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# ham radio

magazine

## SEPTEMBER 1977


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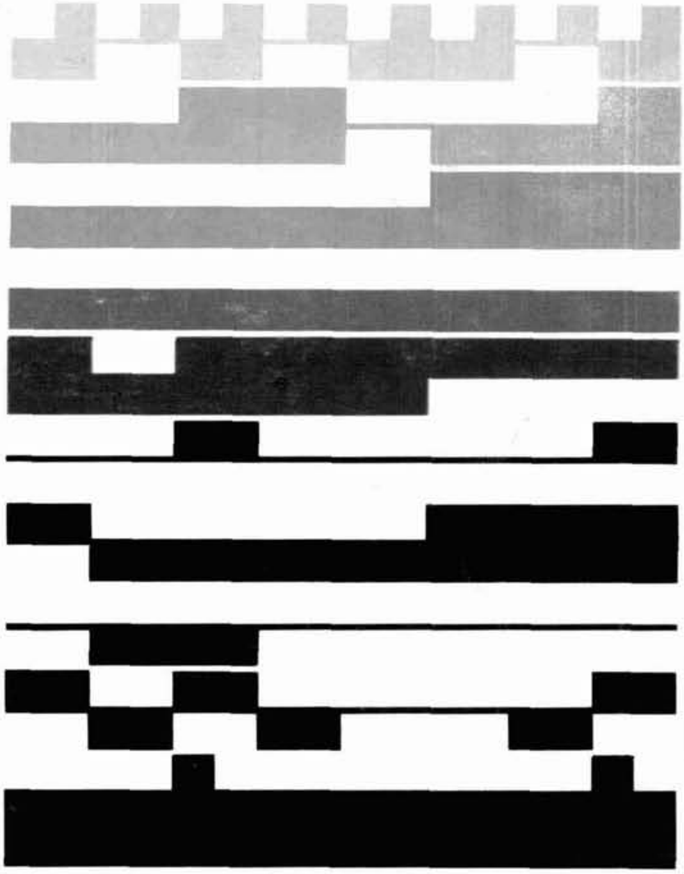

interlaced
sync generator
for ATV camera control

# Drake Accessories

*designed for convenience and accuracy*

## Drake Directional RF Wattmeters

**W-4** 1.8-54 MHz

**WV-4** 20-200 MHz

Drake directional, through line wattmeters, using printed circuits, toroids, and state of the art techniques, permit versatile performance and unsurpassed accuracy, yet at a lower cost.

In contrast to VSWR measuring devices of the past, Drake wattmeters are frequency insensitive throughout their specified range, requiring no adjustments for power or VSWR measurements.

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High accuracy; ideal as laboratory instruments.

Removable coupler allows remote metering.

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|---|---|---|
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| **Line Impedance** | 50 ohm resistive | 50 ohm resistive |
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| **Jacks, Removable Coupler** | Two S0239 input and output connectors | Type N input and output connectors. |
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## Drake RCS-4
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- **Grounds All Antennas in Gnd Position for Lightning Protection**
- **Front Panel Indicator Monitors Antenna Selection Interval**
- **Protected Against Adverse Weather Conditions**
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- **Handles 2000 Watts PEP**
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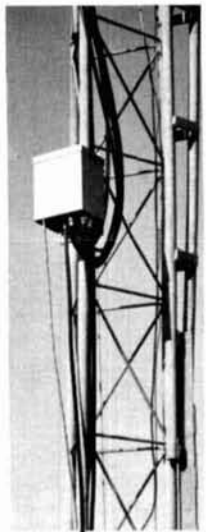

• Control unit works on 110/220 V-ac, 50/60 Hz, and supplies necessary voltage to motor. • Excellent for single coax feed to multiband quads or arrays of monobanders. The five positions allow a single coax feed to three beams and two dipoles, or other similar combinations. • Control cable (not supplied) same as for HAM-M rotator. • Selects antennas remotely, grounds all unused antennas. Gnd position grounds all antennas when leaving station. "Rain-Hat" construction shields motor and switches. • Up to 30 MHz, insertion of switch changes VSWR no more than 1.05:1. • From 30 MHz to 150 MHz, insertion changes VSWR no more than 1.5:1. • Motor: 24 V-ac, 2 amp. Lubrication good to −40°F. • Switch Rf Capability: Maximum legal limit.

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More Details? CHECK—OFF Page 142

# This NEW MFJ Super Antenna Tuner . . .

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# ham radio magazine

**SEPTEMBER 1977**

**volume 10, number 9**



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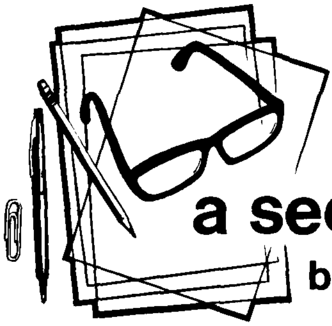

# a second look

by Jim Fisk

**At a recent meeting with FCC staffers** in Washington, it wasn't surprising that the two items which received the most attention were type acceptance and the proposed linear amplifier ban. Both were brought on by the illegal use of amateur equipment by CBers, and it was generally agreed that neither type acceptance nor an outright ban on linear amplifiers would cure the basic problem — that can be solved only by preventing amateur equipment from getting into the hands of unlicensed operators.

The proposal by the San Antonio Repeater Organization (SARO) that would require presentation of a valid amateur license at the point of sale before amateur equipment could be purchased (*Second Look*, June) is one possible answer to the problem which has been widely endorsed by the amateur equipment manufacturers. Unfortunately, members of the FCC legal staff don't feel the FCC has the authority to impose such a regulation under their present charter. The Communications Act is presently being overhauled by Congress, however, and it is suggested that amateurs write to their Congressmen, asking that authority for point-of-sale control be given to the FCC.

The recently formed Amateur Radio Manufacturers Association (ARMA) has endorsed the basic SARO proposal, as have Dentron, Drake, Heath, Kenwood, and most other large manufacturers. Only one major amateur equipment manufacturer has refused to endorse point-of-sale control, and it's widely reported that their transceiver sales to CBers are greater than those to the legitimate amateur market! Many of the amateur manufacturers and dealers have also agreed to follow ARMA's guidelines for point-of-sale control, but a voluntary program is not likely to be very successful; if a CBer is unable to buy the amateur equipment he wants from his local dealer, both Sears and Wards list amateur equipment in their catalogs, and neither, apparently, has any inclination to require the purchaser to produce a valid amateur license. So while the flow of amateur equipment into CB hands can be slowed down, without the necessary rule making by the FCC, it can't be completely stopped.

As further proof that the ban on 24- to 35-MHz linear amplifiers is unworkable, at least one resourceful manufacturer is now selling "amateur" six-meter linears — the user simply has to remove a jumper across the tuning coil to put the unit on 27 MHz!

Here at *ham radio* we have been occasionally faced with the problem of deciding what is, and what obviously is not, a valid amateur product. More than one manufacturer of an "amateur'" linear has tried to legitimize his product by advertising the unit in an amateur magazine. Since we had no published guidelines on the subject, in at least one case we were forced, under threat of legal action, to accept advertising for a product which we felt had no place in *ham radio*. Therefore, we have advised all equipment manufacturers that advertising for external rf power amplifiers designed for use on frequencies below 60 MHz, other than those operating class C, must meet the following requirements:

1. Amplifiers must meet all applicable FCC requirements for operating in the Amateur Radio Service.
2. Amplifiers shall be capable of operating with at least 50 watts rms rf input drive power without exceeding FCC specifications for spurious and harmonic output.
3. Amplifiers shall be bandswitching and shall have no 11-meter (27 MHz) bandswitch position.
4. Amplifiers shall require the use of an *external* ON-OFF keying line for transfer from the standby to operate modes of operation.

These standards have been designed to reflect the requirements and practices currently in use in the Amateur Radio Service. As the state of the art advances, it may be necessary to revise these requirements, but there will be no special exceptions or case-by-case dispensations. This policy becomes effective with the October, 1977, issue of *ham radio*.

There is probably no way to completely cut off the flow of amateur equipment into the CB marketplace, but if it can be reduced to a trickle, perhaps amateurs won't be saddled with regulations which would virtually eliminate commercial linears that operate on the amateur 10-meter band.

**James Fisk, W1HR**
**editor-in-chief**

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FM ± 16 KHz or less at −60db
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FM 0.4 uv for 20db Q.S.

**Power Supply:** Internal, 117V AC or 13.8V DC
**Power Output:** 10W PEP (SSB), 10W (CW, FM)
**Size:** 111mm H x 241mm W x 264mm D
**Weight:** 6.8 kg

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# presstop

COMMUNICATOR LICENSE WAS KNOCKED DOWN but not entirely out by the FCC in late July. As proposed, the Communicator privileges would have been phone only on 220-225 and 420-450 MHz, reserving 435-438 for satellite communications. The Communicator would become the entry level license, with element 2 (the present Novice written exam) re-oriented to include phone, and Field Office administered. To upgrade to Novice, a Communicator would pass a volunteer-administered CW exam.

The Commissioners' Final Vote was unanimous against funding the Communicator in next year's budget. Their rejection was tempered, however, by a recommendation that the concept be recoordinated with the objectors and then resubmitted at a later date. Rejection at this time pretty well pushes the time-table for the Communicator back another year, until early 1980.

FCC-HOSTED "MEDIA WORKSHOP" in Washington July 13th provided an FCC/Amateur rap session that was rated "simply outstanding" by the 50 or so who attended. The well-filled and well-organized program lasted from 9:00 AM until almost 5:00, with lunch and a short break to see the Commissioners at work on several Amateur agenda items (they okayed "AAx2" callsigns for the Extra Class callsign program) the only pauses. As an open, public meeting the limits placed on Amateur-FCC dialogue by the Home Box Office rule did not apply. Personal Radio Division Chief John Johnston chaired the session smoothly but flexibly, with give-and-take rather than formal type presentations the format. Only limitations were that we were not to "advise" or "recommend" — only "discuss" and "provide information."

ARRL'S BOARD MEETING in Hartford July 21-22 covered a mixed bag of topics, old and new, recording some very significant accomplishments. One of the more important decisions was to have the League become more active on the Washington scene, with a Newington staffer to spend full time on ARRL Washington activities; the League President, Vice President, General Manager, and General Council designated to represent the ARRL at forthcoming Congressional hearings that concern Amateur Radio; and the taking of necessary steps to ensure that the League complies with Lobbying regulations while maintaining an effective voice in Washington.

RUSSIAN AMATEUR SATELLITE'S FREQUENCIES have just been officially filed by the Russians with the International Frequency Registration Board, further confirming the impending launch of a Soviet Amateur spacecraft. Called the "USSR Amateur System 'RS" in the IFRB filing, the spacecraft is to have a 950 km (590 mile) high gear circular, 102 minute orbit with 82° inclination, with a 145.8-145.9 MHz in, 29.3-29.4 MHz out, 1.5 watt peak output transponder. Three to four satellites in all are proposed, to be launched in 1977-1978.

AMSAT's AO-D Launch is now firming up for February 23 and is planned to put the satellite into 102.8 minute orbit with an apogee of 935.4 km (577.38 miles) and a perigee of 888.8 km (548.665 miles).

AMATEUR LICENSE FORMS have arrived at Gettysburg to break up an almost six-week logjam in Amateur license distribution. An expedited preliminary shipment of 50,000 forms showed up in early August, and FCC personnel were hopeful they'd have the oldest of the backlogged licenses printed and in the mail within a week.

TWO-METER SIGNALS CROSSED THE ATLANTIC the end of June when PY2OB in Sao Paulo, Brazil heard TU2EF in the Ivory Coast on 145.2-MHz CW! A two-way contact didn't result at the time, but a series of followup attempts were under way by TU2EF and TU2GA with PY2OB and other Brazilian VHF buffs on the other end of the 3496-mile (5665km) circuit.

On Six Meters, long haul has also been prevalent with a contact between WB2RLK/VE1 and KH6HI, and a number of U.S. stations working into northern South America. The 50-MHz beacon on Gibraltar is supposed to be back on the air shortly, supplementing France's FX3VHF on 50.1 MHz while South Africa has another form of six-meter beacon with a new channel 1 TV station.

HAM RADIO/HAM RADIO HORIZONS Assistant Advertising Manager, Cindy Schlosser, left Greenville August 12th to become Advertising Manager for Solar Age, a trade magazine. A nice upward move for Cindy, who'll be missed in Amateur circles.

DenTron amateur radio products have always been strikingly individual. This is the result, not of compulsion to be different, but of a dedication to excellence in American craftsmanship. This dedication now extends to one of the worlds finest high performance Military amateur amplifiers.

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Compare the MLA-2500. It has the lowest profile of any high performance amplifier in the world. It's modular construction makes it unique, and at $799.50 it is an unprecedented value.

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Complete SB-104A SPECIFICATIONS

Frequency Coverage: 3.5 MHz through 29.7 MHz amateur bands, 15 MHz WWV receive only. Frequency Stability: Less than 100 Hz/hr drift after 30-min. warmup; less than 100 Hz drift for ±10% change in primary voltage. Readout Accuracy: Within ±200 Hz ±1 count. Dial Backlash: 50 Hz max. Phone Patch Impedance: 4 ohm output to speaker; high impedance to transmitter. TRANSMITTER — RF Power Output: High Power: (50-ohm non-reactive load). SSB: 100 watts PEP ±1 dB; CW: 100 watts ±1 dB. Low Power SSB: 1 watt PEP (minimum); CW: 1 watt (min.). Output Impedance: 50 ohms, less than 2:1 SWR. Carrier Suppression and Unwanted Sideband Suppression: −50 dB down from 100 watt single-tone output at 1000 Hz reference. Harmonic Radiation: 40 dB below 100 watt output. Spurious Radiation: −40 dB within ±4 MHz of carrier; −60 dB farther than ±4 MHz. Microphone Input: High impedance, −45 to −55 dB; approx. 22k ohms. RECEIVER — Sensitivity: 0.5 μV for 10 dB S+N/N for SSB. Selectivity: 2.1 kHz minimum at −6 dB, 5 kHz max. at −60 dB. (2:1 nominal shape factor). CW Selectivity: (with accessory CW filter) 400 Hz at −6 dB, 2 kHz max. at −60 dB. Audio Output: 2.5 watts into 4 ohms, 1.25 watts into 8 ohms, less than 10% THD. 4-8 ohm headphones. AGC: Less than 1 millisecond attack time; switch selectable 100 msec and 1 sec. release, and OFF. IM Distortion: −65 dB min.; −57 dB typ. with noise blanker. Image Rejection: −60 dB min. Dimensions: 5¾" H x 14¹⁵⁄₃₂" W x 13⅞" D.

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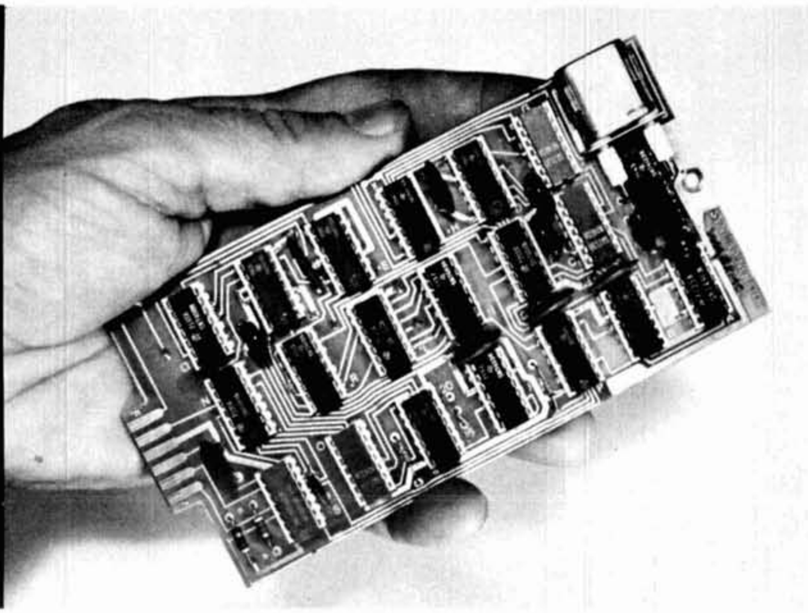

# interlaced sync generator

## for ATV camera control

Complete, interlaced camera control is provided by this digital sync generator

**Over the last few years** a number of fast-scan television sync generators have been described, some simple and others complex. In general, most of these designs were either too costly or they required expensive test equipment to accurately adjust pulse widths and timing. Recently though, a number of manufacturers have developed single IC sync generators. However, both the cost of the IC and the amount of additional logic required makes that approach rather expensive. (Although it does eliminate the need for external setup adjustments). This sync generator provides all of the control signals that are required to run a broadcast-quality television camera, yet it is inexpensive and requires no adjustments to provide accurate pulse timing.

I believe the sync generator to be described here eliminates both high cost and external setup drawbacks by providing the following features:

**1**. Readily available TTL ICs are used throughout, providing easy access to parts.

**2**. All components are inexpensive.

**3**. No timing or alignment adjustments are required.

**4**. Low power requirements simplify power supply design, +5 volts at 350 mA.

**5**. A free-running oscillator can be used for those designs not needing extreme frequency stability.

**6**. Compact size. The entire circuit (exclusive of the power supply) can be built on one 3 x 6 inch (7.6 x 15.2cm) circuit board.

This sync generator has a number of very practical

**By Arthur Towslee, WA8RMC**, 180 Fairdale Avenue, Westerville, Ohio 43081

uses considering its cost and overall size. My primary purpose is for ATV interlaced camera control. A future article will describe full construction details of the RMC (**R**eliable **M**ini **C**amera). Other applications include main timing for an accurate bar-dot generator for TV alignment or the master control for TV character generators.

## general description

A block diagram of the unit is shown in **fig. 1**. All

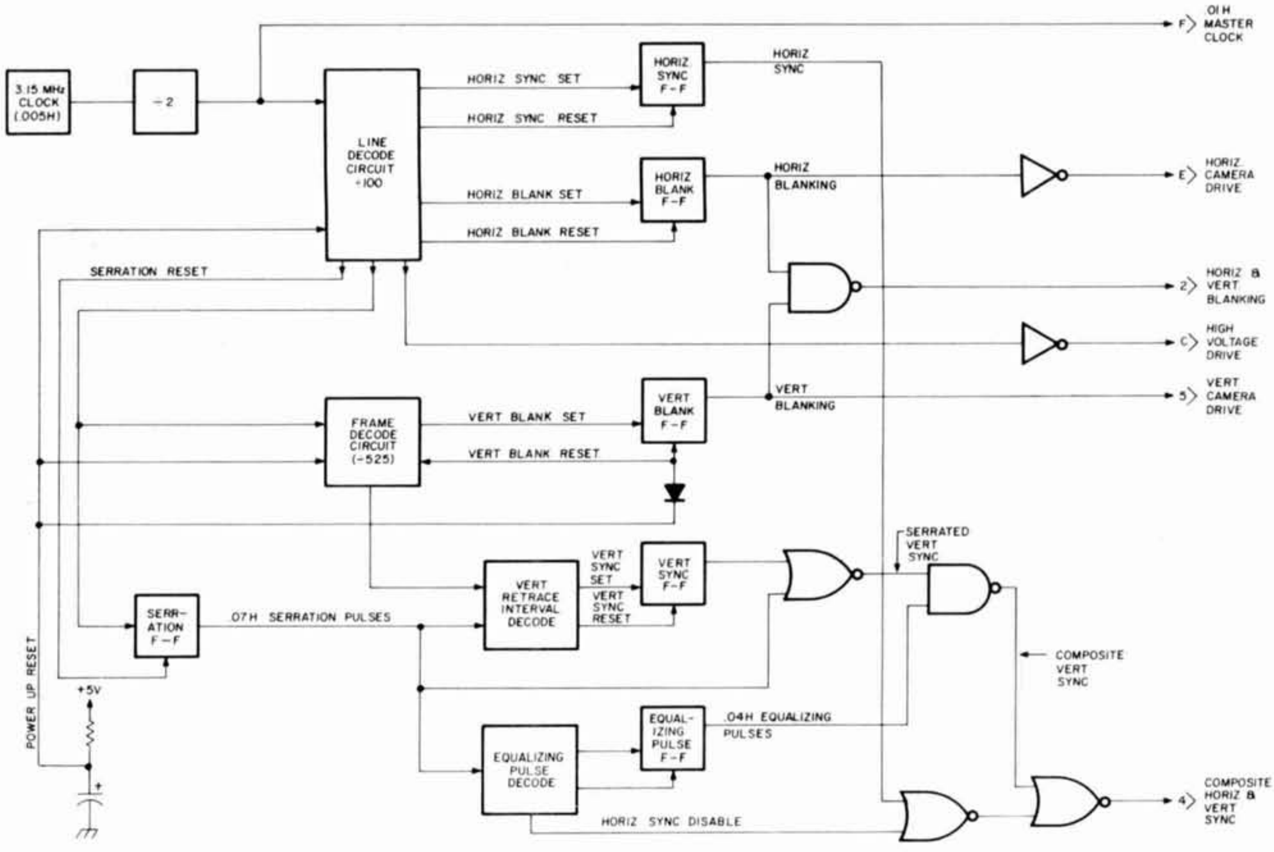


**fig. 1. Block diagram of the complete interlaced sync generator.**

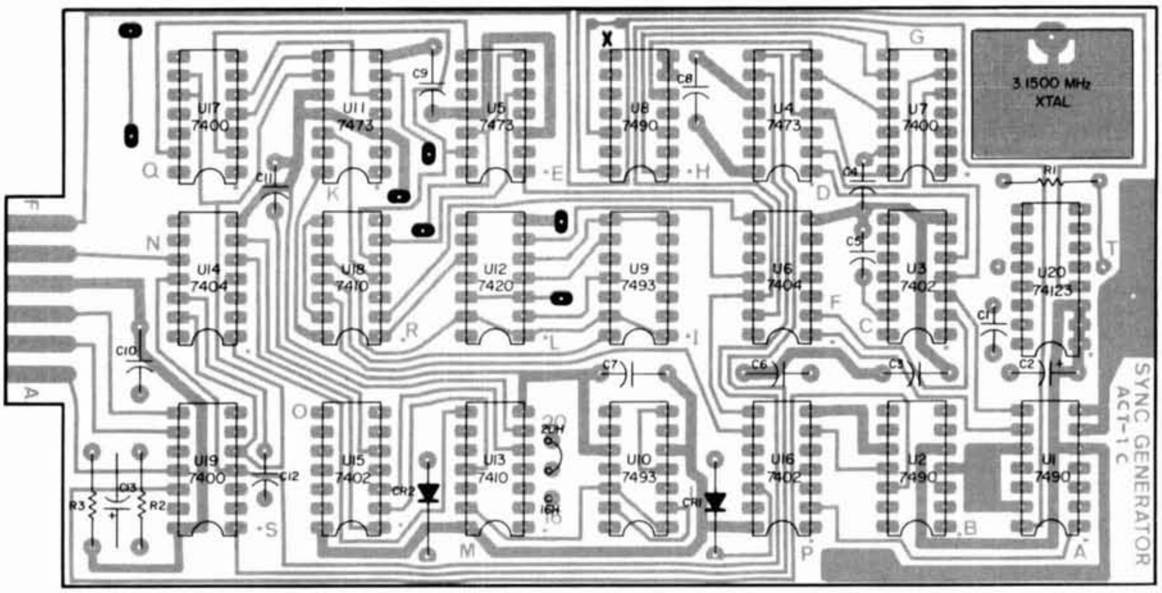


**fig. 2. Parts overlay for the generator. The oval pads indicate a feedthrough point which does not contain a component. The jumper must be connected for the desired vertical blanking time. Pin 1 of each IC is designated on the circuit board to prevent installing the IC improperly. The crystal socket is an Augat 8000D or equivalent.**

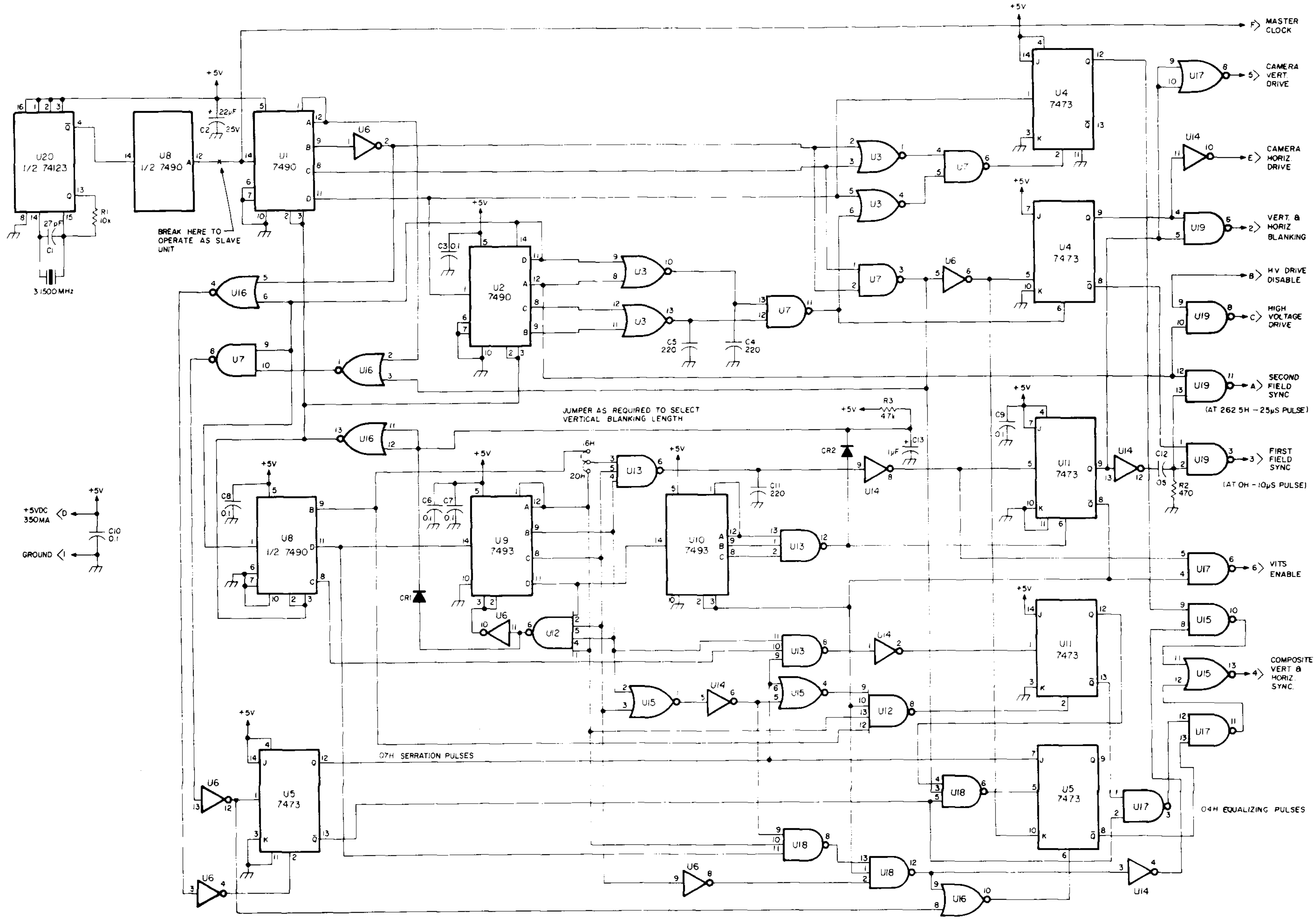


fig. 3. Schematic diagram of the sync generator. Capacitors C3 through C12 are disc ceramics; resistors R2 and R3 are ¼-watt. CR1 and CR2 (1N270 or 1N47A) and C13 are omitted when slaves are not used.

ICs are standard, easy-to-obtain 7400 series TTL devices mounted on a single 3 x 6 inch (7.6 x 15.2cm) double-sided printed circuit board. All outputs are standard totem pole voltage levels. These outputs will be described using the following definitions: H is the total time required for the scanning beam to travel across one horizontal line and is equal to 63.5 microseconds. V is the time required for the same beam to travel from the top left to the bottom center of the TV raster and is equal to 262.5 horizontal lines or 16.66 milleseconds. V is equal to one picture field where two fields are required for each frame. One complete frame contains 525 horizontal scan lines. Therefore, 2V = 33.33 milliseconds or 1/30 Hz, producing 30 complete frames per second.

## outputs

Before discussing the outputs (**fig. 3**), there should be an understanding of the terminology used. When referring to the logic signals, either plus or ground is used to denote the true state. For example, if the desired signal is a positive-going pulse it would be referred to as a plus true signal. For a negative pulse, it would be ground true.

