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Ham Radio Magazine
February 1974

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The first two issues of HR Report are now off the presses and in the hands of subscribers around the country. If you want to know what's happening behind the scenes in amateur radio, and rapidly, as the news breaks, HR Report is the only way to do it. For example, did you know that we will probably lose the upper 2 MHz of the 420-MHz band (448 to 450 MHz) to the Emergency Medical Service? Did you know that the ARRL's first ten-meter contest was a partial success, with openings to Africa and South Pacific? Did you know that more than 500 two-meter repeater licenses have been issued by the FCC, nearly clearing up the backlog? Did you know that a large variety of quality-made coils, chokes and terminal boards, packaged for the amateur, are now available from Cambridge Thermionics Corporation (CTC)? These are just some of the items covered in detail in recent issues of HR Report. For subscription details for this new bi-weekly amateur newsletter, look on page 72.

This month we will kick off the latest project of our more for 74 program, an Automatic License Renewal Service for all FCC-licensed amateurs (except Novices), subscribers to ham radio or not. The cost to you? Absolutely nothing, except for the effort to open an envelope. It will work like this: 60 to 90 days before your amateur license is due to expire you will receive in the mail a copy of FCC Form 610 plus a supplementary instruction sheet prepared by our staff which will include some info on such things as renewal fees, operating after your license expires if you filed a timely renewal application, etc. All you have to do is fill out the Form 610, enclose your check or money order, and mail it back to the FCC.

No last-minute scurrying around to find the proper form, or discovering that your license expired a month ago. However, for the Automatic License Renewal Service to operate successfully, your correct address must be on file with the FCC as required by the regulations. If you have moved since you last renewed your amateur license and the FCC does not have your current address you will not receive your License Renewal packet. It's as simple as that.

Early this month the first Automatic License Renewal packets will be in the mail to amateurs whose licenses expire in March and April, 1974. In early March License Renewal packets will be mailed to amateurs whose licenses expire in May. From then on mailings will be made the first of every month so you should receive yours at least 60 days before your license expires.

Jim Fisk, W1DTY
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More Details? CHECK—OFF Page 94

February 1974
solid-state transmitting converter
for 144-MHz ssb

Complete construction details for a solid-state transmitting converter that provides more than 30-watts output on two meters

In the past few years numerous articles have been published describing transistorized fm and CW transmitters and class-C power amplifiers for use in the 144- to 148-MHz band. However, there has been a noticeable lack of information covering single-sideband applications or linear transistor amplifiers, due primarily to the problem of generating reasonable amounts of power in linear amplifiers operating in the vhf region.
has excellent characteristics in this respect, thus eliminating one stumbling block.

I also decided that if I were going to have major problems (more than just the expected ones), there was no point in constructing the entire unit, and that if a problem was to prove insurmountable, it would show up before the final stage. Therefore the logical approach would be to build up the circuit to the driver stage, and then cover the final amplifier as a separate subproject. As it turned out, this was a fortunate decision, since it allowed me considerable flexibility in designing the final stage.

driver unit

A complete block diagram of the transmitting converter appears in fig. 1, showing the approximate stage gains and power levels throughout the circuit. The schematic of the driver unit is shown in fig. 2. The 28- to 30-MHz ssb input is applied to the RF (R) input port of double-balanced mixer Z1, and should not exceed -3 dBm (0.5 mW) to keep distortion products to a minimum. The 50-ohm pad formed by resistors R1 through R3 has been included to insure proper termination of the transmission line from the SSB exciter and to provide the mixer with a 50-ohm source. Values have not been specified for the pad resistors, since the required attenuation will depend on the output power of the exciter and the amount of attenuation present in your external power attenuator. The total loss in the two attenuators must be sufficient to limit the input to the mixer to the specified 0.5 mW. Design equations for calculating the resistance and is directly available from the manufacturer in single-lot orders.

In order to achieve minimum loss through the mixer, a local-oscillator signal of at least 7 dBm (5 mW) is required. This is easily obtained from a 2N3563 operating in a Miller oscillator circuit which uses a 116-MHz overtone crystal. The oscillator output is taken from a tap on the collector coil, chosen to provide maximum power transfer to the mixer.

The output of the mixer is obtained at

Top view of the driver unit and MSA7503 final amplifier. The metal disc is the heat sink for the driver transistor; top-hat heat sinks are used on the 2N4427 and FMT4170 transistors. The 1N4001 and 1N4719 diodes are inside the clamps on the driver and amplifier mounting studs, respectively.
the i-f (X) port and is applied to a double-tuned top-coupled filter, resonant at 145 MHz. The Q of each tuned circuit and the coupling coefficient have been selected for a bandwidth of approximately 4 MHz. The input and output taps on L1 and L2 provide impedance matching additional .01-μF emitter bypass capacitor were included to suppress a tendency of this stage to oscillate. The output of the 2N4427 is matched to the base of transistor Q1 by means of a trimmer capacitor tapped down on the collector coil.

fig. 2. Schematic diagram of the driver unit. Sources of asterisked items are listed in the appendix. All 1-10 pF capacitors are piston type.

Several types of transistors were tried at Q1, all with some degree of success. The best of these was found to be the Fairchild FMT4170, although the lower-priced 2N5913 or HEP-S3001 (in that order of preference) should also be satisfactory. This stage operates closer to class-AB than class-A to keep the transistor power dissipation within acceptable
limits. The RC network between the collector and base improves the linearity of the stage. Parasitic oscillations in the hf region are suppressed by the 10-μH rf choke in parallel with a 10-ohm resistor, plus the large bypass capacitors in the collector supply circuit.

To prevent thermal runaway of the transistor, the base current is controlled by a 1N4001 diode which is thermally coupled to the transistor case. This is physically accomplished by mounting the diode on the stud of the transistor so that it follows the temperature of the device.

The driver stage was designed around a Fairchild MSA8507 vhf power transistor which is characterized only for class-C operation. The transistor is forward biased into class AB operation by means of a bias circuit described by Roy Hejhall, K7QWR. Quiescent collector current is set by adjusting the base bias by means of the 100-ohm adjustable resistor.

It is essential that there be approximately one-half ohm dc resistance between the base and bias source for the bias circuit to operate properly. I used a 1.8-μH rf choke from my junk box because it had a resistance of 0.6 ohm. Any choke having an inductance between 0.47 and 2 μH will be satisfactory, provided that it has the required resistance. Otherwise a resistor may be inserted between the rf choke and the bias source to make the total resistance about 0.5 ohm.

Therefore, as an increase in transistor temperature tends to increase the base and collector currents, the increase in diode temperature causes the base bias to decrease, thereby reducing the base and collector currents to the equilibrium values set by the bias-adjust resistor.

The collector-to-base RC linearizing network and the collector-supply hf table 1. Characteristics of the Fairchild MSA8507 transistor at 175 MHz with 12-volt collector supply.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{out}$</td>
<td>12 watts minimum</td>
</tr>
<tr>
<td>$P_{in}$</td>
<td>3.5 watts maximum (at rated $P_{out}$)</td>
</tr>
<tr>
<td>$Z_{in}$</td>
<td>1.5 + j1.3 ohms</td>
</tr>
<tr>
<td>$Z_{out}$</td>
<td>3 - j2.7 ohms</td>
</tr>
<tr>
<td>$C_{cb}$</td>
<td>35 pF (at 1 MHz)</td>
</tr>
<tr>
<td>$B_VCES$</td>
<td>36 volts</td>
</tr>
<tr>
<td>$V_{CEO}$</td>
<td>18 volts</td>
</tr>
<tr>
<td>$I_C^*$</td>
<td>2.0 amperes maximum</td>
</tr>
<tr>
<td>$P_D$</td>
<td>22 watts</td>
</tr>
</tbody>
</table>

f ebruary 1974
parasitic-suppression network are both similar to those used in the preceding stage. Power is coupled into and out of the transistor by means of conventional T-networks, resulting in an output from this stage of approximately 6 watts PEP when fed into a 50-ohm load.

The circuit is shown in fig. 3. The first obvious question is why a nominal 28-volt transistor was used when the rest of the converter uses 12-volt devices. The answer is equally obvious when you look at the typical characteristics of 12-volt, 50-watt transistors—they do not have the necessary power gain. And as will be seen later, the dual voltage requirement is not a major problem.

Unfortunately, the Fairchild MSA8507 is no longer in production, although there may be some to be found as old stock or at surplus outlets. However the B12-12, manufactured by Communications Transistor Corporation, has similar characteristics and should be as good, if not better. For those interested in trying other transistors, the pertinent characteristics of the MSA8507 are listed in table 1. Reference 3 contains the design equations for the input and output networks, which must be redesigned if you use a transistor having input and output impedances substantially different from the MSA8507 or B12-12.

**final amplifier**

Two different amplifiers were designed, built, and operated on the air. The first uses a transistor characterized for class-C service in the 100- to 175-MHz region and having internal emitter stabilizing resistors. The circuit is shown in fig. 3. The first obvious question is why a nominal 28-volt transistor was used when the rest of the converter uses 12-volt devices. The answer is equally obvious when you look at the typical characteristics of 12-volt, 50-watt transistors—they do not have the necessary power gain. And as will be seen later, the dual voltage requirement is not a major problem.

The circuit configuration is similar to that used in the driver stage, and uses a Fairchild MSA7503 transistor. The input and output networks are designed to match a 50-ohm source and load, respectively. As with the MSA8507, the MSA7503 is also out of production. However, the technique of placing a 50-watt transistor in linear service, when it was designed for class-C operation, may be of interest. The bias circuit is the same as previously described for the driver stage, except for one minor difference. Because of the relatively large value of base current, an rf choke having less inductance but using larger wire was used in the base circuit. Therefore a 2-ohm resistor was added between the choke and bias source to provide an empirically determined optimum value of resistance.
The transistor operates as close to true class B as possible. That is, the base is just barely forward biased, so that the quiescent collector current is 2 or 3 mA. Considering that the peak dc collector current is about 2 amperes, that is truly class B. All attempts to increase the static collector current resulted in catastrophic failure of the device when excitation was applied, probably caused by secondary breakdown. (See reference 4 for a discussion of this phenomenon.) However, as long as the static collector current is limited to 3 mA or less, the amplifier is stable, reliable, and entirely satisfactory. The output powers obtained at collector voltages between 20 and 26 volts are shown in fig. 4.

A second amplifier was then designed and built, using a commercially available transistor and a different biasing scheme. A TRW PT6727 is used in the circuit shown in fig. 5. This transistor is emitter-ballasted and is designed not only for CW operation at 150 MHz, but for a-m service as well.

The heart of the bias network in this circuit is a device called a byistor, which is manufactured by Communications Transistor Corporation, and shown in fig. 5 as a Y-shaped symbol (originated by CTC) with its type designation BY1. The byistor acts as a low-impedance dc bias source and consists of a diode and silicon resistor; fig. 6 shows the internal arrangement. The device is packaged in a ceramic stripline configuration, identical to that used for rf power transistors, and is meant to be mounted on the same heat sink as the transistor for temperature tracking. The diode is fabricated using the same material, geometry, and diffusion as an rf power transistor, so that it will thermally track the transistor. Tracking is further improved by the temperature characteristics of the silicon resistor.

A constant current of approximately 350 mA is applied to injector terminal I, causing the diode to act as a voltage source having about 0.3 ohm impedance. The silicon resistor adds approximately 0.7 ohm and increases the apparent source impedance to approximately 1 ohm at supplier terminal S. The voltage at the supplier terminal will be between 0.45 and 0.85 volt, depending on the current being drawn from S and the temperature of the device. Thus, if a variable resistor is connected between the supplier (S) and reference (R) terminals, the supplier voltage can be adjusted. This is accomplished by the 4.7- and 100-ohm resistors shown in fig. 5; a single 5-ohm adjustable resistor could be used, but a 4.7-ohm, half-watt resistor in parallel with a printed-circuit type trimmer potentiometer provides finer control.

As the temperature of the byistor increases, the resistance of the silicon

---

**table 2. Inductors and capacitors used in the amplifier circuits of figs. 3 and 5. Numbers in parentheses following the capacitance values are Arco/El Menco part numbers.**

<table>
<thead>
<tr>
<th>L101</th>
<th>MSA7503</th>
<th>PT6727</th>
</tr>
</thead>
<tbody>
<tr>
<td>C101</td>
<td>1.5-20 pF (402)</td>
<td>7-100 pF (423)</td>
</tr>
<tr>
<td>C102</td>
<td>7-100 pF (423)</td>
<td>24-200 pF (425)</td>
</tr>
<tr>
<td>C103</td>
<td>same as C102</td>
<td>3-35 pF (403)</td>
</tr>
<tr>
<td>C104</td>
<td>same as C102</td>
<td>2-25 pF (421)</td>
</tr>
<tr>
<td>L101</td>
<td>1½ turn no. 18, 3/8&quot; copper strap, 1&quot; long, 3/8&quot; wide</td>
<td></td>
</tr>
<tr>
<td>L102</td>
<td>1 turn no. 14, 3/8&quot;</td>
<td>3 turns no. 14, ID, 1¾&quot; lead length</td>
</tr>
<tr>
<td>L103</td>
<td>7 turns no. 20, 3/16&quot;</td>
<td>7 turns no. 20, ID, 3/8&quot; long</td>
</tr>
<tr>
<td>L104</td>
<td>35 turns no. 20E wound on Micrometals T80-2 core</td>
<td></td>
</tr>
</tbody>
</table>
resistor increases and the diode voltage decreases. This results in an increase in the apparent source impedance and lowers the bias voltage at the supplier terminal. Consequently, the base current of the associated transistor is reduced, preventing thermal runaway and providing improved dc stability of the amplifier. A more rigorous explanation of the byistor, with temperature-characteristic curves, appears in reference 5.

Aside from the biasing arrangement, the amplifier circuits of figs. 3 and 5 are identical. Different values of inductance and capacitance in the input and output networks are required for each type of transistor, but either transistor can be used in either circuit. However, the improved construction of the PT6727 permits class-AB operation, which reduces the intermodulation distortion products to some extent. Table 2 contains inductance and capacitance data applicable to either circuit, for each type of transistor.

The PT6727 appears to be somewhat better than the MSA7503 in terms of power gain, output, and distortion products, which is to be expected in view of its intended application. The power outputs obtained from the PT6727 appear in fig. 4, plotted against collector supply voltage.

**power supplies**

The low-power stages require a 12- to 12.6-volt dc source which is capable of supplying approximately 1.5 amperes at peak power output. The MSA7503 final amplifier draws about 2 amperes, while the PT6727 requires a 2.5-ampere supply, both values being the peak current. Both of the supplies must be reasonably well regulated because of the varying load inherent in ssb operation.

![Schematic diagram of the final amplifier which has its base bias controlled by the CTC byistor.](image)

Details of parts identified by reference designators appear in table 2.

A convenient way to obtain the two supply voltages is to use a 20- to 26-volt supply capable of providing the total load current, and incorporate a simple regulator circuit to drop the voltage to the nominal 12 volts required for the driver unit. Such a regulator is shown in fig. 7. The value of dropping resistor R will depend on the input supply voltage, and may be calculated from the equation shown on the diagram.

If the 20- to 26-volt supply is regulated with a circuit similar to or better than that shown in fig. 7, the 12-volt regulator is more than adequate for local-oscillator stability. Purists may want to add a 10- or 11-volt zener diode at the
local oscillator for additional regulation, but it was found to be unnecessary.

**construction**

Construction of the driver unit and the final amplifiers is shown in the various photographs. I started out using a piece of single-sided copper-clad board approximately 6-1/2 by 9-1/4 inches, since the circuits were developed stage by stage. I ultimately ran out of board, so for that reason the driver stage runs at a right angle to the low-level circuits. This is no problem except for the fact that it leaves a large portion of the board unused. To run all of the stages in the driver unit in a conventional straight line, I suggest using a piece of board approximately 12-inches long by 4-inches wide.

The normal techniques used for vhf construction should be followed—short leads and small, high-quality components. The low-level stages are each enclosed within shielded partitions which are made of pieces of copper-clad board soldered to the main board. The partitions should be placed across the transistor sockets to isolate the input and output circuits, thus minimizing any tendency of the high-gain stages to oscillate on their own. Liberal use of feedthrough capacitors and rf chokes for the supply voltages, with the dc wiring run on the top side of the board, prevents stray coupling through the power leads.

L1 and L2 in the mixer output circuit are shielded from one another by placing L1 and its associated capacitor on the mixer side of a shield partition, and L2 and its capacitor on the other side. The 0.47-pF coupling capacitor is then connected to the top end of each coil via a feedthrough terminal in the partition.

