formulas for its design. In August, 1937, Sigurd Varian finished assembling the first tube, and the trio watched in amazement as the very first surge of voltage set it generating waves as short as 10 cm (3000 MHz), one-tenth the length of the shortest radio waves then used outside the laboratory. To demonstrate their success they made a dipole from two short pieces of wire and soldered it to the base of a flashlight bulb — when they held the dipole in the path of the tube's output, the bulb glowed brightly. The first klystron was delivering a watt of power!

This was one of the first cases in the history of technology development where a device based on calculations worked the first time it was turned on. The achievement was widely acclaimed in the scientific press, and broad uses were forecast for its future. The Sperry Gyroscope Company moved quickly to back the development of the klystron for high-resolution radar systems, the Bell Telephone Company saw it as the heart of a transcontinental relay network, and others considered it for coast-to-coast television transmission. The rest is history — a $100 investment in 1937 spawned a whole new industry which now has sales measured in the billions of dollars.

Before the war, Amateurs gave little thought to the frequencies above 400 MHz because there was nothing in the way of practical equipment available, but when the Amateur microwave bands were made available on November 15th, 1945, it was a different story — military surplus klystrons were inexpensive and many Amateurs had been exposed to the microwave art during the war. Rube Merchant, W2GLF, and Art Harrison, W6BMS, were the first to use the new medium when they put 2K23 klystrons and crystal mixers to work on the 5300-MHz band for communications over a 5-mile path on Long Island. In early May, 1946, W1LZV and W2JN worked over a 2-mile path in New Jersey on 10 GHz, and later that month W1NVL and W9SAD in Schnectady were the first Amateurs on 21 GHz — best DX was 800 feet! It was to be another year before 3300 MHz was opened for the first time, and then only because W6IFE built two complete stations and had W6IZM operate one of them.

In the mid 1950s members of the San Bernadino Microwave Society developed the polaplexer system and proceeded to break most of the microwave distance records. They later phase locked the klystron to a crystal reference to increase range, but little has happened in the past ten years. Some microwave enthusiasts have replaced their bulky vacuum-tube power supplies, modulators, and receivers with solid-state gear, but klystrons still provide the output power when modern solid-state sources could do the same job with a lot less hassle. Although Amateurs in England have been using Gunn diodes on 10 GHz for several years, for some reason the idea has never caught on in America. Device availability is certainly not the problem — Amateurs have shown time and time again that they can obtain hard-to-get components if they really put their minds to it (remember the parametric amplifier, 432-MHz varactor multipliers, and low-noise transistors for 2304 MHz).

I think it's time for Amateur microwavers to take a close look at their klystron systems and consider the solid-state alternatives. Gunn diodes are being manufactured by the thousands for 10.525-GHz speed radar systems so cost is low, and Microwave Associates has recently introduced a 20 mW *Gunnplexer* for transceive operation on the 10-GHz Amateur band (see page 86). In light of WARC 79 we need a good deal more activity on the Amateur microwave bands — perhaps the new *Gunnplexer* will provide the impetus amateurs need to try this part of the spectrum.

Jim Fisk, W1HR
editor-in-chief

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presstop

WARC ADVISORY COMMITTEE FOR AMATEUR RADIO met January 25 and prepared new and strengthened supporting arguments for new HF bands at 10, 18, and 24 MHz. Even though the FCC's Notice of Inquiry had not included those previously-requested bands, the group felt they were important enough that another strong plea was called for.

The Committee Endorsed, for the most part, the remaining Amateur assignments proposed in the Notice of Inquiry. The 15-meter shift down to 20.7 MHz was one notable exception, but this appears to have been worked out with the Maritime group to put the band back where it presently is.

Considerable Discussion took place concerning the microwave assignments, and a strong recommendation emerged urging restoration of 48-50 GHz (or a comparable slot) to the proposed Amateur spectrum.

THE AMATEUR RADIO MANUFACTURER'S ASSOCIATION is the name chosen for a self-governing body of radio equipment manufacturers formed at SAROC this January for the purpose of promoting Amateur Radio, promoting high ethical standards among its membership and throughout the industry, encouraging legislation and rule-making favorable to Amateur Radio, and supporting its members' activities through market research.

ARMA's Formation Came About through a Dentron-sponsored meeting of linear amplifier manufacturers who initially met to discuss the linear amplifier issue. Finding that it had greater potential then the single issue originally addressed, ARMA elected Dennis Had of Dentron as its President and began making plans for meetings with members of Congress, representatives of the FCC, and other government officials.

This Broad-Based Trade Group invites membership applications from manufacturers and importers marketing in the U.S., as well as suppliers, publishers, associations, and others interested in furthering the group's aims.

ARMA's Recent Washington Trip was rated "highly successful" by both the visitors and those they came to see. The group sat down with all three FCC Commissioners they had appointments with and the Commissioners welcomed the ARMA delegation as representatives of the legitimate Amateur industry and expressed concern for that industry, the small businesses involved in it, and — last but not least — for the Amateur fraternity.

Senator Barry Goldwater — K7UGA — spent a good deal of time with the ARMA representatives. The visitors also held highly informative meetings with Ray Spence, Bob Luff, and other key FCC personnel during their two day stay.

"PERSONAL RADIO DIVISION" is the new handle adopted by FCC's Amateur and Citizens Division. The name change is just a name change, though it could eventually reflect future concern with other general public radio such as marine and aircraft.

PERSONAL DELIVERY OF AMATEUR APPLICATIONS to Gettysburg gives the applicant no advantage and can tie up FCC personnel who could otherwise be working on the Amateur license backlog.

Applications For 1X2 Callsigns May Be Submitted before the official acceptance date to insure they'll receive prime consideration. For example, Extras licensed before July 1, 1976 could mail their applications any time after March 15 to be sure they'd reach Gettysburg before the April 1 acceptance.

"INSTANT UPGRADE" will finally become a reality and give the Amateur who successfully passes an exam at an FCC Field Office his new privileges immediately. The temporary authority is to be issued on the spot by the examining Field Office, and will be good for 90 days or until an upgraded license is issued. It will require the user to indicate his "interim" status with a special identifier, added to his call when he's using his newly won privileges, will probably go into effect in the next few months.

ALTHOUGH SETTLEMENT OF THE 900 MHZ VS 220 MHZ issue for Class E Land Mobile (CB) may still be months away, more and more indicators seem to be pointing to 900 MHz. It's also becoming apparent that the FCC may no longer look with favor on the placement of Amateur and CB Personal Radio Services adjacent to one another, wherever the frequency assignments may be located.

OSCAR 6'S TELEMETRY indicates a battery cell has failed, and there's fear other cells may be close to failure after more than three years in space. With rumors going around that LANDSAT (and OSCAR 8) won't be launched until the year's end, OSCAR users must be especially gentle with both the ailing Amateur Radio birds.

VHF/UHF ADVISORY COMMITTEE was established by the ARRL Board of Directors at their January meeting in West Hartford. The new VUAC is to work on spectrum utilization, ATV, Satellite and EME communications, work closely with the VRAC.

First Formal Assignment for the VUAC is a 1215 MHz bandplan.


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i-f amplifier design

Further comments by a recognized authority on the optimum design of shortwave receivers

Many articles have been published during the past few years on receiver design with emphasis on the front end, but few efforts have been made to exploit the possibilities of good i-f amplifier design. Such design involves several areas: proper i-f selectivity, low distortion, a-m and ssb detectors, agc control, and noise blankers. This article presents some methods of designing these circuits to obtain a high-performance i-f system.

noise blankers

Very few noise-blanker circuits for multipurpose applications have been published. Probably the best noise blanker ever built is the circuit used in the Collins KWM2; however, since this design is based on tubes, it's no longer considered within the state of the art. While the principle of the Collins noise blanker avoids difficulties of crystal-filter ringing, it does produce some distortion because of the circuit used for gating in the i-f path.

The principle of the Collins noise blanker is based on the idea that noise pulses originating either from ignition or other man-made noise are of fairly short duration and therefore, have enough energy, even at frequencies above 30 MHz, to produce radio-frequency interference. Collins uses a multistage 40-MHz amplifier that brings the noise pulses up to a suitable level for detection in a peak detector, and the dc voltage thus derived is used to disable the receiver rf front end and i-f, including the i-f filters, during the detection of the pulses. Since some of the pulses do not have a rectangular response, the gate circuit for switching remains for a few milliseconds in a state between **on** and **off**, during which most of the noticeable intermodulation occurs.

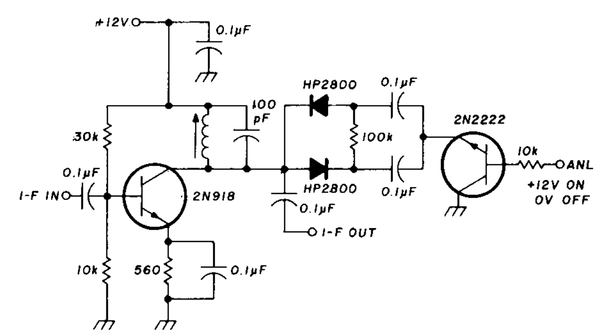


fig. 1. Rf noise limiter with self-adjusting action.

Noise blankers in present amateur transceivers measure the noise pulses in the i-f bandwidth, and rf signals, such as CW key clicks, can't be distinguished by

By Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458

the circuit from other interference. Therefore all these circuits suffer from added distortion.

Fig. 1 shows a noise blanker published in the *ARRL Handbook*, which is supposedly derived from TV receivers and suppresses only certain types of noise pulses. A detailed discussion of this circuit is found in reference 1. **Fig. 2** shows the principle of an i-f noise blanker that derives its information from the i-f path. This circuit, in my opinion, however, is only a compromise; however, it is found very often. **Fig. 3** shows a circuit that takes advantage of the idea on which the Collins noise blanker is based and has the additional feature that it can also be used on the 160-meter band for suppressing Loran pulses. Its design is based on a suggestion by Siemens, who are the makers of the IC used in this circuit.

The TCA440 IC, to the best of my knowledge, has no equivalent American replacement. It contains a complete a-m receiver. Because of the wideband application, oscillator stability is no problem, and a fairly simple single-conversion receiver can be built to convert the arbitrarily chosen input frequency of 50 MHz to a 2-MHz i-f, where the noise pulses are then amplified to a suitable level for detection. In addition, a 2-MHz input is provided, which can be used when operating in the 160-meter band.

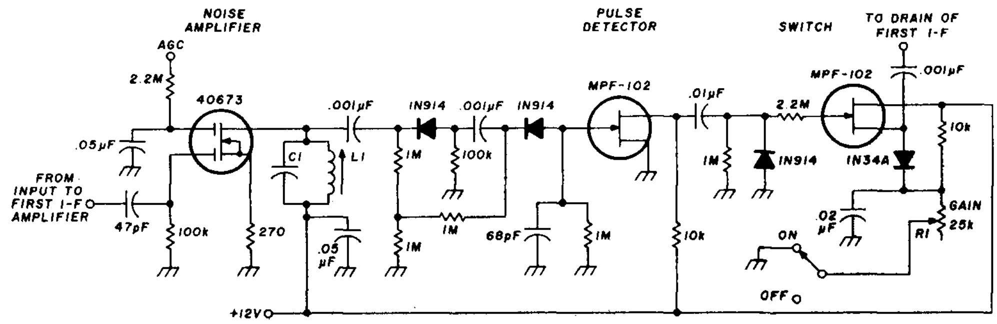


fig. 2. Schematic of a noise-blanker that derives its information from the i-f path.

The IC output, which can be monitored by a special test output, is fed into a limiter and amplifier using an fet and a bipolar transistor. The TTL output is then fed into a 74LS122 IC for pulse processing, and a TTL-level noise-blanking output is available.

This circuit has substantial advantage over the Collins noise blanker but does not solve the problem of suitable

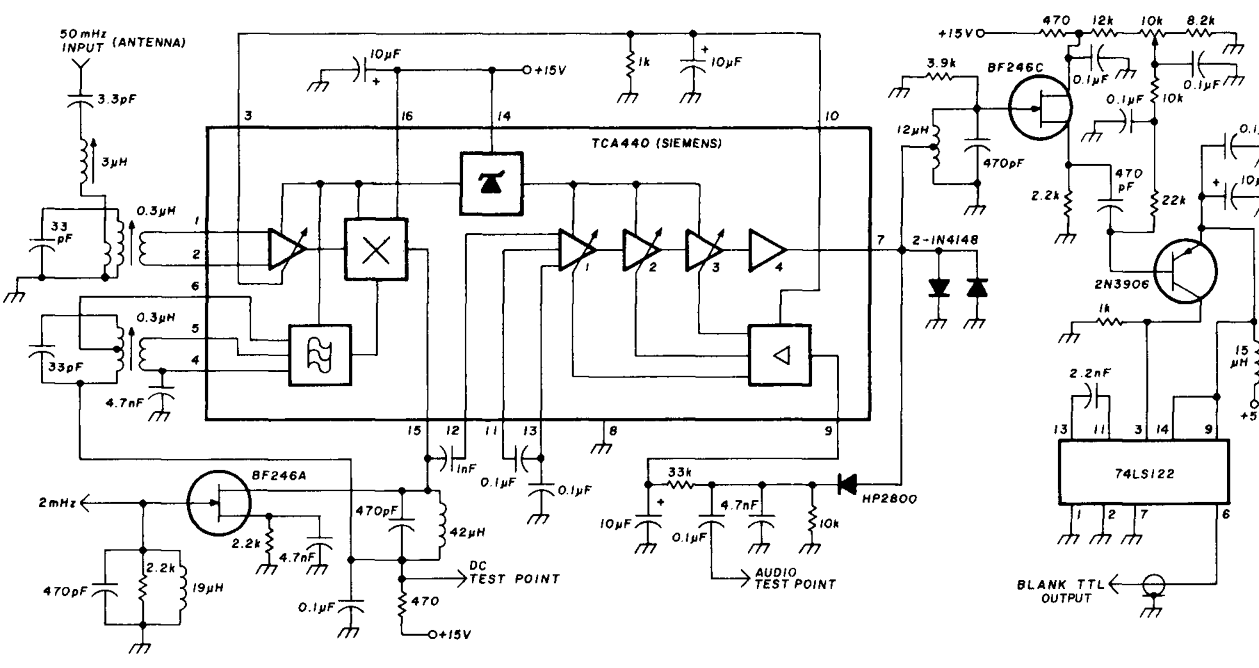


fig. 3. Noise-blanking receiver for high-performance operation. Design is based on a suggestion by Siemens, who makes the TCA440 IC.

gating. **Fig. 4** shows an rf input stage described earlier,[2] which has a suitable push-pull arrangement that accepts these blanking pulses without producing the distortion found in most circuits. A similar gating circuit had been proposed by Swan in their SS200 series; however, since the noise-blanker circuit was extremely critical, it did not operate too successfully.

input selectivity

For reasons explained in reference 2, selectivity should be used immediately following the first mixer to prevent overload of a possible second mixer and to avoid spurious signals. General-coverage receivers require the first i-f to be higher in frequency than the highest frequency of reception, and i-fs between 30 and 120 MHz have been used. As discussed in reference 2, the selectivity is provided by vhf crystal filters, which have 4-8 poles and are commonly *called cross-modulation* filters. They are available either in discrete components or as monolithic filters. Probably the most popular is the 75-MHz monolithic filter made by Piezo Technology in Florida.

Because of the losses of this filter, the stage immediately following the filter must have an extremely low noise figure and simultaneously a high intercept point. A good choice for this requirement is the circuit shown in **fig. 5**, which uses a neutralized field-effect transistor to obtain stability and low noise figure through rf feedback. Such a stage has about 10 dB gain. A second i-f stage with presettable gain can be used ahead of the second mixer. Because of the voltage step-down transformer, overall gain is kept very low; however a large, highly distortion-free agc range is possible.

The main selectivity is always achieved at lower frequencies. While the commonly used frequency for vhf/uhf receivers is 21.4 MHz, most attempts to make ssb or CW filters at these high frequencies have failed. For CW and ssb, crystal filters are available at frequencies of 10.7 MHz, 9 MHz, 8.8 MHz, 5.5 MHz, and 1.6 MHz, while the intermediate frequencies of 525 kHz, 455 kHz, 200 kHz, and 100 kHz take advantage of available mechanical filters. Some receivers still use LC filters at 50 or 30 kHz, but the shape factors obtainable are not very impressive.

Variable-bandwidth system. In military receivers that require a substantial number of bandwidths, seven or more individual filters may be required, which makes the i-f portion both bulky and expensive. To overcome this problem a double mixing scheme, as briefly discussed in reference 2, permits quasi-continuous selection of bandwidths between 75 Hz and 6 kHz at a constant shape factor of 1:1.6, independent of the bandwidth setting. **Fig. 6** is a selectivity curve of a filter that provides *quasi-continuous selection of i-f bandwidths.*

An additional advantage of this system is that ringing from mechanical or crystal filters of very narrow bandwidths is dramatically reduced. The filter is based on a) a dual-mixing system using four mixers and two ganged local oscillators to vary bandwidths, and b) two high-grade 30-kHz lowpass filters to provide the steep slopes. **Fig. 7** shows the block diagram of this circuit.

By correct choice of oscillator frequencies and, in one case, the use of sideband inversion, the two sidebands of the incoming i-f signal can be shifted toward or away from the sharp cutoff characteristics of two identical 30-kHz lowpass filters. After the two sharp edges have been imposed on the i-f signal, it is then converted back to the original i-f center frequency, which is 300 kHz. In effect, a variable bandpass filter is synchronized with two fixed lowpass filters. The basic relationship between the oscillator frequency, intermediate frequency, lowpass frequencies, and the bandwidths are:

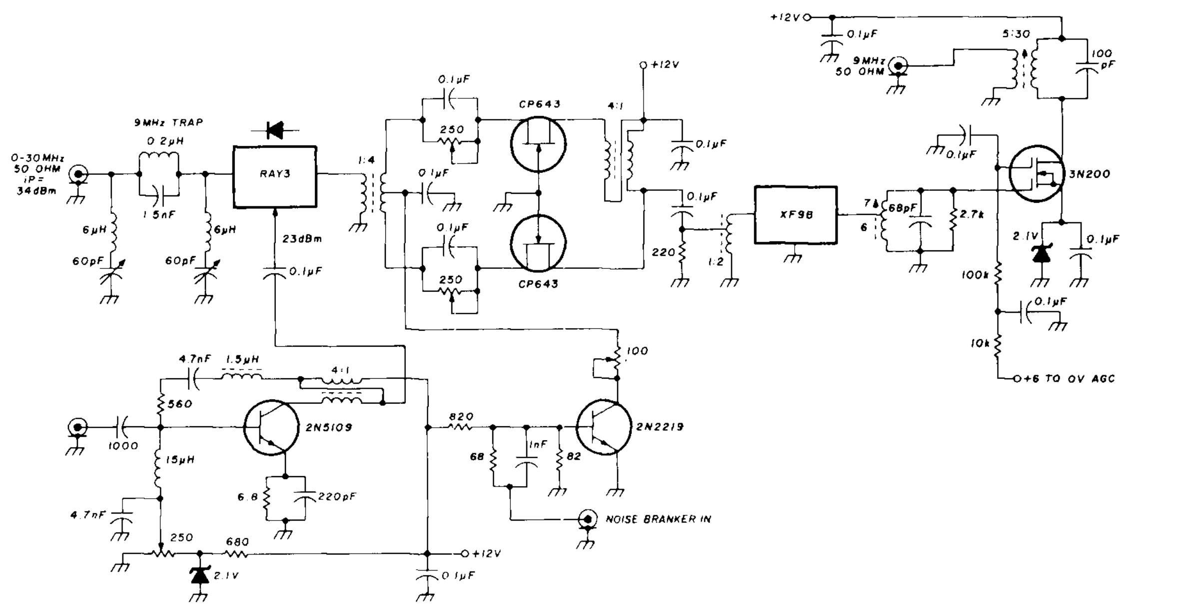


fig. 4. Rf-input stage for a high-performance receiver. Push-pull arrangement accepts blanking pulses without producing the distortion found in most circuits.

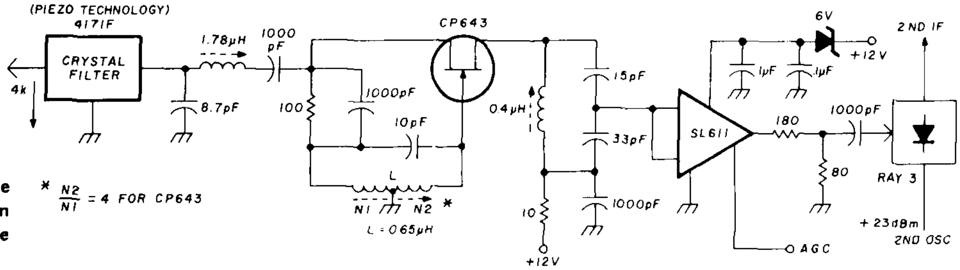


fig. 5. Low-noise neutralized input stage with crystal-filter matching and an output stage for i-fs in the vhf range. The filter is by Piezo Technology Co.

$$f_1 = f_{i\text{-}f} - f_g + f_b$$
$$f_2 = f_{i\text{-}f} + f_g - f_b$$

where

$f_{i\text{-}f}$ = the intermediate frequency
f_g = the cutoff frequency of the lowpass filter
$\pm f_b$ = the required filter bandwidth
f_1 = the first oscillator frequency
f_2 = the second oscillator frequency

As the oscillator frequencies change (in opposite directions), the filter bandwidth narrows. By independent adjustment of the oscillator frequencies, various asymmetrical filter characteristics can be set up.

The advantages of this quite complex filter derive from the fact that it is possible to build high-grade lowpass filters at 30 kHz using crystals for improving the selectivity; therefore, they have an almost ideal slope characteristic. This slope is almost exactly the same for all bandwidths. The advantage of being able to select the optimum bandwidth for all signal conditions does not have to be stressed.

Bandpass tuning. A technique that has become quite popular is "bandpass tuning." This method of shifting the i-f bandwidth toward the carrier center frequency was first used by Collins. It should not, however, be confused with the technique described above to achieve a variable bandwidth, since the absolute bandwidth remains the same.

The bandpass tuning cannot improve the selectivity, although it sometimes appears as if this happens because the audio pitch has changed and sometimes the filter center frequency is moved into the opposite sideband. This popular technique is used mainly in receivers where the designer wants to avoid the expense of crystal filters with better skirt selectivity. Bandpass tuning as presently used does not only leave the selectivity the same as it was before, but because of the additional oscillators required, receiver performance is degraded. The additional mixing stages make the receiver more vulnerable to overload, and the limited amount of shielding does not suppress oscillator harmonics sufficiently, so that an

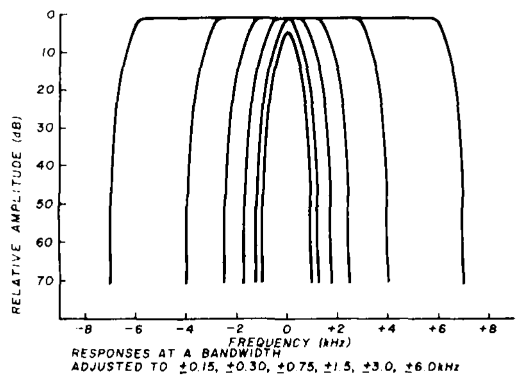


fig. 6. Frequency response of a quasi-continuous-bandwidth i-f system.

enormous amount of birdies are produced. An example for these tradeoffs is the otherwise very good R4C receiver made by Drake.

The use of the R4C on 10 meters, together with converters for 2 meters and higher frequencies, is very limited because of the large number of in-band birdies. **Fig. 8** shows a typical scheme to obtain bandpass tuning. This scheme is designed so it can work with a transceiver, as mentioned in my article[3] on various synthe-

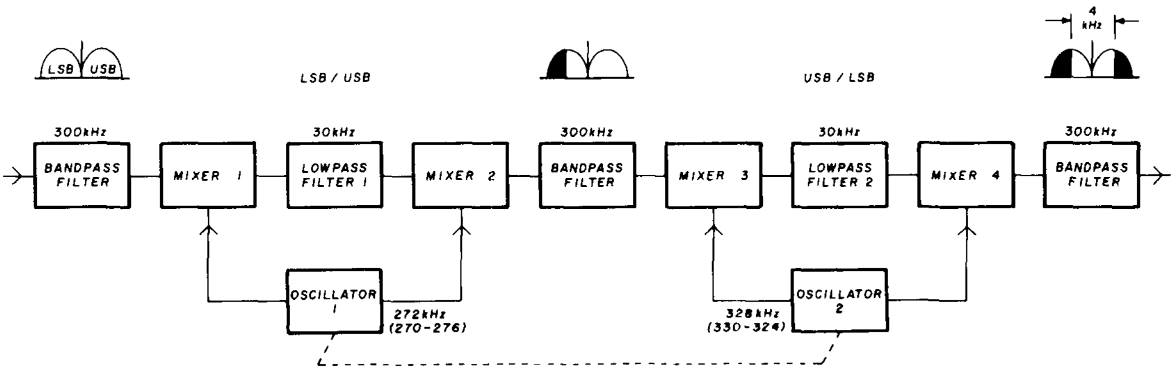


fig. 7. Block diagram of a variable bandwidth i-f system.

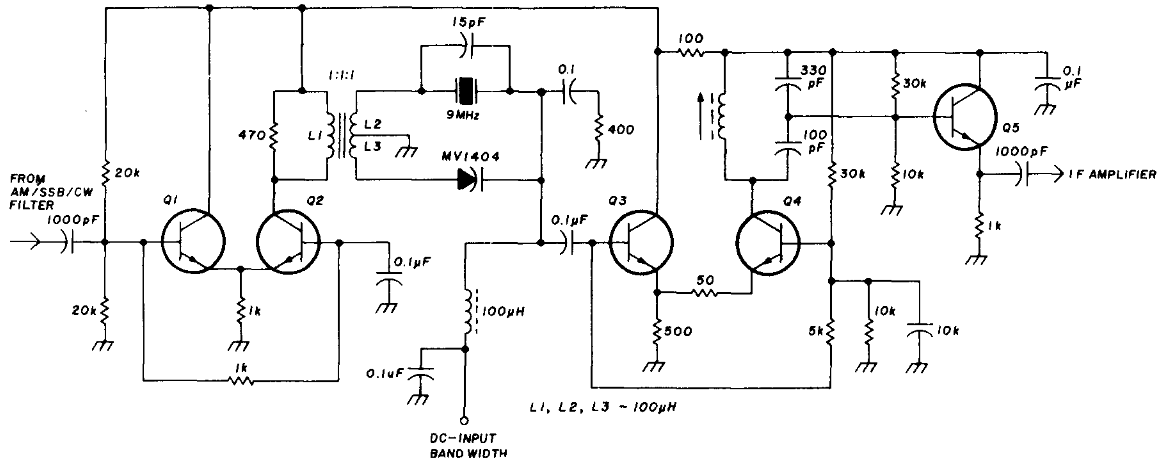


fig. 9. Crystal notch filter for frequencies between 5-20 MHz. A half-lattice network with phasing capacitor forms the basis for this circuit.

sizer techniques. Because of the frequency differences used in this case, the amount of spurious response is small.

While the Drake receiver has comparatively little shielding, the Signal-1 CX7, with a much more complex local oscillator, avoids some of the spurious response by selecting more suitable auxiliary frequencies. However, the two units should not be compared because the CX7 uses a 42-MHz i-f, which creates other problems.

For CW and ssb reception, notch filters can be a tremendous help. While earlier receivers used notch filters at very low frequencies; *e.g.*, 30 kHz, hardly any receivers at the new standard i-fs between 5 and 20 MHz are equipped with such a device. The solution to this problem is the design of a crystal notch filter.

Fig. 9 shows the circuit of a notch filter that can be added to practically all receivers. In designing the filter it is important to make the 3 dB bandwidth slightly wider than the bandwidth of the preceding ssb filter, since only the nulling effect (parallel-resonant mode of the crystal filter) is used.

The 3-dB bandwidth is determined primarily by the 470-ohm resistor in parallel with L1. If the resistor is made smaller the bandwidth decreases, and if the resistor is made larger, the bandwidth increases but the notch depth becomes less. For proper termination and loss compensation, the circuit is built around the CA3086 IC, using two differential amplifiers. The series-resonant frequency of the crystal must be at the center frequency of the i-f. The circuit will work well at any i-f between 5 - 20 MHz. It should, however, be pointed out that the half-lattice filter has a very poor slope characteristic and must be used in conjunction with a normal filter for ssb. A separate filter for CW should be used also. The notch depth is about 1 Hz wide. This filter arrangement, which costs less than bandpass tuning, provides added selectivity, which bandpass tuning does not, and is of much greater value.

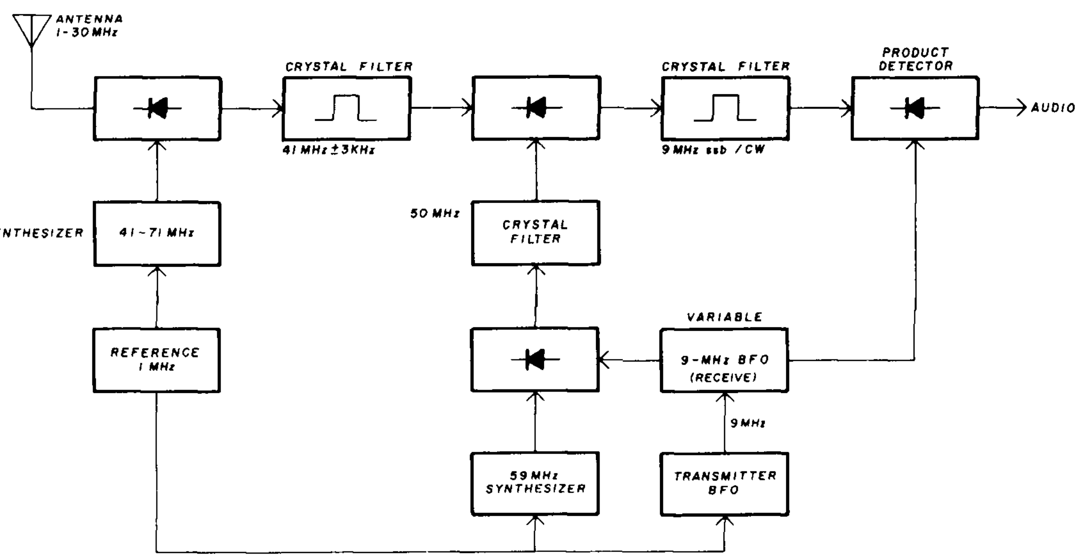


fig. 8. Bandpass-tuning system for a transceiver.

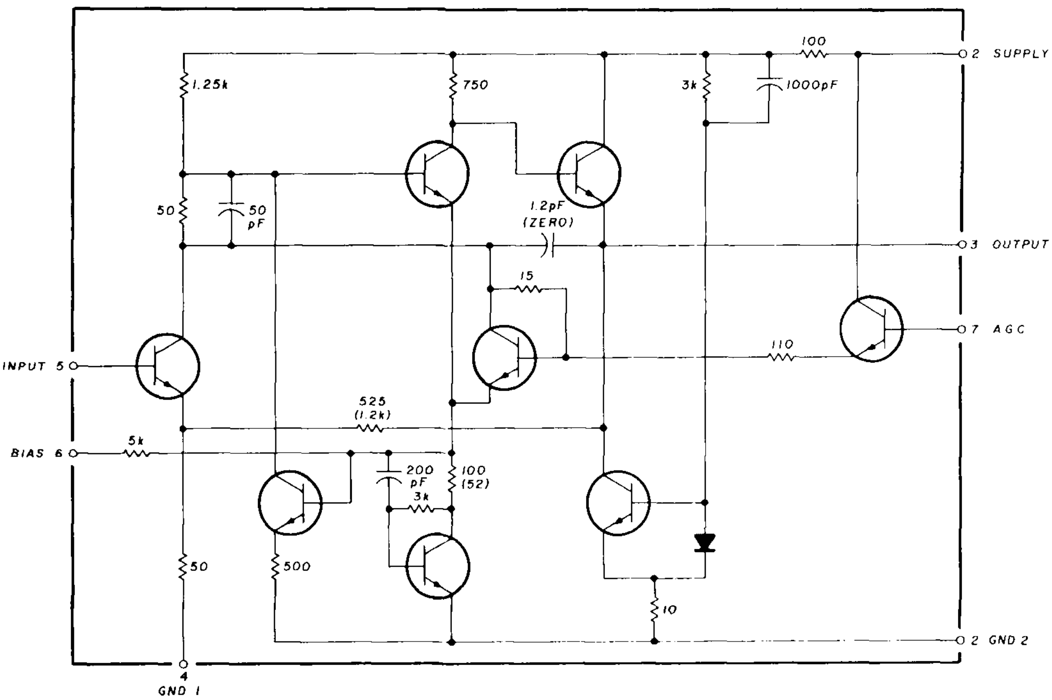


fig. 10. Schematic of the Plessey SL610/11/12 IC. Device is useful for forward agc but requires a high load impedance to avoid distortion.

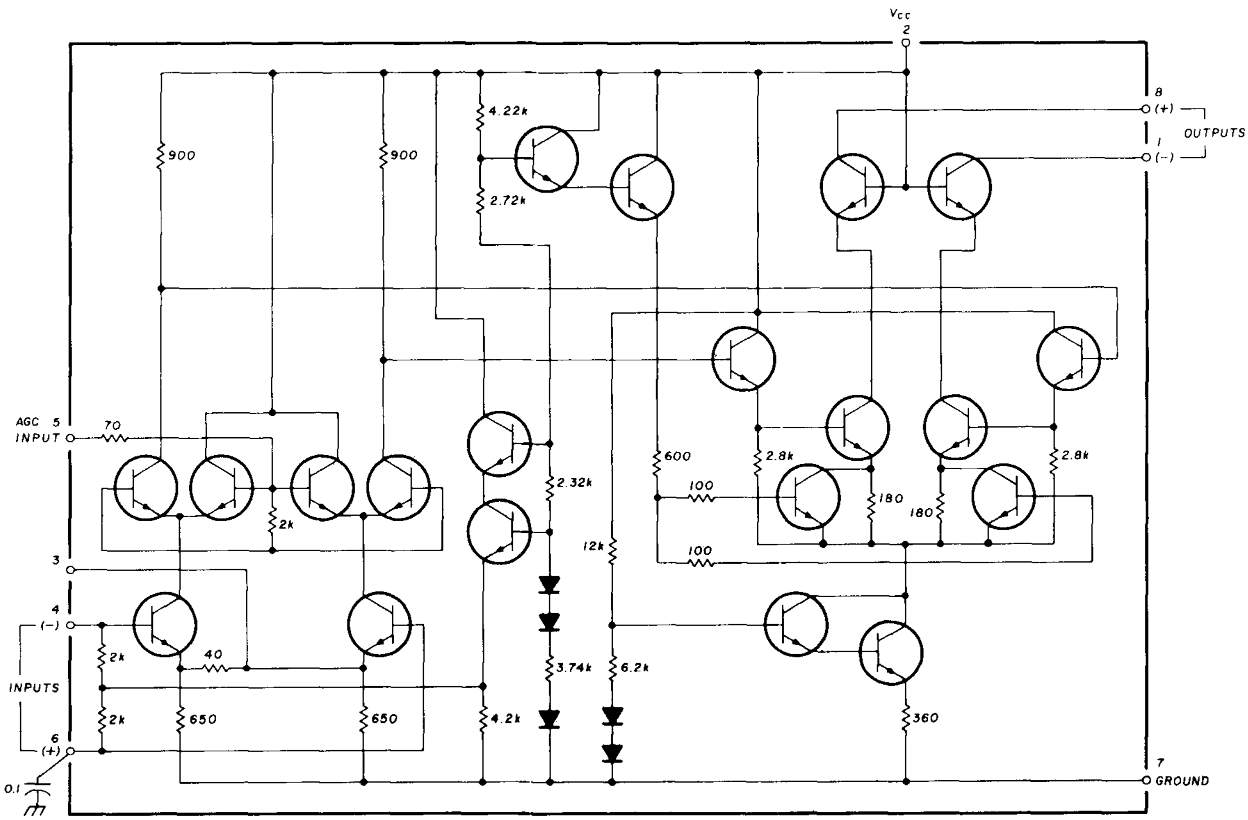


fig. 11. Schematic of the Motorola MC1349 IC. Recommended for optimum i-f circuit design using forward agc.

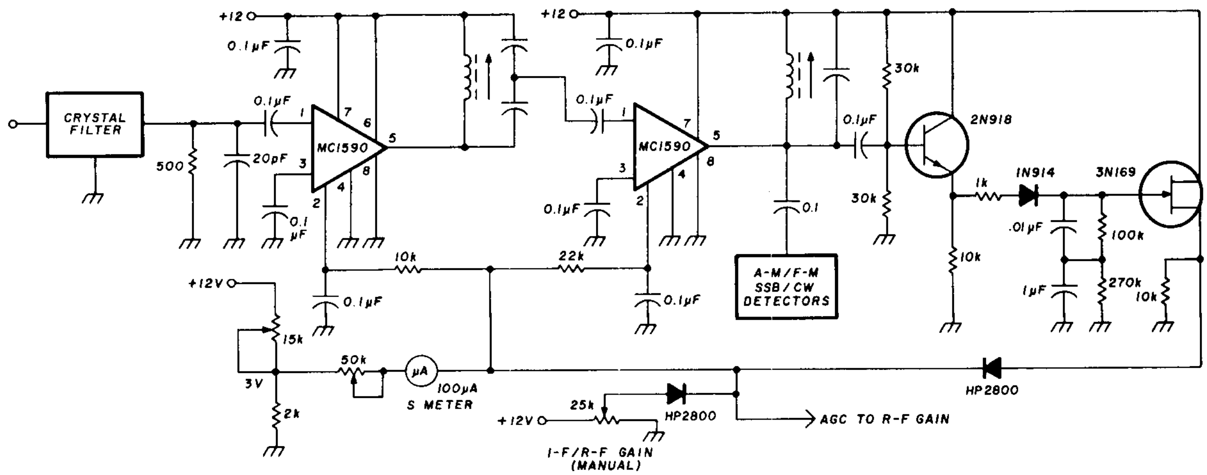
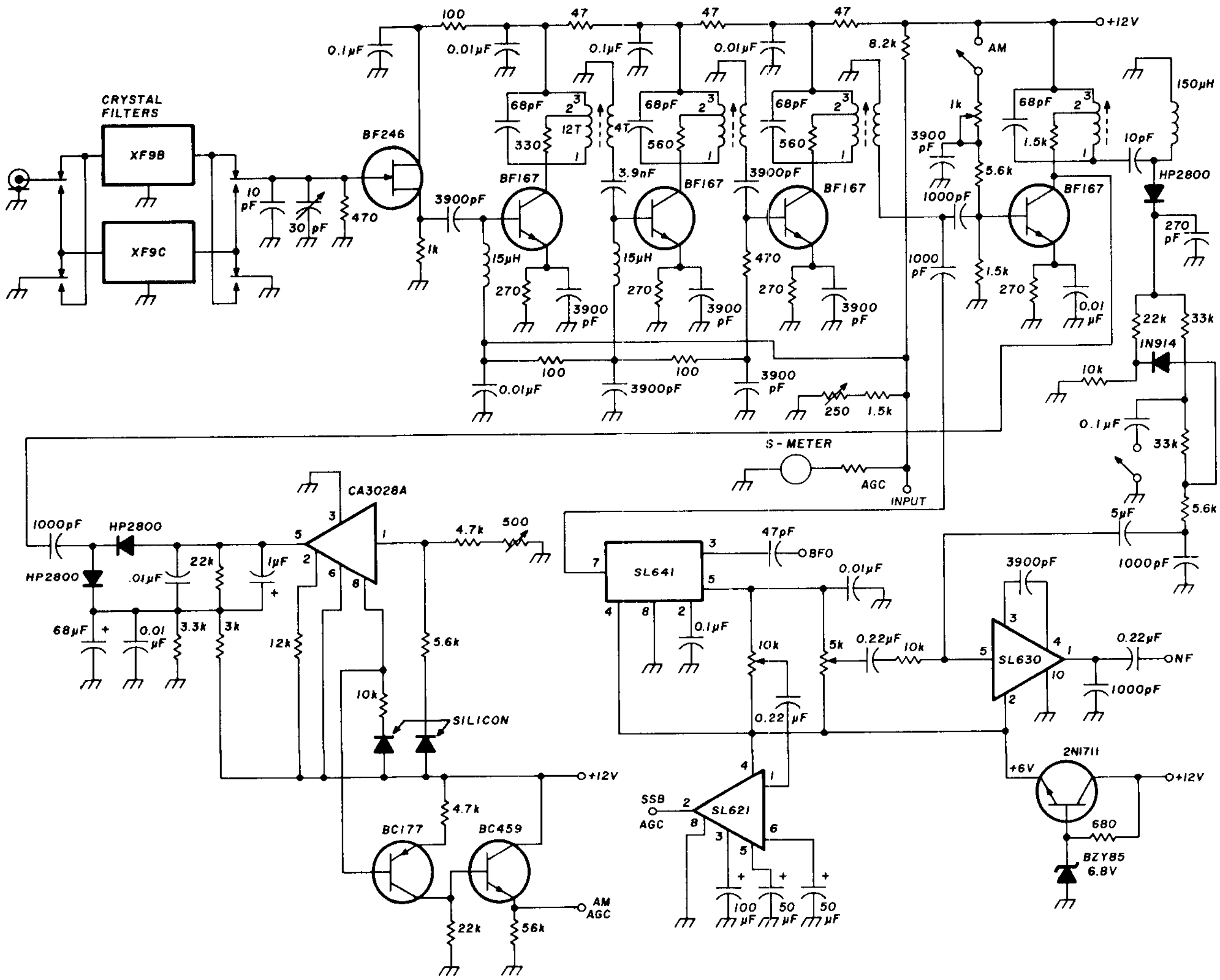


fig. 12. I-f amplifier strip with tuned circuits using Motorola MC1590 ICs. Circuits can be used for any frequency between 0.1-30 MHz.



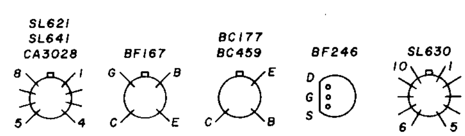


fig. 13. Complete i-f strip for a-m, ssb, or CW using discrete transistors. Forward agc is used for an ultralinear S-meter. The agc input is connected to either the ssb/CW agc output or the a-m agc output by the mode switch.

Depending on the application, the i-f stage following the main selectivity circuits can be built in various ways.

General-coverage receivers. General-coverage receivers differ from amateur-band-only receivers mainly by the requirement for high-performance a-m and fm detectors. Amateur-band-only receivers are tailored more for ssb and CW reception. The otherwise very interesting Plessey SL600-series IC, for example, is not suited for high-performance a-m reception because the wideband noise generated by two or more cascaded SL612s would demand very high selectivity; *i.e.*, an expensive crystal filter. Otherwise, no suitable signal-to-noise ratio is obtainable.

Amateur receivers. Amateur receivers in many cases use audio-derived agc to save costs. Audio-derived agc, which is not found in commercial or military receivers, has two significant drawbacks:

1. Inband intermodulation distortion is produced, which cannot be tolerated for many receiver uses.

2. When an a-m station carrier is not modulated, the agc will pump and create heavy distortion.

A fast attack time is somewhat difficult to obtain because of the limited bandwidth of the agc system. Before going into further details, it is important to take a look at the transistors and integrated circuits available for i-f stages.