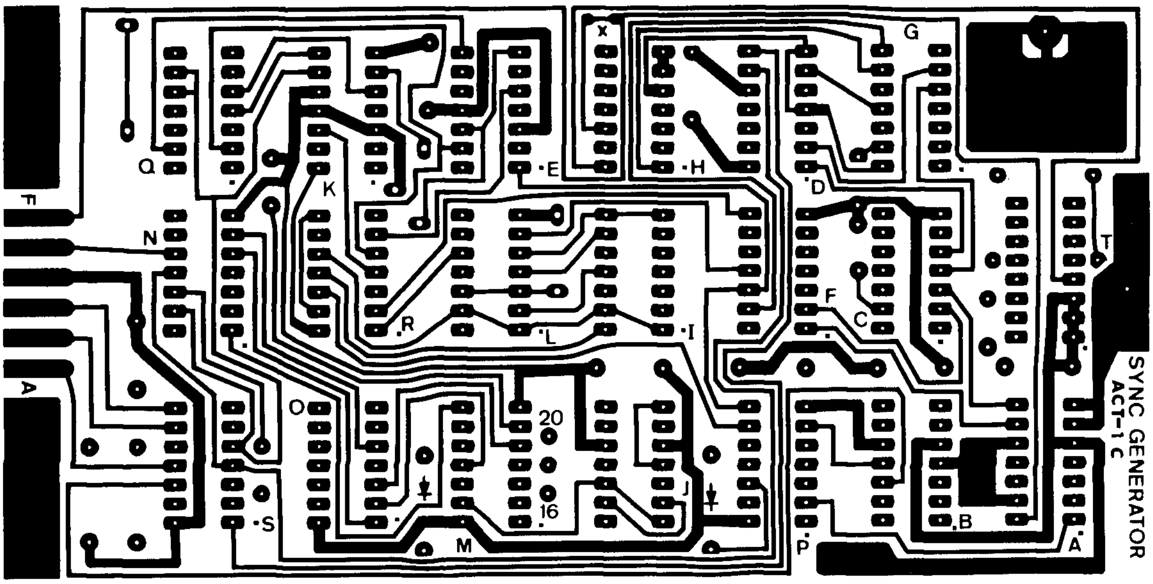


**fig. 4. Circuit board layout for the top side of the board. At the point on the board marked with a small X, the trace can be broken for slave operation as explained in the text.**

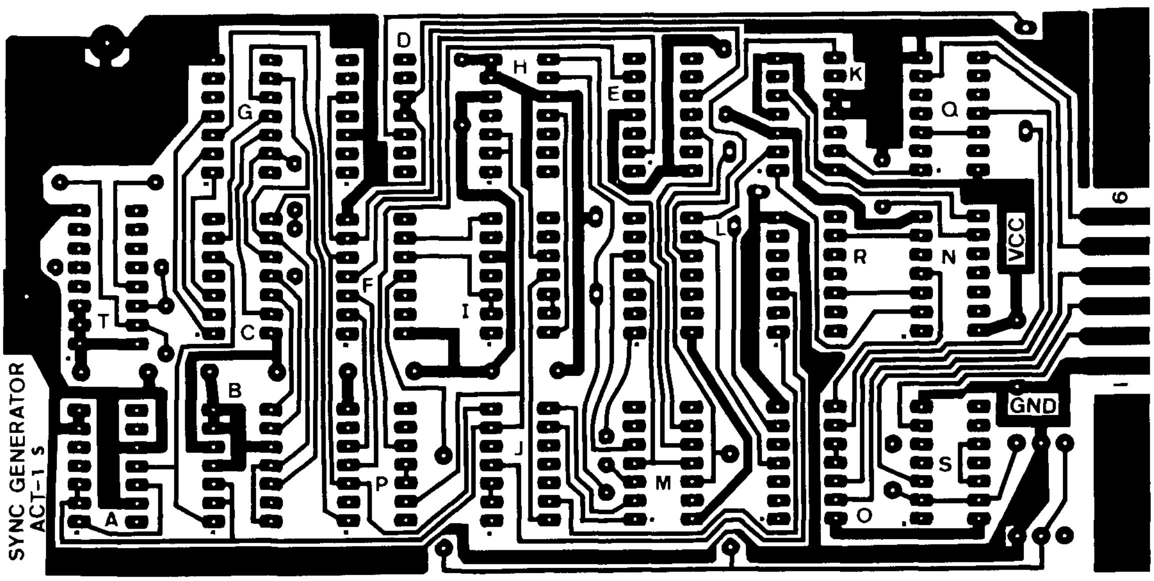


**fig. 5. Layout for the bottom side of the printed circuit board.**

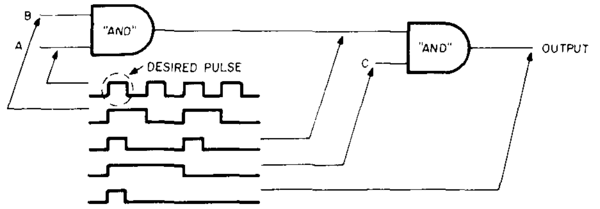


**fig. 6. Method of windowing pulse trains to obtain a single desired pulse.**

**1.** Pin E — Camera horizontal drive. This is a plus true pulse 0.16H wide, starting at zero H, and is used for driving the camera horizontal sweep circuit and for vidicon horizontal blanking.

**2.** Pin 5 — Camera vertical drive is a plus true pulse 20H wide starting at zero V and is used for driving the camera vertical sweep circuit and for vidicon vertical blanking.

**3.** Pin 2 — Processor mixed blanking. This is a plus true pulse that is the combination of the vertical and horizontal drive pulses. It is used in the video processor to insert blanking into the video.

**4.** Pin 4 — Processor composite sync is a combination of ground true pulses composed of serration pulses, equalizing pulses, vertical sync, and horizontal sync pulses. A more detailed description of this pulse chain will be covered later.

**5.** Pin F — Master clock. This pulse chain, with a symmetrical period of 0.01H, is used when it is desired to slave one or more sync generators from a master unit. On the slave units, point **X** is broken and the crystal removed.

**6.** Pin C — High voltage drive. This is a symmetrical square wave signal with a period of 1H used to trigger a high-voltage converter for vidicon operating voltages.

**7.** Pin B — High voltage disable is a ground true *input* that will kill the high-voltage drive upon the failure of any correct operating condition. If this pin is not used, it must be connected to pin D (+5V).

**8.** Pin 3 — First field sync. This is a ground true pulse approximately 10 microseconds wide starting at zero H. It facilitates troubleshooting the circuitry by providing an oscilloscope trigger to view the first (odd) field.

**9.** Pin A — Second field sync is a ground true pulse approximately 25 microseconds wide starting at 262.5H. It provides triggering to view the second (even) field.

**10.** Pin G — VITS enable. This pulse is ground true, 2.5H wide starting at 17.5H and 280H. It is used to enable test signals presented to the video waveform for 2.5 horizontal lines immediately prior to unblanking of the waveform. Broadcast TV uses this time to generate **V**ertical **I**nterval **T**est **S**ignals critical to quality analysis of the video waveform. However, little if any use of this feature is needed in most television cameras.

**11.** Pin 1 — Ground

**12.** Pin D — Vcc, +5 volts at approximately 350 mA.

**Master oscillator.** The master oscillator is a novel design[1] using half of a 74123 dual one-shot retriggerable multivibrator. A 74122 may be used instead, but it is not pin compatible. I believe the 74123 is also a bit easier to obtain. Minimal parts are needed and the output is a symmetrical TTL compatible square wave. R1 and C1 form a series resonant RC circuit slightly above the crystal frequency. Without the crystal the oscillator would free run at the frequency determined by these values. The 74123 **Q** output starts in a low state and switches to a high state after C1 charges. The high state is unstable, however, and the one-shot discharges the **Q** output through R1 returning **Q** to a low state which repeats the cycle. Even though I use a crystal to make this oscillator stable, by careful selection of R1, a good metal film resistor, and C1, a good silver mica capacitor, the oscillator will free run with sufficient stability

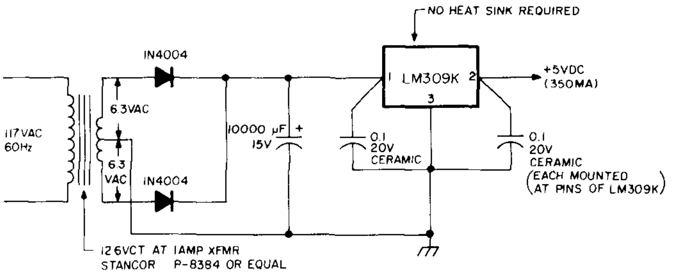


**fig. 7. Typical power supply for the interlaced sync generator.**

for ATV operation. I use an International Crystal type Ex crystal because of its low cost and easy crystal availability.

Following the oscillator is a simple divide-by-two flip-flop to produce the main control clock for the rest of the circuitry. The total period at this point is 0.01H which has a low state for 0.005H and a high state for 0.005H. At this point the circuit may be broken for slave operation from another source or it could serve as the master clock for other devices.

**Line decoding.** A number of counters and flip-flops combine to form *window* circuits for the purpose of extracting the horizontal sync and blanking pulses (**fig. 8**). A total frequency division of 100 provides a

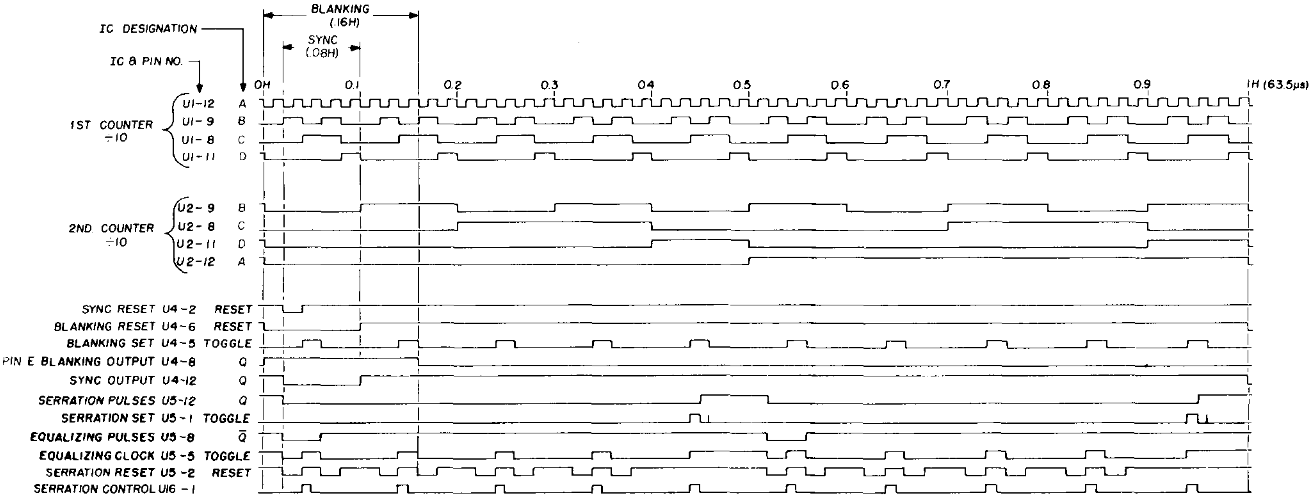


**fig. 8. Horizontal interval waveforms. Note that the sync pulse starts after blanking starts and ends before the picture is unblanked.**

1H pulse chain to drive the vertical circuits. The windowed pulses from U1 and U2 combine to form the set and reset lines for the J-K flip-flops, U4.

It is appropriate at this time to briefly describe window circuits because the entire logic is built upon this approach. To window a pulse chain simply means to extract only a portion of the pulse information, with respect to time. For example, in **fig. 6**, a particular line (input A) has four pulses in a given time frame and it is desired to extract only the first one. This series of pulses is logically ANDed with pulses of a lower repetition rate (input B), producing an output only when both inputs are plus. Therefore, of the four pulses at input A and the two pulses at input B, the output is true for only two of them. This is subsequently repeated with a third pulse train (input C) to produce the desired output. By extending this approach, it is easy to identify one pulse in a series of thousands, within any given time period.

**Frame decoding.**, The 1V time interval requires 1H to be divided by 525. The combination of U8, U9, and U10 provide division by 5, 15, and 7, respectively, for a total of 525. The outputs then feed U11 to obtain the basic vertical frame rate (**fig. 9**). I've provided an optional vertical blanking time of either 16H or 20H, the latter being the standard. If it is desired to unblank after the 16th horizontal line, providing four extra lines of active video, put the jumper in the corresponding position. In reality, this feature has only minimal value and, I confess, wouldn't have been provided had it not been for an available 3-input gate with just 2 inputs used.

**Vertical retrace and equalizing pulse decoding.**

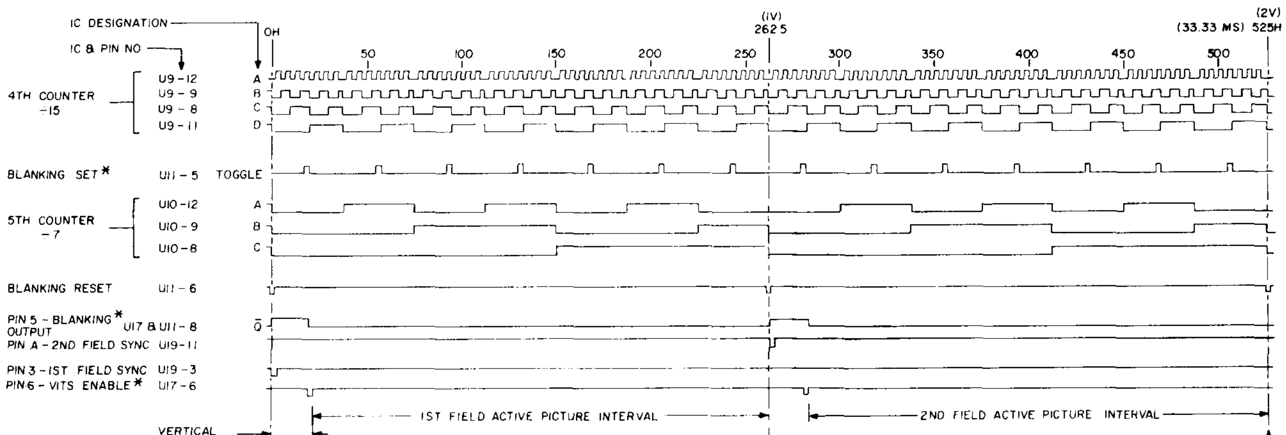


**fig. 9. Vertical interval waveforms. Both fields are shown. The first field starts at OH and the second at 262.5H. The first field covers from the top left to the bottom center of the picture while the second covers the bottom center to bottom right.**

This circuitry produces the vertical serration, sync, and equalizing within the vertical blanking time. No further frequency division is required, but some rather fancy manipulation of flip-flops and window circuitry is necessary to generate the waveforms required by EIA standards. The serration pulses are combined with the vertical sync to produce serrated vertical sync (U17 p3) which is then added to the equalizing pulses, providing composite vertical sync serration pulses determine proper operation of the vertical retrace and also the accuracy of the interlace. Good interlace is not only determined by the quality of the camera, but also by the proper functioning of the receiver sync separator. Providing a crystal-controlled time base and dividing the horizontal frequency by 525 by itself does *not* guarantee true interlace!

**Logic reset circuit.** Although no power up resetting

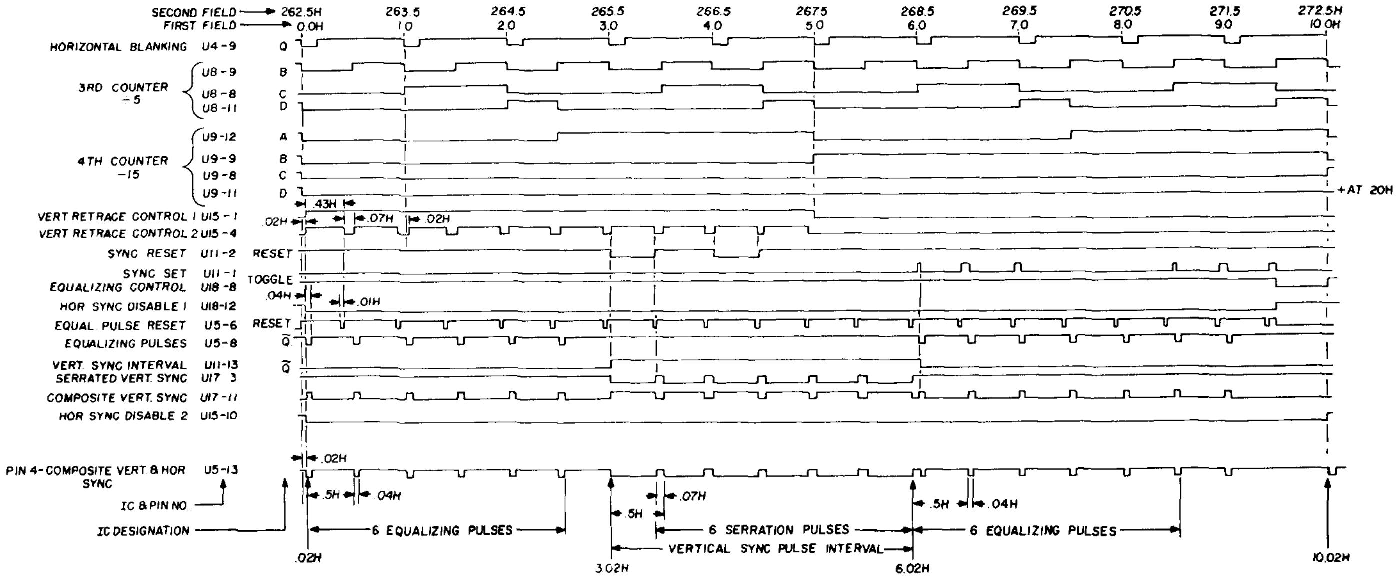


**fig. 10. Vertical retrace interval waveforms. This illustrates how the composite sync is constructed.**

(U17 p11). The horizontal sync is next added to produce composite processor sync which contains serrations, equilizing pulses, vertical sync, and horizontal sync. A basic understanding of the significance of serration and equalizing pulses is required to fully appreciate the required logic.

At every 1H, or multiple thereof (**fig. 10**), a sync pulse must occur to keep the receiver horizontal oscillator on frequency. Therefore, equalizing and serration pulses occur at a 1/2H repetition rate during vertical blanking to provide a uniform transition from the even to the odd fields. Also, looking at the receiver's sync separator circuitry, it's observed that the capacitor-coupled integrator depends upon average dc level to separate vertical from horizontal sync. Therefore, the negative-going equalizing pulses help establish this transition by providing a higher positive average voltage just prior to vertical sync. When the transition to vertical sync takes place, the positive-going serration pulses keep the horizontal oscillator locked while producing a lower average dc level. The receiver integrator charges at this point until it resets its own vertical ramp and retrace takes place, so the existence of equalizing and is required for normal single camera operation, provisions have been made when using a master-slave approach to reset all generators to zero and start from the same point. This can be accomplished by making the value of C13 significantly larger in the master unit than in each slave. Then at power up, all units will be reset to zero and held there for a time determined by C13 and R3. If the master unit has a longer time constant it will be held reset longer than each of its slaves. Since the master feeds the control clock to each slave, when the master is reset the slaves also stay reset. The purpose is to prevent the master unit from feeding pulses to the slaves before they complete the reset command. If the generator is not used with slaves, C13 as well as CR1 and CR2 may be omitted.

One final point, the placement of CR1 and CR2 appears to violate the loading rules of TTL active gate outputs. However, the time duration that a short circuit exists is not long enough to present

*A drilled printed circuit board for $9.00 postpaid is available from Automation Engineering Company, 3621 Marine Drive, Toledo, Ohio 43609.

problems, and is within the safe operating parameters of these devices.

The complete sync generator is contained on a 3 x 6 inch (7.6x15.2cm) double-sided printed-circuit board. Artwork for the top and bottom is shown in **figs. 4** and **5** for those who wish to duplicate the board.* If desired, breadboard or wire-wrapped versions can be constructed if the following precautions are observed. First, all leads should be as short as possible. This is especially true in the oscillator and counter (U1) areas. The high frequencies involved could cause noticeable radiation to other units, especially video preamps.

Make liberal use of bypass capacitors at the +5 volt terminal of each counter or flip-flop. A good ceramic capacitor of at least 0.1 $\mu$F or higher should be used. Note also that I have used 220 pF capacitors at strategic points in the circuit. This is to eliminate possible switching spikes being generated in the ripple counters. It is possible to redesign this circuit using synchronous counters, but no problems have been encountered in a number of units constructed. Finally, I do not recommend sockets for the integrated circuits! More time has been spent troubleshooting faulty socket connections than for bad ICs.

## power supply

As mentioned earlier, a single 5 volt, 350 mA regulated power supply is required. A simple rectifier circuit followed by an LM309K regulator (**fig. 7**) is quite satisfactory. The regulator does not require a heatsink.

## conclusion

A good sync generator, easy on the pocketbook and also to build, is always welcomed by the serious ATV enthusiast. I believe that this article meets these criteria. My intentions were not to dive into a theory session on TV sync generation, but to accentuate some key points that have been left out of previous articles on amateur television. A future article will describe a complete television camera using four printed-circuit boards including this sync generator.

### references


1. *Reference Data for Radio Engineers*, 5th Edition, Howard W. Sams & Company, Incorporated, page 28-13.
2. Gerald A. Eastman, "Measurement Concepts," Tektronix, Incorporated, 1969, page 44.
3. "Television Signal Analysis," Second Edition, American Telephone & Telegraph Company, April, 1963, page 5.


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1. Mark Trueblood, "Three Components Make A Stable Crystal Oscillator," *EDN Magazine*, July, 15, 1972, page 54.


**ham radio**

# tracking the OSCAR satellites

## Orbital positions and your range capabilities can be determined easily with the aid of a few simple charts

**Many articles,** aids, information, and data[1-6] have been published on the use of the OSCAR 7 satellite. However, some questions still remain unresolved: How do you work over long distances? How do you communicate with the satellite over periods of one or two minutes? How do you establish the physical limitations of your communications capabilities?

The article attempts to provide answers to these questions. All you need are the few easy-to-make visual aids described here and an understanding of some of the basic concepts about OSCAR 7 and your ground station.

### background

OSCAR 7 is located 900 nautical miles (n. mi.) (1036 statute miles or 1668 km) above the earth's surface.* OSCAR 7 completes one orbit around the earth every 114.9 minutes. The satellite moves at about 23,000 fps (7000 mps). It can see a section of the earth's surface of 2250 n. mi. (4167 km) in all directions.

Theoretically, if you were riding in OSCAR 7, you could see two points on the earth's surface that are 4500 n. mi. (8334 km) apart. There is, though, a very significant limit to OSCAR 7 as a communications tool. OSCAR 7 is usable only if it's in the visibility region of your ground station. Your visibility region is limited to the line-of-sight distance between your station and the satellite as it moves in space. Unless two stations on the earth's surface are closer than 4500 n. mi. (8334 km) they can't communicate, since OSCAR 7 is a line-of-sight repeater.

Each operator using OSCAR 7 is faced with the following problems. He must be able to **1)** locate OSCAR 7, **2)** establish what cities or stations are within his maximum communications capability, and **3)** know when and where OSCAR 7 will be passing through the region of mutual visibility.

### graphical aids

These three problems are not difficult to resolve, and learning to use OSCAR 7 is a simple process. The starting place is in constructing or obtaining the few simple graphical aids required. We call them the Precision Orbital Position Plotting Chart, (POPP chart is shown). The POPP has been instrumental for establishing satellite communications between San Jose, California and Sapporo, Japan during communications periods as short as one minute. The POPP chart is shown in two forms: a polar-sterographic map projection of the northern (or southern) hemisphere, **fig. 1**, and a Mercator map projection of

*Distance measurements are given in nautical miles (n. mi.), which are longer than the statute mile by 1.15. The nautical mile is used for navigational purposes. Each nautical mile is the distance of longitude measured at the equator (6086 feet or 1.85 km). **Editor.**

**By W. R. Harmon and N. Patrick Peterson, WA6UAP.** Mr. Harmon's address is 10560 Stokes Avenue, Cupertino, California 95014; WA6UAP may be reached at 1422 Bretmoor Way, San Jose, California 95129

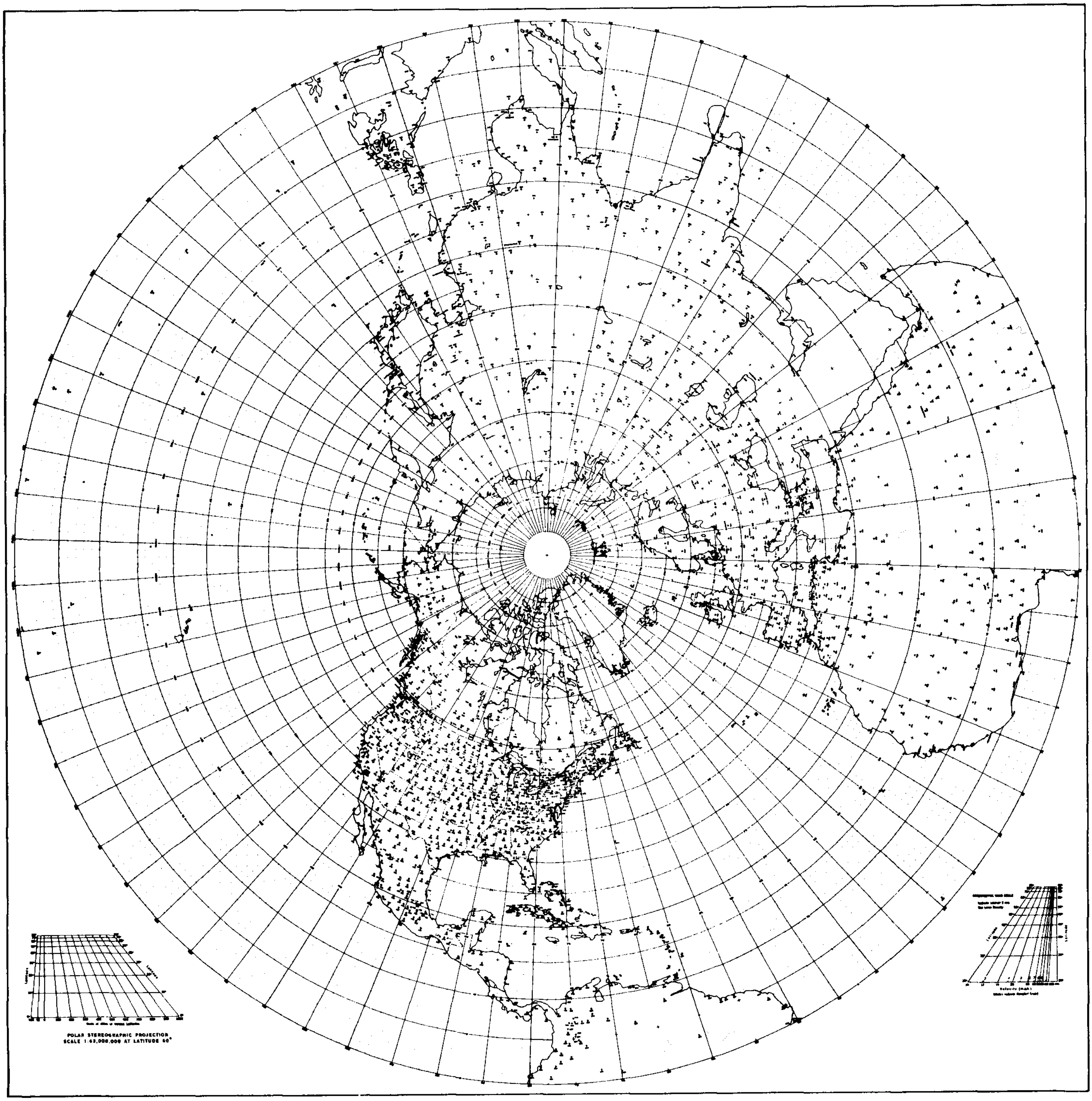


**fig. 1. Polar-stereographic projection of the northern hemisphere used for the Precision Orbital Position Plotting (POPP) chart. A similar projection for the southern hemisphere is available from *ham radio*.***

the world, **fig. 2**. The polar-stereographic projection is preferred for good reason; because of the geometric characteristics of such a projection, the ground-station mutual visibility regions may be plot-

*Large polar-stereographic projections of the northern and southern hemispheres, suitable for constructing your own graphical tracking aid, are available for $1.00 postpaid from *ham radio*, Greenville, New Hampshire 03048.

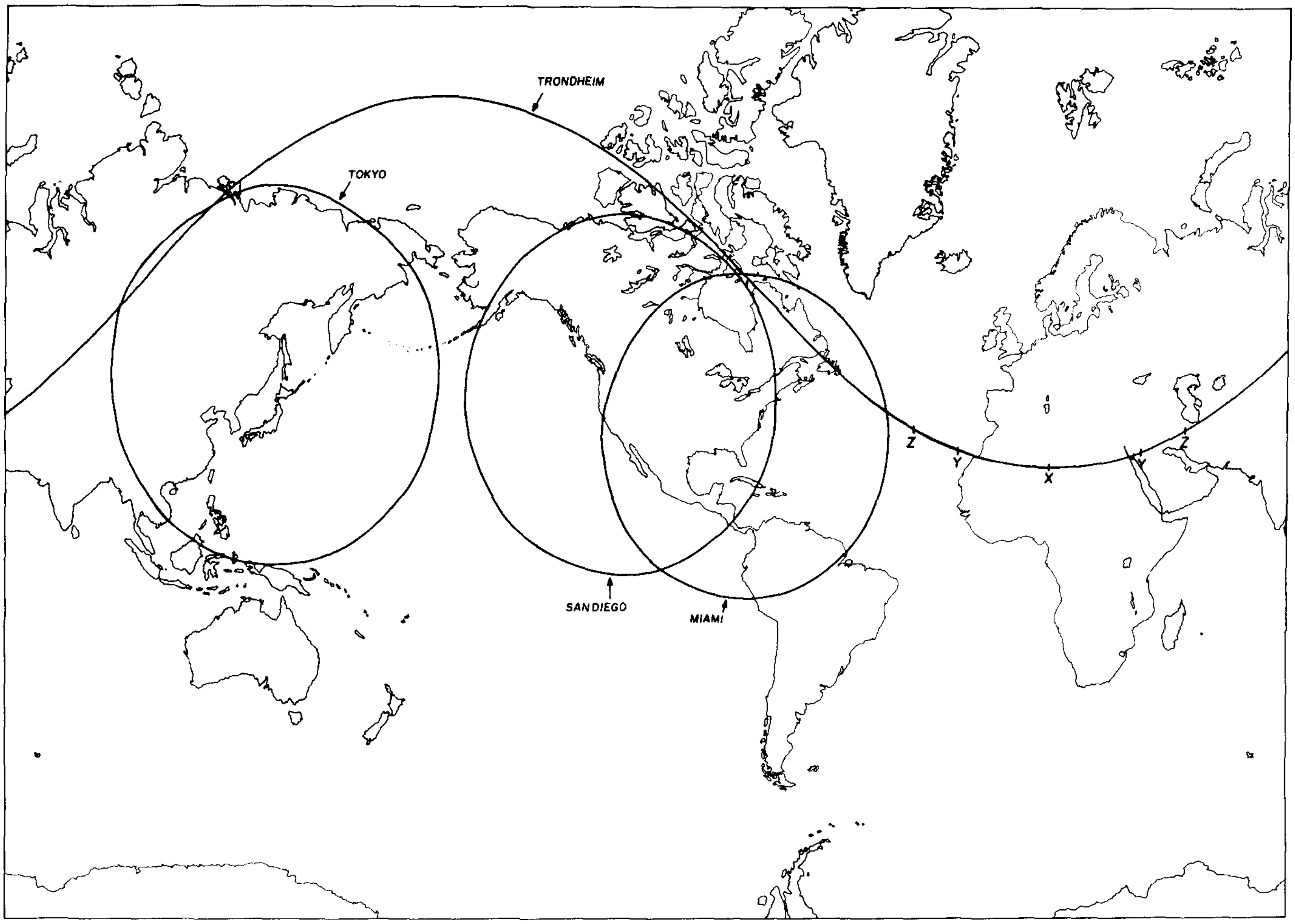



**fig. 2. Mercator projection of the world showing visibility regions of four ground stations. Note that the visibility regions are not circles. This projection is less desirable for a POPP chart than the polar-stereographic projection of figs. 1 and 3.**

ted as perfect circles, **fig. 3**. This is not true for the Mercator projection, nor for the polar projections which are usually used by Amateurs for satellite tracking. The Mercator projection is complex and difficult to use, particularly for stations at latitudes more than 45 degrees north or south.