The MSA8507 (or B12-12) and PT6727 transistors are in stripline-opposed-emitter packages, which require some care in mounting. Virtually all of the published articles employ this package configuration in circuits which use printed-wiring inductances or transmission-line sections. Since my design uses only discrete components, the mounting and connection techniques are slightly different.

There are two major conditions which must be met when mounting stripline transistors: the emitter leads must be grounded as closely as possible to the case, in order to minimize emitter lead inductance, and the case must be mounted on a heatsink without putting undue strain on any of the transistor leads. Considering the latter condition first, it can be satisfied by mounting the transistor to the heatsink, through a hole in the copper-clad board, before soldering to any of the leads. A sparse application of silicone thermal compound should be used between the body of the transistor and the heatsink.

Reducing the emitter lead inductance, as accomplished by soldering the leads close to the case, creates the annoying problem of what to do with the collector and base leads. Fortunately, operation at 144 MHz is not so critical as to preclude using one of the arrangements shown in fig. 8. In fig. 8A, the base and collector leads are soldered to lands which are insulated from the ground plane. These lands may be formed in one of two ways.

![fig. 6. Schematic diagram of the byistor (courtesy CTC).](image-url)
The copper can be routed out around the transistor leads, creating areas that are isolated from ground, and the leads then soldered to these lands. An alternate method is to cut small pieces of copper-clad board and cement them to the ground plane to form small insulated platforms to which the transistor base and collector leads can be soldered. In both cases, the heatsink must be spaced away from the main board so that the emitter leads are level with the ground plane or close enough to the ground plane so that they can be bent down slightly without too much strain.

**Fig. 8B** shows a third method which allows the heatsink to be mounted directly to the board without spacers. The base and collector leads are folded back on themselves, by means of long-nose pliers, and the folded ends carefully bent up away from the stud. This provides a relatively rigid terminal for connections to the transistor. The emitter leads are carefully bent down to the ground plane and soldered.

The heat sink for the driver transistor was made from a scrap piece of aluminum and has an area of about 6-1/2 square inches. This is enough radiating surface to keep the transistor from getting any more than barely warm to the touch. Of course, any one of the many commercial heat sinks having equivalent radiating surface could be used.

The 1N4001 diode is thermally coupled to the driver transistor by means of a clamp mounted on the transistor stud, as shown in **fig. 8B**. The clamp is made of a small piece of sheet copper which is formed around the diode to fit snugly. The diode and clamp surfaces should be coated with a thin film of thermal compound before being secured to the transistor stud. The diode cathode is soldered to the clamp, which is grounded via the heatsink, while the anode lead is connected to the bias-adjust resistor through a feedthrough capacitor.

The final amplifier is built on another piece of single-sided copper-clad board which measures 4 by 5 inches. The heatsink, which has a radiation surface of 33.4 square inches, is an Archer 276-1360, available at Radio Shack stores. The PT6727 stripline-packaged transistor is mounted to the board and heat sink in one of the ways previously described.

The MSA7503 is packaged in a TO-60 stud-mount case, which poses an additional problem in securing a low-impedance emitter-to-ground path. The emitter is connected internally to both the case and a terminal pin on the body, but using the pin is not practical because of the high internal lead inductance. The scheme shown in **fig. 9** was finally reached, and should be a useful method for mounting any similar transistor. First mount the heatsink to the board and, using a number-9 drill, drill a 0.196-inch hole through the heat sink and board for the transistor mounting stud. Then disassemble the heat sink from the board and enlarge the hole in the board to a diameter of 1/2 inch. Remount the heat sink on the board.

Obtain a small piece of copper foil (the kind used for electrostatic shields between power-transformer windings) and cut out a disc 1 to 1-1/4 inch in diameter. Carefully cut a hole in the
center of the disc just large enough to clear the transistor stud. Apply thermal compound to that part of the heatsink which is accessible through the enlarged hole in the board. Place the copper foil on the stud and mount the transistor to the heatsink. (Note that thermal compound is not used between the copper foil and the transistor, in order to maintain a good rf path between emitter and ground.) Slit the edges of the copper foil, now protruding from the hole in the board, so that the foil can be pressed flat against the copper board, and solder it down. This results in a continuous ground plane from the board to the transistor emitter.

If a 1N4719 diode is to be used to control the bias, mount it to the transistor stud in the same manner as described for mounting the 1N4001 on the driver transistor. If you use the BY1 byistor, mount it in one of the ways described for stripline packages, except that there is no need for concern about lead inductance. I located the byistor stud 1 inch from the transistor stud, on a line with the base lead. This places it under the input inductor, which hides it in the photograph of the PT6727 amplifier.

Adjusting and tuning the driver

One of the advantages of having the final amplifier separate from the driver unit is being able to tune up the low-power stages independently of the final. And since two relatively high-power transistors are involved, having to worry about just one at a time makes the process much easier.

Before making any power connections, set the 100-ohm adjustable resistor in the driver bias network for maximum resistance. Then temporarily break the collector supply circuit in the driver stage and insert a 0-50 or 0-100 mA meter between L8 and the supply. Be sure the meter will indicate only the collector current and not the current drawn by the 1N4001 diode. Connect a good 50-ohm load and power meter to the driver output connector.

Connect the 12-volt supply and apply power. The meter should read zero or close to it. Adjust the 100-ohm resistor until the collector current is approximately 20 mA; this sets the operating bias on the driver transistor. Next check the operation of the 2N3563 oscillator, using an electronic voltmeter and rf probe at the output, or a sensitive detector coupled to the collector tank circuit. Tune the oscillator for maximum output. If the circuit fails to oscillate, it may be necessary to experiment with the value of the emitter bypass capacitor.

Turn off the power supply and replace the milliammeter with a 0-1 ammeter. Now connect the hf single-sideband transmitter, tuned to 29 MHz, to the input connector of the driver unit. Be sure that you have enough attenuation between the transmitter and converter to limit the power at the mixer input to 0.5 mW. Reapply power to the mixer unit and slowly insert carrier at the transmitter while watching the driver-stage collector

Bottom of the driver unit and MSA7503 amplifier. The local oscillator is at the left side, followed by the mixer and low-level stages to the right. The driver stage runs along the right side of the larger driver-unit board. The amplifier input circuit is at the top of the smaller board, and the collector circuit is at the bottom. Note the use of shield partitions to prevent feedback.
current. If the collector current starts to increase, immediately adjust the tuning capacitors in the driver output network for maximum output power. Actually, there is little likelihood of this occurring before the low-level stages have been tuned, so reduce the 29-MHz excitation and tune up the converter by means of the following technique.

Tune each stage for maximum power output. An electronic voltmeter with an rf probe, connected at a point which follows the circuit or stage being adjusted, makes a good tuning indicator without loading down the circuit (e.g., connect the probe to the collector of the stage following the one being tuned). As each stage is tuned, gradually increase the 29-MHz carrier and monitor the driver collector current so that the driver output circuit can be tuned for maximum output as soon as the collector current starts to increase. As excitation to the driver stage is increased, the collector current will rise to a maximum of 0.75 to 1 ampere. Tune the driver output circuit for maximum output consistent with minimum collector current. Since the Q of the output circuit is low, tuning is relatively broad, making it easy to pick the point of best efficiency.

As the 29-MHz drive is increased and as each stage is tuned, the output should gradually rise to at least 6 watts. However, if the output goes to 9 watts or so, it is an indication that one or more of the low-level stages are saturated. If this happens, reduce the excitation to the point where the output power drops sharply. This is the limit of linear operation, and all tuning adjustments should be repeated at this level. Vary the frequency of the ssb transmitter from 28 to 30 MHz and retune it for constant output at several points within the frequency range, but do not retune the transmitting converter. The output from the converter should vary less than 10 percent.

Deenergize the power supply, remove the ammeter, and restore the driver collector circuit to its original state. You now have a 6-watt ssb signal, ready to put on the air or to drive the final stage. If you want to get it on two meters at this point, be sure to read the section headed operation before connecting the antenna.

adjusting and tuning the final amplifier

If you are using the amplifier circuit shown in fig. 3, set the 100-ohm adjustable resistor for maximum resistance. If you are using the circuit of fig. 5, set the 100-ohm pot for minimum resistance between the byistor supplier terminal and ground. Temporarily open the collector circuit, as was done for the driver, and insert a milliammeter between L104 and the power supply so that it will measure only the collector current. A 0-50 or 0-100 mA meter can be used for the PT6727; a 0-10 mA meter is preferable if an MSA7503 or equivalent is used.

Using the lowest supply voltage which will provide you with the output power that you need, turn on the power supply and adjust the bias resistor on the amplifier for a collector current of 25 mA if the PT6727 is being used. If you are using an MSA7503 or an equivalent transistor, adjust the bias resistor to the point where the collector just starts to draw current—about 2 or 3 mA. Remove power and replace the milliammeter with an am-
meter having at least a 2.5 ampere range.

Connect the driver unit to the amplifier by means of a short length of 50-ohm coax cable, and terminate the amplifier with a power meter and good 50-ohm load. Energize the driver unit and amplifier power supplies, and gradually apply rf excitation. Tune the amplifier input and output capacitors for maximum output each time the drive is increased. The output should rise smoothly until it reaches the approximate value indicated in fig. 4 for the supply voltage being used. As with the driver stage, the final tuning should provide maximum efficiency (maximum output consistent with minimum collector current). The collector efficiency of the PT6727, operating class AB, should be approximately 60 percent. The efficiency of the MSA7503 or any other transistor operating virtually at cut-off may be as high as 75 percent. Tuning the exciter over a 2-MHz range should not affect the output of the transmitting converter by more than 10 percent.

Driver-stage tuning may be refined during the amplifier tuning procedure by peaking the capacitors in the driver collector circuit for maximum amplifier output, but this must not be done until after the amplifier input tuning capacitors have been adjusted for maximum output. Then remove all power, disconnect the ammeter, and restore the final collector circuit to its original condition.

**operation**

The transmitting converter is now ready to feed an antenna or to drive a high-power linear amplifier. In the latter case, connect the converter to the amplifier through a 50-ohm coax cable (assuming that the amplifier being driven has a 50-ohm input impedance) and retune the converter amplifier collector circuit for maximum drive. It is advantageous to monitor the transistor amplifier collector current to achieve maximum efficiency, which can be done simply by inserting an ammeter in the lead from the dc supply. Remember, however, that you will now be measuring the collector current plus the current drawn by the bias-control diode or byistor, so that the total current through the meter will be 200 to 350 mA greater than the collector current alone.

If the transmitting converter is fed directly to an antenna, a lowpass filter must be inserted between the output connector and the transmission line to attenuate harmonics which will be passed by the low-Q output network of the driver or amplifier. (The higher-Q tuned circuits in a vacuum-tube amplifier following the converter will provide sufficient filtering, and eliminate the need for a lowpass filter.) Two such filters are shown in fig. 10. The constant-k pi-section in fig. 10A is slightly simpler than the elliptical pi-section of fig. 10B, but the latter will provide at least 6-dB, and as much as 16-dB, more attenuation to the second harmonic than will the constant-k configuration.

After making the necessary connections and applying power, retune the output collector circuit for maximum output power. Again, it is wise to monitor the collector current, as described above. Once the preceding tuning procedures have been completed, it will not be necessary to retune any of the circuits.
appendix

Most of the parts used in the transmitting converter are available through regular distributors. The following list is provided for those items which must be ordered from other sources, and includes prices (as of July 1973) for those of major importance.

<table>
<thead>
<tr>
<th>item</th>
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<td>CTC B12.12</td>
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<td>Communications Transistor Corporation, 301 Industrial Way, San Carlos, California 94070</td>
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<tr>
<td>BY1</td>
<td>6.00</td>
<td>Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154</td>
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<tr>
<td>Anzac MD108</td>
<td>7.00</td>
<td>Request name and address of closest distributor from Marketing Department, TRW Semiconductor Division, 14520 Aviation Boulevard, Lawndale, California 90260</td>
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<tr>
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<td>Request name and address of closest distributor from Marketing Department, Fairchild MOD, 4001 Miranda Avenue, Palo Alto, California 94304</td>
</tr>
<tr>
<td>Fairchild FMT4170</td>
<td>5.50</td>
<td>Amidon Associates, 12033 Otsego Street, North Hollywood, California 91607</td>
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<tr>
<td>Micrometales cores</td>
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over long periods of time, provided that you do not change the load or supply voltages. The low-Q tuned circuits are relatively insensitive to other changes.

conclusions

Operation on two meters during the past several months, using both amplifiers, has shown that the transmitting converter is stable and trouble-free. A spectrum analyzer was not available for distortion measurements, but rough measurements using a receiver and calibrated step attenuator indicate that the third-order products are down approximately 24 dB when using the MSA7503 amplifier, and approximately 27 dB for the PT6727. The limitation in the latter case is probably due to the distortion products generated in the MSA8507 driver stage.

acknowledgements

I would like to acknowledge the technical and material assistance received from the following: Joe Reisert, W6FZJ, of Fairchild Microwave and Optoelectronics Division; Jack Manon, W6FIG, of TRW Semiconductors; and Bob Artigo, W6GFS, Lee Max, and Mike Mallinger of Communications Transistor Corporation. Thanks are also due to Alan Stein for the photography.

references

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Model 60: $249
Model 61: $239

4 LENSES
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<th>Min. focus</th>
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All Robot equipment carries a one-year warranty. Four easy ways to purchase: cash, C.O.D., Master Charge, Bank-Americard.

More Details? CHECK-OFF Page 94
Depending on your point of view, this instrument may be called a capacitance meter which will also function as a frequency counter or it can be called a frequency counter which will also measure capacitance. To me it's a capacitance meter since that was my need at the time I designed it. However, to provide one function without the other would be foolish since circuitry for both is practically identical and requires only the switching of a few points in the control logic to implement either mode of operation.

**theory of operation**

The capacitor to be tested is placed in a timing circuit whose output gates a train of fixed-frequency pulses into a standard counter. The output pulse length from the timer circuit is proportional to the size of the capacitor, thus varying the gate time. The resultant count is indicated by the digital readouts. A large capacitor would result in a long gate time and a high pulse count.

If the resistance factor in the RC time constant is used as a calibrating device, it could be adjusted in conjunction with a known value of capacitance to give a known gate time and, therefore, a known count. For example, if $R$ were adjusted to provide a 1.0-millisecond output pulse in conjunction with a 1000-pF capacitor and the pulse rate was 1.0 MHz, during the 1.0-ms opening of the gate 1000 pulses would get through to the counter and register on the readouts. A 900-pF capacitor would shorten the gate time sufficiently to allow only 900 pulses through. Larger capacitors permit proportionately longer count times with resulting higher counts.

In the capacitance meter frequency is fixed and gate time is variable, while in the counter gate time is fixed and frequency is variable.

**circuit details**

About the time I first started thinking about this idea, Signetics introduced their NE555 IC timer. This little item requires only two external components, a resistor and a capacitor, and is just the thing for
generating the timing pulses. In this case the resistor would be a calibrating pot and the capacitor would be the unit under test.

Inside the NE555 are two comparators, a flip-flop, an output stage and a discharge transistor. Initially, the capacitor is held discharged by the transistor connected across it. When a negative-going pulse is applied to pin 2 of the IC, the flip-flop is set, releasing the short across the capacitor and charging commences.

A circuit operating in this mode is the old familiar one-shot or monostable. The NE555 may also be wired as an astable if free-running operation is desired. For interested readers, the data sheets show many other interesting applications for this IC.

The control logic circuit used in this instrument was borrowed from an article by W1EO in QST. A 1-MHz crystal oscillator and SN7404 hex inverter IC were added to provide the clock input (see fig. 1). Five SN7490 decade counters divide the crystal frequency down to 10 Hz — this results in a string of pulses spaced exactly one-tenth second apart. An SN7493 is used as a divide-by-twelve counter to provide a period of 1.2 seconds or 12 clock pulses for a complete timing cycle.

A

Table 1. Capacitance ranges used in the instrument built by the author.