In the past, the most common mistake in designing receivers was to use very little i-f gain for obvious reasons. In moderately priced receivers, which do not use extensive shielding, it is not easy to have i-f gain. Transistor circuits in this respect offer a distinct advantage over vacuum-tube circuits since the former can be designed with low impedances. Also, because the feedback capacitors, which are mostly determined by the circuit layout, are more or less the same, transistor stages permit higher gain. Some receiver designers still use discrete transistors, because they already have them, which tends to complicate the design.

Forward agc. Very few transistors are suitable for forward agc characteristics. A better way of doing this is to use differential amplifiers for agc. The RCA CA3028 is a suitable choice.

A somewhat more convenient way is to use ICs

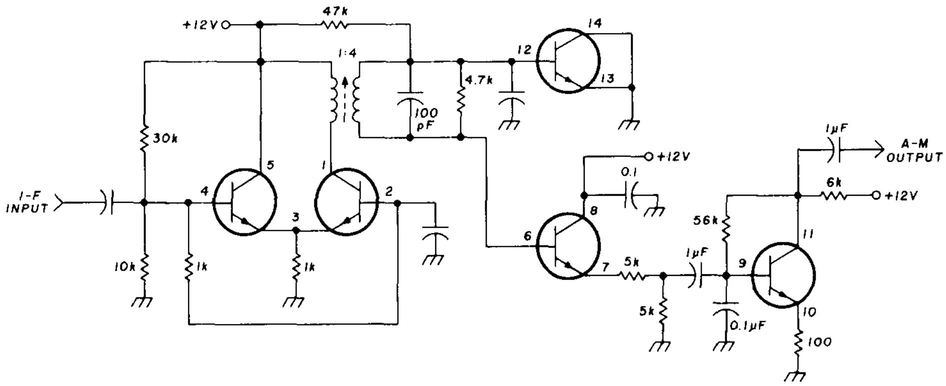


fig. 14. High-performance a-m detector for higher frequencies. Less than 1% distortion is claimed at 99% modulation.

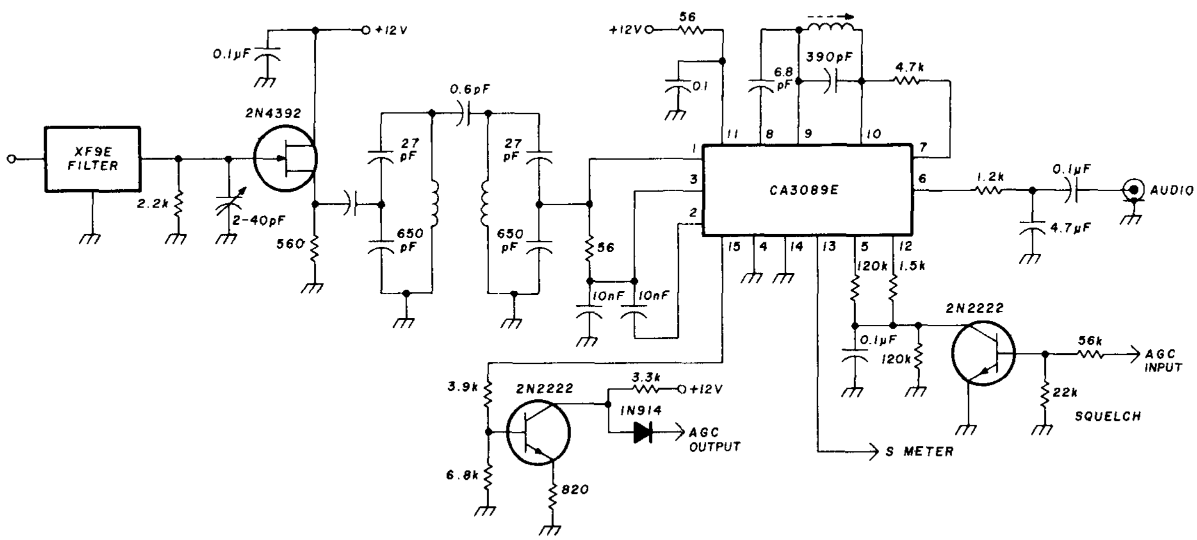


fig. 15. Narrowband fm detector including agc and squelch circuits.

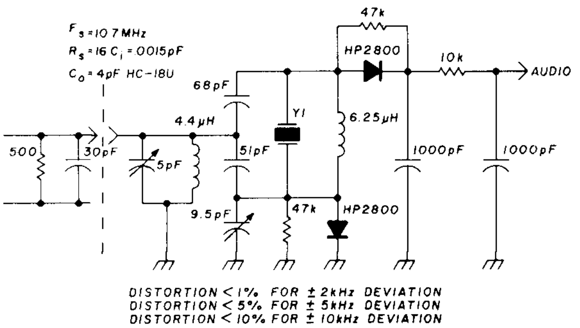


fig. 16. High-performance cyrstal discriminator. Bandwidth is ±30 kHz with less than 10% distortion for ±10 kHz deviation. Slew rate is −75 mV per kHz. Crystal Y1 is series resonant at 10.7 MHz.

specifically designed for this purpose, such as the Plesssy SL600 series or the Motorola MC1349/50. To understand the inherent advantages of these devices, let's take a look at their schematics. **Fig. 10** shows the circuit of the SL610/11/12, and **fig. 11** shows the MC1349 IC. The basic differences between them are:

1. The SL610 is a single-ended arrangement, which requires few external components, while the Motorola MC1349/50 series use a push-pull arrangement, which has somewhat wider applications and better dynamic range.

2. Because of the open collector, the MC1349 can be used very conveniently in narrowband applications, *i.e.*, where a-m reception is required, and still can be used with good gain at medium output impedances.

3. The SL600 series requires fairly high load impedances to avoid instability. Cascading more than two of them can become quite exciting!

National Semiconductor offers the 300 series IC for linear operation, but these amplifiers include too many functions and don't leave the designer much choice for optimum circuit design. In my opinion, the MC1349/50-series IC is the best choice, unless the full military temperature range is required or steady levels are available. In this case, the SL600 series ICs are favored.

Fig. 12 shows a typical multipurpose i-f amplifier operating around 9 MHz, using two of the Motorola ICs with suitable agc distribution and output selectivity. If only ssb operation is desired, the tuned circuit can be replaced by 1k resistors.

Fig. 13 shows a somewhat less expensive i-f amplifier with low-cost discrete transistors as used in some European TV receivers. Forward agc is used.

demodulators

General-coverage receivers require a-m, ssb/CW and also fm detectors. The fm detector is required because 29.7 - 30 MHz is a popular NATO frequency range where portable fm units are being used.

A-m detectors. Although the a-m detector may not be all that important for most amateur purposes, I believe everyone should have a general-coverage receiver for a-m reception of foreign news services, which can be most interesting. If this is done with the usual ssb detector, the long-term stability requirements of the local oscillator and bfo are fairly high, because the carrier will otherwise introduce distortion.

High-quality a-m detection is very expensive because the rf level must be several times the diode threshold voltage to avoid distortion. On the other hand, this means that the i-f gain must be so high that a certain minimum amount of shielding, even with low-impedance, wideband circuits, becomes vital. At lower frequencies (either the 20 - 30 kHz range or the 100 - 500 kHz range) this is quite easily accomplished, because the amount of feedback is negligible. At higher frequencies, because of instability problems, special circuits should be used, which on the one hand accept very little rf drive and on the other exhibit extremely low distortion.

Probably the best circuit for this requirement is shown in **fig. 14.** This detector is basically an emitter follower with extremely little forward bias, which barely compensates the threshold voltage of the transistor. Because of temperature drift, a temperature-compensating diode is required. Although it has no gain, this circuit exhibits less than 1 per cent distortion even up to 99 per cent modulation, and is commonly called a class-D detector.

Ssb and CW detectors, often called product detectors, are mixers in which the suppressed carrier is reinserted. This carrier is very close, if not equal to, the i-f center frequency, which can create a problem. If the rf feedback in the i-f system is too high, radiation into the first i-f stage can cause instability and inband distortion. The best way of determining whether this problem occurs is to check the product-detector stage dc levels to ascertain whether any dc voltage offsets occur. Many good circuits

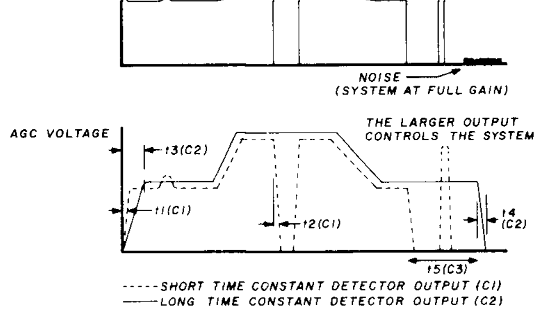


fig. 17. Agc characteristic and pulse performance of the Plessey SL621 agc generator.

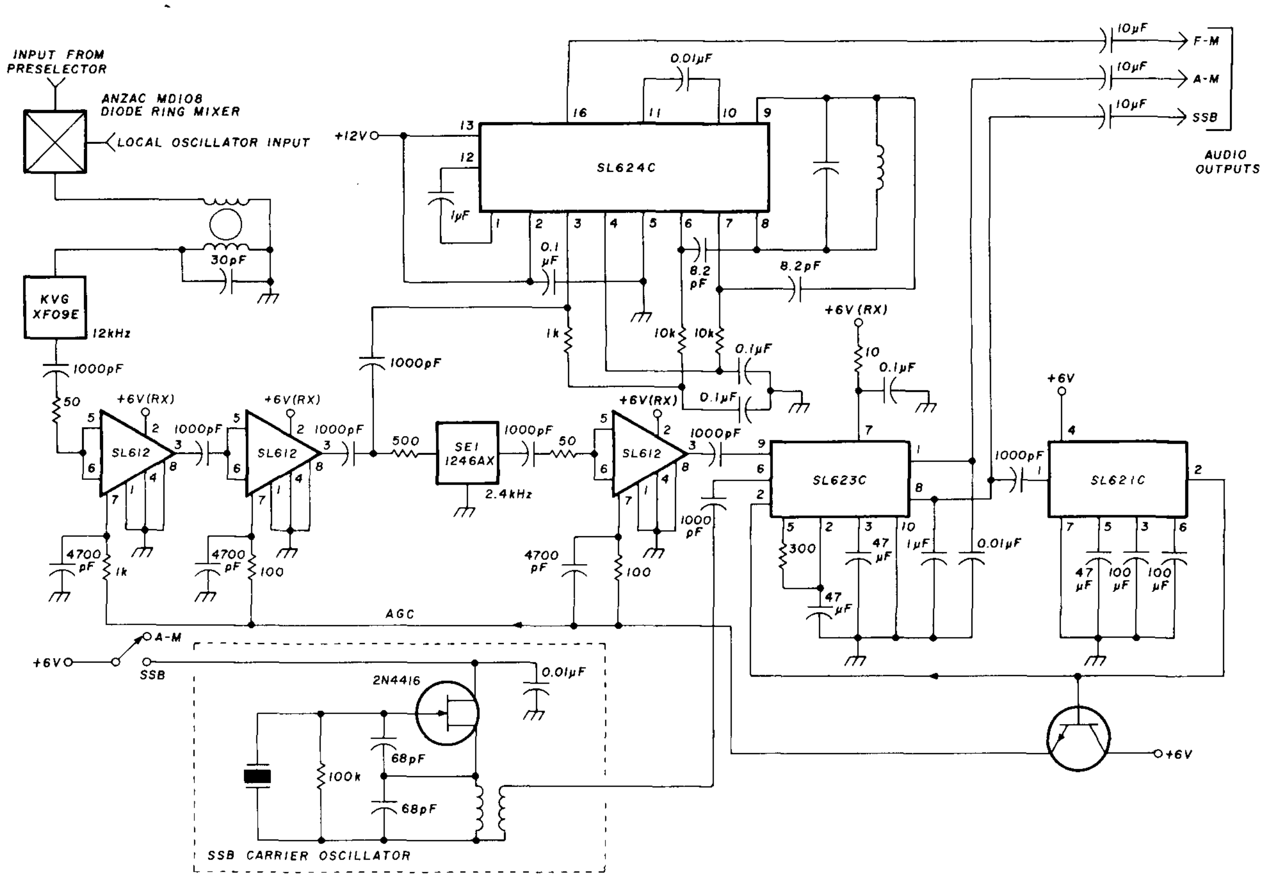


fig. 18. I-f arrangement using the Plessey SL600-series ICs.

are available for use as product detectors; often fancy names are used for these mixers.

The product detector is essentially a high-level mixer in which rf signals of 5 mV and higher are converted into audio signals. Lower values of rf are not recommended, because the signal-to-noise ratio then becomes problematic. Despite comments made by various authors, it is not necessary to use a four-diode ring modulator, which requires fairly high bfo signals. A popular solution is to use dual-gate mosfets or the Motorola MC1496 integrated-circuit mixer.

The dual-gate mosfet, because it is not a balanced or double-balanced switch, has no noise sideband cancellation and still requires fairly high bfo signals, while the MC1496, to operate successfully, requires an unjustified amount of external circuitry.

In my opinion, the only good choice is either the Plessey SL640 or SL641, which require few external components. Fifty mV of local-oscillator drive is sufficient for low-distortion detection, and the intermodulation distortion figures are extremely low. Detailed information on the Plessey ICs and their application are found in reference 4.

Fm detectors. Very few good fm detectors with little compromise are available. However, the RCA CA3089E is a unique device. It is ideally suited for amateur purposes because it offers not only excellent fm detection, high audio output, and squelch operation, but also offers a field-strength indication. The CA3089E can be used for narrowband as well as wideband fm with very low distortion, and it has been used very often. **Fig. 15** shows a recommended circuit using this IC for narrowband fm detection.

Crystal discriminators. *In general it is not so easy to* design low-distortion crystal discriminators, and most of the application data is not complete. **Fig. 16** shows a proven circuit that has ±30 kHz bandwidth. The output is ~75 mV/kHz and distortion is less than 10 per cent for ±10 kHz deviation. The crystal parameters are significant in this particular circuit, which should be terminated with a load greater than 100k.

Depending on the i-f, the crystal series-resonant frequency may vary; however, the following dynamic values should be obtained:

Series resistor, $R_s = 16$ *ohms*

Series capacitance, $C_s = 0.015\ pF$

Crystal capacitance, $C_o = 4\ pF$

The drive impedance should be 500 ohms with 30 pF in parallel.

agc stages

Very often amateur receivers use audio-derived agc. I am not very much in favor of this method because of heavy agc pumping on a-m signals. However, it is a convenient way of deriving agc. The overall i-f gain doesn't have to be very high, since about 14 mV of rf energy will be converted into audio voltage by the product detector, which can be used to derive the agc voltage. Regardless of how the agc voltage is derived, the time constants must be considered carefully.

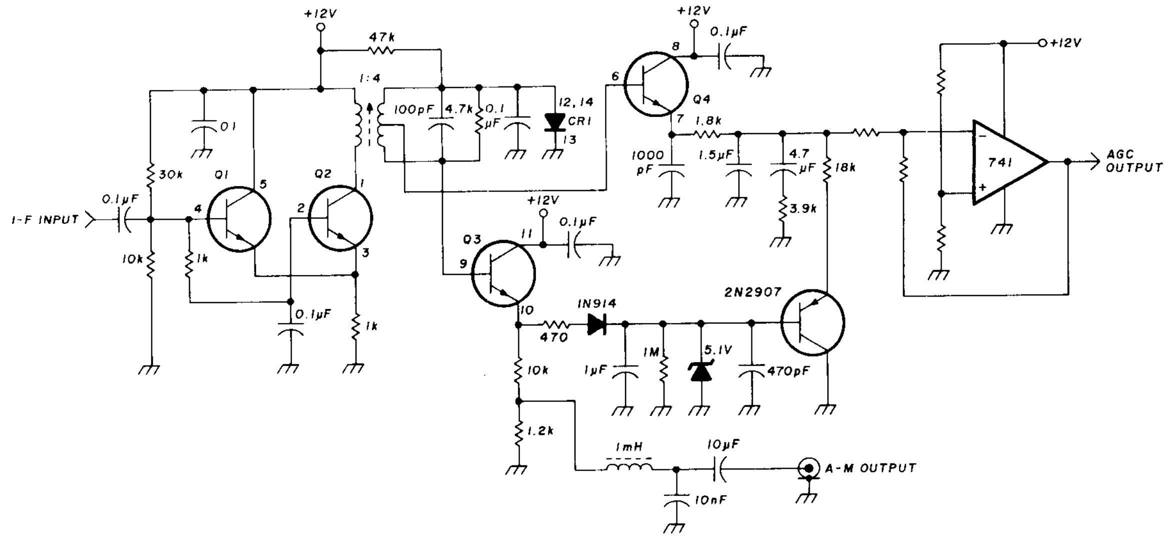


fig. 20. Rf-derived agc system for a high-performance, general-coverage receiver. Transistors Q1, Q2, Q3, Q4 are in the RCA CA3086 IC.

For ssb and CW reception a fairly fast attack time (of the order of 2 ms) is desirable. A faster attack time has the disadvantage that the peak value of *all* noise pulses is rectified, thus blocking the receiver. A long attack time; *i.e.*, 20 ms and higher, results in unpleasant noise bursts, and some time is required before agc overshoot settles.

Hang agc. In earlier receiver designs agc decay time depended on the discharge of a capacitor, so that a long recovery time was required for the receiver to regain its sensitivity and selectivity. Modern circuits now use a system known as hang agc. In this system the agc values change for a given amount of time to compensate for noise bursts; thus short pauses in the signal are smoothed out. Once transmission of the signal ceases, the receiver agc voltage decreases very rapidly; therefore the receiver regains its full sensitivity and selectivity within a very short time.

A novel approach to the hang agc circuit was made by Plessey in their SL621 agc generator, although this circuit uses audio-derived agc. **Fig. 17** shows the response of this detector; the schematic is shown in **fig. 18**. The circuit consists of an audio amplifier and two peak detectors with two different time constants which, within certain limits, permit you to select the desired attack, hold, and decay time.

Unfortunately, in this particular circuit it is not

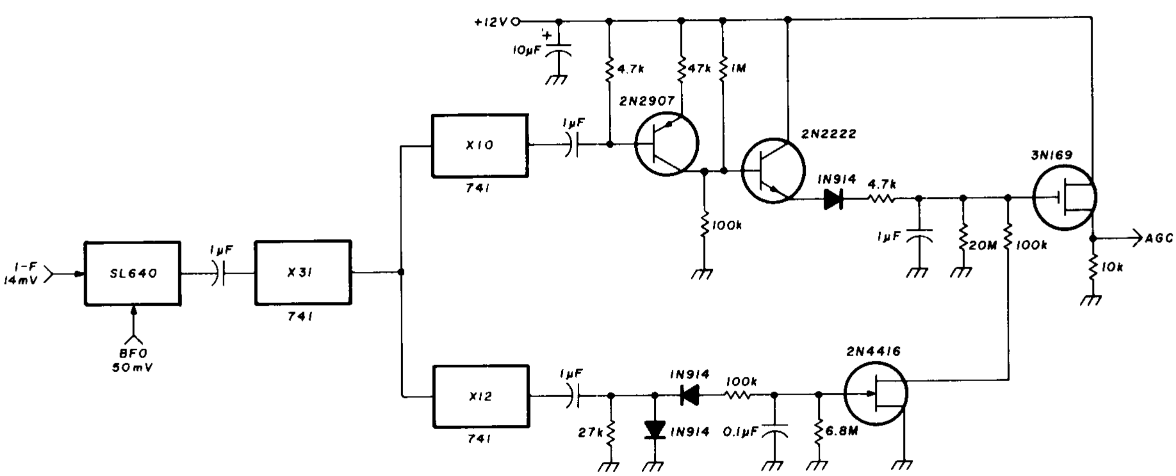


fig. 19. Audio-derived, dual-time-constant agc system/i-f amplifier in which attack, hold, and decay time can be set independently.

possible to reduce the attack time below 20 ms. Therefore a similar circuit was developed where all three time constants could be chosen independently. Credit for this circuit should be given to Wes Hayward,[5] although he uses split operation whereby part of the agc voltage is derived from the i-f signal and part from the af signal. The circuit shown in **fig. 19** is fully audio-derived and is suggested for those who are interested only in a simple ssb/CW receiver.

The emitter-follower is responsible for the fast attack time. The high impedance input of the fet, together with the 1-μF capacitor and 10-megohm time constant, gives a 10-second maximum hold time. However, the actual hold time is determined by the auxiliary pnp circuit, which is activated after the signal disappears and which determines the actual hold and decay time.

agc for a-m

For a-m detection, a dc voltage is available from the class-D detector described earlier. With the aid of operational amplifiers it can be brought to the required level and polarity. A suitable general-purpose agc detector for a-m and ssb/CW is shown in **fig. 20** using the same principle.

Fm receivers do not need agc, although to avoid severe saturation of the i-f amplifier, which results in nonlinear phase shifts that unfortunately then become

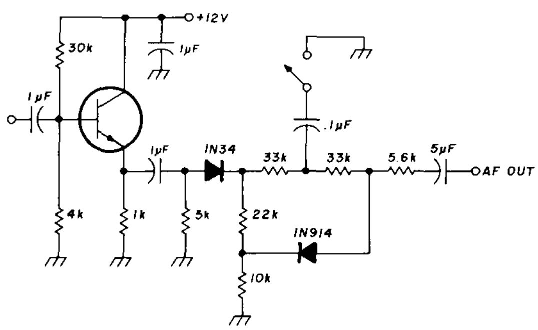


fig. 21. Audio noise limiter with low distortion.

an fm-detectable signal, a certain amount of agc can be derived from the fm detector described earlier.

audio stages

Although not considered as part of the receiver i-f system, the audio stages deserve some mention when considering overall receiver design. Described below are two methods of enhancing receiver performance in terms of noise limiting and selectivity in the audio section.

Noise limiter. Noise pulses measured immediately after the first mixer can be as high as 100 times the level of the desired signal. The crystal filter reduces the amplitude of these pulses but introduces a delay, which causes ringing, or overshoot. Audio noise limiters, in my opinion, are generally worthless. However, there is one circuit that is fairly efficient. **Fig. 21** shows the circuit, which I have not yet seen in the American literature. Its basic principle is similar to that of the delay line. The voltage developed across the voltage divider at the germanium-diode output is instantaneous, while the dc

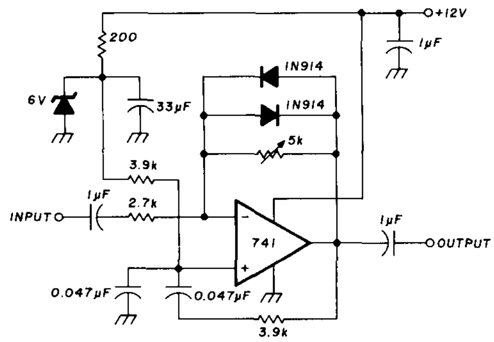


fig. 22. Bandpass-type active filter with 800-Hz center frequency. Circuit features adjustable bandwidth and noise-limiting capability.

voltage at the output of the circuit is delayed. If no pulses are present, and the 0.1-μF capacitor is not at ground potential, the silicon diode will have a floating voltage potential and will not be activated. Heavy positive pulses will charge the 0.1 μF capacitor and the silicon diode will short circuit the audio voltage. Negative pulses will disable the germanium diode directly. Therefore, a noise blanker at audio level in both directions is obtained.

Audio selectivity. Additional selectivity can be obtained with suitable audio stages. A common way of doing this is to use active filters. Either lowpass or bandpass arrangements can be used. It is very important to use a design in which the three parameters can be chosen independently: gain, bandwidth, and operating frequency. When not properly designed, these circuits act like a Q multiplier, which has a sharp, needle-like frequency response and little skirt selectivity.

One way out is to cascade some lowpass filters; however, the signal-to-noise ratio can be degraded. **Fig. 21** shows an active bandpass filter I've used in the past. It is very well suited for CW reception, and the two back-to-back diodes act as a very convenient noise limiter.

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ham radio

improved digital afsk

An answer to the need for high-quality peripheral equipment in amateur RTTY and remote computer applications

For many years the biggest problem for RTTY enthusiasts has been in mating teleprinter units to amateur equipment. As far as the receiving converter or TU is concerned, much effort has been expended to maximize performance, since the result of such effort is obvious. The transmitting converter, or afsk, however, has been generally neglected. Few really new designs have been developed since the inception of RTTY in the 1940s, and practically all have suffered from shift clicks, shift bounce, slow shift, instability, loop noise, and voltage sensitivity. Anyone who has built and attempted to use a phase-shift type afsk[1] is well aware of these problems. Some attempts have been made to incorporate digital innovations,[2,3,4,5] but these still had some drawbacks. Invariably, parts count and current drain were high, multiple power supplies were needed, portions of the design were redundant, and others neglected or omitted. The design presented here is an attempt to correct these shortcomings.

This article offers improved quality in RTTY hardware for amateur use. Also, with the expansion in data communication and computer experimentation, much need exists for high-quality interface equipment. The circuit described here is also designed to accommodate tone frequencies used in remote computer applications.

objectives

The design criteria to be met by this circuit are:

1. Minimize the number of special or critical components.
2. Maximize stability and eliminate the need for sophisticated equipment for setup and test.
3. Minimize distortion and switching transients.
4. Incorporate a keyboard debounce circuit to reduce mechanically induced noise.
5. Produce sine-wave output at moderately low impedance and at reasonably high level.
6. Operate from a single unregulated power supply at low current.
7. Obtain complete electrical isolation of afsk from the loop to minimize ground-path noise coupling.
8. Minimize adjustments for balance and level.
9. Make loop connections polarity insensitive.

To see how these objectives have been met, and to understand the operation of the circuit, refer to **fig. 1** while following the technical description.

technical description

U1C and U1D are two independent continuous-duty, Pierce-type, crystal oscillators running at 2048 (or 4096 for 1070-1270-Hz data shift) times the desired mark and space frequencies respectively. R1 and R2 set the dc bias on the gates. The unused inputs are tied to V_{cc}/V_{dd} through R3 and R4 to ensure logic 1 on the inputs. C1 and C2 ensure reliable oscillator start up. The outputs of these oscillators are buffered by U1A and U1B and are fed to the selector gate, U2. Both oscillators run continuously to eliminate startup delay. The U2A output is either the mark or space harmonic as determined by the state of U3. If U3, pin 3, is high (loop closed, loop current flowing) then U2C is enabled, gating the mark tone harmonic. If the loop opens, U3, pin 3, will be low, enabling the space harmonic through U2D. (The action of U3 will be described later). A maximum of one cycle of distortion is introduced by this switching action, but this distortion appears at 2048 (or 4096 for 1070-1270-Hz data shift) times the mark or space frequency, and thus only contributes about 0.05 per cent maximum distortion to the output tone shift.

U2A output is fed through an eleven- or twelve-stage ripple counter, U4, whose output is a symmetrical square wave at the desired mark or space frequency. A CD4020 14-stage divider is used, but the Q10 or Q11 output is used to allow oscillator operation near the frequency of maximum stability. The divider output is fed through a single second-order active bandpass filter, U5, whose Q is set at about ten, gain at about 0.2, and center frequency between the desired mark and space

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table 1. Changes required to the schematic for operating frequencies other than standard mark and space.

jumper	afsk use	Y1 (MHz)	Y2 (MHz)	R5 (ohms)	R6 (ohms)	R7 (ohms)	mark (Hz)	space (Hz)
15-A	RTTY	4.352	4.700	270k	120k	1k	2125	2295
15-A	ASCII comp	4.557	4.147	270k	120k	1k	2225	2025
1-A	ASCII term	5.202	4.383	6.8k	27k	250	1270	1070

all resistors 1/4 watt 10% nominal.

bandpass amplifier formulas:

select C3 and C4 to be 0.01 μF, then

$$R7 = \frac{Q}{f_o C3} \qquad R5 = \frac{R6}{2A} \qquad R6 = \frac{R5R7}{4Q^2R5 - R7}$$

where Q = 10, A = desired gain, and f_o = desired center frequency. The value of R6 should be chosen to allow variation over the desired range; e.g., if R6 is calculated at, say, 300 ohms for a given center frequency, then a 500-ohm pot should be used.

frequencies. R6 is adjusted to slew the filter center frequency, thus balancing the audio level of the mark and space tones. R10 is the audio output level adjustment. C3 and C4 are the only critical components in the system and should be stable with respect to temperature over the range anticipated in use. Mylar or polystyrene types are suggested, but disc ceramics may be used if environmental conditions are stable.

Note that U5 is operated single ended; that is, with only one power-supply polarity. This is accomplished by biasing the noninverting input at 0.5 V_{cc}/V_{dd} with the network composed of R8, R9 and C6. C6 ensures a noise-free reference point. Because of the low-gain, moderate-Q characteristics incorporated in the filter, ringing is minimized and distortion to the switching rate is undetectable with the TU used for measurements.

Because of the imperfection of many surplus keyboards, debounce was incorporated in U3. Optical isolation with bridge input of the loop to the afsk was also incorporated to eliminate noise coupling and polarity sensitivity.

The operation of U3 and its components is as

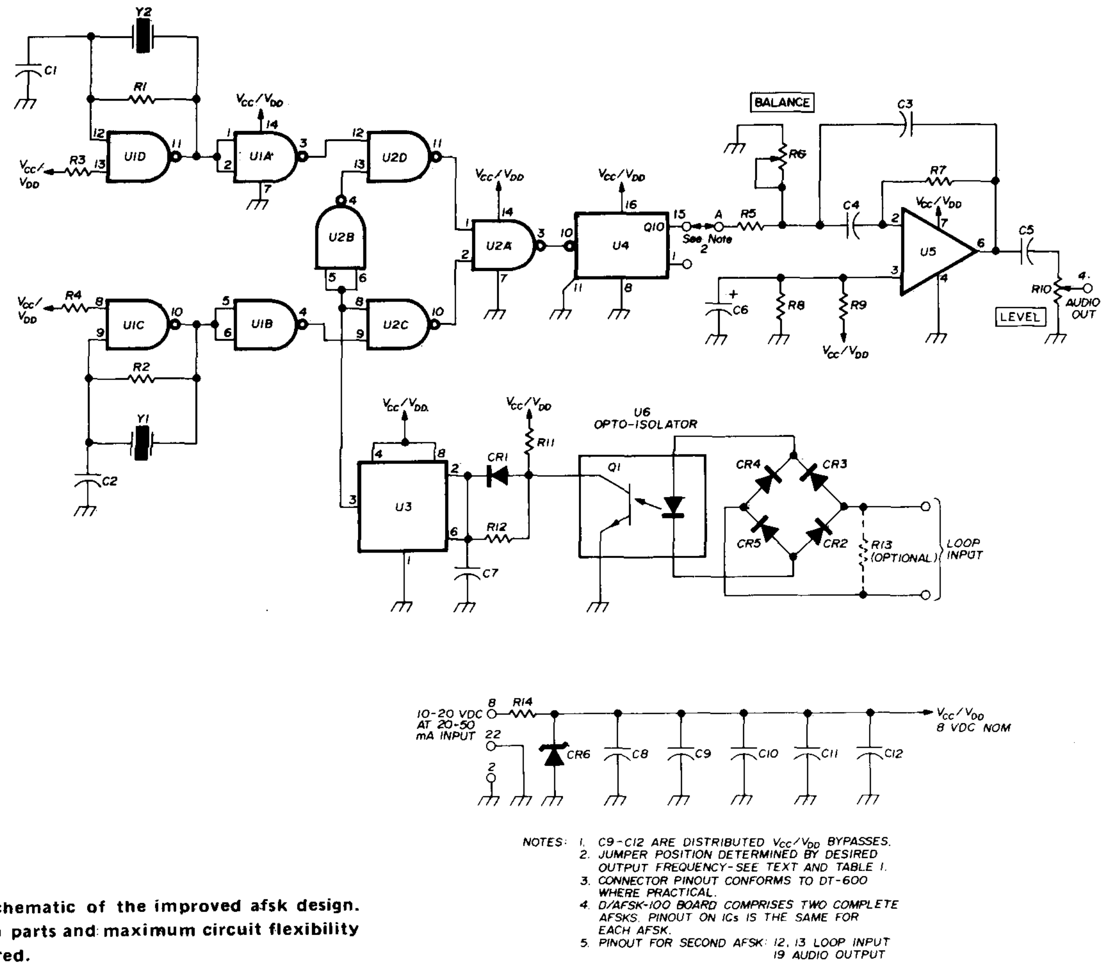

fig. 1. Schematic of the improved afsk design. Minimum parts and maximum circuit flexibility are featured.

follows: Assuming the loop is closed, isolator transistor Q1 is saturated, and C7 is discharged through R12. When the loop opens, C7 charges through CR1 and R11. Since CR1 and Q1 have similar junction characteristics, charge and discharge times will be essentially identical with no contact bounce. If bounce on loop closure occurs discharge time will extend; if it occurs on opening charge time will extend.

U3 is connected as a Schmidt trigger whose trigger point is $1/3V_{cc}/V_{dd}$ and whose reset point is $2/3V_{cc}/V_{dd}$, thus providing symmetrical action with wide hysteresis. If debounce is not desired or needed, R12, CR1 and C7 may be deleted, with a jumper added in place of CR1. U3 is retained to insure fast mark-space transition. The loop input is designed for 20 mA operation. If 60-mA loop operation is desired, add a 33-ohm resistor in parallel with the isolator input (optional resistor R13 in **fig. 1**).

table 2. Parts list. A ready-to-use PC board with assembly and troubleshooting information is available (see text).

Y1, Y2	EX grade, 32 pF series resonant. See table 1
U1, U2	CD4011AE or equivalent cmos quad 2-input NAND gate
U3	NE555V timer or equivalent
U4	CD4020AE or equivalent cmos 14-stage ripple counter.
U5	LM741CN or equivalent 741-type op-amp
U6	H-11A or equivalent opto-isolator
R1, R2	1 meg ¼ watt 10%
R3, R4 R11, R12	10k ¼ watt 10%
R5	see table 1
R6, R10	1k trimpot CTS X201-R102B or equivalent. See also table 1
R7	see table 1
R8, R9	2.2k ¼ watt 10%
R13	33 ohm ¼ watt 10%
C1, C2	47 pF ceramic disc
C3, C4	0.01μF mylar or polystyrene
C6	10 μF 15 wVdc aluminum electrolytic
C5	0.22 μF ceramic disc
C10-C12	0.1 μF ceramic disc
C8, C9	50 μF 15 wVdc aluminum electrolytic
C7	0.01 μF ceramic (60 wpm Baudot) or 0.005 μF ceramic (100 wpm ASCII)
CR1	1N914 or equivalent silicon diode
CR2-CR5	1N4002 or equivalent
CR6	1N959 zener, 8.2 volt, 400 mW or equivalent

*An etched, drilled and plated PC board is available from Precision Technical Labs, P.O. Box 6743, Richmond, Virginia, 23230. A copy of this article plus component layout and troubleshooting information will be included with the board. The boards are laid out to accept two complete afsk circuits to allow simultaneous independent Baudot and ASCII operation. Order part number D/AFSK-100 and remit $10.95 (check or money order) for each board desired. Allow 2 to 3 weeks for delivery. Clubs and groups should write for quantity discounts. Boards are designed to conform to the DT-600 supply bus pinouts.

Power supply requirements are relaxed by including the zener regulator circuit R14, CR6, and C8-C12. This circuit allows operation from supply voltages between 10 - 20 Vdc. Current drain is 20 - 50 mA depending on supply voltage.

If operating frequencies other than the standard 2125-Hz mark and 2295-Hz space pair are desired, changes to the active filter and crystal frequencies may be calculated by the formulas given in **table 1** and in reference 6. The circuit is not designed for operation with shifts beyond 200 Hz since wide-shift RTTY is fast disappearing.

construction and adjustment

Printed-circuit construction and good mechanical practices should be used in assembling this unit.* A parts list is provided in **table 2**. Since moderate rf levels are used, attention should be paid to parts placement. Setup is simple and should take little time after construction. Upon applying supply voltage to the unit, some level of tone should appear at the output. Set the output level control for maximum, and adjust the balance control for maximum output. The open-circuit output at this point should be about 1 to 1.5 Vac and should be the space tone. Connect the unit into the loop, and the tone should shift to the mark frequency. If this is the case, run a test tape and adjust the balance control for unchanging output amplitude. Adjust the output level control for the desired audio level, and the unit is operational.

conclusion

This afsk unit was designed for optimum quality and stability in keeping with modern design methods and components. Ease of assembly, checkout, and troubleshooting is ensured by a minimum of adjustments and critical circuits. Most sources of noise, distortion and poor stability have been eliminated. By careful selection (or elimination, where practicable) of debounce time constants, this unit may be used at maximum speeds encountered in normal RTTY and data operation using an afsk. Total cost is under $30, including the PC board (less with a well-stocked junk box). Excluding the crystals, all parts should be available at most parts houses.

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ham radio

reducing intermodulation distortion in high-frequency receivers

Understanding and improving intermodulation performance of amateur band receivers

Judging by some recent articles in *ham radio*, amateurs are finally discovering that even the best of our high-frequency receivers are marginal when it comes to frontend performance in the presence of strong signals. Interestingly enough, the problem has not been caused by any lack of suitable technology, but rather most amateurs have simply been unable to clearly recognize and define the symptoms. We also have placed little pressure on manufacturers to produce receivers with cleaner frontends. Over the last several years, however, we have had to operate our receivers in increasingly dense rf environments. As a result, most of us have become well acquainted with a wide variety of frontend maladies in our communications receivers.

Recently, we have read about amateurs who have built receiver frontends employing special components and techniques that result in superior performance.[1,2] It is probably only a matter of time before the amateur receiver manufacturers incorporate some of these features into a new generation of amateur receivers. To a limited extent, this has already begun. Realistically speaking, I don't believe that most amateurs are contemplating homebrewing a receiver from scratch or unloading a present receiver for a new one in the near future. This then leaves two choices; live with the problem or modify our existing receivers to improve frontend performance. The first choice is easy, but I endeavored to determine if the second could reasonably be accomplished by a technically competent amateur. I ascertained that it can be done, but only with considerable time and effort.

what's right about our present receivers

Before we tear apart the designs of existing receiver frontends, let's attempt to understand the philosophy behind those designs. You may suspect a concept that has lasted all these years can't be entirely bad, and would have some compensating virtues. This is certainly the case. **Fig. 1** is a simplified block diagram of a typical amateur receiver frontend. Dual conversion is used, with the first i-f high enough to obtain good image rejection and the second i-f low enough to permit high gain while providing the required selectivity. The first LO (local oscillator) is a fixed-frequency, crystal-controlled oscillator for high stability, while the second LO (the vfo) can be operated at a low frequency where it also can be made stable. Another factor that enhances vfo stability is the absence of a vfo bandswitching requirement. Bandswitching is accomplished by changing crystals in the first LO. What we really have here is a low frequency tunable i-f preceded by heterodyne converters. With this one basic design, we buy sensitivity, selectivity, image rejection, and frequency stability in one neat package. So, rest assured that there has been no conspiracy among the manufacturers to sell us receivers with inferior frontends. They have simply employed a design incorporating nearly all the frontend qualities that most amateurs have asked for in the past.

what's wrong

Now let's flip the coin and take a hard look at the other side. In a receiver frontend, such as the one shown in **fig. 1**, we have three active stages preceding the second i-f filter. The composite bandwidth of the frontend could be on the order of hundreds of kHz, permitting strong in-band signals to find their way through all three stages. The second i-f filter eliminates all but the desired signal. Speaking in terms of frontend intermodulation, cross modulation, and desensitization, though, the damage has already been done. Simply stated, the active devices cannot handle the high signal levels produced as a result of the broadbanded gain. You might guess that the active stage most likely to cause trouble is the second mixer, since it is preceded by the most gain. Therefore, if you want to improve the frontend performance of a dual-conversion receiver similar to

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the one shown in **fig. 1**, you should direct your efforts toward cleaning up the second mixer.

Before we discuss methods of cleaning up the second mixer, let's briefly review some of the more common receiver frontend maladies and what causes them. The problem that is probably most familiar to amateurs is receiver desensitization. This is caused by the presence of a strong signal close to the desired signal. Whenever the strong signal comes on the air, the desired signal amplitude decreases. Desensitization occurs because the strong signal has driven one or more of the active frontend stages into gain compression, thereby reducing the frontend gain for all signals.

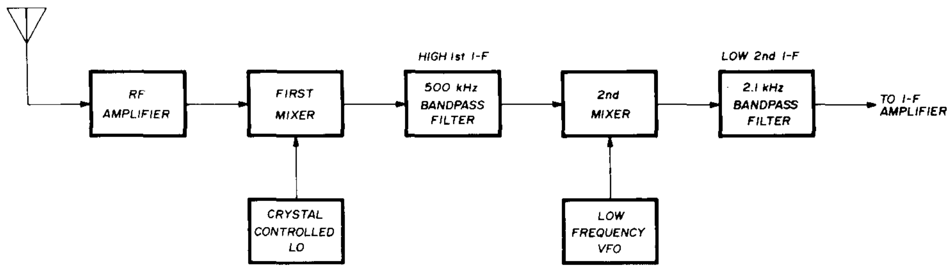

fig. 1. Typical front-end of a dual-conversion amateur-band receiver.

Another frontend problem is cross modulation. This occurs when a strong signal, close in frequency to the desired signal, imparts some of its modulation to that signal. Again, the cause of cross modulation is nonlinearity in one or more of the active frontend stages.

When two signals at frequencies f_1 and f_2 interact in a nonlinear device, intermodulation (IM) products result. As long as these IM products fall outside the rf passband of the receiver frontend, no damage is done. Otherwise, there will be spurious responses as we tune the receiver across the band. IM products can be further categorized as being either even-order or odd-order. Even-order products (2nd, 4th, etc.) are normally of no concern in amateur receiver frontends, since either f_1 or f_2 (or both) would have to be well outside the receiver rf passband in order to produce in-band IM products. As long as the rf passband is less than an octave, as is ordinarily the case in an amateur receiver, even-order IM products will not be troublesome. Odd-order IM products (3rd, 5th, etc.) however, do cause trouble. They can be produced by in-band signals and no practical degree of frontend selectivity can eliminate them.

To summarize then, the three receiver frontend maladies that seem to give amateurs the most trouble are desensitization, cross modulation, and odd-order intermodulation products. Are separate remedies required? Fortunately, a remedy for any one of these problems is ordinarily applicable to the others. Therefore, we will only address the problem of odd-order IM distortion. More specifically, we will confine our efforts to the reduction of 3rd-order IM products, as higher odd-order products are usually less troublesome.

One of the reasons for the general lack of knowledge by amateurs concerning IM distortion has been the absence of an industry-wide method of specifying it. Among the few amateur receiver manufacturers who even bother to specify IM performance at all, no two receivers are specified in such a manner that one can be meaningfully compared against the other. The figures provided are often meaningless mumbo-jumbo anyway, since the measurement conditions are neither standardized nor specified. *What we really need then is a method of specifying IM performance that is universal and does not involve so much hand-waving.*

intercept point method

A general and succinct manner of specifying the 3rd-order IM performance of a receiver (or any device) is the intercept-point method. Not only does the intercept-point method permit you to compare the IM performance of two different receivers, but it also actually lets you compute the level of the resultant IM products given the strength of the two offending in-band signals. The intercept point method is well discussed in a 1967 article by McVay.[3] It has also been discussed in recent amateur magazine articles.[1-4] Hopefully, the manufacturers will soon take the hint and adopt the 3rd-order intercept point as a standardized specification, as has been done elsewhere in the communications industry.