The steps in making a POPP chart for use with OSCAR 7 are:

**1.** Inscribe on your selected map projection the 2250 n. mi. (4167 km) visibility region of your ground station. Also mark the 4500 n. mi. (8334 km) range from your station.

**2.** Obtain an orbit ground track for a single OSCAR 7 pass and plot this orbit on a clear acetate overlay of the map you plan to use. The orbital path should include the times marked at one-minute intervals (see **figs. 4** and **5**).

**3.** Obtain the schedule of the OSCAR 7 longitudes of ascending node (LAN) times and locations.[7,8,9] The LAN is the time and longitude when the satellite's ground track crosses the equator on each south-to-north pass.

**4.** Select a potential contact inside the 4500 n. mi. (8334 km) range and plot his visibility region on your chart. This circle of visibility should include your station visibility region to form a region of mutual visibility.

**5.** With the satellite-orbit overlay, find an LAN that results in the orbit transversing the region of mutual visibility.

**6.** Add the time of the LAN to the elapsed orbit ground-track time entering and leaving the region of mutual visibility. This time period then becomes the *communications-time window*.

**7.** Calculate or estimate your antenna pointing azimuth for the region of mutual visibility.

**8.** Set up equipment, wait for the proper time, then table 1. Latitude and longitude of OSCAR 7 orbits at one-minute intervals for the northern hemisphere.

| time (min.) | latitude (deg. north) | longitude (deg. west) | time (min.) | latitude (deg. north) | longitude (deg. west) |
|---|---|---|---|---|---|
| 0 | 0 | 140.00 | 29 | 78.23 | 242.37 |
| 1 | 3.07 | 140.89 | 30 | 77.56 | 257.29 |
| 2 | 6.15 | 141.70 | 31 | 76.20 | 270.05 |
| 3 | 9.22 | 142.60 | 32 | 74.33 | 280.25 |
| 4 | 12.29 | 143.60 | 33 | 72.12 | 288.22 |
| 5 | 15.36 | 144.52 | 34 | 69.66 | 294.46 |
| 6 | 18.43 | 145.47 | 35 | 67.04 | 299.42 |
| 7 | 21.49 | 146.47 | 36 | 64.31 | 303.45 |
| 8 | 24.55 | 147.45 | 37 | 61.51 | 306.78 |
| 9 | 27.61 | 148.49 | 38 | 58.64 | 309.60 |
| 10 | 30.67 | 149.50 | 39 | 55.73 | 312.03 |
| 11 | 33.71 | 150.72 | 40 | 52.79 | 314.16 |
| 12 | 36.75 | 151.93 | 41 | 49.82 | 316.04 |
| 13 | 39.79 | 153.21 | 42 | 46.83 | 317.74 |
| 14 | 42.81 | 154.60 | 43 | 43.83 | 319.28 |
| 15 | 45.02 | 156.09 | 44 | 40.81 | 320.70 |
| 16 | 48.81 | 157.74 | 45 | 37.78 | 322.02 |
| 17 | 51.79 | 159.55 | 46 | 34.74 | 323.25 |
| 18 | 54.74 | 161.59 | 47 | 31.70 | 324.41 |
| 19 | 57.66 | 163.91 | 48 | 28.64 | 325.52 |
| 20 | 60.54 | 166.50 | 49 | 25.59 | 326.57 |
| 21 | 63.37 | 169.73 | 50 | 22.53 | 327.59 |
| 22 | 66.13 | 173.50 | 51 | 19.46 | 328.57 |
| 23 | 68.79 | 178.11 | 52 | 16.40 | 329.53 |
| 24 | 71.31 | 183.87 | 53 | 13.33 | 330.46 |
| 25 | 73.62 | 191.20 | 54 | 10.26 | 331.38 |
| 26 | 75.62 | 200.59 | 55 | 7.18 | 332.28 |
| 27 | 77.17 | 212.49 | 56 | 4.11 | 333.18 |
| 28 | 78.09 | 226.79 | 57 | 1.04 | 334.07 |

table 2. Latitude and longitude of OSCAR 7 orbits at one-minute intervals for the southern hemisphere.

| time (min.) | latitude (deg. south) | longitude (deg. west) | time (min.) | latitude (deg. south) | longitude (deg. west) |
|---|---|---|---|---|---|
| 0 | 0 | 334.40 | 29 | 78.23 | 76.77 |
| 1 | 3.07 | 335.29 | 30 | 77.56 | 91.69 |
| 3 | 6.15 | 336.10 | 31 | 76.20 | 104.45 |
| 3 | 9.22 | 337.00 | 32 | 74.33 | 114.65 |
| 4 | 12.29 | 338.00 | 33 | 72.12 | 122.62 |
| 5 | 15.36 | 338.92 | 34 | 69.66 | 128.86 |
| 6 | 18.43 | 339.87 | 35 | 64.31 | 137.85 |
| 7 | 21.49 | 340.87 | 36 | 64.31 | 137.85 |
| 8 | 24.55 | 341.95 | 37 | 61.51 | 141.18 |
| 9 | 27.61 | 342.99 | 38 | 58.64 | 144.06 |
| 10 | 30.67 | 343.90 | 39 | 55.73 | 146.43 |
| 11 | 33.71 | 345.12 | 40 | 52.79 | 148.56 |
| 12 | 36.75 | 346.33 | 41 | 49.82 | 150.44 |
| 13 | 39.79 | 347.61 | 42 | 46.83 | 152.14 |
| 14 | 42.81 | 349.00 | 43 | 43.83 | 153.68 |
| 15 | 45.02 | 350.49 | 44 | 40.81 | 155.10 |
| 16 | 48.81 | 352.14 | 45 | 37.78 | 156.42 |
| 17 | 51.79 | 353.95 | 46 | 34.74 | 157.65 |
| 18 | 54.74 | 355.95 | 47 | 31.70 | 158.81 |
| 19 | 57.66 | 358.31 | 48 | 28.64 | 159.92 |
| 20 | 60.54 | 0.90 | 49 | 25.59 | 160.97 |
| 21 | 63.37 | 4.13 | 50 | 22.53 | 161.99 |
| 22 | 66.13 | 7.90 | 51 | 19.46 | 162.97 |
| 23 | 68.79 | 12.51 | 52 | 16.40 | 163.93 |
| 24 | 71.31 | 18.27 | 53 | 13.33 | 164.86 |
| 25 | 73.62 | 25.60 | 54 | 10.26 | 165.78 |
| 26 | 75.62 | 34.99 | 55 | 7.18 | 166.68 |
| 27 | 77.17 | 46.89 | 56 | 4.11 | 167.58 |
| 28 | 78.09 | 61.69 | 57 | 1.04 | 168.47 |

communicate. If the other station is prepared and waiting, you should achieve communications for one minute or longer, even at long distances.

## finding oscar

The AMSAT *Newsletter* publishes a daily listing of a *single* OSCAR 7 LAN, the time for that LAN in GMT, and the orbit number. (The LAN is simply a listing of the geographical location on the equator where OSCAR 7 can be found during a south-to-north pass at one specific time on that day.)

As OSCAR 7 moves in its orbit, the earth rotates under the OSCAR-7 orbit. After 114.9 minutes, OSCAR 7 will again cross the equator. This orbit will cross the equator 28.725 degrees west of the LAN given in the AMSAT listing. On each succeeding orbit of OSCAR 7, a new LAN is obtained, 28.725 degrees west and 114.9 minutes later than the preceding orbit. Thus, the listing given by AMSAT gives you the tool to locate OSCAR 7 on a regular basis.

## the oscar orbit

OSCAR 7 is in a retrograde orbit with an inclination of 101.7 degrees and a period of 114.94 minutes. It makes approximately twelve orbits per day. A retrograde orbit has an inclination greater than 90 degrees as measured from a plane running through the equator. The retrograde orbit also has a very long life. The rate of orbit decay is very low, and the orbit ground track will not change appreciably for several years. Thus, any effort spent in plotting the orbit

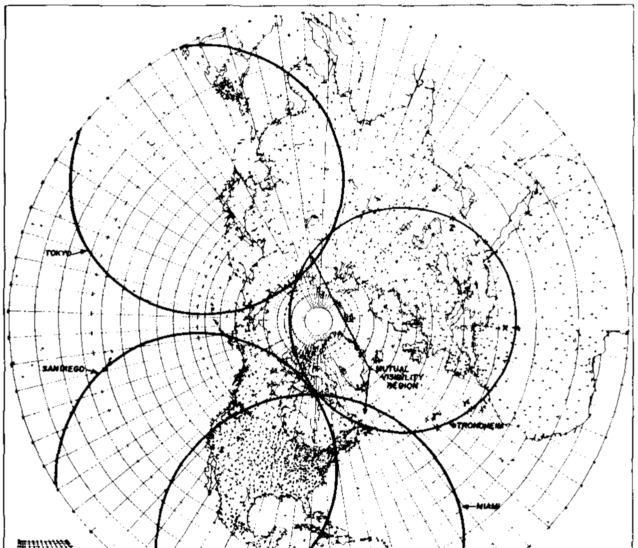



fig. 3. Ground-station mutual visibility regions plotted on a polar-stereographic projection of the northern hemisphere.

will not be wasted. **Tables 1** and **2** give latitude and longitude of OSCAR 7 orbits at one-minute intervals for the northern and southern hemispheres, respectively. This orbit starts at 140 degrees west longitude. (The first half of the orbit was calculated manually.)

The orbit should be plotted onto a clear acetate overlay of the map projection to be used, using drafting ink or other permanent medium. Carefully plot accurate registration marks such as the equator or the north or south pole. Note that the end of the orbit is 168.5 degrees west and 28.5 degrees east of the starting point. This occurs because of the earth's rotation beneath the satellite orbit track. Earth rotation has been accounted for at every instant along the orbit ground track, with the end of the orbit becoming the starting point for the next orbit.

The orbit overlay is used on the polar-stereographic projection with a tack or a pin at the pole, leaving the overlay free to rotate. The Mercator projection overlay must be moved back and forth along the equator. In either case, locate the start of the orbit at the location of the selected LAN. The orbit overlay then locates OSCAR 7 at one-minute intervals for that orbit.

An orthographic-meridional projection of the earth provides a convenient and accurate method for plotting a ground station visibility region. To illustrate the plotting techniques, we'll construct the visibility regions of four ground stations. The first step is to determine the northern most point (NMP) and southern most point (SMP) of the visibility region. To find these regions, you must add to, and subtract from, the *latitude* of each station the earth central half-angle for OSCAR 7, which is 37.5 degrees. It has been assumed that, for each station, there exists a zero-degree horizon and a zero-degree antenna elevation.

The following table shows the NMP and SMP for the four ground stations. Note that the NMP for Trondheim is over the north pole at $63.4 + 37.5 = 200.9$ *degrees* (actually $90 - 10.9 = 79.1$ *degrees*).

| station | latitude (degrees) | longitude (degrees) | NMP (degrees) | SMP (degrees) |
|---|---|---|---|---|
| San Diego | 32.7 N | 117.0 W | 70.2 N | 4.8 S |
| Miami | 25.8 N | 80.2 W | 63.3 N | 11.7 S |
| Trondheim | 63.4 N | 10.4 E | 79.1 N | 25.9 N |
| Tokyo | 35.7 N | 140.0 E | 73.2 N | 1.8 S |

The next step is to plot the NMP and SMP for each station on the orthographic-meridional projection

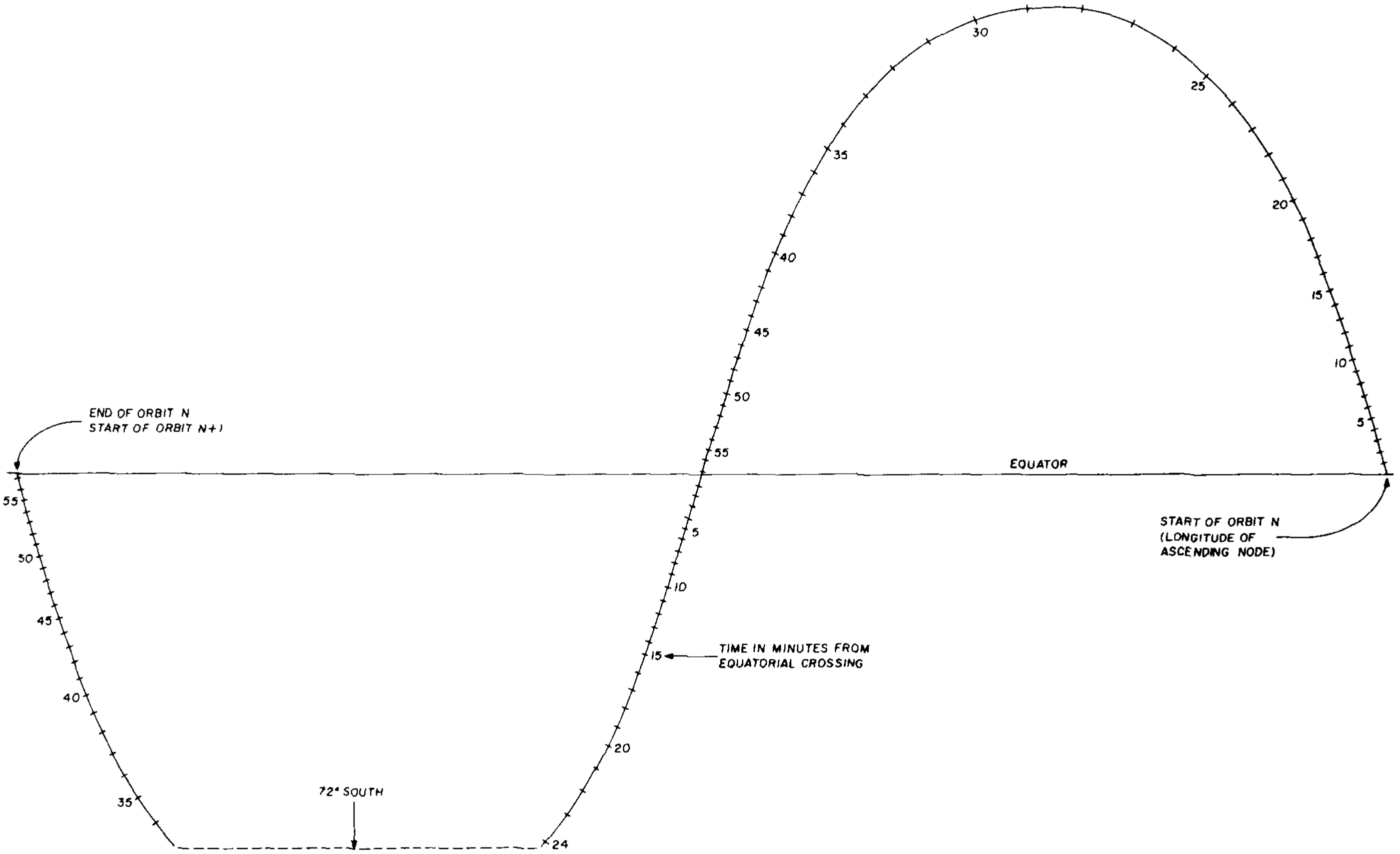
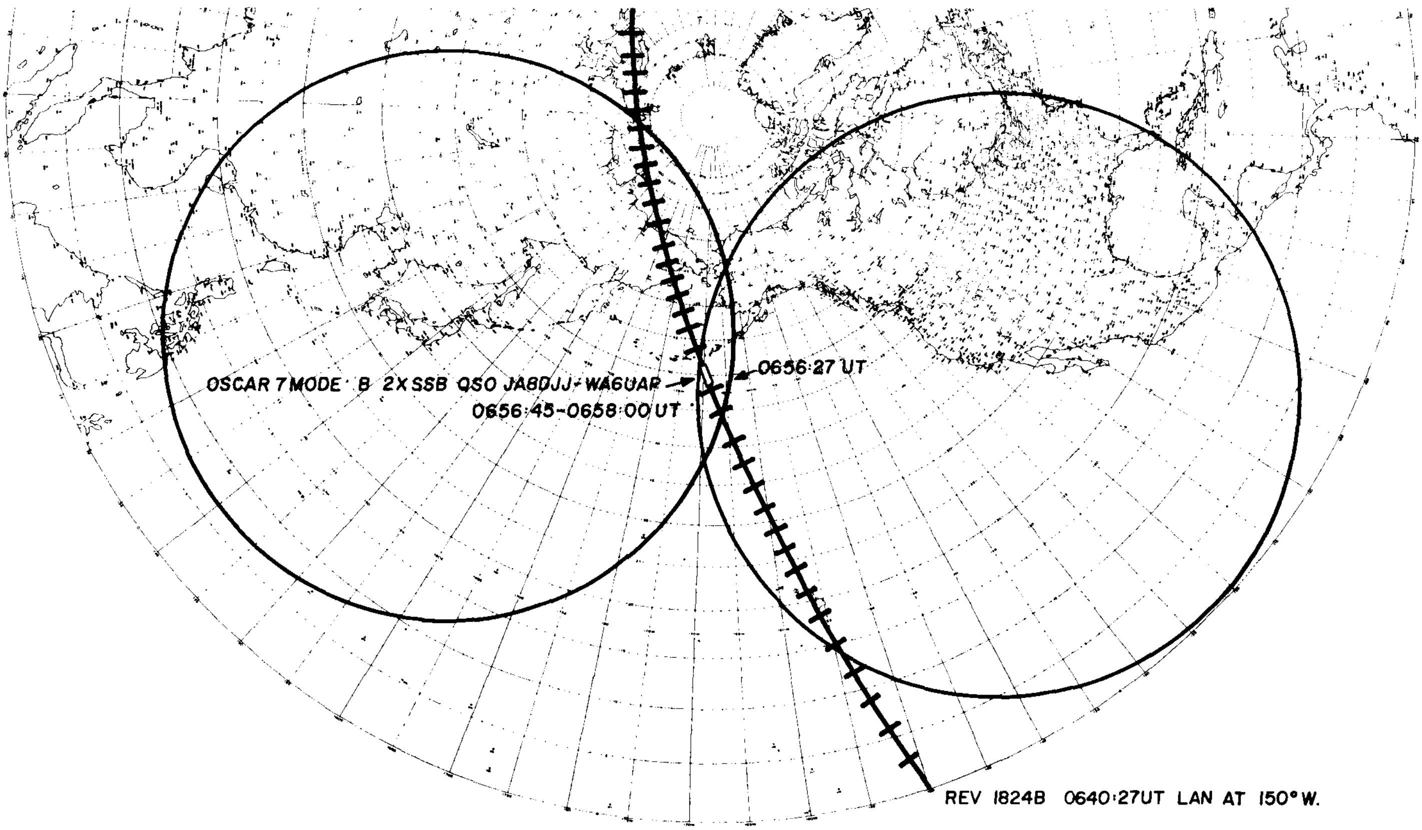



**fig. 4. Single-orbit overlay for a Mercator map projection. The overlay must be slid along the equator until the start of the orbit is on top of the longitude of the OSCAR 7 longitude of ascending node (LAN). The overlay will then show the orbit of the satellite.**




**Plot on polar-stereographic map showing mutual satellite visibility circles of WA6UAP in San Jose, and JA8DJJ in Sapporo, Japan. Two-way ssb communications have been established a number of times between these two stations, but OSCAR 7 is in the proper postion only one or two times per month.**

(**fig. 6**) and connect the points with a straight line. Note that only the NMP and SMP for Trondheim are completed to keep the figure uncluttered for further use. The table of longitudinal corrections is made by recording the value, as read from **fig. 6**, for each increment of latitude. For example, at the SMP (25.9 degrees north) the correction line starts at zero degrees (**A**). At 30 degrees north, the correction line intersects at 26.5 degrees (**B**). Proceeding to 35 degrees north latitude, the line intersects at 40 degrees (**C**). This process is continued until the correction for NMP (180 degrees) is reached. By using smaller increments, a higher degree of accuracy can be obtained for plotting the region of visibility.

To complete the region of visibility, it's necessary to plot the latitude and longitude plus its corrections.

***table 3.* Longitude correction values for the four ground-station examples discussed in the text.**

| Trondheim | | San Diego | | Miami | | Tokyo | |
|---|---|---|---|---|---|---|---|
| north latitude (degrees) | correction (degrees) value | north latitude (degrees) | correction (degrees) value | north latitude (degrees) | correction (degrees) value | north latitude (degrees) | correction (degrees) value |
| 79.1 | 180.0 | 70.2 | 0 | 63.3 | 0 | 73.2 | 0 |
| 75.0 | 128.0 | 65.0 | 31.x | 60.0 | 24.x | 70.0 | 25.x |
| 70.0 | 107.0 | 60.0 | 39.0 | 55.0 | 32.0 | 65.0 | 39.0 |
| 65.0 | 94.5 | 55.0 | 43.2 | 50.0 | 37.2 | 60.0 | 45.0 |
| 60.0 | 84.5 | 50.0 | 45.5 | 45.0 | 40.0 | 55.0 | 47.5 |
| 55.0 | 76.0 | 45.0 | 46.1 | 40.0 | 42.0 | 50.0 | 48.5 |
| 50.0 | 67.5 | 40.0 | 46.0 | 35.0 | 42.5 | 45.0 | 48.5 |
| 45.0 | 59.0 | 35.0 | 45.5 | 30.0 | 42.5 | 40.0 | 47.8 |
| 40.0 | 50.0 | 30.0 | 44.0 | 25.0 | 41.8 | 35.0 | 46.5 |
| 35.0 | 40.0 | 25.0 | 42.1 | 20.0 | 40.5 | 30.0 | 44.5 |
| 30.0 | 26.5 | 20.0 | 39.5 | 15.0 | 38.8 | 25.0 | 42.0 |
| 25.9 | 0 | 15.0 | 36.5 | 10.0 | 36.2 | 20.0 | 39.0 |
| | | 10.0 | 32.5 | 5.0 | 32.9 | 15.0 | 35.0 |
| | | 5.0 | 27.0 | 0 | 28.2 | 10.0 | 30.5 |
| | | 0 | 19.0 | 5.05 | 22.3 | 5.0 | 23.5 |
| | | 4.85 | 0 | 10.05 | 12.5 | 0 | 12.5 |
| | | | | 11.75 | 0 | 1.85 | 0 |

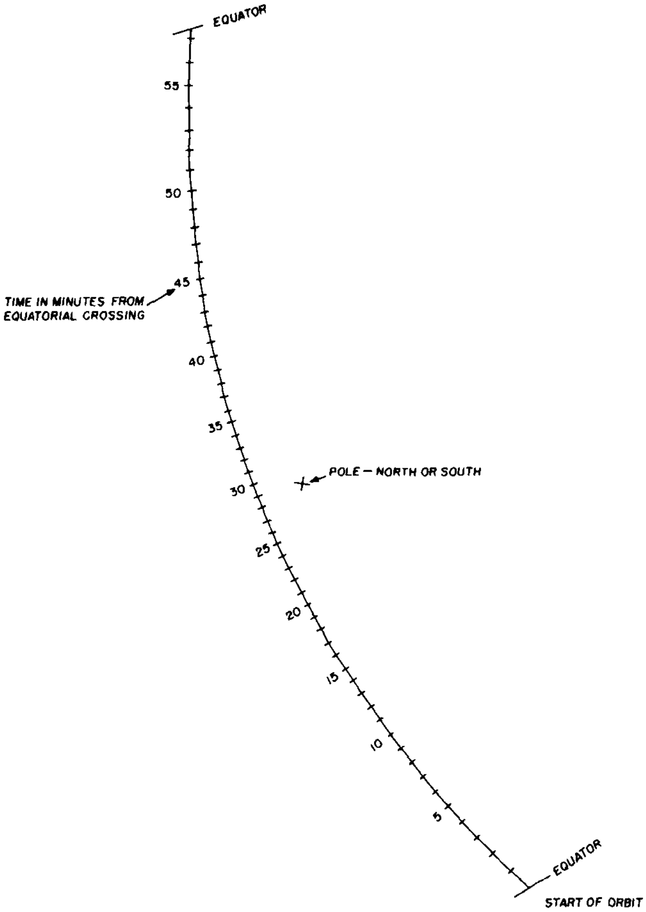



**fig. 5. Single-orbit overlay for a polar-stereographic map projection. Placing the overlay at the longitude of the ascending node (LAN) will show the OSCAR 7 orbital path. The marks indicate the position for each minute after the equatorial crossing.**

Using Trondheim, the longitude is 10.4 degrees east and the latitude of the SMP (0 degrees correction) is 25.9 degrees north (X). Now, referring to **table 3**, the longitude correction for 30 degrees north latitude is 26.5 degrees. This correction is added to, and subtracted from, the initial longitude, *10.4 degrees east + 26.5 degrees = 36.9 degrees east* (**Y**) and *10.4 degrees east − 26.5 = 16.1 degrees west* (**Y′**). Again for 35 degrees north, the longitude points are *10.4 + 40 = 50.4 degrees* (**Z**) and *10.4 − 40 = 29.6 degrees west* (**Z′**). Once the points have been plotted they can be connected with a smooth curve to form the region of visibility.

The procedure described above works for any map projection. For the polar-stereographic projection, however, the visibility region of stations located at or above 37.5 degrees can be plotted using the following shortcut. Locate the NMP and SMP on the longitude line running through the north (or south) pole and your station. Bisect the line connecting the NMP and SMP and use that point as the center of your visibility region. A few seconds with a compass and you'll have your region of visibility. The same technique can be used to plot the 4500 n. mi. (8334 km) range. The only difference is that the earth central half angle is 75.0 instead of 37.5 degrees. This plot should only be done for your own station location to establish the extreme limits of your communications capability.

## antenna elevation

The visibility region discussed previously was based on an antenna elevation of zero degrees (antenna horizontal to the earth's surface). Normally, the amateur using OSCAR 7 and working stations at maximum ranges will be content with this condition. However, if you wish to elevate your antenna, the nomograph of **fig. 7** may be used to assess the effects of antenna elevations up to 15 degrees. If, for example, you elevate your antenna 15 degrees, the earth central half angle will be reduced to 25.25 degrees and your communications range (radius) will be reduced to 1510 n. mi. (2797 km).

## results

Communications with distant stations using antennas fixed in azimuth and elevation has been quite successful. A reproduction of a POPP chart, showing a contact through Mode B between JA8DJJ and WA6UAP, illustrates the usefulness of knowing the mutual visibility area. Knowing the satellite's ground track precisely permits low power experimentation. Numerous contacts have been made through Mode B while operating mobile using a ten-watt output ssb transceiver.

The POPP chart has been in use by the authors only since OSCAR 7 was launched in November, 1974. The basic ideas, methods and applications,

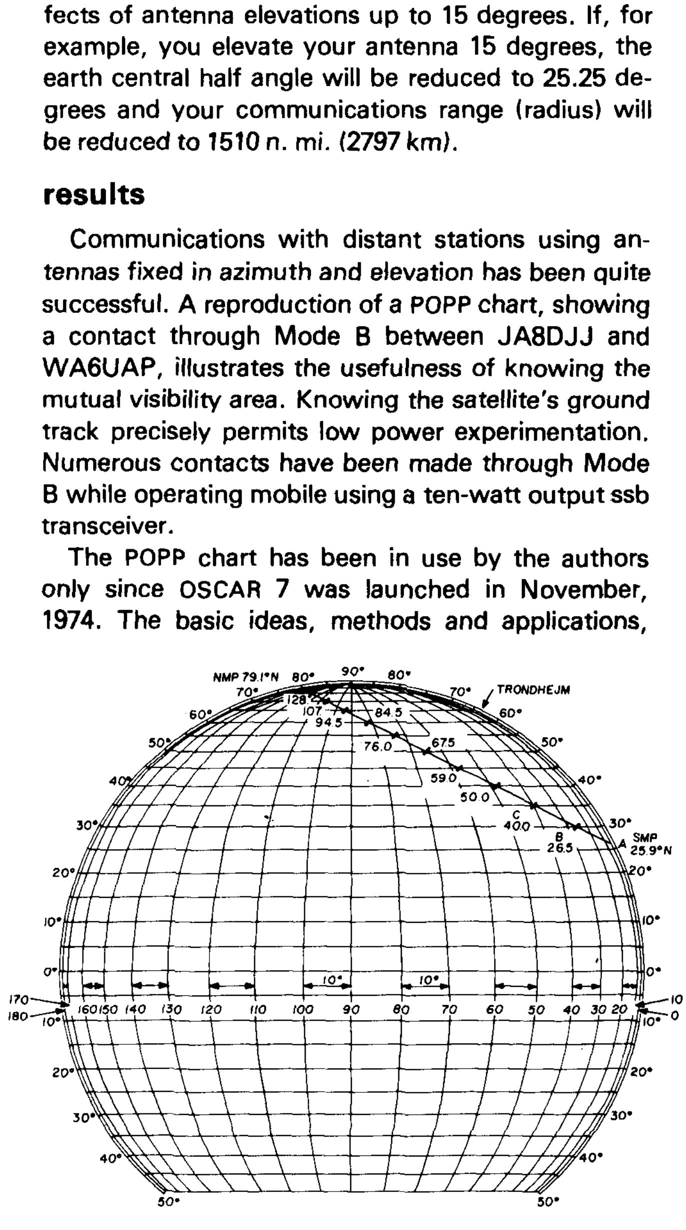



**fig. 6. Orthographic-meridional projection. The longitude corrections are read from the line that connects the northernmost point (NMP) and southernmost point (SMP) of the visibility region.**

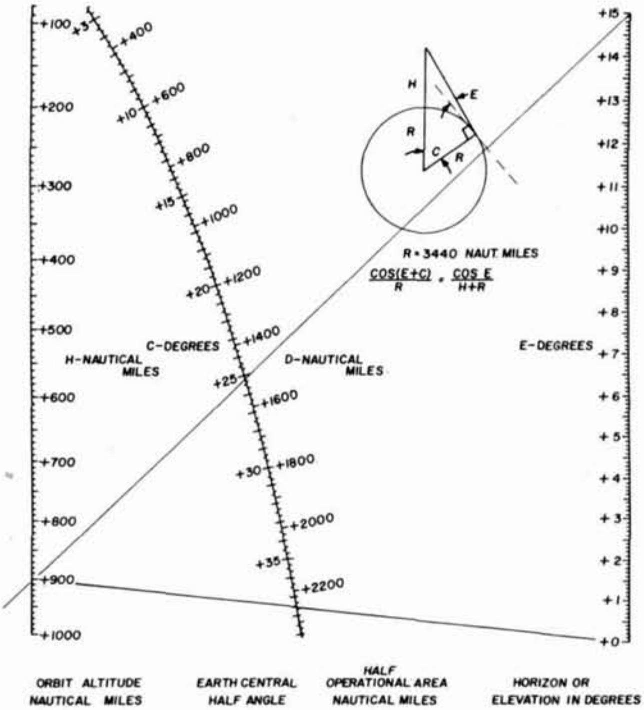



**fig. 7. Nomograph for determining the effects of antenna elevation on satellite communications range. An antenna elevation of zero degrees provides maximum range; about 2250 nautical miles for OSCAR 7 (4500 nautical miles to another ground station). Antenna elevation of 15 degrees gives about 1500 nautical mile half range.**

however, can be applied to any satellite in a circular orbit if the satellite altitude and period are known.