<table>
<thead>
<tr>
<th>Range</th>
<th>Calibration</th>
<th>Clock Frequency</th>
<th>Readout Format</th>
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<td>1000 µF</td>
<td>1.0 µF = 0.1 ms</td>
<td>100 kHz</td>
<td>1000.0</td>
</tr>
<tr>
<td>1.0 µF</td>
<td>.001 µF = 0.1 ms</td>
<td>100 kHz</td>
<td>1.0000</td>
</tr>
<tr>
<td>0.1 µF</td>
<td>.001 µF = 0.1 ms</td>
<td>1.0 MHz</td>
<td>0.1000</td>
</tr>
</tbody>
</table>

The reference voltage for the comparator is internally set at two-thirds of the operating voltage. When the voltage ramp across the capacitor reaches this level, the circuit fires, resetting the flip-flop and discharging the capacitor. Upon receipt of another trigger pulse, the cycle repeats.
The initial 1-second portion is the count period during which the count gate is open. During the 0.2-second interval between counting periods, a transfer pulse is generated which allows the information stored in the latches (if used) to be shifted to the decoder/drivers for readout of the latest count.

A subsequent reset pulse is also generated during this interval which returns all counters to zero in preparation for the next 1-second counting period. These latter two pulses are formed by interconnecting various gates contained in an SN7400 and an SN7410 IC. The pulse appearing at pin 11 of U7 is negative-going at the start of the timing period and is used to trigger the NE555 for capacitance measuring.

When the instrument is operating as a capacitance meter, the control pulse for the count gate comes from the timer circuit and the pulse train to be counted is generated by the internal clock. When functioning as a straightforward counter, the count gate reverts to internal control and the signal to be counted comes from an external source. These and other points require switching and are combined into a single multi-pole switch. In my unit this switch provides three capacitance ranges and two for counter operation. Sections of the function switch are also used to apply power and trigger pulses to the timer when operating in the capacitance-measuring mode (see fig. 2).

Table 1 shows the relationships between the various parameters when applied to a 5-digit counter such as that used here. Obviously this scheme is not a mandatory one and can be altered to suit other situations. If you are planning to place decimal points at appropriate points in the display, don't forget to reserve a pole on the function switch for that purpose.

construction

The heart of the capacitance meter is the control logic and timer circuitry. A two-sided PC board was laid out to accommodate all of the circuitry in an uncrowded area 2.5 by 4.6 inches. Since the TTL logic ICs come in dual-inline packages, a similar version of the Signetics NE555 timer was used. This is their 8-pin mini-DIP known as the V package (NE555V).

The 1-MHz crystal is in an HC6-U holder with wire leads. The calibrating trimmers are the common 1-inch type which have pin spacings of 0.2 and 0.3 inch with a 0.2-inch stradle. The decoupling filter capacitor is a 65-μF dipped
tantalum but any substitute unit of 50-μF or so may be used if it fits on the board. Circuit pads are provided at all points being switched as well as at inputs and outputs. A pad is provided at the crystal the blank board so that it just fits in the opening without moving around. Position one of the negatives over the opening with the proper side up and tape the edges to the cardboard frame. Turn the output as well as at each decade although not all frequencies will be used in this particular application. The most practical scheme I’ve been able to devise for making double-sided PC boards is to cut out a cardboard frame for frame over and place the second negative so that the two are back-to-back and in perfect registration. Tape this one along one edge so that it may be lifted to allow insertion of the blank PC board. After both sides have been exposed, develop

fig. 3. Full-size layout for both sides of the double-sided circuit board.
and etch in the normal manner. The board in the photograph was homemade in this way (see fig. 3 for the layout).

If you are planning to build one of these instruments from scratch, you'll need several decades of counting and readout circuitry. Many of the advertisers in *ham radio* sell kits consisting of a counter, a latch, a decoder/driver and a readout device, along with a PC board for easy assembly. Four decades would be the minimum required. Anything over that would be at the builder's discretion.

I used five stages because I happened to have five hybrid assemblies on hand which were suitable for this application. Each of these dual-inline packages contained a counter, a latch and a decoder/driver. I mated these with five homemade readouts and ended up with a neat 5-digit counter section.

I would have used one or two more stages if I'd had more of the hybrids since it would have made the frequency counter a little more useful. For capacitance measurements, however, the five digits are adequate since the accuracy of the system doesn't really warrant any greater resolution.

If you already own a counter and don't mind tearing into it, you could do a little rearranging along the lines described here to add the capacitance measurement feature. In counters that provide for external gate control the output from the timer could be fed into this connection. In addition, a suitable trigger pulse must be brought out to fire the timer at the start of the cycle. Suitable clock pulses could also be brought out for the various operating ranges.

It is by no means mandatory that a PC board be used for assembly. The circuit described here was at one time made up on a piece of perforated board and wired from point-to-point. It worked just fine.

**calibration**

All you need for calibration are a couple of fairly close tolerance capacitors of suitable values. With a capacitor connected to the test jacks and the instrument switched to the high range, adjust the 500-ohm trimmer for proper display of the value. Adjust the 50k trimmer for either of the two remaining ranges.

A capacitor of around 1.0 μF could be used for setting both trimmers since there is an overlap between ranges. The more points you can check, of course, the more accurate the instrument. From my experience it seems reasonable to expect at least 10% accuracy across the operating range of 1000 pF to 1000 μF.

Since this unit was intended primarily to measure large capacitors, readings should be close enough for most experimental work. They will also bear out the fact that most electrolytics have values a lot higher than marked.

It should be pointed out that the unit will read well over 1000 μF but accuracy falls off rapidly above 1500 μF. This is apparently due to shortening of the output pulse from the timer as the duty cycle increases. At the opposite end, reading values below 1000 pF seems to be...
impractical due to bad jitter on the timer output pulse. The comparator input which the capacitor is connected across is a high impedance point and consequently picks up all kinds of noise and hum. Looking at the trailing edge of the output pulse on a scope will verify this. The end result is that the count gate sees a decade divider. A calibrating trimmer capacitor could also be added in series with the crystal for precise adjustment of the clock. This would be primarily for improving frequency measuring accuracy.

Incidentally, you may find that some 1-MHz crystals won't oscillate at their constantly varying count time which makes valid readings impossible.

All circuitry is powered from a single 5-volt supply capable of supplying the required current. In my instrument maximum current is about 1.5 amperes. Close regulation is not essential as voltage variations will not affect the timer output. When you are measuring electrolytic capacitors, remember that they should have a minimum rating of 6 volts just to be safe.

**summary**

Parts of this circuit may be of interest to some readers even if not all of it is. The control logic may be suitable for a counter you've been thinking of building or the timer circuitry may be extracted for use with an existing counter. The crystal oscillator could be modified for 10-MHz operation by adding another fundamental frequency. A scope should be used to check this. Holes have been provided on the circuit board to install a capacitor across one of the feedback resistors if this problem is encountered. Try about 100 pF as a starting value and substitute values until you're sure the oscillator will start properly every time you fire up.

A preamplifier and conditioning circuit for the counter was not included on the board. There have been numerous examples of such circuits in all the amateur publications so finding what you want should not be too difficult.

**reference**

Graphical methods of designing L-networks have been presented several times in the past. As shown in reference 1, there are eight possible L-networks for matching a pure resistance to any impedance. In most amateur cases the pure resistance is the 52-ohm coaxial transmission line, and the impedance is that at the base of a vertical antenna.

It is important to note that only certain networks can be used to match certain ranges of impedance. Also, because of possible mutual coupling, networks using two inductors are less desirable than the others. The lowpass filter network is the most desirable, but can be used only for some load conditions. One criteria which affects the choice of network is whether or not the antenna resistance is greater or less than 52 ohms. A more definite way of selecting the correct network is shown in the graphs that follow.

One of my former graduate students, John Lewis, studied the L-network situation and found that there are three different networks that will match any conceivable load impedance. He developed equations for these three networks and wrote a computer program that would, for a given problem, select the proper network and calculate the two necessary L-network element values. This article will give those equations, and describe them so that you can design your own L-networks, using simple equations and elementary arithmetic.

He developed the equations by writing the network equations for a given network, calling the input impedance $R_i$ (50
ohms in our case). He then solved the equations for the network element values. For example, for the case of the network in fig. 1C

\[ R_i = \frac{-j X_c (R + j (X_L + X))}{R + j (X + X_L - X_c)} \]

John called these equations for the network element values. Networks A, B, and C as shown in fig. 1.

The best way to show which load impedances each network can match is by means of a graph, first presented by Smith in *Electronics*. The shaded part of each graph shows those load values which that particular network cannot match. The network can provide a match for any impedance in the non-shaded area. The graphs are normalized, which means that all graph values are divided by the impedance value of transmission line used (50 ohms). Thus, a load resistance of 50 ohms shows up on the graph as 1 unit horizontally.

When using the graphs and formulae presented in fig. 1, solve first for the networks A, B, and C as shown in fig. 1.

\[ X_L = \frac{R_i}{(R - R_i)} \]  

\[ X_c = \frac{X_L (R - R_i) - R_i X}{R} \]

\[ X_L = \left(\sqrt{R_i R - R_i^2}\right)^{-1} X \]

\[ X_c = \frac{X_L + X + R^2}{X_L + X} \]

The steps in the solution are not shown here. To do that the first equation was expanded and the real and imaginary terms properly equated, resulting in solutions for \( X_L \) and \( X_c \).
work element given in the left-hand column. For example, assume you have a vertical antenna with an input impedance of $142 + j90$ ohms and want to feed it with 50-ohm coaxial cable. Therefore, $R = 142$ ohms, $X = 90$ ohms and $R_i = 50$ ohms. Normalizing, $R/R_i = 2.84$ and $X/R_i = 1.8$. In this case either network A or B must be used because the normalized impedance $(Z = 2.84 + j1.8)$ falls into the forbidden region in the graph for network C.

To use network A, first calculate the constant, $k$, from eq. 7. Then find $X_C$ and $X_L$, respectively, using eqs. 1 and 2.

$$k = \sqrt{(4 \cdot 50^2 \cdot 90^2) + (4 \cdot 50 \cdot (142 - 50)) (90^2 + 142^2)} = 24516.48$$

$$X_C = \frac{(2 \cdot 50 \cdot 90) + (24516.48)}{2(142 - 50)} = 84.33 \text{ ohms}$$

$$X_L = \frac{(50 \cdot 90) + 84.33(142 - 50)}{142} = 86.33 \text{ ohms}$$

To determine the component values for network B calculate $X_L$ and $X_C$ from eqs. 3 and 4, respectively. The constant, $k$, is the same as before.

$$X_L = \frac{(2 \cdot 50 \cdot 90) + 24516.48}{2(142 - 50)} = 182.15 \text{ ohms}$$

$$X_C = \frac{182.15 (142 - 50) - (50 \cdot 90)}{142} = 86.32 \text{ ohms}$$

These values check with the graphical solutions shown in figs. 2 and 3 (see reference 3 for application with a 7-MHz vertical antenna).

As another example, assume that you want to match a 50-ohm transmission line to an antenna with an input impedance of $40 - j20$ ohms. Therefore, $R = 40$ ohms, $X = -20$ ohms and $R_i = 50$ ohms; $R/R_i = 0.8$ and $X/R_i = -0.4$. The normalized input impedance is $0.8 - j0.4$ ohms. This value can be matched by network C but
falls into the forbidden region in networks A and B.

To determine the proper values for network C first calculate $X_L$, using eq. 5. Then find $X_C$ using eq. 6.

$$X_L = [(50 \cdot 40) - 1600]^{\frac{1}{2}} + 20 = 40 \text{ ohms}$$

$$X_C = \frac{(40 - 20)^2 + 1600}{40 - 20} = 100 \text{ ohms}$$

To check the correctness of these values it is necessary to calculate the impedance seen at the input terminals. From inspection, it can be seen that $Z_C$ is in parallel with the series combination of $Z_L$ and the complex load impedance $Z$. Using the formula for parallel impedances:

$$R_i = \frac{(Z_C)(Z + Z_L)}{Z_C + (Z + Z_L)}$$

$$= \frac{(-j100)(40 - j20 + j40)}{(-j100)(40 - j20 + j40)}$$

$$= \frac{(-j100)(40 + j20)}{(-j100) + (40 + j20)}$$

$$= \frac{-j4000 + 2000}{40 - j80}$$

Multiplying by the conjugate:

$$\left(\frac{-j4000 + 2000}{40 - j80}\right)\left(\frac{40 + j80}{40 + j80}\right)$$

$$= \frac{400 \times 10^3}{8 \times 10^3} = 50 + j0$$

This network provides a perfect match to 50-ohm transmission line.

references

Complete construction details for an RTTY message generator that uses TTL digital logic to generate the message using digital logic. This increases reliability and makes maintenance easier as well as lowering the cost. Moreover, some electro-mechanical message generators are mechanically peculiar to a specific type or family of teleprinters. The digital logic method is directly applicable to any machine or circuit of any family of teleprinters using compatible signaling codes.

**RTTY signaling code**

The presently used Baudot (Murray) RTTY code is a binary code, a two-state condition, such as the presence or absence of current. As applied to most teletypewriter circuits, it is a condition of current flowing in a loop (mark) or no current flowing in the loop (space). Each printed character or machine function is determined by the sequence of mark and space pulses received by the machine.

The format of the signaling code depends on the maximum number of different characters to be printed or functions to be performed by the machine. The two most common arrangements used are the 5-level and 8-level formats. The term level refers to the number of unit intervals or pulses in the intelligence-determining portion of the code. Each unit interval is either a mark or space as determined by the code for the desired character. The 5-level code has $2^5$ (32) character permutations available and the 8-level code has $2^8$ (256) available permutations.

To keep the transmitting and receiving machines in synchronization a start pulse...
is placed in front of the group of intelligence pulses. A stop pulse is placed at the end of the group of intelligence pulses to complete the synchronization function. The start pulse is always a space condition and has the same pulse width or unit interval as an intelligence pulse. The stop pulse is always a mark condition and its minimum duration may be up to two unit intervals.

The 5-level code may be divided into three subcode types, depending on the width of the stop pulse. For example, a 60 word-per-minute 5-level code character includes the start pulse and five intelligence pulses, each of which has a pulse width of 22 milliseconds. Each 22-ms pulse or bit may be referred to as a unit. If the stop pulse in this group is also 22-ms wide then the group is called a 7-unit code. If the stop pulse is 31-ms wide then it is a 7.42-unit code. The 7.42-unit code is the most common 5-level code.

Another code in use is the 7.5-unit code where the stop pulse is 33.1 ms wide. The intended effect of the longer stop pulse is to decrease the amount of message garble under marginal operating conditions. However, the longer stop pulse has the undesirable effect of slightly decreasing the circuit speed capability.

**functional description**

The design objective was a simple, semi-programmable, all-electronic message generator using low-cost TTL IC logic packages and meeting the following requirements:

1. The required serial message format is: letters (LTRS), space, DE, space, K, X, figures (FIGS), 6, letters (LTRS), I, T, space, carriage return (CR), and line feed (LF).

2. The message generation cycle is initiated by an external momentary contact closure and/or a TTL compatible negative-going pulse.

3. The device must be self-stopping at the end of the message generation cycle.

4. The device keyer output must be compatible with any normal RTTY loop without regard to loop polarity or voltage level.

5. The device’s message must be field programmable, either by means of plug-in boards or minor hardware changes, or both.

Fig. 1 illustrates the operation of the device at a basic functional block diagram level. A detailed logic diagram is shown in fig. 2.

**System control.** When the circuit is in an idle state, U6 generates a signal that inhibits 2 clock pulse generation (U1) and sets the 8-unit big generator and function gate generators to a cleared condition. On receipt of an external start signal, system control removes the clock inhibit and system clear signal. The device now begins the message generation cycle. At the end of the message, the function gate generator provides an end-of-cycle signal which returns system control to idle.
fig. 2. Logic diagram for the RTTY message generator. A complete parts list for the unit is given on the facing page. Power supply and ground connections to the ICs in the unit are not shown in the schematic but are given in the table above. For a supply voltage of +5 volts, current drain is 275 mA.
K1 spst printed-circuit relay (Clare LA-005, 5-volts, 380 ohms, DIP package)

K2 spst normally closed reed relay (Grisby-Barton GB8218B-2)

S1, S2 spdt toggle switch

S3 dpdt toggle switch

U1 dual NAND Schmitt trigger (SN7413)

U2, U4 4-bit binary counter (SN7493)

U3 BCD-to-decimal decoder (SN7442)

U5 4-line to 16-line decoder/demultiplexer (SN74154)

U6 dual J-K master-slave flip-flop (SN7476)

U7 triple 3-input positive NAND gate (SN7410)

U8, U9 quadruple 2-input positive NAND gate (SN7400)

U10, U17 8-input positive NAND gate (SN7430)

U11 quadruple 2-input positive NAND buffer (SN7437)

U12, U13 hex inverter (SN7404)

U14
status, thereby terminating the message cycle.