Since the 3rd-order intercept-point concept has been described elsewhere, let's not dwell on it too much here, except to define it and indicate its application. The general rule of thumb is that if we know the 3rd-order intercept point of a receiver frontend is X dBm (0 dBm = 1 mW), and two in-band signals (f_1 and f_2) each have

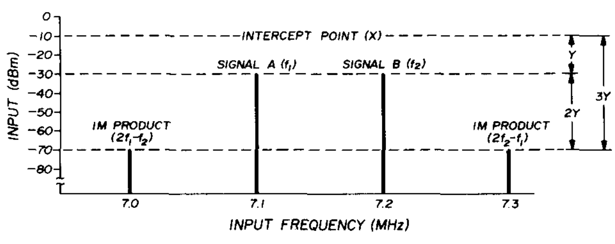

fig. 2. Two signals and their resultant inband 3rd-order intermodulation products.

an amplitude of Y dBm below the intercept point, then the two resultant in-band 3rd-order IM products will have equivalent input amplitudes of $X - 3Y$ dBm. Note that everything is referenced to the receiver input.

Plugging in some real numbers, suppose that a receiver is known to have a 3rd-order intercept point of −10 dBm referenced to the input. Let's further assume that two signals within the receiver rf passband each have amplitudes of −30 dBm. X is then equal to −10 dBm, and $Y = -10$ dBm − (−30) dBm = 20 dB, and by plugging these values into $X - 3Y$ we get $-10 - 3(20) = -70$. Thus, the two resultant in-band 3rd-order IM products would each have equivalent input amplitudes of −70 dBm.

Fig. 2 is a graphical representation of this situation, similar to what you might observe on a spectrum analyzer connected to the second mixer output before the i-f filter. The frequency axis has been referenced to the actual incoming signal frequency rather than the intermediate frequency. In addition, the signal levels are all referenced to the receiver input. Signal **A** (f_1) and signal **B** (f_2) are the two −30 dBm signals and are on 7.1 and 7.2 MHz, respectively. Notice that the frequencies of the two resultant in-band IM products occur at $2f_1 - f_2$ (7.0 MHz) and $2f_2 - f_1$ (7.3 MHz). If the receiver was tuned to either 7.0 or 7.3 MHz, the IM product would be indistinguishable from another input of −70 dBm. Since a −70 dBm input level is better than S-9 on most receivers, you could expect interference to valid stations that we might be trying to copy on either frequency.

An interesting implication is that the IM products will increase in amplitude in proportion to the signals that cause them. Suppose that signals **A** and **B** increase in amplitude by 10 dB (to −20 dBm). Since the amplitude difference (Y) between these signals and the −10 dBm intercept point is now only 10 dB ($-10 - (-20) = 10$), the IM products will now have equivalent input amplitudes of $X - 3Y = -10 - 3(10) = -40$ dBm. As a result, the amplitude of the IM products has increased a hefty 30 dB for an increase of only 10 dB in signals **A** and **B**. **Fig. 3** illustrates this point. If we continue to raise the levels of signals **A** and **B** until they reach the −10 dBm intercept point, the IM products will also be −10 dBm ($X = -10$; $Y = -10 - (-10) = 0$; $X - 3Y = -10 - 0 = -10$ dBm). If we were to simultaneously graph (**fig. 4**) the receiver output level of either signal **A** or **B** and either IM product output amplitude as a function of input

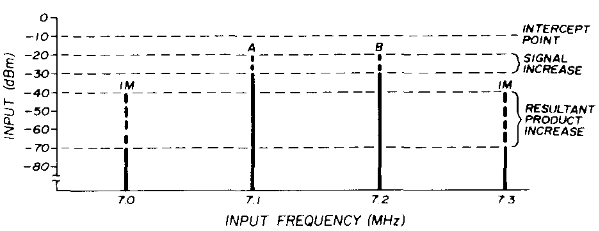

fig. 3. The change in the IM product level as caused by a change in the fundamental signal levels. The IM products will increase by a factor of three as the signal increases. Conversely the IM products will decrease by the same factor.

signal amplitude, the lines would intercept each other at an input level of −10 dBm which, appropriately enough is called the "intercept" point. If, instead of raising the levels of signals **A** and **B**, we lower them, the level of the IM products will *decrease* at the same 1:3 ratio.

In the real world, the intercept point can only be inferred by extrapolation of the two lines, since the receiver front-end reaches its gain compression region at an input level that is typically 10 to 15 dB below the intercept point. As a result, the curves would tend to flatten out to the right and would never reach the intercept point.

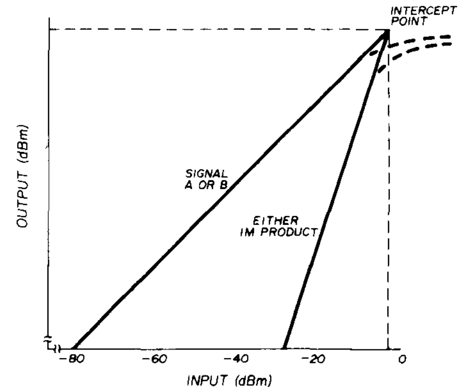

fig. 4. Intercept point graph. The intercept point is really an extrapolation of the signal levels. The active stages will go into gain compression before the intercept is reached.

The intercept point model presented above is valid as long as the receiver front-end is not being driven into its gain compression region. Also, we have assumed that signals **A** and **B** are equal in amplitude. If the two signals are different in amplitude, a correction factor must be applied. Finally, the rf bandpass characteristics of the receiver can modify the input levels of signals across an amateur band.

receiver performance

High-performance receivers exist today with 3rd-order intercept points in excess of +25 dBm, but this performance comes at a steep price. Fortunately, this type of performance is far better than most amateurs really need and can reasonably expect. The IM performance of commercially designed amateur receivers varies over a wide range. Interestingly enough, many of the new receivers on the market are more prone to IM distortion than the older ones. If you have a single-conversion, tube-type receiver, you are probably reasonably well off with regard to IM. On the other hand, the high sensitivity solid-state multi-conversion receivers tend to suffer more from IM distortion. In terms of round numbers, the 3rd-order intercept point of amateur receivers might be −40 dBm or even worse at the bottom of the scale, and perhaps −10 dBm or somewhat better at the high end. It's difficult to pinpoint what is "good" or "bad", but I feel that an amateur receiver with a 3rd-order intercept point of −10 dBm or better will provide excellent IM performance in most cases.

practical revisions

As mentioned earlier, in most dual-conversion receivers, the second mixer is the worst offender in terms of IM distortion, and any efforts to raise the 3rd-order intercept point should be directed toward improving the performance of this mixer. **Fig. 5** is a block diagram of my receiver front-end prior to modification. Note the similarity to **fig. 1**. Even though high quality fets are used throughout, severe IM distortion was experienced, particularly at night on 40 meters. Standing alone, the IM performance of the second mixer is not bad, but this performance is degraded by whatever gain precedes this mixer, which in this case is quite considerable. For example, if the second mixer had a 3rd-order intercept point of −10 dBm and was preceded by 30 dB of gain in the rf amplifier and first mixer, the overall receiver 3rd-order intercept point would be −40 dBm (assuming that the second mixer was the primary cause of the IM). A receiver with a 3rd-order intercept point of −40 dBm has *very* poor IM performance.

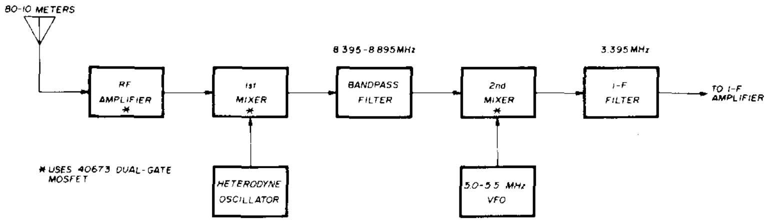

fig. 5. Block diagram of the author's receiver.

I decided that the best solution to the problem was to replace the fet second mixer with a hot-carrier diode double-balanced mixer. With proper vfo injection levels and correct termination, a mixer 3rd-order intercept point of +10 to +15 dBm can be realized. A Watkins-Johnson (relcom) M6 low-level, double-balanced mixer was chosen, although comparable units made by Anzac, Mini-Circuits Laboratory, and other firms could have been substituted with essentially the same results.

At the outset, it seemed that three basic problems had to be solved: building a low-noise, high-intercept point i-f post-amplifier to compensate for the 6 to 7 dB conversion loss of the M6, setting the vfo drive level so that a constant +7 dBm LO signal would be injected into the M6 mixer across the entire vfo tuning range, and changing circuit impedances to accommodate the 50-ohm port impedances of the M6. Unfortunately, solving these problems led to other problems that made the task considerably more difficult than I had first imagined.

The circuit that finally evolved is shown in **fig. 6**. Several points should be mentioned. For one thing, the M6 does not like reactive terminations at its i-f port, and to a lesser extent at the LO port. Reactive terminations at these two ports adversely affect the conversion loss and the IM performance. Thus, it is not permissible to terminate the i-f (dc-coupled) port with a filter, since it becomes highly reactive at all frequencies outside the passband. Consequently, a grounded-gate jfet amplifier, biased to present an input impedance of 50 ohms, immediately follows the M6. The U320 jfet is specifically designed to provide high transconductance and outstanding IM performance in grounded-gate applications (and accordingly these outstanding qualities are reflected in its price). Other suitable "super jfets" are the U310, CP643, and CP651. It is important that the jfet installed in this circuit has a 3rd-order intercept point no less than 6 to 7 dB below that of the M6. Otherwise, the jfet becomes the weak link in the chain and the full benefit of the superior IM qualities of the double-balanced mixer is not realized. The pi-network output circuit couples the 2000-ohm output of the jfet stage to the i-f filter (also 2000 ohms in this case).

Fortunately, sufficient vfo output was available to provide the required +7 dBm of drive at the M6 LO port. The 3 dB resistive pad on the LO port tends to swamp out any impedance variations. The loaded vfo maintains a reasonably constant output amplitude over its frequency range. The impedance matching problem was solved by using a low-Q impedance matching network to transform the high output impedance of the 8.395 - 8.895 MHz bandpass filter down to 50 ohms. Matching the 50-ohm output impedance of the M6 to the high-impedance i-f filter was accomplished using the jfet grounded-gate amplifier as explained earlier. There was no difficulty in matching the 25-ohm output impedance of the vfo to the M6 LO port.

The first iteration of the circuit did not use the vfo lowpass filter or the second 8.395 - 8.895 MHz (50 ohm) bandpass filter. In addition, no special precautions were taken to shield the added circuitry. The result was obnoxious birdies every few kHz across the entire receiver tuning range. This was very perplexing — the original idea was to *reduce* spurious responses.

After some investigation, I discovered that the birdies were caused by high-order harmonics of the vfo (generated in the double-balanced mixer) heterodyning with harmonics of the heterodyne oscillator located elsewhere in the receiver. Don't forget that double-balanced mixers are extremely broadband devices that do a very efficient job of mixing, even up to several hundred MHz.

Further investigation revealed that the harmonics of the heterodyne oscillator were entering the double-balanced mixer through all three ports. Thus, the entire unit was placed in an aluminum mini-box and filtering was added at the LO and rf ports. The 50-ohm 8.395 - 8.895 MHz bandpass filter was needed (despite the existing 8.395 - 8.895 MHz bandpass filter) to increase rejection of first LO feedthrough via the first mixer.

Even after all these measures were taken, some birdies were still noticed. More investigation revealed still another problem — "contaminated" +15 volt lines. It turned out that the decoupling circuits in the +15 volt line were not adequate to prevent healthy jolts of the first LO energy getting everywhere in the receiver, including the double-balanced mixer. Therefore, I liberally applied a heavy dose of L-C decoupling circuits throughout the relevant sections of the receiver. The decoupling circuits consist of 0.001 μF bypass capacitors and small, single-layer rf chokes close-wound with no. 32 AWG (0.2mm) wire on 1 megohm, half-watt resistors. This involved considerable effort but it solved the problem.

The entire project from beginning to end was laborious and time consuming. Yet, the tremendous improvement in receiver IM performance justified the effort. I no longer notice IM distortion on 40 meters at night and strong local stations operating in the same band do not desensitize the receiver in all but the most extreme cases. An evaluation of the modified receiver front-end indicated that the second mixer was no longer the primary cause of IM distortion; that dubious distinction now belongs to the first mixer. There is really no reason why a repeat performance of the second mixer modification can't be made here, although the task could be somewhat more complicated. For one thing, the rf stage output circuitry would have to be modified to work into 50 ohms without degrading image rejection. In addition, the heterodyne oscillator signal would have to be amplified to a constant +7 dBm level for all amateur bands. I'm not saying that this all can't be done, but for the moment, I'll let someone else carry the ball.

other remedies

Using low-level, double-balanced mixers in a dual-conversion receiver substantially improves the frontend IM performance, but you do have other options. For example, the low-level mixers can be replaced with high-level types. These high-level double-balanced mixers require higher LO injection levels (up to one watt in some cases), but can provide 3rd-order intercept points in excess of +30 dBm, depending upon the device selected. For example, the Watkins - Johnson (Relcom) M9E yields a 3rd-order intercept point of typically +32 dBm with an LO injection level of +27 dBm. Active double-balanced mixers using jfets can also be built to provide similar performance, with the added advantage of providing conversion gain instead of the conversion loss inherent in passive double-balanced mixers. Unfortunately, high-level double-balanced mixers are quite expensive.

conclusion

Not all amateur receivers are indentical, so I have intentionally been somewhat general about the modifications. Different receivers have different requirements, so if you want to modify your receiver, you will have to tailor the work to your specific situation. Therefore, the main point of this exercise has not been to provide a step-by-step method of cleaning up a particular receiver frontend, but to review the nature of the receiver frontend maladies and illustrate some of the considerations and problems involved in upgrading receiver frontend IM performance. My efforts in this regard have been successful and I'm sure that other amateurs who attempt to improve their receiver frontends can realistically expect similar or even better results.

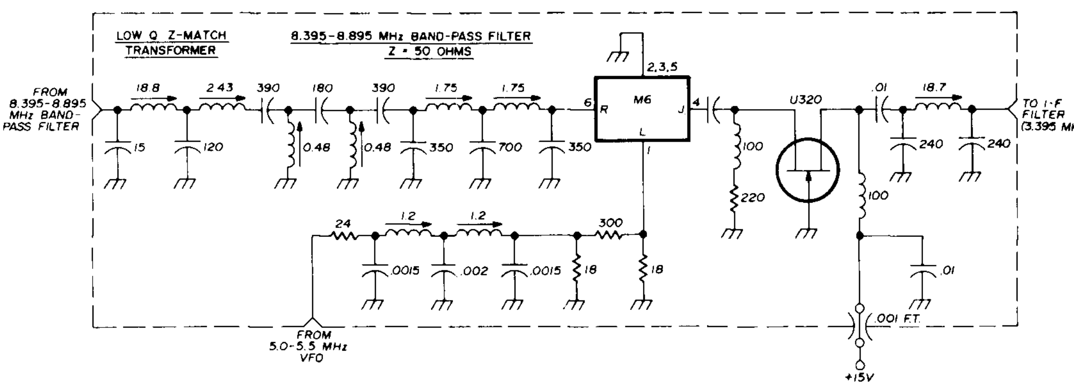

fig. 6. New second mixer incorporating the double-balanced mixer. All inductance values are in μH.

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ham radio

second-generation IC voltage regulators

A survey of easy-to-apply second-generation ICs for use with inexpensive voltage-regulated power supplies

Shortly after the monolithic IC operational amplifier made its appearance as a low-cost circuit component, those intrepid linear IC designers who gave us the μA709 and similar op amps began plans to offer IC voltage regulators. This was not accidental, because the IC op amps had already found a major market in regulated power supplies. Early IC voltage regulators were relatively awkward to use, requiring a considerable number of external components to make them work. Fairchild had its μA723, National had its LM300, and Motorola had its MC1460. These ICs are still useful; and they, or their slightly improved descendants, are still found in new commercial designs (the LM300 has been superseded by the LM305, and the MC1460 by the MC1469).

In the last few years, however, a new generation of IC voltage regulators has appeared on the scene. These newer types are *much* easier to use than the earlier regulators, and some are so inexpensive that they have even cut into the zener diode market.

The National LM309 was one of the earliest three-terminal voltage regulator ICs to be introduced, and is typical of the new generation of such devices. It is a +5 volt (output) regulator designed to regulate V_{cc} in TTL and DTL circuits for the immense digital logic market. The case of the LM309, normally grounded to the chassis for both electrical and heat conductivity, serves as the regulator's common lead and makes it really simple to use. As shown in **fig. 1**, the LM309 is available in two case styles: TO-3 and TO-39 (similar to TO-5), and supplies up to one ampere output current, depending upon the adequacy of the heatsink with which it is used.

By a curious quirk of fate, an *earlier* three-terminal voltage regulator made by Continental Devices Corporation (now a part of Teledyne), never really got off the ground. The CDC 513-4 was a +15 volt regulator enclosed in an inexpensive TO-5 plastic case. Had the CDC 513-4 been available with a different output voltage, or had it been released at a different time, perhaps it would have been the first successful three-terminal regulator. As it is, the CDC 513-4 is just an "also-ran" in the IC race.

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The success of the LM309 prompted further three-terminal regulator designs, and European Electronic Products (EEP) soon introduced the LM335, LM336, and LM337 in +5, +12 and +15 volts output versions, respectively; but available only in the TO-3 package.

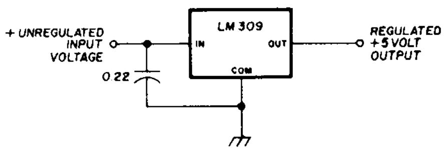


fig. 1. Simple circuit illustrates extreme simplicity for using the National LM309 three-terminal IC voltage regulator. Note that case is grounded and that a capacitor is used between input terminal and ground.

EEP is now known as Energy Electronic Products, and the foldback current-limited regulation curves of the EEP devices are shown in **fig. 2**.

The best attributes of the first three-terminal regulators of CDC, EEP, and National were combined in the Fairchild μA7800 series, which had the high-current capability of the LM309, the plastic package economy of the CDC 513-4, and the variety of output voltages of the EEP series. The Fairchild μA7805, 7806, 7808, 7812, 7815, 7818, and 7824 devices were packaged in either TO-3 enclosures or the less expensive TO-220 plastic power packages. The last two digits in each IC number identify the positive output voltage, and mean that +5, +6, +8, +12, +15, +18, and +24 volts, respectively, are available. Like the LM309 and EEP units, the case or metal-mounting tab is the common terminal, and is usually chassis grounded. Like the LM309 and the CDC 513-4, the μA7800 family is temperature-protected; that is, temperature rise of the chip controls shut-down. For this reason, the amount of current that the regulator will put out is dependent upon how well the heatsinking is accomplished, *and* which output voltage device you choose. For example, at 25°C the μA7805 will put out 500 mA, whereas the μA7824 will put out only 150 mA.

The Fairchild μA7800 family is perhaps the most popular, and also the most widely "second-sourced" three-terminal regulator of all. Similar devices, with similar part numbers, are produced by Motorola, National, Signetics, Silicon General, and others. These equivalents are shown in **table 1**.

low- and medium-current regulators

The basic μA7800 family has been expanded to create the μA78M00 and the μA78L00 subfamilies; the difference being that these subfamilies, using smaller packages, are designed to limit at lower currents. If you remember the "M" is for medium current, and "L" is for low current, you'll get the general idea. The μA78M00 family is packaged in TO-220 and TO-39 enclosures, while the μA78L00 family is produced in TO-39 and TO-92 packages. The TO-92 enclosure is, of course, a small plastic inline transistor package. At 25°C the respective output currents of the μA7805, μA78M05, and μA78L05 are approximately 500 mA, 300 mA, and 40 mA. One other difference to be noted in the μA78L00 family is that it is available with an output of +2.6 volts, as well as the aforementioned higher values. As with the μA7800 family, the "M" and "L" series are second-sourced by other manufacturers. **Tables 2 and 3** cover the μA78M00 and μA78L00 equivalents.

multivoltage regulators

National Semiconductor made a significant, if somewhat late, step forward with their LM340 and LM320 families of multivoltage, three-terminal IC voltage regulators. The LM340 series of devices is similar to the μA7800 series, and is produced in TO-3 and TO-220 packages. The companion LM320 series, however, is a family of *negative* voltage regulators, long needed by electronic circuit designers. The LM320 offered −5, −5.2, −6, −8, −12, −15, −18, and −24 volts. Now, the designer could easily construct a regulated power supply with outputs of ±5, ±6, ±8, ±12, ±15, ±18, and ±24 volts for operation of op amps and other linear ICs. Also, the

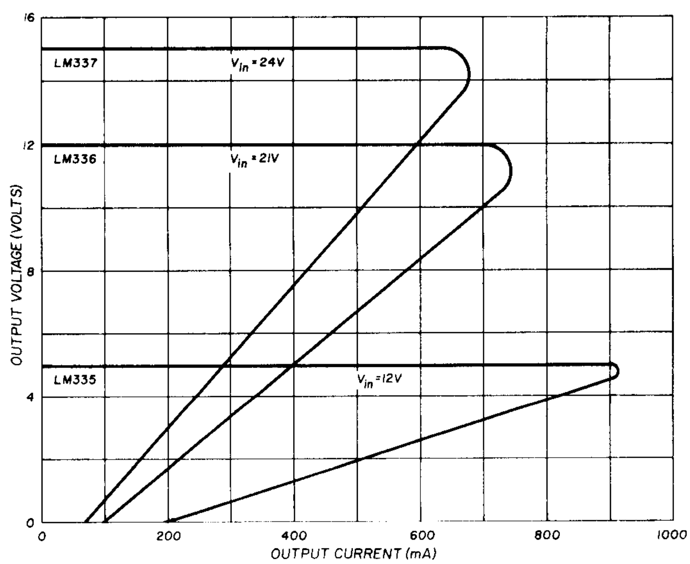


fig. 2. Output voltage and current characteristics of EEP voltage regulators LM335, LM336, and LM337. Note the relationship between input and output voltage, and the current-limiting characteristics of each.

important +12, −6 volt pair could be provided (for voltage comparators like the μA710 and μA711) as well as −5.2 volts for ECL ICs. Motorola and Fairchild quickly followed with negative-voltage three-terminal regulators offering the same output voltages, but with the addition of a −2 volt output member in their families. The three-terminal, negative-voltage regulators are shown in **tables 4 and 5**.

A word of caution is appropriate when using these negative regulators: *do not ground the case*! The case is *not* the common terminal, but rather, the input terminal. This is unfortunate from the user's point of view, but apparently is dictated by the subtlties of IC chip design and a knowledge of which element must be at substrate potential. As with the positive voltage three-terminal regulators, an input capacitor is placed across the IC (and in close proximity, to provide a low inductance connection) for stability. Such a negative voltage regulator is shown in **fig. 3**.

In Europe, the SGS/ATES company produces the L129, L130, and L131 series of voltage regulators furnishing +5, +12, and +15 volt outputs. These are enclosed in TO-126 plastic power packages (the smaller of two *Thermo-pad* packages manufactured by Motorola in the U. S.). Electrically, the L129, L130, L131 regulators are remarkably similar to the EEP LM335, LM336, and LM337 types in that they also employ foldback current limiting, rather than thermal protection.

high-current regulators

More recently, National introduced a higher current three-terminal regulator for +5 volt system regulation. The LM323 is a +5 volt, 3 amp device available only in a TO-3 case. Like its smaller relative, the LM309, the case is the common terminal, and – for stability – its input terminal requires a capacitor connected to the common terminal.

The National LM345 is similar to the LM323 in that it, too, is a 3-amp device, but provides negative output voltages. The LM345 is available with regulated outputs of −5.0 and −5.2 volts. As with the LM320 series, the case is the *input*, not the *common*, terminal. The LM345, also, is made only in a TO-3 package. National makes three other groups of proprietary three-terminal regulators designated as the LM341, LM342, and LM3910. The LM341 series is available with output voltages of +5, +6, +8, +12, +15, +18, and +24 volts, and is roughly comparable to the Fairchild μA78M00 family. The LM341 series is only available in a TO-202 plastic power package (similar to the package that General Electric uses for its plastic power transistors).

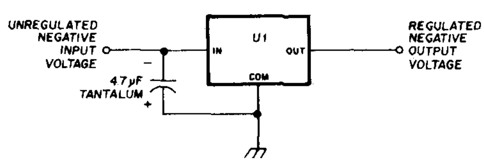


fig. 3. Application of the three-terminal IC negative-voltage regulators such as the National LM320 or National μA7900 series. Note that the case must not be grounded. See text for details.

The LM342 series is available in both TO-202 and TO-39 packages, and is also available with the same voltages as the LM341 family. The LM342 family has lower output current than the LM341 family.

A still-lower-current three-terminal IC regulator made by National is the LM3910 series packaged in TO-39 or TO-92 cases. This series is meant to replace the μA78L00 family with tighter output voltage tolerance, higher ripple rejection, better regulation, and lower

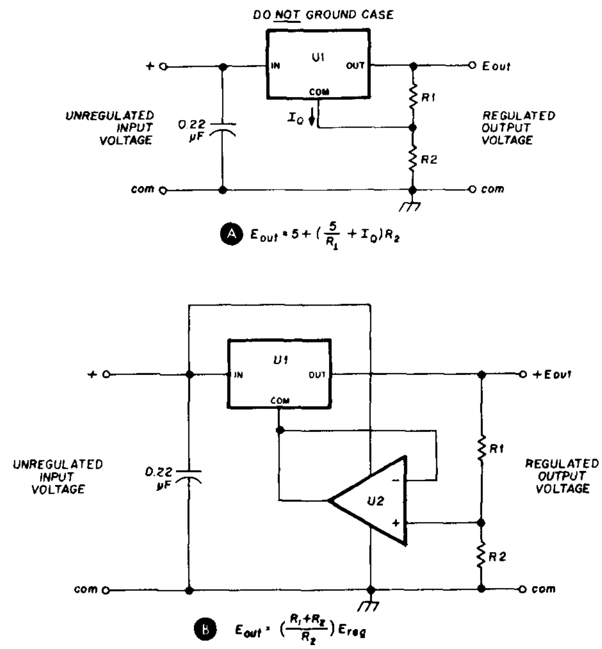


fig. 4. The circuit in (A) shows a simple method of increasing nominal output voltage of a three-terminal IC voltage regulator such as the National LM340-05. R1, R2 form a simple voltage-divider network. The circuit in (B) shows how a three-terminal IC positive-voltage regulator can be combined with an op amp to increase the regulated output voltage. Text has details.

quiescent current. To see the relative output currents of the LM341, LM342, and LM3910 families, let's compare the output current of each at +5 volts. At 25°C, the LM341-05 furnishes 500 mA, the LM342-05 furnishes 200 mA, and the LM3910-5.0 furnishes 100 mA.

circuit applications

Many three-terminal IC regulators may be paralleled to provide higher current output. This is not advisable with the various LM309 types, but works well with the LM320, LM340, μA7800, and μA7900 ICs (and their equivalents).

There are several circuit tricks that may be played with three-terminal regulators to change their output voltages. The simplest one is shown in **fig. 4A**. Note that this technique can be used only to *raise* the regulated output voltage and that it slightly degrades regulation. The smaller the value of R2, the better the regulation, so it follows that the IC furnishing the closest voltage *on the low side* of the desired output voltage should be used.

A technique which allows variation of the output voltage uses an op amp as a non-inverting follower to table 1. Three-terminal positive IC voltage regulators by type number, voltage rating, and manufacturer. All are similar to the Fairchild µA7800 series. See text for current ratings and other characteristics. Blanks indicate that an equivalent IC is not available.

manufacturer	+5V	+6V	+8V	+10V	+12V	+15V	+18V	+20V	+24V	+28V
Fairchild	µA7805	µA7806	µA7808	-----	µA7812	µA7815	µA7818	-----	µA7824	-----
Lambda	LAS1505	LAS1506	LAS1508	LAS1510	LAS1512	LAS1515	LAS1518	LAS1520	LAS1524	LAS1528
Motorola	MC7805	MC7806	MC7808	-----	MC7812	MC7815	MC7818	MC7820	MC7824	-----
Motorola-HEP	C6110P	C6111P	C6112P	-----	C6113P	C6114P	C6115P	-----	C6116P	-----
National	LM340-5	LM340-6	LM340-8	-----	LM340-12	LM340-15	LM340-18	-----	LM340-24	-----
National	LM7805	LM7806	LM7808	-----	LM7812	LM7815	LM7818	-----	LM7824	-----
Raytheon	RC7805	RC7806	RC7808	-----	RC7812	RC7815	RC7818	-----	RC7824	-----
Signetics	µA7805	µA7806	µA7808	-----	µA7812	µ7815	µ7818	-----	µA7824	-----
Silicon General	SG7805	SG7806	SG7808	-----	SG7812	SG7815	SG7818	-----	SG7824	-----

table 2. Medium-current (designated by the letter M), three-terminal, positive voltage-regulator IC by type number, voltage rating and manufacturer. See text for description.

manufacturer	+5V	+6V	+8V	+10V	+12V	+15V	+18V	+20V	+24V
Fairchild	µA78M05	µA78M06	µA78M08	-----	µA78M12	µA78M15	µA78M18	µA78M20	µA78M24
Motorola	MC78M05	MC78M06	MC78M08	-----	MC78M12	MC78M15	MC78M18	MC78M20	MC78M24
National	LM341-5	LM341-6	LM341-8	-----	LM341-12	LM341-15	LM341-18	-----	LM341-24
Signetics	µA78M05	µA78M06	µA78M08	-----	µA78M12	µA78M15	µA78M18	µA78M20	µA78M24
Motorola	MC7705	MC7706	MC7708	-----	MC7712	MC7715	MC7718	MC7720	MC7724
Teledyne	78M05	78M06	78M08	-----	78M12	78M15	-----	78M20	78M24

table 3. Low-current (designated by the letter L), three-terminal, positive voltage-regulator ICs by type number, voltage rating, and manufacturer. These devices are very popular for regulating single op amp or linear IC stages.

manufacturer	+2.6V	+5V	+6V	+8V	+10V	+12V	+15V	+18V	+20V	+24V
Teledyne	-----	-----	-----	-----	-----	829	830	-----	-----	-----
Fairchild	µA78L02	µA78L05	µA78L06	-----	-----	µA78L12	µA78L15	-----	-----	-----
Motorola	-----	MC78L05	-----	MC78L08	-----	MC78L12	MC78L15	MC78L18	-----	MC78L24
National	-----	LM342-5	LM342-6	LM342-8	LM342-10	LM342-12	LM342-15	LM342-18	-----	LM342-24
National	-----	LM3910-5	LM3910-6	LM3910-8	LM3910-10	LM3910-12	LM3910-15	LM3910-18	-----	LM3910-24
National	-----	LM78L05	-----	LM78L08	-----	LM78L12	LM78L15	LM78L18	-----	LM78L24
Signetics	µA78L02	µA78L05	µA78L06	-----	-----	µA78L12	µA78L15	-----	-----	-----
Plessey	-----	SL78L05	SL78L06	SL78L08	-----	SL78L12	SL78L15	SL78L18	SL78L20	SL78L24

table 4. Three-terminal negative IC voltage regulators by type number, voltage rating, and manufacturer. All are similar to the Fairchild µA7900 series. See text for current ratings and other operating characteristics.

manufacturer	−2.0V	−5.0V	−5.2V	−6V	−8V	−12V	−15V	−18V	−24V
Fairchild	-----	µA7905	µA7952	µA7906	µA7908	µA7912	µA7915	µA7918	µA7924
Motorola	C6117P	C6118P	C6119P	C6120P	C6121P	C6122P	C6123P	C6124P	C6125P
Motorola	MC7902	MC7905	MC7905.2	MC7906	MC7908	MC7912	MC7915	MC7918	MC7924
National	-----	LM320-5	LM320-5.2	LM320-6	-----	LM320-12	LM320-15	LM320-18	LM320-24
Silicon General	-----	SG320-5	SG320-5.2	-----	-----	SG320-12	SG320-15	-----	-----

table 5. Low- and medium-current, three-terminal negative IC voltage regulators manufactured by Fairchild and Motorola. The low-current version is designated by a letter L in the part number, while the letter M indicates medium-current capability.

manufacturer	−3V	−5V	−5.2V	−6V	−8V	−12V	−15V	−18V	−20V	−24V
Motorola	MC79L03	MC79L05	-----	-----	-----	MC79L12	MC79L15	MC79L18	-----	MC79L24
Fairchild	-----	µA79M05	-----	µA79M06	µA79M08	µA79M12	µA79M15	-----	µA79M20	µA79M24

sample the output voltage divider and drive the common terminal of the three-terminal regulator. This circuit overcomes the degradation of regulation of the simpler circuit shown in **fig. 4A**. The op amp variation is shown in **fig. 4B**. Again, only voltages higher than the nominal regulated voltage may be achieved.

The circuit of **fig. 5** shows a "real-value" circuit which is capable of output voltages from +7 to +20 volts. Reference 1 shows many more uses for three-terminal IC voltage regulators, but many are so complex as to defeat the purpose of these simple ICs.

Three-terminal voltage regulators have made it possible for commercial firms to offer simple, inexpensive modular power supplies that even experimenters can afford. For instance, for $8.95, plus $1.25 handling, Adva* offers kits including PC board, transformers, and

*Adva Electronics, Box 4181 BE, Woodside, California 94062.

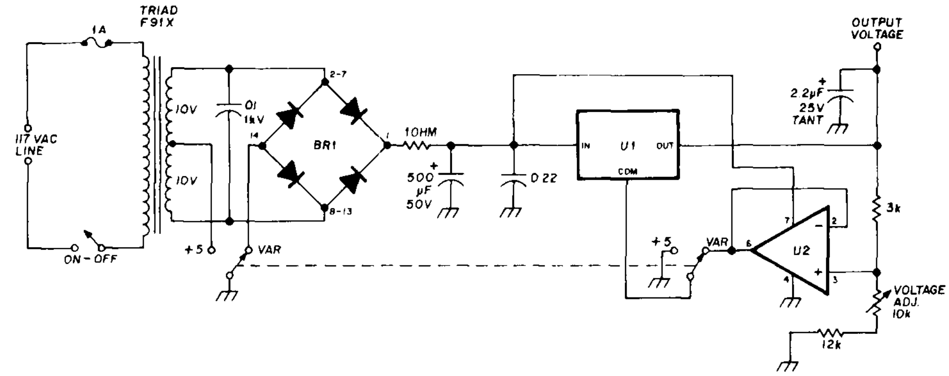


fig. 5. Circuit capable of providing fixed-variable output voltages; for example, +5V at 200 mA or 7-20V at 100 mA. Heatsink tab of U1 must be connected to floating heatsink. BR 1 is Adva bridge, U1 is LM340-05, and U2 is National LM741 CM op amp.

parts for construction of +5, +6, +9, +12, and +15 volt fixed, voltage-regulated power supplies. These supplies are based on the National LM340 series of three-terminal IC voltage regulators. Since all the Adva power supplies use the same type PC board, and the 9-volt unit uses two circuits like that of **fig. 4A**, output voltages are readily trimmable by adding a couple of resistors.

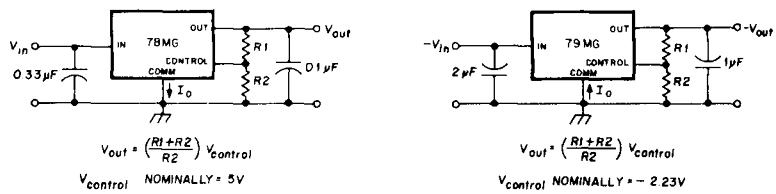


fig. 6. Fairchild 78MG and 79MG four-terminal IC voltage regulators. The 79MG can provide +5 to +30 volts and 79MG can provide −2.2 to −30 volts, regulated. Current through R2 should be approximately 1 mA; therefore, R2 = 5k ohms for the 78MG, and 2.2k ohms for the 79MG.

Two recent ICs introduced by Fairchild are the 78MG and 79MG four-terminal voltage regulators. The 78MG is a positive voltage, and the 79MG a negative voltage regulator. They operate in the same general manner as the combination three-terminal voltage regulator and op amp of **fig. 4B**, requiring only a resistive divider to set the output voltage. Circuits using the 78MG and 79MG regulators are shown in **fig. 6**. These two ICs are offered in a plastic power package that has four pins on what appears to be a half-DIP package, with heatsink "ears" protruding from each side. The package is shown in **fig.**

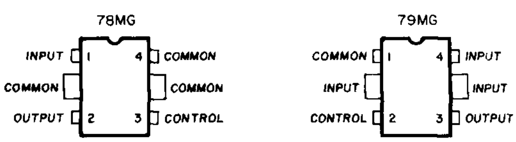


fig. 7. Top views of package connection diagram for Fairchild 78MG and 79MG voltage regulators of fig. 6.

7. The 78MG and 79MG regulators may be set for output voltages from +5 to +30 and −2.2 to −30 volts.

Some regulators are devoted to fixed *dual* output voltages. Inasmuch as ±15 volts is the most common voltage for powering op amps, it is also the most common voltage rating for fixed, dual voltage regulators. There are also several dual positive-negative regulators available, such as the Silicon General SG3501, Motorola MC1468, and Raytheon RC4194, which may be used to produce *adjustable* dual outputs. These devices require one or more external resistors to establish the desired output voltages. Dual regulators built around these units are shown in **fig. 8**. The current capability of all three of these ICs may be increased by adding external power transistors and other discrete components, as discussed in references 2, 3, and 4.

Raytheon's RC4195 and National's LM325, 326, and 327, however, take the dual-voltage regulator a step further in the direction that made the three-terminal regulator so popular. These four ICs offer *fixed*, dual output voltage and simplicity of application — as well as an inexpensive power package option. The Raytheon RC4195 is available in a 9-pin TO-66, an 8-pin TO-5 and a plastic half-DIP. The TO-66 (RC4195TK) has the greatest heat dissipation, and may be used up to currents of 100 mA. The smaller RC4195T and RC4195DN (TO-5 and half-DIP) are better suited for spot-regulating op amps in which lower currents are required. A simple ±15 volt regulator using the RC4195T or RC4195DN is shown in **fig. 9**. Note that the pin connections would be changed if the RC4195TK unit were used.[4]

The National LM325, LM326, and LM327 are for ±15, ±12, and +5, −12 volts, respectively. They are available in the 14-pin DIP (suffix N), the 14-pin DIP power package (suffix S), and the 10-pin TO-100 package (suffix H). The TO-100 package is similar to the

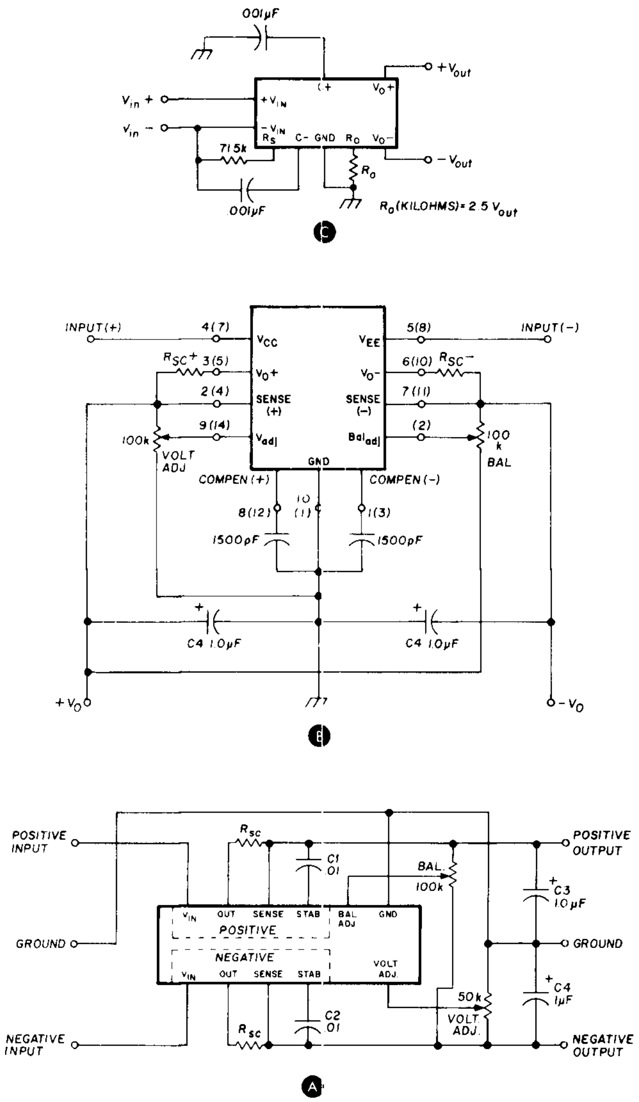


fig. 8. Silicon General SG3501 (A) is shown in variable ± voltage-regulator circuit. External resistors establish (dual) output voltages. Motorola MC1468 (B) and Raytheon RC4194 (C) in similar circuits serve the same purpose and perform the same function.

TO-5 package, but has 10 pins. These fixed, dual regulators are aimed at the linear IC market, the very large MOS logic market in which common output voltages are +5, and −12 volts.

The S package is similar to that used by SGS/ATES

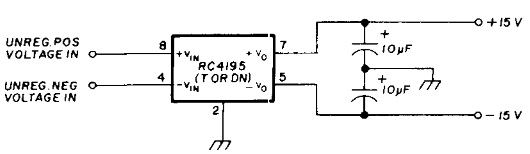


fig. 9. Raytheon RC4195T (or RC4195DN) in simple voltage-regulator circuit provides dual output voltages (±15 volts) at currents of up to 100 mA. This device is suitable for "spot" regulation of op amps.

and others in their audio power amplifier ICs in that it has a thick metal strap running the length of the DIP, which is bent over at the ends. The idea is to solder these bent-over ends into the copper lands of a PC board, to facilitate heat dissipation. The use of these ICs as dual regulators is shown in **fig. 10**. Different pin connections will be required if the N or H packages are used. With good heatsinking, the S version is capable of up to 100 mA output. The LM325, 326, 327 family may also be used with external power transistors to increase their current capability; this is covered in reference 1.

higher-current regulators

Finally we come to the brutes of the voltage regulator scene, the MPC900 (negative) and the MPC1000 (positive). These are *not* fixed-voltage regulators at all, but they do represent the ultimate (to date) in current capability for single-regulator ICs. Ten amperes is the maximum output current of these devices, and they may be set to provide output voltages of −4 to −30 volts and +2 to +35 volts, respectively. **Fig. 11** shows these ICs in useful circuits. Of course, very low thermal resistance heatsinking should be used with these ICs if maximum current is to be drawn from them. These ICs are relatively expensive, and most amateurs will probably choose smaller and more complicated, but less expensive IC voltage regulators with external power transistor(s) to boost output current.

summary

In this article I have attempted to cover only the newer generation of IC voltage regulators, touching only briefly, for comparison purposes, on the older types. The older types are still useful, and many companies still elect to use them in new designs because they are so widely second-sourced and have become so inexpensive. References to new ICs have, in this article, been made to the least expensive commercial grades of each IC, which is what amateurs find most available. It should also be borne in mind that all of these IC types are *series* regulators, and require a certain minimum difference voltage across the chip — typically between 2 and 3 volts. The input (unregulated) voltage *must* be at least 2 or 3 volts higher than the output (regulated) voltage.