## acknowledgements

We wish to thank Takashi Ishigaki, JA8DJJ, for keeping numerous early morning schedules and Tom Berthold for his assistance with the HP-9100A computer.

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2. John M. Franke, WA4WDL, "How to Find a Satellite," *73*, February, 1975, page 62.
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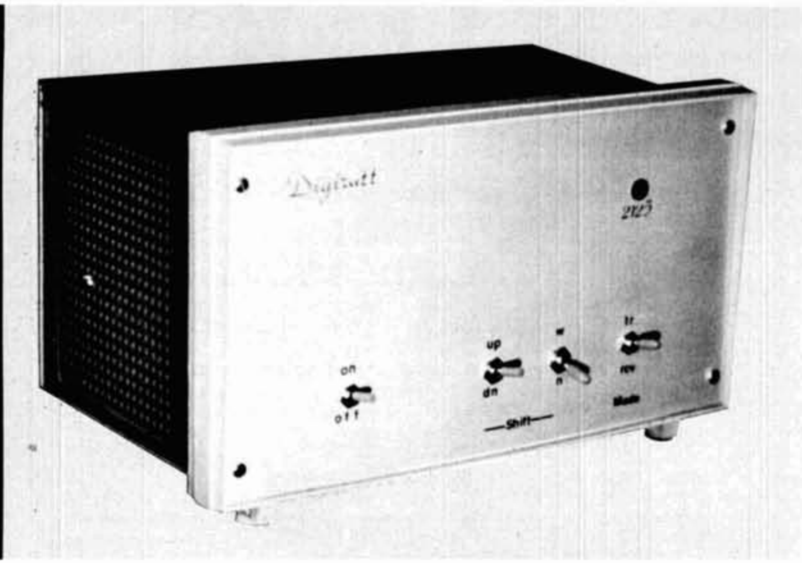
**ham radio**




# digiratt — RTTY AFSK generator and demodulator

Complete details for a precision AFSK generator and phase locked loop terminal unit

**The *Digiratt* is a complete** terminal unit and AFSK tone generator for use on the vhf bands. The tones are digitally synthesized and will remain accurate to within 0.1 Hertz. The terminal unit is a phase-locked loop unit which is capable of resolving 170-Hz narrow-shift as well as the 850-Hz shift normally found on the vhf amateur bands.

Briefly, the features of the *Digiratt* are,

**1.** Upward/downward operation by means of front panel switches.

**2.** Visual indication of 2125-Hz tones by means of an LED. No oscilloscope is needed for proper operation.

**3.** Built-in test functions for PLL alignment.

**4.** Constant system performance checking.

And finally, as noted above, long-term tone accuracy to 0.1 Hz in the AFSK generator. Additionally, a PLL terminal unit will inherently follow a drifting signal and copy signals which are missing mark or space information.

## circuit description

The demodulator (U1) compares the incoming frequencies to its internal current-controlled oscillator and generates a digital signal that indicates when the frequencies are identical. Additionally, the IC has provisions to lock the internal oscillator to the incoming signal, provided that signal is within the detection bandwidth. At 2125 Hz the detection bandwidth for this circuit is approximately 220 Hz, or 110 Hz either side of 2125 Hz, which is adequate for 170-Hz shift. At 2975 Hz the detection bandwidth is about plus or minus 135 Hertz. All bandwidth measurements were made with a 300 mV input signal. Although the oscillator can be shifted down below 1400 Hz, the detection bandwidth widens out to plus or minus 198 Hz, and 170-Hz copy becomes doubtful. Readers with this particular application are referred to a 567 specification sheet for bandwidth reduction suggestions.

The output of U1 is low with a detected input, and provisions have been made to invert that signal

**By John Loughmiller, WB9ATW,** Route 1, Box 480C, Borden, Indiana 47106

when required. A front panel switch selects either the 567 output or its complement (U2) to drive the selector magnet transistors, thereby resulting in either normal or reverse copy.

The selector magnet drivers, (Q1 and Q2), provide a current return path for the loop supply. This portion of the *Digiratt* is very similar to the NS-1A.[1]

## afsk generator

The precision AFSK generator consists of a master oscillator running at 5.95 MHz. A trimmer is provided for setting the frequency. However, since such a great division of the crystal frequency takes place, the oscillator can be off frequency 100 kHz and the resultant AFSK tone error will be 1 Hz or less. Counter U4 and U5 divide the frequency to 59.5 kilohertz. U6 further lowers the frequency to 5950 Hz and U8 divides it by two, resulting in a symmetrical 2975-Hz square wave at pin 12 of U8. U7 is a programmable counter which divides the 59.5 kHz down to 4250 Hertz. The other half of U8 next divides by two, resulting in a symmetrical 2125-Hz square wave at pin 9 of U8.

Square waves are very rich in harmonics. Therefore, the combination of R11, R12, C8, C9, C10 and C11 are used to turn the square waves into trapezoids. Diodes CR3 and CR4 then smooth the tops, resulting in 1 volt p-p quasi-sinewaves at the output.

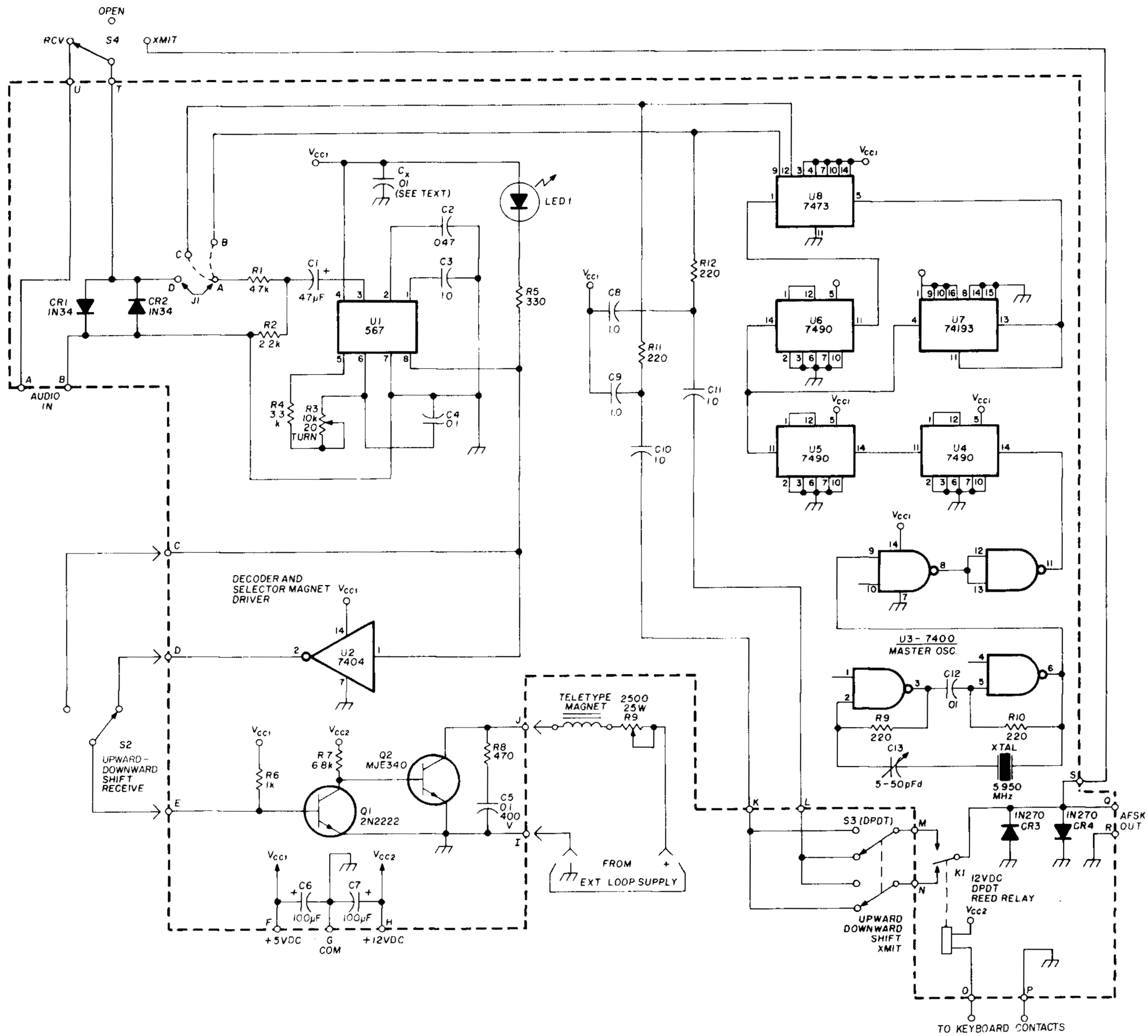



**fig. 1. Schematic diagram of the complete terminal unit. The dashed line indicates the components mounted on a circuit board. K1 is a 12-volt dpdt reed relay. The external loop supply is approximately 100 volts at 100 milliamperes.**

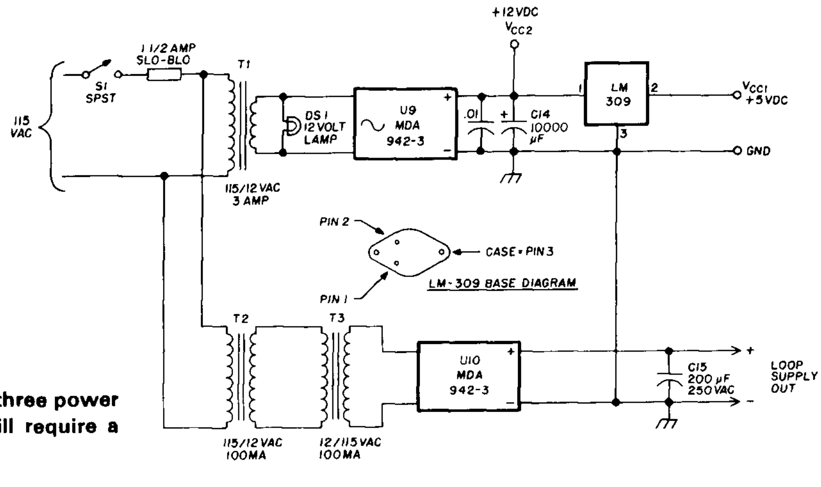



**fig. 2. Schematic diagram of the three power supplies. The 5-volt regulator will require a heatsink.**

If signals above 1 volt p-p are required, a simple transistor amplifier will be sufficient.

The power supplies are straightforward and the only minor precaution is to make sure the LM 309 is mounted on a heatsink. Also, don't fail to install C6 and C7 on the circuit board and bypass U1s pin 4 at the IC with a 0.01 μF capacitor. You may have to bypass the rest of the ICs at their $V_{CC}$ pins if you run into oscillation problems. A novel feature of the *Digiratt* is LED 1. When jumper J1 is in the A-B position, the PLL oscillator can be adjusted to the same frequency as the precision AFSK generator's 2125-Hz output. This assures correct PLL alignment. When the jumper is in the A-D position, the LED will light when receiving 2125-Hz signals from your receiver. An oscilloscope is not needed because a PLL only cares about the frequency within its bandwidth and disregards the other frequencies all together. This will be explained in more detail in the setup and operation section.

## construction

The prototype is housed in a 5 x 6 x 9 inch (12.7x15.2x22.9cm) cabinet. All power supplies, the loop supply, and the circuit board are mounted within the enclosure. Use care with lead routings; lead lengths should be kept to a minimum and ground loops should be avoided. If you are using the *Digiratt* in a high intensity rf field, use a single point-ground system on the ground returns.

## setup and operation

Set the master oscillator on frequency if you have a frequency counter. If you don't, C13 can be left 50 per cent meshed (the resultant error won't be more than 1 Hz at the output frequencies). Place jumper J1 in the A-B position and turn R3 all the way to one end. When the PLL is locked, LED 1 will come on. The final position for R3 should be midway or between the two dropout points. The PLL is now aligned to 2125 Hz and will not require any further adjustments unless 2125 Hz is no longer used. In that case, the PLL will have to be aligned to one of the two new frequencies. For normal amateur use you can set it to 2125 Hz and forget it.

Reconnect the jumper to A-D. Connect the unit to your vhf receiver and tune in an RTTY signal. Flip S2 to the opposite direction if the copy is garbled. That's all there is on vhf where the tones are fixed. For high-frequency use, adjust the receiver until the LED is blinking on and off as the tones shift. Again, flip S2 to clear up the copy. Make sure you have at least 200 mV of audio into the *Digiratt*. Diodes CR1 and CR2 will limit any excessive signals to a level the PLL can handle. Remember to keep the loop supply *off* the keyboard. This system encodes the keyboard output, then detects it to drive the selector magnet. This way you always know the complete system is working even in local loop operation. Also, you shouldn't use the AFSK generator on ssb in the high-frequency bands since the instantaneous switch points between tones contain no modulation. This would result in clicks being transmitted and a possible citation from the FCC.

One final note on the *Digiratt*: if you're a purist at heart and want perfect sine waves at the AFSK output, construct two pi-section filters using 88 mH toroids and place one in each line just ahead of relay K1. Diodes CR3 and CR4 will then have to be removed.

My thanks to Gus, K9FUI, who shared his considerable knowledge of *Teletype* machines with me and also to my wife, Donna, for her patience while I worked many late nights on the project.

## reference

1. Nathan H. Stinnette, "Update of the Phase-Locked Loop RTTY Demodulator," *ham radio*, August, 1976, page 16.

**ham radio**

# Vhf engineering

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

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| | | |
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| RX50C Kit | 30-60 MHz rcvr w/2 pole 10.7 MHz crystal filter | 59.95 |
| RX50C W/T | same as above–wired & tested | 104.95 |
| RX144C Kit | 140-170 MHz rcvr w/2 pole 10.7 MHz crystal filter | 69.95 |
| RX144C W/T | same as above–wired & tested | 114.95 |
| RX220C Kit | 210-240 MHz rcvr w/2 pole 10.7 MHz crystal filter | 69.95 |
| RX220C W/T | same as above–wired & tested | 114.95 |
| RX432C Kit | 432 MHz rcvr w/2 pole 10.7 MHz crystal filter | 79.95 |
| RX432C W/T | same as above–wired & tested | 124.95 |
| RXCF | accessory filter for above receiver kits gives 70 dB adjacent channel rejection | 8.50 |
| RF28 Kit | 10 mtr RF front end 10.7 MHz out | 12.50 |
| RF50 Kit | 6 mtr RF front end 10.7 MHz out | 12.50 |
| RF144D Kit | 2 mtr RF front end 10.7 MHz out | 17.50 |
| RF220D Kit | 220 MHz RF front end 10.7 MHz out | 17.50 |
| RF432 Kit | 432 MHz RF front end 10.7 MHz out | 27.50 |
| IF 10.7F Kit | 10.7 MHz IF module includes 2 pole crystal filter | 27.50 |
| FM455 Kit | 455 KHz IF stage plus FM detector | 17.50 |
| AS2 Kit | audio and squelch board | 15.00 |

### TRANSMITTERS

| | | |
|---|---|---|
| TX50 | transmitter exciter, 1 watt, 6 mtr | 39.95 |
| TX50 W/T | same as above–wired & tested | 59.95 |
| TX144B Kit | transmitter exciter–1 watt–2 mtrs | 29.95 |
| TX144B W/T | same as above–wired & tested. | 49.95 |
| TX220B Kit | transmitter exciter–1watt–220 MHz | 29.95 |
| TX220B W/T | same as above–wired & tested | 49.95 |
| TX432B Kit | transmitter exciter 432 MHz | 39.95 |
| TX432B W/T | same as above–wired & tested | 59.95 |
| TX150 Kit | 300 milliwatt, 2 mtr transmitter | 19.95 |
| TX150 W/T | same as above–wired & tested | 29.95 |

### POWER AMPLIFIERS

| | | |
|---|---|---|
| PA2501H Kit | 2 mtr power amp–kit 1w in–25w out with solid state switching, case, connectors | 59.95 |
| PA2501H W/T | same as above–wired & tested | 74.95 |
| PA4010H Kit | 2 mtr power amp–10w in–40w out–relay switching | 59.95 |
| PA4010H W/T | same as above–wired & tested | 74.95 |
| PA50/25 Kit | 6 mtr power amp, 1w in, 25w out, less case, connectors & switching | 49.95 |
| PA50/25 W/T | same as above, wired & tested | 69.95 |
| PA144/15 Kit | 2 mtr power amp–1w in–15w out–less case, connectors and switching | 39.95 |
| PA144/25 Kit | same as PA144/15 kit but 25w | 49.95 |
| PA220/15 Kit | similar to PA144/15 for 220 MHz | 39.95 |
| PA432/10 Kit | power amp–similar to PA144/15 except 10w and 432 MHz | 49.95 |
| PA140/10 W/T | 10w in–140w out–2 mtr amp | 179.95 |
| PA140/30 W/T | 30w in–140w out–2 mtr amp | 159.95 |

Blue Line . . . RF power amp, wired & tested, emission–CW-FM-SSB/AM

| Model | BAND | Power Input | Power Output | |
|---|---|---|---|---|
| BLC 10/70 | 144 MHz | 10W | 70W | 139.95 |
| BLC 2/70 | 144 MHz | 2W | 70W | 159.95 |
| BLC 10/150 | 144 MHz | 10W | 150W | 259.95 |
| BLC 30/150 | 144 MHz | 30W | 150W | 239.95 |
| BLD 2/60 | 220 MHz | 2W | 60W | 159.95 |
| BLD 10/60 | 220 MHz | 10W | 60W | 139.95 |
| BLD 10/120 | 220 MHz | 10W | 120W | 259.95 |
| BLE 10/40 | 420 MHz | 10W | 40W | 139.95 |
| BLE 2/40 | 420 MHz | 2W | 40W | 159.95 |
| BLE 30/80 | 420 MHz | 30W | 80W | 259.95 |
| BLE 10/80 | 420 MHz | 10W | 80W | 289.95 |

### POWER SUPPLIES

| | | |
|---|---|---|
| PS15C Kit | 15 amp–12 volt regulated power supply w/case, w/fold-back current limiting and overvoltage protection | 79.95 |
| PS15C W/T | same as above–wired & tested | 94.95 |
| PS25C Kit | 25 amp–12 volt regulated power supply w/case, w/fold-back current limiting and ovp | 129.95 |
| PS25C W/T | same as above–wired & tested | 149.95 |
| PS25M Kit | same as PS25C with meters | 149.95 |
| PS25M W/T | same as above–wired & tested | 169.95 |
| O.V.P. | adds over voltage protection to your power supplies, 15 VDC max. | 9.95 |
| PS3A Kit | 12 volt–power supply regulator card with fold-back current limiting | 8.95 |
| PS3012 W/T | new commercial duty 30 amp 12 VDC regulated power supply w/case, w/fold-back current limiting and overvoltage protection | 239.95 |

### REPEATERS

| | | |
|---|---|---|
| RPT50 Kit | repeater–6 meter | 465.95 |
| RPT50 | repeater–6 meter, wired & tested | 695.95 |
| RPT144 Kit | repeater–2 mtr–15w–complete (less crystals) | 465.95 |
| RPT220 Kit | repeater–220 MHz–15w–complete (less crystals) | 465.95 |
| RPT432 Kit | repeater–10 watt–432 MHz (less crystals) | 515.95 |
| RPT144 W/T | repeater–15 watt–2 mtr | 695.95 |
| RPT220 W/T | repeater–15 watt–220 MHz. | 695.95 |
| RPT432 W/T | repeater–10 watt–432 MHz. | 749.95 |
| DPLA50 | 6 mtr close spaced duplexer | 575.00 |
| DPLA144 | 2 mtr, 600 KHz spaced duplexer, wired and tuned to frequency | 379.95 |
| DPLA220 | 220 MHz duplexer, wired and tuned to frequency | 379.95 |
| DPLA432 | rack mount duplexer | 319.95 |
| DSC-U | double shielded duplexer cables with PL259 connectors (pr.) | 25.00 |
| DSC-N | same as above with type N connectors (pr.) | 25.00 |

### TRANSCEIVERS

| | | |
|---|---|---|
| TRX50 Kit | Complete 6 mtr FM transceiver kit, 20w out, 10 channel scan with case (less mike and crystals) | 229.95 |
| TRX144 Kit | same as above, but 2 mtr & 15w out | 219.95 |
| TRX220 Kit | same as above except for 220 MHz | 219.95 |
| TRX432 Kit | same as above except 10 watt and 432MHz | 254.95 |
| TRC-1 | transceiver case only | 19.95 |
| TRC-2 | transceiver case and accessories | 39.95 |

### SYNTHESIZERS

| | | |
|---|---|---|
| SYN II Kit | 2 mtr synthesizer, transmitt offsets programmable from 100 KHz–10 MHz, (Mars offsets with optional adapters) | 169.95 |
| SYN II W/T | same as above–wired & tested | 239.95 |
| MO-1 Kit | Mars/cap offset optional | 2.50 |
| TO-1 Kit | 18 MHz optional tripler | 2.50 |

### WALKIE-TALKIES

| | | |
|---|---|---|
| HT 144B Kit | 2 mtr, 2w, 4 channel, hand held transceiver with crystals for 146.52 simplex | 129.95 |
| NICAD | battery pack, 12 VDC, ½ amp. | 29.95 |
| BC12 | battery charger for above | 5.95 |
| Rubber Duck | 2 mtr, with male BNC connector | 12.95 |

### OTHER PRODUCTS BY VHF ENGINEERING

| | | |
|---|---|---|
| CD1 Kit | 10 channel receive xtal deck w/diode switching | $ 6.95 |
| CD2 Kit | 10 channel xmit deck w/switch and trimmers | 14.95 |
| CD3 Kit | UHF version of CD1 deck, needed for 432 multi-channel operation | 12.95 |
| COR2 Kit | carrier operated relay | 19.95 |
| SC3 Kit | 10 channel auto-scan adapter for RX with priority | 19.95 |
| Crystals | we stock most repeater and simplex pairs from 146.0-147.0 (each) | 5.00 |
| CWID Kit | 159 bit, field programmable, code identifier with built-in squelch tail and ID timers | 39.95 |
| CWID | wired and tested, not programmed | 54.95 |
| CWID | wired and tested, programmed | 59.95 |
| MIC I | 2,000 ohm dynamic mike with P.T.T. and coil cord | 12.95 |
| TS1 W/T | tone squelch decoder | 59.95 |
| TS1 W/T | installed in repeater, including interface accessories | 89.95 |
| TD3 Kit | 2 tone decoder | 29.95 |
| TD3 W/T | same as above–wired & tested | 39.95 |
| HL144 W/T | 4 pole helical resonator, wired & tested, swept tuned to 144 MHz ban | 24.95 |
| HL220 W/T | same as above tuned to 220 MHz ban | 24.95 |
| HL432 W/T | same as above tuned to 432 MHz ban | 24.95 |

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# pi network design and analysis

A new approach to the design of pi networks for amateur transmitting equipment which allows the designer to determine how the network will perform at different frequencies, with varying antenna loads

**Simplified procedures for the** design of pi networks have appeared in numerous magazine articles and are included in the *ARRL Handbook* and other reference books. No equation solving is required with these procedures since the design data is provided in terms of inductance and capacitance which the user reads directly from tables or curves.[1-6] All of these data are based upon the three classic reactance equations for the design of pi networks.

However, the simplicity afforded by these procedures is not obtained without penalty. Only design center information is provided, and in some cases the network may not perform as expected. Characteristics which are of prime importance to the amateur, *e.g.,* the usable tuning range, and the tolerable limits of load variation due to the vswr of the antenna system, cannot be evaluated so the serious designer is handicapped. It is not unusual to encounter circumstances where the loading control exhibits less than normal effectiveness, and it is difficult or impossible to obtain normal plate current loading. Some contemporary commercially designed equipment, as well as homebrewed equipment, will exhibit this condition unless the vswr of the transmitter load is kept very close to 1:1.

Prior amateur literature is virtually void of discussion on the behavior of pi networks when the operating conditions depart from the values used for the initial design of the network. More often than not such departure is normal in amateur operations; therefore, an investigation along these lines appeared to be a project worth pursuing. Some unexpected and very interesting results came from this work, including the development of a new procedure for the design and performance evaluation of pi networks, and discrete criteria for determining when supplemental impedance transformation must be used.

These developments were based upon two relatively obscure equations which also provided the *seed* from which other equations used in the procedure were derived. Compared with contemporary design methods, more work is involved in the application of the new procedure, but the benefits of greatly increased design control, and the addition of a means for performing detailed performance analysis, are substantial compensation for the added effort.

The objectives of this article are twofold: first, to describe the practical application of the new design procedure, and secondly, to provide some insight into the analysis which led to its development. Readers who shy away from the mathematical discussions should note that numerical solutions of all the equations in this article require only basic arithmetic and square-root operations — the modern, hand-held calculator is completely adequate for designing a new pi network, or for analyzing an existing one.

It should be understood at the outset that no lack of generality is inferred by having oriented the following discussions in terms of networks for use with vacuum-tube amplifiers. This approach was chosen because of the widespread application of tube amplifiers, and the probable continued use of vacuum tubes in the final stages of amateur transmitters for some time to come. However, readers should find it amply apparent that the equations and design procedures presented in this article can be applied to the design of any lowpass pi network where there is no provision for adjustment of the inductive branch.

## design equations

The basic pi network is shown in **fig. 1A**. When used for coupling a low impedance load to a vacuum

**By Earl W. Whyman, W2HB,** 375 Mount Vernon Road, Snyder, New York 14226

tube, $C1$ is the loading control and $C2$ is the plate tuning control, $R1$ represents the external load impedance, and $R2$ is the required plate load resistance as measured at terminals 1 and 2. In network design and analysis work, however, reactance terms must be used in place of inductance and capacitance, and the component designators are modified as shown in **fig. 1B**. With very few exceptions reactance terms are used throughout the text of this article.

**Equations 1, 2** and **3**, or minor variations thereof, are the three classic pi network design equations upon which the simplified design procedures are based

$$X_{C2} = \frac{R2}{Q} \quad (1)$$

$$X_{C1} = R1\sqrt{\frac{R2}{R1(Q^2+1)-R2}} \quad (2)$$

$$X_L = \frac{QR2 + \frac{R1R2}{X_{C1}}}{Q^2+1} \quad (3)$$

These equations are used to calculate the three network reactances when appropriate values are substituted for $R1$, $R2$, and $Q$. Normally the nominal antenna load impedance of 52 ohms is substituted for $R1$; $R2$ is the required plate load resistance; and $Q$ is selected in the range from 10 to 20.

## analysis considerations

In class-AB1 and class-B linear amplifiers the dc plate current, and the linearity of the amplifier, depend upon the value of plate load resistance. Thus the optimum value of plate load resistance is coincident with a specific value of plate current to which the amplifier must always be adjusted; this load must also be non-reactive. In a properly neutralized amplifier the latter requirement is obtained by tuning to the center (minimum current point) of the plate current dip. The adjustment procedure consists of alternately adjusting $C1$ and $C2$ until the specified value of plate current is obtained at the dip point.

Since capacitors $C1$ and $C2$ are the only network adjustments, they must permit the optimum value of plate load resistance to be maintained regardless of changes in operating frequency and/or changes in antenna load impedance. Thus, an analysis of network performance with respect to any external influence which will effect its adjustment must be made in terms of the requirements imposed upon $C1$ and $C2$.

It might be expected that **equations 1** and **2** could be used for this purpose. However, their use is precluded by the presence of $Q$ in both equations, and the lack of $R1$ as a factor in **equation 1**. $Q$ is not an independent variable and therefore does not remain constant as the frequency and/or the value of $R1$ is changed. The following equations are elegantly suited to the desired analysis because they are totally free of such limitations

$$X_{C1} = \frac{R1X_L}{R1+\sqrt{R1R2-X_L^2}} \quad (4)$$

$$X_{C2} = \frac{R2X_L}{R2+\sqrt{R1R2-X_L^2}} \quad (5)$$

In these equations the reactance of $C1$ and $C2$ is stated in terms of the independent variables $R1$ and $X_L$; $R2$ is treated as a constant. These equations were first derived by classical methods, and can be found in the 1932 edition of Everitt's *Communications Engineering*.[7] It is strange that these equations have been available for more than 40 years but have been neglected in the amateur literature except for a footnote reference by George Grammer in *QST* in 1957.[3]

Since the pi network is usually used to provide a match between two dissimilar impedances, its basic symmetry is easily overlooked, and the identical forms of **equations 4** and **5** may be surprising. They are markedly different from **equations 1** and **2**, just as **equations 1** and **2** have no resemblance to each other and give no clue to as to the symmetry of the pi network.