Clock. IC U1 is connected as a gate-controlled pulse generator. The time between the negative-going edges of two adjacent pulses is set to equal the desired unit or bit width, i.e., 22 ms for a 5-level, 60-wpm machine.

RTTY 8-unit bit generator. The clock pulse from U1 is fed to the 4-bit binary counter, U2. The output of the binary counter is decoded by 1-of-10 decoder U3. This decoder sequentially produces eight unit bits each character generation cycle. In order of generation they are start, five intelligence bits and stop, which is 2 units in length. At the end of the 7th unit bit (halfway through the stop pulse) a step pulse is applied to the function gate generator. Complements of the bits are available through hex inverter U12. An 8-unit code is used instead of the standard 7 or 7.42-unit codes in the interest of circuit simplicity and minimum package count.

Function gate generator. The function gate generator is functionally similar to the 8-unit bit generator described above. The decoder section is a 1-of-16 decoder. The active function gate is advanced to the next decoded line each character generation cycle of the 8-unit bit generator. The last (16th) function gate pulse is inverted and applied to system control, U6, to terminate the message generation cycle. ICs U13 and U14 invert all function gates to match the character coding logic.

Fixed character. The 2-input and 3-input gate ICs in this block combine the active function gate and selected intelligence bits from the 8-unit bit generator to form the desired fixed print and non-print RTTY functions.

Variable character. This block is functionally similar to the fixed character block, combining function gates and selected bits to form the desired printing functions. It is labeled variable as this is the area of the circuit that can be programmed for different station call signs by use of plug-in circuit boards.

Spacing override. To realize gate and interconnection economy in the fixed and variable character circuits during the generation of certain characters, it was convenient to allow a spacing condition to exist at the outputs of these blocks during the stop-pulse generation period. The logic gates in the spacing override block ensure that the stop pulse is always fed to loop keyer, even if a spacing condition from the fixed or variable character blocks happens to be present simultaneously with the stop pulse.

Loop keyer. ICs U11C and U11D drive the loop keying relay, K1. Only one gate is used when driving a normally-open contact relay. The second gate is used as an inverter if a normally-closed contact relay is used. A high-voltage transistor could replace the relay if loop polarity is observed.

character coding logic

The idle condition of a teleprinter is the marking (loop current flowing) state. Moreover, examination of a coding chart reveals a slight preponderance of mark over space in the code as a whole if you disregard the seldom used blank character. Thus, it is logical to set up a condition at the loop keyer where it is only necessary to create a spacing condition at the proper intervals to generate the desired message.

The first space pulse in any character or machine function is the start pulse. In the letters (LTRS) function, where all five information pulses are marking, the start pulse is the only spacing pulse in the entire code group. Therefore, to generate a LTRS function, it is only necessary to apply the start pulse to the loop keyer — and the machine performs the LTRS function.

Refer to the logic diagram in fig. 2 to follow the formation of the LTRS function. Initially, the circuit is in the standby state. Clock U1 is inhibited. Binary counters U2 and U4 are set to zero count.
One-of-ten decoder U3 is low on output zero and is high on the remaining 7 outputs (outputs 8 and 9 are not used for 5-level codes).

Output zero of U3 (pin 1) is labeled stop 2. This is the last half of the 2-unit stop pulse and is applied to U8A as a low level. The remaining input to U8A is a high level from output 7 (stop 1).

The output of U8A is inverted by U8B, and applied to both U11A and U11B as a low. Therefore, with one input of both U11A and U11B at a low level, the output of these AND gates will always be high, regardless of whether highs or lows appear at the remaining gate inputs.

For example, in the case of generating characters with only one or two information bits marking, it is convenient to set up the character coding logic so that a spacing condition (a high level at the output of U17) is applied to the remaining input of U11B during the last half of the stop pulse. Thus, a low on one input of U11B overrides the spacing condition, keeping the output of U11B high. This, in turn, keeps the loop in the marking state during the entire stop-pulse period.

To initiate generation of the message and the first character (LTRS), momentarily depress the start switch, S4. This sets the Q output of flip-flop U6 to low, removing the inhibit from the clock, U1, and removing reset from U2 and U4. The first negative-going edge of the clock pulse toggles binary counter U2, causing output zero (stop 2) of U3 to go high and output 1 (start) of U3 to go low.

At this time both inputs of U8A are high, its output is low, and the output of U8B is now high and applied to one input of both U11A and U11B. Simultaneously, output 1 (start) of U3 is low and is applied to one input of U10, causing the output of U10 to go high. This high is applied to the remaining input of U11A. Both inputs of U11A are now high, causing the output to go low, creating a spacing condition at the loop keyer.

Thus, it may be seen that the loop is in a spacing condition immediately following arrival of the first negative-going edge of the clock waveform. It remains in this condition until the next negative-going edge of the clock again toggles binary counter U2; then output 1 (start) of U3 goes high and output 2 (intelligence bit 1) goes low. As soon as output 1 goes high, the output of U10 goes low, and the resulting high output of U11A causes the loop keyer to return to the marking condition. This sequence completes the generation of the start pulse, which is always a spacing condition.

Successive clock pulses applied to binary counter U2 move the low output of U3 through outputs 2 through 6 (intelligence bits 1 through 5). Since the function gate generator, U4 and U5, is still set high level from output 7 (stop 1). The output of U8A is a high, inverted by U8B, and applied to both U11A and U11B as a low. Therefore, with one input of both U11A and U11B at a low level, the output of these AND gates will always be high, regardless of whether highs or lows appear at the remaining gate inputs.

**Classification of characters according to number of marking pulses.**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>[V1]</td>
<td>A</td>
<td>[M1,2]</td>
<td>3</td>
</tr>
<tr>
<td>T</td>
<td>[M5]</td>
<td>B</td>
<td>[S1,3]</td>
<td>K</td>
</tr>
<tr>
<td>SPACE</td>
<td>[M3]</td>
<td>C</td>
<td>[S1,5]</td>
<td>Q</td>
</tr>
<tr>
<td>LF</td>
<td>[M2]</td>
<td>E</td>
<td>[S1,4]</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>[M1,4]</td>
<td>F</td>
<td>[S1,2]</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>[M3,3]</td>
<td>H</td>
<td>[S1,4]</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>[M1,3]</td>
<td>I</td>
<td>[S5,5]</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>[M1,5]</td>
<td>J</td>
<td>[S3,4]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>K</td>
<td>[S7,4]</td>
<td></td>
</tr>
</tbody>
</table>

**fig. 3. Callsign programming chart.**

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to zero, and because output zero of U5 (labeled LTRS) is not connected, no space pulses are generated during the periods of the five intelligence bits and the loop keyer remains in the marking state. Clock pulses continue to move the counter and decoder through 7 (stop 1) and returns it to output zero (stop 2). These two units of stop pulse complete the formation of the LTRS function.

**space function**

The machine space function character code has only bit 3 of the five intelligence bits in the mark state. Examination of 1-of-16 decoder U5 in fig. 2 shows that output zero (pin 1, labeled LTRS) is low during the idle condition and during the first character generation cycle of U3. At the time output 7 (stop 1) goes high, a pulse is applied to the clock input to U4. This changes the count from zero to 1 and moves the active low from output zero to output 1 in U5.

Output 1 from U5 (labeled space 1) is connected to one input of U7A through switch S1. This input goes low (all three inputs were high), the output goes high and is applied to U9B. At this time the B3 input to U9B is still high so the output goes low, causing the U10 output applied to U11A to go high. However, since the stop 2 bit applied to U8A is now low, the remaining input to IC-U11A, is also low, and, the loop keyer, U11C, continues to hold relay K1 in the marking state.

The next clock pulse applied to U2 moves the active low output of U3 to start. This low is applied to pin 12 of U10, but because of the low already on pin 3 of U10, the output and input to pin 9 of U11A remain high. At the same moment the active low in U3 moves from stop 2 to start, the output of U8B goes high and the U11A output goes low, creating a spacing condition at K1 for the duration of the start pulse. Successive clock pulses continue to move the active low through the outputs of U3.

Because input to pin 3 of U10 remains in the high state, the loop keyer remains spacing throughout the periods of information bits 1 and 2. At the instant bit 3 goes low, the signal at pin 4 of U9B goes from high to low and U10 has all inputs high. This causes the loop keyer relay K1 to go to the marking condition for the duration of intelligence bit 3. Relay K1 returns to a spacing condition during the periods of bits 4 and 5 and then goes to marking during stop 1 and stop 2 periods. The space machine function character is now complete.

**message characters**

Completion of the space machine function character described above has advanced the count in U4 to three. Decoder U5 is now low on pin 3, labeled D. This low is inverted by one section of U13 and applied as a high level to pin 9 of U9D. The character D has intelligence bits 1 and 4 marking. These two bits are applied to the inputs of U7B. Both inputs are high at all times except during the periods of bits 1 and 4. Thus, a spacing condition exists at the output of U9D during the formation of the letter D except during the periods of bits 1 and 4, which are marking.

It is now apparent that as each character is completed, the gate function generator, U4 and U5, is advanced one count, and the associated active output is
applied to a logic gate or group of logic gates, enabling the appropriate selection of marking or spacing intelligence bits from the bit generator, U2 and U3, to form the desired characters.

Character generation continues until the beginning of the 17th pulse input to U4 which sets output 15 (pin 17) of U5 from low to high, and applies a negative-going level to the clock input (pin 1) of flip-flop U6. This causes the U6 Q output to go low, resetting both binary counters to zero and inhibiting the clock, U1, returning the message generator to idle. Should the clear input (pin 3 of U6) be held low continuously, it will override the end-of-cycle signal on pin 1 and the message generator will repeat itself until the low on pin 3 is removed.

**programming**

Switch S1 is provided to inhibit the space 1 machine function if a space is not desired before the first printed character in the message. When space 1 is inhibited, the message generator forms the non-printing machine function LTRS. Switch S2 inhibits a space after the last printed character in the message. Switch S3 inhibits the carriage return (CR) and line feed (LF) machine functions when a continuous line of print across the page is desired.

As many as four different character gating configurations are required for programming the generator. The gating configuration selected for a specific character is dependent upon the number of marking pulses in the character. Fig. 3 tabulates characters according to their marking pulse content and illustrates the appropriate gating configuration. The notation FG at a gate input in fig. 3 indicates connection to the inverted function gate originating at U5. The notation M' indicates connection to the appropriate marking bit from the bit generator. Note that marking bits are selected only when the character contains one or two marking pulses.

The notation S' indicates connection to the appropriate spacing bit from U3. Spacing bits are selected when the desired character contains three or four marking pulses. The numerals to the right of each character in columns one and two refer to the location of marking pulses in the 5-bit pattern. The numerals in columns three and four refer to the location of spacing pulses in the bit pattern.

In gate D (fig. 3) note the absence of a prime mark after the S input reference. This means that the spacing bit for characters in column four must be inverted instead of coming directly from the outputs of U3. Refer to connections in U8C and U12, pin 8 in fig. 2 for an example.

As previously covered in the text, no gating or connections are required for the LTRS function.

**construction**

The physical configuration of the prototype message generator consists of two printed-circuit boards (main and station call) with edge connectors, a regulated power supply and a fully enclosed aluminum cabinet to provide radio frequency interference shielding as well as control mounting facilities. The main printed-circuit board is a universal dual in-line package (DIP) type breadboard with 15 sets of DIP IC pads for the 14 ICs and one DIP reed relay. Each IC pin pad has up to three solder pads for interconnection. The station call board is about half the size of the main circuit board and contains the three ICs indicated within the station call coding logic box in fig. 2.

Total cost of the IC packages for this unit is less than ten dollars. The cost of all components including ICs, power supply and transformer, but not including the printed-circuit boards, connectors and cabinet, amounts to less than $35.00. These costs are based on single unit prices.

Although not indicated in the logic diagram or in the parts list, the prototype unit uses a 4-position, single-pole rotary switch to select one of four 1000-ohm trimpots (R1) in the clock circuit. Each trimpot is adjusted for one of the four operating speeds listed in the speed-time chart in fig. 2. Also not shown on the
logic diagram are $V_{cc}$-to-ground bypass capacitors for ICs U1 through U6. These are 0.1-$\mu$F disc ceramic capacitors mounted as closely as possible to the $V_{cc}$ and ground pins of each of the indicated ICs. These capacitors are required for suppressing noise generated by internal IC switching transients.

The spark suppression network (C2, R7) across the contacts of the keying relay is mandatory. Operation of the device without this network will result in premature failure of relay contacts, and in erratic operation of the circuit due to noise. Diode CR1 suppresses the voltage transient caused by back-emf generated in the coil of the relay at de-energization.

The normally open, spst reed relay, K1, is the type actually used in the prototype. It is less costly and easier to obtain from supply sources than the normally-closed, spdt reed relay, K2, shown in the alternate loop keyer configuration in fig. 2. Actually, the alternate configuration is preferred for most applications because loop continuity is maintained when power is removed from the unit.

The power supply consists of a 6.3 volt, one ampere power transformer and a rectifier-regulator circuit with 1% line-load regulation of the 5-volt dc $V_{cc}$ output. The $V_{cc}$ supply should be maintained within the limits of 5 volts, ± 5%.

**Troubleshooting**

Troubleshooting improper operation is simplified if a typing reperforator is available as this permits recording of all normally non-printing machine functions on paper tape. Should a character not be the same as programmed, correlation of the tape readout with the appropriate area of the logic diagram should assist in isolating the problem. Experience has shown that almost all initial checkout problems in a handwired prototype result from improper or missing connections.

Rf interference can cause problems, although the prototype has functioned without error in the immediate vicinity of gain radiators with power inputs of 100 watts rms at 14 MHz. Most rfi problems can be cured with proper application of shielding and installation of bypass capacitors on all the input and output lines.

**Summary**

A simple, reliable, low-cost method of generating short RTTY messages has been described. An operational prototype message generator using state-of-the-art integrated circuits has been constructed and tested under field operation conditions. This unit was built with components costing less than thirty-five dollars at unit quantity prices.

**Bibliography**


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**Ham Radio**

"I've discovered how to keep it playing a little longer at a time. I put a time-lag fuse in the box."
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...spec for spec...

We think we know how you will come out.

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1. 22 channel capacity... plenty of room for today's and tomorrow's use.
2. 10 xtal installed... (that's about $45 worth of xtals included in the price of the rig!)
3. Solid state T-R relay... nothing to wear out.
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5. 1/10 watt switch power saving option.
6. Mosfet front end and 5 helical resonator cavities.
7. Noise canceling mike included.
8. Quick disconnect mobile mount... taking the rig in and out is a snap!
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universal frequency standard

A precision frequency standard featuring a high-accuracy crystal, stable transistor oscillator and TTL logic.

This frequency standard has been designed to supply precision frequencies for several purposes. Its main use is with my station receiver as a precise and reliable frequency calibrator. It may also be used as a digital counter time base, a scope calibrator or to drive a digital clock. With all integrated circuit packages installed on the board there are no less than eighteen frequencies available extending from 2 MHz down to 1 Hz. Ten of these, of your choice, are connected to a rotary switch for calibrator use while the lower frequencies below 1 kHz that would not normally be used with the station receiver, are picked off terminals on the circuit board by a small clip lead when needed.

The design is flexible. If you do not need the versatility of the complete unit, the photo shows a frequency standard that will provide markers at 1 and 2 MHz, and at 500, 250, 100, 50, 25 and 12.5 kHz with the installation of only three digital IC packages. Provision is made on the circuit board for as many or as few output frequencies as are likely to be needed.

features

Features include excellent frequency stability, front panel calibration and a precise, self-contained, regulated power supply. An adjustable level control is included so the calibrator output can be matched to incoming signals such as WWV for really accurate zeroing or advanced full on for strong, clear markers.
With proper temperature compensation, the frequency standard will stay within 1 Hz of WWV at 10 MHz over an extended period of time with no adjustment.

This precision is not needed if the unit is used only to find band edges or set the receiver graticule. However, for frequency measurement or use as a time base for a move, capacitors change value. Solid-state circuitry has substantial advantages over vacuum-tube circuits; much heat is eliminated, components run cooler and the crystal is driven at the low levels recommended by the manufacturer. However, a substantial amount of drift can come from the semiconductor alone.

counter or digital clock, you need all the accuracy you can get. The best reason for going first class is that it costs little more, and probably less, in this do-it-yourself project. The required stability can be obtained with inexpensive construction.