Most regulator ICs require some sort of external compensating capacitor, and will oscillate without this

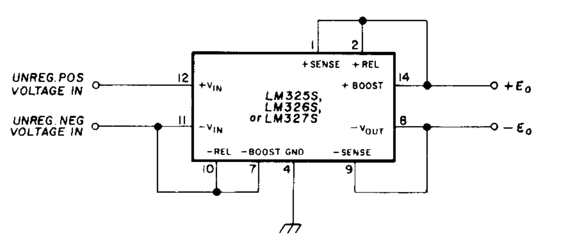
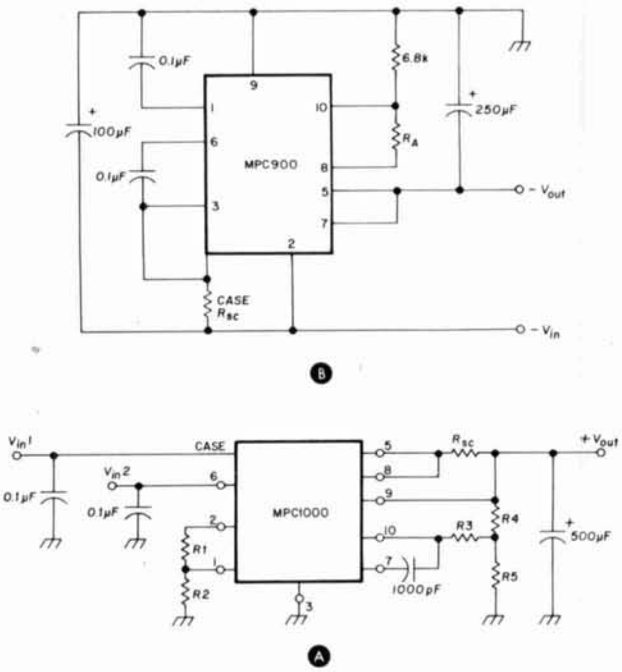


fig. 10. National LM325S, LM326S, and LM327S provide interesting dual-voltage regulated outputs at +15, +12; and +5, −12 volts, respectively. These are available in DIP configurations and aimed at linear IC applications.



PARAMETER VALUES FOR BEST RESULTS

	$2V < V_O < 7V$	$7V < V_O < 35V$
R1	$\cong \frac{R2\,(7-V_O)}{V_O}$	$\cong \left[\frac{R4\,R5}{R4+R5}\right]$
R2	$10k < R1+R2 < 100k$	∞
R3	$\cong \left[\frac{R1\,R2}{R1+R2}\right]$	–
R4	–	$\cong \frac{R5\,(V_O-7)}{7}$
R5	∞	$10k < R5 < 100k$
R_{sc}	$\cong \frac{0.66}{I_{sc}}$ @ $T_J = 25°C$	

fig. 11. High-current, up to 10 amperes, can be handled by the MPC1000 and MPC900 IC devices; the MPC1000 is for positive output voltages and the MPC900 is for negative output voltages. These regulators may be set from +2 to +35 and −4 to −30 volts, but require special heatsinking.

capacitor. This capacitor *must* be wired close to the IC to minimize the inductance of the leads. It is always a good idea to check the manufacturer's data sheet of the regulator IC for the connections of each particular package because different package versions of the same IC can have quite different connections. Finally, the same spec sheet should also be consulted to find out what the IC's built-in heatsink is connected to. Arbitrary grounding of the heatsink tab or case can spell instant demise of the IC.

references

1. *Voltage Regulator Handbook*, section 7, National Semiconductor Corporation, Santa Clara, California, 1975.
2. Silicon General Technical Bulletin 1501, "Dual Voltage Tracking Regulator," October, 1970.
3. Motorola Semiconductor DS9213, "Dual ±15 Volt Regulator," October, 1972.
4. *Total Linears Handbook*, Raytheon Company, Semiconductor Division, Mountain View, California.

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More Details? CHECK—OFF Page 126

the polarization diplexer — a polaplexer

The polaplexer combines orthogonally-polarized signals from receiver and transmitter to permit full duplex operation

The polaplexer is a coined name for the POLArization-diPLEXER used by the San Bernardino Microwave Society (SBMS) to provide isolation between a microwave transmitter and receiver. This method uses the transmitter as the receiver local oscillator, thereby economizing on microwave sources. The polaplexer allows duplex communications (simultaneous transmission and reception) with minimum power loss. The use of the polaplexer within the complete communications system has been covered in past articles.[1,2,3]

The polaplexer uses circular waveguide as a transmission line, supporting orthogonal (at right angles) polarization for transmitting and receiving. In use, the polarizations are neither vertical nor horizontal, but at angles of 45 degrees to the vertical. The standard in use by the SBMS is that the polarization of the transmitted wave from all antennas is 45 degrees to the right, looking in the direction of transmission; the polarization of the received signal, orthogonal or at right angles to the transmitted signal, is 45 degrees to the left, looking in the direction of the other station. It can be seen in **fig. 1** that at the receiving site the signal coming from the distant transmitter will be polarized properly to be intercepted.

waveguides and polaplexers

The circular waveguide used for construction of the polaplexer does not have to be silvered brass. Ordinary tin cans can be used if they have the proper diameter. The circular waveguide can be used as a feedhorn for a parabolic reflector or used to excite a circular horn. As will be shown, the circular waveguide must be within a proper size range for the frequency being used. The polaplexer operates in the dominant circular waveguide mode known as the TE_{11} mode; the field configuration is shown in **fig. 2**. In order not to excite other waveguide modes, the waveguide diameter must be selected to exclude other modes. The waveguide size must be such that it will sustain propagation above the cutoff frequency of the TE_{11} waveguide mode and below the cutoff frequency of the next higher TM_{01} mode. The cutoff frequency is that frequency below which the attenuation of the waveguide, to that particular mode, increases at a rate which makes the waveguide useless except as an attenuator. To support the desirable TE_{11} mode in circular waveguide the cutoff frequency, f_c, is defined by

$$f_c(TE_{11}) = \frac{175698.51}{d\ (mm)} = \frac{6917.26}{d\ (inches)} \qquad (1)$$

where

f_c = cutoff frequency in MHz for TE_{11} mode
d = waveguide inside diameter

The TM_{01} mode can be supported in circular waveguide whose cutoff frequency is defined by

$$f_c(TM_{01}) = \frac{229485.13}{d\ (mm)} = \frac{9034.85}{d\ (inches)} \qquad (2)$$

Another term that will be used in calculations is guide wavelength, λg. The wavelength in a circular waveguide always exceeds the free-space wavelength and is related

By George Tillitson, K6MBL, San Bernardino Microwave Society, Inc., 1080 Sapphite Lane, Corona, California 91720

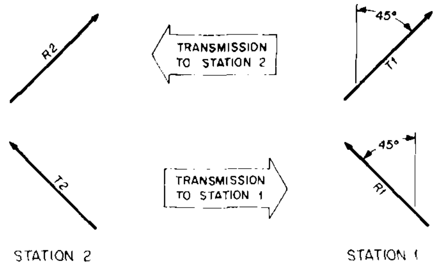

fig. 1. Polarization standards adopted by the San Bernardino Microwave Society.

to the cutoff frequency and operating frequency by the following equation

$$\lambda g = \frac{299792.5(mm)}{\sqrt{f_o{}^2 - f_c{}^2}} = \frac{11802.85(inches)}{\sqrt{f_o{}^2 - f_c{}^2}} \quad (3)$$

where

λg = guide wavelength
f_o = operating frequency
f_c = TE_{11} waveguide cutoff frequency

In practice two operating frequencies are used, separated by the i-f frequency. The operating frequency should be the geometric mean of the two operating frequencies or

$$f_o = \sqrt{f_{01} f_{02}} \quad (4)$$

where

f_o = mean operating frequency
f_{01} = lower communications frequency
f_{02} = upper communications frequency

Substituting the second equation into the first,

$$\lambda g = \frac{299792.5(mm)}{\sqrt{f_{01} f_{02} - f_c{}^2}} = \frac{11802.85(inches)}{\sqrt{f_{01} f_{02} - f_c{}^2}} \quad (5)$$

probes

Since many of our microwave devices have coaxial terminations, we must have a transition from coaxial (TEM mode) to the circular waveguide TE_{11} mode. This can be accomplished by inserting a 1/4-wavelength ground plane or probe. It should be placed 1/4-guide wavelength from the closed end of the waveguide as shown in **fig. 3**.

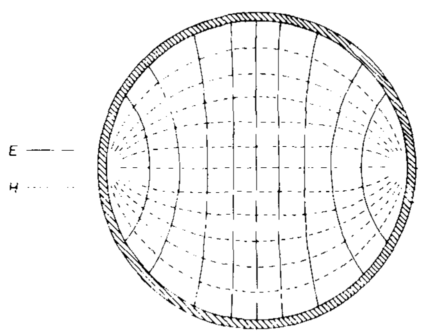

fig. 2. TE_{11} field configuration in circular waveguides.

In the polaplexer, the transmitter and receiver terminations are orthogonal. If they were both placed 1/4-guide wavelength from the closed end of the polaplexer, they would touch. Further, even if they had no physical contact, the close proximity would reduce the desired isolation between them. Fortunately, in a transmission line impedances repeat each ½ wavelength along the line. If the orthogonal coaxial-to-waveguide transition is placed ½-guide wavelength toward the open end of the circular waveguide from the other transition, both polarizations can be excited in the waveguide with 20 to 40 dB isolation between them. **Fig. 4** depicts the orthogonal transition.

To make the basic polaplexer complete, a method of controlled injection of the transmitter signal into the receiver input must be devised because the transmitter is used as the receiver local oscillator. The first thought might be to place an injection screw halfway between the two orthogonal probes. Wrong! Well, half wrong anyway. Halfway between the two probes is ½-guide wavelengths from the closed end of the waveguide. The injection screw will do little more at this location than isolate the inboard probe. Therefore, the injection screw

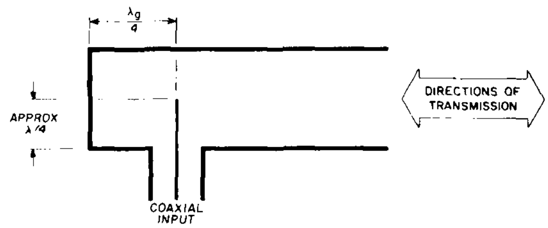

fig. 3. Circular waveguide to coaxial transition.

should be placed 1/3-wavelength (spacing arbitrary on my part) from the closed end of the waveguide at an angle which bisects the orthogonal probe polarizations. The designer has a choice of equally effective locations to select from.

polaplexer design

The total length of the polaplexer should approach an odd number of quarter-guide wavelengths. This will provide the best impedance match within the waveguide. A waveguide that is not perfectly matched becomes a form of a resonant transmission line. If you assume you have a resonant transmission line and design the polaplexer length with this in mind, you cannot go wrong, even if you operate with a 1.00:1 vswr.

It will be shown that, using the three equations presented previously, a can with an inside diameter of 2-9/16 inches (about 2.56 inches or 65.0 mm) can be used as a polaplexer for the 3300-MHz amateur microwave band. First, the cutoff frequency for the TE_{11} mode is

$$f_c = \frac{175698.51}{65.0} = 2699.4\ MHz$$

That tells us the waveguide will support the TE_{11}

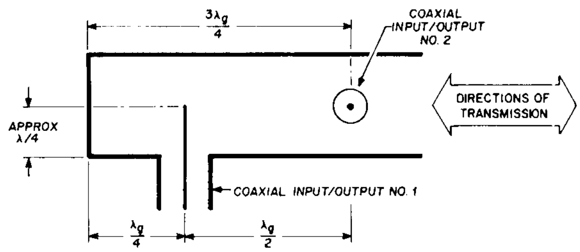

fig. 4. Circular waveguide with orthogonal coaxial inputs.

mode above 2700 MHz. Second, the cutoff frequency for the TM_{01} mode is

$$f_c = \frac{229485.13}{65.0} = 3525.8 \text{ MHz}$$

This tells us that if we operate below 3525 MHz we will not excite the TM_{01} waveguide mode. The third important parameter is guide wavelength. The 3300-MHz operating frequencies in southern California are 3335 MHz and 3365 MHz. Applying these and the TE_{11} mode cutoff frequency to **eq. 5** we obtain

$$\lambda g = \frac{299792.5}{\sqrt{3335 \cdot 3365 - (2699.42)^2}} = 151.1 \text{mm}$$
$$= 5.95 \text{ inches}$$

The dimensions needed to design a polaplexer are

1/4λg	=	37.8 mm	=	1.49 inches
3/4 λg	=	113.3 mm	=	4.46 inches
5/4 λg	=	188.9 mm	=	7.44 inches
7/4 λg	=	264.5 mm	=	10.41 inches
1/3 λg	=	50.4 mm	=	1.98 inches

Since the 7/4-λg length is a bit long, the 5/4-λg polaplexer length should be selected as a goal. The actual construction of a polaplexer is usually custom designed for and by the individual dependent upon the designer's resources. One configuration that I have used, on both the 3300 and 5700-MHz amateur bands, is illustrated in **fig. 5.**

One problem facing the polaplexer designer who uses simple probe injection is the probe length. An empirical equation that I have used successfully is

$$\ell = \frac{74948.13\,(1 + P - \sqrt{P})}{f_o} \text{ (mm)}$$

$$\ell = \frac{2950.71\,(1 + P - \sqrt{P})}{f_o} \text{ (inches)} \qquad (6)$$

where

ℓ = probe length
f_o = mean operating frequency
P = periphery of probe
$= \frac{\pi D}{\lambda_o}$ for circular cross section
D = probe diameter

For example, assume the probe to be a no. 18 AWG (1mm) copper wire and the operating band to be 3300 MHz. The wire diameter is 1.0 mm (0.0403 in.). The operating wavelength is

$$\lambda_o = \frac{299792.5}{f_o} \text{ (mm)} = \frac{11802.85}{f_o} \text{ (inches)}$$
$$= \frac{299792.5}{\sqrt{3335 \cdot 3365}} = 89.5 \text{ mm} = 3.52 \text{ inches}$$

The periphery of the probe is

$$P = \frac{\pi D}{\lambda_o} = \frac{\pi 1.0}{89.5} = 0.035$$

The length therefore is

$$\ell = \frac{74948.13\,(1 + 0.0359 - \sqrt{0.0359}\,)}{\sqrt{3335 \cdot 3365}}$$
$$= 18.9357 \text{ mm} = 0.7455 \text{ inches}$$

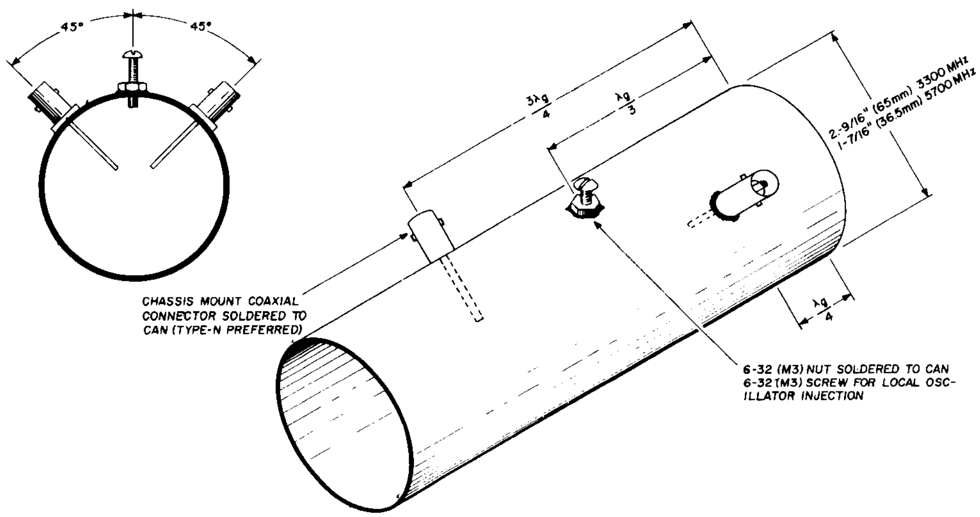

fig. 5. Typical polaplexer showing layout and dimensions of principle parts.

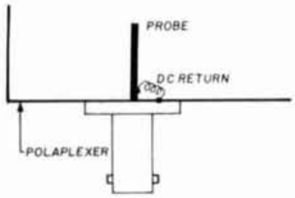

fig. 7. Ground return for the receiver port in a polaplexer. The coil is 3 or 4 turns no. 30 AWG (0.25mm) wound over a piece of no. 20 AWG (0.8mm) wire as a coil form. The coil is soldered to the probe and the side of the polaplexer after removing the coil form.

mixers

There are many methods of providing a satisfactory transition from the coaxial TEM mode to the circular waveguide TE_{11} mode. The method illustrated in **fig. 5** is perhaps the simplest. However, it has the disadvantage of not providing the necessary dc return for a simple crystal mixer. I prefer using a coaxial-crystal mixer that provides the dc return with a tunable stub. Although the many and varied means of providing a dc return for a crystal mixer are beyond the scope of this effort, one method which I have used is shown in **fig. 6**. It provides a complete tunable mixer assembly. The BNC output subassembly was obtained from a surplus rectangular-waveguide mixer assembly and includes the necessary microwave-bypass capacitor to provide efficient conversion. The insulator in **fig. 6** is the capacitor dielectric.

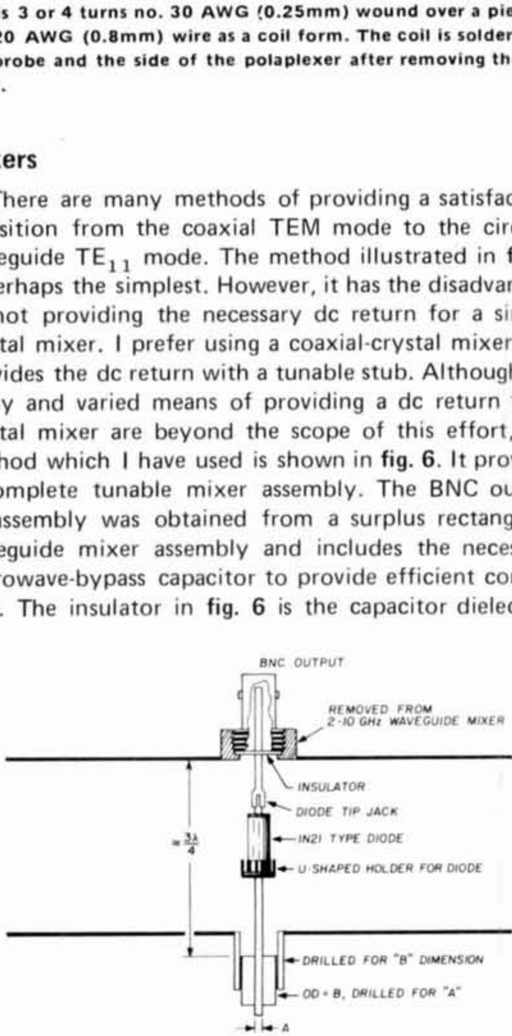

fig. 6. Coaxial crystal mixer.

The actual sizes of the adjustable short are left up to you and your own resources. The tolerances should be close. The center adjustment (identified by dimension **B**) could be threaded if desired and locking hardware used to maintain the adjustment once optimized. The crystal can be any good IN21-type crystal diode.

references

1. Richard Kolbly, K6HIJ, "Standards for Amateur Microwave Communications," *ham radio*, September, 1969, page 54.
2. Richard Kolbly, K6HIJ, "A Low Cost Amateur Microwave Antenna," *ham radio*, November, 1969, page 52.
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ham radio

24-hour clock

with digital readout and line-frequency time base

Complete construction details for a four-digit clock which uses a total of six ICs

During recent visits to other amateur stations, I noticed the increased use of electronic digital displays. These range from displays on very expensive transceivers, both hf and vhf, to frequency counters, clocks, voltmeters, thermometers, and even one that converts received CW signals to an alphanumeric display. Some even contain lighting that simulates a digital readout!

the digital clock

Returning to my station and looking at the old reliable HT-37 and its companion receiver made me feel that something was lacking. However, the price tags on some of the newer gear made my equipment seem more acceptable. Still these electronic displays really caught my fancy — I *had* to have a piece of digital-display gear!

After some thought I came up with some requirements. My first digital display project had to be low in cost, simple, and small, in that order. My old 24-hour clock had given up the ghost after four years of faithful but loud service, so I decided on a digital clock for a first project. I'd seen a number of articles on digital clocks. These were not overly complex, but the component count was high, with many discrete components required in the display circuits. Most of these designs used a crystal time base operating at a high frequency and required a long countdown chain to divide the high-frequency signal to the frequency required by the clock circuit. To keep the component count down I looked into the use of the 60-Hz frequency as a time base. I found that, because of the power grid system used by the power companies to maintain the 60-Hz frequency, the clock accuracy over a long period would be nearly as good as that using a crystal time base. The short-term accuracy of the crystal system is better, but for a 24-hour clock for amateur use the 60-Hz line is a very good choice.

The next area for component reduction was the display system and the drivers usually associated with it. Most circuits use 11 driver transistors and as many as 22 resistors. After a little looking I found some display units that require only a simple four-line BCD input. The component count was coming down fast! You've all seen ads for the "Clock on a Chip," but a close look shows that it takes much more than just a chip. After some reading, shopping, and two evenings of wiring I got the clock down to two chips and no discrete transistors. Nothing fancy, but it functions well, is very easy to build, and looks great.

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The heart of the unit is the MM5312 IC (**fig. 1**). The internal functions of this chip are quite complex, but basically the chip divides the 60-Hz line frequency to one pulse per minute and advances its internal storage register at that rate. The output of that register is available in binary form at pins 1, 2, 3, and 24. The outputs are synchronized with the digit-enable outputs, pins 18, 19, 20 and 21. The coincidence of these signals allows you to apply the binary data to all four displays in parallel, with the digit-enable lines controlling which display accepts data at the correct time. This scheme minimizes the number of output lines required to operate the display. The second IC is a type SN7404N inverter. This chip converts the MM5312 binary output data to a TTL level for operation of the display units.

The display units actually contain ICs that store and decode the data and drive the LEDs that form the digital display. The displays have a blanking input, which we use to control their intensity in this application.

The power supply furnishes +5 and −12 volts to operate the circuitry and furnishes a 60-Hz reference for the clock chip through the 0.1 Meg resistor to pin 16 of U1. Zener-diode regulation maintains the output levels.

construction

The digital clock was built using perf board and wire-wrap techniques since the circuit contains only two ICs. The perf-board and wire-wrap technique is fast and easy; best of all it is very forgiving. If you make an error or want to change a circuit, simply remove the wire and wrap on a new lead. The tool required for this technique is available from the source shown in the parts list, **table 1**. Number 30 AWG (0.25mm) wire is used with the wire-wrap tool, Strip insulation back about one inch (25mm) insert the wire into the tool, and place the tool over the pin to be wrapped. Turn the tool clockwise until the wrap is complete. This method provides excellent connections of the type used in many large-scale computer systems.

Layout and wire routing is not critical and any packaging scheme you might desire could be used. I cut a piece of perf-board slightly smaller than the inside dimensions of the case, then I cut a second piece of board large enough to hold the single socket used for the four displays. The smaller display board was then epoxied to the front edge of the larger board to form a right angle for the display, as shown in **fig. 4**. The

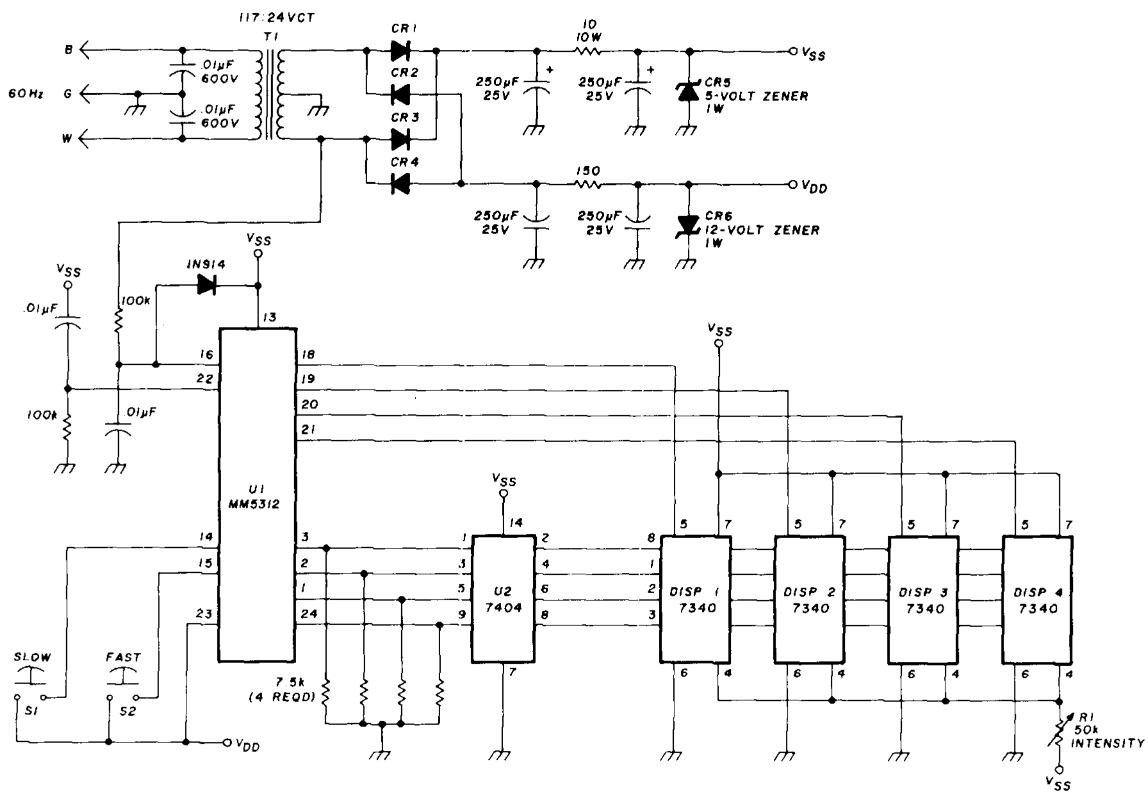


fig. 1. Schematic of the 24-hour digital-display clock including power supply. Resistors are ½ watt and capacitors are 50 volts or greater unless indicated otherwise.

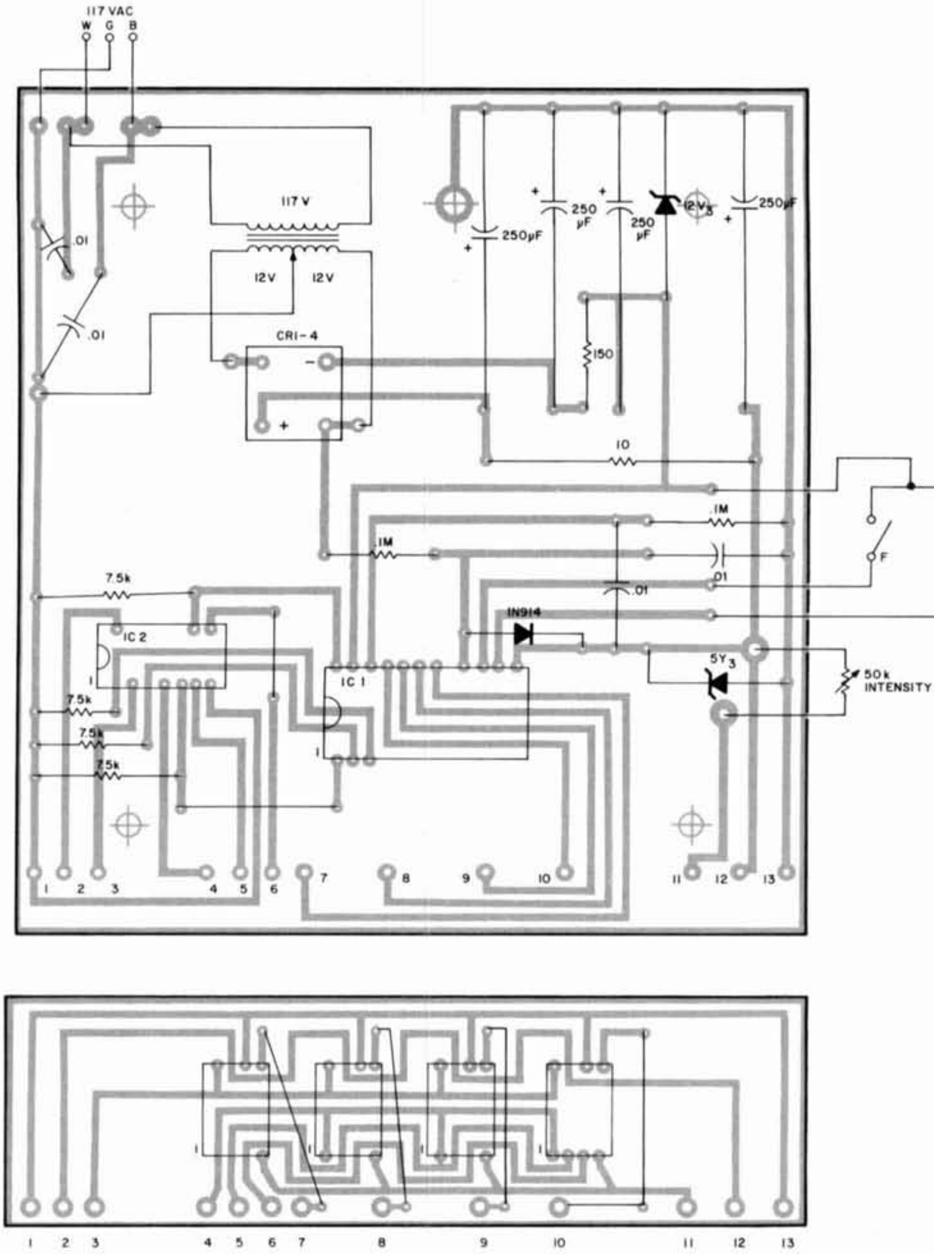


fig. 2. Top view of the circuit board showing parts placement, and external wiring.

display and IC sockets were mounted next. **Fig. 5** shows pin layout and other useful information for the ICs and display devices.

The discrete component leads were bent at right angles and inserted into the board near their respective connection points. A drop of household cement will hold the discrete components to the board and make wiring easy. The wire wrap can be used on small-diameter component leads as well as on the socket pins; however, on the round leads of the resistors and capacitors it will pay you to put a little solder on the connection after wrapping to prevent intermittents later on. The larger leads, which are too large in diameter for wrapping, can be hand wired with the no. 30 AWG (0.25mm) wire, then soldered. After mounting all the components on the board the wiring can be completed in accordance with **fig. 1**. The leads for the fast and slow set switches and the dimmer control can be dressed out of the board and connected to their respective components after the board is mounted in the case. The board

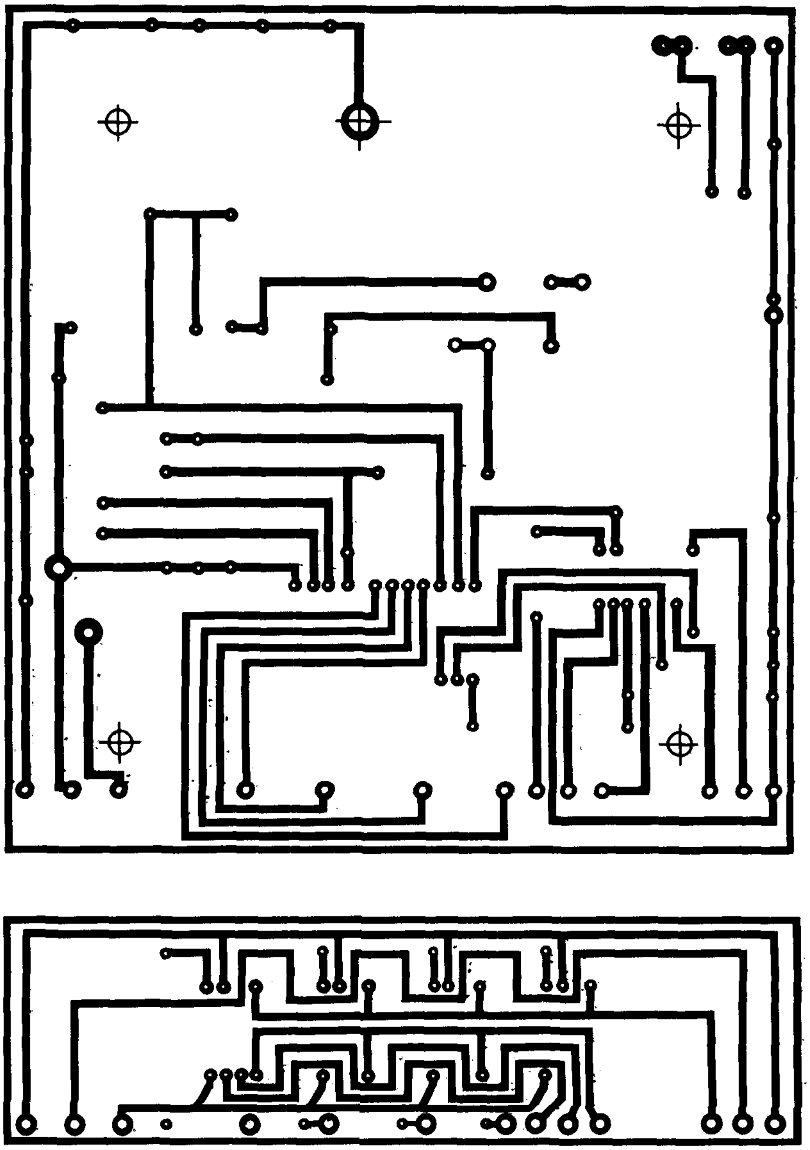


fig. 3. View of the circuit board from the foil side.

table 1. Component list for the digital clock using perf-board and wire-wrap construction. Numbers in parentheses refer to product sources.

U1	National MM5312N (3,5)
U2	Texas Inst. SN7404N (2,5)
Display 1-4	Hewlett Packard 5082-7340 (4)
T1	SSS 11-08180 (1) or 273-1480 (2)
S1, S2	275-1547 (2)
R1	271-1716 (2)
CR1-4	276-1146 (2)
CR5	276-561 (2)
CR6	276-563 (2)
Socket U1	SSS 41-38964 (1)
Socket U2	SSS 41-38974 (1)
Socket, Display	SSS 41-38934
Case	270-253 (2)
Perf board	SSS 22-44062 (1) or 276-1583 (2)
Wrap Tool	SSS 43-18160 (1)
Bezel	915-60 (6)

product sources

(1) Solid State Systems, Box 773, Columbia, Missouri 65201.

(2) Radio Shack Stores.

(3) Poly-Paks, Box 942, Lynfield, Massachusetts 01940.

(4) Tinkers Electronics, 805D Union Ave., Los Gatos, California 95100.

(5) International Electronics Unlimited, Box 1708, Monterey, California 93940.

(6) Tracy Design, 15870 Schaefer, Detroit, Michigan 48227.

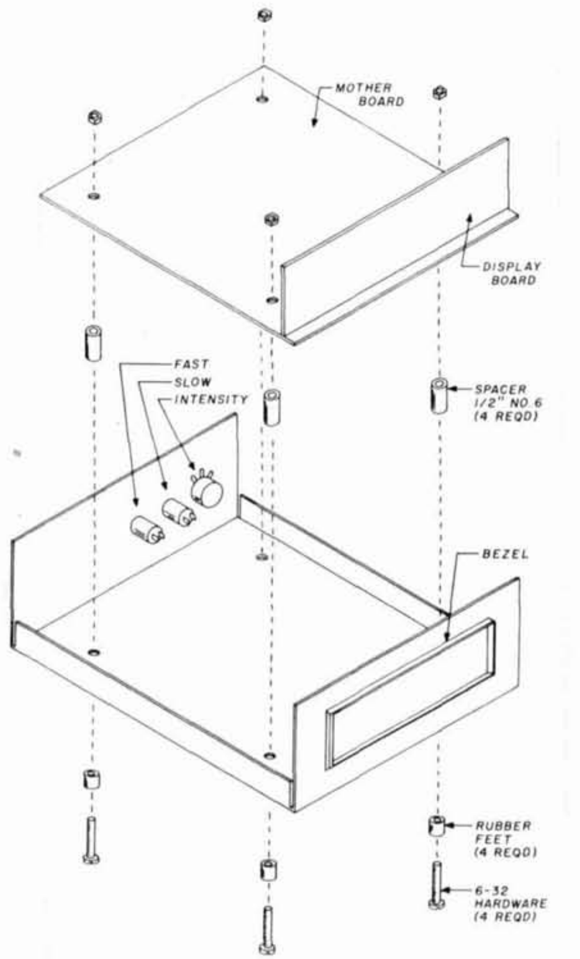


fig. 4. Isometric of the 24-hour clock showing assembly details.

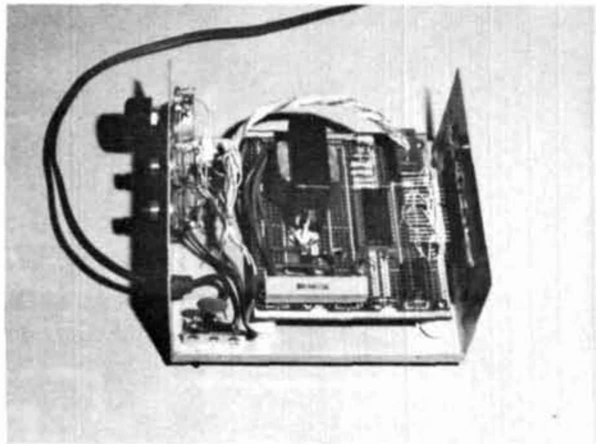
was supported from the bottom of the case with four spacers.

checkout

After completing the wiring and before installing the ICs and displays, check the wiring against the schematic. The 0.100-inch (2.5mm) centers on the IC pins are very close and can be counted incorrectly quite easily. If all checks out well, plug in the ICs and the display units, apply power and give the circuit a smoke test. The initial display will probably scare you as some very odd configurations can appear before setting the correct time. The time is set by pressing the fast and slow set switches. The fast-set switch advances the clock at the rate of one hour per second. The slow-set switch advances the clock at the rate of one minute per second. Once set, you should have a very accurate 24-hour clock.

conclusion

This project is a good starter in the transition from working with 807s to new gadgets like ICs and digital electronic displays, since the circuit requires no adjustment or elaborate test equipment. Parts are available at modest cost with a little shopping around, and the finished unit is a functional adjunct to your station. In



Top view of the 24-hour digital-display clock with case removed.

shopping around for the display units I found that the reverse sides of the units had been painted black to obscure the HP part numbers, but holding the units up to the light made the part numbers easily readable. I found two other types of HP displays that also work in this unit, types 5082-7300 and 5082-7302. If these are used, pin 4 on each display must be grounded and the dimmer control eliminated. Devices that are functionally identical to the HP units can also be found under other manufacturer's part numbers.

If you're interested in the technical aspects of the ICs used in the clock, you should request data sheets when you purchase the ICs. The data sheets provide a very

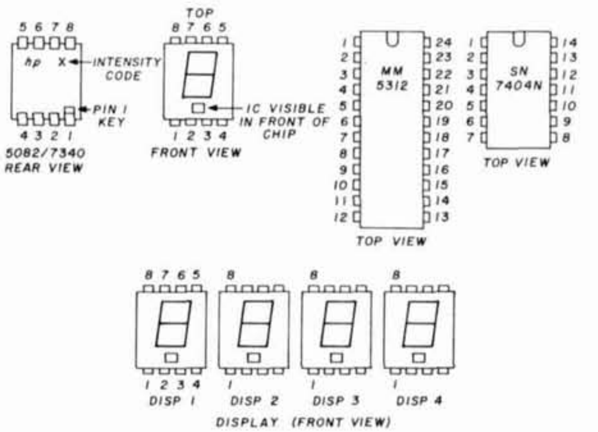


fig. 5. Pin numbers of the ICs and display LEDs used in the 24-hour clock.

thorough explanation of the internal chip functions as well as very good application notes.

This project has been a lot of fun and very educational. It has really stirred up my interest in digital techniques. What's on the work bench now? A frequency counter built in the same-size case as the clock. "Old Reliable" may soon have a digital dial.

ham radio

audible S-meter for repeaters

More audio tones on the repeater — this time they indicate signal strength

The audible S-meter can be used to check transmitter performance, antenna comparisons, site testing and so on, whenever relative signal levels are required. This unit, when connected to a repeater, will add a tone-burst shortly after the input signal has dropped out. During the "tail," the pitch of the tone indicates the strength of the preceding received signal. The S-meter can be built entirely from junk-box type components. In addition to the normal results, it adds a new experimental facility to any repeater.

the repeater tail

Most fm repeaters have a "tail" period — the over run or run on time of the transmitter after the input signal has dropped out. It is assumed that the tail period is noise-free, *i.e.*, an unmodulated carrier. This time can be used to accomodate a toneburst or "beep" to telemeter the repeater receiver S-meter reading back to the original station.

The beep generated by this audible S-meter unit is about 60 milliseconds long — about the length of a time-signal "pip." It is long enough for the pitch of the signal to be understood and used, though not long enough to be annoying. It is possible to adjust the amplitude of the beep from zero to full deviation. The time delay between the input signal going off and the tone can also be adjusted from zero to about seven seconds, again to suit the requirements of the particular repeater.

The pitch of the resulting beep varies with the strength of the incoming signal. A high-pitched beep (3500 Hz) represents a weak signal, a low-pitched beep (350 Hz) represents a strong input signal. In between signals are reported accordingly. The pitch of the beep therefore varies inversely to signal strength. The high-pitch beep, for weak signals, is more useful to a distant station. If a low-pitch signal had been chosen for this condition it could be lost in the noise. Signal-to-noise considerations influenced the choice of this method of presentation.

This 10-to-1 change in pitch enables users to obtain the information without the necessity of installing accessory equipment to decode the beep. The human ear is quite good at sensing relative tones and the use of this unit is learned very quickly. Once installed, talk of its removal is soon squashed!

The audible S-meter has been installed at the Mount Climie Channel C repeater in New Zealand for some time and has been found to be very useful. Each beep was purposely timed to be 3 seconds into the tail and serves the additional purpose of setting a 3-second gap between stations to permit emergency or priority traffic time to break in between ordinary ham conversations. This 3-second delay is a local operating custom. The design can be modified to suit the requirements of other repeater groups and other regulatory bodies. It is described here in the hope that it may give inspiration to other experimenters.

the repeater receiver

An S-meter must already be available at the repeater receiver. Just what form this takes will vary from repeater to repeater. This unit has been built around a receiver using an RCA CA3089E in its tail end — but the idea could be adapted to other receivers. The CA3089E has an S-meter output (called a "tuning indicator" on the data sheet) at pin 13. A 33k resistor and a 300 μA meter are normally connected to act as a tuning indicator. A switch changes the output over to the audible encoder as shown in the schematic, **fig. 1**.