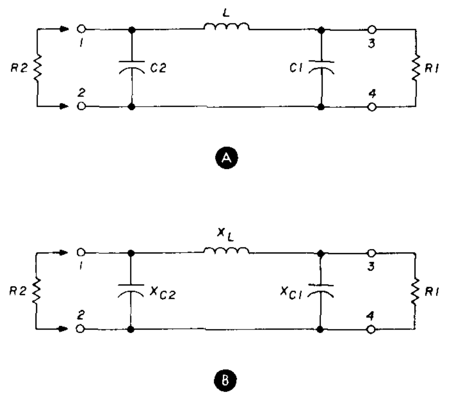


**fig. 1. Basic pi network used for impedance matching in rf power amplifiers. In *A* $R1$ is the load impedance (usually 52 ohms), $R2$ is the plate load impedance, $C1$ is the loading control, $C2$ is the tuning control, and $L$ is the fixed inductor. *In the circuit in B the inductor and capacitors are shown as reactance terms.***

Curves showing the relationships expressed in **equations 4** and **5** are plotted in **fig. 2**. These curves are based upon an arbitrary prototype network designed to provide a plate load resistance of 2500 ohms and to accommodate variations in output load impedance in a nominal 52-ohm antenna system. The data for plotting the curves was obtained from repeated solutions of **equations 4** and **5** with a value of 200 ohms for $X_L$, and $R1$ varied incrementally from 16 ohms (the value of $R1A$ in this case) to over 100 ohms.

Frequent reference to these curves, and particularly the points designated as $R1A$ and $R1B$, will occur throughout the following text. Equations for the determination of the value of $R1$ at these points, and a discussion of the significance of each point will be covered later.

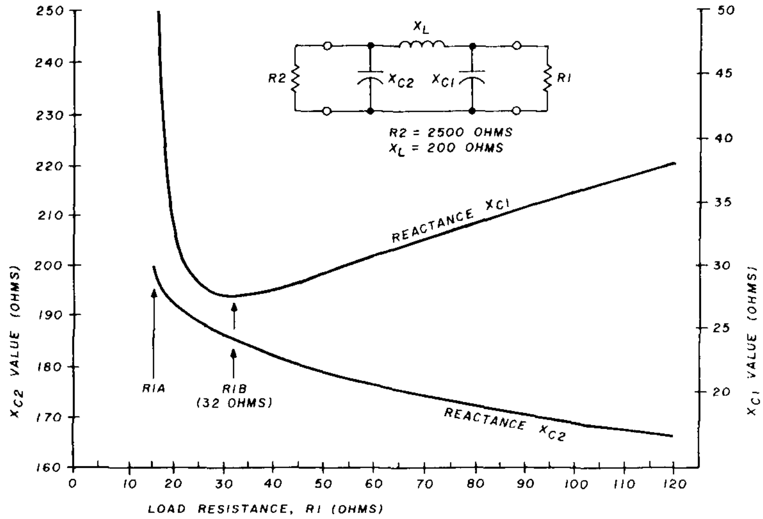


**fig. 2. Plot of capacitive reactance $X_{C1}$ and $X_{C2}$ vs load resistance, $R1$. Note that the $X_{C1}$ curve is double valued; for most designs values below point $R1B$ should be avoided (see text). Slope of reactance curve above $R1A$ is excessive and may result in critical tuning.**

Comment on the curve of $X_{C2}$ (plate tuning) is necessarily brief since it has no unusual or critical characteristics. Operation is smooth and continuous throughout its required tuning range, and the moderate change in tuning rate is of no consequence. No operational problems should exist as long as sufficient capacitance range is available.

Cause for design and operational problems with the pi network is apparent in the characteristics revealed by the curve $X_{C1}$. In terms of $R1$, the $X_{C1}$ curve is double valued for all values of $X_{C1}$ except the minimum. These dual values of $R1$ cause two mutually inverted calibrations to exist for the loading control, effectively dividing the $R1$ range into two sections. Division occurs at the point $R1B$ so that all values of $R1$ less than $R1B$ may be defined as being in the *minor section*, while all values of $R1$ above and including $R1B$ may be defined as being in the *major section*. It is preferable to design the network so operation is confined to only the *major section*. When this is done, ambiguity is avoided with respect to the direction of loading control rotation to obtain increased loading, there is no confusing area of dual and inverted calibrations, and the tuning rate of the loading control does not change drastically.

The minimum point of the $X_{C1}$ curve locates the value of $R1$ below which undesirable changes in the network's operating characteristics begin to take place. If a sufficiently low value of $R1$ cannot be obtained at $R1B$, the designer must either use a supplemental impedance transformation, or resort to a compromise design with a part of the *minor section* included in the operating range. The latter option is not an unconditional alternative since only limited extension of the $R1$ range can be obtained in this way. The conditions associated with this limitation, and a design criteria for applying the compromise design, will be discussed later.

## significance of $R1A$ and $R1B$

Mathematical proof can be given, but it will suffice to state here that solutions of **equations 4** and **5** are valid for this analysis only when the quantity under the radical sign is equal to or greater than zero. Since the plate load resistance, $R2$, must remain constant and the $R1R2$ product cannot be less than $X_L^2$, $R1$ is limited accordingly to a critical minimum value. An equation defining the critical value of $R1$ is obtained when the expression under the radical sign is equated to zero, and then solved for $R1$.

$$R1R2 - X_L^2 = 0 \qquad \textbf{(6A)}$$

$$R1R2 = X_L^2 \qquad \textbf{(6B)}$$

$$R1\ (\text{critical}) = R1A = \frac{X_L^2}{R2} \qquad \textbf{(6C)}$$

From these equations it can be seen that whenever $R1$ is less than $R1A$ the network cannot be adjusted to provide the required value of $R2$; the maximum plate-current loading, therefore, will be less than normal.

It is worth noting that a unique but seldom used condition exists when the product $R1R2$ is equal to $X_L^2$, causing the radical term to become zero. The remaining $R1$ and $R2$ terms cancel out in **equations 4** and **5**, with the result that both $X_{C1}$ and $X_{C2}$ equal $X_L$! This is the familiar situation when the pi network behaves like a one-quarter wavelength section of transmission line with a characteristic impedance equal to $X_L$. This form of the pi network has been used in cascaded pairs to form an effective narrowband harmonic suppression filter.

The value of $R1$ at the minimum point of the $X_{C1}$ curve is designated $R1B$, and as the following derivation will show, it is always twice the value of $R1A$. Subsequent discussions will also show that $R1B$ is a major factor influencing the design of any pi network. Since, by definition, $R1B$ is the value of $R1$ at the minimum point (point of zero slope of the $X_{C1}$ curve), the derivation of the equation for $R1B$ involves the application of differential calculus. Thus the prerequisite slope equation* (**equation 7**) is derived from **equation 4**, then equated to zero and solved for $R1$ to obtain the equation for $R1B$. Initially **equation 7** appears somewhat formidable, but its terms contain only three factors, and considerable cancellation may be performed when it is equated to zero and solved for $R1$.

$$S = \frac{X_L(R1R2 - 2X_L^2)}{[2\sqrt{R_1R_2 - X_L^2}\,][R_1 + \sqrt{R_1R_2 - X_L^2}\,]^2} \qquad \textbf{(7)}$$

where $S=$ slope of the $X_{C1}$ *curve. Substituting zero for S*, and solving for $R1$†,

$R1$ (at minimum point of $X_{C1}$ curve) $=$

$$R1B = \sqrt{\frac{2X_L^2}{R_2}} \qquad \textbf{(8)}$$

## factors $T_r$ and $K$

Both $T_r$ and $K$ are simple dimensionless ratios which are inversely proportional to the value of $R1B$; since they are important factors in some of the following equations, it's important to define them.

**1.** $T_r$ is the ratio of $R2$ to $R1B$ ($R2$ divided by $R1B$); therefore $T_r$ represents the transformation ratio of the network when, and only when, $R1 = R1B$.

**2.** $K$ is the ratio of $R1$ to $R1B$ ($R1$ divided by $R1B$); it is the value of R1 normalized with respect to $R1B$. Values of $K$ below 1.0 are in the *minor section* of the network, whereas values of $K$ of 1.0 or above are in the *major-section* of the network. $K$ can never be less than 0.50, and although there is no maximum limit for $K$, it will seldom be greater than 6.0.

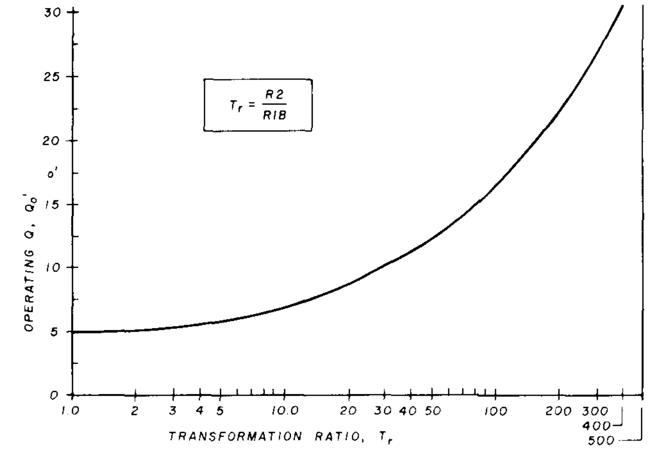


**fig. 3. Operating $Q$ ($Q_o$) of a pi network versus the impedance transformation ratio, $T_r$.**

The dominant component of the pi network is the series-connected reactance. In transmitter output circuits this component is usually an inductor so the network functions as a lowpass filter as well as an impedance transformer, and useful attenuation of harmonic energy is obtained. An equation for determining the required reactance of this inductor may be derived by keeping the definition of $T_r$ in mind and re-arranging **eq. 8**.

$$X_L = \frac{R2}{\sqrt{2T_r}} \qquad \textbf{(9)}$$

Inasmuch as the value of $R2$ (plate load resistance) is fixed by the design specifications, $T_r$ is the only *independent variable in this equation which the designer* can use to control the value of $X_L$. However, this control by way of selecting the value of $R1B$, and $R1B$ must be limited to only those values which will place the operating $Q$ of the network ($Q_o$) within the range of 10 to 20. These limits represent a prudent compromise between harmonic attenuation and network efficiency. Harmonic attenuation deteriorates rapidly as $Q_o$ falls below 10; network losses become excessive as $Q_o$ approaches 20. Roughly speaking, changes in $Q_o$ between these limits is accompanied by an 8 dB change in harmonic attenuation, and a 3 dB change in power loss. For the general case the operating $Q$ of a pi network is defined as

$$Operating\ Q = Q_o = \frac{R1 + R2 + 2\sqrt{R1R2 - X_L^2}}{X_L} \qquad \textbf{(10)}$$

*Derivation of this and other equations is available from *ham radio* upon receipt of a self-addressed, stamped envelope.

†Theoretically, in any given pi network $R1$ can be *increased* without limit. In practice, however, excessive circuit losses ultimately restrict the maximum usable value. As $R1$ is increased, $Q_o$ also increases, causing the ratio of unloaded to loaded $Q$ to become progressively lower, and more power to be dissipated in the inductor. The effect is shown in the following data which is based upon the prototype network, and the assumption of an unloaded $Q$ of 300. As a general rule it is advisable to avoid values of $R1$ greater than six times $R1B$.

| R1 | $Q_o$ | power lost | |
|---|---|---|---|
| 52 | 15.76 | −0.23dB | 5.25% |
| 100 | 17.58 | −0.26dB | 5.86% |
| 200 | 20.28 | −0.30dB | 6.76% |
| 500 | 26.00 | −0.39dB | 8.67% |
| 1000 | 33.18 | −0.51dB | 11.06% |
| 5000 | 72.80 | −1.21dB | 24.27% |

This equation can be used to compute $Q_o$ for any value of $R1$ within the operating range of pi network.

Note that **equation 10** differs considerably from the equation, $Q = R2/X_{C2}$, shown in the handbooks.* Errors as great as minus 50% will result when the handbook equation is used to compute $Q$ for pi networks having a very low impedance transformation ratio; errors between 6% and 20% can be expected for pi networks commonly used in vacuum-tube linear amplifiers. An example of typical errors may be seen in the following data calculated for the prototype network at three values of output load resistance.

| Load resistance, $R1$ | **26** | **52** | **104** |
|---|---|---|---|
| $Q_o$ (from **eq. 10**) | 14.21 | 15.76 | 17.71 |
| $Q$ (**eqs. 1, 2, 3**) | 13.29 | 14.00 | 14.85 |
| Error | − 6.48% | − 11.17% | − 16.18% |

For the particular case where $R1$ is equal to $R1B$, the operating $Q$ is designated as $Q_o'$

$$\text{Operating } Q \text{ at } R1B = Q_o' = 2 + \sqrt{2(T_r + \frac{1}{T_r} + 2)} \quad \textbf{(11A)}$$

where $T_r = R2/R1B$. When $T_r$ is equal to or greater than 5, the following equation can be used with less than 1% error.

$$Q_o' = 2 + 2\sqrt{\frac{T_r}{2} + 1} \quad \textbf{(11B)}$$

**Equation 11** is unique, and indeed remarkable, because it shows that $Q_o'$ is dependent *only* upon the transformation ratio, $T_r$, a value readily obtained by dividing $R2$ by $R1B$. Therefore, a graph of **equation 11** is universally applicable to all pi networks that fall within the range of the scales chosen for $Q_o'$ and $T_r$! Thus the graph of **fig. 3**, or **equation 11**, is invaluable for determining a value for $T_r$ that will result in an acceptable value of $Q_o'$. This value of $T_r$ is then used in **equation 9** to obtain the value for $X_L$.

However, if it is found that $R1B$ must be greater than desired, and the difference is too great to consider the application of a compromise design, it indicates that the pi network by itself cannot satisfy the design requirements, and supplemental impedance transformation must be used. Values of $T_r$ high enough to cause this condition are likely to occur in the design of pi networks intended for use with tubes that require a high plate load resistance such as the 4-1000A. In these cases a pi network by itself will usually fail to provide matching capability for loads much below 52 ohms, since the 52-ohm load point may already be well within the network's *minor section*.

*The error due to the design procedure using **equations 1, 2,** and **3**. These equations treat the pi network as two back-to-back L-networks. The selected value of $Q$ applies only to the input section. It can be shown that the overall operating or loaded $Q$ of the network is the sum of the input section $Q(R2/X_{C2})$ and the output section $Q(R1/X_{C1})$. Therefore, the operating $Q$ will always be higher than the selected $Q$ when using this design procedure.
**Editor**

## pi network design

A step-by-step procedure for the design of pi networks, based on the technique discussed in the previous text, will clarify any questions you may have about this method. A pi network will be designed to match a plate load resistance of 2500 ohms to a nominal 52-ohm system, and will accommodate antenna load variations which might be expected in an amateur station. Operating $Q$ is not specified since it is standard practice to keep $Q_o$ within the range from 10 to 20, and to favor the lower values of $Q_o$ in the interest of circuit efficiency.

**Preliminary considerations.** When a maximum vswr of 2:1 is expected, and the nominal impedance of the antenna system is 52 ohms, the load on the pi network can be any value from 26 to 104 ohms. This impedance range can be covered in the *major section* of a network if $R1B$ is chosen as 26 ohms, and $Q_o'$ does not exceed 15. This limitation on $Q_o'$ is required if $Q_o$ is not to exceed the limit of 20 at the maximum value of R1 (104 ohms). In the following procedure the **steps 1** and **2** will either confirm that $R1B$ can be 26 ohms or provide a value which will enable the $Q_o$ limitation to be maintained.

**1.** Determine value of $Q_o'$ for desired value of $R1B$; use **fig. 3** or **eq. 11**. (For prototype network $T_r = 96.15$ when $R1B$ is 26 ohms, thus from **fig. 3**, $Q_o' = 16$).

**2.** If $Q_o'$ from **step 1** is greater than 15, the value of $R1B$ is too small. Increase the value of $R1B$ by an appropriate increment and repeat **step 1**; repeat **steps 1** and **2** until $Q_o'$ is less than 15. For the prototype network the value of $R1B$ was increased in 2-ohm steps, yielding the following values for $Q_o'$:

| $R1B$ | $T_r$ | $Q_o'$ |
|---|---|---|
| 26 | 96.15 | 16.00 |
| 28 | 89.29 | 15.51 |
| 30 | 83.33 | 15.06 |
| 32 | 78.125 | 14.66 |

**3.** Compute the value of $K$ for the minimum value of $R1$. If the value of $K$ is less than 0.8, see the discussion under *compromise design* (page 36). For the prototype design, $K = 0.81$.

**4.** Compute the value of $X_L$. Use $T_r$ from **step 2** in **eq. 9**. For the prototype network $X_L = 200$ ohms since $T_r = 78.125$.

**5.** Use **eq. 10** to compute $Q_o$ for the upper and lower table 1. Twelve complex impedance values which fall on a 2:1 vswr circle plotted on a Smith chart (fig. 4), and the required pi-network reactance values required to provide a match to a plate load resistance of 2500 ohms.

| point on 2:1 vswr circle (fig.4) | worst-case antenna load impedance | | equivalent parallel components | | required $X_{C1}$ | required $X_C$ of loading control, C1 | required $X_{C2}$ |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G |
| 1. | 26.00 | j 0.0 | 26.00 | + inf. | 28.24 | 28.24 | 188.10 |
| 2. | 27.38 | -j 10.27 | 31.23 | -j 83.27 | 27.59 | 41.27 | 185.52 |
| 3. | 32.00 | -j 20.78 | 45.50 | -j 70.05 | 28.70 | 48.62 | 180.40 |
| 4. | 41.60 | -j 31.20 | 65.00 | -j 86.67 | 31.33 | 49.06 | 175.44 |
| 5. | 59.43 | -j 38.60 | 84.50 | -j 130.10 | 33.91 | 45.87 | 171.60 |
| 6. | 86.60 | -j 32.47 | 98.77 | -j 263.40 | 35.68 | 41.27 | 169.21 |
| 7. | 104.00 | -j 0.0 | 104.00 | + inf. | 36.30 | 36.30 | 168.40 |
| 8. | 86.60 | +j 32.47 | 98.77 | +j 263.40 | 35.68 | 31.42 | 169.21 |
| 9. | 59.43 | +j 38.60 | 84.50 | +j 130.10 | 33.91 | 26.90 | 171.60 |
| 10. | 41.60 | +j 31.20 | 65.00 | +j 86.67 | 31.33 | 23.01 | 175.44 |
| 11. | 32.00 | +j 27.80 | 45.50 | +j 70.05 | 28.70 | 20.36 | 180.40 |
| 12. | 27.38 | +j 10.27 | 31.23 | +j 83.27 | 27.59 | 20.73 | 185.52 |

A. Resistive component of the load impedance.
B. Reactive component of the load impedance.
C. Equivalent parallel resistance of the load impedance.
D. Equivalent parallel reactance of the load impedance.
E. Required reactance of $X_{C1}$ (based upon resistance value in column **C**).
F. Required reactance of the loading control capacitor (obtained by combining values shown in columns **D** and **E**).
G. Required reactance of $X_{C2}$ (based upon resistance value in column **C**).

limits of the $R1$ range. If the values of $Q_o$ are not within the range from 10 to 20, use one of the following alternatives:

**A.** Determine whether or not a modification of the value of $R1B$ will resolve the problem.

**B.** Use the design as is but be aware of its limitations and change operating specifications accordingly.

**C.** Use the design as is and use an antenna tuner to limit the vswr at the transmitter.

**D.** Redesign the pi network for use with supplemental impedance transformation.

For the prototype network $Q_o = 14.21$ when $R1$ is 26 ohms, and $Q_o = 17.71$ when $R1$ is 104 ohms.

**6.** Compute the values of $X_{C1}$ and $X_{C2}$ for the upper and lower limits of the $R1$ range; use **eqs. 4** and **5**. For the prototype network see **table 1**, lines 1 and 7, columns E and F.

**7.** Compute the capacitance values at the desired frequency of operation using the values of $X_{C1}$ and $X_{C2}$ from **step 6**. See **table 1** for prototype network values.

**8.** Compute the inductance value for the desired operating frequency using the value of $X_L$ found in **step 4**. For the prototype network $L = 8.51 \mu H$ when $f_o = 3.74$ MHz, the geometric center frequency of the amateur 80-meter band.*

Pi networks that operate at low values of $Q_o$ are frequently used as input and output circuits for *solid-state* devices. These are fixed-tuned networks designed for singular values of $R1$ and $R2$, and a particular value of $Q_o$ to exist at $f_o$, the geometric center frequency of the network. The design procedure for this type of network is appreciably less complex than that for tunable networks, and **equation 12** below is particularly useful since $X_L$ can be determined directly as a function of $R1$, $R2$, and $Q_o$. The values of $X_{C1}$ and $X_{C2}$ then follow directly from the use of **equations 4** and **5**. The design should not be considered complete, however, until the value of $K$ for $R1$ has been computed and judged to be acceptable. The value of $R1B$ which is needed for this calculation is found with **equation 8**.

Values of $K$ that are not less than 0.70 are acceptable for fixed-tuned networks, whereas values of $K$ that are less than 0.65 should definitely be avoided; otherwise, the network will be difficult to adjust. When the value of $K$ must be increased, it can only be done by an increase in the value of $Q_o$.

$$X_L = (R1 + R2)\ \frac{Q_o^{\,2} + \sqrt{Q_o^{\,2} - \left(Q_o^{\,2} + 4\right)\left(\frac{R2 - R1}{R1 + R2}\right)^2}}{Q_o^{\,2} + 4} \qquad (12)$$

## effects of antenna load impedance

Load impedance matching capability is succinctly specified for transmitters in terms of a maximum allowable vswr and a system characteristic impedance. In most cases the values specified for amateur equip-

*A series of HP-25 programs for designing pi-networks, plotting frequency responses, checking the impedance matching range, and selecting inductance and capacitance values are available for $2.50 postpaid from Calculator Design, Box 429, Hollis, New Hampshire 03049.

ment are a vswr of 2:1 and a system impedance of 52 ohms. Impedance values from 26 to 104 are therefore permissible at the transmitter's output terminals, and the impedance will usually be complex (containing both reactance and resistance). Specific values are readily determined with a Smith chart on which a 2:1 vswr circle has been inscribed; the output network of the transmitter should be capable of transforming any impedance whose coordinates are located on or within this circle to a pure resistance equal to $R2$.

Matching is most difficult for the loads associated with the highest vswr values; therefore, the loads with coordinates located on the circle constitute the worst-case requirements of the design specification. There are an infinite number of impedance coordinates located on the 2:1 vswr circle, so it's impractical to evaluate network performance for all of them. However, an adequate evaluation can be performed by using the twelve values of impedance whose coordinates are located by the dots on the vswr circle shown in **fig. 4**. The resistive and reactive components of these twelve impedance values and their

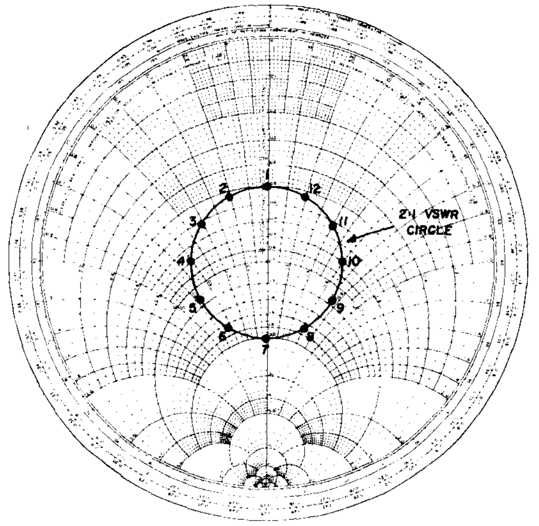


**fig. 4. Normalized Smith chart plot of worst-case load impedance for a 2:1 vswr. These impedance points are used in the evaluation of the pi network (see table 1).**

equivalent parallel components, are included in **table 1**.

The equivalent parallel components are included because they are essential for computing the effect of each load impedance on the adjustment of the pi network. And since these components are in parallel with the loading control capacitor, $C1$, the effective parallel resistance is the value of $R1$ loading the network, and the effective parallel reactance must be combined with the reactance of the loading control capacitor so the net value is equal to the required value of $X_{C1}$. Using the prototype network as an example, calculations were made to determine the required value of $X_{C1}$, $X_{C2}$, and the reactance of the loading control capacitor for each of the worst-case load impedances; these data complete **table 1**. The required capacitance ranges of the plate-tuning and loading-control capacitors can be computed from the minimum and maximum values of reactance contained in columns **F** and **G** of **table 1**. Based upon the geometric center frequency of the 75-meter band (approximately 3.74 MHz) these ranges are

| | |
|---|---|
| Plate tuning | 226 to 253 pF |
| Loading Control | 867 to 2089 pF |

Additional calculations can be made to prepare charts similar to **table 1** for the low- and high-frequency band edges. In these calculations the value of $X_L$ must be changed in proportion to the change in frequency; thus $X_L$ becomes 186.92 ohms at 3.5 MHz, and 214.0 ohms at 4.0 MHz. Using these values of $X_L$ in **equations 4** and **5**, the tabulated reactance data results in the following final capacitance ranges

| | |
|---|---|
| Plate tuning | 196 to 290 pF |
| Loading Control | 705 to 2395 pF |

Since the operating $Q$ changes as the frequency and/or load resistance changes, it is advisable to check the value of $Q_o$ at different frequencies and load values. Using **equation 10**, the values computed for the prototype design are

| frequency | 26-ohm load | 104-ohm load |
|---|---|---|
| 3.50 MHz | $Q_o = 15.37$ | $Q_o = 19.01$ |
| 3.74 MHz | $Q_o = 14.21$ | $Q_o = 17.71$ |
| 4.00 MHz | $Q_o = 13.10$ | $Q_o = 16.49$ |

## compromise designs

A compromise design of the pi network was defined previously as extending the operating range into the *minor-section*. Although this mode of operation is less than ideal in some respects, its objectionable characteristics can be minimized by proper design; in addition, it may offer the only means for meeting some specifications that would otherwise require the use of supplemental impedance transformation.

To understand the limitations that restrict the extent to which the *minor-section* can be used, refer to **fig. 2** and the curve of $X_{C1}$. The slope of the $X_{C1}$ curve progressively increases in the *minor-section* so that virtually all tuning control is ultimately lost as $R1$ approaches the value of $R1A$. Although it is technically valid for $R1$ to have any value down to and including $R1A$, the minimum value of $R1$ must be limited if the region of excessive slope is to be avoided.

Evaluating the degree of slope is easily done by the use of **equation 7**, and in general it is desirable to limit the slope at the minimum point of $R1$ so it does not exceed approximately 2.5 times the slope where $K$ is equal to 1.5. These calculations are not difficult to make, but they are time consuming and cumbersome, and can be avoided by using the value of $K$ at the minimum point of $R1$ as the sole criterion. When this value of $K$ is not less than 0.80, the slope ratio will closely approximate 2.5 as a maximum.

The practical significance of permitting a slope ratio of 2.5 is its indication that the adjustment of the loading control will be 2.5 times as broad at the minimum point of $R1$ as it is for the values of $R1$ in most of the *major-section*. Therefore a drastic change in tuning *feel* does not take place. Another point is the considerable response assymetry which the loading control exhibits as it is adjusted to either side of a particular point in the *minor-section*. The continually increasing slope of the $X_{C1}$ curve is the cause of this effect, and the degree of severity increases as lower values of $R1$ are used.

The following chart shows how rapidly the slope ratio increases as the value of $K$ is decreased; it may be used by the designer as an indication of what to expect if a $K$ of less than 0.80 is used.

| $K$ | slope ratio |
|---|---|
| 0.80 | 2.5 |
| 0.70 | 6.6 |
| 0.65 | 11.5 |
| 0.60 | 23.5 |
| 0.55 | 67.4 |

When the value of $K$ at the minimum point of $R1$ is close to but less than 0.80, the designer may find it helpful to know what this out-of-limit condition means in terms of $R1$, i.e., what is the value of $R1$ when $K = 0.80$, and how does it compare with the desired minimum value of $R1$? This information is obtained by simply multiplying the value of $R1B$ by 0.80 and comparing the result with the desired minimum value of $R1$.

From the foregoing it is apparent that it may be necessary to modify some design specifications to permit the use of the pi network by itself. In addition, some specifications will be such that they are realizable by only the addition of supplemental impedance transformation.

Since output loads below 32 ohms are in the *minor-section* of the prototype network the operation of this network with the loads defined in the analysis would require its classification as a compromise design. At $f_o$, or the frequency where $X_L = 200$ *ohms*, $K = 0.81$ when the load is 26 ohms. If $f_o = 3.74$ *MHz*, and a load of 26 ohms is maintained, $K$ will become 0.93 and 0.71 at 3.5 MHz and 4.0 MHz, respectively. The value of $K$ at 4.0 MHz (0.71) is appreciably below the limit recommended above; in fact, $K$ is out of limit for all frequencies above 3.8 MHz.

## the pi-L network

From **fig. 3** it is apparent that pi networks can be operated at high impedance transformation ratios if no limit is placed on the maximum value of $Q_o'$. However, the trade-off is excessive power loss in the network inductor, in even moderate power rf power amplifiers. Minimizing this source of power loss is the primary purpose for using supplemental impedance transformation; it also provides a match to a greater range of load impedances and avoids any need for operating the pi network in its *minor-section*.

The L-network is by far the best choice for providing the supplemental impedance transformation.* Its efficiency is superior to that of any other network, and only one inductor must be added to form the pi-L combination. **Equation 12** has been specially formulated for determining the required reactance of the L-section inductor for load vswr up to 2:1.

Reactance of L-section inductor =

$$X_L' = \sqrt{Z_o(2R1B = Z_o)} \quad (12)$$

In this equation $Z_o$ is the characteristic impedance of the antenna system, and the value of $R1B$ is obtained from the graph of **fig. 3** and the known relationship between $R2$ and $T_r$. In this use of **fig. 3**, $Q_o'$ may be assigned any desired value as long as the resulting value of $R1B$ is not less than one-half the value of $Z_o$. Contrary to contemporary design practice, it is not sufficient to assign an arbitrary transformation ratio to the L-section. The value should be no more than is necessary to allow the pi section to operate in its *major-section*.