The oscillator circuit in this calibrator was first used as a stable time base for a digital clock and later in a receiver. Several circuits evaluated in drift tests showed the Clapp-Colpitts to be most stable — not a new circuit, but seldom used in recent designs. While both the circuit used and the TTL logic is familiar, it is the combination of circuit, crystal and construction that makes this calibrator better. Stability comes when a few hertz drift is removed or greatly reduced from each of several sources. A 10-Hz drift caused by a trimmer might be tolerated, but when the drift from other sources is combined, the total becomes excessive.

Most oscillator circuits would cause even a perfect crystal to drift. Voltage and temperature changes cause changes in the semiconductor’s internal impedance. Trimmers don’t stay where set, wires

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**fig. 1. Solid-state crystal oscillator circuits.** Fet circuit in (A) is considerably more stable than the bipolar circuit shown in (B). For a more stable bipolar oscillator circuit, see fig. 2.

How much? Two circuits are shown. Fig. 1A shows a fet oscillator circuit using crystals in the 1- to 9-MHz range. The crystal ground for 32-pF load is sometimes brought on frequency with a small trimmer. If this circuit is built so the semiconductor is isolated, it can be heat cycled without affecting other components and the drift can be measured on a

**fig. 2. This transistor crystal oscillator circuit is stable because impedance changes are swamped out by the 1500-pF silver-mica capacitors.**
Frequency standard and power supply are installed in a 3x5x7-inch (7.6x12.7x17.8-cm) Minibox.

digital counter. The best of several fets caused a change of 12 Hz at 4 MHz with a 5-degree ambient temperature variation.

Fig. 1B shows a transistor in a similar oscillator circuit, not recommended, but sometimes used. Although not as sensitive as the fet to temperature, a change of only one volt caused a 70-Hz frequency shift. If this circuit is modified as shown in fig. 2, there is a substantial improvement. Changes of ten degrees and one volt did not cause a frequency change readable on the counter. The transistor case could be heated with a soldering iron to the point where it burned the fingers with a 2 Hz change registered at 4 MHz.

These experiments show both the extent of drift that can be contributed by the semiconductor and indicates the solution. The more stable the capacitance used across the transistor, the better the stability. The 1500-pF capacitors have a very low reactance at 4 MHz, swamping out any other impedance changes in the circuit. This circuit will not oscillate with some transistors because there must be enough gain to sustain oscillation. This requirement is met by the Motorola HEP715, a pnp device with a typical beta of 120. Other transistors with similar current gain can be substituted.

the crystal

Some time ago while working with digital counter time bases2 I noticed that the ordinary 100-kHz crystal was not as stable as it might be. A time base derived from the power line was nearly as accurate. Although used in amateur calibrators for many years, the 100-kHz rock is
A new crystal might require anything from a maximum of 30-pF (N1500) to a 30-pF silver mica (NPO), depending on its temperature vs frequency characteristic. Since there is no way to know what will be needed, it is advisable to have a supply of different values of N750 and N1500 coefficient capacitors on hand, with small silver micas to pad the total to 30 pF, before starting any temperature compensation work. A piston trimmer is recommended because of the smoother adjustment and lack of drift. It is also easier to determine if capacitance is being added or removed, useful information when temperature compensating the calibrator.

If you don’t need the versatility of the complete unit, this photograph shows a frequency standard that will provide markers at 1 and 2 MHz, and at 500, 250, 100, 50, 25 and 12.5 kHz with the installation of only three logic packages.
the circuit

In fig. 5 the pnp oscillator transistor, Q1, is coupled to the TTL logic by transistor Q2. The 7493 binary dividers U1 and U5 are used to divide by factors of 2, with 7490 decade packages making up the remainder of the logic. IC U5 has two inputs for 5 kHz and 100 kHz. Reset pins 2 and 3 control operation of the logic, either by switch S1, the standby switch, or by progressively shorting contacts on the rotary switch.

This way, the oscillator runs contin-
uously for best stability, and unused packages are disabled. It prevents some markers from leaking across the selector switch and being heard in the receiver. If this feature is not wanted, pins 2 and 3 should be jumpered to ground.

Board outputs and compensating capacitor terminals appear at convenient terminals at the top of the board made by forcing short lengths of bare number-12 wire into 5/64-inch holes. This facilitates exchange of compensating capacitors, or selection of a different logic output at some future time. After completion, it is difficult to work on the underside of the board without removing several wires.

The fast switching TTL logic has active transistor pull-up circuitry which is well suited to driving external loads. The 2900th harmonic of the 10-kHz marker is over S9 in the ten-meter band. In the unlikely event that a logic package fails, repair would be facilitated if Molex sockets are used. The full current drain with all IC packages installed is 5 volts at 260 mA.

capacitor terminals are easily supplied by a LM309K voltage regulator IC mounted on a heatsink (fig. 6). All power supply components except the power transformer are mounted on the circuit board. High temperature shutdown and overcurrent protection are provided by the regulator.

fig. 6. Power supply for the universal frequency standard.

circuit board. After completion, it is difficult to work on the underside of the board without removing several wires.

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fig. 4. Frequency vs temperature chart for typical high-accuracy AT-cut crystals.

duction

This frequency calibrator is simple to build. The circuit board may be hand duplicated following the layout given in fig. 7, or an etched, plated epoxy board is available which speeds construction and minimizes errors.* Parts locations and identifications are screened on the board. It is only necessary to drill the IC holes with a number-60 drill, insert parts, and solder. The assembly is mounted in a compact 3x5x7-inch Minibox.

temperature compensation

Crystals should be ordered for 0.0005% tolerance, F-700 or SP7-P holder (depending on manufacturer), 32-pF load, 4 MHz at room temperature. New crystals should be operated for a time before starting any compensation work. You will need the previously mentioned supply of N750 and N1500 capacitors, and a receiver with an S-meter that will tune WWV.

Start with 15 pF in parallel with a 15-pF N750, allow an hour for the unit to stabilize, and adjust to frequency using the S-meter on the receiver as an aid to exact zeroing. Select a time when WWV is

*An epoxy, plated 4x6-inch printed-circuit board for this frequency standard is available from the author. $8.00, postpaid, in the United States.
The temperature compensation is easier to accomplish than it appears and makes the difference between an ordinary and a precision instrument.

some uses

The photos show a frequency standard supplying pulses for a digital clock. This clock controls nineteen slave clocks in a broadcast installation, so reliability and accuracy are important. The clock is made immune to momentary power-line failures by floating the dc supply across a nicad battery large enough to operate the logic until emergency power can be started or service is restored, whichever comes first.

Fig. 8 shows diodes used to drop the battery voltage to TTL requirements. The one-second pulses from this standard are so accurate that this clock stays on the tick with WWV for weeks with no correction.

In this circuit the 4-MHz crystal frequency is divided by a factor of \(4 \times 10^6\) to obtain the one-second pulses. If this crystal drifted an extreme 1 Hz away from nominal, it would require four million seconds (or 46.3 days) for the clock to accumulate an error of one

 moderately strong, with little fading, so the meter remains reasonably steady.

The standby switch, S1, is turned on and the calibrator level control advanced about halfway so both signals are heard. At first, the calibrator will probably be so far off frequency that an audible beat note will be noted, mixed with the WWV tone. As it is zeroed, the warble in the WWV tone will decrease in pitch until it is no longer heard and the S-meter will swing, rapidly at first, then slower, as tuning becomes more exact.

The amplitude of this swing will maximize when the calibrator level is equal to WWV's strength. It should be easy to set the calibrator exactly in zero beat with WWV at 10 or 15 MHz. When this is finished, note the temperature of the room on a thermometer, and record it for reference. Recheck the frequency with WWV periodically, and if there is any drift note the temperature and the direction the trimmer must be adjusted—to add or remove capacitance. If this trim-
Precision digital clock discussed in the text. The frequency standard board used to provide the 1-second driving pulses is located in the foreground on the upper deck. Nicad battery to the right is part of the failsafe power supply (see fig. 7).

second. But, since the crystal is compensated closer than this, and any minor drift is above and below the frequency, the average error is very small.

The secondary frequency standard would also make a good time base for a digital or Rec-Counter. Readout kits with the tubes, storage latches and counter ICs are advertised in this magazine, so only the gating circuitry would have to be hand wired. Other applications for the standard include audio oscillator or signal generator calibration, or calibration of the sweep time base in oscilloscopes.

1-MHz output of the frequency standard as observed on a 10-MHz oscilloscope. Rounded waveform shows bandpass limitation of the scope. Horizontal scale is 0.2 microsecond per cm.

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*february 1974*
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I recently completed a homebrew receiver project which included a 455-kHz i-f strip, and I needed a signal source to align it. My home workshop doesn't boast a signal generator, and even if I had one, I would have no way of precisely setting its output frequency to 455 kHz. A little thought and investigation provided a fairly cheap and easy solution.

**455-kHz i-f alignment signal generator**

Simple, crystal-controlled signal generator for aligning i-f strips — modulation is built in.

A schematic of the resulting generator is shown in fig. 1. It consists of an fet crystal oscillator and an amplitude modulator. I decided on crystal frequency control because it would set the frequency accurately and because 455-kHz crystals are available from JAN Crystals for $1.75 plus 10 cents postage.* These crystals are supplied in an FT-241 holder;

*JAN Crystals, 2400 Crystal Drive, Ft. Myers, Florida 33901.
the pins are 0.093 in diameter with 0.486 spacing. JAN sells the mating SSO-1 socket for 15 cents.

Transformer T1, the drain load for the fet oscillator, is a 455-kHz i-f transformer salvaged from a junked a-m transistor radio. This provides a simple way to tune the drain circuit and obtain a low output impedance. Removing these transformers from the radio PC board is tricky because you have to simultaneously melt the solder at several different points. A large soldering iron is an advantage.

The junked radio had three i-f transformers, and I tried all three. I couldn’t get the first one (mixer output) to oscillate at all, but it may have been damaged in removing it from the PC board. The last i-f transformer (which feeds the detector) had the highest output, but oscillations stopped if it was loaded with less than 200 ohms. I used the middle transformer because it would still oscillate when loaded with 50 ohms.

Another source of i-f transformers is Radio Shack. They sell a kit of four transformers for $1.39 (catalog number 273-1383). I believe the one in this kit which would correspond to the one I used is color-coded white.

A Colpitts audio oscillator is used to provide amplitude modulation, and a switch allows the modulation to be turned on or off. A surplus 88-mH toroid is used in the audio oscillator. These can be found listed in surplus and classified ham ads for about 50 cents each or less.

The one I used has four leads, and two adjacent leads must be tied together to provide the center-tap. The audio frequency is about 1-kHz, but this may be altered by changing the value of the 0.47-µF tank capacitors.

I used a 2N3819 fet, but a Motorola MPF102 or Siliconix U183 should perform identically. The 2N5449 modulator should be available at local Radio Shack stores for 79 cents (catalog number 276-2014).

construction

As shown in the photographs, the generator is housed in a 2¼x2¼x5-inch Minibox. A piece of perfboard holds most of the schematic components. A socket for 15 cents.

fig. 2. Arrangement used to adjust transformer T1 for maximum rf output.
of the circuit components. It is mounted in the Minibox by two screws with \( \frac{1}{2} \)-inch spacers. The 88-mH toroid is held to the perfboard by a screw and two discs (one metal, one plastic) which were furnished with the toroid. I detected nothing critical in the layout.

One end of the Minibox holds the modulation switch, output phono jack and level control. Two 5-way binding posts are mounted on the other end for connecting the generator to a dc power source.

**operation**

The fet may not oscillate until T1 is adjusted. Connect a sensitive vom to the output through a germanium diode detector as shown in fig. 2. Set the level control at maximum and the vom to its most sensitive dc volts scale. Now adjust the tuning slug in T1 for a maximum reading on the vom. This will only be a fraction of a volt, but this is more than enough for i-f amplifier alignment. The level control pot will not set the output voltage low enough for sensitive i-f circuits, and I found it necessary to use the external attenuator shown in fig. 3 to prevent overdriving the i-f strip.

Although the circuit was originally designed to operate from a 12-volt dc supply, it appears to perform well using only a 9-volt transistor radio battery for a power source. Current drain is about 7 mA with a 12-volt supply and 5 mA using the 9-volt battery.

**conclusion**

This little gadget is intended only for 455-kHz i-f alignment which is a rather limited use. However, it has a limited cost too — only a few dollars. A well stocked junk box can cut the dollar outlay to a very nominal amount. I haven’t had an opportunity to check its frequency on a counter or observe its output waveform on an oscilloscope, but it performed its intended function to my satisfaction. If amplitude modulation is not required, the unit could be simplified to a single fet circuit. This would reduce battery drain substantially. A worthwhile addition would be a built-in step attenuator which would permit setting the output voltage to micro-volt levels.
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How to use commercial FM receiver strips in a multichannel, two-band VHF FM receiver

Surplus public-service VHF-FM equipment, which is sold in strip form, can be used as the basis for a low-cost, multichannel, two-band FM receiver. This is accomplished simply by adding a two-meter converter and a logic crystal oscillator to a single-channel 30-50 MHz Motorola Sensicon receiver strip as shown in block form in fig. 1. If the output of the two-meter converter is fed into the strip receiver’s first-conversion i-f input, and a logic oscillator is provided as the local oscillator (17.775 to 17.830 MHz) the strip will cover the FM channels for 146.34/94 MHz. By adding a multiple crystal oscillator operating at approximately 16 MHz and appropriate switching controls, two-band control and channel selection is possible.

These modifications are not limited to Motorola receivers, as there are a number of commercial FM receiver strips sold in the same way. Any of these strips can be adapted to perform the same task. However, before modifying one of these units it’s a good idea to put it into operating condition before adding to the confusion. A circuit diagram and receiver tuneup data, if you can find them, are a great help in this respect. Information on many of these units is included in The FM Schematic Digest.2

Two-meter converter

If you already have a good two-meter converter, all you have to do is convert its output frequency to the same frequency as the receiver strip you are going to use (4.3 MHz in the Motorola Sensicon receiver strip). This may be as simple as
plugging in the two-meter logic oscillator and realigning the converter, or it may require more extensive circuit modifications. If considerable modification is required, it might be easier to build a two-meter converter specifically for use with the fm receiver strip.

My two-meter converter consists of a single mosfet rf stage using an RCA 40822 mosfet. Another mosfet, an RCA 40823, is used as the mixer (see fig. 2). Both of these devices were designed for vhf work and provide good performance on two meters. The rf amplifier has excellent gain as an unneutralized rf amplifier, a low noise figure, and wide dynamic range which results in low cross modulation. The dual-gate mosfet used in the mixer stage isolates the input from the output and allows low-level local-oscillator injection.

The tuned input network to the rf amplifier is designed to match a 50-ohm antenna. The small trimmers, C1 and C2, the inductor, L1, and the rf amplifier transistor, Q1, are located in a shielded compartment made from 1-inch-wide strips of copper-clad PC material. The drain lead of Q1 passes through a small hole in the shield wall and is connected to inductor L2. Gate 2 and the source lead of the mosfet are connected directly to 1000-pF standoff capacitors. The 275-ohm source resistor is grounded next to the source bypass capacitor with as short leads as possible. A ferrite bead is installed on the drain lead.

Similar construction is used for the mixer stage. A small coaxial cable must be used to connect gate 2 of the mixer to the output of the multiplier chain. This is because the mixer requires only a small amount of local-oscillator signal — unwanted signals can leak in and appear in the 4.3-MHz output.

local oscillator

Construction of the logic oscillator will not be discussed as that was covered in detail in the previous article. Crystal frequencies for the logic oscillator may be determined from the following formula

\[ f_{xtal} = \frac{f_0 - f_{f-I}}{8} \]  
(144 MHz)

\[ f_{xtal} = \frac{f_0 - f_{f-I}}{3} \]  
(50 MHz)

where \( f_{xtal} \) is the crystal frequency, \( f_0 \) is the desired operating frequency and \( f_{f-I} \) is the intermediate frequency of the receiver strip (often 4.3 MHz). For example, the crystal required for a two-meter input frequency of 145.500 MHz is

\[ f_{xtal} = \frac{145.500 - 4.30}{8} = 17.650 \text{ MHz} \]

For a six-meter input at 52.525 MHz, the required crystal frequency is

\[ f_{xtal} = \frac{52.525 - 4.30}{3} = 16.075 \text{ MHz} \]
L1, L2 6 turns number 22, air wound, ¼" diameter
L3 6 turns number 22, air wound, ¼" diameter, center tapped
L4 37 turns number 32 on Amidon T50-2 toroid core

fig. 2. Simple two-meter converter for the two-band fm receiver. The ferrite bead on the drain lead of Q1 is an Amidon 45-101.