Transistor Q1 is a dc amplifier, with its operating conditions and gain adjusted by R1 and R2. Q2 is an

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emitter follower, that provides a low-impedance charging circuit from its emitter to fast charge C1 (the memory capacitor) via diode CR1. A memory is necessary to store the information and hold it ready for broadcast after the input signal has gone off. Diode CR1 is

A tone-burst has to be generated from this continuous tone. Q8 acts as a clamp across C6 and prevents the audio oscillator from running constantly. The base of Q8 is forward biased and, as a result, Q8 is normally conducting. This transistor has to be shut off to produce the

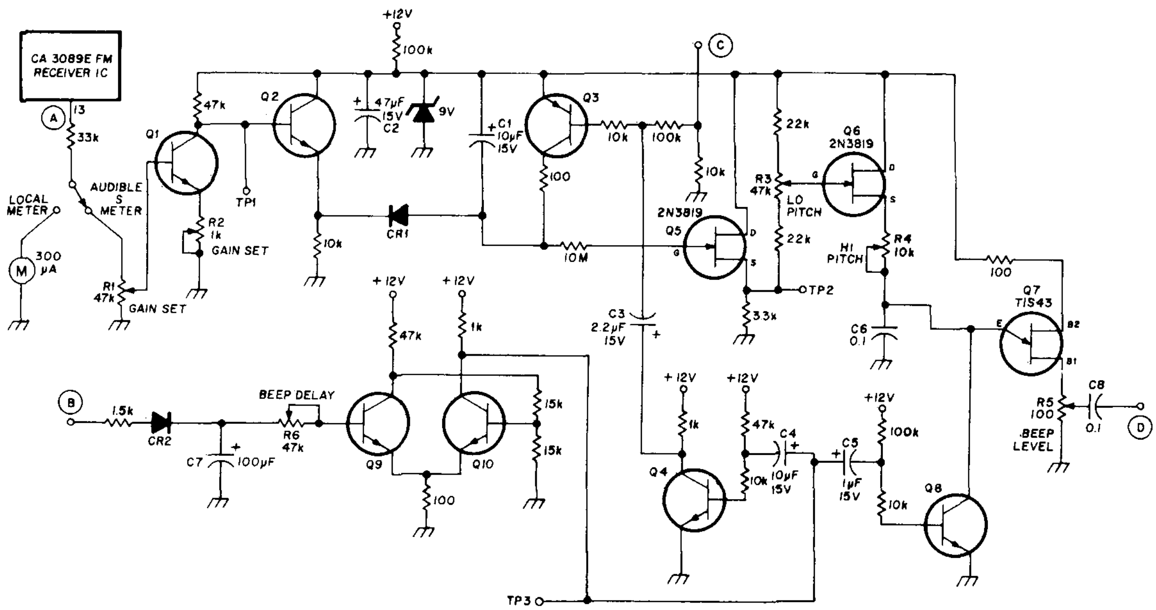

fig. 1. Schematic diagram of the audible S-meter. Input B is connected to the squelch circuit. Point C is connected to a source of +12 volts that indicates when the transmitter is on. The tone output is available at point D. Changing the value of C5 will alter the length of the time "beep." Unless otherwise indicated the transistor types are discussed in the text.

required to prevent the memory capacitor from discharging after the input signal has gone off.

generating the tone

The voltage across the memory capacitor is "read" by the high impedance electronic voltmeter, Q5, acting as a source follower. Q5 effectively repeats the voltage on the capacitor but at a much lower impedance which can readily be metered for test purposes. The variable resistance of Q6 plus R4 act as the resistor portion of an RC network with C6 as the capacitor. Q7 is a unijunction transistor connected to act as an audio oscillator. The resulting tone from across R5 is applied to the repeater transmitter audio stages. As the effective resistance of Q6 changes, so does the frequency of the tone.

The operation of the unit as an S-meter current-to-audio tone converter can now be seen. Various levels of input current create a voltage across C1 and in turn cause corresponding tones from the audio oscillator. The high and low pitch ends of the audible operating range are set by R3 and R4. The output tone amplitude is controlled by R5. Because there is a standing dc current from pin 13 of the CA3089E, R1 is used to set the operating point of Q1 over the required current range only. R2 acts as a gain adjustment to set the required sensitivity of the system.

beep. This unclamping is achieved by Q9 and Q10 which form a Schmitt trigger circuit.

Lead B is connected to another part of the repeater receiver – the squelch and control system. This input is about +10 volts when a signal is being received and goes to ground immediately after the signal goes off. While the input is being received, C7 charges via CR2 to some positive value. Q9 is therefore conducting and Q10 is held cut-off so TP3 is at a high positive value.

When the received input signal goes off, point B goes to ground and C7 discharges via the base of Q9, maintaining Q9 on for the delay period. When C7 has discharged, as determined by R6, Q9 can no longer hold Q10 cut off and TP3 drops very suddenly to a low positive value, when Q10 starts conducting. This sudden drop is transferred through C5 to cutoff Q8. The tone oscillator can now operate until C5 has discharged. This takes about 60 ms – the beep length. We have now converted our tone into a beep which is of a desired length (selected by C5) and at an adjustable duration during the "tail" (set by R6).

resetting

One problem remains. Some means must be provided to discharge the memory capacitor after it has been read, so it can recharge each time from the same initial voltage. Two discharge circuits perform this action, with Q3 acting as another clamp. When no receiver input signal is present, it places a short circuit across C1. As the input signal appears, the repeater transmitter turns on and point C goes to 12 volts, thus unclamping Q3. At the end of the tail period, Q3 conducts and discharges C1.

In addition, the negative-going voltage transition at TP3 is applied to Q4, cutting it off. Since Q3 is already unclamped because of the 12 volts on C, the positive pulse that comes through C3 only adds to keeping Q3 unclamped. When C4 has discharged, Q4 will come back into conduction. The negative-going pulse from the collector is transferred through C3 and clamps Q3, thus discharging the memory capacitor.

The two cancellation circuits are necessary to ensure the initial charging conditions of C1 are the same over long periods of time or over periods of little repeater activity, and also to ensure that capacitor C1 is discharged after every beep to allow for those cases where the repeater tail does not drop out before the next station begins transmission. We now have an audible beep which follows and stores the input current value on lead A and automatically resets after each readout.

construction

Details pertaining to the construction of this unit are not considered to be necessary. It is one of those devices that is unlikely to be attempted by persons not already experienced in the noble art of wielding a soldering iron. The npn and pnp transistor types have purposely not been quoted. There is such a range of suitable substitutes that any one of many would be acceptable. The ones actually used were BC107 and BC177 of European origin. Any small-signal npn and pnp silicon transistors of medium gain should be suitable. Small signal silicon diodes should be used for low leakage.

general

The unit in effect reads the *maximum* input signal received over a period because it is, in essence, a peak-reading voltmeter. Such an S-meter, relying on a 60 ms beep to send back information, can only operate on a sampling basis anyway. The maximum received strength is perhaps the most useful value to sample. Over a fading path this aspect must be remembered if useful interpretations are to be made. In practice, few problems in this regard occur because path conditions (except for mobile use) are surprisingly constant with fading occuring on a regular basis with each test.

A remote readout unit, that can be connected to transceivers, has been built. This puts the S-meter at an unusual end of the radio link – back at the transmitter where it is probably of much more use! A means of switching the encoder to another receiver at the repeater site for listening to a distant beacon station for propagation studies is also in operation. This too may bear telling at a future time. Meantime, this basic unit lets repeater users learn of their relative signal levels at the repeater receiver. I would like to know of any repeater installations where this or similar units are in use or brought into use as a result of this article.

ham radio

repair bench

Joe Carr, K4IPV

basic troubleshooting: is that oscillator running?

Whether the discussion is among amateur or professional troubleshooters, one often-heard question is, "How do you tell if the oscillator is running?" In some cases this question is easy to answer, but in others you must resort to some reasonably clever troubleshooting. This is especially true when some of the possible methods that might be applied could easily cause oscillations to cease, in which case "no" is a hardly useful answer in all instances!

First, let's discuss some aspects of oscillator circuits. All such circuits have two subcircuits as part of their anatomy. These could be called the dc and the ac circuits. In the dc circuit, dc currents flow. The dc circuit includes elements such as bias resistors and emitter or cathode resistors. The ac path, on the other hand, contains feedback elements, crystals, tank circuits, and most (perhaps all) capacitors. These two paths are not mutually exclusive, as ac and dc components exist at many points. At the plate of a vacuum-tube amplifier, for example, a high dc voltage and an ac signal will be found. Similarly, if a stage is shunt fed the rf tank will be common to both ac and dc paths.

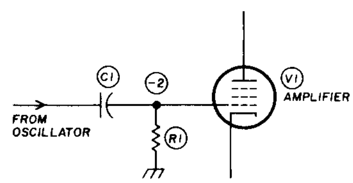

fig. 1. Input circuit found in many small amateur transmitter amplifiers. Negative voltage on the grid of the amplifier tube provides a good indicator of oscillator operation.

The point is that we must be careful when troubleshooting not to create a situation that gives a false result. Some test procedures, for example, may interfere with the operation or may only be valid for one path or the other.

Certain properties of oscillator circuits exist that cause dc voltages to occur only when the oscillator is running. Consider, for example, a simple grid-leak bias situation as in **fig. 1**. This is a common circuit of many transmitters of the master-oscillator, power-amplifier type. Assuming oscillator input voltage, the negative voltage on the V1 grid is caused by grid-leak action of R1, C1. Absence of this negative voltage can mean one of three thines: R1 open, C1 open, or the oscillator signal is missing. R1 can be checked by measuring its resistance with an ohmmeter. C1 can be also checked using an ohmmeter by following this simple procedure:

1. Disconnect one end from the circuit.

2. Short both capacitor leads briefly; then remove the short.

3. Connect the ohmmeter (-) to one end of the circuit.

4. Touch the ohmmeter probe to the other end of the capacitor.

If the capacitor is good, a brief downscale-flicker of the meter pointer will occur at the instant the probe touches the capacitor free end. The pointer will increase to "infinity" as the capacitor charges. With capacitors less than 0.001 μF, this flicker will be brief and shallow, so you may miss it during the first attempt. This test must be made using the highest-possible ohmmeter scale (X1 megohm is desirable). If the capacitor is leaky the ohmmeter will not return to infinity after the capacitor is charged but will hang at some value. In most circuits, this would have made the voltage at the grid of the amplifier tube positive instead of negative.

checking variable-frequency oscillators

Many vfo and crystal oscillators will also present a negative voltage due to grid-leak action at their *own* grids. Furthermore, this voltage exists only when the oscillator is running and will vary as the vfo is tuned through its range; what better indicator could you want? Of course, we must expect this variation to be roughly

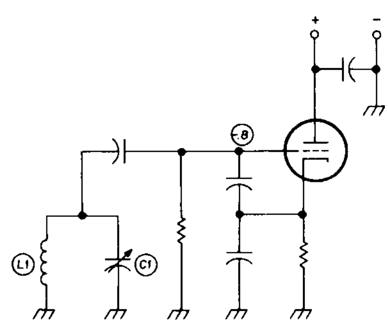

fig. 2. LC-tuned fixed-frequency oscillator. L1, C1 can be short-circuited to check oscillator operation (not recommended for transistor circuits — see text).

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proportional to frequency change (ΔF). In the vfo of an ssb transceiver, which covers only 250 kHz per bandswitch position, we'll find less variation in the dc grid potential than on a general-coverage receiver vfo, which covers a range of about 3.2:1. The variation will, however, be great enough to see on a sensitive dc voltmeter. This indication will tell you whether or not the local oscillator is running. If the stage is not oscillating, the grid voltage may drop to zero or will become a few millivolts positive.

checking fixed-frequency oscillators

The oscillator grid-bias test is also useful with crystal or LC-tuned fixed-frequency oscillators. In these circuits it's necessary to disable the crystal (or LC tank) and look for an abrupt change in the bias level. Almost anything that will disable the oscillator or cause it to shift frequency by a large amount will do. You might want to try the following:

1. Touch the tank or crystal with a metal screwdriver. (Make *certain* that no high dc potentials exist at this point).

2. Remove power and remove or disconnect the crystal or one of the tank-circuit components.

3. Shunt a large-value capacitor across the crystal or tank. In most oscillators, anything in the range 0.001-0.05 μF will do.

4. Place a jumper wire across the crystal or tank circuit. Be certain of the circuit; *know* what current is being shorted and to where it is going. In **fig. 2** no damage will result if the tank is shorted to ground; but in at least one version of the Pierce circuit, and in some vfo circuits, this maneuver will cause further damage, especially in transistor circuits. A rule of thumb is: Avoid this method if B+, cathode, emitter, or base voltages share a common terminal with the crystal or tank.

Of these four methods, I prefer either **2** or **3** as those least fraught with danger. If any of these methods produces a sudden shift in or loss of the negative bias

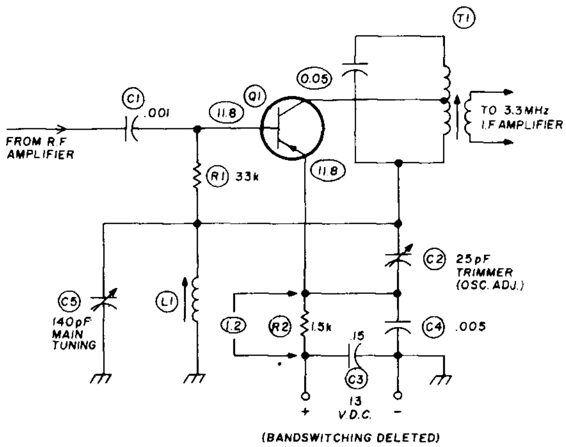


fig. 3. General-coverage receiver converter vfo circuit. Such circuits can be checked by observing changes in emitter-to-base voltage.

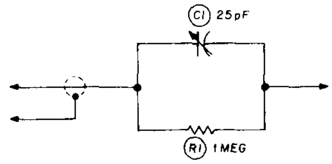


fig. 5. Low-capacitance probe for use with an oscilloscope or digital frequency counter.

voltage at the grid, then you can assume the osillator is running.

checking converters

Fig. 3 shows a converter (oscillator and mixer combined in a single stage) as used in a general-coverage amateur receiver. Both emitter and base will be at the same dc potential when the oscillator is running: A good test point. If problems in the ac path cause the oscillator to stop running, then emitter and base voltage will

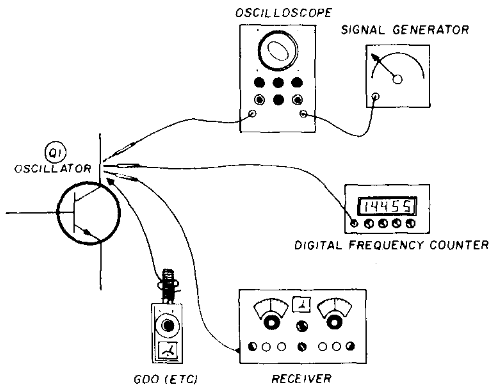


fig. 4. Methods for checking oscillator frequency using common test equipment.

change slightly, and the stage will act more like an amplifier. In this case, the base-emitter voltage will increase from zero to between 0.1 and 0.7 Vdc. Unfortunately, this test isn't always reliable but offers a good reason to become extremely suspicious. A better indicator of operation is the voltage drop across the emitter resistor, R2. This voltage always varies as the oscillator is tuned across its operating range. This method can also be used with fixed-tuned oscillators by disabling the crystal or tank and using the methods described above.

Before proceeding further, some cautionary words are in order against arbitrarily disabling an oscillator, especially in transmitters or other relatively high-power circuits where grid-leak bias is used: in many low- or medium-power transmitters, the grid leak provides the only bias for the final amplifier tube or tubes. If this bias is removed, the tube may be permanently damaged. In such cases it will be necessary to a) clamp the grid with a negative voltage high enough to cause cutoff, b) remove the tube or tubes, or c) disconnect the B+. Of these methods, the last is the most desirable.

Dc testing with a simple dc voltmeter does not always tell the tale, or at least the truth! In many cases, the dc

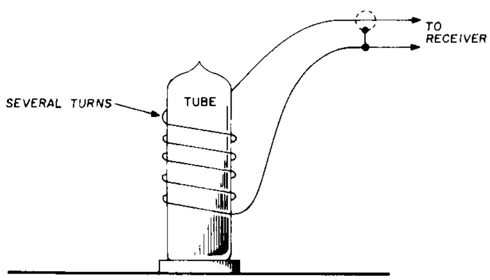


fig. 6. Coupling method using the time-honored gimmick capacitor.

indications merely cloud the issue and give a false sense of security. For example, how useful are the dc checks when the oscillator is still running but at an incorrect frequency? In that case, the dc checks will only lead you astray. Clearly, some method for measuring the oscillator frequency should be employed.

checking oscillator frequency

There are several ways to rough-check the frequency of a running oscillator that usually do not cause any undesirable frequency shifts (**fig. 4**). One is to use a calibrated oscilloscope and measure the period of a single cycle of the oscillator signal by counting spaces on the scope time base (horizontal) and multiplying by the time base control setting. Or you could feed the oscillator signal to the vertical input and the output of a calibrated signal generator to the horizontal input. This action will create a Lissajous pattern. Adjust the signal generator until the trace remains steady and apply the normal rules for Lissajous figure ratios.

Alternatively, you could use a digital frequency counter or a heterodyne frequency meter. These instruments are available at low cost and many amateurs own them. It's also possible to find amateur clubs that have these instruments, especially those that operate repeaters.

an absorption wavemeter, which can be loosely coupled to the circuit with a *gimmick* capacitor as shown in **figs. 4** and **6** or placed close to the oscillator.

Another method that has wide application is to use a general-coverage receiver. Connect the coax from the *gimmick* to the receiver antenna terminals and tune for the strong oscillator signal. In some cases it will be merely necessary to connect a length of hookup wire to the coax inner conductor and place it near the oscillator circuit.

The technique described above, which has a host of other uses, is one I recommend for every amateur station. Some of the old war horse receivers of the 50s and 60s are available for a price lower than you might think. Even an old ac-dc shortwave version of the five-tube superheterodyne is acceptable for many uses. An old Hallicrafters S38E or National NC-3 can be picked up at many swap meets for little money.

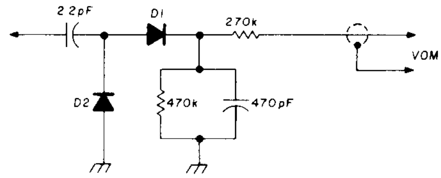
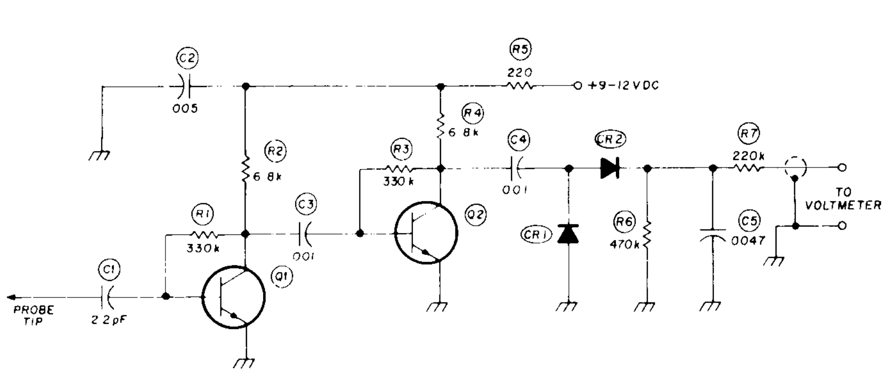


fig. 7 Passive demodulator probe circuit, which can be built into an appropriate housing. CR1, CR2 are 1N60, 1N82, 1N914, etc.

Fig. 7 shows a passive probe for use with a vom. EICO sells probe kits as well as demodulator probes, or you can buy a blank kit and build your own probe into the barrel. This is the approach recommended for the active probe of **fig. 8**. This demodulator probe is useful to two meters or higher. Transistors Q1 and Q2 are an amplifier that feeds a voltage-doubler detector consisting of CR1, CR2. The probe should be built into the same housing as the probe tip to eliminate lead inductance between tip and capacitor C1. The EICO housings can be

fig. 8. Active demodulator probe, which is useful to 2 meters or so. Q1, Q2 are hf npn transisitors (ECG108, etc.) CR1, CR2 are 1N82, 1N914, etc.



Both the frequency-meter and Lissajous-pattern methods have a common fault, which may render them useless in some cases: Their probes may tend to load the circuit and shift its operating frequency. **Fig. 5** shows a low-capacitance probe. A grid-dip meter can be used as

used, or an old probe can be used. One-half inch (12.5mm) copper tubing with end caps is also useful, as are 9-pin tube sockets with shields (see the ARRL *Radio Amateur's Handbook*).

ham radio

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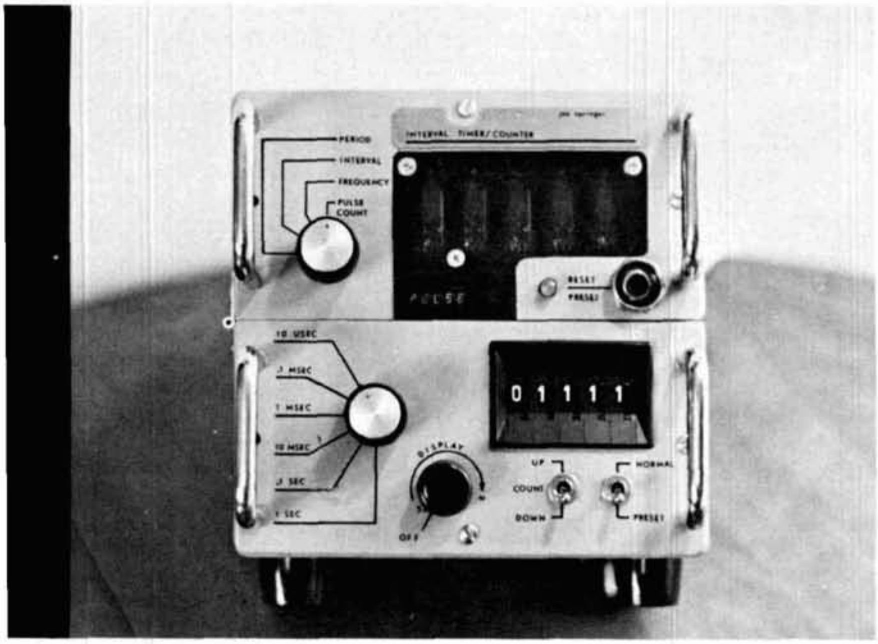

function/units indicator

using LED displays

Design and construction of a simple alphanumeric display system with many applications

Every test instrument uses some form of front-panel display to indicate what is being measured and the units involved. This article provides an attractive alternative to conventional displays. The design uses LEDs and TTL ICs to indicate function and units in an interval timer/counter. However, the circuit is adaptable to a wide range of other instruments.

The display complements the timer/counter and makes reading of measured data easier than with instruments using conventional display methods. Time in milliseconds, for example, is displayed as *SEC-3* (seconds x 10^{-3}) in scientific notation. Frequency is displayed similarly. The indicator circuits use TTL ICs, the heart of the system being programmable read-only memory (PROM). Construction is straightforward. A simple programmer for the Signetics 8223 PROM has also been constructed and included as part of the project.

After a brief discussion of concepts and theory of operation, the design techniques I used are described as well as the evolution of the final circuit. Construction is covered in detail for those who may wish to duplicate the circuits.

function/units indicators

The purpose of a function/units indicator on an interval timer/counter is to describe what is being measured: seconds, milliseconds, or microseconds for time measurement and hertz, kilohertz, or megahertz for frequency

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measurement. Most instruments have abbreviations of these units (sec, msec, μsec, Hz, kHz, MHz, respectively) on the front panel and use either a pointer or panel light to indicate the appropriate display.

The LED indicator displays any one of the six abbreviations with a minimum of five 7-segment digits placed side-by-side. Seven-segment displays are designed to display numbers only; fortunately, enough letters of the alphabet can be produced to simulate the abbreviations. (See **table 1**). Obviously, this method is more complex: it requires considerable circuitry and the cost is higher. Is it practical? Economically, no; but the greater ease in reading the instrument justifies its use.

Circuit operation centers around a 256-bit read-only memory, a Signetics type 8223,[1] into which are programmed all letters and numerals required to form the six abbreviations. One exception exists. Since there was no need to display microseconds (*SEC-6*) in my interval timer/counter, I used that section of memory to

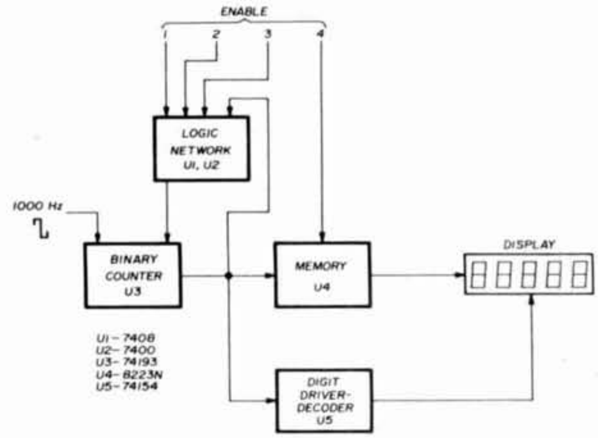
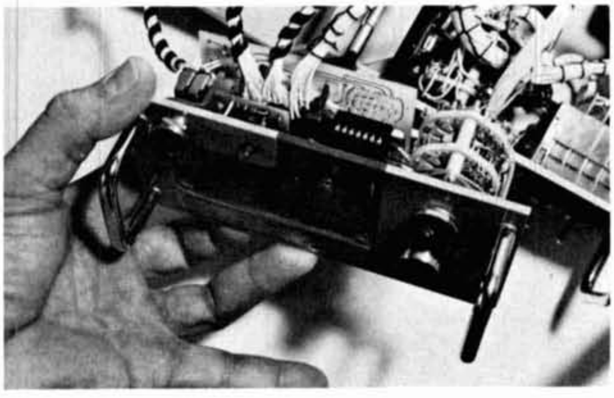


fig. 1. Functional block diagram of the function/units indicator. A binary counter, a 4-16 line decoder, and a 5-digit parallel-connected display form a simple multiplexer. An external 1-kHz oscillator drives the counter and sets the scanning rate.

table 1. Alphanumeric simulation of frequency and time units.

units nomenclature	display
seconds	SEC
milliseconds	SEC-3
microseconds	SEC-6
hertz	HZ
kilohertz	HZ 3
megahertz	HZ 6

program the word *PULSE*. This word is selected for display when the counter is set up to count random pulses or events. The truth table for the memory is provided in **table 2**. A block diagram of the indicator circuit major units is shown in **fig. 1**. A binary counter, a 4-16 line decoder, and a 5-digit parallel-connected display form a simple multiplexer that addresses memory, one word at a time, and transfers data to the display. An external 1000-Hz oscillator drives the counter and sets the scanning rate. The counter is controlled by a logic network, which in turn is controlled by three data lines. The logic network limits the counter to count from 0-4 and reset; or 5-9 and reset; or 10-14 and reset – depending on the input from the data lines. Enable 4 is the most-significant bit address line to the PROM and selects one of two blocks of memory, locations 0-15 (binary) or 16-31 (binary). A schematic of the indicator circuit appears in **fig. 2**. **Table 3** lists the data inputs for each different display.

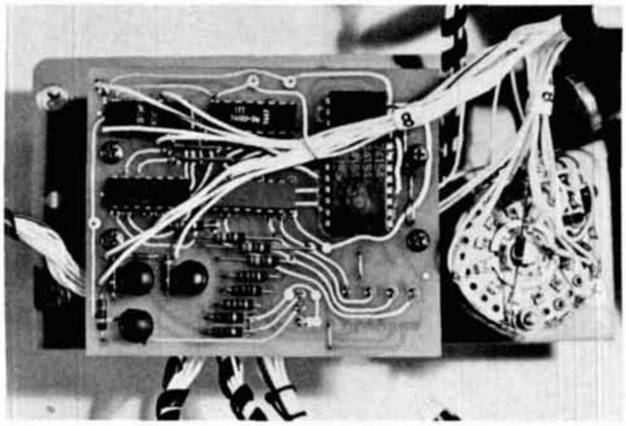


Top view of the function/units indicator.

design

Four areas of special importance were stressed in the design: small size, simplicity of circuit (minimal inputs), parts availability (cost included), and symmetry (printed circuit layout). Small size (3.2 x 2.5 inches or 8 x 2.5cm) was necessary only for my application. This circuit would probably function quite well under almost any configuration. Lead lengths should be kept as short as possible, however, in the interest of good design practice. Simplicity is the keynote for any good design and merited a major effort in this project. All parts are readily available on the surplus market. **Table 4** gives information on parts and suppliers. Cost is within reason ($12.00) if surplus ICs are used throughout. Special attention was given to PC layout, since two-sided foil patterns were necessary and feedback problems might be encountered.

input and output requirements. The function indicator is controlled and operated from the rotary function switch on the main instrument panel through the data-input lines. As **table 3** indicates, each of the six displayed outputs requires a different 4-bit binary code. TTL integrated circuits are used exclusively, so 5 volts dc is the only power source necessary. A 1000-Hz square wave is provided by the main instrument's time-base generator to drive the multiplexer. The square-wave frequency is arbitrary; however, a minimum of approximately 300 Hz is necessary to prevent noticeable blinking of the dis-



Bottom view showing components and wiring harness arrangement.

play. Input signal levels must be compatible with standard TTL drive requirements.[2] The five-digit display is the only output. The display driver, U3, limits the maximum static display sink current to 16 mA per digit.

design techniques. Simplicity was foremost in arriving at a workable circuit. I concentrated on the logic network **fig. 1**, since it determined how many input-data lines would be required. The counter needed four signals from the logic network for proper sequence. (See **fig. 2** for a complete schematic of the logic network). With some trial and error I constructed four circuits, one for each signal, then, borrowing on the techniques of tabular minimization and NAND-NOR implementation,[3] I combined the circuits into a single, minimal circuit.

TTL systems are inherently noisy[2] so some bypassing was necessary. A minimum of 0.1 μF mounted close to the U3 and U4 terminals, where most of the switching noise is generated, is adequate.

The binary counter and logic network form a feedback system, but since there are at least three levels of gate delay from input to output, no interaction was anticipated. The counter output drives only three other inputs, so the counter is well within its fan-out limitations. The values of the pull-up resistors on the memory-output lines were optimized at 680 ohms, ¼ watt, for best display brilliance.

programmable read-only-memory. Now that I had a workable circuit on the drawing board, I set it aside to tackle the job of programming the read-only memory. Commercial programming is available from several companies (**table 4**), but I elected to avoid the additional cost and built a programmer I could use in future projects. Signetics Corporation provides programming procedures in their data book.[1] I used this information to construct the circuit of **fig. 3**.

A word of caution is in order, however, about the use of this programmer for memories of different manufacture. The Texas Instruments type 74188A field-programmable memory[4] is an identical pin-for-pin replacement to the Signetics type 8223, but it *cannot* be

table 2. Truth table for the Signetics 8223 ROM.

decimal	a4	a3	a2	a1	a0	B0	B1	B2	B3	B4	B5	B6	B7	
0	0	0	0	0	0	1	0	1	1	0	1	1	0	S
1	0	0	0	0	1	1	0	0	1	1	1	1	0	E
2	0	0	0	1	0	1	0	0	1	1	1	0	0	C
3	0	0	0	1	1	0	0	0	0	0	0	0	0	
4	0	0	1	0	0	0	0	0	0	0	0	0	0	
5	0	0	1	0	1	1	0	1	1	0	1	1	0	S
6	0	0	1	1	0	1	0	0	1	1	1	1	0	E
7	0	0	1	1	1	1	0	0	1	1	1	0	0	C
8	0	1	0	0	0	0	0	0	0	0	0	1	0	—
9	0	1	0	0	1	1	1	1	1	0	0	1	0	3
10	0	1	0	1	0	1	1	0	0	1	1	1	0	P
11	0	1	0	1	1	0	1	1	1	1	1	0	0	U
12	0	1	1	0	0	0	0	0	1	1	1	0	0	L
13	0	1	1	0	1	1	0	1	1	0	1	1	0	S
14	0	1	1	1	0	1	0	0	1	1	1	1	0	E
15	0	1	1	1	1	0	0	0	0	0	0	0	0	
16	1	0	0	0	0	0	1	1	0	1	1	1	0	H
17	1	0	0	0	1	1	1	0	1	1	0	1	0	Z
18	1	0	0	1	0	0	0	0	0	0	0	0	0	
19	1	0	0	1	1	0	0	0	0	0	0	0	0	
20	1	0	1	0	0	0	0	0	0	0	0	0	0	
21	1	0	1	0	1	0	1	1	0	1	1	1	0	H
22	1	0	1	1	0	1	1	0	1	1	0	1	0	Z
23	1	0	1	1	1	0	0	0	0	0	0	0	0	
24	1	1	0	0	0	0	0	0	0	0	0	0	0	
25	1	1	0	0	1	1	1	1	1	0	0	1	0	3
26	1	1	0	1	0	0	1	1	0	1	1	1	0	H
27	1	1	0	1	1	1	1	0	1	1	0	1	0	Z
28	1	1	1	0	0	0	0	0	0	0	0	0	0	
29	1	1	1	0	1	0	0	0	0	0	0	0	0	
30	1	1	1	1	0	0	0	1	1	1	1	1	0	6
31	1	1	1	1	1	0	0	0	0	0	0	0	0	

Positive Logic: 1 = hi level 0 = lo level

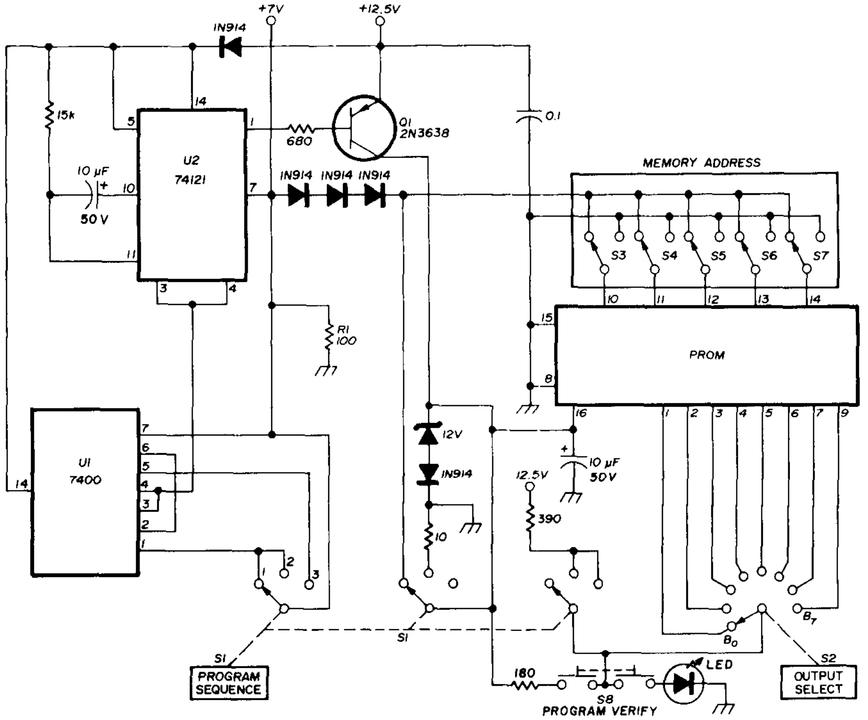


fig. 3. Programmer using the Signetics 8223 IC. Circuit was designed and constructed from information in reference 1. The LED is an MV5753.

programmed by the same procedures. Texas Instruments, Inc. has outlined special instructions.[4]

This programmer is much more elaborate than required but is designed to prevent accidental damage to the device being programmed. It also provides for checking the state of each bit of memory after each programming step. I'll not deal in depth on the theory of operation except for a brief overview. A complete discussion of the operating procedures is presented for those who may want to build this programmer.

Referring to fig. 3, U1 functions as a bounceless switch to trigger U2, a monostable multivibrator. Both

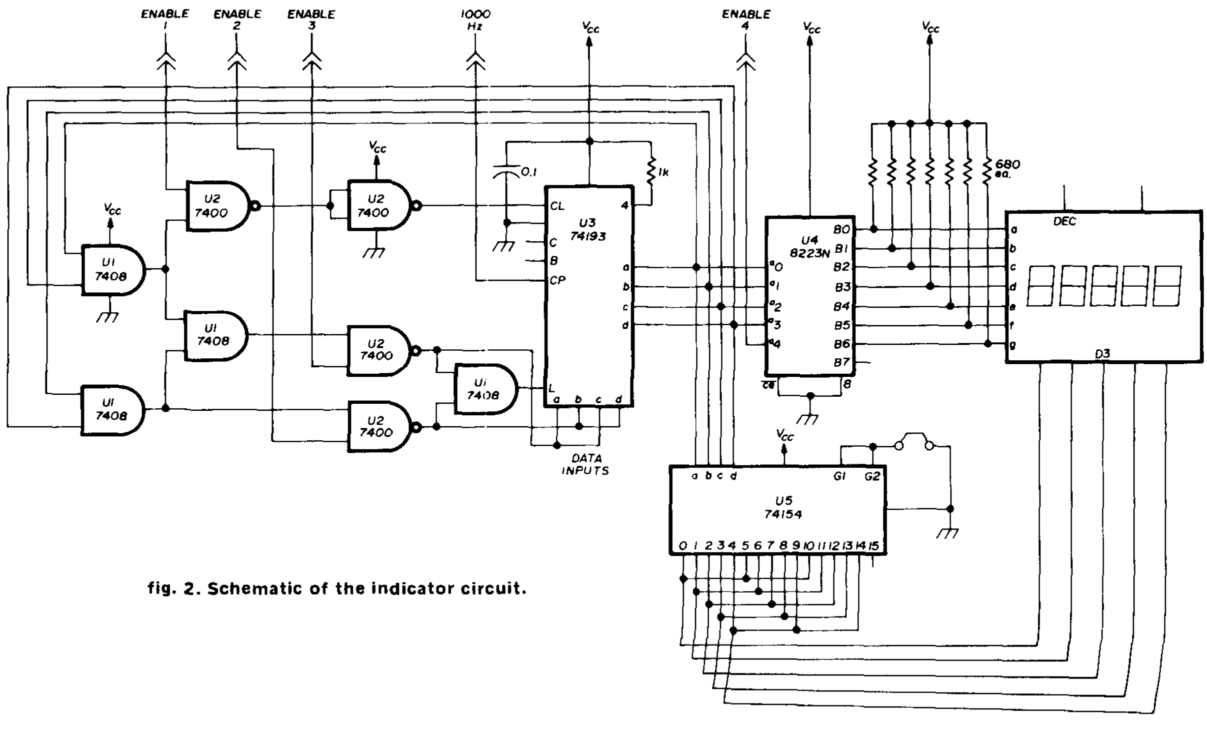
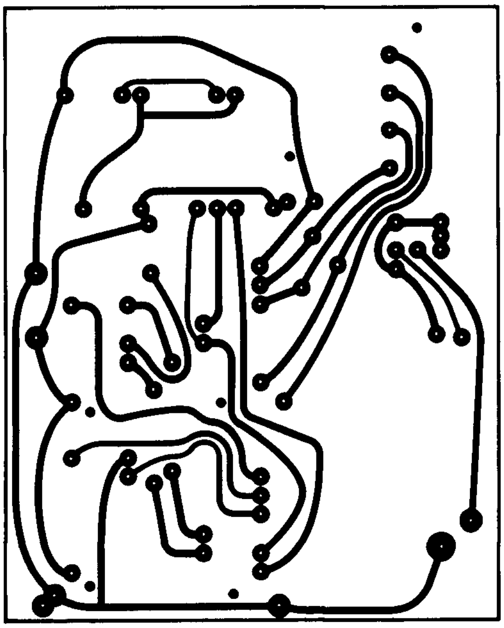


fig. 2. Schematic of the indicator circuit.

U1 and U2 operate at 7 volts above ground. Transistor Q1 saturates upon receiving a pulse from U2 and applies a 250-ms, 12.5-volt programming pulse to the V_{cc} terminal of the memory chip. This pulse opens a fuse at the bit previously addressed and permanently establishes a logic 1 at that bit location. All memory locations are at logic zero before programming occurs. Separate regulated supplies provide the 7- and 12.5-volt inputs. Resistor R1 at the 7-volt terminal increases current and prevents interaction between the two power supplies.



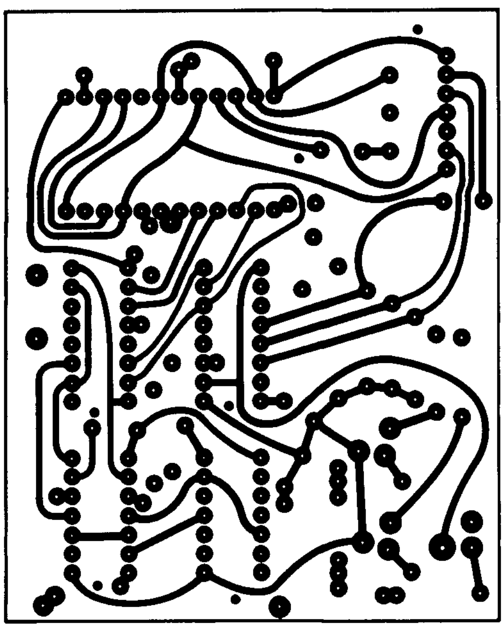


fig. 4. Full-size PC-board patterns for the function/units indicator. Two-sided boards are used; photo-etching technique was employed to make the boards. The top board is the component side foil, while the bottom is the rear foil.

table 3. Data inputs (positive logic).

enable				display
1	2	3	4	
1	0	0	0	SEC
0	1	0	0	SEC-3
0	0	1	0	PULSE
1	0	0	1	H2
0	1	0	1	H2 3
0	0	1	1	H2 b

Programmer operation follows a simple, concise procedure that must be strictly adhered to. Read the following instructions several times and become familiar with them. A few dry runs are an excellent way to avoid a costly mistake. *The steps must be followed exactly as listed.*

1. Set switch S1 to position 1.

2. Address desired memory location (0-31, binary) with switches S3 through S7.

3. Select the output to be programmed (B0-B7) with switch S2.

4. Sequence switch S1 through positions 1, 2, and 3, and back to 1. (Complete the sequence in approximately two seconds).

5. Ensure switch S1 is in position 1. Then verify the bit programmed by pressing switch S8 momentarily. The LED will light if a logic 1 state exists.

   An erroneous reading will occur during verification if switch S1 is not in position 1.

6. Repeat steps 3, 4 and 5 for each output; (B0, B1, B2, B3, B4, B5, B6, B7).

7. This completes the programming of 1 of 32 memory addresses. Return to step 1 and continue.

construction

The function/units indicator circuit is built on glass-epoxy base PC board, copper foil on both sides. A low-heat soldering pencil is absolutely necessary because of the density of circuit components and heat sensitivity of the ICs. A heat sink should be used for all soldering operations. In addition, I recommend tin plating the copper board before soldering components: it makes soldering that is otherwise tedious nearly effortless. It also adds a professional touch to the work.

Etching the circuit board is most efficiently done with the photographic technique, since accurate alignment of the two foil patterns is very critical. The two foil patterns, drawn to scale, are shown in **fig. 4.**

Fig. 5 illustrates component mounting. Notice that the display is mounted on the opposite side of the board from the other components. This layout contains some other circuitry not related to this project, which can be ignored.

performance

Preliminary testing of the project revealed two small problems, both with the data-input lines. Some noise spikes are apparent at the data (enable) inputs, and are generated by external switch contacts during switching. No effort was made, however, to remedy this situation since it was very minor. The other problem was a design error that caused a considerable waste of power. I'll explain. Proper circuit operation requires that the data-input lines, unless activated by an enable (high-level) signal, be at logic zero (low-level). To accomplish this, I had to clamp each data line to a low level with a 330-ohm resistor to ground. An unterminated gate, you recall, is at logic 1. A better design would clamp each line high with a 1000-ohm resistor and activate with a low-level enable signal. The current drain on the data lines would then be reduced from 60 to 20 mA. This is highly significant, since the entire function indicator draws only 220 mA at 5 volts.

The completed project was placed in a closed space and left on for two days in a rather makeshift test of its durability. No apparent heat problems occurred and the indicator functioned admirably. It is a handsome complement to my interval timer/counter.