A step-by-step procedure for designing a pi-L network (such as might be used with a 4-1000A) is included here as a design example. For this example the following specifications were assumed:

*When supplemental impedance transformation is required it is obtained most efficiently by the use of an L-network. However, some additional switching is required for the L-section inductor, which in some cases may be impractical or undesirable. The aperiodic transformer (untuned) is an interesting alternative to the use of tuned networks because it can be designed to operate quite efficiently over the 3- to 30-MHz range. The transformers in mind are the types discussed by Jerry Sevick, W2FMI,[8] John Nagle, K4KJ,[9] and others which use iron or ferrite cores to obtain efficient operation over a wide frequency band.

No data is available on the use of such transformers in the manner suggested here, however, there appears to be no reason why it should not be practical so long as core saturation is avoided.

table 2. Twelve complex impedance values which fall on a 2:1 vswr circle plotted on a Smith chart (fig.4), and the required pi-L network capacitance reactance values required to provide a match to a plate load resistance of 2500 ohms (*series* $X_L = 73.94$ *ohms*)

| point on 2:1 vswr circle (fig. 4) | worst-case antenna load impedance A | worst-case load plus +j73.94 ohms B | equivalent parallel components C | D | required $X_{C1}$ E | required $X_C$ of loading control, C1 F | required $X_{C2}$ G |
|---|---|---|---|---|---|---|---|
| 1. | 26.00 j 0.0 | 26.00 +j 73.94 | 236.27 | +j 83.08 | 85.99 | 42.26 | 390.86 |
| 2. | 27.38 −j 10.27 | 27.38 +j 63.67 | 175.48 | +j 75.44 | 78.36 | 38.44 | 401.63 |
| 3. | 32.00 −j 20.78 | 32.00 +j 53.16 | 120.30 | +j 72.42 | 70.98 | 35.85 | 414.52 |
| 4. | 41.60 −j 31.20 | 41.60 +j 42.74 | 85.51 | +j 83.23 | 67.40 | 37.24 | 425.79 |
| 5. | 59.43 −j 38.60 | 59.43 +j 35.34 | 80.44 | +j 135.28 | 67.23 | 44.91 | 427.82 |
| 6. | 86.60 −j 32.47 | 86.60 +j 41.47 | 106.45 | +j 222.31 | 69.28 | 52.82 | 418.57 |
| 7. | 104.00 j 0.0 | 104.00 +j 73.94 | 156.57 | +j 220.22 | 75.83 | 56.41 | 405.60 |
| 8. | 86.60 +j 32.47 | 86.60 +j 106.41 | 217.36 | +j 176.88 | 83.71 | 56.82 | 393.94 |
| 9. | 59.43 +j 38.60 | 59.43 +j 112.54 | 272.55 | +j 143.92 | 90.16 | 55.43 | 385.45 |
| 10. | 41.60 +j 31.20 | 41.60 +j 105.14 | 307.33 | +j 121.60 | 93.89 | 52.98 | 380.77 |
| 11. | 32.00 +j 20.78 | 32.00 +j 94.72 | 312.40 | +j 105.53 | 94.42 | 49.83 | 380.12 |
| 12. | 27.38 +j 10.27 | 27.38 +j 84.21 | 286.39 | +j 93.11 | 91.67 | 46.19 | 383.53 |

*Required plate load resistance = 5500 ohms*
$Q_0' = 14$
$Z_0' = 52$
*Maximum vswr = 2:1*

The design proceeds in the following steps:

**1.** Referring to **fig. 3**, determine the value of $T_r$ when $Q_0' = 14$. In this case $T_r = 70$.

**2.** Compute $R1B$ by dividing $R2$ by $T_r$. $R1B = 5500/70 = 78.57$ *ohms*.

**3.** Compute $X_L$ by substituting $T_r$ and $R2$ in **equation 9**. $X_L = 464.83$ *ohms*.

**4.** Compute $X_L'$ by substituting $R1B$ and $Z_0$ in **equation 12**. $X_L' = 73.94$ *ohms*.

**5.** Add $X_L'$ to each of the worst-case load impedances (from previous example) and tabulate as in **table 2**.

**6.** Compute equivalent parallel resistance, and equivalent parallel reactance for each value of load impedance and tabulate as in **table 2**.

**7.** Compute required values of $X_{C1}$ and $X_{C2}$ for each value of equivalent parallel resistance. Use **equations 4** and **5** with *464.83 ohms* substituted for $X_L$.

**8.** Compute required reactance of loading control capacitor by combining the reactances obtained in **step 6** with the values of $X_{C1}$ obtained in **step 7**.

**9.** Repeat **steps 5** through **8** with $X_L$ and $X_L'$ appropriately modified to obtain the band-edge values.

## summary

The problems encountered in applying pi network design **eq. 1, 2,** and **3** are due to the fact that these equations should be used only for fixed parameter networks, *i.e.* $R1$ and $R2$ should not be changed from the design values, and the operating frequency should not be varied. Nevertheless it has become common practice to use these equations for the design of pi networks for use in amateur equipment, and to assume that there is adequate tuning flexibility for the application. Unfortunately you can't depend on this assumption, especially when you want to operate with a vswr as great as 2:1.

It is interesting to note that a pi network, identical to the prototype network, can be designed using **eqs. 1, 2,** and **3**, and a value of 14 for $Q$. From the previous discussion it is known that the tuning range of this pi network will meet the desired vswr conditions. Next consider a case similar to the prototype network except that R2 is changed from 2500 to 3500 ohms. **Eqs. 2** and **3** will yield a value of 273.39 ohms for $X_L$, but the designer using this procedure is not normally aware of the fact that this value of $X_L$ results in a value of 42.71 ohms for $R1B$ so the tuning range of the network is limited.

On the other hand, the designer using the procedure recommended in this article is immediately aware of the problem in the first two steps of the design procedure; Allowing $Q_0'$ to be 15, **fig. 3** shows that $T_r$ is about 83, and $R1B$ will therefore be 42.17 ohms (3500 ÷ 83). Thus it is immediately known that this network cannot be expected to work well with low values of antenna load impedance.

At this point the designer may elect to use one of the four options in **step 5** of the step-by-step design procedure. These alternatives give direction to the course of action to be taken when the initial network design falls short of the desired objectives. Regardless of which alternative is ultimately chosen, the designer's choice will be based upon specific knowledge of how the pi network will perform in practice.

Designers who must frequently design pi networks will find the discussion in the *appendix* especially useful. It shows how universal design curves can be developed from the two new equations which have been derived from **equations 4** and **5**. The new equations are unique in that the only independent variables are $T_r$ and $K$, where $K$ is $R1$ normalized with respect to $R1B$. Families of curves drawn from these equations can be made to cover any desired range of pi networks.

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**ham radio**

## appendix

### universal design curves

Curves of $X_{C1}$ and $X_{C2}$ are shown in **fig. 2**, and although the contours of these curves are typical of all pi networks, they apply specifically only to the prototype network. Universal design curves can be plotted to cover any desired range of possible networks, but before this can be done **equations 4** and **5** must be manipulated to obtain equations which are expressed only in terms of $T_r$ and $K$, where $K$ is the factor obtained when $R1$ is normalized with respect to $R1B$

$$K = \frac{R1}{R1B} \qquad \text{(I)}$$

Thus **equation 4** converts to

$$F_1 = \frac{1}{1 + \frac{\sqrt{T_r(K - 0.50)}}{K}} \qquad \text{(II)}$$

and **equation 5** converts to

$$F_2 = \frac{1}{1 + \sqrt{\frac{K - 0.50}{T_r}}} \qquad \text{(III)}$$

where $F_1$ and $F_2$ are proportionality factors which must be multiplied by $X_L$ to obtain specific values of $X_{C1}$ and $X_{C2}$. Therefore

$$X_{C1} = F_1(X_L) \qquad \text{(IV)}$$

$$X_{C2} = F_2(X_L) \qquad \text{(V)}$$

$T_r$ has already been defined as the ratio of $R2$ to $R1B$

$$T_r = \frac{R2}{R1B} \qquad \text{(VI)}$$

Since the factors $T_r$ and $K$ represent ratios of real values, but have no dimensions of their own, they meet the essential requirements for complete generality. **Equations II** and **III** are also completely general, and can be used in the plotting of universal curves.

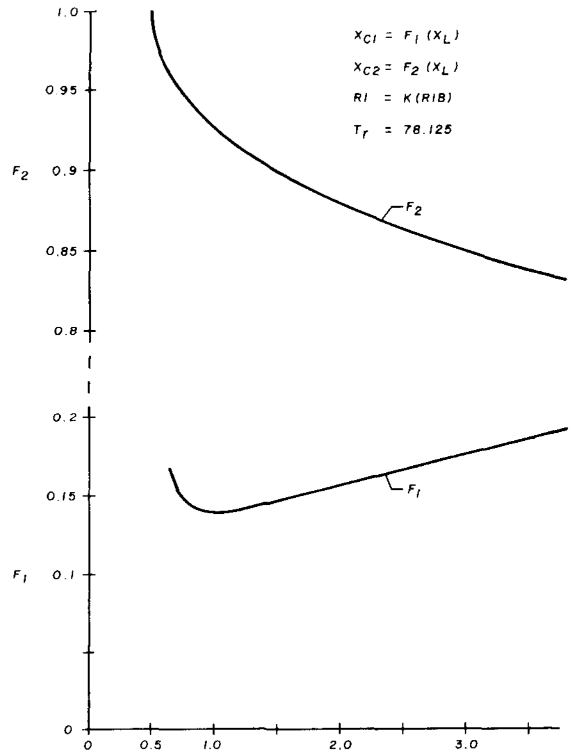
Curves plotted in Cartesian coordinates can accommodate only one variable in addition to the dependent variable so it is necessary to plot a family of curves for both **equations II** and **III**. Individual curves of a family should be based upon a selected value of $T_r$, and $K$ from 0.70 to 4.0 to cover the normal ranges of $R1$. Adjacent curve spacings depend on the selected values of $T_r$ and should be chosen to minimize interpolation errors.

In using the curves the designer reads the coordinate values of $F_1$ and $F_2$ for a particular value of $K$, and then converts them to values of $X_{C1}$ and $X_{C2}$ in accordance with **equations IV** and **V**. The value of $X_L$ in these equations may be obtained by using **equation 9** or the convenient form

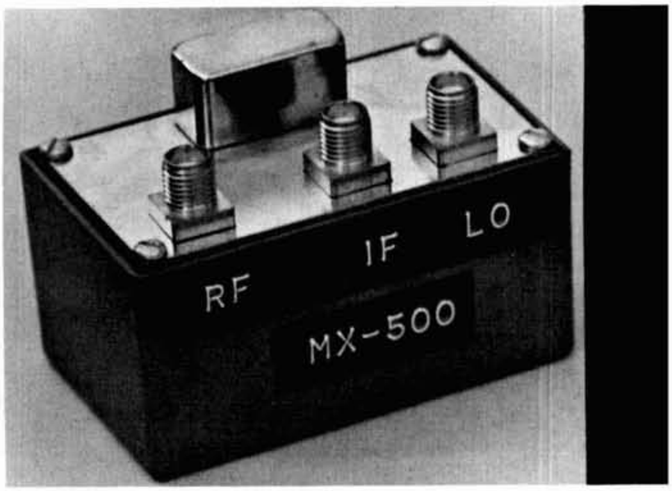
$$X_L = \frac{R2}{\sqrt{2T_r}} \qquad \text{(VII)}$$

The value of $K$ represents a particular value of $R1$ as given by

$$R1 = K(R1B) \qquad \text{(VIII)}$$




In the above graph the curves of **fig. 2** have been redrawn in accordance with **equations II** and **III**. Normally the curves would be based upon integer values of $T_r$; however, in the prototype network $T_r$ has the fractional value of 78.125 and the curves of the above graph are therefore based on this value. These curves can be used for all pi networks where $T_r = 78.125$.




# circuit packaging

## for uhf double-balanced mixers

Versatile PC board for dual-inline packaged double-balanced mixer modules provides flexible operation from dc to 500 MHz

**The use of double-balanced mixers** in transmit and receive converters has been explored in numerous magazine articles.[1-5] The construction of mixers for vhf and uhf service is a relatively straightforward matter, and consists of a quad of matched Schottky-barrier diodes in a ring or bridge arrangement and two wideband toroidal transformers.[6] However, with the cost of commercial double-balanced mixer modules now less than $10, it hardly pays for the experimenter to build his own.

I was first introduced to commercial double-balanced mixers by Joe Reisert, W1JR, who showed me how to use a dual-inline packaged mixer in a 432-MHz converter.[7] He later published information on a DIP pinout which is now used by many manufacturers for dc-500 MHz mixers.[8] (see **table 1**). The standardization of flatpack microwave mixers allowed me to develop a universal PC layout for use at 1296 MHz.[9] In this article I will present a similar PC layout for use with any of the uhf mixer modules listed in **table 1**.

### mixer circuits

The double-balanced mixer circuit shown in **fig. 1** is based upon an article by Reisert.[8] Except for different pin-numbering schemes used by various manufacturers, **fig. 1** is an accurate representation of all the mixers in **table 1**.

Note that two pins (3 and 7 in **fig. 1**) are connected together to form the i-f port. In some (but not all) mixers, these pins are tied together internally. To build a circuit board which is compatible with all the

**By H. Paul Shuch, WA6UAM,** Microcomm, 14908 Sandy Lane, San Jose, California 95124

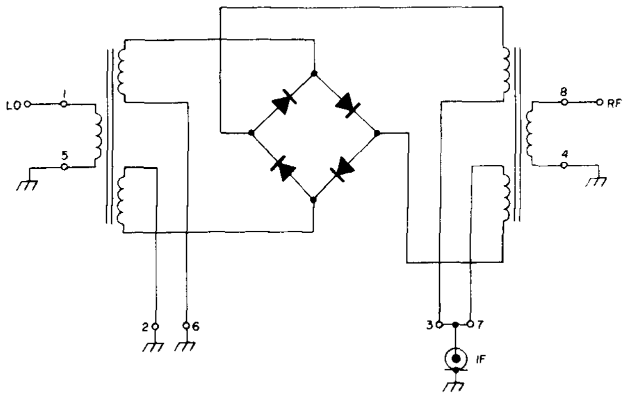



**fig. 1. Practically all uhf double-balanced mixer modules use the circuit shown here, consisting of four hot-carrier diodes and input and output transformers. Some units are grounded internally, as discussed in the text.**

mixers in **table 1**, there must be a circuit trace between these pins. Also, in some mixers, the ground points (shown as pins 2, 4, 5, and 6 in **fig. 1**) are internally connected to the mixer case; in others they are not. Therefore, the PC board must provide for external grounding of these pins.

Of course, in mixers which are not internally grounded, it would be possible to connect pins 2 and 6 together for use as the i-f port, and ground pins 3 and 7. Similarly, if pin 1 were grounded, pin 5 could serve as the LO port. The same possibilities hold for

**table 1. Pin compatible dual-inline package double-balanced mixers. This list is not complete but gives an indication of the wide variety of pin-compatible mixers available on the market.**

| type | frequency range (MHz) | isolation (dB) | price (approx) |
|---|---|---|---|
| Anzac MD108 | 5 - 500 | 25 | $ 8 |
| Anzac MD109 | 0.2 - 200 | 25 | 17 |
| Anzac MD142 | 10 - 1000 | 20 | 55 |
| Mini-Circuits SBL-1 | 1 - 500 | 30 | 4 |
| Mini-Circuits SRA-1 | 0.5 - 500 | 30 | 10 |
| Mini-Circuits SRA-5 | 5 - 1500 | 25 | 30 |
| Merrimac 117A | 0.5 - 500 | 30 | 10 |
| Merrimac DMS-2-200 | 1 - 400 | 30 | 25 |
| Cimarron CM-1 | 5 - 500 | 25 | 6 |
| Cimarron CM-2 | 5 - 1200 | 20 | 15 |
| Summit 769E | 5 - 500 | 30 | 25 |
| Summit 761 | 3 - 1000 | 35 | 40 |
| Watkins-Johnson M6E | 5 - 500 | 30 | 37 |

Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154

Mini-Circuits Lab, 837-843 Utica Avenue, Brooklyn, New York 11203

Merrimac Industries, 41 Fairfield Place, West Caldwell, New Jersey 07006

Cimarron Division, Vari-L Company, 3883 Monaco Parkway, Denver, Colorado 80207

Summit Engineering, Post Office Box 938, Bozeman, Montana 59715

Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, California 94304

pins 4 and 8 at the rf port. For that matter, in any double balanced mixer the rf and LO ports are completely interchangeable. However, since grounding is to be provided on the PC board, an internally grounded mixer will require a particular orientation on the board (more on this later).

When the mixer has been properly grounded, and the i-f pins have been tied together, the three mixer ports can be connected to coaxial connectors. To minimize impedance discontinuities it is advisable to use 50-ohm microstrip transmission lines when interfacing the mixer to coaxial connectors.

## circuit board

**Fig. 2** is a full-sized layout of a circuit board which will accommodate any of the mixers listed in **table 1**. As with all microstripline circuits, it is etched on one side of double-sided printed circuit material. The other side remains unetched and serves as a groundplane. The dimensions of the circuit were chosen to provide a good impedance match to 50 ohms at all

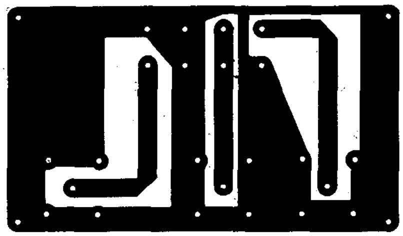


**fig. 2. Full-size printed-circuit board for dual-inline packaged double-balanced mixer modules.**

ports (1/16 inch or 1.5mm thick fiberglass-epoxy circuit board). At the operating frequencies of these mixers the thickness of the copper cladding is of little consequence; I used 2-ounce copper (about 2.8 mils or 70 microns thick) with no observed difficulties in either performance or etching.

The active pins of the mixer, as well as the center pins of the three coaxial connectors, must all be isolated from ground. This can be easily accomplished by using a 1/8 inch (3mm) twist drill as a countersink to remove the groundplane metallization from around the active pins as shown in **fig. 3**. Drilling instructions for the etched board are also shown in **fig. 3**. Note that all mixer and coax connector pins require no. 56 (1.2mm) clearance holes, while the no. 42 (2.4mm) mounting holes in the corner of the board easily accommodate no. 4 (M3) mounting hardware. This circuit board is designed to be used as the top cover of a Pomona Electronics 2417 die-cast aluminum box. This enclosure provides excellent shielding as well as an attractive appearance, as seen in the photograph.

## coaxial connectors

High quality coaxial connectors are recommended to minimize impedance mismatches at uhf. I have had excellent results with type SMA connectors, a military designation standing for Sub-Miniature, Type A. The SMA connector is a gold-plated precision threaded unit, with a 3mm reference plane dimension. They were originally developed by the Omni-Spectra Company under their brand designation OSM, a name by which they are often referred regardless of the manufacturer. SMA-compatible connectors have become a standard catalog item of numerous companies; the ones I use are E. F. Johnson JCM series. Their female chassis connector (part no. 142-2098-001) costs less than $3.00 and operates well into the microwave region. For interconnection to other modules, you will want to make up a few jumper cables. These can be fitted with E. F. Johnson 142-0261-001 plugs which mate well with the female chassis connector and cost about the same.

## mixer pinouts

If you examine the data sheets of the mixers listed in **table 1**, you can be easily misled into believing that the devices have different pinouts. This is because the manufacturers use different pin numbering sequences, as shown in **fig. 4**. Fortunately, all suppliers mark pin 1 in some way, usually by providing an odd-colored glass bead at the seal. Regardless of the pin numbering scheme, the internal mixer configuration is basically the same. Thus it's possible to install all these mixers on the same circuit board.

Installation of the mixer on the board is straightforward. With the board oriented as shown in **fig. 3** (groundplane side up, coax connectors toward you), position the mixer so pin 1 (the one with the odd-colored bead) is away from you and toward the right. The pins will fall readily into place, and can be soldered to the microstriplines on the opposite side of the board.

When installing the coax connectors, run a bead of solder around the connector body on the groundplane side of the board; then solder the four ground pins on the microstripline side. This provides "through-the-board" grounding of the applicable mixer pins.

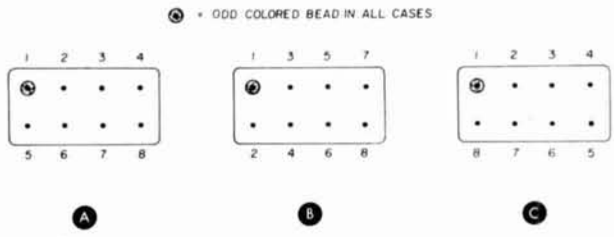



**fig. 4. Pin numbering arrangements used by various manufacturers of double-balanced mixer modules.**

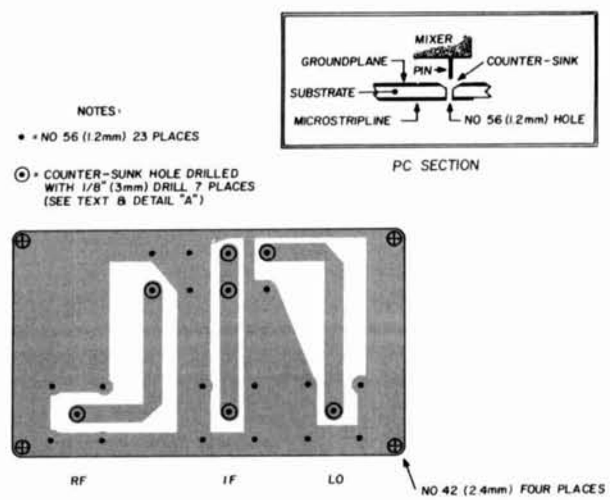



**fig. 3. Drilling instructions for the double-balanced mixer circuit board. Indicated holes must be countersunk to eliminate short circuits to ground.**

## parts availability

Most of the manufacturers listed in **table 1** will sell their mixers directly to the individual experimenter in small quantities; a few may require that orders be placed through a regional representative. Circuit boards can be etched from the artwork in **fig. 2**.*

*Etched, drilled, and plated circuit boards are available for $4.50 from Microcomm, 14908 Sandy Lane, San Jose, California 95124, postpaid.

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**ham radio**

# the frequency counter as a synthesizer

Low-cost ICs provide a method of converting your counter to a frequency synthesizer with 10-Hz readout

**If you're planning to build** a frequency counter here's an inexpensive method for using your counter as a frequency synthesizer with increments of 10 Hz. This frequency synthesizer can be used with any VFO provided an afc input (tuning diode) is available or such modification is possible.

Because of the availability of low-cost integrated circuits, digital frequency counters for receivers, transceivers, and signal generators have become very popular.

In the case of receivers and transceivers in which the frequency being counted is different from the receiving or transmitting frequency, a programmable divider (up-down counter) can be used for i-f preset.

**Fig. 1** shows a block diagram of a frequency counter with an internal resolution of 10 Hz with the 100-Hz digit displayed. The 10-Hz digit is not displayed because the error of ± 1 digit is avoided as well as the annoying appearance of this digit at random intervals. The last (10-Hz) digit determines the highest frequency of operation. Using a low-cost Fairchild type F10010 BCD decade counter (**fig. 2**) **2**), operation to 200 MHz is provided.

Various methods have been developed in the past that are suitable for frequency synthesis. The most elegant, accurate, and expensive method is to use a sample-and-hold discriminator, which samples the frequency at 10-Hz intervals. This method is expensive. It requires lots of pulse-shaping circuitry and therefore is vulnerable to thermal drift. Probably the simplest way of doing this, but not the most accurate, is a method in which a statistical error is determined. **Fig. 2** shows such a circuit.

## average circuit

The disadvantage of the circuit in **fig. 2** is that, because of the average reading, an error of 1 digit is possible (10 Hz). Also two power supply voltages are required. The digital-analog converter converts the ECL pulses from the F10010 counter into a dc voltage, which is then integrated and, through a darlington emitter follower, is available as the afc voltage. While tuning, the numbers 4, 5, 6, or 7 appear at the output of the units decade counter. This means a high output level (L in ECL level) at the $Q_3$ output of the F10010 counter. Therefore, CR24 ceases to conduct. Q31, Q32 conduct, and the voltage across C55 becomes ± 1.3 V. Thus the output voltage becomes − 2.5 V and remains constant during tuning. Once tuning is completed the output will be different from 4, 5, 6, or 7. In the event that the reading is 1, 2, or 3 the voltage across capacitor C54 will decrease. If the result is 8, 9, or 0 the voltage will increase. Ideally, the average from counting should be 0.5; however, because of component tolerances the last digit could be ± 1.

The output of this circuit must be connected to the oscillator, and an increasing voltage will cause a higher frequency. Once the loop is closed, the final result will become 0.5 as a statistical average; therefore the frequency will be stabilized with respect to the counter reference frequency.

## comparator circuit

Because the circuit of **fig. 2** is somewhat limited by drift and component tolerances, a slightly more complex circuit offers the best solution. It uses the 4-bit comparator type 7485. When extremely low power consumption is vital, the National CMOS 74C85 can be used. **Fig. 3** shows the circuit, which is capable of determining counting differences between 0 and 15, so any odd number between 1 and

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

16 can be used. Sometimes using a divide-by-16 rather than a divide-by-10 mode results in the upper cutoff frequency being slightly higher.

The 4-bit comparator receives information from a 7485, which is used as a register and from the actual count of the first known displayed digit. The comparator has two pulse-train outputs that must be integrated and which are used to charge or discharge integrating capacitors. Because of the logic decisions that have to be made, this circuit can't be used below 0 and above 15 because the comparator will not respond to the upper and lower limits. Therefore additional circuitry is required to avoid misreading.

The desired values are now divided into three categories,

**A**. Small values (0-3).
**B**. Medium values (4-11).
**C**. Large values (12-15).
The actual (count) values are divided into two categories,
**D**. Small values (0-7).
**E**. Large values (8-15).

In cases **A** and **B** the desired value is a small number and the count value is a large number; in cases **C** and **D** the desired value is a large number and the count value is a small number. The connection between the comparator output and the charge-pump inputs in this case must be exchanged. In all other cases no change is needed.