The frequency-selector switch is a 2-pole, 6-position rotary wafer switch wired so that +12 volts is applied to the two-meter converter when the two-meter channel crystals are switched into the circuit. More crystal frequencies can be added simply by adding additional logic oscillator stages -- the only limiting factor to the number of logic-oscillator channels is the current handling ability of the voltage regulator.

The logic oscillator will operate properly with fundamental-mode crystals up to about 20 MHz. Above 20 MHz it is

L1, L2 11 turns number 22 on ¼" diameter slug-tuned form
L3, L4 4½ turns number 22 on ¼" diameter slug-tuned form
L5, L6 1½ turns number 20 on ¼" diameter slug-tuned form

fig. 4. Local oscillator multiplier chain. Stagger-tuned circuits provide relatively flat output across the two-meter fm band. L1, L3 and L5 are peaked for the lowest frequency crystal; L2, L4 and L6 are peaked for the highest.
necessary to use higher speed gates than the TTL ICs shown in fig. 3. Do not use overtone crystals in this circuit as they will not oscillate at the same frequency as that marked on the crystal can.

fig. 3. The logic oscillator circuit uses TTL ICs which are suitable for use with fundamental crystals up to approximately 20 MHz. Overtone crystals do not operate properly in this circuit.

Construction of the local-oscillator chain (fig. 4) is very straight forward and should cause no problems. The stagger-tuned stages provide the bandwidth necessary to cover the entire two-meter fm band. Each of the inductors is wound as described in fig. 4, and the coil pairs spaced by the diameter of one coil form (½ inch). The input coil of each pair is peaked for the lowest frequency crystal while the secondary coils are peaked for the highest frequency crystal. The fre-

frequencies indicated in the circuit diagram are the approximate center frequencies of the stagger-tuned stages.

The two-meter converter, logic oscillator and multiplier chain are built on a single piece of copper-clad board 3-inches wide by 8-inches long. The oscillator is
built into a separate shielded compartment as are the multiplier chain and the two-meter rf amplifier and mixer stages. Short lengths of coaxial cable are used to connect these units together and to the fm receiver strip.

receiver strip

The low-band Motorola Sensicon receiver (model PA9244-12) I modified for use in the two-band receiver is easily moved into the six meter fm band by replacing the fixed tuning capacitors in the rf amplifier, mixer and local-oscillator stages. The values for these capacitors are given in the Motorola schematic and are prefixed with the letters L, M or H, depending on the desired operating frequency. The H values (for high-band) are the values that should be installed for six-meters.

To use the receiver strip in the two-band fm receiver it is necessary to add an i-f input jack and an access jack to the first local oscillator. The i-f jack is located close to V103 so that the lead to pin 5 of the 6C86 is as short as possible (see fig. 5). Another jack is mounted on the opposite side of the chassis and connected to pin 2 of V104, the grid of the 12AT7 oscillator multiplier. This completes the modifications to the receiver strip.

The receiver is aligned by connecting a center-scale dc vtvm to the discriminator output and adjusting the frequency control trimmer of each channel crystal until the meter reads zero with an incoming signal.

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vhf fm scanner modifications

Although solid-state equipment is fast becoming the ideal equipment, at the same time there is still quite a bit of tube-type equipment in use. At the time I saw the February, 1973, edition of *ham radio* I was in the process of trying to come up with a scanner to add to my base station receiver. After looking over K2ZLG's vhf fm receiver scanner, I decided it was worth a try. However, the basic design was not completely acceptable for use with tube-type equipment. The following modifications were developed and tried. So far the unit has worked flawlessly.

Since most vacuum-tube receivers produce a negative-going voltage when the squelch is open, the original input circuit will not work. The circuit shown in fig. 1 was finally tried and seemed to work the best of any. One of the major problems with the bipolar input was to get the input impedance high enough to prevent loading of the receiver squelch circuitry; the dual-gate fet takes care of this problem nicely.

![fig. 1. Input circuit for frequency scanner.](image)

A negative-going voltage of more than -2 volts is required to stop the scanner. However, this voltage should not be more than -6 volts at the gate of the fet. For voltages in the range of -2 to -6 volts R2 can be eliminated. For voltages higher than -6 volts, R1 and R2 should limit the gate voltage to less than -6 volts. Typical values are between 1 and 10 megohms. The important thing is to try to keep the input impedance as high as possible since loading of less than about 1 megohm will interfere with normal squelch operation.

The next problem is that most tube-type receivers use separate oscillators for each frequency. Most circuits require that the cathode of the appropriate oscillator be grounded for operation of that particular oscillator. In addition, the ungrounded cathode produces about 30 volts. The simplest way around this seems to be to use an npn transistor to isolate the cathode from the scanner since TTL circuitry will not normally tolerate 30 volts. This is shown in fig. 2. The transistor used is non-critical as long as it will withstand the voltage present when the tube cathode is above ground.

In the unit at my station some MC4039 ICs were on hand instead of the 7446 decoder, so these were used. This IC happens to have an enable pin that was used with an inverting transistor off the
output of the input circuit. I didn’t like seeing the numbers go by as the unit scanned, and this configuration turns the readout off while the unit is scanning. The same thing could be done by putting a switching transistor in the +5-volt line to the readout.

Mike Jones, WA5WOU

10 MHz coverage for the SB-303

The utility of 15-MHz WWV reception on Heath SB-303 receivers is somewhat dubious, considering present propagation conditions in this area. I’ve changed mine to tune WWV-10, finding virtual 24-hour coverage on 10 MHz. Modifications are relatively simple, but refer to the manual and schematic.

The 23.895 MHz crystal, Y104, used for 15 MHz, is replaced with an 18.895 MHz, HC6-U type, third overtone crystal intended for a 32 pF load. This change is made on the crystal switch-board (85.348), whose X-ray pictorial with other PC boards is found at the back of the SB-303 manual.

To resonate the LC circuit marked "15 MHz" on the heterodyne oscillator switch-board, a 33-pF dipped mica or disc capacitor is added across C131. The slug in L117 must be moved in a few turns until oscillation occurs as noted by voltage appearing at TP on the PC board. An extra half-turn provides positive crystal starting when switching bands.

Modification of the rf amplifier switch-board (85.346) involves isolating foil pad areas around switch-points 5 and 6. Switch-point 5 will then be jumpered back to the foil lead coming from L111, the 14-MHz tuned circuit. A new reso- nant circuit for 10 MHz is required. I used 22 turns of number-24 enamel wire on an Amidon T-50-2 toroid, turns spaced evenly around the core. This is approximately 2.9 \( \mu \text{H} \) which, with a 47-pF disc in parallel, will resonate – out of the circuit – at 14 MHz. The older vacuum tube type of grid dipper will dip this unit satisfactorily. One end of this LC combination is soldered to switch-point 6 (on 85-346) and the other to ground foil near the rf in phone jack. Mount it close to the board, avoiding shorts.

Operation of the receiver on 10 MHz may be checked by attaching a short antenna through a few pF to rf in at C106 on the amplifier switch-board. The preselector should resonate broadly at about 30 to 40 percent of its range.

The antenna switch-board (85-345) is modified similarly to the previous PC board. Again, switch-point 5 and 6 pad areas are isolated, 5 being jumpered back to the foil lead running to the 14-MHz tuned circuit L103-C103. Also, between and clear of switch-points 6 and 7, drill about a number-58 hole. This board has a double-section rotary switch, the section nearest the board being the secondary, and the outer, the primary. Switch-points 5 and 6 on the primary are isolated by unsoldering the blue wire and jumper between 5 and 6. Resolder the blue wire directly to switch-point 5 (14 MHz).

Primary switch-point 6 is left blank for the moment. The LC antenna circuit also uses an Amidon T-50-2 toroid with 22 turns of number-24, with the addition of 6 turns of number-26 or -28 wire forming the primary. Use an adjacent winding rather than over-winding for the primary. The tuning capacitor is again a 47-pF disc paralleled with the 22-turn secondary. The combination mounts on the foil side of the board (85-345).

One end of the secondary goes to switch-point 6 and the other to any convenient ground-foil point. One side of the 6-turn primary also ties to this point, the other side being fed through the pre-drilled hole and soldered to outer switch-point 6. An adjustment of a turn on the secondary may be desirable for better tracking, but I found the pre-selector tuning to be adequately sharp.

This application can be used for other 500-kHz segments. The crystal frequency must be 8895 kHz above the lowest signal frequency.

Bill Fishback, W1JE
The Measurements Model 800A series of solid-state fm signal generators cover all mobile communication frequency bands allocated by the FCC. Any desired frequency can be quickly obtained by selecting one of the six frequency bands, tuning the coarse tuning control, and making narrowband adjustments with either the electronic fine tuning or incremental frequency controls.

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Internal modulators provide frequency modulation at 1000 Hz sine wave or 20 Hz sawtooth. External modulation from dc to 30 kHz may be applied through front-panel binding posts. Sync out and sync phase are available for external modulation (up to ±32 kHz peak deviation) so that dual-trace sweep alignment techniques may be used.

For complete technical data write to Edison Electronics, Division of McGraw-Edison Co., Grenier Field, Manchester, New Hampshire 03103, or use check-off on page 94.

WWV data folder

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Maximum utilization of this valuable "natural resource" depends upon a complete knowledge of the current broadcasting schedules and transmitting frequencies. The folder supplies this data, as
well as information on suitable methods of comparison with local chronometers or instrumentation. Also included are the hourly broadcast schedules of National Bureau of Standards stations WWV, WWVH, WWVB, with supporting data.

Write to True Time Instrument Company, 225 Melbrook Way, Santa Rosa, California 95405, and request Bulletin 373-1, or use check-off on page 94.

**swr meter**

Carvill International has announced its new in-line swr and power meter, the model ME-IIN. The ME-IIN is a direct-reading swr and power meter which measures the ratio of the forward and reflected wave on a coaxial transmission line. In this instrument a printed-circuit transmission line is used to eliminate unbalanced rf pickup which is often a problem in more simple swr meters. The swr meter is usable on all bands from 3.5 to 150 MHz.

For more information, write to Carvill International Corporation, 825 Constitution Drive, Foster City, California 94404, or use check-off on page 94.

**signal intensifier**

The new SABA-5 (Symtek Automatic Broadband Amplifier) provides low-noise and high useful gain for amateur communications receivers. This new amplifier, which covers 80, 40, 20, 15 and 10 meters with no tuning has a typical noise figure of 2.5 dB and gain of 20 dB (minimum). Input and output impedance is 50 ohms.

The SABA-5 uses a dual-gate, diode-protected mosfet to take advantage of its low noise characteristics as well as its...
OPCOA SLA
FOA SLA 1 33
3PCOA
THE MOST POPULAR KEYSI0N BOARD
THE MOST POPULAR DUAL GATE PROTECTED MOSFET
around Good to over 400 lor
RF POWER TRANSISTORS
The SABA-5 carries a 30-day money-back guarantee and 1-year warranty, and
is priced at $79.95. Models for 160 meters, 6 meters and 2 meters are also
available. For more information, write to Symtek, Inc., Box 128, Clearwater, Flori-
da 33517, or use check-off on page 94.

three-pin
voltage regulators

Many times the need arises for a simple, low-cost voltage regulator which
can provide a moderate amount of cur-
rent without complex current-boosting
circuitry. Applications include on-card
regulation and power supply distribution
in large systems.

A new Motorola device family com-
posed of seven fixed-voltage regulators

RG - 174/U
WE WENT THROUGH 20 MILES OF IT LAST TIME! We are authorized Belden Distributors and new shipments
come in from the factory. Split a 500' spool with a friend and
save $$$$$. Belden NO. 8216
100'/$4.80 - 500'/$16.85

LED Readouts
OPCOA SLA 1 33 Red Yes 4.95 4/$16
OPCOA SLA 1 33 Green Yes 4.95 4/$16
OPCOA SLA 3H. .70 Red Yes 4.50 4/$16
All use 7447 Drivers. Spec included.

RF POWER TRANSISTORS
We did it again. All brand new, with standard markings and
most were manufactured this year. A major manufacturer
dropped his RF power line and we bought his inventory.

2N5989 3 Watts Out $ 3.50
2N5989 10 Watts Out 0.00
2N5989 25 Watts Out 12 00
2N6080 4 Watts Out 5.00
2N6082 25 Watts Out 10 00
2N6083 30 Watts Out 12 00
2N6084 40 Watts Out 15 00

All are Silicon NPN and power output ratings are good to
175 MHz. Hurry some quantities are limited.

KEYSTONE PERF BOARD
G 10 Glass Epoxy
Pent Board 3.64” Thick

<table>
<thead>
<tr>
<th>No</th>
<th>Size (in.)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEC</td>
<td>2 x 4.5</td>
<td>$ 86</td>
</tr>
<tr>
<td>4230</td>
<td>2 x 6</td>
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<tr>
<td>4231</td>
<td>4 x 6</td>
<td>1.55</td>
</tr>
<tr>
<td>4232</td>
<td>17 x 6</td>
<td>5.75</td>
</tr>
</tbody>
</table>

We GUARANTEE WHAT WE SELL!!!!

We ship UPS whenever possible. Give street address. Include
enough for postage. excess refunded in cash. Florida residents
include 4% Tax.
housed in a popular plastic power transistor package fulfills these needs. The MC7805/24 series positive voltage regulators can supply in excess of 1 ampere at nominal voltages of 5, 6, 8, 12, 15, 18 or 24 volts (as designated by the last two digits of the device number). However, unlike most voltage-regulator ICs, these devices have only three terminals — input, output and ground — and they require no external components. The devices can be easily attached to a heatsink surface with a machine screw through the hole in the package to attain higher maximum power dissipation.

To insure a rugged device, internal current limiting, thermal shutdown, and output transistor safe operating area compensation techniques are employed. These features make the regulators essentially burn-out safe.

For further information contact the Technical Information Center, Motorola Inc., Semiconductor Products Division, Post Office Box 20912, Phoenix, Arizona 85036, or use check-off on page 94.

spring-type fuse holder

Oneida Electronics has recently introduced a new coil-spring fuse holder that makes it easier than ever to replace fuses. The new holder eliminates the need for using more costly type pig-tail fuses and does away with cutting and re-soldering pig-tail leads.

Regular fuses can be snapped into the coil-spring holder in seconds. Service people will find them ideal for use in those hard-to-get at places. Replaces permanently installed pig-tail fuses by merely soldering the leads of the new...
HERE IS A FIST FULL of 2 METER POWER

NEW

Model HRT-2
5 Channel, Narrow Band
2.2 watt FM Transceiver

This lightweight, "take anywhere" transceiver has the "Regency-type" interior componentry to give you what others are looking for in portable communications. You get a heavyweight 2.2 watt signal . . . or if you want, flip the HI/LO switch to 1 watt and the receiver gives you 0.7 uv sensitivity and 0.5 watts audio. Both transmitter and receiver employ band-pass circuitry so that power and sensitivity are maintained across the entire band. Get one to go . . . only $179.00

Regency ELECTRONICS, INC.
7707 Records Street
Indianapolis, Indiana 46226

An FM Model For Every Purpose . . . Every Purse

spring holder to stubs of removed pig-tail fuse. The spring holders have been designed to accommodate TV, radio, hi-fi and most other electronic device fuses.

The new spring-type holder is permanent — quality constructed of tempered spring steel with dip soldered leads. Available packaged 5 pair per pack on dealer cords and in bulk for OEM use. For detailed information write Oneida Electronic Manufacturing, Inc., Meadville, Pennsylvania 16335, or use check-off on page 94.

new allied catalog

Allied Electronics (Division of Tandy Corporation) has published their new catalog number 740. Previous catalogs have served as the electronics industry's "answer book," and the new catalog is even better. In addition to the easy-to-use tab-index format and easy-to-use 9 x 11-inch size introduced in 1973, even more useful product information is included in the book. Prime feature of the Engineering Manual and Purchasing Guide catalog is the inclusion of Engineering Drawings of all electrical components. All physical dimensions are given to allow efficient design of electronic packages before components are purchased. Electrical characteristics of all items are also included.

Allied has also introduced a new policy for obtaining a copy of their
catalog: instead of the $5.00 price, or $10.00 order requirement, anyone can now obtain a copy for the cost of postage and handling—just $1.00. All items shown are in stock at all Allied warehouses. With Allied enjoying the best order filling record in the industry, this, as always, is the one catalog you can’t do without. For your copy, send $1.00 for postage and handling to Allied Electronics, 2400 W. Washington Boulevard, Chicago, Illinois 60612.

transistor substitution handbook

The Transistor Substitution Handbook is updated continuously, and a new edition is published annually. This 13th edition has been published in an easy-to-read 8-1/2x11-inch format, and contains over 100,000 transistor substitutions. To guarantee the most accurate possible substitutions, the electrical and physical parameters as described in the manufacturers’ published specifications for each bipolar transistor were fed into a computer; then each transistor was compared with all others. Consequently, transistors which matched within prescribed limits are listed as substitutes.