The circuit is usable in a wide range of other instruments. The memory can be programmed for virtually any display configuration. I hope that this circuit, or portions of it, will stimulate some ideas for new applications.

table 4. Parts and ordering information for the function/units indicator.

Integrated Circuits: The following list contains just a few of the many dealers in surplus components

Solid State Sales P. O. Box 74A Somerville, Massachusetts 02143	Digi-Key Corporation P. O. Box 126 Thief River Falls, Minnesota 56701
International Electronics, Unltd. P.O. Box 1708 Monterey, California 93940	James Electronics P. O. Box 822 Belmont, California 94002

Displays: Hewlett-Packard type, 5-digit, mounted on a 14-pin DIP socket

Radio Shack P. O. Box 2625 Fort Worth, Texas 76101 (see your local distributor)	Poly Paks P. O. Box 942R Lynnfield, Massachusetts 01940

Programming Services: (fees are generally around \$5.00)
Semiconductor Specialists
Box 66125 O'Hare Airport
Chicago, Illinois 60666

Available Programmers:
Curtis Electro-Devices programmer
Spectrum Dynamics I/O programmer
Data I/O programmer

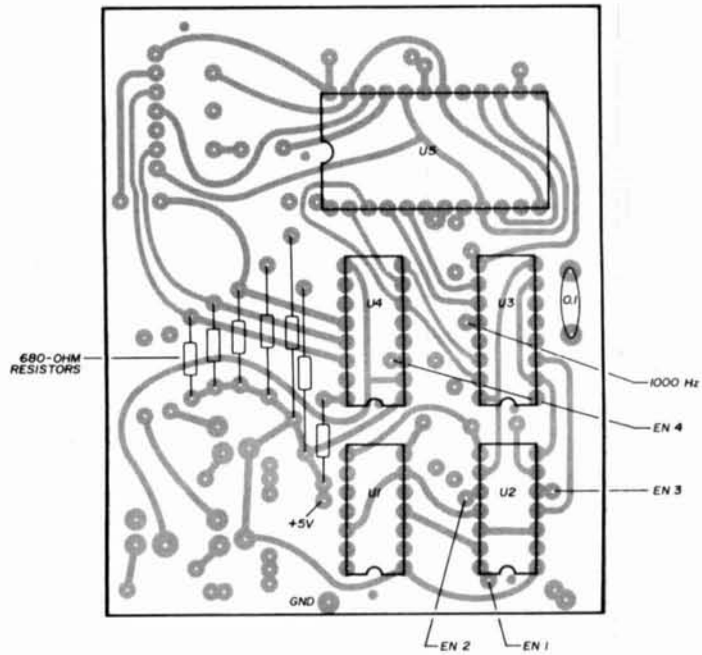


fig. 5. Component layout for the indicator. Some of the circuitry is not related to this project and should be ignored.

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1. *Signetics Integrated Circuits Data — Digital, Linear, MOS*, Signetics, Inc., Sunnyvale, California, 1972, pages 4-8, 4-10.
2. *Designing with TTL Integrated Circuits*, IC Applications Staff, Texas Instruments, Inc., McGraw-Hill, New York, 1971, pages 27-30.
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TS-700A
KENWOOD 2m ALL MODE TRANSCEIVER
POWER SEND CEN NB RIT TONE
OFF REC S OFF
REPEATER NORMAL OFF REV.
DRIVE
FINAL
RIT
SQUELCH
AF GAIN RF GAIN
BAND
FIX.CH
MIC
PHONES
MODE FM CW USB LSB AM
LSB USB


TS-600
KENWOOD 6m ALL MODE TRANSCEIVER
POWER SEND CEN NB RIT CAL
OFF REC S OFF
RF POWER
AM CAR.
DRIVE
RIT
SQUELCH
AF GAIN RF GAIN
BAND
FIX.CH
MIC
PHONES
MODE FM CW AM USB LSB
LSB USB

VHF

TR-7400A

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Kenwood's other 2-meter FM mobile transceiver . . . compact, rugged and packed with features like a priority channel for your favorite frequency, 146-148 MHz coverage, 22 channels (6 supplied), completely solid state, and 10 watt output. Shown with the PS-5 AC power supply for home operation.

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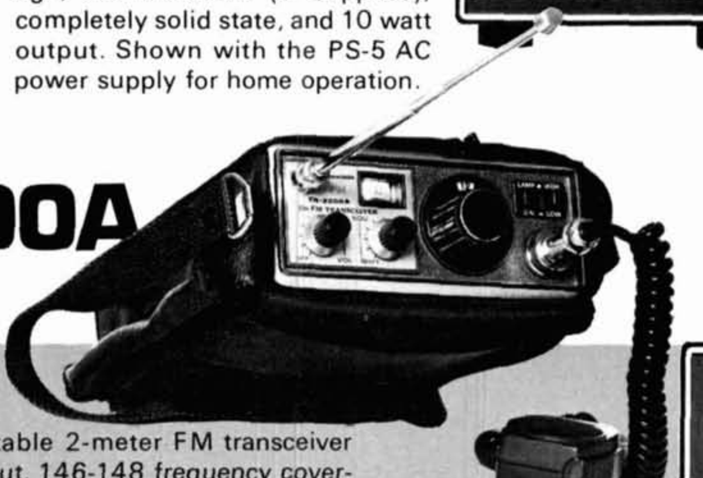

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control function decoder

Repeater accessory access can be regulated by this control function decoder

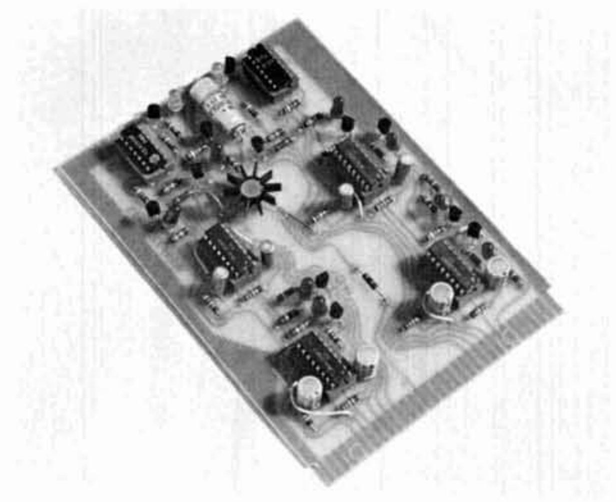
As repeaters become more sophisticated, the need for remote control of special repeater functions becomes necessary. Switching to remote receivers, autopatch control, and selectable repeater linking are only a few of the special repeater functions that lend themselves to remote control. The *Touch-Tone* signaling system is rapidly becoming the standard for repeater control. The control function decoder described here is designed to be operated from the output of a *Touch-Tone* decoder. The circuit detects a 3 digit sequence of *Touch-Tone* signals and sets a flip-flop. Another three-digit sequence is required to reset the flip-flop. The first two digits are the same for the set and reset functions. For example, the sequence 1, 2, 3 could be used to turn the function on, the sequence 1, 2, 4 could be used to turn the function off. The set and reset sequences must be received in the proper order and completed within a prescribed length of time.

The control function decode has several features that make it adaptable to a wide variety of systems.

1. On-card voltage regulation
2. Printed-circuit board construction
3. Plug-in module construction
4. CMOS chips for low power consumption
5. Fully TTL compatible inputs and outputs
6. Indicator LEDs monitor circuit functions

circuit description

The circuit shown in **fig. 1** uses two dual monostable multivibrators. The output of the first monostable (U1A) is connected to the reset terminal of the second (U1B). The first digit in the access sequence is the trigger



The complete control function decoder. The status of the timers is given by the light-emitting diodes mounted on the board.

By Thomas E. Doyle, WA9FTH, 5222 Big Bow Road, Madison, Wisconsin 53711

for the first monostable and the second digit of the access sequence is the trigger for the second monostable. Until the first monostable is triggered, the second is held in the mode. The output of the second monostable is connected to the reset terminals of the two remaining monostable multivibrators (U2A and U2B). The third digit in the *on* sequence is connected to the trigger input of one of the monostables (U2A) and the third digit in the *off* sequence is connected to the trigger input of the other (U2B). Note that the first two digits are the same for the *on* and *off* sequences.

The output of the *on* monostable is connected to the set input of an RS flip-flop. The output of the *off* monostable is connected to the reset input of the RS flip-flop. U1A is triggered by the first digit in the access sequence. U1B must be triggered by the second digit of the access sequence before the first monostable times out. The *on* or *off* digit of the access code must trigger its associated monostable before times out.

interfacing

The output of the RS flip-flop is buffered by a transistor amplifier. An auxiliary direct clear input is provided to the RS flip-flop. This allows power-on clear or manual override. LED indicators are provided on all monostable outputs and the RS flip-flop output. The access sequence digits and clear inputs require positive going TTL level signals. The output voltage from the RS flip-flop is approximately 4 volts at a current level limited by R3. This resistor value may be adjusted dependent on output loading. The circuitry is operated from a 5-volt supply regulated by an LM309H regulator. This allows the decoder to interface with TTL circuitry. The power input should be in the range of 11 to 15 volts dc.

The R1, C1, and R2, C2 values control the length of time in which the three-digit sequence must be completed. The value of these components may be changed if desired. One of these boards is used in the WR9ABT 16-76 repeater to control the autopatch and also the repeater mode from carrier to tone access.

construction

The control function decoder is built on a 4.5 x 6-inch (11.4x15.2cm) single-sided printed-circuit board. The board contains all the necessary circuitry for two complete decoders. These sections are completely separate and share only the voltage regulator. If only one decoder is required, the components for the other can be deleted.

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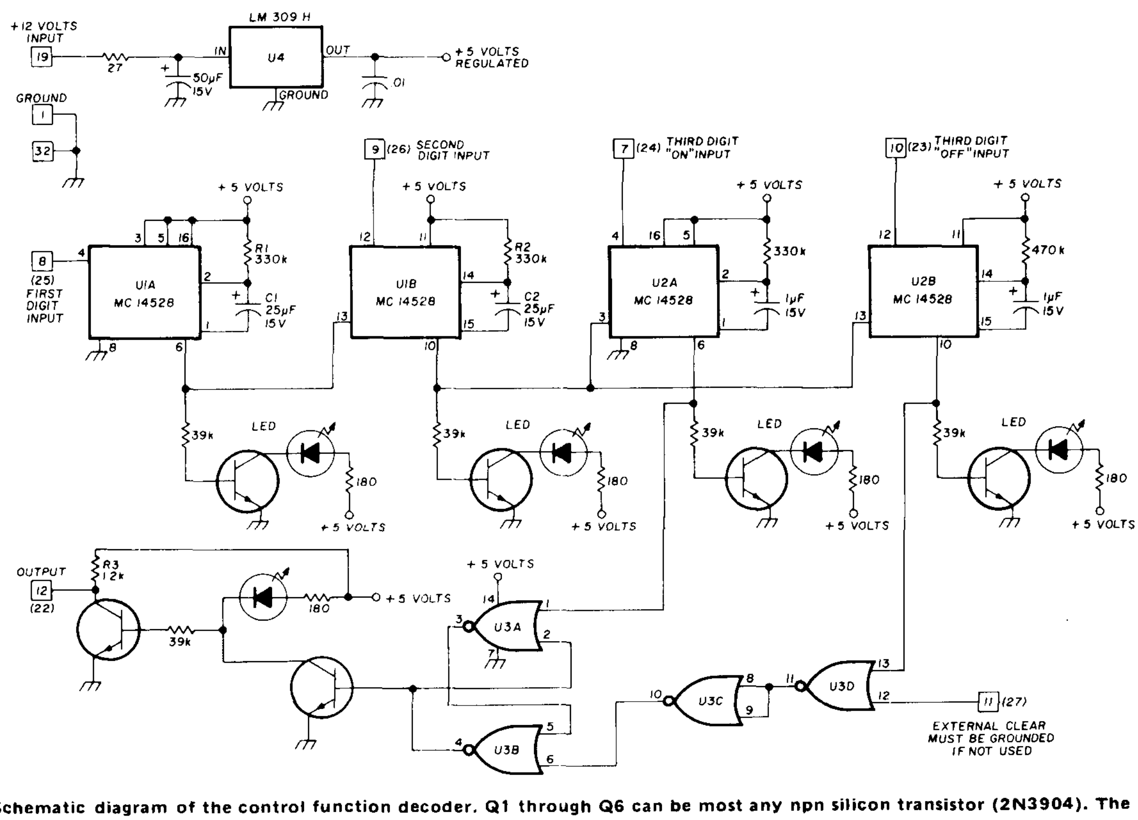
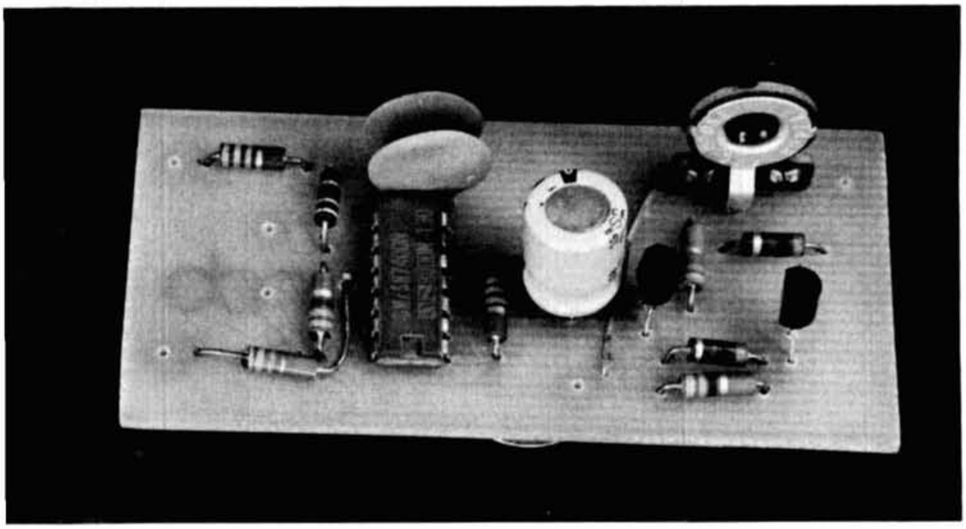


fig. 1. Schematic diagram of the control function decoder. Q1 through Q6 can be most any npn silicon transistor (2N3904). The LM309H and associated heatsink are mounted on the circuit board. U3 can be an MC14001 or CD4001. The numbers in the boxes and parentheses refer to the edge connector pins. Note that there are two complete decoders on a single printed-circuit board. All resistors are ¼ watt, 10%. A copy of the printed-circuit layout is available from HAM RADIO upon receipt of an sase.



synthesized channel scanning

Simple and easy channel scanning for the GLB 400 synthesizer

After acquiring one of the GLB 400B Channelizers, I found that it would be convenient to monitor our local repeater while hunting for others on the band. WAØAQO's[1] system was far too complicated for me so I incorporated a simple flip-flop to replace the function of the receive switch and presto, I had a two-channel scanner that would alternate between the two frequencies set into the Channelizer by the switches.

circuit description

As shown in **fig. 1**, gates 1 and 2 are connected as an astable multivibrator with its frequency controlled by R6 and C1. Lowering the value of C1 will cause the oscillator frequency and consequently, the scan frequency to increase. Conversely, the scan frequency will be slower if the value of C1 is decreased. The square wave produced by this oscillator is used to drive gates 3 and 4, connected as a dual flip-flop.

The basic action of a flip-flop has one output high while the other is low. With each incoming pulse from the oscillator, the outputs will change to the opposite state. The high output of gates 3 and 4 is used to alternately select the frequency determining switches.

Now that the channelizer is scanning the two frequencies indicated by the settings of your switches, a method is needed to stop the oscillator when a signal is received. Note that **fig. 1** shows two circuits for stopping the oscillator. Check your receiver to determine whether the point you desire to tie onto for scan lock goes positive or negative. A good place to tie in is the area of the squelch or limiter circuit. If this point goes in a negative direction when a signal is received, then use the circuit A. If the point goes positive, use circuit B.

In lock circuit A, Q1 is normally conducting and will cease conducting when a negative voltage or ground is applied. A positive voltage will then forward bias the base of Q2, effectively shorting gate 1 to ground and stopping the oscillator. Gates 3 and 4 will then remain in their respective states.

Q2 in lock circuit B operates in the same manner as circuit A. It is initially cut off until there is an incoming signal. Switch S1 is used to turn the Channel Scanner off and return the Channelizer to its original configuration.

construction

The circuit can be built on a piece of perforated board* and mounted anywhere within your Channelizer that space permits. Three additional holes are needed in the front panel. Locate a spot to mount the switch S1, and carefully drill an appropriate size hole for it. Mark

*Circuit Board Specialists, Post Office Box 969, Pueblo, Colorado 81001. The complete kit of parts including switch and circuit board is priced at $11.00; the circuit board alone is $3.00.

By Robert D. Shriner, WAØUZO, 1740 East 15th Street, Pueblo, Colorado 81001.

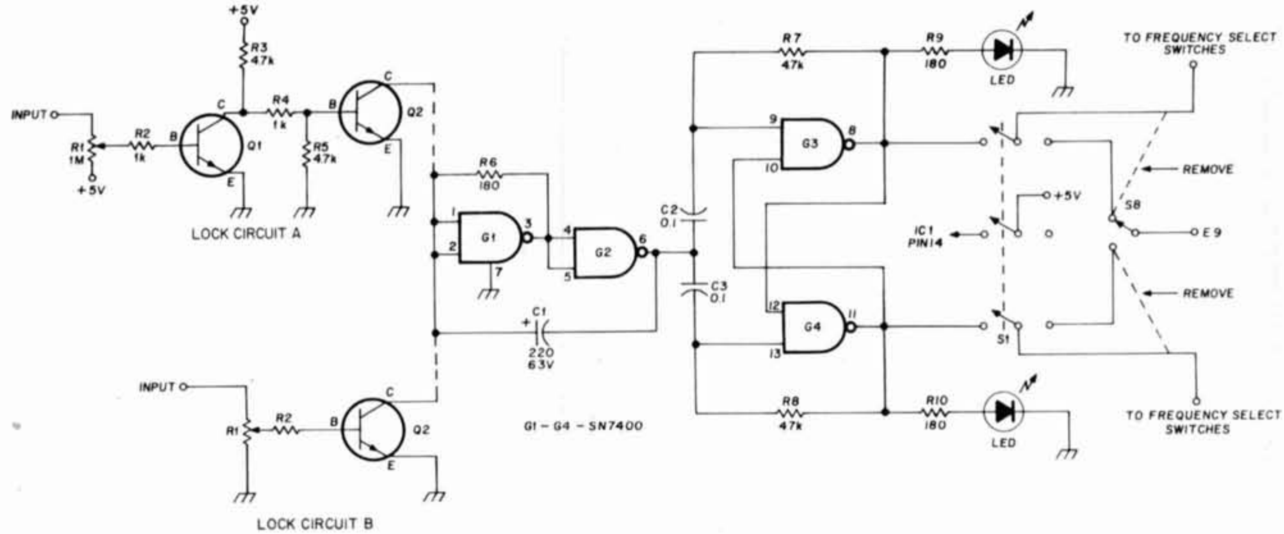


fig. 1. Schematic diagram of the channel scanner. The leads to the frequency-select switches provide a high or low voltage that alternately programs the counters in the GLB 400 to the correct frequency. The appropriate lock circuit must be chosen for the receiver used.

your panel with "instant lettering" – scanner *on* and *off*.

The indicator lights should be mounted in such a manner on the front panel so that they will show which set of switches is activated. Drill two holes to fit the light-emitting diodes. After locating switch S8 in your Channelizer, remove the two wires that are connected to the frequency-select switches and connect these to the new switch as shown. Five volts for the scanner is also run through S1 so that in normal operation (not scanning) the LEDs will not be blinking on and off.

This little circuit has added a very valuable feature to an already fine piece of equipment. I do not know how many other synthesizers this will adapt to but I am sure that they exist.

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improved method for calibrating time-base oscillators

Two receivers coupled to a common vfo plus an a-m detector and vtvm yield accuracies to better than 2 parts in 10^8

Here is a method that will eliminate the uncertainties of time-base oscillator calibration when listening for a zero beat with WWV or when watching a receiver S-meter. A much more accurate technique is presented for measuring time-base oscillator calibration and stability.

Consider a frequency counter made from a kit and calibrated by ear to WWV. Such a subjective method has the potential for missing errors in frequency calibration over several seconds. There is also a chance for error due to WWV carrier fading. Both of these problems translate directly into TBO calibration inaccuracies.

calibration method

Fig. 1 shows a method that virtually eliminates these chances for error. With two high-frequency receivers, a vtvm and some ingenuity, a frequency-counter TBO can be calibrated to an accuracy better than 2 parts in 10^8 cycles. Note that the two receivers in **fig. 1** are coupled to the same vfo (both have a 455-kHz i-f). One of the receivers is tuned to WWV, and the other is tuned to the TBO harmonic that matches the WWV carrier frequency being received. With both receivers using the same vfo, any phase difference between the two i-fs would be attributable to a phase difference between the TBO and WWV.

Fig. 2 shows the two i-fs fed into an a-m detector. The vtvm is connected to the agc bus and measures the agc voltage developed by the two signals. As long as the two i-f voltages remain constant in amplitude, the only thing that will cause the agc to fluctuate is any phase differences between the TBO and WWV signals. If the two signals vary in phase, fluctuations in the agc voltages will occur.

The WWV signal must be strong and steady for this method to work. My HQ-150 receiver was converted to solid state and the fets in the i-f stage were forced into hard limiting of the carrier by a high rf gain control setting. This principle is identical to fm limiting, where undesirable amplitude modulation of the fm-carrier is clipped. Care was also taken to make sure the TBO did not overdrive the receiver front end. This was done to keep the receiver from radiating signals into the WWV receiver front end. To prevent interaction between the two i-f strips, an IC CA3020 tuned amplifier was placed between the HQ-150 receiver and the a-m detector.*

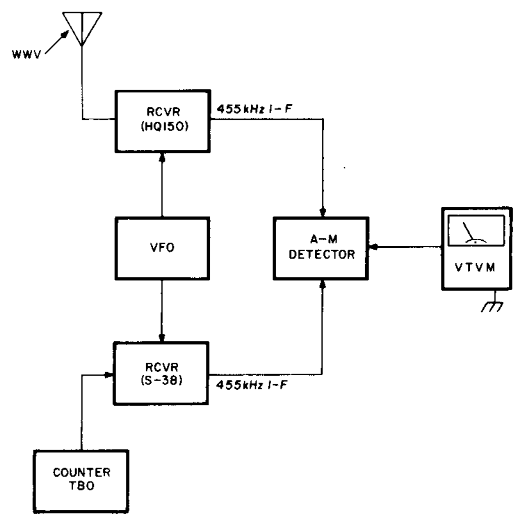

fig. 1. System block diagram using two receivers and a common vfo. One receiver is tuned to WWV; the other is tuned to the time-base oscillator harmonic that matches the WWV carrier. The S-38 vfo is disabled and the HQ-150 vfo is fed to the S-38 mixer through a CA3020 amplifier circuit (see text).

Once the receivers had been properly set up, the TBO was calibrated. Adjusting the TBO crystal-oscillator trimmer capacitor caused the vtvm needle fluctuations to speed up or slow down as the TBO became more or less in phase with WWV. Once the slowest possible move-

*The CA3020 amplifier can be found on page 234 of the 1970 RCA *Linear Integrated Circuits Handbook.* My circuit was identical to that of the text with the exception of the substitution of a 455 kHz primary winding from an old i-f transformer in place of the coil shown in the text. This was done to tune the amplifier to 455 kHz.

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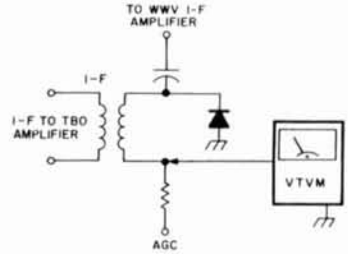

fig. 2. I-f output of the two receivers is fed to an a-m detector. The vtvm is connected to the agc bus and measures the agc voltage developed by the two signals.

ment had been observed, the period length of the error was measured.

The vtvm dc-scale level was set for a value that allowed the fluctuations to be observed over a wide enough arc to ensure accurate timing of the cycle. As the needle moved from one end of the scale to the other and back again, the period length of the movement was timed. If the movement took ten seconds and the receiver was tuned to 10 MHz, then the TBO error was computed as one cycle in 100 MHz of WWV; *i.e.*, 10 MHz x 10 seconds = 100 MHz. The error is then of 1 part in 10^8 cycles.

accuracy

The accuracy of this method was verified by calibrating the TBO as described above and comparing the results with a laboratory standard, in this case a Gertsch RLF-1 60-kHz WWV receiver-comparator using a comparator frequency of 300 kHz. **Fig. 3** shows the chart-recorder results. In one hour there were 21 cycles of TBO drift. Dividing this drift by (300 kHz x 60 seconds x 60 minutes); *i.e.*, 21/(1.08 x 10^9), yields 1.94 parts of error in 10^8 cycles. The results confirmed by the Gertsch comparator were almost identical with those computed by the dual-receiver, single vfo method of **fig. 1**.

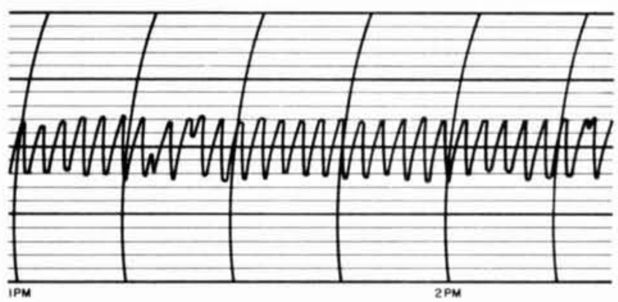

fig. 3. Calibration results of the measurement method using a Gertsch RLF-1 60-kHz WWV receiver-comparator and a comparator frequency of 300 kHz. About 21 cycles of TBO drift occurred in one hour, yielding 1.9 parts of error in 10^8 cycles.

The TBO used for this experiment was enclosed in a crystal oven, and the entire unit was housed in a Styrofoam box to further isolate the TBO from the environment. The procedure described here provides an excellent method for a more accurate calibration of any TBO.

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MICROPROCESSORS

microcomputer interfacing: the MOV and MVI 8080 instructions

In the preceding column, we indicated that within an 8080 microprocessor chip there exist seven general purpose registers (B, C, D, E, H, L, and the accumulator) each of which operates on eight bits at a time. These registers are used for many varied purposes, *e.g.*, the storage of an 8-bit constant, an 8-bit timing byte, a 16-bit pointer address, or an intermediate result from an arithmetic or logical operation.

By examining the data transfer instructions, MOV D,S, in the 8080 instruction set it can be seen how the general purpose registers may be used. We will assume that there is some data initially present within each register. There are sixty-three different MOV instructions, each of which specifies both the source register, S, of the data and the destination register, D, to which the data is moved. For example, to move data from register E to register B, you would use the instruction MOV B,E which is the Intel mnemonic notation for the operation of moving data to register B from register E. Unfortunately, an 8080-based microcomputer has no way to understand or interpret a mnemonic instruction such as MOV B,E. What is required is the binary representation for MOV B,E, – 01000011_2. These eight bits, which comprise the instruction code for MOV B,E, can be manipulated digitally, *i.e.*, they can be stored in a semiconductor memory device, transmitted over a data bus, stored in an instruction register within the 8080 chip,

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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.

and decoded by an instruction decoder into a series of actions that the 8080 performs internally.

How do you convert from the general mnemonic for a move instruction, MOV D,S, to the specific binary instruction code? First, the general form of any MOV instruction is,

0 1	d d d	s s s
MOV class of instructions	3-bit binary code for destination register	3-bit binary code for source register

and second, each general-purpose register has associated with it a unique 3-bit code.

register	3-bit register code
B	000
C	001
D	010
E	011
H	100
L	101
*	110 (to be dis-
accumulator (A)	111 cussed later)

After the source and destination registers have been selected, insert the respective 3-bit codes into the appropriate places in the general MOV instruction format given above. Some examples are as follows:

data transfer operation	mnemonic	instruction code
E→B	MOV B,E	01 000 011
H→A	MOV A,H	01 111 100
B→C	MOV C,B	01 001 000
D→L	MOV L,D	01 101 010
L→D	MOV D,L	01 010 101
E→E	MOV E,E	01 011 011

Since binary code is difficult to remember, it is convenient to represent the above 8-bit instruction codes in octal code. Thus:

data transfer operation	mnemonic	octal instruction code
E → B	MOV B,E	103
H → A	MOV A,H	174
B → C	MOV C,B	110
D → L	MOV L,D	152
L → D	MOV D,L	125
E → E	MOV E,E	133

In each case, you have copied data from one register into another. The destination register contains the copy, *the source register remains unchanged.* Notice that the MOV L,D and MOV D,L instructions have the source and destination registers reversed. In the MOV E,E instruction, you have copied the contents of register E back into register E. The net result is that E remains unchanged. This is a valid 8080 instruction, but it has no visible effect and can be called a "do nothing" instruction. Similar "do nothing" instructions exist for the other six general purpose registers.

You may recall that the IN and OUT instructions permit data transfer to occur between the accumulator (register A) and external I/O devices. The MOV D,S instructions offer one means of temporarily storing input and output data bytes elsewhere within the 8080 chip. Besides the IN instruction, how else can data be transferred into the general purpose registers? There are generally two ways of doing so, from the program (for permanent constants), and from memory (for temporary constants, results, data files, etc.).

To get data directly from a program into one of the registers, *immediate* instructions can be used. These are multi-byte instructions that contain the desired data within the instruction. The first instruction byte is always the 8080 instruction code; it tells the 8080 chip what to do next. The next one or two instruction bytes contain the actual data. The two-byte *move immediate* instructions,

MVI r
< B2 >

permit you to move the data contained in the second byte into the specified register, r. The < B2 > notation means that space must be left in the program for the second instruction byte. The general form of the MVI r instruction is,

0 0	d d d	1 1 0
instruction class	3-bit code for destination register	

or 0D6 in octal code. Some examples include:

data transfer operation	mnemonic	octal instruction code
< B2 > → A	MVI A	076
	< B2 >	< B2 >
< B2 > → B	MVI B	006
	< B2 >	< B2 >
< B2 > → H	MVI H	046
	< B2 >	< B2 >

To output the ASCII letter Q to output port 6, you would execute the following program:

octal instruction code	mnemonic
076	MVI A
321 (ASCII Q)	321
323	OUT
006	006

As indicated in the program, you first load the 8-bit ASCII code into the accumulator register; having done so, you then output the accumulator contents to port 6. Data or constants can be moved into individual registers at any point in an 8080 microcomputer program, and as often as needed, simply through the use of MVI r instructions. Remember, each MVI r instruction consists of two instruction bytes.

The transfer of data between memory and the general purpose registers is more complex since *you must clearly and unambiguously specify which one of a possible 65,536 different locations you wish to use for the transfer operation.* This requires a 16-bit address that is stored in the H,L register pair, register H containing the *high* (HI) address byte and register L containing the *low* (LO) address byte. Once you specify these two address bytes, you can readily transfer data back and forth between *the specified memory locations M* and any of the seven general purpose registers. To do so, you use a MOV, D,S instruction, where the 3-bit code for memory location M is 110 (or 6 in octal code).

As an example, if you wish to transfer data from memory location HI = 030 and LO = 123 to register D, you execute the following program:

octal instruction code	mnemonic	comments
056	MVI L	Load register L with the following LO address byte
123	123	LO address byte
046	MVI H	Load register H with the following HI address byte
030	030	HI address byte
126	MOV D,M	Move data from the memory location addressed by register pair H,L to register D

Remember, whenever you perform an 8080 instruction involving memory location M as "register M," which has a register code of 6_8, you must specify beforehand the absolute memory address of M in register pair H,L. We shall continue this discussion of the 8080 instruction set in our next column.

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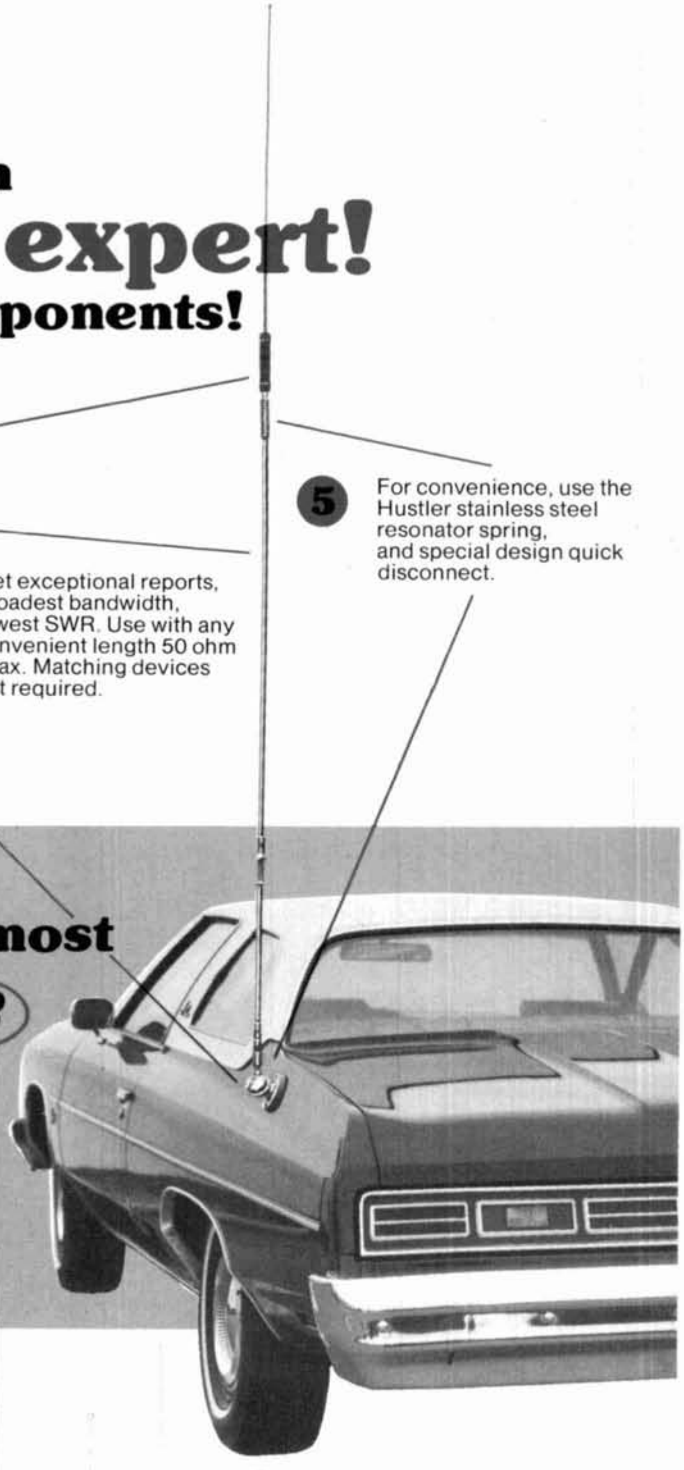

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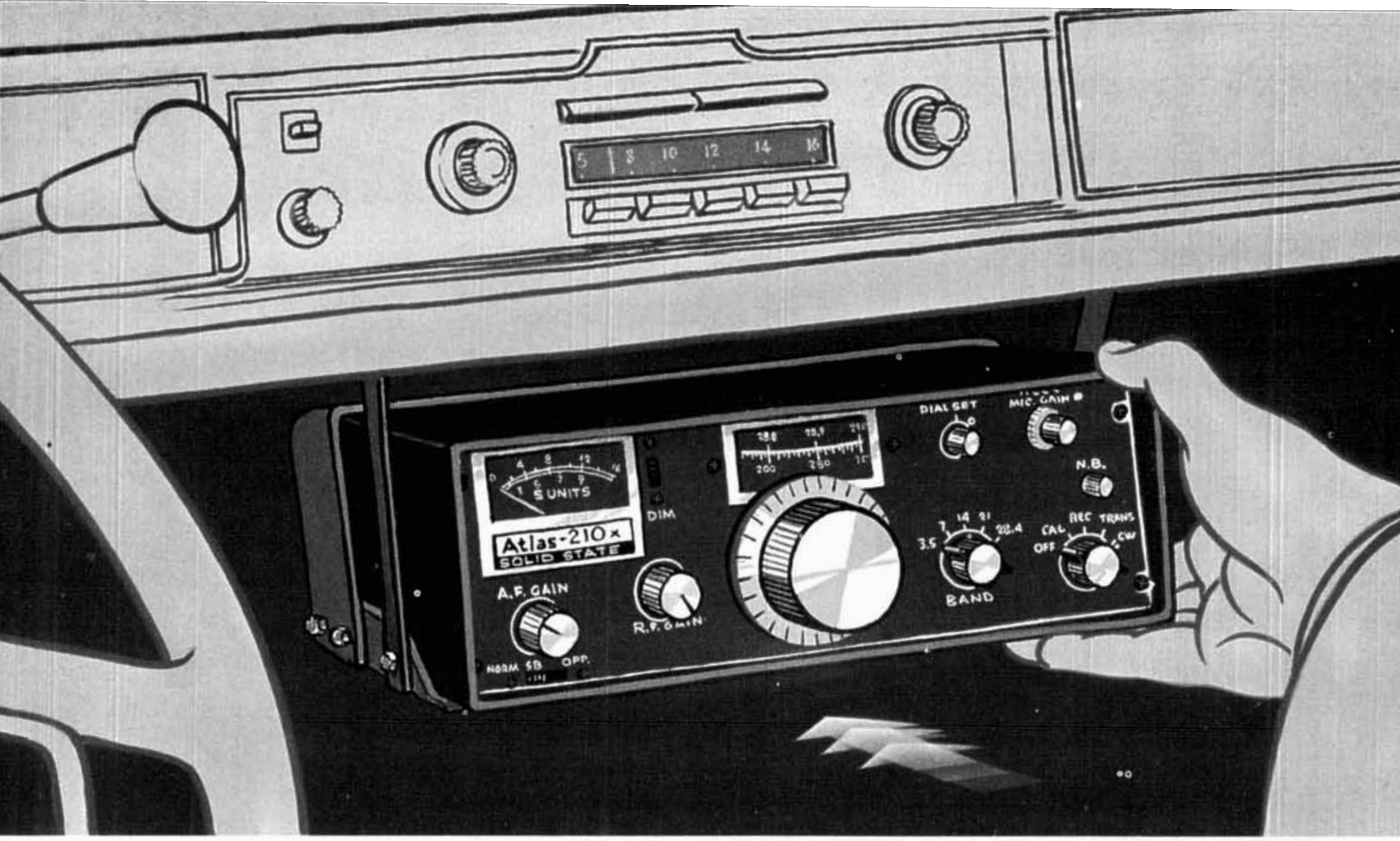

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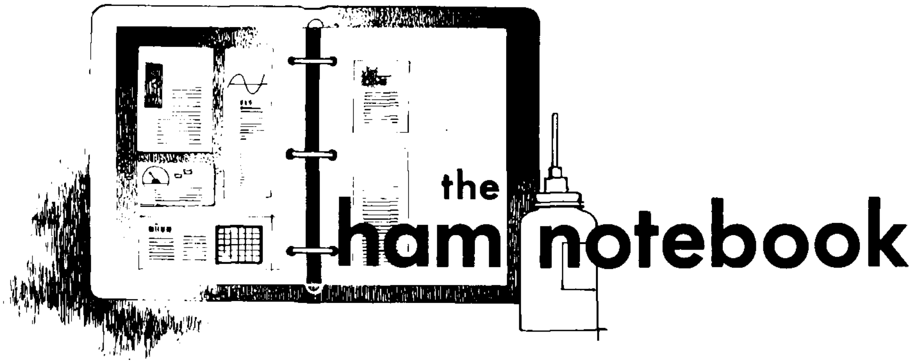

drilling template for integrated circuits

Any amateur scanning the amateur magazines is amazed at the diverse and ambitious construction projects presented. One item that might prevent a large number of amateurs from tackling similar projects is the problem of making printed-circuit boards. Most amateurs lack the necessary equipment and area to fabricate PC boards by the photographic method. The sticky-back foil patterns available are relatively expensive and can result in the board costing more than the components. The remaining technique of resist pen and ink is slow but economical. In the past,

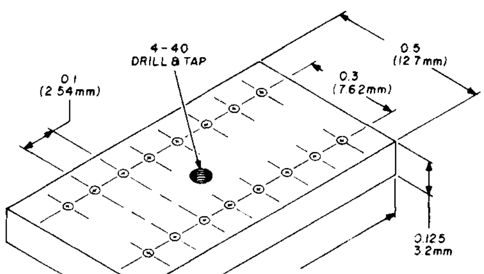

fig. 1. Dimensions of template block for drilling DIP holes in printed-circuit boards.

straight sketching on the cleaned copper-clad board was adequate for simple transistor circuits, but the advent of dual-in-line packages has imposed a need for higher accuracy.

One method to fill the gap between foil and resist-pen techniques is shown in **fig. 1**. A 1/8-inch (3mm) thick plate has been precision-drilled for a 16-pin dual-in-line hole pattern. The same plate can be used for 8- or 14-pin layouts. In practice, a single hole is drilled with a no. 32 (3mm) drill and the plate is

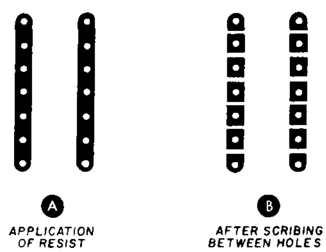

fig. 2. Applying resist pattern for DIP IC packages, (A) application of resist; (B) after scribing between holes.

clamped to the foil side of the board with a single 4-40 (M3) screw through the hole. With the plate in place, the drilling of the required hole pattern is simple and rapid. The result is an accurate hole pattern with evenly spaced holes.

Next, the pads must be marked with a resist pen. This is easily accomplished by first marking each line of holes with a continuous stroke as shown in **fig. 2A**. Then a scribe is used to separate and isolate each hole pad as shown in **fig. 2B**. Using this method, a clock driver circuit using four 14-pin packages was drilled, laid out, etched, and completed in less than two hours.

The drilling template can be made by any amateur or professional machinist.

heterodyne crystal switching in Heathkit SB-series equipment

Heterodyne crystal frequency changing has come into some use due to the desire by many amateurs to communicate with Oscar and MARS stations. Rather than permanently replacing the crystal (which seems permanent) or using a relay to switch the crystal (which isn't really necessary), I devised the following means.

A small Z-shaped aluminum bracket was secured to the chassis between tubes V-10/11 and V19 by two 4-40 (M3) nuts and screws which replaced the existing ones. A crystal socket and a spdt switch are mounted on the bracket and wires as shown in **fig. 3**. This enables *any* heterodyne crystal to be

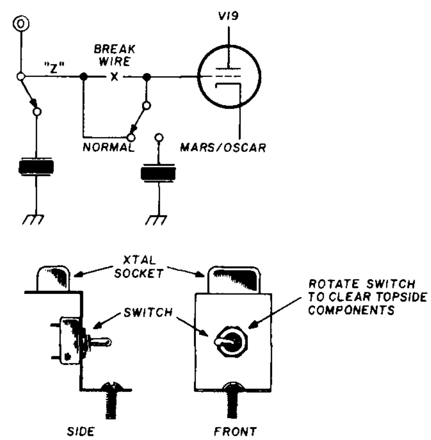

fig. 3. System for improved heterodyne crystal switching in the Heath SB-series equipment.

changed easily. Nothing is lost or permanently changed, just added and easily removed. I used a socket which accepts FT-243 and HC-17/U holders since pins can be soldered to HC-6/U holders to fit that socket as well.