Assume the case in which the desired value is 15

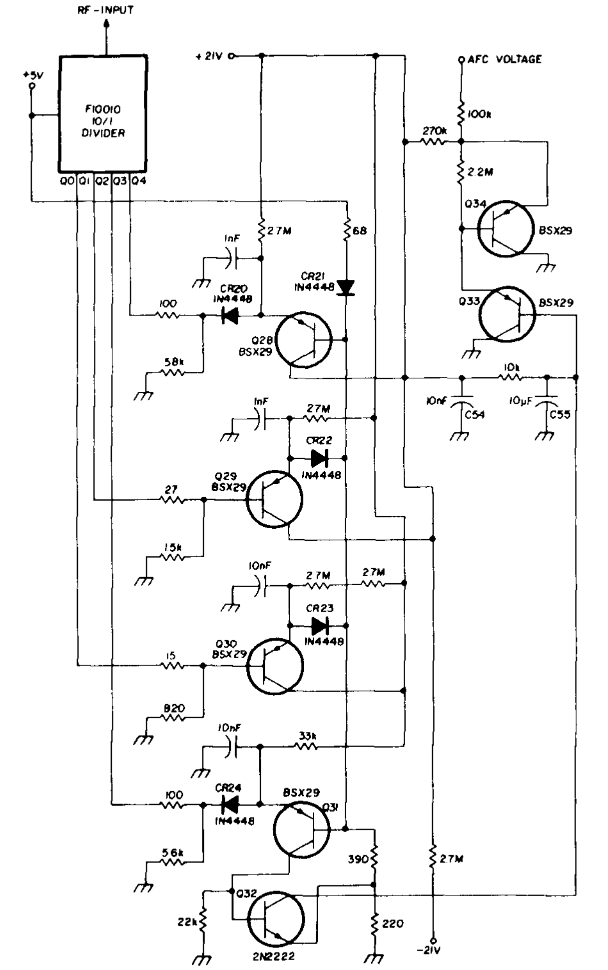


**fig. 2. Averaging circuit to obtain an afc voltage from the first ECL counter in fig. 1.**

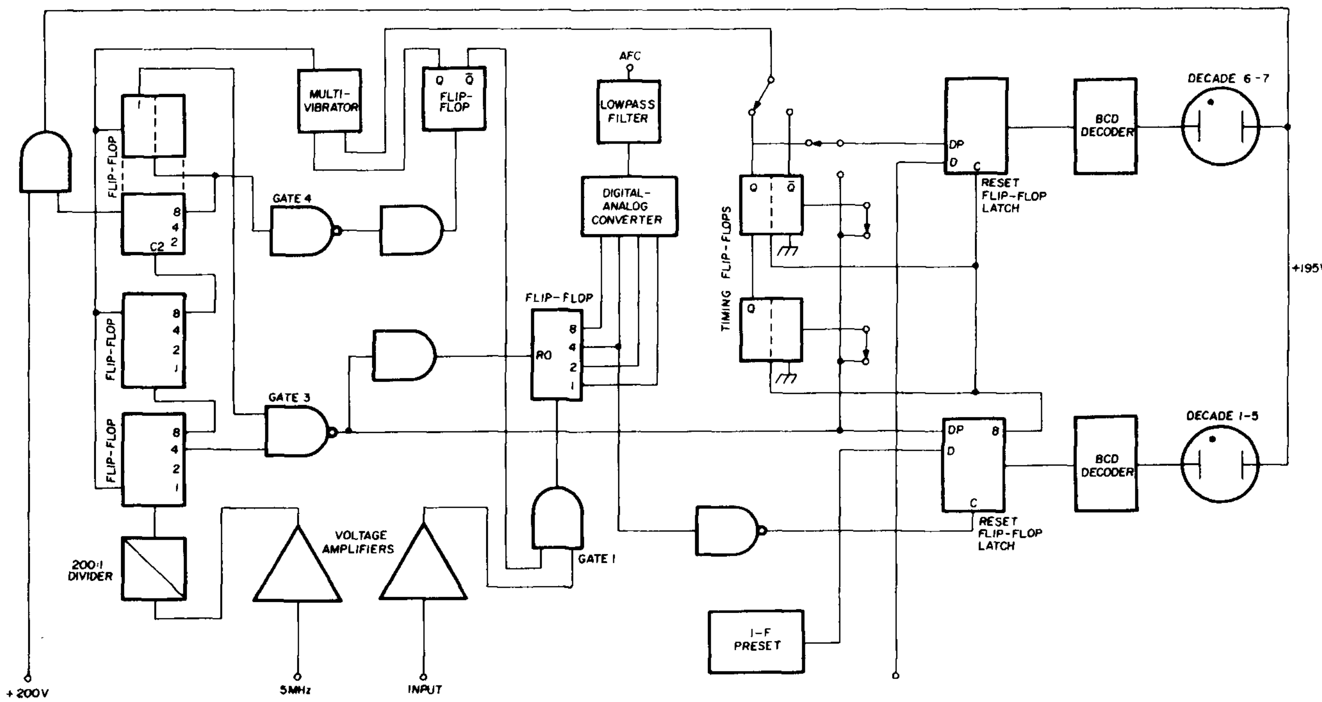


**fig. 1. Block diagram of a frequency counter-synthesizer with i-f preset capabilities and nixie display.**

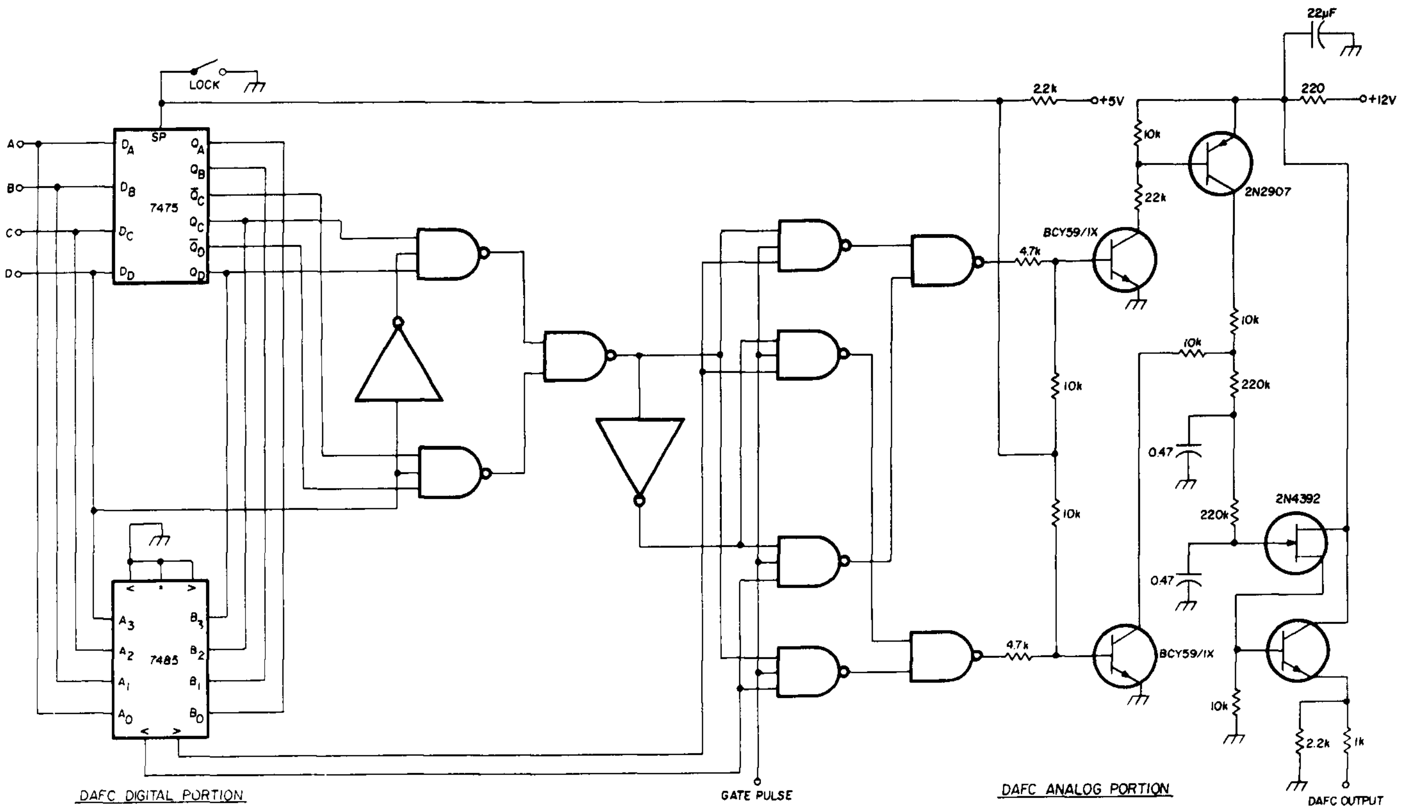



**fig. 3. Comparator or digital automatic frequency correction circuit (DAFC). Inputs A, B, C, D must be connected to the level-shifter outputs of the ECL A, B, C, D decade counters/4-bit binary counters as shown in fig. 4.**

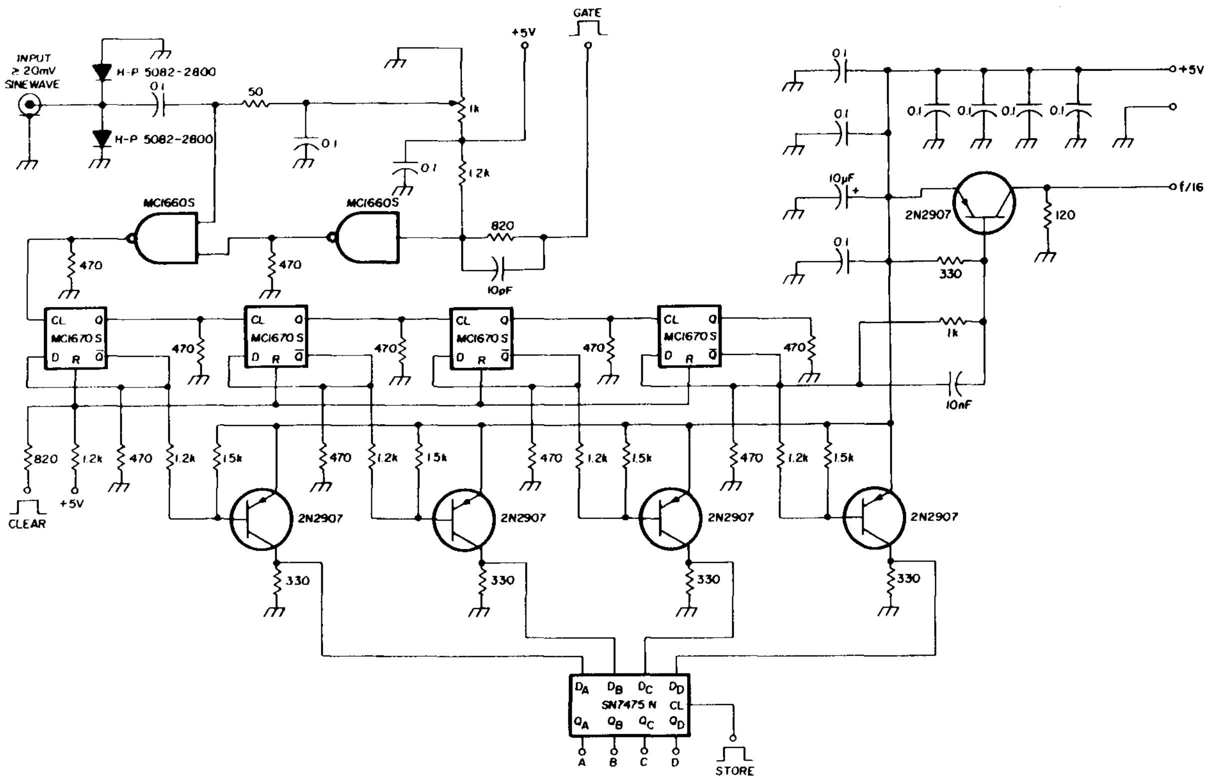



**fig. 4. Input stage for a 350-MHz frequency counter and level shifters for the TTL stages. Input threshhold level can be adjusted by a 1-k pot.**

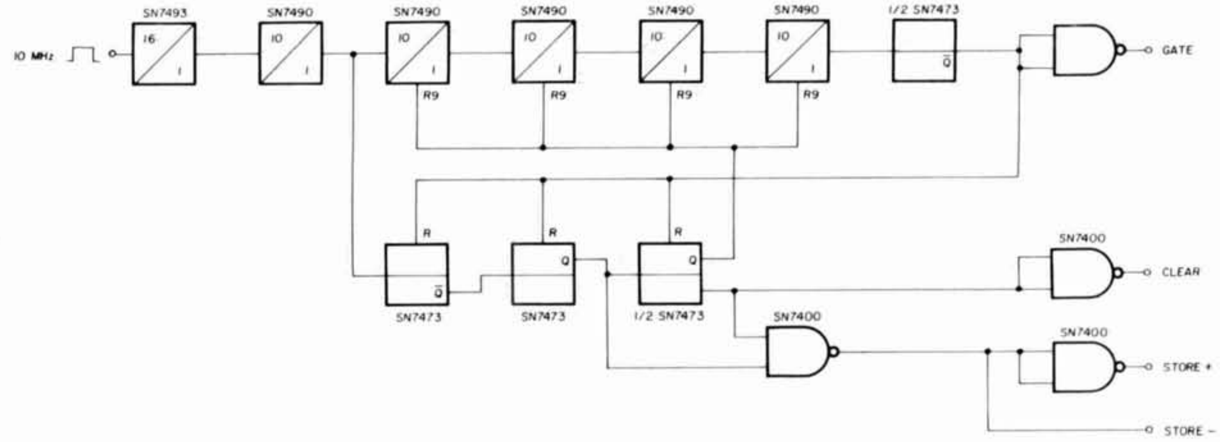
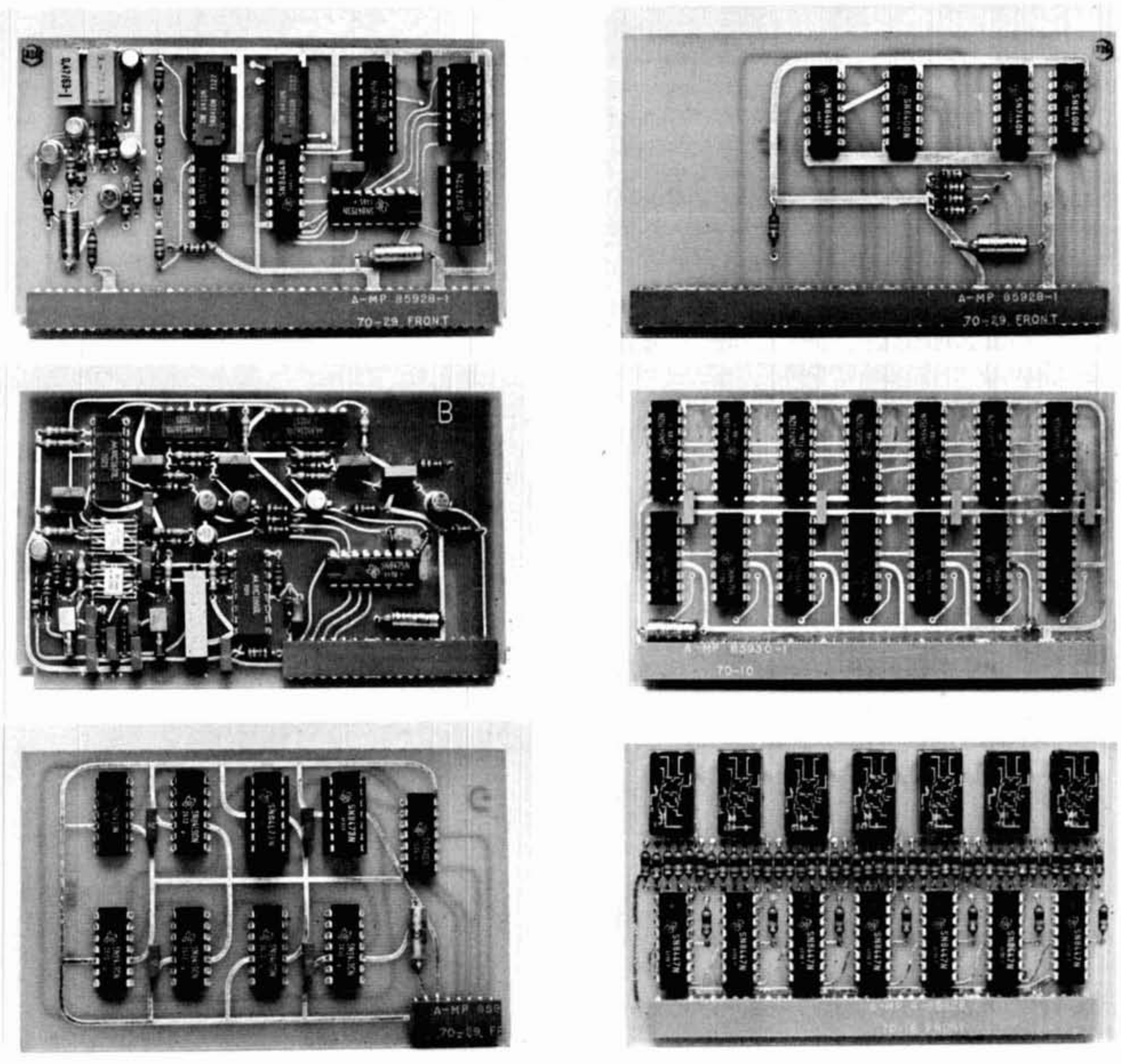



**fig. 5. A recommended time base/generator.**




**Photographs of the circuit boards developed for the counter. Starting from the upper left and working clockwise; PC board using a similar circuit as in fig. 3. To achieve a digital sweep capability, the 7475 was replaced by an 8493. Programming card for the i-f preset. Up/down counters and latches. BCD/7-segment decoder and MAN-1 displays. Time base divider/generator. Input stage for a 350-MHz counter/synthesizer for 100/16-Hz locking steps. The schematic is shown in fig. 4.**

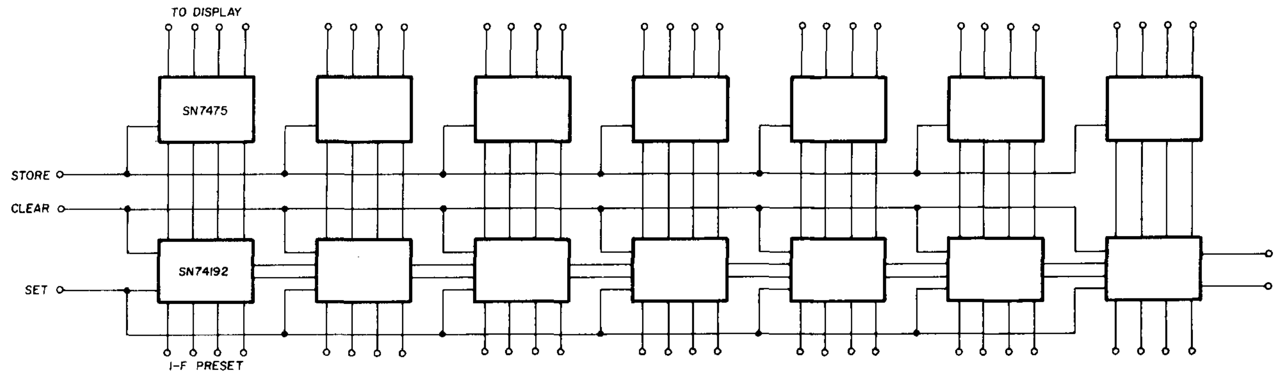



**fig. 6. Programmable dividers and latches.**

and the oscillator drifts to a higher frequency. The count value should read zero. In this case the comparator reads an actual value smaller than the desired value; however, input and output have been exchanged with the aid of an additional gate, since 15 is a large number and zero is a small number (cases **C** and **D**). As mentioned before, the circuit has been designed to read values between zero and 15, so it will also work using a decade counter. In this case, however, actual count and preset value can only be between zero and 10. If type 74192 programmable counters are used instead of the 7490 decade counter, i-fs can be preprogrammed and therefore actual readings can be obtained.

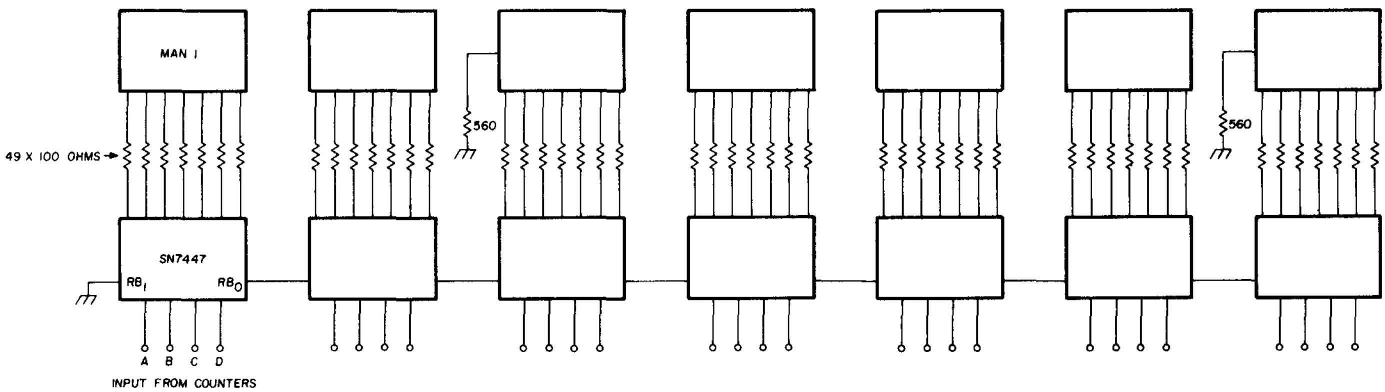



**fig. 7. BCD 7-segment decoders and MAN-1 display.**

## 350-MHz system

For even higher resolution such as 5.25 Hz (100 Hz divided by 16), **fig. 4** shows the input portion of a counter for the divide-by-16 requirement. It works to about 350 MHz. The circuit is basically as that described above using the F10010. **Fig. 5** shows the time-base generator circuit. Note the first 1/16 divider, which compensates for the 1/16 divider of the counter input. **Fig. 6** shows the programmable dividers and latches. Frequency stepping in 5.25-Hz increments is possible by feeding suitable pulses into the up-down counters. The BCD decoders and MAN-1 displays are shown in **fig. 7**. The polarity of the diode and the pulling range are important for stability considerations.

This circuit provides good stability over an ±8-kHz pulling range and, depending on the gate frequency, compensates for a drift of 25-100 Hz. During the initial switch-on period, most transceivers built by radio amateurs drift 1 or 2 kHz, so this circuit compensates for this effect.

## concluding remarks

No PC-board layouts are available for the counter; however, wiring can be accomplished easily by using perf boards. The input gates and flip-flops shown can be substituted with low-cost MECL-II ICs, such as the MC1007 or MC1027. However, this will reduce the maximum input frequency to around 100 MHz.

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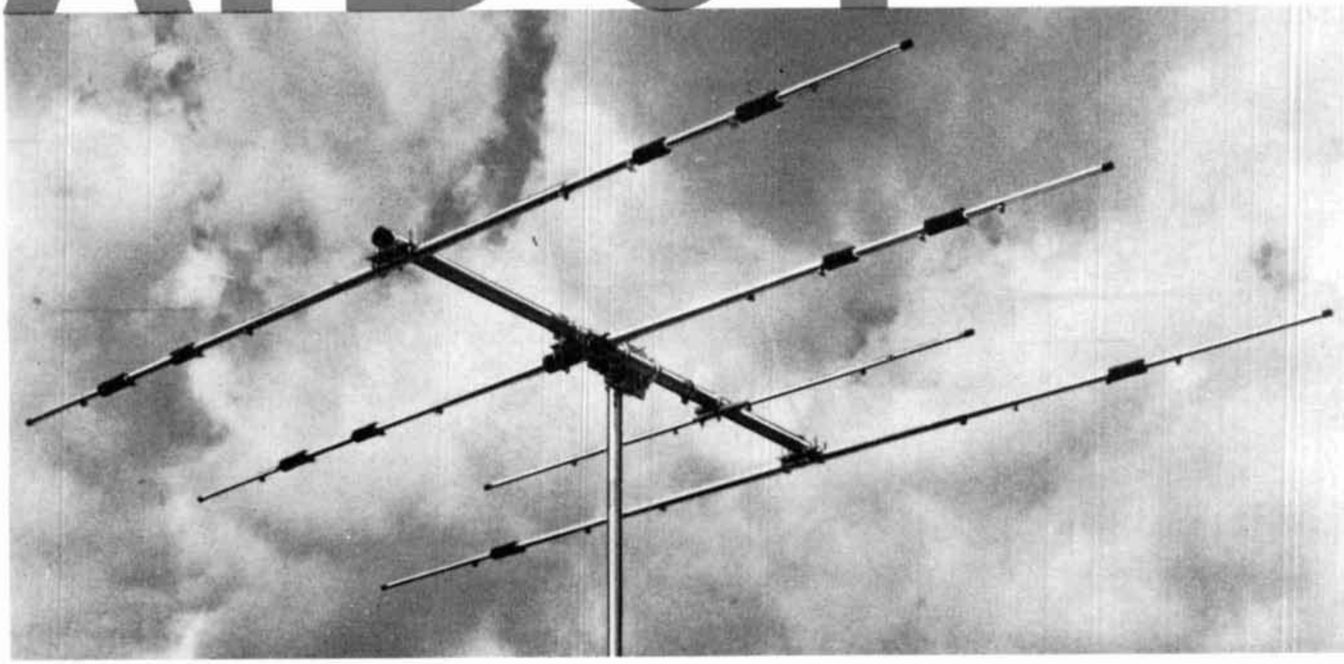
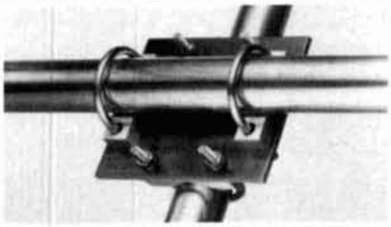
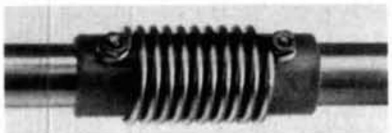
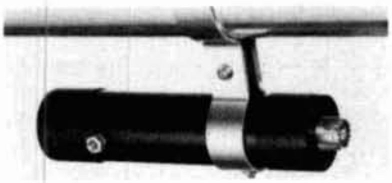
**ham radio**

# ATB-34









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# an amateur hydroelectric station

Amateurs are known for their ingenuity — this article describes a primary electrical system powered by a water wheel

**This is a report on the development** of an amateur hydroelectric system, which is located in the wilderness of the California mountains. The development began in 1932 when Arch Warnock, W6GQL, and his wife, Marian, W6HQV, acquired a mountain cabin located far from telephone or power lines. Arch and Marian decided they needed a way to keep in touch with home, and this is when I was asked to help with the hydroelectric project.

This article presents the development of the hydroelectric power system as it evolved from the first primative system to that used at present, which includes features such as pushbutton control and direct-reading circuits for line-voltage frequency. Information is also included on how to determine water flow rate and electrical and hardware requirements for duplicating this system. The information serves as a baseline for developing a system of even higher sophistication.

The first power source (in 1932) was an auto battery, which energized a dynamotor. The dynamotor supplied plate voltage for a single type 210 tube crystal oscillator. The inconvenience of hauling the battery down the mountain for charging prompted the idea of using water power for battery charging from a nearby mountain stream. Thus the amateur hydroelectric system described here was born.

Our first water wheel was built in 1933 — a low-pressure, high-volume affair 2 feet (0.6m) in diameter. It was made of sheet metal and was mounted in an open 4 x 4 foot (1.2x1.2m) wooden frame. An old Ford car wheel with a flat rim served as the driving wheel for an arrangement of V pulleys on a counter shaft. Sufficient speed was thus obtained to drive a 15-volt dc Dodge car generator. Seventy feet (21.3m) of 8-inch (20cm) irrigation pipe carried a 5-foot (1.5m) head of water along the natural gradient of the stream bed. The water was applied undershot to the wheel, and the open construction caused a lot of spray. A few well-placed shields made it possible to approach the generator for servicing.

This assembly underwent minor modifications during the next several years. Several different generators, including a modified rotary converter for ac, were used but the maximum power generated never exceeded about 200 watts. The first hydroelectric plant was washed away in a flood that occurred in 1938.

The second water wheel, which was built in 1938, was considerably improved. It had been suggested by two local FCC inspectors, John and James Homsy. The rear end of an old Essex auto was used because it had a high gear ratio. One axle was removed and the housing was cut back to the center

**By I. L. McNally, K6WX,** 26119 Fairlane Drive, Sun City, California 92381

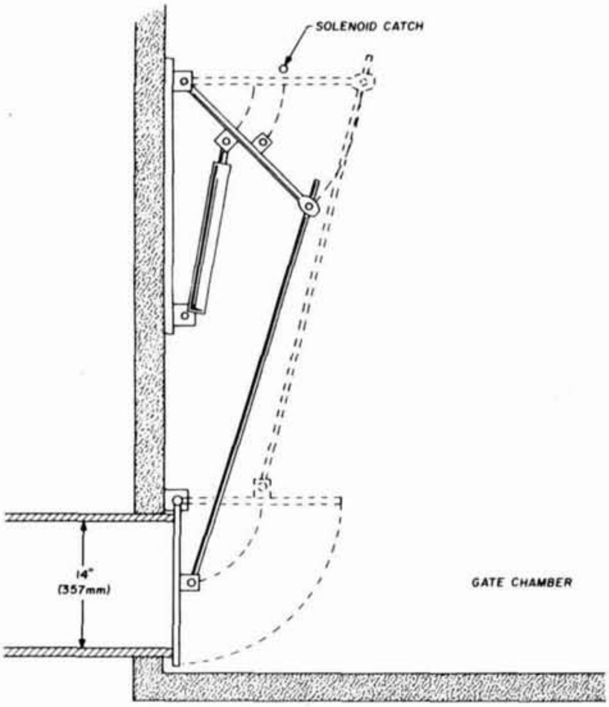
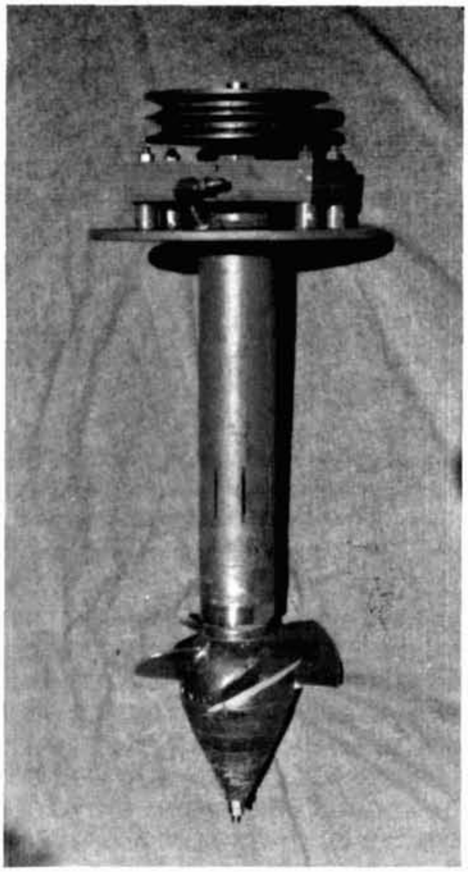



**fig. 1. Hydraulic gate lifter for controlling water into the turbine. A hydraulic piston and lever system powered by a 12-volt-dc hydraulic pump operates the mechanism.**



**Photograph of the complete impeller assembly.**

and sealed. Both brake drums were placed back-to-back on the remaining axle. Around the circumference ten 10-inch (25.4cm) concave tank tops were welded radially to the drums at equal intervals. The wheel, which was 3 feet (0.9m) in diameter, was operated undershot (to maximize the head with a 4-inch (10.2cm) nozzel). A 14-inch (36cm) wooden V

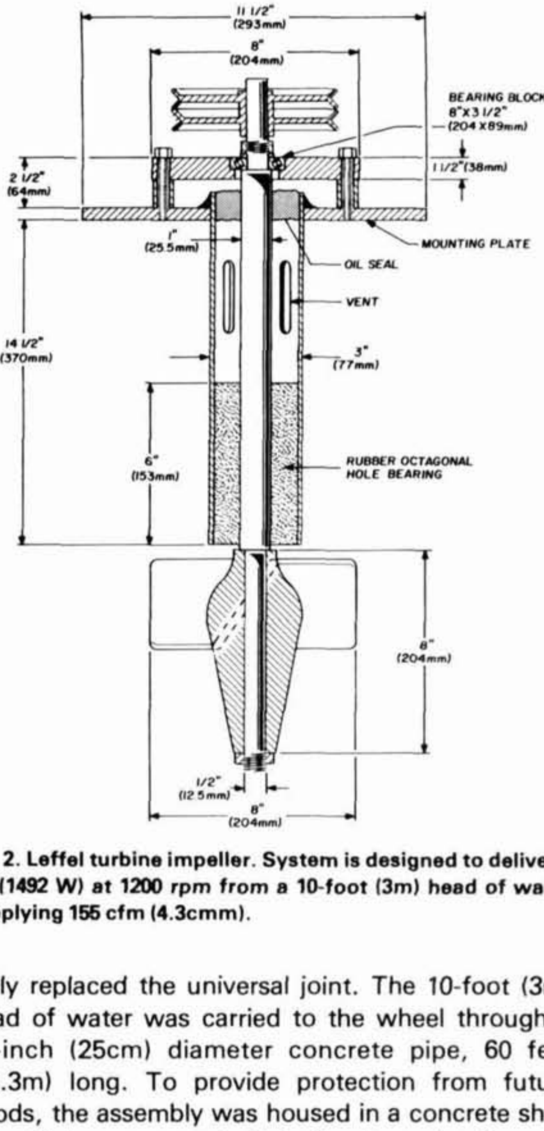
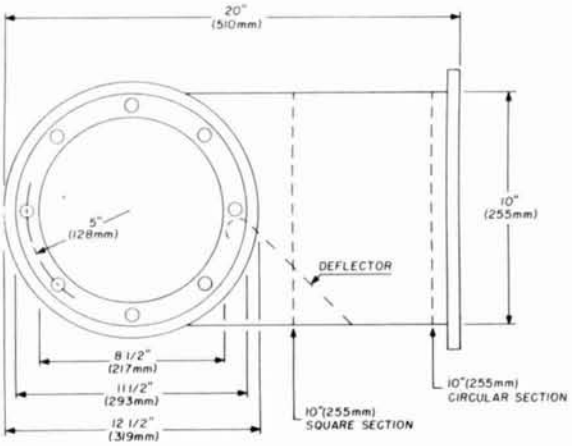



**fig. 2. Leffel turbine impeller. System is designed to deliver 2 hp (1492 W) at 1200 rpm from a 10-foot (3m) head of water supplying 155 cfm (4.3cmm).**

pulfy replaced the universal joint. The 10-foot (3m) head of water was carried to the wheel through a 10-inch (25cm) diameter concrete pipe, 60 feet (18.3m) long. To provide protection from future floods, the assembly was housed in a concrete shelter, which was excavated into the stream bank.