Section 1 of the handbook contains substitutions for both American and foreign-made transistors which are arranged in numerical and alphabetical order. Types recommended by the manufacturers of general-purpose replacement transistors are included at the end of each list of substitutes. Additional data on these general-purpose replacement types—manufacturer, npn or pnp, germanium or silicon, and the recommended applications—are also reviewed.

The Transistor Substitution Handbook is a valuable source of information for amateurs concerned with transistor replacement in communications industrial, commercial or home-entertainment equipment. 144 pages, softbound. $2.95 from Comtec Books, Greenville, New Hampshire 03048.

Regecy HR-2B gives a lot to talk over

American Made Quality at Import Price

Full 12 Channel, 15 Watts with HI/LO power switch

Here is everything you need, at a price you like, for excellent 2 meter FM performance. The 12 transmit channels have individual trimmer capacitors for optimum workability in point-to-point repeater applications. Operate on 15 watts (minimum) or switch to 1 watt. 0.35 uv sensitivity and 3 watts of audio output make for pleasant, reliable listening. And the compact package is matched by its price. $229.00

Amateur Net

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An FM Model For Every Purpose . . . Every Purse

More Details? CHECK-OFF Page 94

february 1974
10.7 MHz CRYSTAL FILTERS FOR FM
SYNONYMOUS FOR QUALITY AND ADVANCED TECHNOLOGY

MATCHING CRYSTAL DISCRIMINATORS
NBFM XD107-01
WBFM XD107-02
(1-9) $22.10 each

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>XF107-A</th>
<th>XF107-B</th>
<th>XF107-C</th>
<th>XF107-D</th>
<th>XF107-E</th>
<th>XF107-S04</th>
<th>XF102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>NBFM</td>
<td>NBFM</td>
<td>WBFM</td>
<td>WBFM</td>
<td>WBFM</td>
<td>NBFM</td>
<td>NBFM</td>
</tr>
<tr>
<td>Number of Filter Crystals</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>12.0 kHz</td>
<td>15.0 kHz</td>
<td>30.0 kHz</td>
<td>36.0 kHz</td>
<td>40.0 kHz</td>
<td>14.0 kHz</td>
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<tr>
<td>Insertion Loss</td>
<td>3.5 dB</td>
<td>4.5 dB</td>
<td>4.5 dB</td>
<td>4.5 dB</td>
<td>4.5 dB</td>
<td>3 dB</td>
<td>15 dB</td>
</tr>
<tr>
<td>Input-Output</td>
<td>Zt</td>
<td>Ctt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(70 dB)</td>
<td>(90 dB)</td>
<td>(70 dB)</td>
<td>(90 dB)</td>
<td>(70 dB)</td>
<td>(90 dB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>2.8</td>
<td>2.2</td>
<td>2.9</td>
<td>2.7</td>
<td>2.5</td>
<td></td>
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<tr>
<td>Termination</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(70 dB)</td>
<td>(90 dB)</td>
<td>(70 dB)</td>
<td>(90 dB)</td>
<td>(90 dB)</td>
<td>(90 dB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.9</td>
<td>2.0</td>
<td>2.0</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Shape Factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultimate Attenuation</td>
<td>&gt; 90 dB</td>
<td>&gt; 60 dB</td>
<td>&gt; 30 dB</td>
<td>&gt; 30 dB</td>
<td>&gt; 30 dB</td>
<td>&gt; 30 dB</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>1:27/64&quot;</td>
<td>1:3/64&quot;</td>
<td>1:3/64&quot;</td>
<td>1:3/64&quot;</td>
<td>1:3/64&quot;</td>
<td>1:3/64&quot;</td>
<td></td>
</tr>
<tr>
<td>Mounting Hardware Included</td>
<td>can</td>
<td>can</td>
<td>can</td>
<td>can</td>
<td>can</td>
<td>can</td>
<td></td>
</tr>
<tr>
<td>Price (1-9)</td>
<td>$40.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$18.95</td>
<td>$7.95</td>
</tr>
</tbody>
</table>

In order to simplify matching, the input and output of all filters (except XF102) comprise tuned differential transformers with the "common" connections internally connected to the metal case.

Think of it as the best tester in your bag. Only $299

Now you can get a high performance Model 8000A Digital V.O.M. from Fluke, America's foremost maker of quality digital multimeters, especially designed for TV, radio, stereo and audio service. No other digital V.O.M. gives you the resistance range to check breakers and switches, the high resolution voltage to look at emitter base and other transistor voltages, excellent ac accuracy and full accuracy with a 3 second warm-up.

Measures in 26 ranges 100 µV to 1200 V, 0.1 mA to 2A, and 100 mV to 20 mV with a basic dc accuracy of 0.1%. Full year guarantee. Low cost options include rechargeable battery pack, printer output, deluxe test leads, HV, RF & 600-amp ac current probes, carrying case, and rack mount. Unique self zero eliminates offset uncertainty. Electronics securely mounted in high-impact case. Service centers throughout U.S., Canada, Europe and Far East for 48-hour turnaround repair.

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USED TEST EQUIPMENT
All checked and operating unless otherwise noted. FOB Monroe. Money back (less shipping) if not satisfied.

Boonton 190A Q-mtr 20.260 MHz Q5-1200 375
Boonton 202B Sig Gen AM-FM 5-216 MHz 325
Boonton 202E - Later version of above 355
Boonton 260A Q-mtr 0.5-50 MHz Q10-625 375
HP100D-Freq. stand. w/scope-Acc. 1 ppm 85
HP185A Scope 1.5-15 MHz 375
HP330C Dist. gen 15 MHz 325
HP608D (T510A/Ur) sig. gen. 10-420 MHz 450
Nenis Clark 1671 FM rcvr 175-260MHz 125
Polarad MDS-34 Sig. Gen. 4.2-11GHz calib. attn.
AM-FM-Pulse mod. 495
Polarad R dwave rcvr 4.84GHz with plug-in AM, FM, CW, Pulse — less plug-in 225
Polarad TSA Spec. Anal 0.1-44GHz with plug-in AM, FM, CW, Pulse — less plug-in 225
Polarad VA260 Q-mtr (sim. Boonton 260A) 185
Solitron 200A SCR tester-checks anode, gate volts current, leakage and holding 165
Stoddart NM10A (URM-6) RF intns mtr 10-250 kHz, complete with acc. 630
Stoddart NM20A (PRM-1) RF intns mtr 15-25MHz, complete with acc. 655
Stoddart NM52A-RFI mtr. 375-1GHz, w/ acc. 985
Tek RM 15-DC-15MHz GP scope 265
Tek 181 Time mark generator 95
Tek 190A Const. Amp. Sig. Gen. 35-50MHz 125
Tek 531 DC-15MHz scope-takes letter plug-in 175
Tek 565 dual beam 10 MHz scope, less plug-ins 625
SG24/TRM3 Sweep Gen. 15-400 MHz, CW, FM XTL markers, scope-Dev. to 20% 245
TS-403A Sig. Gen. (HP616) 1.8-4GHz 385
URM 7 R-FI mtr (sim. NF-105) 20-400MHz 750

(Send SASE for complete list)

GRAY Electronics
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TOUCH TONE PADS
More features than any other pad including built-in monitor speaker and latest Phase-Lock loop circuitry.
- TTP-1 Standard pad for portable transceiver mounting.
- TTP-2 Standard pad in attractive case for home or mobile use.
- TTP-3 Mini-pad in attractive case for home or mobile use.
- TTP-4 Mini-pad for portable transceiver mounting.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Weight (lb)</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>TTP-1, 2, 3 &amp; 4</td>
<td>Sh. wt. 1 lb.</td>
<td>$44.50</td>
<td></td>
</tr>
<tr>
<td>TTP-1K, 2K, 3K &amp; 4K</td>
<td>Sh. wt. 1 lb.</td>
<td>$34.50</td>
<td></td>
</tr>
</tbody>
</table>

CRICKET 1
A popularly priced IC keyer with more features for your dollar. Cricket 1 is a small size, solid state keyer designed for the beginner as well as the most advanced operator. It provides the user with fatigue-free sending and its clean, crisp CW allows for easy copying at all speeds. Turned on its side, the Cricket can be used as a straight key for manual keying.

<table>
<thead>
<tr>
<th>Model</th>
<th>Weight (lbs)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cricket 1</td>
<td>Sh. wt. 3 lbs.</td>
<td>$49.95</td>
</tr>
</tbody>
</table>

2-METER PREAMP
Specially made for both OLD and NEW receivers. The smallest and most powerful preamp available. Provides 20dB gain at 2.5 N.F. to bring in the weakest signals.

<table>
<thead>
<tr>
<th>Weight (oz)</th>
<th>Kit Price</th>
<th>Wired Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 oz.</td>
<td>$9.50</td>
<td>$12.50</td>
</tr>
</tbody>
</table>

Please include sufficient postage for shipping.

DATA ENGINEERING INC.
Ravenswood Industrial Park, Springfield, Va. 22151
5554 Port Royal Road • 703-321-7171
**WHY FIGHT QRM & QRN?**

Are your CW contacts lost because of QRM or QRN? The NEW DE-101 family of Signal Discriminators is designed to fight QRM and QRN for you without rig modifications. Each discriminator unit consists of two 3 pole operational filter stages for a flat 100 hertz band pass at 1.000 Hz. A buffer amplifier is included for driving earphones, or a 3 watt power amplifier for driving an 8 ohm speaker. No adjustments, factory tuned, plug in installation, one year warranty, and 15 day return privilege.

**DE-101** For earphones only. 115 VAC $29.95 + $2 ship.

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**DE-101C** For earphones only. 12 VDC $19.95 + $1 ship.

**DE-101B** For speaker & headphones. 12 VDC $19.95 + $1 ship.


**SUPER CRYSTAL**

THE NEW DELUXE DIGITAL SYNTHESIZER!! FROM RP

**MFA-22 DUAL VERSION**

Also Available MFA-2 SINGLE VERSION

- Transmit and Receive Operation: All units have both Simplex and Repeater Modes
- Accurate Frequency Control: .0005% accuracy
- Stable Low Drift Outputs: 20 Hz per degree C typical
- Full 2 Meter Band Coverage: 144.00 to 147.99 MHz. in 10KC steps
- Fast Acting Circuit: 0.15 second typical setting time
- Low Impedance (50 ohm) Outputs: Allow long cable runs for mobiles
- Low Spurious Output Level: similar to crystal output

**SEND FOR FREE DETAILS**

RP Electronics

Prices MFA-2 $210.00 BOX 1201H
MFA-22 $275.00 CHAMPAIGN, ILL.
Shipping $3.00 extra 61820

**MINIATURE SUB-AUDIBLE TONE** $14.95

**ENCODER** Wired and Tested

- Compatible with all sub-audible tone systems such as Private Line, Channel Guard, Quiet Channel, etc.
- Glass Epoxy PCB, silicon transistors, and tantalum electrolytics used throughout.
- Any miniature dual coil contactless reed may be used (Motorola TLN6824A, TLN6709-B - Bramo RF-20)
- Powered by 12vdc @ 3ma
- Use on any tone frequency 67Hz to 250Hz
- Miniature in size 2.5 x .75 x 1.5" high
- Complete with Reed $28.45 (Specify Freq.)
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2-METER FM for most Transceivers ea. $3.75
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Frequency Standards
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Any Amateur Band in FT-243 1.50
(Both-meter, $3.00 - 150-meter not avail.) 4 for 5.00
For 1st class mail, add 20c per crystal. For Airmail, add 25c. Send check or money order. No dealers, please.

Division of Bob Whan & Son Electronics, Inc. 2400 Crystal Drive Ft. Myers, Florida 33901
All Phones (813) 936-2397

Send 10c for new catalog with 12 oscillator circuits and lists of frequencies in stock.

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YOU CAN AFFORD!

TOP QUALITY RTTY... WITH THE HAL MAINLINE ST-6 TU. Only 7 HAL circuit boards (drilled GI0 glass) for all features, plug-in IC sockets, and custom Thordarson transformer for both supplies, 115/230 V, 50-60 Hz. Kit without cabinet, only $135.00; screened, punched cabinet with pre-drilled connector rails, $35.00; boards and complete manual, $19.50; wired and tested units, only $290.00 (with AK-1, $320.00).*

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ID-1 Repeater Identifier (wired circuit board) ... $75.00*
ID-1 (completely assembled in 1½" rack cabinet) ... $115.00*
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W3FFG SSTV Converter Kit ... $55.00*
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Mainline AK-1 AFSK Kit ... $27.50*

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Box 365 L, Urbana, Ill. 61801 • 217-359-7373

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HAL provides a complete line of components, semi-conductors, and IC's to fill practically any construction need. Send 24¢ to cover postage for catalog with info and photos on all HAL products.

More Details? CHECK-OFF Page 94
THE MOST COMPLETE
2 METER REPEATER AVAILABLE...

THE MOST COMPLETE
2 METER REPEATER AVAILABLE...

DYCOMM
ECHO III

- INCLUDES EVERYTHING
- NEEDED
- BUT THE ANTENNA
- AND DUPLEXER
- DESIGNED
TO COMPLY
WITH NEW FCC
REQUIREMENTS
- ASK FOR FLYER SHEET

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(305) 844-1323

MODEL "A" Frequency Counter  Price $299.00
10Hz to 80 MHz (± 1Hz) Direct Count guaranteed (1Hz to over 100MHz) typical
Read Out: 5 LED digits + LED Over Range
Sensitivity: Less than 100 millivolts over entire range.
Power Req.: Either 120 VAC or 12 VDC 15 watts approx.
Small Size: 2.34" x 5.68" x 8.18"
Overload protected input and DC power input.
MODEL "AS" Frequency Counter  Price $375.00
Exactly as above plus an internal 250MHz Scaler (±10Hz to well over the guaranteed
frequency of 250 MHz) No external power is required.
Shifting DECIMAL POINT gives a DIRECT READOUT of VHF Frequencies.
One BNC INPUT for both ranges. No cable changing from HF to VHF.
(CA residents add State Sales Tax)
Dealer inquiries invited

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VISTA, CA. 92083
714-726-1313

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- PROPAGATION
- CONTESTS
- DX

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(or more when things get busy)

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when it happens. not
weeks later

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hr REPORT
GREENVILLE, NH 03048

More Details? CHECK-OFF Page 94
LITRONIX-OPCOA-MAN "7-SEGMENT" LED Readouts

All fit 14-pin IC sockets. All 7-segments. MAN Series "all LED" and made by well-known West Coast manufacturer. Measures 7-segment display. The 7-segment display allows you to see a segment. MAN's are BIG! All readouts 0-99-999, plus letters and decimal points. Output currents range from 20-100 mA on MAN-1, MAN-4. All 5V TTL compatible.

<table>
<thead>
<tr>
<th>LED CHARACTERISTICS</th>
<th>TYPE</th>
<th>COLOR</th>
<th>DECIMAL</th>
<th>DRIVER</th>
<th>SPECIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 MAN-1 equal</td>
<td>27</td>
<td>Red</td>
<td>Yes</td>
<td>20</td>
<td>$7.447</td>
</tr>
<tr>
<td>7 MAN-1 equal*</td>
<td>27</td>
<td>Red</td>
<td>Yes*</td>
<td>20</td>
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<tr>
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<td>115</td>
<td>Red</td>
<td>Yes</td>
<td>10</td>
<td>$7.448</td>
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<td>Red</td>
<td>Yes*</td>
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<td>Red</td>
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<td>190</td>
<td>Red</td>
<td>Yes***</td>
<td>15</td>
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*Reflex Lite Bar* (Segment LED Readouts)

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<th>LED CHARACTERISTICS</th>
<th>TYPE</th>
<th>COLOR</th>
<th>DECIMAL</th>
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<tr>
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<td>Red</td>
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<td>Red</td>
<td>Yes***</td>
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<td>190</td>
<td>Red</td>
<td>Yes***</td>
<td>15</td>
<td>$7.448</td>
</tr>
</tbody>
</table>

Same as our famous USA $10.95 10-po. '70's GA model, but those who wish to design and build their own equipment to control individual or industrial uses. Includes plunger switch with diagram and instructions. Contacts open and closed by gold-finished silver alloy. Rated 250V ac, 15A. 12VDC 2A. 110VAC 2A. Center pin for mounting. Can be made equal to any 110 or 220VAC type. 0.75". 1/16". 0.472". 0.540".