Paul Pagel, K1KXA

Drake R4-C modification

At low listening levels, when using headphones or speaker with the Drake R4-C receiver, the audio is noticeably contaminated with power supply ripple. This may be corrected by a remarkably simple modification which will become obvious after examination of the chassis layout.

In order to connect the diode and regulator board located near the rear of the chassis with the filter capacitors located near the front of the chassis, connecting wires have been run in a circuitous manner alongside the audio cables and through the wiring harness. Return currents to the power transformer center taps travel through the chassis underneath the audio board ground connections.

To re-route these ground currents, simply clip the red-yellow transformer lead from the grounded tie-point at the rear of the chassis and, by splicing in another piece of wire, connect it to a ground lug of filter capacitor C163. In a similar manner, move the blue-yellow transformer lead to a ground lug of filter capacitor C166, and dress both wires along the inner edge of the chassis. Next, locate the white-purple lead which goes into the wiring harness and emerges again to connect with capacitor C166 Δ, clip one end of this wire from the base of regulator transistor Q2, and clip the other end of the wire where it is fastened to the capacitor. Replace this wire with another and dress it with the two wires already installed and dressed along the inside edge of the chassis as previously described. This procedure should be repeated with the white-orange lead to capacitor C166D, and the white-yellow lead to C163□. Additional capacitance across filter capacitor C166 helps to a small degree, but the major improvement is obtained simply by moving the wires as described.

George R. Bailey, WA3HLT

Heath SB-102 modifications

I have previously written about R955, a 100k resistor, being underrated. It avalanches down in value and burns up. Replace R955 with a 1- or 2-watt resistor (page 58, June, 1975, *ham radio*). There is at least one other resistor, R103, which has similarly burned up. Replace it with a 1- or 2-watt resistor as well.

In both of my Heath SB-102s I have encountered another problem which is especially bad in the CW mode. After transmitting for a couple of minutes and then reverting to the receive condition, the S-meter drops nearly to zero for two or three seconds and then quickly builds up to a high value (S9+20 dB or more), which desensitizes the receiver to a weak incoming signal for about 30 to 60 seconds. There is an easy top-of-the-board fix for this problem, however.

Without going into all the detail, tube V2 is acting as a noise generator for the short time that screen voltage remains on the tube after reverting to the receive mode. I found an easy way to cut this stage off promptly when reverting to the receive condition, without unduly upsetting the ALC action of the stage. After much "cut and try" of values, the following was adopted as a satisfactory solution to the problem.

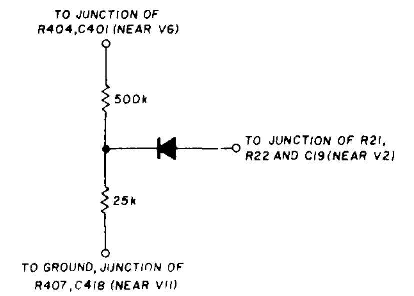

fig. 4. V2 will be cut off completely using this addition to the bias.

Locate R404 (near V6) where it joins C401. Attach one end of a 500k, ½-watt resistor to this point. Connect the other end of the new 500k resistor to the cathode end of a diode *and* to one end of a 25k, ½-watt resistor. The other end of the 25k resistor goes to ground, which can be conveniently picked up at the junction point of R407 and C418 (near V11). The other end of the diode goes to the junction point of R21 and R22. The schematic diagram is shown in **fig. 4**.

Lowell White, W2CNQ

suppression of rf interference in telephones

Contemporary telephone design often fails to take into account interference from a potentially large number of rf energy sources. Varistors are used in telephones as high-level audio limiting devices, but they also detect and rectify rf, making each telephone behave somewhat like a crystal receiving set in the presence of strong rf fields.

Several telephone manufacturers have designed and developed telephones capable of satisfactory operation in the presence of strong rf fields, but these special sets are not normally stocked by most local telephone company offices. Therefore, it is desirable, if not essential, to find another means of filtering rf energy from ordinary telephones. Fortunately, a simple modification to the telephone renders the set immune to rf interference and makes complete rf suppression possible.

An inductor, designated 1542-A, consists of two rf chokes and serves as an effective rf filter at broadcast frequencies. Moreover, 1542-A inductors are readily available at most telephone company offices and are often installed in home telephones to suppress rf from powerful local broadcast stations. Unfortunately, at some amateur frequecies, the rf chokes of 1542-A inductors becomes highly reactive and may burn up in the presence of very strong rf fields. Although such an occurence is unusual, it can happen, and may be easily prevented in the following manner.

For Bell Telephone series-500 telephone sets:

1. Place a 1542-A inductor in series with the telephone set.

2. Connect a 0.01 μF capacitor across the receiver element.

3. Connect a 0.01 μF capacitor between terminal RR and terminal C of the telephone network.

4. Connect a 0.01 μF capacitor between terminal GN and terminal R of the telephone network.

For General Telephone series-80 telephone sets:

1. Place a 1542-A inductor in series with the telephone set.

2. Connect a 0.01 μF capacitor across the receiver element.

3. Connect a 0.01 μF capacitor between terminal 4 and terminal 23 of the telephone network.

4. Connect a 0.01 μF capacitor between terminal 1 and terminal 23 of the telephone network.

These modifications render the telephone immune to interference from rf energy and disable it as a crystal set. The 1542-A inductor limits the rf passed to the telephone, and the capacitors bypass rf energy.

When building or installing a phone patch, it is desirable to install a 1542-A filter in the telephone line to the patch. If a filter is not available, two 2.5 mH rf chokes can be installed in series with the telephone line to the patch, one choke in each side of the line. They should be mounted inside the patch cabinet or box, and a 0.01 μF capacitor connected across the telephone line on the patch side of the rf chokes. The microphone side of the patch should also be decoupled by a 2.5 mH rf choke placed in series with the microphone lead inside the phone patch. A 470 pF bypass capacitor should be connected between the microphone side of the rf choke and ground. With this simple modification, telephone patching is immune to rf interference.

Rf detection by phone patches and telephone sets can also be a good indication of a poor ground or a poor antenna system at the rf source. It is therefore desirable to have a good antenna and ground system at the transmitter for radiation efficiency as well as for reducing stray rf energy.

Ken Anderson, K7LDZ

S-meter for Genave transceivers

Since Genave transceivers do not have tuning meters or S-meters to assist in tuning weak stations, I installed the simple circuit of **fig. 5** in my GTX-200 to take care of this omission. I drilled a hole for a phone jack in the rear panel and installed the rest of the components by short leads on the bottom of the board. I have used a Heath IM-104 fet vom voltohmmeter and have also used a 25 micro-amp meter, direct. On my Genave, IC101 is the same as an RCA 3065E.

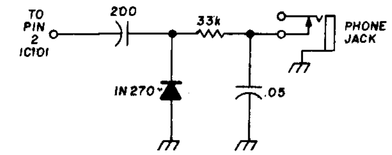

fig. 5. Simple circuit for adding an S-meter to the Genave two-meter transceiver. Meter is connected to the phono jack.

Larry M. Chrisman, K9OXX

low-cost, two-meter mobile antenna

Have you ever wanted a simple two-meter mobile antenna that could be used in a hurry, that didn't have to be permanently mounted, that didn't cost much, and didn'trequire any hole drilling? I was in that category a few months ago — on a Sunday, as I recall. The stores were closed, but I wanted to go mobile with my TR-22 for a short trip and work some repeaters along the way. Here's how I solved the problem (with help from my wife).

I used a large stationery spring-clip, the kind with wide, flat clamping jaws and a pair of tabs or "ears" with holes in them. The holes looked to be the right size to accept the shell of an auto-type antenna connector that I happened to have in the junk box. I reamed the hole just a bit to accept the connector body, and bent the connector tabs over the edge of the clamp "ears" to secure the two together. After this was done, I attached a short length of RG-58/U coax to the assembly; shield braid to the clamp-shell and center conductor to the "hot" pin on the connector. Now for the antenna element.

I used the mating auto-antenna plug to mount a 19-inch (48.3cm) piece of music wire soldered to the tip. For insulation and security, I filled the top of the plug surrounding the wire with some five-minute epoxy and let it cure. Presto! The antenna was done, and it took only about one-half hour to build.

Results were just great. I clipped the makeshift antenna to the rain gutter molding on the mobile, and bent the tab holding the antenna just enough so that the antenna was vertical. The coax was led through the partly-open window to the TR-22 on the seat next to me. Just for fun, I put an swr bridge in the circuit and was surprised — and pleased — to find that it was less than about 1.3:1. Until I bought my new 5/8-wave magnetic mount antenna, this little gutter-clamp job did the trick. Neither the electrons, nor the amateurs I talked to, knew the difference.

Jim Gray, W2EUQ

IC230 modification

The ICOM model IC-230 transceiver has a push-button selector switch on the front panel labelled "megacycle switch." Also a slide switch on the top right corner, labelled A/B, provides ±600-kHz offset for repeater operation. When switching from 146 to 147 MHz or vice versa, the A/B switch must also be switched. Failure to do so, or forgetting what position it should be in, could put you outside the band. I have incorporated a minor modification to

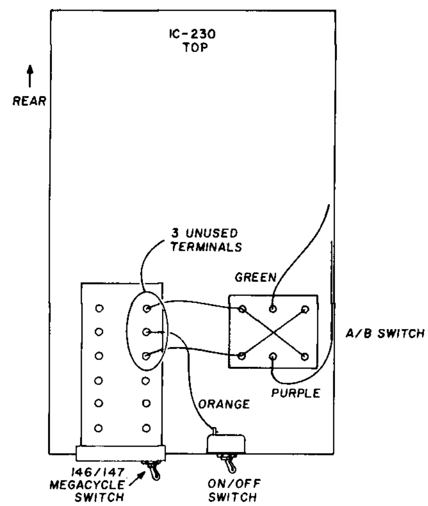

fig. 6. IC-230 modification to avoid out-of-band operation.

my IC230 to allow proper offset under all conditions when the A/B switch is left in position A (**fig. 6**). For special applications, opposite shift may be selected by switching the A/B switch to position B.

Bill Theeringer, W8PEY

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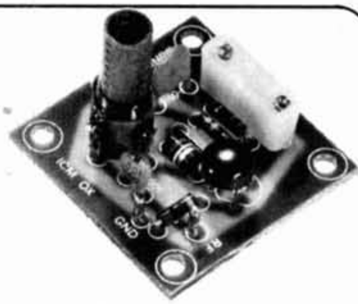

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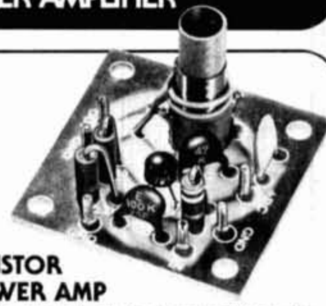

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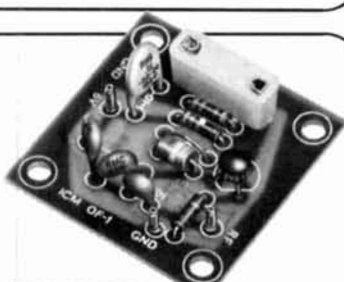

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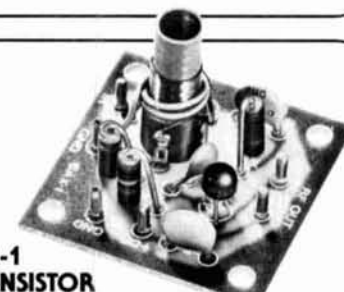

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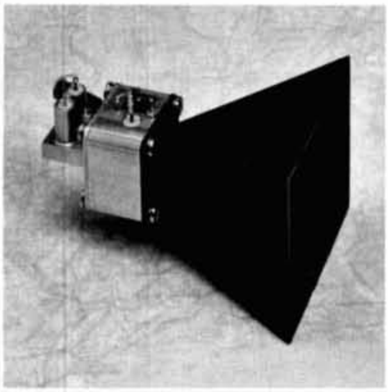
Highly pleased with performance. **WA8ACZ** — A real nice rig. I have owned about every other make. **W5EGK** — Works nicely. **WB4ECO** — I tried this rig, a pleasure to operate. **WA4YRK** — *Excellent reports on audio.* **WB8NKB** — Wonderful. **W9QPQ** — An excellent rig. Love it. **W8SOP** — Makes running SSB nets a real breeze. Also good on CW nets. **WL7IRT** — Fantastic rig. **W4MDB** — Has rekindled my interest and enthusiasm in Amateur Radio to an extent I hadn't thought possible. It far out distances any competitive product at **any** price. **W6EYR** — Very nice. Been a ham for 45 years and now solid state perfection. **W2RPH** — Excellent rig. **WN0TDK** — TRITON IV is a fabulous piece of equipment. **W5VIW** — Very nice rig **WB2LQF** — Wow! **W9JCV** — Tnx for giving us a FB piece of equipment made in the USA. **W8GHO** — Very pleased. **K4KXB** — Seems to have everything desired. **W4SZ** — *A pleasure to operate.* **W2FKF** — Greatest rig I ever had. So far in a month 34 QSO's without one miss. Been a ham since 1922. **W4GVC** — Nothing but complements. **WB9EZE** — Well pleased with performance and simplicity of operation. **K4ETI** — Rig is great. **W8CNV** — Man—! what a rig. I've had this call since 1929. Never saw anything like it and I've seen them *all!* **WB2MZU** — *Seems like everything* the S - - - - - O - - was supposed to be at one third the price. **WN0VHE** — I think it is a very good rig. **WB9FTD** — Break-in CW is very impressive. **K0CBA** — I believe it is one of the finest HF transceivers on the market. I can't tell you how pleased I am with the noise blanker. I can get on the air from my home station again for the first time in a few years. Other rigs with noise blankers just didn't hack it. **WA7YHW** — I am very pleased with this equipment. It is certainly of high quality. **W7IIA** — Excellent equipment. **WB0RWA** — Couldn't be more pleased with it. It certainly has performed beautifully and is all I expected and more. **WB4QJT** — *Like it very much — keep up the good work.* **WN1YVX** — Really impressed with looks and performance. **W0NC** — Very FB rig. Performs up to specifications, an excellent design. **K8PBZ** — Already have TRITON II and IV. **W7KD** — This little "T-4" is smooth as silk . . . I've received some very flattering reports about transmitter voice quality and the CW operation is the greatest. **WN8TTO** — *I found* that the TRITON IV was the best rig on the market for around $800. I love it! **W2JBK** — It is absolutely fantastic. **W8FEI** — Am amazed at receiver performance. I thought I had a top notch receiver with the H - - - - - - - - -! **W1FYM** — Your guarantee is refreshingly proper. **W8MOK** — Sure makes a guy look twice at his old tube type gear. **W1TFS** — Finest CW ever, CW selectivity very good. **WB6IVR** — Very satisfied with TRITON IV. Just what I was looking for to use on my yacht. Thanks. **WA8ONP** — Also have a TRITON II. I am pleased that Al Kahn and the **good guys** at TEN-TEC thought of the CW operator! **W2EMX** — Excellent Amateur gear meets and exceeds advertised *claims.* **W0AMJ** — *It looks like there is nothing left to be desired.* It is beautiful. **W6SE** — The receive function is outstanding. It is superb in transmit. **W1BV** — In love with this fantastic gem. It's so easy and a pleasure to operate. **W6ASH** — Very happy with performance. Particularly impressed with full break-in and light weight. **WA0IMS** — By far the best rig I have ever operated. I am glad I decided on the TRITON IV and not one of the other transceivers on the market. **WA8HQO** — Thank you gentlemen.

Add your name to the growing list. See your TEN-TEC dealer or write for full details.

TEN-TEC, INC.
SEVIERVILLE, TENNESSEE 37862
EXPORT: 5715 LINCOLN AVE., CHICAGO, ILL. 60646

NEW products

Amateur 10-GHz Gunnplexer



Microwave Associates has recently announced a new solid-state transceiver designed especially for the Amateur 10-GHz band which consists of a varactor-tuned, frequency-modulated Gunn-diode oscillator and Schottky mixer diode. The rear portion of the unit pictured above consists of a Gunn-diode oscillator which directly converts dc (+10 Vdc nominal) to 20 mW of rf energy. The oscillator is preset to 10.250 GHz, the center of the Amateur band, unless otherwise specified. Mechanical tuning allows the center frequency to be tuned ±100 MHz; the built-in varactor is used for frequency modulating the device and will deviate the center frequency up to 60 MHz, depending upon the applied tuning voltage.

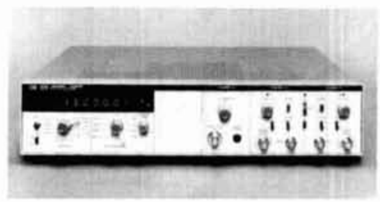
The receiver section of the *Gunnplexer* consists of a low-noise Schottky mixer diode which has a noise figure of about 12 dB when used with a low-noise i-f strip. A small amount of power from the Gunn oscillator (about 0.5 mW) is applied to the mixer diode through a ferrite circulator integrated into the waveguide mount. The circulator also isolates the receiver and transmitter functions of the module. A horn antenna with 17 dB gain is available as an accessory.

Since the Gunn oscillator provides both transmit power and mixer injection, the setup for radio communications is similar to that used with klystron-based polaplexers (see page 40, this issue), *i.e.*, the center frequencies of the *Gunnplexers* used at each end of a communications link must be offset by the i-f frequency, typically 30 MHz. Fm broadcast receivers can also be used for the i-f system, with afc applied to the *Gunnplexer* tuning varactor to minimize frequency drift (which is −350 kHz/°C maximum without afc).

Maximum range with the 20 mW Microwave Associates *Gunnplexer* depends on a number of factors including required fm signal-to-noise ratio, fm deviation, i-f bandwidth, and antenna gain. However, assuming a 10-dB signal-to-noise ratio (the threshold of speech in an fm system), a line-of-sight path between stations, and the accessory 17-dB horn antennas, maximum range is about 25 miles with a 240-kHz i-f bandwidth (that used in fm broadcast receivers). If the i-f bandwidth is decreased to 50 kHz, maximum range is about 55 miles.

The *Gunnplexers* can be used for two-way communications, as a link between repeater sites, security alarms, or fm doppler radar systems. A separate power supply, fm modulator, and receiver must be provided by the user. The MA87127 *Gunnplexer* is priced at $85. Also available is the MA87108 which consists of the Gunn oscillator and tuning diode module ($60). A *Gunnplexer* with the accessory 17-dB antenna is priced at $108. Two complete transceivers with horn antennas, MA87141, are $185. For more information, write to Microwave Associates, Inc., Northwest Industrial Park, Burlington, Massachusetts 01803.

H-P frequency counter extends range to 1300 MHz



Frequency measurements to 1300 MHz covering mobile communications bands, vhf and uhf television, am and fm broadcast, TACAN and DME frequencies are now possible with Hewlett-Packard's Model 5328A Universal Counter using a new module. Called Option 031, the module adds five features to the counter's capabilities:

1) Extends frequency range to 1300 MHz

2) Provides 20 millivolt sensitivity for measuring low-level signals

3) Adds automatic gain control (AGC) for protection against overload

4) Includes a fused 50 ohm input channel

5) Provides accessory power for a 20 dB preamplifier for more sensitivity.

The basic Model 5328A with no options makes frequency measurements to 100 MHz, and single-shot time interval measurements to 100 nanoseconds reso-

More Details? CHECK—OFF Page 126

lution. Time interval averaging increases resolution to 10 picoseconds for repetitive events. It also measures period, period average and frequency ratio, and will totalize and scale inputs. Frequency measurement sensitivity is 25 millivolts rms to 40 MHz and 50 millivolts rms to 100 MHz. With its eight-digit display and a standard crystal time base, the basic Model 5328A sells for $1300. U.S. price of Option 031 is $600, and delivery is 4 weeks.

For additional information write to Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, California 94304, or use *check-off* on page 126.

circuit-stik/centron catalog

Circuit-Stik and its sister company, Centron Engineering, announce the release of their new condensed catalog no. 503, merging three distinct product areas of the two companies: Circuit-Stik's unique sub-elements for making instant circuit boards, pre-etched GP (general purpose) prototype and wire wrap socket boards, and Centron Engineering's printed circuit drafting aids for making circuit board master artworks.

Each area features new products and detailed information for many applications, assembly ease and time-saving features. A *How to Use* section with technical specifications is included. Several new microprocessor oriented GP boards, as well as new card cages and accessories, are featured in the GP Board section, New IC DIP continuous patterns are offered in the drafting aid area.

For further information, contact: Circuit-Stik/Centron Engineering, Inc., 24015 Garnier Street, Torrance, California 90505.

variable speed tape transport for microprocessors

The Triple I Division of The Economy Company of Oklahoma City is now offering a new low-cost variable-speed model to its line of electronic cassette tape transports. Features of the variable speed model include: four-motor control, remote control capabilities, fast start-stop, less than 30-second rewind, ac or battery-operated and variable speeds (0.4 to 10 IPS). Nominal power requirements are 7.0 volts dc at 600 mA.

In addition to use in microprocessors, the unit has applications in data recording/logging/storage, programming, instrumentation, industrial controls, data duplicating, security/automatic warning systems, testing apparatus, audio-visual education, hi-fi, and other general applications.

Four separate motors control take-up, rewind, play or record, and head engagement. The separate motors allow the most complex tape deck function to be accomplished by remote control. Flutter, wow and jitter are minimal because the capstan drive motor has only one job – moving the capstan.

Control Boards for the Phi-Decks, which are TTL, DTL, and CMOS compatible, contain all the circuitry for proper control of the Phi-Deck tape transport.

Options such as EOT/BOT sensing, record/play, read/write, electronics, cassette-in-place sensing, and others are available.

For further information, write or call Triple I, a division of The Economy Company, 1901 North Walnut, Box 25308, Oklahoma City, Oklahoma 73125; telephone (405) 528-8444, Ext. 71 or 79, or use *check-off* on page 126.

four-channel hi-fi decoder

National Semiconductor Corporation and Tate Audio Limited have combined efforts to produce a kit of three types of integrated circuits that will accurately reproduce quadraphonic four-channel high-fidelity sound from phonograph records. Quad hi-fi, which can reproduce sound with concert-hall realism, is expected to become a standard format of the recording industry, and could eventually replace stereophonic sound formats.

Tate designed its system to decode CBS SQ-type program material from phonograph records and tape cassettes after making an exhaustive analysis of the theories and practicality of all techniques for reproducing four channels of sound. The SQ technique uses standard, existing pick-up components that are compatible with monaural and stereophonic formats. In addition, the SQ format is compatible with stereophonic broadcasting methods to make use of a broad range of records and tapes already produced by CBS and other major companies.

Separation of channels in any direction approaches 40 dB across the entire audio bandwidth, while the signal-to-noise ratio is 70 dB. Total harmonic distortion is only 0.05 per cent. These parameters meet the most demanding specifications of high-fidelity sound technology.

Although the Tate system is sophisticated in concept, its comparatively low number of external components permits a circuit board size of only 1.5x3.25 inches (36x80mm).

Additional information may be obtained by contacting Roy L. Twitty, National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051; telephone (408) 737-5287; or Wes Ruggles, Tate Audio Limited; telephone (213) 822-3189; or use *check-off* on page 126.

microcircuit computes true rms value

The first genuinely low-cost *true rms* converter with guaranteed accuracy, crest factor, and frequency response is now available from National Semiconductor. Known as the model LH0091, the new converter will compute the root-mean-square value of virtually any combination of ac or dc input signal from dc to 2 MHz. The device is ideal for use in digital voltmeters, in digital multimeters, in measuring audio signals or noise levels, in making harmonic or vibrational analyses, and in power measurement and control. An uncommitted amplifier is provided for filtering, gain, or high-crest-factor configuration.

The *LH0091* is manufactured in two kinds of 16-lead dual in-line packages. Available in both commercial and military temperature range, the device is priced between $22.50 and $44.00, depending on the temperature range. For more information write National Semiconductor, 2900 Semiconductor Drive, Santa Clara, California 95051.

More Details? CHECK—OFF Page 126

NOW FROM Wilson:

AMATEUR: ANTENNAS • ROTORS • TOWERS

3 CRANK-UP TOWER MODELS AVAILABLE

TT-45 FREESTANDING CRANK-UP TOWER, 45 Ft.
The TT-45 will support 9 sq. ft. at a height of 39 ft. freestanding when properly bracketed to a house or wall at the 8 ft. level. The loads decrease as the tower extension Mast is lengthened. (Loads are based at 50 mph and load permitted on the tower decreases with increases in wind speed over 50 mph). The tower can be completely freestanding with our new concrete or tower rotating bases, which allow the use of our raising fixture. Using these accessories, the towers can be installed by one man easily.

List . . . **$329.00**

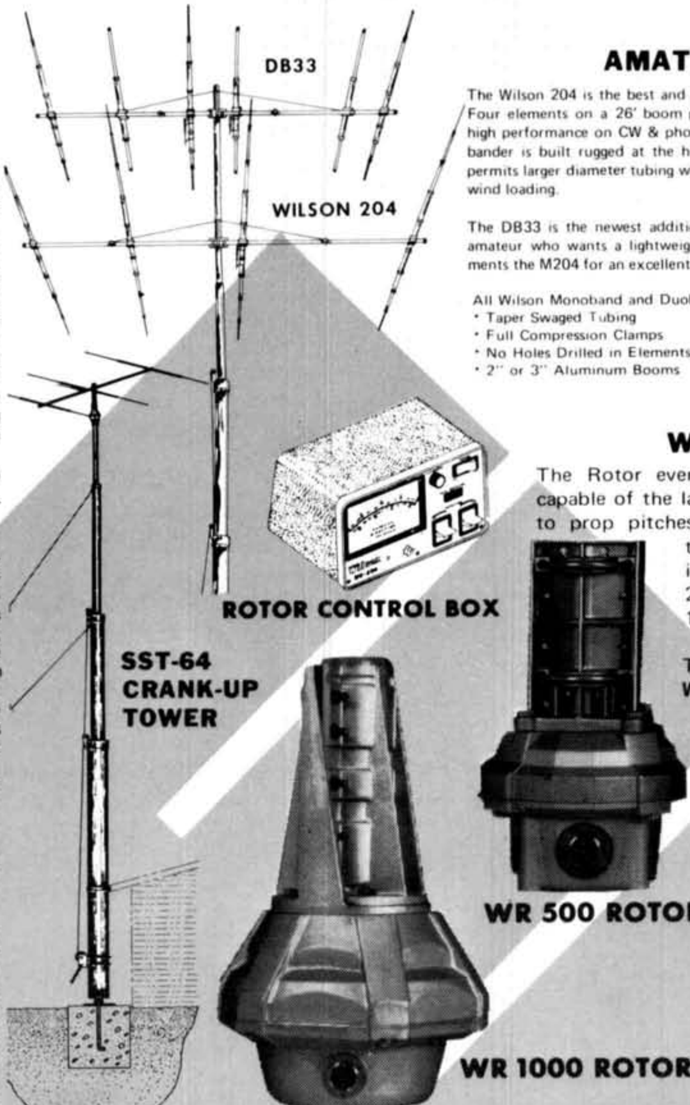
FOR THE TOWERING SIGNAL - WILSON'S SST-64 GUYED CRANK-UP TOWER, 64 Ft.
All steel tubing is galvanized plated and conforms to ASTM specifications for years of maintenance free service. The SST-64 is made of 4 sections, being 4.5", 3.5", 2.5" and 2". These large diameters give unexcelled strength and virtually makes the thin push-up poles a thing of the past. The large loads of today's antennas make the Wilson SST-64 the best value on the market today.

List **$397.00**

THE WILSON GT-46 GUYED CRANK-UP TOWER, 46 Ft.
The GT-46 features quality construction and materials, with the stability of the Guyed System.

FEATURES OF THE GT-46:
• Low cost • High capacity • all steel. Conforms to ASTM (American Standard of Testing Materials) • Fully galvanized • 800 lb. winch standard • Guy kits available for factory recommended installations • 2000 lb. raising cable standard (Aircraft Quality) • Can be roof mounted for extra height • Great looking, slim flag pole design, for the ecology minded.

List **$235.00**



AMATEUR ANTENNAS

The Wilson 204 is the best and most economical antenna of its type on the market. Four elements on a 26' boom plus a Gamma Match (no balun required) make for high performance on CW & phone across the entire 20 meter band. The 204 Monobander is built rugged at the high stress points. Using taper swaged slotted tubing permits larger diameter tubing where it counts, for maximum strength with minimum wind loading.

The DB33 is the newest addition to the Wilson line of antennas. Designed for the amateur who wants a lightweight economical antenna package, the DB33 compliments the M204 for an excellent DXers combination.

All Wilson Monoband and Duoband beams have the following common features:
- Taper Swaged Tubing
- Full Compression Clamps
- No Holes Drilled in Elements
- 2" or 3" Aluminum Booms
- Adjustable 52 Ω Gamma Match
- Quality Aluminum
- Handle 4kw
- Heavy Extruded Element to Boom Mounts

WR 1000 ROTOR

The Rotor everyone has been waiting years for — capable of the largest arrays up to 25 sq. ft.—Superior to prop pitches — Full 4,000 inch lbs. of turning torque. Braking system requires 12,000 inch lbs. before over-riding — accepts 2" - 3" masts — Weighs 60 lbs. — Size: 11" diameter, 19" high.

The Finest Rotor in the Market Today
WR 1000 . . . . **$429.00** List

WR 500 ROTOR

The Wilson WR500 Rotor has 780 inch lbs. of turning torque before stalling.

In addition, a Special Braking System requires 1300 inch lbs. of torque before windmilling—This is more than twice the braking ability of the other comparable rotor being marketed.

Full 98 Steel Ball Bearing raceway assures elimination of side torque jamming when Rotor is mounted in line with the mast.

Recommended for antennas of 7.5 sq. ft. or less . . . weighs 20 lbs.

The WR500 Rotor . . **$129.95** List

WILSON AMATEUR ANTENNA SPECIFICATIONS

Model No.	Frequency	Forward Gain (dB)	Front-to Back Ratio (dB)	Front-to Side Ratio (dB)	Boom Length (ft.)	Number Elements	Longest Elements (ft.)	Turning Radius (ft.)	Surface Area (sq. ft.)	Wind Loading at 80 MPH (lbs.)	Assembled Weight (lbs.)	Shipping Weight (lbs.)	Price
M340	40	8.5	20	30	40	3	70'0"	39'0"	15	300	180	220	$749.00
M620	20	13.0	28	35	58	6	36'0"	32'0"	10.5	210	98	123	420.00
M520	20	12.0	26	30	40	5	36'4"	27'0"	8.75	175	74	96	299.00
M204	20	10.0	25	30	26	4	36'4"	22'6"	6.8	136	42	48	169.00
M203	20	8.5	20	30	19	3	36'0"	20'5"	5.25	105	35	40	129.00
M155	15	12.0	26	30	26	5	24'3"	18'0"	5.0	100	41	44	159.00
M154	15	10.0	25	30	19	4	24'3"	15'9"	4.0	80	30	33	109.00
M153	15	8.5	20	30	17	3	24'3"	14'0"	3.0	60	21	24	89.00
M108	10	13.5	26	30	40	8	18'0"	22'0"	5.5	110	49	77	219.00
M106	10	13.0	26	30	31	6	19'0"	16'1"	4.0	80	34	36	119.00
M105	10	12.0	26	30	26	5	18'0"	15'8"	3.0	60	29	32	109.00
M103	10	8.5	20	30	11½	3	18'0"	10'0"	2.0	40	10	12	39.00
DB54	20	12.0	26	30	40	5	36'4"	27'0"	12.75	255	94	119	349.00
	15	10.0	25	30		4	24'3"						
DB43	15	8.5	20	30	19	4	24'3"	15'8"	6.0	120	38	43	149.00
	10	10.0	25	30		3	18'0"						
DB33	15	8.5	20	30	17	3	24'3"	12'2"	4.5	90	30	33	109.00
	10	8.5	20	30		3	18'0"						

AVAILABLE THRU YOUR LOCAL DEALER

FOR THE NAME OF YOUR NEAREST AMATEUR DEALER *OR FOR A FREE CATALOG OF THE ABOVE PRODUCTS, CONTACT:*

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Prices Effective March 31, 1977

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Measures continuity and resistance to 2K. Test LED's, diodes & transistors. Less Speaker. Requires 6 to 12 volts, (batteries not included). **$1.95**

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Emits a piercing dual tone blast that is impossible to ignore. Great with our **Sender Receiver Kit**. All components and quality PC Board included. Speaker and power switch not included. (3-15V) **$2.50 (kit)**

MINI GRANDFATHER CLOCK KIT

The most fascinating kit we have ever offered features: *Large LED Simulated swinging pendulum matches tick-tock sound* Electronic tone chimes the hour (ie: 3 times for 3 o'clock)* Quality components & 2 PC boards measuring 4.5" x 6.5"* All CMOS IC construction* Transformer provided, no case included* Large ½" LED readouts. $44.00 Postpaid

BULLET SUPER STAR PS–01A **$14.95**

A compact, well regulated triple output power supply. Gives +5VDC @ 1.5A and +15 @ 150ma and −15 @ 150ma. Complete with PC Board, components, heatsinks & quality transformer. **PS–01B** same as above but with +/−12 output instead of +/− 15; **Please specify model number when ordering.**

ULTRASONIC SENDER-RECEIVER KIT 19.95

A complete transmitter/receiver kit that will flood an average sized room with 23KHZ sound and detect any movement in the area. The output is a DC level that can be used to trigger a relay, bell or alarm. Uses 2 quality transducers. All components & PC Board included. **(Requires 9-15 VDC @ 60ma [not supplied]).**

AUTOMATIC TIME OUT CIRCUIT for ultrasonic or mechanical switch alarms. Provides a five second entry delay, sounds alarm for one minute, then re-arms itself. Requires 6-15 VDC. **$3.95**

PS–12 POWER SUPPLY KIT

We Guarantee your Satisfaction!
Not only is the PS–12 able to supply a continuous 10 AMPS (15 AMPS intermittent) of low ripple, regulated DC voltage, but it is also variable from 3 to 30 volts! Use it as a building block for a fantastic bench supply. *We leave the chassis work up to you!*

FEATURES:
- Output adjustable from 3 to 30 Volts DC
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- Special Pre-regulator circuit eliminates need for massive heat sinks.
- Better than 1% Load & Line Regulation from 0 to 15 amps
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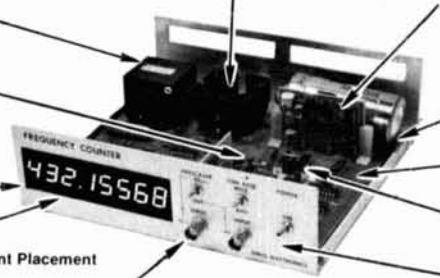
- Heavy duty 10 lb. Transformer

KIT INCLUDES:
- Transformer
- Heatsink (drilled)
- Semiconductors (diodes, transistors, etc.)
- All Components (resistors, caps)
- Transistor mounting hardware & insulators
- Drilled & plated PC Board
- Wire

$49.95
add $3.70 for postage

(the outside looks nice)
BUT
IT'S WHAT'S INSIDE THAT COUNTS



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- 500 MHz • ±.0002% ACCURACY
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500 MHz Kit **$249.95**
Kits include all parts, drilled and plated PC boards, cabinet, switches, hardware and a complete instruction manual with calibrating instructions.
All parts are guaranteed for 90 days. Factory service available for $25.

500 MHz Factory Assembled **$349.95**
Shipping Charges **$2.00**
Instruction and Calibrating Manual **$3.00**
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Factory assembled units are tested and calibrated to specifications, and are guaranteed for 1 year.

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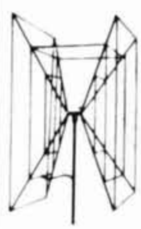
GEM-QUAD FIBRE-GLASS
ANTENNA FOR 10, 15, and 20 METERS

Two Elements $129.00
Extra Elements $90.00
Price is F.O.B. Transcona
INCLUDES U.S. Customs Duty



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WINNER OF MANITOBA DESIGN INSTITUTE AWARD OF EXCELLENCE

Buy two elements now — a third and fourth may be added later with little effort.

Enjoy up to 8 db forward gain on DX, with a 25 db back to front ratio and excellent side discrimination.

Get maximum structural strength with low weight, using our "Tridetic" arms.

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An AFFORDABLE, SILENT, RTTY System

New Model 150 RTTY Keyboard

Features:

4 speeds (60,66,75,100 wpm)

Built-in AFSK with 3 shifts (170, 425, 850 hz)

Automatic CR & LF at end of 64 or 72 character line

Built-in low shift CW ID provision

Priced at **$289.50**

F.O.B. St. Louis

New Model 75 RTTY to Video Converter

Features:

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Built-in T.U. with 3 shifts (170, 425, 850 hz)

32 character x 16 line video output with scrolling

Connects directly to receiver audio & video monitor

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F.O.B. St. Louis

- Send for data sheets on these products
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- Master Charge welcome

INFO-TECH INCORPORATED *Specializing in Digital Electronic Systems*

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WE BUILT ONE FOR YOU!

- Send and Receive : 800 Channels
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AMCOMM FORT LAUDERDALE

Manufacturers of the Finest in Digital Communication Equipment

S–225 TWO METER SYNTHESIZED VHF-FM TRANSCEIVER

Introductory Package Price

$499.95

(Regular Price $549.90) Price subject to change without notice

TRANSMITTER SPECIFICATIONS

Frequency Range: 144 to 148 MHz. **Front Panel Frequency Splits:** Simplex, +0.6MHz, −0.6MHz, +1MHz, −1MHz. **Frequencies:** 800 (5KHz separation). **Modulation:** 16F3 ± 5KHz for 100% at 1,000Hz. **RF Power Output:** 1-25 Watts, variable. **Frequency Stability:** Within ±0.001% from −20 C. to +60 C. **Hum & Noise:** Better than −30dB 2/3 rated system deviation at 1,000Hz. **Antenna Impedance:** 50 Ohms. **Switching:** Solid-state type. **Spurious & Harmonic:** At least 60dB below rated carrier power. **Microphone:** Tumer, low impedance. **Audio Frequency Response:** 300Hz to 3,000Hz, referred to +1, −8dB of 6dB/Octave de-emphasis curve. **Audio Distortion:** Less than 7% at 1,000Hz, 2/3 system deviation. **Frequency Display:** 6 digit, 7 segment HP LED. **Optional Accessory:** Plug in touch-tone encoder. Face plate also available in black.

RECEIVER SPECIFICATIONS

Frequencies: 143 to 148.995MHz. **Usable Sensitivity (12dB sinad):** 0.35uV @ 50% audio. **Quieting Sensitivity (20dB):** 0.5uV minimum. **Squelch Threshold Sensitivity:** 0.25uV minimum. **Squelch Limit Sensitivy:** 2.0uV or less. **Modulation Acceptance Bandwidth:** ±7.5KHz minimum. **Adjacent Channel Selectivity:** 70dB minimum. **Spurious Response Attenuation:** 70dB minimum. **Intermodulation Attenuation:** 60dB minimum. **Local Oscillator Frequency Stability:** ±10 parts per million. **Audio Output Power:** 4.0 Watts into a 4 Ohm load @ less than 10% distortion. **Audio Frequency Response:** +2dB to −8dB from the standard 6dB per Octave de-emphasis from 300Hz to 3,000Hz. **Hum & Noise:** −50dB squelched and −30dB unsquelched. **Chassis Size:** 7 1/8 "W x 2 5/8 "H x 10".

The AMCOMM Connection.

An optional plug in touch-tone pad ($49.95) truly expands the capability of the S 2 25 in areas where auto-patch facilities are available. The auto-patch feature enables your S 2 25 to hook into the telephone system, allowing calls to any telephone in the local calling area, providing you are a member of a local repeater association which has auto-patch facilities.

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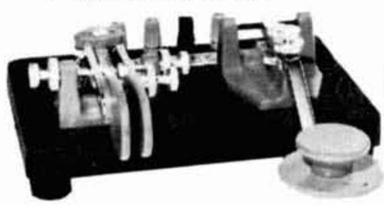

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SIGNAL-ONE CX7B CW filter wanted, either standard or deluxe. K. Lesh, K3RYL, 2750 Belaire Rd, Bethlehem, Pa. 18017. Ph: 215-691-0669.

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FOR SALE: Swan 250c, 117xc, 510x, vx-2, noise silencer. Excellent working condition. $450. Ron Leedy, WB8ONG, 236 S. Beverly Ave., Youngstown, Oh. 44515, Tel: 216-799-6268.

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WANTED: WRL Duo Bander 84 SSB transceiver state price and condx. Gerald L. Lyssy, W5BRZ, 8775 Kimberly Dr., Beaumont, Tex. 77707.

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

COLLINS KWM-2 round emblem #30254-516F2 P.S.-SPK-plus 30L1 linear-472-3033, NH W1CPI.

MANUALS for most ham gear, 1939/70. List $1.00. Send SASE (or 25¢) for one specific model quote. Hobby Industry, WØJJK, Box H864, Council Bluffs, Iowa 51501.

HELP need information on Poly Comm B, Can Copy, will pay, Barry Bird, WA4NNJ, 6003 Wonderland La., Mechanicsville, Va. 23111.

STAINLESS AND GALVANIZED STEEL antenna guy wire our specialty. Wilcox Electronics, Box 1331, S. L. C. Utah 84110.

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UNCONVENTIONAL SWAP FEST, Saturday, March 5, 1977 Marshall High School, Marshall, Michigan (near I-94 at I-69). Tech sessions, computer sessions, DX, VHF, YL meetings, plus a home tour of Historical Marshall, and dine at the world famous Win Schulers. Details and reservations - Goodrich, 117 Parrott Drive, Marshall, Michigan. Call it anything but a convention.

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WANTED: Inoperative Collins R-390A to repair and for maintenance of my R-390A. Ed Wagner, 1018 Birch Haven Cir., Monona, WI 53716.

Coming Events

W6LS 12th Los Angeles Amateur Radio Convention. Saturday and Sunday, May 21 & 22. 2814 Empire Ave., Burbank, CA 91605.

THE ROCK RIVER RADIO CLUB HAMFEST is April 24, 1977, at Amboy, Illinois, Lee County at the 4H Center, Routes 30 and 52. Same place as last year. Tickets $1.00 advance. $2.00 at gate. Camper parking available at a nominal fee. Write Carl Karlson, W9ECF, Nachusa, Illinois 61057. Indoor and outdoor facilities.

INTERNATIONAL DX CONVENTION — Fresno Hilton Hotel, Fresno, California, April 1, 2, & 3, 1977. Contact Northern California DX Club, Inc., PO Box 608, Menlo Park, CA 94025.

AUCTION & FLEA MARKET — Saturday, March 26, 10:00AM at St. Joseph's Church, East Rutherford, N.J. — Free admission/parking. Knight Raiders VHF Club. (201)473-7113 evenings only.

RALEIGH, N.C. HAMFEST will be held Saturday night, April 16 & Sunday, April 17 at the Crabtree Valley Mall, Highway 70W. Eyeball social & doorprizes Saturday night. Sunday a huge covered flea market, prizes, meetings & ladies programs. Admission: $3.00. For more information write RARS Hamfest, PO Box 17124, Raleigh, N.C. 27609.

KANSAS CITY: Eighth Annual Norhtwest Missouri Hamfest, April 23, 24, 1977 at Exhibit Hall 2, Municipal Airport. Forums, swap tables, commercial exhibits, contests, YL-XYL program, free parking. Banquet Saturday evening at world famous Gold Buffet with ARRL President Harry Dannals as guest speaker. Preregistration, $2.00; door, $2.50; preregistration with banquet, $8.00. Info: PHD, P.O. Box 11, Liberty, MO 64068.

THE BIGGEST LITTLE HAMFEST in America will be held March 19, and 20, 1977, in Vero Beach, Florida. Make your plans to attend the treasure coast hamfest now. Prizes — Atlas 210 with console and an Icom 22s. Tickets $2 advance, $3 at door. For more information write to 2226 11th Lane, Vero Beach, Florida 32960.

26th DAYTON HAMVENTION at Hara Arena April 29, 30, May 1, 1977. Technical forums, exhibits, and huge flea market. Program brochures mailed March 7th., to those registered within past three years. For accommodations or advance flyer, write Hamvention, P.O. Box 44, Dayton, Ohio 45401.

STARVED ROCK RADIO CLUB HAMFEST — June 5. S.A.S.E. after 4/1/77 for details. SRRC/W9MKS, RFD #1, Oglesby, Ill. 61348.

NEW JERSEY Delaware Valley Radio Association (W2ZQ/WR2ADE) flea market and auction will be held on Sunday, May 1, 1977, 9 AM rain or shine at the Villa Victoria Academy in West Trenton, N. J. (The school is located adjacent to Rt. 29 near the junction of Rt. 29 and I-95.) Talk in on 07/67 and 146.52. Refreshments are available. Advance registration $1.00; or $1.50 at the gate. For additional information or tickets write: DVRA, P.O. Box 7024, West Trenton, New Jersey 08628, s.a.s.e. please.

MICROPROCESSOR WORKSHOPS
Microcomputer Interfacing Workshop, June 9, 10, 11. A three-day workshop based on the popular 8080 micro processor. Over 20 operating 8080 computers are available for participant use.
Digital Electronics for Automation Workshop, June 7, 8. A two-day workshop based on the small scale and medium scale TTL integrated circuits. Many hours of laboratory time with individual breadboarding stations will be provided along with indepth lectures. For more information on these workshops contact Dr. Norris Bell, V.P.I. and S.U. Continuing Education Center, Blacksburg, Virginia 24061, (703) 951-6328.

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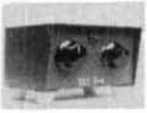

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590G	17.95	5	Axial	Grounds all except selected output circuit.
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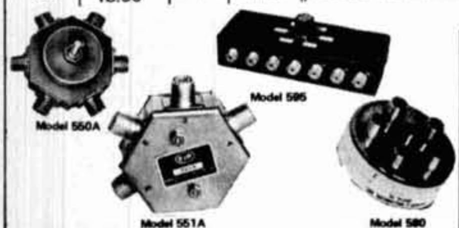
595	18.50	6	In-line	Grounds all except selected output circuit.

Model 376 Model 375 Model 550A-2 Model 592 Model 590G



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MODEL 104R

NPC 6 Amp Power Supply Regulated. Solid State. Dual Overload Protection.

Converts 115 volts AC to 13.6 volts DC ±200 millivolts. Handles 4 amps continuous and 6 amps max. Ideally suited for applications where excellent DC stability is important, such as CB transmission, small Ham radio transmitter, and high quality eight-track car stereos. Can be used to trickle-charge 12 volt car batteries.

	MAXIMUM	TYPICAL
Output Voltage	13.6 ± 2 VDC	13.6 ± .3 VDC
Line/Load Regulation	20 mV	50 mV
Ripple/Noise	2 mV RMS	5 mV RMS
Transient Response	20 uSec	
Current Continuous	4 Amp	
Current Limit	6 Amp	
Current Foldback	2 Amp	

$49.95

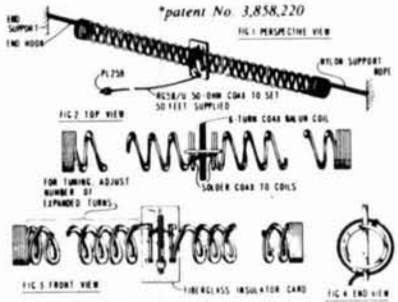
Case: 3½" (H) x 5½" (W) x 6½" (D). Shipping Weight: 6 lbs.

SLINKY!® $39.95 kit

A LOT of antenna in a LITTLE space

New Slinky® dipole* with helical loading radiates a good signal at 1/10 wavelength long!

*patent No. 3,858,220



• This electrically small 80/75, 40, & 20 meter antenna operates at any length from 24 to 70 feet • no extra balun or transmatch needed • portable—erects & stores in minutes • small enough to fit in attic or apartment • full legal power • low SWR over complete 80/75, 40, & 20 meter bands • much lower atmospheric noise pickup than a vertical and needs no radials • kit includes a pair of **specially-made 4-inch dia. by 4-inch long coils,** containing 335 feet of radiating conductor, balun, 50 ft RG58/U coax, PL259 connector, nylon rope & instruction manual • now in use by US Dept. of State, US Army, radio schools, plus thousands of hams the world over

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Now get TPL COMMUNICATIONS quality and reliability at an economy price. The new Econo-Line gives you everything that you've come to expect from TPL at a real cost reduction. The latest mechanical and electronic construction techniques combine to make the Econo-Line your best amplifier value. Unique broad-band circuitry requires no tuning throughout the entire 2-meter band and adjacent MARS channels. See these great new additions to the TPL COMMUNICATIONS product line at your favorite amateur radio dealer.

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Designed and engineered to be compatible with the full-power highly efficient modern amplifiers now available to the amateur. In our opinion the finest tuner on the market today. $229.50

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FREE Gift With Every Order! ALL SALES FINAL !

More Details? CHECK—OFF Page 126

flea market

PHOENIX, ARIZONA, MARCH 6, 1977. Winter Hamfest at South Mountain Park — Swap Meet, Eyeball, Pot Luck. South Mountain Park is at the south end of Central Avenue, Phoenix. Sponsored by the Amateur Radio Council of Arizona.

A BIG THANK YOU to everyone who attended the First Annual Sangamon Valley Radio Club HAMFEST at New Berlin, Illinois on September 26, 1976. Your attendance made the event a huge success and we'll be back next year, bigger and better, on Sunday, September 25, 1977. See you there!

TOLEDO MOBILE RADIO ASSOCIATION, INC. 22 Annual Ham Auction, Sunday, March 20, 1977 at the Lucas County Recreation Center, Maumee (Toledo), Ohio. Auction, Flea Market, Commercial displays and good Eyeball QSO's. From 8 AM to 5 PM. $2.00 advance, $2.50 after March 1, 1977 or at the door. Talk-in on 52-52 and all Toledo area repeaters. Send s.a.s.e., Toledo Mobile Radio Association, Inc., Box 7548, Oregon, Ohio 43616.

MOULTRIE AMATEUR RADIO KLUB 16th. Annual hamfest the last sunday of April at Wyman Park, Sullivan, Ill. Heated indoor area and large outdoor parking area. No charge to vendors. For information write Mark Radio Klub, PO Box 327 Mattoon, Ill. 61938. Talk In 146.94.

GREATER BALTIMORE HAMBOREE, Sunday April 3rd at 9:00 AM at Calvert Hall College Goucher Blvd. and La Salle Rd., Towson, Md. 21204 (1 mile south of Exit 28, BELTWAY-INTERSTATE 695). Food Service, Prizes, Giant Flea Market. Admission Charge $2.00. 225 Tables inside Gym. Over 1700 attended last year. INFORMATION AND TABLE RESERVATION: Contact Bro. Gerald Malseed, W3WVC at School Address or call 301-825-4266.

"MICHIGAN CROSSROADS" Amateur & Computer Hobbyists FLEAMARKET! Junction I-94 & I-69 Saturday MARCH 5 8a-4p. Forums-YL Tours! MARSHALL HIGH SCHOOL. Sponsors WB8QQU (MHS "AMPS") and W8DF (SMARS, Inc.) Information K8UCY Secy 616-781-3554.

F.M. B*A*S*H*, DAYTON, OHIO, April 29, 1977, on the Friday night of the DAYTON HAMVENTION. This is a social evening for all hams and their friends from 8PM til midnight at the Dayton Biltmore Towers, First and Main Street. Admission is free. Sandwiches, beverages, snacks and C.O.D. bar will be available. Live entertainment by TV personality Rob Reider (WA8GFF) and his group. 11PM prize drawing featuring ICOM IC-245 and other prizes. See you where the action is!

TEXAS. Midland Amateur Radio Club SWAP Fest Saturday and Sunday, March 26th and 27th. It will be held in the County Exhibit Bldg. on Highway 80, just East of Midland, Texas. Pre-registration will be $3.50 per person, and $4.00 at the Door. Please send pre-registration fees to Midland Amateur Radio Club, Box 4401, Midland, Texas 79701.

THE MESILLA VALLEY RADIO CLUB Sponsors Whitey's Bean Feed and Swap-Fest Sunday, April 24th, at 10:00a.m. Located near Las Cruces, New Mexico at La Mesa with talk-ins on 16-76, 04-64 and 3940 KC. Fun for all the family with big prizes, plenty of food and the usual beverage truck. All included for $5.00 for adults $1.75 for kid tickets. Eat, drink and win a prize with Whitney, K5ECQ as host. Free overnight parking at grounds so come for a spell. All correspondence should be made with Thomas B. Rapkoch Jr., 640 W. Las Cruces Ave., Las Cruces, New Mexico 88001.

Stolen Equipment

ICOM 22S SN: 2265, stolen from: Ed Weiss WØSSJ, 4501 West Kentucky #56, Denver, Colo. 80219.

STOLEN between December 18, and 22, 1976 from truck at 11318 Gravenhurst Dr. Cincinnati, Ohio. Regency HR-2A Serial 04-06931 and Regency AR-2 Two Meter Amplifier, Serial 115-0388. A 50 dollar reward is offered leading to conviction of suspects involved notify W8QIL, 11318 Gravenhurst Dr., Cincinnati, Ohio 45231, or your local police department, items have been entered into (NCIC) FBI computor.

FOLLOWING EQUIPMENT WAS STOLEN from the WA3RCA club station between five and eight PM, December 12, 1976. Collins KWM-2 Transceiver #10272, and 516F2 P/S #19920, Drake TR4-C #35245, and AC-4 P/S and unfinished Heathkit HW-2021. Report information to Cheltenham Police at: 215-887-6200; officer #12. An award of $100.00 is being offered for identification of the robbers, or other substantial information, and/or return of the equipment.

More Details? CHECK—OFF Page 126

GENAVE

The HAM Gear for 1977

GTX-IT
Hand-Held
2-meter FM, 6-channel, 3.5 watts hand-held with factory-installed tone encoder
$299.95

GTX-I
Hand-Held
2-meter FM, 6-channel, 3.5 watts hand-held
$249.95

CHECK THESE FEATURES:
- All metal case
- American made
- Accepts standard plug-in crystals
- Features 10.7 MHz crystal filter
- Trimmer caps on TX and RX crystals
- 3.5 watts output
- Battery holder accepts AA regular, alkaline or nicad cells
- Mini hand-held measures 8" high x 2.625" wide x 1.281" deep
- Rubber ducky antenna,
- Wrist safety-carrying-strap included
- 6 channels
- Factory-direct to you!

Accessories Available
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- Charger for GTX-1 battery pack
- Leather carrying case
- TEIII tone encoder for auto patch

TONE ENCODER PAD
Plug-in installation on most amateur transceivers.

TE-II **$49.95** TE-I **$59.95**

GTX-202
$239.95
(Incl. 146.94 MHz)

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SELECTIVITY? Really Super
NUMBER OF CHANNELS? From 1 to 22

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CHECK THESE OUTSTANDING FEATURES:
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2-meter FM, 100 channel combinations, 30 watts with factory installed tone encoder (Incl. 146.94 MHz) **$249.95**

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2-meter FM, 10 channels, 10 watts (Xtals not included)
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☐ GTX-200	$199.95	☐ TE-I Tone Encoder Pad	$59.95
☐ GTX-10-S	$149.95	☐ TE-II Tone Encoder Pad	$49.95
☐ GTX-2	$189.95	☐ PS-I AC Power Supply for use with all makes of transceivers 14 VDC—6 amp	$69.95
☐ GTX-1	$249.95	and the following standard crystals @ $4.50 each	$
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Add $4 per Radio for Shipping, Handling, and Crystal Netting.

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H-3

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☐ **TE-III** Tone Encoder (for use with GTX-1)	$49.95

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A brilliant new 2 meter transceiver with every in-demand operating feature and convenience

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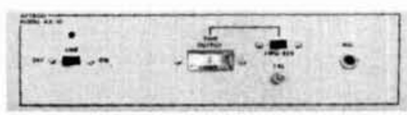

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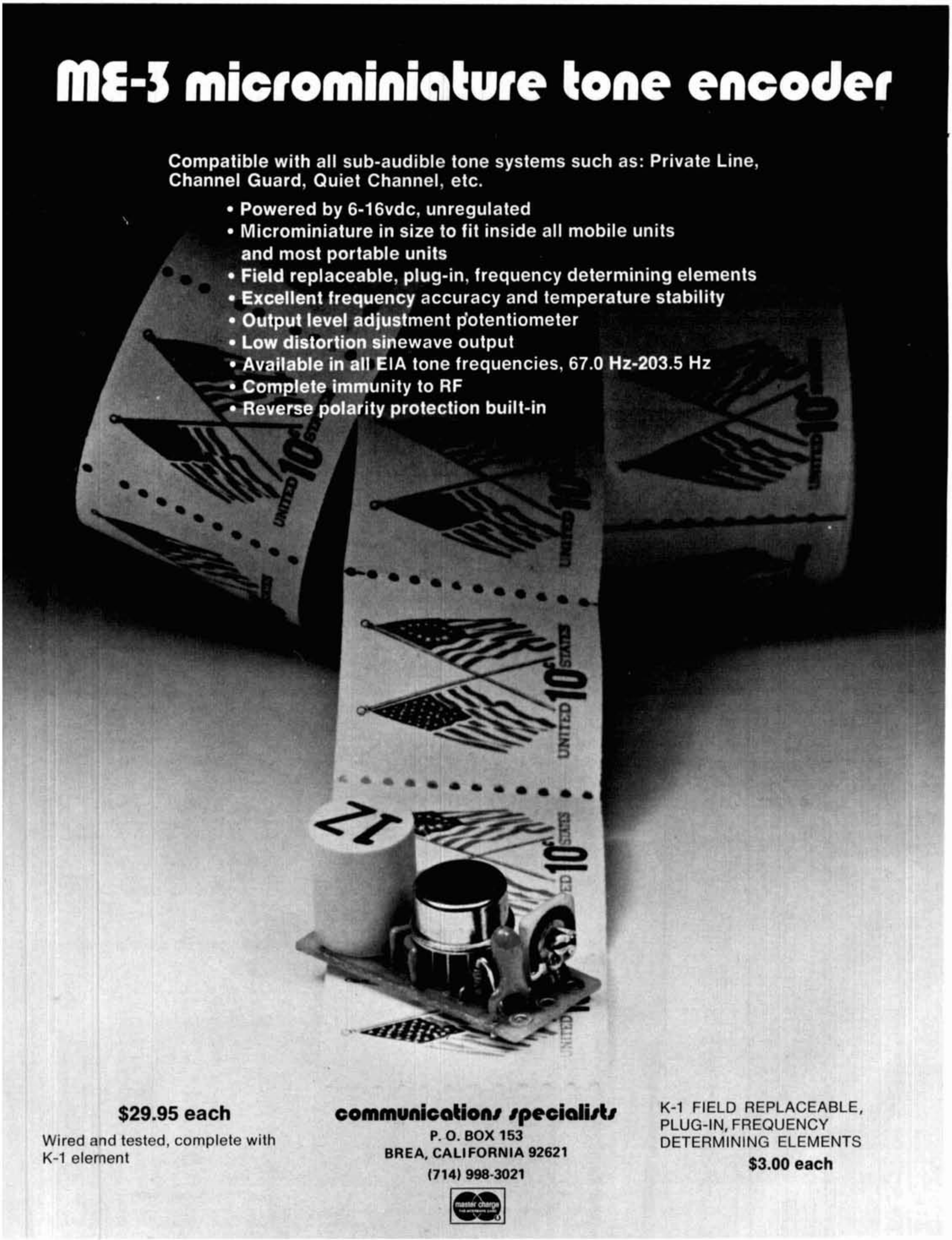
ME-3 microminiature tone encoder
Compatible with all sub-audible tone systems such as: Private Line, Channel Guard, Quiet Channel, etc.
• Powered by 6-16vdc, unregulated
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SPECIALS FROM MHz electronics

Fairchild VHF Prescaler Chips

11C01FC	High Speed Dual 5-4 Input no/nor	15.40
11C05DC	1 GHz Counter Divide by 4	74.35
11C05DM	1 GHz Counter Divide by 4	110.50
11C06DC	UHF Prescaler 750 MHz D Type flip/flop	12.30
11C24DC	Dual TTL VCM same as MC4024P	2.60
11C44DC	Phase Freq. Detector same as MC4044P	2.60
11C58DC	ECL VCM	4.53
11C70DC	600 MHz flip/flop with reset	12.30
11C83DC	1 GHz 248/256 Prescaler	29.20
11C90DC	650 MHz Prescaler Divide by 10/11	16.00
11C90DM	same as above except Mil. version	24.00
11C91DC	605 MHz Prescaler Divide by 5/6	16.00
11C91DM	same as above except Mil. version	24.00
95H90DC	350 MHz Prescaler Divide by 10/11	9.50
95H90DM	same as above except Mil. version	16.50
95H91DC	350 MHz Prescaler Divide by 5/6	9.50
95H91DM	same as above except Mil. version	16.50

T.I. TMS4060/C2107, 4K RAM 19.01

Batteries

NI-CAD's AA cells 1.25 volts at 500 mahr. $0.49
Gel-Cell 12 volts at 1.5 Amp Hr. #GC-1215 $19.95

Crystals

1.000000 MHz	4.95
5.000000 MHz	4.95
3579.545 KC	2.95

JUST ARRIVED! These radios have just been pulled out of service. Set up for approx. 150 MHz. Clean. All tubes included. No accessories. Prices FOB Phoenix.

Motorola U43 GGT	$49.95
GE TPL	$99.95
GE MT-33	$39.95
Collins 26U	$150.00
CBS Labs Model IIIs, AUDIMAX	$775.00
CBS Labs 450	$375.00

NEW

Motorola, Motorcycle Radio — Model T33BAT $39.95 FOB Phoenix

Motorola MC14410CP CMOS tone Generator uses 1 MHz Crystal to produce standard dual frequency telephone dialing signal. Directly compatible with our 12 key Chomeric pads. Kit includes the following.
1 MC14410CP
1 Touch Tone Pad
1 1 MHz Crystal
1 Printed Circuit Board (From Ham Radio Sept. 1975)
And all other parts for assembly.
$19.95

Fairchild 95H90DC Prescaler divide by 10 to 350 MHz. Will take any 35 MHz Counter to 350 MHz. Kit includes the following.
1 95H90DC
1 2N5179
2 UG-88/u BNC's
1 Printed Circuit Board
And all other parts for assembly.
$29.95

Fairchild 11C90DC Prescaler divide by 10 to 650 MHz. Will take any 65 MHz Counter to 650 MHz or with a 82S90 it will divide by 10/100 to 650 MHz. This will take a 6.5 MHz counter to 650 MHz. Kit includes the following.
1 11C90DC
1 2N5179
2 UG-88/U
1 MC7805CP
1 Bridge
1 Printed Circuit Board and all other parts for assembly.
82S90 add $5.70 to total.
$59.95

Fairchild 3817 Clock Kit from Ham Radio, Feb. 1976, Pg. 26 — All parts included except transformer and case. 12 hour $24.95 24 hour $29.95

I.C.'s

8223B	$3.00
2102	$1.99

MuRata 10.7 MHz Ceramic Filters #SFW-10.7MA $3.95

Johanson and Johnson Trimmer Capacitors
1 to 14 pf. $1.95
1 to 20 pf. $1.95

Ferrite Beads
12 for .99 or 120 for 9.99

FET's

2N3070	1.50	2N5460	.90	MFE3002	3.35
2N3436	2.25	2N5465	1.35	MPF102	.45
2N3458	1.30	2N5565	5.45	MPF121	1.50
2N3821	1.60	3N126	3.00	MPF4391	.80
2N3822	1.50	MFE2000	.90	U1282	2.50
2N4351	2.85	MFE2001	1.00	MMF5	5.00
2N4416	1.05	MFE2008	4.20	40673	1.39
2N4875	1.75	MFE2009	4.80	40674	1.49

TUBES

2E26	5.00	811	6.95	7984	4.95
3B28	4.00	811A	9.95	8072	32.00
4X150A	15.00	931A	11.95	8156	3.95
4X150G	18.00	5849	32.00	8908	9.95
4CX250B	24.00	6LQ6	4.50	8950	5.50
4CX350A/8321	35.00	6146A	5.25	4-400A	29.95
4CX1500A	150.00	6146B/8298A	6.25	4-250A	24.95
DX415	25.00	6360	7.95	4-125A	20.95
572B/T160L	25.00	6907	35.00	4-65A	15.95
		7377	40.00		

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F-18X	6.3vct at 6 amps	3.56
F-93X	6.5v to 40v at 750 ma.	3.53
F-92A	6.5v to 40v at 1 amp	4.59
F-91X	6.5v to 40v at 300 ma.	2.72
N-51X	Isolation 115vac at 35va.	2.80
Model D-2	6.5v at 3.3 amps	4.95
	6.5v at 3.3 amps	
C-912-034	22vct at 200 ma.	
	11v at 250 ma.	1.49
BE-12433-001	30v at 15 ma.	.49
C-404-024	18vct at 400 ma.	1.49
BGH-9	6.3vct at 10 amps.	6.95
F-107Z	12V @ 4A or 24 V @ 2A	7.80
P6377	12v @ 4a or 24v @ 2a	6.31
P6378	12v @ 8a or 24v @ 4a	10.31
P8196	80vct @ 1.2a	6.28

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TSK-209-000
Input 24vdc
output #1 100 vdc — 12.95
#2 400 vdc +
#3 15000 vdc
Size: 3½" x 2" x 2¾"
This power supply was used in a CRT Terminals

DIODES

1N270 Germanium Diodes $7.95/c
HEP170, 2.5A, 1000 PIV $4.95/20
Semtech SFMS 20K, 20KV, 10 ma, fast recovery $1.26 ea.

FANS

Pamotor Fans, Model 4500C 117 VAC, 60 Hz, 19 w. $7.95

RF TRANSISTORS

2N1561	15.00	2N3866 JAN TX	4.85	2N5591	10.35
2N1562	15.00	2N3925	6.00	2N5635	4.95
2N1692	15.00	2N3927	11.50	2N5636	11.95
2N1693	15.00	2N3948	2.00	2N5637	20.70
2N2631	4.20	2N3950	26.25	2N5643	20.70
2N2857	1.80	2N3961	6.60	2N5641	4.90
2N2876	12.35	2N4072	1.70	2N5643	20.70
2N2880	25.00	2N4073	2.00	2N5764	27.00
2N2927	7.00	2N4135	2.00	2N5841	11.00
2N2947	17.25	2N4427	1.24	2N5842/MM1607	19.50
2N2948	15.50	2N4430	20.00	2N5849/MM1622	19.50
2N2949	3.90	2N4440	8.60	2N5862	50.00
2N2950	5.00	2N4957	6.30	2N5942	49.50
2N3287	4.30	2N5070	13.80	2N5922	10.00
2N3300	1.05	2N5090	6.90	2N6080	5.45
2N3302	1.05	2N5108	3.90	2N6081	8.60
2N3307	10.50	2N5109	1.55	2N6082	11.25
2N3309	3.90	2N5177/MRF5177	20.00	2N6083	12.95
2N3375/MM3375	7.00	2N5179	.68	2N6084	14.95
2N3553	1.80	2N5184		2N6094	5.75
2N3571	4.10	2N5216	47.50	2N6095	10.35
2N3818	6.00	2N5583	5.60	2N6096	19.35
2N3824	3.20	2N5589	4.60	2N6097	28.00
2N3866	1.09	2N5590	6.30	2N6166	36.80
2N3866 JAN	4.14				

RF TRANSISTORS

MRF207	2.00	Amperex BLY90	22.50	MM3375	7.00
MRF208	10.20	Amperex A209	8.60	MM3904	1.50
MRF209	12.35	MSC 2001	20.00	MM3906	1.43
MRF237	1.85	MSC 3000	20.00	MM4000	1.24
MRF238	8.55	MSC 3001	20.00	MM4001	1.39
MRF450	16.55	MSC 80205	20.00	MM4003	1.85
MRF453	19.55	MSC 80206	20.00	MM4036	1.60
MRF504	6.75	MSC 80255	20.00	MM4044	3.00
MRF509	5.50	Fairchild SE7056	3.00	MM4545	3.00
MRF511	8.60	MM1051	2.00	MM8006	2.15
MRF620	27.00	MM1500	32.20	MM1552	50.00
MRF8004	1.90	MM1550	10.00	MM1553	56.50
HEPS3013/75	2.95	MM1601	5.50	HEPS5026	2.48
HEPS3014/76	4.95	MM1602	7.50	MSC 80256	20.00
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HEPS3005	9.55	MM1620	17.50	CTC E1-28	20.00
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HEPS3008	2.18	MM1669	17.50		
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More Details? CHECK—OFF Page 126

7400N TTL

SN7400N	.16	SN7459A	.25		
SN7401N	.16	SN7460N	.22	SN74154N	1.00
SN7402N	.21	SN7470N	.45	SN74155N	.99
SN7403N	.16	SN7472N	.39	SN74156N	.99
SN7404N	.18	SN7473N	.37	SN74157N	.99
SN7405N	.24	SN7474N	.32	SN74160N	1.25
SN7406N	.20	SN7475N	.50	SN74161N	.99
SN7407N	.29	SN7476N	.32	SN74163N	.99
SN7408N	.25	SN7479N	5.00	SN74164N	1.10
SN7409N	.25	SN7480N	.50	SN74165N	1.10
SN7410N	.18	SN7482N	.98	SN74166N	1.25
SN7411N	.30	SN7483N	.70	SN74167N	5.50
SN7412N	.33	SN7485N	.89	SN74170N	2.10
SN7413N	.45	SN7486N	.39	SN74172N	8.95
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SN7417N	.35	SN7490N	.45	SN74175N	.99
SN7420N	.21	SN7491N	.75	SN74176N	.90
SN7421N	.33	SN7492N	.49	SN74177N	.90
SN7422N	.49	SN7493N	.49	SN74180N	.99
SN7423N	.37	SN7494N	.79	SN74181N	2.49
SN7425N	.29	SN7495N	.79	SN74182N	.95
SN7426N	.29	SN7496N	.89	SN74184N	1.95
SN7427N	.37	SN7497N	4.00	SN74185N	2.20
SN7429N	.42	SN74100N	1.00	SN74186N	15.00
SN7430N	.26	SN74107N	.39	SN74187N	6.00
SN7432N	.31	SN74121N	.39	SN74188N	3.95
SN7437N	.27	SN74122N	.39	SN74190N	1.19
SN7438N	.27	SN74123N	.50	SN74191N	1.25
SN7439N	.25	SN74125N	.60	SN74192N	.89
SN7440N	.15	SN74126N	.60	SN74193N	.89
SN7441N	.89	SN74132N	1.09	SN74194N	1.25
SN7442N	.59	SN74136N	.95	SN74195N	.75
SN7443N	.75	SN74141N	1.15	SN74196N	1.25
SN7444N	.75	SN74142N	4.00	SN74197N	.75
SN7445N	.75	SN74143N	4.50	SN74198N	1.75
SN7446N	.81	SN74144N	4.50	SN74199N	1.75
SN7447N	.69	SN74145N	1.15	SN74200N	5.59
SN7448N	.79	SN74147N	2.35	SN74279N	.90
SN7450N	.26	SN74148N	2.00	SN74251N	1.79
SN7451N	.27	SN74150N	1.00	SN74284N	6.00
SN7453N	.27	SN74151N	.79	SN74285N	6.00
SN7454N	.20	SN74153N	.89	SN74367N	.75

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CD4002	.25	CD4040	2.45	74C20N	.65
CD4006	2.50	CD4042	1.90	74C30N	.65
CD4007	.25	CD4044	1.50	74C42N	2.15
CD4009	.59	CD4046	2.51	74C73N	1.50
CD4010	.59	CD4047	2.75	74C74	1.15
CD4011	.25	CD4049	.79	74C90N	3.00
CD4012	.25	CD4050	.79	74C95N	2.00
CD4013	.47	CD4051	2.95	74C107N	1.25
CD4016	.56	CD4053	2.95	74C151	2.90
CD4017	1.35	CD4060	3.25	74C154	4.00
CD4019	.55	CD4066	1.75	74C157	2.15
CD4020	1.49	CD4069	.45	74C160	3.25
CD4022	1.25	CD4071	.45	74C161	3.25
CD4023	.25	CD4081	.45	74C163	3.00
CD4024	1.50	CD4511	2.50	74C164	3.25
CD4025	.25	CD4518	2.50	74C173	2.60
CD4027	.69	CD4566	3.00	74C193	2.75
CD4028	1.65	74C00N	.39	74C195	2.75
CD4029	2.90	74C02N	.55	MC4044	4.50
CD4030	.65			MC14016	.56

LINEAR

LM300H	.80			LM1310N	2.95
LM301H	.35			LM1351N	1.65
LM301CN	.35			LM1414N	1.75
LM302H	.75			LM1458C	.65
LM304H	1.00	LM370N	1.15	LM1496N	.95
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LM307CN	.35	LM377N	4.00	LM2111N	1.95
LM308H	1.00	LM380N	1.39	LM2901N	2.95
LM308CN	1.00	LM380CN	1.05	LM3065N	.69
LM309H	1.10	LM381N	1.79	LM3900N	.55
LM309K	.99	LM382N	1.79	LM3905N	.60
LM310CN	1.15	NE501K	8.00	LM3909	1.25
LM311H	.90	NE510A	6.00	LM5556N	1.85
LM311N	.90	NE531H	3.00	MC5558V	1.00
LM318CN	1.50	NE536T	6.00	LM7525N	.90
LM319N	1.30	NE540L	6.00	LM7535N	1.25
LM320K-5	1.35	NE550N	.79	8038B	4.95
LM320K-5.2	1.35	NE555V	.39	LM75450	.49
LM320K-12	1.35	NE561B	5.00	75451CN	.39
LM320K-15	1.35	NE562B	5.00	75452CN	.39
LM320T-5	1.75	NE565H	1.25	75453CN	.39
LM320T-5.2	1.75	NE565N	1.25	75454CN	.39
LM320T-8	1.75	NE566CN	1.25	75491CN	.79
LM320T-12	1.75	NE567H	1.95	75492CN	.89
LM320T-15	1.75	NE567V	1.50	75494CN	.89
LM320T-18	1.75			**RCA LINEAR**	
LM320T-24	1.75	LM703CN	.45	CA3013	2.15
LM323K-5	9.95	LM709H	.29	CA3023	2.56
LM324N	1.80	LM709N	.29	CA3035	2.48
LM339N	1.70	LM710N	.79	CA3039	1.35
LM340K-5	1.95	LM711N	.39	CA3046	1.30
LM340K-6	1.95	LM723H	.55	CA3059	3.25
LM340K-8	1.95	LM723H	.55	CA3060	3.25
LM340K-12	1.95	LM733N	1.00	CA3080	.85
LM340K-15	1.95	LM739N	1.00	CA3081	2.00
LM340K-18	1.95	LM741CH	.35	CA3082	2.00
LM340K-24	1.95	LM741CN	.35	CA3083	1.60
LM340T-5	1.75	LM741-14N	.39	CA3086	.85
LM340T-6	1.75	LM747H	.79	CA3089	3.75
LM340T-8	1.75	LM747N	.79	CA3091	10.20
LM340T-12	1.75	LM748H	.39	CA3123	2.15
LM340T-15	1.75	LM748N	.39	CA3130	1.39
LM340T-18	1.75	LM1303N	.90	CA3140	1.25
LM340T-24	1.75	LM1304N	1.19	CA3600	1.75
LM350N	1.00	LM1305N	1.40	RC4194	5.95
LM351CN	.65	LM1307N	.85	RC4195	3.25

74LS00 TTL

74LS00	.29			74LS139	1.95
74LS02	.29			74LS151	1.55
74LS03	.29	74LS74	.49	74LS153	1.89
74LS04	.35	74LS75	.69	74LS157	1.55
74LS05	.35	74LS76	.49	74LS162	2.25
74LS08	.29	74LS83	1.75	74LS163	2.25
74LS10	.29	74LS85	2.49	74LS164	1.95
74LS13	.69	74LS86	.49	74LS175	1.95
74LS14	1.75	74LS90	1.25	74LS181	3.69
74LS20	.29	74LS92	1.25	74LS190	2.85
74LS26	.39	74LS93	1.25	74LS191	2.85
74LS27	.39	74LS95	1.95	74LS192	2.85
74LS28	.39	74LS96	1.89	74LS193	2.85
74LS30	.29	74LS107	.59	74LS194	1.89
74LS32	.39	74LS109	.59	74LS195	1.89
74LS40	.39	74LS112	.59	74LS257	1.75
74LS51	.29	74LS132	1.25	74LS260	.55
74LS55	.29	74LS136	.59	74LS279	.79
74LS73	.49	74LS138	1.89	74LS670	3.95

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$9.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1 PPS Output	6.95
MM5318	Video Clock Chip, For Use With MM5841	9.95
CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

DATA HANDBOOKS

7400 Pin-out & Description of 5400/7400 ICS $2.95
CMOS Pin-out & Description of 4000 Series ICS $2.95
Linear Pin-out & Functional Description $2.95
ALL THREE HANDBOOKS $6.95

FAIRCHILD TECHNOLOGY KITS FAIRCHILD

- Complete Specifications on back of each kit
- Packaged for WALL DISPLAY APPEARANCE
- Dealer's Inquires Invited — Price List Available

7205 - Stop Watch Chip $19.95

DIGITS

FTK0001	0.5" High Common Cathode Digit	$1.00
FTK0002	0.5" High Common Anode Digit	1.00
FTK0003	.357" High Common Cathode Digit	.75
FTK0004	0.8" High Common Cathode Digit	2.00
FTK0005	0.8" High Common Anode Digit	2.00

0.8" HIGH DISPLAY ARRAYS

FTK0010	12 Hour, 3½ Digit Clock Display	7.00
FTK0011	24 Hour, 4 Digit Clock Display	8.00

LED LAMPS

FTK0020	10 Red LED Lamps	1.00
FTK0021	5 Mixed Colored LED Lamps	1.00
FTK0022	10 LED Mounting Clips	1.00
FTK0023	5 Three Piece LED Mounting Adapters	1.00

PHOTO TRANSISTORS

FTK0030	5 Flat Lens Photo Transistors	1.00
FTK0031	5 Round Lens Photo Transistors	1.00
FTK0032	3 Flat Lens Photo Darlingtons	1.00
FTK0033	3 Round Lens Photo Darlingtons	1.00

PHOTO ARRAYS

FTK0040	9-Element Tape Reader Array	16.00
FTK0041	12-Element Card Reader Array	24.00
FTK0042	Reflective Opto Coupler	4.00

COUPLERS

FTK0050	3 General Purpose Opto Couplers	1.00
FTK0051	Darlington Opto Coupler	1.00

MOS CLOCK CIRCUITS

FTK0400	Digital Clock/Calendar Circuit (FCM7001)	7.00
FTK0401	Digital Clock/Calendar with BCD Outputs (FCM7002)	7.00
FTK0402	Direct Drive Digital Clock Circuit with AC Output (FCM3817A)	5.00
FTK0403	Direct Drive Digital Clock Circuit with DC Output (FCM3817D)	5.00
FTK0405	Direct Drive Digital Clock/Calendar Circuit (FCM7015)	6.00

KITS

FTK0106	Automobile Clock Kit	40.00

DISCRETE LEDS

.125" dia.

XC209	Red	10/$1
XC209	Green	4/$1
XC209	Orange	4/$1

.90" dia.

XC111	Red	10/$1
XC111	Green	4/$1
XC111	Yellow	4/$1
XC111	Orange	4/$1

.200" dia.

XC22	Red	10/$1
XC22	Green	4/$1
XC22	Yellow	4/$1
XC22	Orange	4/$1
SSL-22	RT	4/$1

.185" dia.

XC526	Red	10/$1
XC526	Green	4/$1
XC526	Yellow	4/$1
XC526	Orange	4/$1
XC526	Clear	4/$1

.200" dia.

XC556	Red	10/$1
XC556	Green	4/$1
XC556	Yellow	4/$1
XC556	Orange	4/$1
XC556	Clear	7/$1

.085" dia.
MV50
.085" dia. Micro red LED
6/$1

SPECIAL * — XC556 Red 100/$8.00 1000/$60.00 — SPECIAL *

DISPLAY LEDS

DL707 DL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3620	Common Anode-orange	300	1.75
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 3640	Common Cathode-orange	300	1.75
MAN 3	Common Cathode	125	.39	MAN 4710	Common Anode-Red	400	1.95
MAN 4	Common Cathode	187	1.95	DL701	Common Anode-red ± 1	300	.99
MAN 7	Common Anode	300	1.25	DL704	Common Cathode	300	.99
MAN 7G	Common Anode-green	300	1.95	DL707	Common Anode	300	.99
MAN 7Y	Common Anode-yellow	300	1.95	DL 728	Common Cathode	500	1.95
MAN 52	Common Anode-green	300	1.75	DL 747	Common Anode	600	2.25
MAN 64	Common Anode-red	400	1.75	DL 750	Common Cathode	600	2.49
MAN 72	Common Anode	300	1.25	DL 338	Common Cathode	110	.50
MAN 74	Common Cathode	300	1.50	FND70	Common Cathode	250	.75
MAN 82	Common Anode-yellow	300	1.75	FND503	Common Cathode	500	1.00
MAN 84	Common Cathode-yellow	300	1.75	FND507	Common Anode	500	1.00

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
18 pin	.52	.47	.43	40 pin	1.75	1.58	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

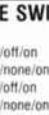
10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

Plastic Push Button Switch

- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	.59	.49
J-188-2	Normally Open	.59	.49
J-188-3	Normally Closed	.59	.49

MINATURE TOGGLE SWITCH



JMT-221	DPDT	on/off/on	$1.95
JMT-223	DPDT	on/none/on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none/on	$1.25

CLIPLITE *SPECIAL* NEW LED MOUNTING SYSTEM — to be used with XC556 LEDS — **SPECIFY COLORS** — RED — GREEN — AMBER — YELLOW **8/$1.49**

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.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$10.95 ea.**

$5.00 Minimum Order — U.S. Funds Only
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Spec Sheets - 25¢ — Send 24¢ Stamp for 1977 Catalog
Dealer Discount Available — Request Pricing

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WIRE WRAP CENTER

HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (0.25 inch)

Complete with built-in bit and sleeve

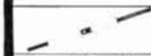
$34.95
(batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP

- Tool for 30 AWG Wire
- Roll of 500 ft. White 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped white wire

$11.95



WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY

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.

SF - Front Mount SR - Rear Mount

SERIES SF Front Mount Assembly SERIES SR Rear Mount Assembly

ACCESSORIES

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

ACCESSORIES

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

Permacel Electrical Tape

• ¾" (wide) X 66 ft (long) • All weather • Not import
$1.49 per roll — $12.50 per 10 roll package

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

MPS A05	5/$1.00			PN4249	4/$1.00
MPS A06	5/$1.00			PN4250	4/$1.00
2N2219A	3/$1.00	PN3567	3/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3568	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	PN3569	4/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3704	5/$1.00	2N4403	4/$1.00
2N2369A	5/$1.00	2N3705	5/$1.00	2N4409	5/$1.00
PN2415	5/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3724	$.65	2N5089	4/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3903	5/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3904	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N3906	4/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	C106B1SCR	2/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	2N5432	$2.00
		2N4123	10/$1.00		

CAPACITOR CORNER

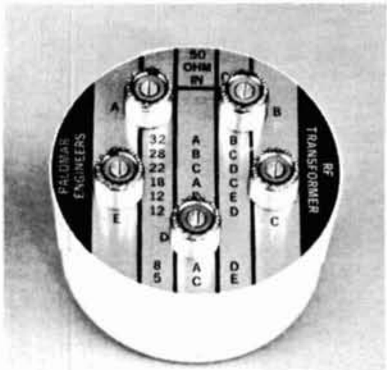
50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.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**			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

More Details? CHECK—OFF Page 126

More Details? CHECK—OFF Page 126

RF TRANSFORMER



- New! Broadband antenna matching.
- For all verticals and mobile whip antennas.
- Smaller size and higher efficiency. Only 3½" diameter for full 5-Kw PEP capability.

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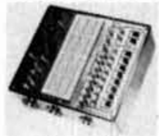

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Features 3 Regulated power Supplies. 3 Output wave forms. 8 digital level switches. 2 no bounce pulser switches. 8 LEDs with drivers. 1 AP Super strip. Easily constructed. Designed by RETS Electronic Schools.
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or $4.50 with purchase of clock kit.
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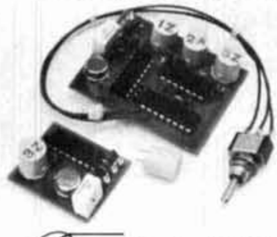
TG-3 three frequency



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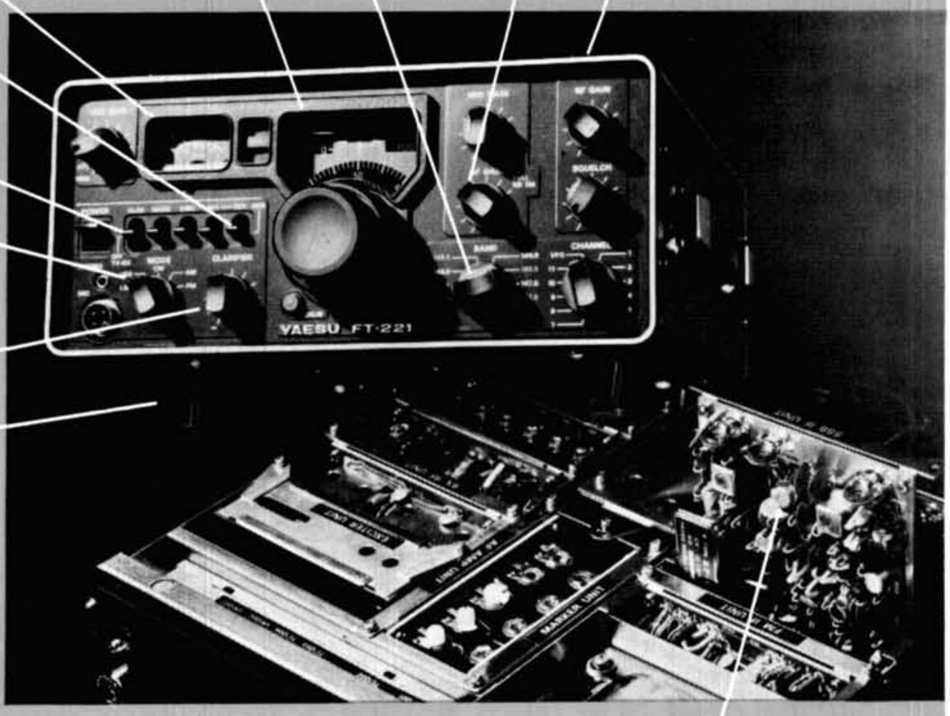

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