National Equations on "Digital Clock on a Chip"

<table>
<thead>
<tr>
<th>Mfrs</th>
<th>Description</th>
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<td>5311</td>
<td>28-pin, ceramic, any readout</td>
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<td>5312</td>
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<td>28-pin, ceramic, any readout</td>
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<td></td>
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<tr>
<td>5314</td>
<td>24-pin, plastic, any readout</td>
<td>84.88</td>
<td></td>
</tr>
<tr>
<td>5315</td>
<td>24-pin, plastic, any readout</td>
<td>84.88</td>
<td></td>
</tr>
<tr>
<td>5316</td>
<td>40-pin, any readout</td>
<td>$14.95</td>
<td></td>
</tr>
</tbody>
</table>

Code: A=Hold Count, C=1 PPS Output, B=Outlet Stroke, D=BCD

- 1-MMS83B, DIGITAL ALARM CLOCK FACTORY FALLOUT 49 EACH $9.99

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More Details? CHECK-OFF Page 94
Your assurance of Performance and Quality

FTdx401-B Transceiver

More For Your Money

<table>
<thead>
<tr>
<th>FTdx401</th>
<th>$599.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-in AC Power Supply</td>
<td>No charge</td>
</tr>
<tr>
<td>Built-in WWV 10 MHz Band</td>
<td>No charge</td>
</tr>
<tr>
<td>Built-in Noise Blanker</td>
<td>No charge</td>
</tr>
<tr>
<td>25 and 100 KHz Calibrators</td>
<td>No charge</td>
</tr>
<tr>
<td>VOX</td>
<td>No charge</td>
</tr>
<tr>
<td>Clarifier</td>
<td>No charge</td>
</tr>
<tr>
<td>Break-in CW with Sidetone 1 KHz Readout</td>
<td>No charge</td>
</tr>
<tr>
<td>Selectable SSB</td>
<td>No charge</td>
</tr>
<tr>
<td>6 Month Warranty by Dealer</td>
<td>No charge</td>
</tr>
<tr>
<td>Cooling Fan</td>
<td>No charge</td>
</tr>
<tr>
<td>AM Position</td>
<td>No charge</td>
</tr>
</tbody>
</table>

Total only $599.00
Amateur Price Net
Price Subject To Change

Tomorrow's Transceiver Today: 20 tubes plus 50 silicon semiconductors, passive crystal filter (6 pole), velvet smooth tuning, superb noise blanker, standard electrical parts. This is truly the best buy in the amateur field today. See your local dealer for brochure & demonstration.

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231 Commonwealth Avenue, Orlando, Florida 32803

Electronic Exchange Co.       508 834 0000
608 Papworth, Metairie, Louisiana 70005

Freck Radio Supply            704 254 9551
38 Biltmore Avenue, Asheville, North Carolina 28807

Graham Electronics            317 634 0486
133 S. Pennsylvania St., Indianapolis, Indiana 46204

Ham Radio Center             314 983 0060
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Ham Radio Outlet             415 342 5757
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Hamtronics                   215 357 1409
4033 Brownsville Rd., Trevose, Pennsylvania 19047

Harrison Radio               516 293 7990
20 Smith Street, Farmingdale, L.I., New York 11735

Henry Radio                  213 272 8661
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Juge Electronics            817 926 5221
3650 S. Freeway, Fort Worth, Texas 76110

Queen City Electronics, Inc. 513 931 1577
1583 McMullen Ave., Cincinnati, Ohio 45231

Racom Electronics            206 255 6656
15951 E. 128th St., Renton, Washington 98055

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Wilson Electronics           702 451 6650
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City ______ State ______ Zip ______

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- **2N3799** 60 150 NPN-S .75
- **2N5301** 40 200 NPN-S 1.25
- **2N5301** 40 200 NPN-S 1.00

*Removed from used equipment*

**TRANSFORMERS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>BRAND NEW, 115 volt AC input, OP AMP</td>
<td>$3.50</td>
</tr>
<tr>
<td>XFMN, out puts: 16VCT 1/2 amp, 17 VCT 1/4 amp.</td>
<td></td>
</tr>
</tbody>
</table>

**FILAMENT or BTRY CHARGER XFMN**

- Output of 18 volts at 4.5 amp $3.50

**CALCULATOR KEYBOARD**

Brand new keyboards for hand held calculators. Two styles available. One for use with calculator chip CALTEX 5001-5002-5012 or MOSTEK 5010-5012. Another for use with Gen. Inst. chip OS00. Priced at $8.00 each or two for $15.00.

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With schematic for GIANT clock.

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More Details? CHECK-OFF Page 94

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  2. Eight digit resolution by range selection
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BUILDING STUFF — ALL NEW FACTORY FRESH PARTS

<table>
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<th>RF POWER TRANSISTORS</th>
<th>Typ</th>
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<th>Freq</th>
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<td>400MHZ</td>
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<td>175MHZ</td>
<td>16.50</td>
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80 february 1974

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This calculator set provides all of the electronics for an 8-digit, floating point calculator with left-hand entry. Keyboard, display, clock generator, and display driver is included. It needs to be added to make a calculator that will add, subtract, multiply and divide. Complete instructions are also provided. Complete instructions to build a calculator include:

CT5005 CALCULATOR
This calculator chip has a full four-function memory, which is controlled by Left Key, Shifl, and Mem. Mem (memory enter or clear function) entry, -M (subtracts entry from memory), CM (clear memory). There is a clear memory, which will clear all registers, CM (clear memory or use as entry).

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Fixed decimal at 0, 1, 2, 3, 4, or 5
Leading zero suppression
7-segment multiplex output
True credit display sign
Single 28-pin chip
CHIP AND DATA....ONLY $9.95
DATA ONLY (Refundable)....1.00

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40-Pin calculator chip will add, subtract, multiply, and divide. 12-digit display and calculate. Chains calculations. True credit balance sign output. Automatic over-flow indication. Fixed decimal point at 1, 2, 3, or 4. Leading zero suppression. Complete data supplied with chip.
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CD-2 Counter Kit
This kit provides a highly sophisticated display drive module for clocks, counters, and other numerical displays. The kit is 8.6x4.3/8 wide. A single 5-volt power source powers just one digit of the display tube. It can attain typical count rates of up to 30 MHz and also has a lamp test, causing all 7 segments to light, This kit includes a 2-sided (plated through holes) fiberglass printed circuit board, 7490, 7474, and a 10 OR 20 RCA Numericum display tube, complete instructions, and enough 10x10 pins for the ICs. NOTE: boards can be supplied in a single panel up to 10 digits (with all decoders and drivers included). When ordering, please specify which you want in single panels or in one multiple digit board. Not specifying will result in manufacturing delays.
COMPLETE KIT.
ONLY $1.95
FULLY-ASSEMBLED
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NE556 phase lock loop............ $1.25
NE561 phase lock loop 70-5........ $1.25
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NE567 tone decoder................. 4.00
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NE560 voltage comparator........ $1.75
NE561 dual comparator............ $0.50
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NE702 op amp TO-5................. $1.00
NE810 dual op amp................ $1.00
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V5667 2A 600V........ 1.10
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Special 811: Hex Inverter
This kit provides a highly sophisticated driver IC for use with any 7400 series logic. It uses 7400 chips, which are new and fully-tested; ICs are brand new and are branded by signetics and marked "811."

MAN 3M
Right-hand decimal point. Right-hand type case. Ideal for pocket calculators! 30/6 DECIMAL! 1.50

MAN4 Seven-segment, 0-9 plus letters. Right-hand decimal point. Snap in 16-pin DIP socket or Molex. IC voltage requirements. Ideal for desk or pocket calculators!

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SPECIAL 874
256-BIT RANDOM ACCESS MEMORY
Title: five-pole fully-decoded 256 x 1 bit:

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3. Single memory expansion thru 3-chip select lines

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74118 .75
74119 .75
74120 .75
74121 .75
74122 .75
74123 .75
74124 .75
74125 .75
74126 .75
74127 .75
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Babylon Electronics

More Details? CHECK—OFF Page 94
1000 PIV AT 2.5 AMP DIODES. New Motorola HEF-170. 10 for $2.50, 100 and up 20¢ each, postpaid. K. E. Electronics, Box 1279, Tustin, California 92680.

THE ANNUAL CUYAHOGA FALLS RADIO CLUB AUCTION to be held Friday, February 22nd at the United Electronics Institute Building, 1225 Orlan Ave., Cuyahoga Falls, Ohio. Hours are 7 p.m. to 11 p.m. More details are available from WABZGL Tom Carroll, Box 106, Cuyahoga Falls, Ohio 44222.

RTTY Baudot LOOP to ASCII CONVERTER accepts loop signal at any RTTY speed and delivers corresponding 6 or 8 level parallel ASCII, all on one 4 x 6 inch card. Information: Pet Logic Systems, Box 51, Oak Harbor, Ohio 43442.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

TRAVEL-PAK QSL KIT Converts photos, post cards to QSLs! Send call and 25¢ for personal sample. Samco, Box 203H, Wynantskill, N. Y. 12198.

BUY—SELL—TRADE. Write for monthly mailer. Give name, address, call letters. Complete stock of major brands new and reconditioned equipment. Call us for best deals. We buy Collins, Drake, Swan, etc., SSB & FM. Associated Radio, 8012 Conser, Overland Park, Kansas 66204, 913-381-5901.

FINE DX LOCATION, outstanding NW Chicago suburb (343 countries with 2-element yagi and honest key). 4 acres for $60,000. 2½ story modern kitchen, full basement with fireplace. City park with tennis, swimming, skating and picnic area at end of street; 2½ mile to grammar school and junior high. Contact W9UVV/1, Ham Radio Magazine, Greenville, N. H. 03048 (603) 876-1441.

B.A.R.T.G. SPRING RTTY CONTEST: 0200 GMT, March 23rd to 0200 GMT, March 29, 1974. 40 countries. Not more than 36 hours of operation is permitted. Listening counts as operating time. Off periods may not be less than 2 hours at a time. Times on and off are to be recorded. Multiple contacts are allowed on the same transmission. Log and score sheets. Also open to short wave listeners. 3.5, 7.0, 14, 21 and 28 MHz Bands. Stations may only be contacted once on any band, but additional contacts may be made on other bands. Use ARRRL countries list, except KL7, KH6 and VO are separate countries. Message exchange will consist of: Time GMT, message number and RST. All two-way RTTY contacts with one's country earn TWO points. All two-way RTTY contacts outside one's country earn TEN points. All stations receive a bonus of 200 points for each country worked including their own. Any country may be counted again if worked on a different band and contact confirmed. SCORING: Two way exchange points times total countries worked, plus total country points times number of contacts worked. Use one log for each band and indicate any rest periods. Include date, time GMT, message and RST numbers sent and received, and any exchange points claimed. Logs must be received by May 31, 1974 to qualify. Send your contest logs to: Ted Double, G8CDW, 89 Linden Gardens, Enfield, Middleton, England. ENI 4DX.

PLAY arctan(X), tan(X), sin(X), cos(X), arccos(X), arctan(X), log(X), logarithms, exponentials, and more! Quickly, accurately, Easily! Send today for the Improved and Ex- tended Edition of the first and best calculator manual — now in use throughout the world . . . only $2.00 postpaid! Be sure to try this manual if you haven't already. Absolutely Unconditional Money-back Guarantee — and Fast service! Mallman Optics and Electronics, Dept-G, 836 South 113, West Allis, Wisconsin 53214.

DAYTON HAMVENTION expands to three days April 26, 27, 28, 1974 at HARA Arena and Exhibition Hall, Fairfield. Admission for information if you have not attended the last two years. P. O. Box 44, Dayton, Ohio 45401.


FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada. M1S 3B4.

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PA107J 5 - 12 12 7.0 54.89
PA1011R 5 - 11 11 10.0 74.95
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- VHF power transistors by CTC-Varian
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RESISTORS: Carbon composition brand new. All standard values stocked. 1/2W 10% 40/$1.00; 1/4W 10% 30/$1.00 — 10 resistors per value, please. Minimum order $5.00. 15W RMS 1C Audio Amplifier — Panasonic. Frequency response 20Hz-100 kHz. 1/2% distortion. Price $6.95 Postpaid. Pace Electronic Products, Box 161-H, Ontario Center, New York 14520.

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FREE: 18 crystals of your choice with the purchase of a new Genevac GTX-200 at $259.95. Send cashier’s check or money order for same-day shipment. For equalizer, what you buy by us, Its. government, D. Clegg, Regency, Hallicrafters Tempo, Kenwood, Midland, Ten-Tec, Galaxy, Hy-Gain, CushCraft, Mosley, Sony, and Hustler, write to Hoosier Electronics, your ham headquarters in heart of the Midwest. Become one of our many happy and satisfied customers. Write or call today for your low prices and individual service. Hoosier Electronics, R. R. 25, Box 403, Terre Haute, Indiana 47802. (812) 894-2397.

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More Details? CHECK-OFF Page 94

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More Details? CHECK-OFF Page 94
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These are fully assembled and tested boards only, you add your own cabinet, etc. Write for details.

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We will do most any printed circuit board for individuals or prototypes. If required we will also do the layout of the boards. All our boards are G-10 glass-epoxy solder plated and come drilled only. At present time we can do only single boards. All component parts used in our kits are new manufacturers stock. We Do Not Use Any Used or Surplus Parts. All inquiries are answered promptly.

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There has never been an amateur linear amplifier like the new 2K-ULTRA. Small and lightweight, yet rugged and reliable... all that the name implies. The ULTRA loafs along at full legal power without even the sound of a blower. Its anode heat is silently and efficiently conducted to a heat sink through the use of a pair of Eimac 8873 tubes. In fact, all of its components are the very best obtainable.

TEMPO/2001
Small but powerful, reliable but inexpensive, this amplifier is another top value from Henry Radio. Using two 8874 grounded grid triodes from Eimac, the Tempo 2001 offers a full kilowatt of output for SSB operation in an unbelievably compact package (total volume is .8 cu. ft). The 2001 has a built-in solid state power supply, a built-in antenna relay, and built-in quality to match much more expensive amplifiers. This equipment is totally compatible with the Tempo One as well as most other amateur transceivers. Completely wired and ready for operation, the 2001 includes an internal blower, a relative RF power indicator, and full amateur band coverage from 80-10 meters.

TEMPO/6N2
The Tempo 6N2 joins the Henry Family of fine HF amplifiers, bringing the same high standards of performance and reliability to the 6 meter and 2 meter bands. Using a pair of advanced design Eimac 8874 tubes, it provides 2,000 watts PEP input on SSB or 1,000 watts input on FM or CW. The 6N2 is complete in one compact cabinet with a self-contained solid state power supply, built-in blower and RF relative power indicator. Price... $695.00

3K-A COMMERCIAL/MILITARY AMPLIFIER
A high quality linear amplifier designed for commercial and military uses. The 3K-A employs two rugged Eimac 3-500Z grounded grid triodes for superior linearity and provides a conservative three kilowatts PEP input on SSB with efficiencies in the range of 60%. This results in PEP output in excess of 2000 watts. In addition, the 3K-A provides a heavy duty power supply capable of furnishing 2000 watts of continuous duty input for either RTTY or CW with 1200 watts output.

Prices subject to change without notice.
Simplify UHF circuits with EIMAC's 8938 high mu triode.

All the advantages of grounded-grid, high-mu triodes become even more important when you're designing at UHF. And now EIMAC introduces a coaxial-base, focused-beam, high-mu triode especially designed for kilowatt-level UHF applications.

At UHF, cavities are small and closely coupled to the tube. There's no room for bulky bypass capacitors, rf chokes, or feedthrough capacitors. With the 8938 in cathode-driven (grounded-grid) service, there's no need for the grid circuit bypass capacitor; and no need for screen capacitors, bias or screen power supplies and associated decoupling circuitry. The internal tube structure is simple and the surrounding circuitry is much less complicated.

The rugged, ceramic/metal 8938 is the latest addition to EIMAC's 8877 family of tubes. Because of the beam focusing action of a series of strip electron guns in the cathode-grid region, the 8938 produces very high mu with exceptionally low grid interception. This results in high power gain with no sacrifice of low intermodulation characteristics in cathode-driven Class AB2 amplifier service.

It's one more example of EIMAC's ability to provide tomorrow's tube today. For details, contact EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070, (415) 592-1221. Or any of the more than 30 Varian/EIMAC Electron Tube and Device Group Sales Offices throughout the world.