The third system, built in 1945, evolved into the present system. The vertical housing was made by using a 14-inch (36cm) section of an old 12-inch (30cm) diameter hot water tank. The upper end was closed with a mounting plate that had an 8½-inch (22cm) hole. The lower end was tapered to an 8-inch (20cm) diameter throat into which a boat propeller was suspended. The propeller suspension shaft was housed in a 3-inch (7.6cm) OD pipe, which was



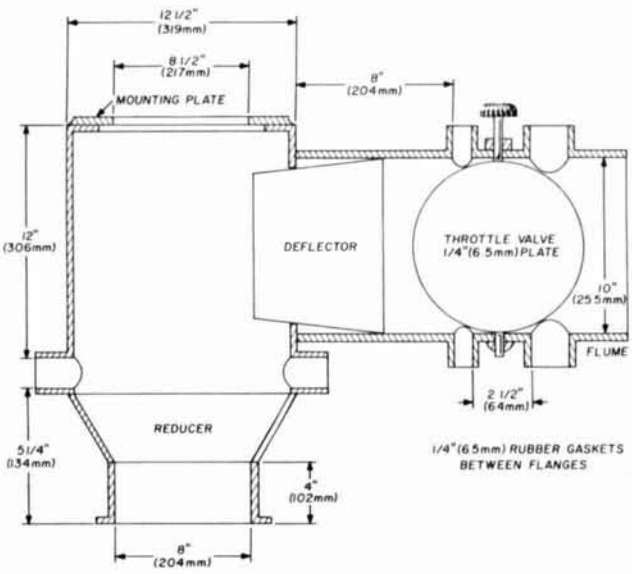




**fig. 3. Turbine chamber detail. The throttle valve is controlled from several remote locations. Deflector plate imparts a spinning motion to the water as it enters the turbine housing.**

welded to the top cover plate. Water brought in at a right angle to the upper chamber drove the propeller in conventional turbine fashion.

The fourth system, which was started in 1958, uses an 8-inch (20cm) Hoppes-type HL impeller supplied by the Leffel Company, which is designed to deliver 2 hp (1492 W) at 1200 rpm from a 10-foot (3m) head of water at 155 cfm (4.3cmm). The turbine impeller is made of bronze and consists of four curved rectangular blades mounted around a tapered hub. The blades are attached to the hub at a 45-degree angle and are machined to occupy the inside of the throat with a 1/16-inch (1.5mm) clearance. The lower end of the shaft, which is in the water, rotates in a hard-rubber boat-propeller shaft bearing. The upper

**table 1. data for determining the amount of water flow across a weir.**

| water depth, D, | | water flow, F, | |
|---|---|---|---|
| in. | (mm) | cfm | (cmm) |
| 1 | (25.5) | 0.4 | (0.0004) |
| 2 | (51) | 1.14 | (0.0013) |
| 3 | (76.5) | 2.00 | (0.0022) |
| 4 | (102) | 3.22 | (0.0036) |
| 5 | (127.5) | 4.50 | (0.0049) |
| 6 | (153) | 5.90 | (0.0065) |
| 7 | (178.5) | 7.44 | (0.0083) |
| 8 | (204) | 9.10 | (0.0101) |
| 9 | (229.5) | 10.86 | (0.0121) |
| 10 | (255) | 12.71 | (0.0141) |

bearing, which is housed in an aluminum-alloy block, is from a Ford Fairlane automobile wheel.

## design

The first step in planning a hydroelectric system is to determine the quantity and head of water available. The approximate flow of a stream may be determined by measuring the average stream depth, $D$, average stream width, $W$, and average distance of water flow per minute, $L$. The formula is

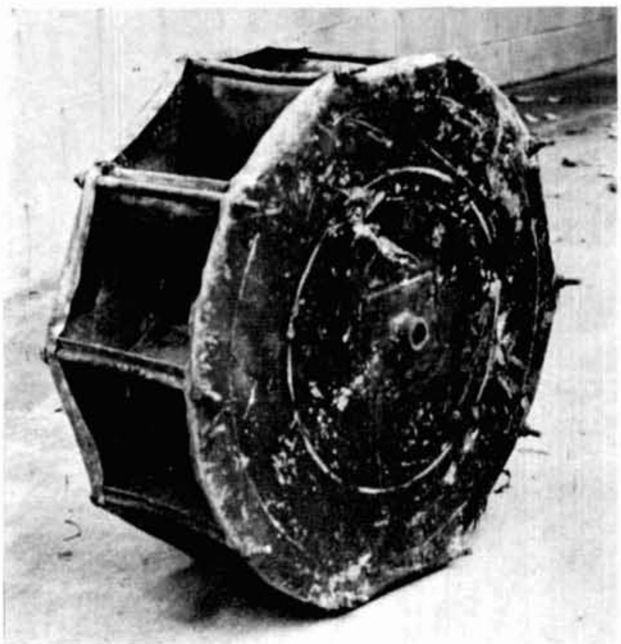
$$F = 0.8WDL \quad \textbf{(1)}$$

where

$F$ = water flow rate
$W$ = stream width
$D$ = water depth
$L$ = water flow distance

The distance, $L$, can be determined by measuring the movement of a half-submerged float in the stream for a given period of time.

**Example:** Water depth is 0.75 foot (0.23m), stream width is 5 feet (1.5m), and float movement is 10 feet



**First water wheel, which was made of sheet-metal.**

(3.0m) in 12 seconds, or $L = 50$ feet (15.2m). The flow rate, $F$, in this case is

$$F = 0.8 \times 0.75 \times 5 \times 50$$
$$= 150 \text{ cubic feet per minute (cfm)}$$

In metric terms the water flow rate is

$$F = 0.8 \times 0.23 \times 1.5 \times 15.2$$
$$= 4.2 \text{ cubic meters per minute (cmm)}$$

A more accurate method is to use a weir. A weir, consisting of a plank placed across the stream, must be constructed as the top section of a dam. The plank has a notch cut in it that is about six times as wide as the depth of water flowing over it. The notch is beveled on all sides with a sharp edge on the downstream side. A stake is placed about 3 feet (0.9m) upstream with its top level with the bottom of the weir notch to measure water depth, $D$. **Table 1** gives data for determining water flow, $F$, in terms of weir width for water depth up to 10-inches (25.4cm). For example:

6 inches of water over a 3 foot wide weir:

$$36 \times 5.90 = 212.4 \text{ cfm}$$

The metric equivalent is:

$$918 \times 0.0065 = 5.97 \text{cmm}$$

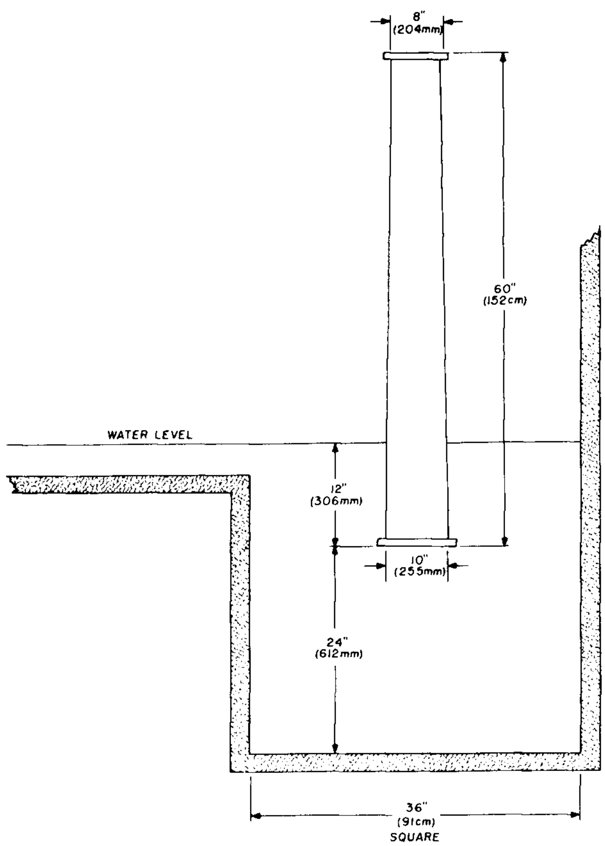



**fig. 4. Discharge pipe (or draft tube) assembly and exhaust chamber, which are essential for good turbine efficiency.**

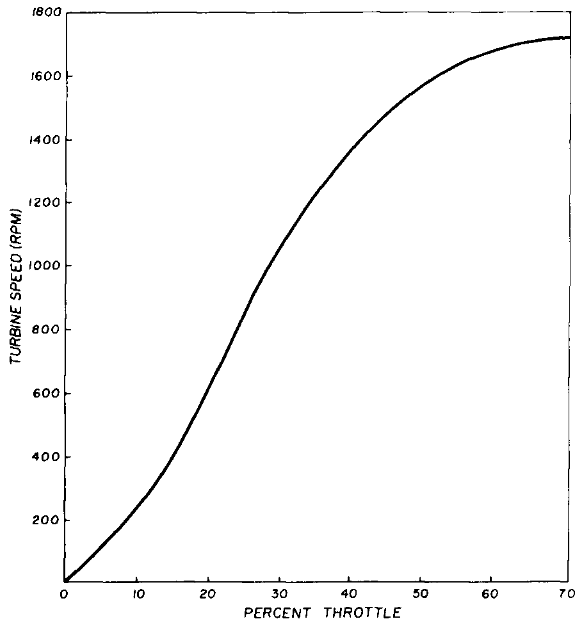



**fig. 5. Turbine speed as a function of percent throttle opening with 500 cfm (14cmm) of water flow.**

The next measurement to be made is the water height at the turbine. In the present system the dam and stream gradient gave a 10-foot (3m) head of water with 60 feet (18m) of pipe. All but 4 feet (1.2m) of this flume is 10-inches (25.4cm) in diameter. The flume was made as smooth as possible with a minimum of discontinuities.

**Intake chamber.** The intake chamber is located about 4 feet (1.2m) upstream from the dam. It is protected by a trash screen about 4 feet (1.2m) high, which is made of 5/16-inch (8mm) vertical rods spaced 1-inch (25mm) apart. The distance from the trash screen to the 14-inch (36cm) opening into the flume pipe is 3½ feet (1m).

The first 4 feet (1.2m) of the flume pipe is 14-inch (36cm) in diameter. This pipe is attached to a 3-foot (0.9m) sheet-metal cone, which tapers from 14 to 10 inches (36cm to 25cm). The remainder of the 60 feet (18m) of flume pipe is 10-inches (25cm) in diameter.

A surge chamber, which is located about 10 feet (3m) from the turbine is also used. It consists of 6 feet (1.8m) of 10-inch (25cm) diameter pipe mounted vertically on a concrete pad. A 4-inch (10cm) opening in the top of the flume pipe allows water to rise in the vertical surge chamber.

**Gate lifter.** When the turbine is not operating, a horizontally hinged ½-inch (12.5mm) circular iron plate closes the intake opening (**fig. 1**). The plate is raised to the open position by a hydraulic piston and system of levers and a 12-volt dc airplane hydraulic pump located in the turbine house. (A stand-

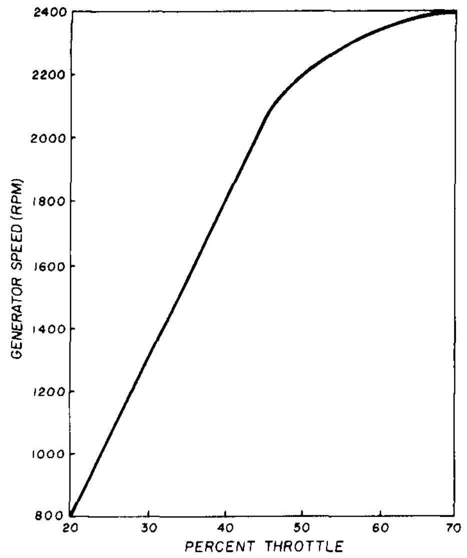



**fig. 6. Generator speed as a function of percent throttle opening with 500 cfm (14cmm) of water flow. Pulley ratios were adjusted to give 1800 rpm (60 Hz line frequency) at 40 percent throttle to provide a margin when water supply is low.**

by, manually-operated pump also opens the gate.) The gate is held in the open position by a solenoid-operated catch. To close the gate, the solenoid-operated catch is released, while hydraulic fluid is bled into the cylinder. Gravity and the force of water close the gate tightly against the opening.

**Propeller.** The Leffel turbine impeller (**fig. 2**) revolves counterclockwise, viewed from above, in a 4-inch (10cm) deep throat 8-1/16 inch (21cm) in diameter. The shaft, which is 1 inch (25.5mm) in diameter, is housed in a 3-inch (77mm) OD pipe, which has a B.F. Goodrich no. RFG 16P hard-rubber bearing at the lower end. A Ford Fairlane wheel bearing, part no. BCA RW-207-CCR, which is mounted in an aluminum block, is located 1-inch (25.5mm) above the turbine housing. An oil seal, National no. 5441130, at the top of the shaft prevents water leakage.

**Turbine chamber.** This assembly is shown in (**fig. 3**). A circular metal-plate butterfly valve is mounted in a section of the 10-inch (25cm) pipe just before the pipe enters the turbine chamber. The lever arm of this valve is actuated by a 12-volt dc reversible motor-driven screwjack, which is controlled from several remote locations. A deflector plate is placed at an angle to give the water a spinning motion as it enters the turbine housing.

**Draft tube.** After the water has passed the impeller, it enters the discharge pipe, which is called a draft tube (**fig. 4**). This tube, which is a 5-foot (1.5m) vertical pipe, expands from a diameter of 8-inches (20cm) at the top to 10-inches (25.5cm) at the lower end. A concrete discharge chamber, measuring 3 x 3 x 3 feet (0.9x0.9x0.9m), provides water overflow into a tailrace. The draft tube and discharge chamber, with the dimensions shown, are essential for good turbine efficiency.

**Impeller efficiency.** To determine the electrical power to be expected it's necessary to know the efficiency of the turbine impeller. From the data furnished with the Leffel impeller, the efficiency is 68 per cent. With 200 cfm (5.7cmm) of water available

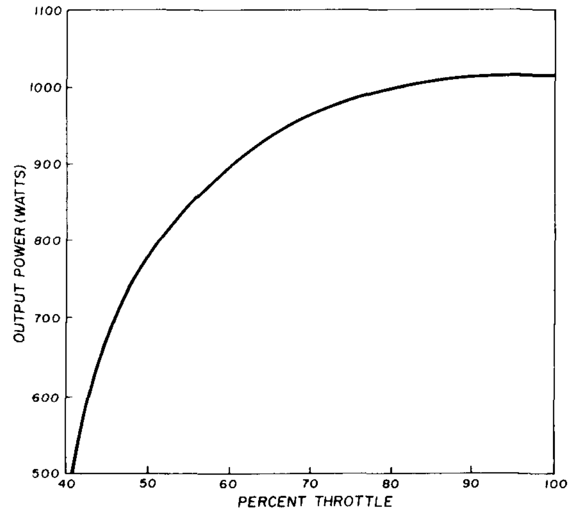



**fig. 7. Power output as a function of percent throttle opening with 200 cfm (5.7cmm) of water flow available.**

and a 10-foot (3m) head, 100-percent efficiency would give a power of

$$P = \frac{62.4 \times F \times H \times 746}{33{,}000} \qquad \textbf{(2)}$$

where

$P$ = power (watts)
$F$ = water flow (cfm)
$H$ = water head (feet)

Thus,

$$P = \frac{62.4 \times 200 \times 10 \times 746}{33{,}000} = 2821 \text{ watts}$$

Substituting metric equivalents for water flow, $F$, and water head, $H$:

$$P = \frac{62.4 \times 5.6 \times 3 \times 746}{277} = 2823 \text{ watts}$$

Under these conditions, about 1 kW will be delivered for an overall efficiency of approximately 35 percent.

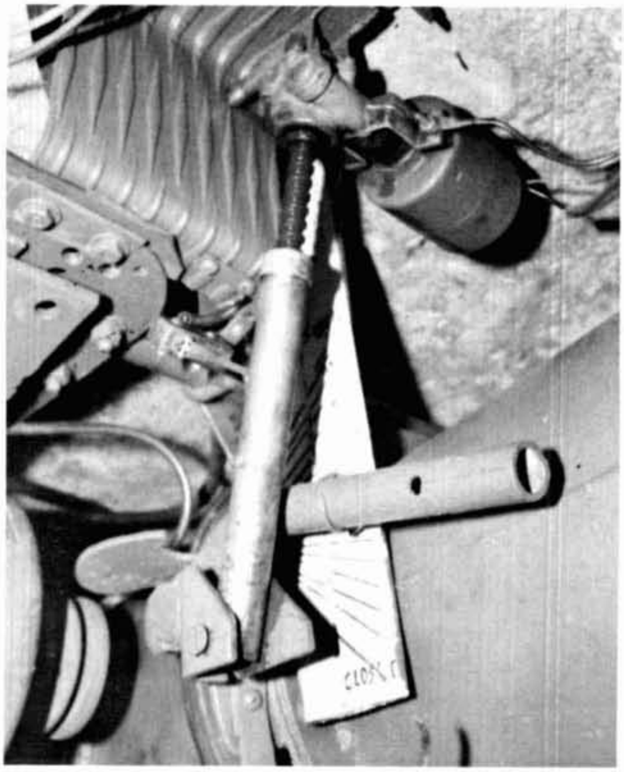
**System data.** Data was plotted to show turbine speed as a function of throttle opening (**fig. 5**). Data was also plotted to show generator speed with pulley ratios to give 1800 rpm (60 Hz) at 40-percent throttle. (See **fig. 6**). This allows a margin during times when the water supply is low. A third graph (**fig. 7**) shows power output under these conditions.

## control circuits

Most of the control circuits perform simple switching functions. However, a couple of ideas are offered for those interested in monitoring line frequency and building automatic control circuits for the dc-motor relays.

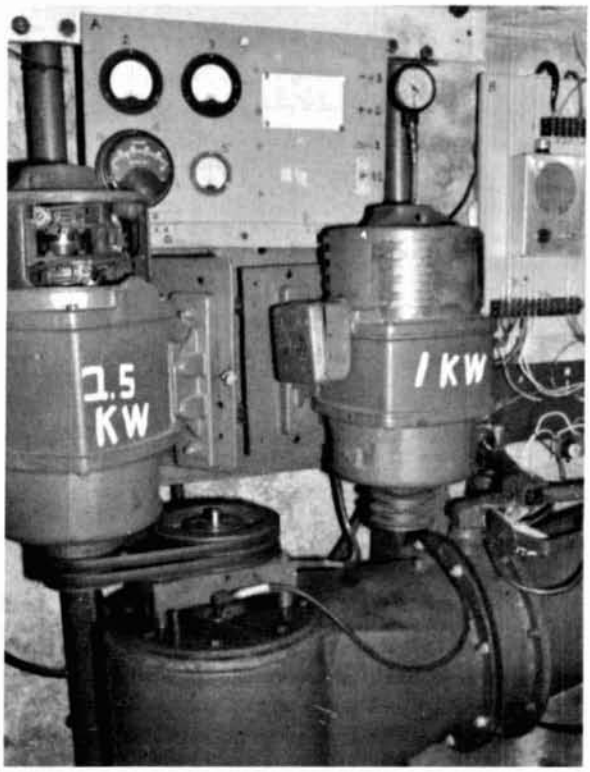
**Line-frequency metering.** Most surplus meters for measuring low-frequency ac voltage cover $60 \pm 2$ Hz. To obtain a greater frequency range a parallel LC network was used, which resonates at about 25 Hz. The linear portion of the resonance curve extends to 40-80 Hz, which gives a direct reading of line frequency.

**Automatic controls.** Manual pushbutton control is used for the reversible 12-volt dc motor, which moves the throttle-valve arm to the open or closed position. An automatic circuit energizes these motor-control relays by using an old Jewel ac meter and three photoelectric cells. The three photocells are located under the meter pointer at the 100-, 115-, and



Throttle valve showing screwjack, lever arm, and limit switches.

130-volt positions. When the meter pointer passes over the photocell at the low-voltage position, a relay opens the throttle. This relay is actuated by a transistor-operated sensitive relay and a latching relay. When the meter pointer passes the midpoint photocell the latching circuit opens, stopping the movement of the throttle throttle-valve arm. The same sequence occurs when the meter pointer passes the high-point photocell, which causes the throttle valve to close at midpoint. The throttle operates only when the load changes significantly.




Generator installation.

**Periperal circuits.** The ac generator and its standby circuit are mounted vertically on hinged plates, which allows either to be moved into position and driven by dual V belts. The throttle-valve control is also used in conjunction with a 5-kW variac. The original 15-volt Edison battery bank is still used to operate numerous controls as well as a 12-volt lighting system. A 50-ampere bridge rectifier allows the batteries to be charged at all times.

## acknowledgement

Many have contributed time and effort to this project, but two people deserve special thanks: Henry Backlund, a skilled machinist, and Jack Venturini, an expert mechanic and welder. Both worked full time on the amateur hydroelectric system.

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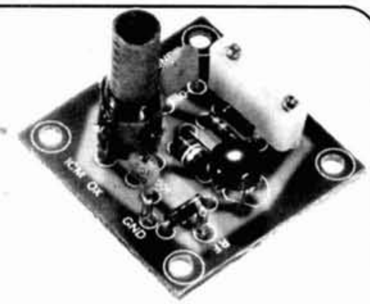

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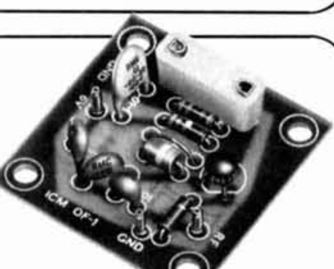

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More Details? CHECK — OFF Page 142

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# how to design
# regulated power supplies

How to choose the correct values for components in your regulated supply — a typical 5-volt supply is used as a design example

**Probably one of** the most overlooked areas of electronic circuit design is the power supply. Try finding information on how to design a power supply and you'll probably find either a circuit that doesn't fill your needs or a design procedure (if you can find one) so caged in higher mathematics as to make it undecipherable. The one mysterious area in power-supply design is the determination of capacitor size. How often have you asked yourself just what capacitor is needed for a power-supply circuit?

With modern solid-state equipment, a regulated power supply is a must. With the new "regulators on a chip," we need only a power transformer, a set of diodes, a capacitor, and the regulator chip. The question that still remains, however, is "what size of everything do I need?"

## determining component sizes

The problem is not as difficult as it first seems. Since diode and transformer sizes are most easily obtained, we'll look at them first. Having decided on a regulated supply, you obtain a regulator chip. These chips are available in a variety of voltages and current ratings and will probably be in a TO-3 case unless it's the adjustable-voltage variety. Having determined your requirements, you purchase a chip that has the desired voltage and current rating. A quick reference to the data sheet for the device (to find the maximum input voltage), and you're ready to design your circuit. Since the power-supply output is to be regulated, the voltage developed by the transformer can be anything that produces a dc voltage not greater than the regulator maximum input voltage, nor less than the minimum voltage required by the regulator. Expressed mathematically, this voltage is

$$E_{reg\,min} < E_c < E_{reg\,max} \qquad (1)$$

where

$E_{reg\,min}$ = regulator minimum input voltage
$E_{reg\,max}$ = regulator maximum input voltage
$E_c$ = voltage across the filter capacitor

The reason for maintaining the input voltage above the minimum voltage is to establish a "guard voltage," which prevents the input voltage from decreasing below the regulator level. Any voltage between the minimum and maximum input voltage for the regulator will produce acceptable results. Convert this value to a transformer secondary voltage by the following formula:

For bridge and half-wave rectifiers,

$$E_{sec\,(rms)} = (0.707)\,E_c \qquad (2)$$

For center-tapped transformers in full-wave supplies,

$$E_{sec\,(rms)} = (1.414)\,E_c \qquad (3)$$

The transformer dc-current rating for full-wave supplies using center-tapped transformers may be obtained by

$$I_{dc} \geqslant I_L/1.6 \qquad (4)$$

and for half-wave and bridge rectifiers

$$I_{dc} \geqslant I_L/0.8 \qquad (5)$$

where $I_L$ is the amount of current in amperes that

By **Chris Cogburn, K5VKQ**, 1554 Clematis Lane, Winter Park, Florida 32792

the supply provides. The symbol $\geqslant$ means that any value larger than that obtained will work. For example, if $I_L = 1$ ampere and $I_{dc} \geqslant I_L/0.8$, any transformer capable of supplying more than 1.25 amperes will work. The numbers 0.8 and 1.6 are safety factors to ensure that the transformer won't be underrated.

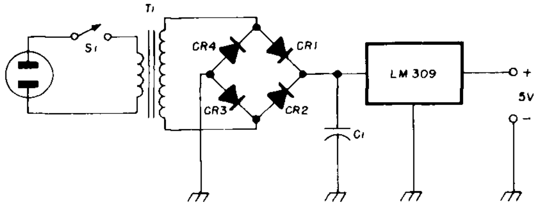


**fig. 1. Bridge rectifier circuit used in the design example.**

The current and peak-reverse voltage ratings can be obtained similarly. The peak-reverse voltage ratings for the diodes would be

$$E_{PIV(rated)} \geqslant \frac{E_{sec(peak)}}{0.8}$$

for all full-wave rectifiers and

$$E_{PIV(rated)} \geqslant \frac{2E_{sec(peak)}}{0.8}$$

for half-wave circuits.

The value $E_{sec\ (peak)}$ is obtained by multiplying the full secondary rms by 1.414.

The current ratings for the diodes are

$$I_{(average\ rated)} \geqslant I_L/1.6 \qquad \textbf{(8)}$$

for all full-wave rectifiers and

$$I_{(average\ rated)} \geqslant I_L/0.8 \qquad \textbf{(9)}$$

for half-wave rectifiers.

The remaining task is to determine capacitor size. Since the capacitor is rated according to capacitance and voltatge rating, a minimum value must be determined for each.

The capacitor will charge to the peak value of the voltage produced by the rectifiers, so the working voltage for the capacitors should be

$$WVDC \geqslant \frac{E_{sec\ (peak)}}{0.8} \qquad \textbf{(10)}$$

for non-center-tapped transformers, and

$$WVDC \geqslant \frac{E_{sec\ (peak)}}{1.6} \qquad \textbf{(11)}$$

for center-tapped transformers.

The value for $E_{sec\ (peak)}$ is found by multiplying the secondary rms voltage by 1.414. For center-tapped transformers, use the entire secondary voltage.

The capacitor value can be found by

$$C \geqslant \left(\frac{I_L}{E_c}\right) X \qquad \textbf{(12)}$$

where $X$ is obtained from the accompanying tables. The value for $C$ is in farads and can be converted to microfarads by multiplying by $10^6$. $I_L$ is again the current that the supply is to provide, and $E_c$ is the voltage across the capacitor (obtained from the rectifier).

Although the tables are for 60-Hz line frequency, the values may be converted to any other line frequency (such as 400 Hz) by

$$X_{full\ wave} = \frac{120\ X_{FW}(from\ table)}{F} \qquad \textbf{(13)}$$

$$X_{half\ wave} = \frac{60\ X_{HW}(from\ table)}{F} \qquad \textbf{(14)}$$

where $F$ is the supply ripple frequency (Hz).

**Tables 1-3** provide a range of per cent ripple voltages between 0.1 and 32 per cent with corresponding factors for $X_{FW}$ and $F_{HW}$.

## design example

Now that we have the procedure down, let's see how it works. Assume we need a 5-volt supply capable of providing 1 ampere of current. Several regulator chips are available, such as the National Semiconductor LM-309. A quick reference to the

**table 1. Multiplying factors for use in eq. 12 to determine capacitor values (0.1 - 0.9 per cent ripple voltage).**

| per cent ripple voltage | $X_{(FW)}$ | $X_{(HW)}$ |
|---|---|---|
| 0.1 | 8.21 | 16.54 |
| 0.2 | 4.08 | 8.24 |
| 0.3 | 2.71 | 5.48 |
| 0.4 | 2.02 | 4.10 |
| 0.5 | 1.61 | 3.27 |
| 0.6 | 1.34 | 2.72 |
| 0.7 | 1.14 | 2.33 |
| 0.8 | 0.996 | 2.03 |
| 0.9 | 0.882 | 1.80 |

**table 2. Multiplying factors for use in eq. 12 to determine capacitor values (1-9 per cent ripple voltage).**

| per cent ripple voltage | $X_{(FW)}$ | $X_{(HW)}$ |
|---|---|---|
| 1 | 0.792 | 1.62 |
| 2 | 0.386 | 0.799 |
| 3 | 0.252 | 0.526 |
| 4 | 0.186 | 0.390 |
| 5 | 0.146 | 0.309 |
| 6 | 0.120 | 0.254 |
| 7 | 0.101 | 0.216 |
| 8 | 0.087 | 0.187 |
| 9 | 0.076 | 0.165 |

**table 3. Multiplying factors for use in eq.12 to determine capacitor values (10-32 per cent ripple voltage).**

| per cent ripple voltage | $X_{(FW)}$ | $X_{(HW)}$ |
|---|---|---|
| 10 | 0.0677 | 0.147 |
| 11 | 0.0607 | 0.132 |
| 12 | 0.0549 | 0.120 |
| 13 | 0.0500 | 0.110 |
| 14 | 0.0458 | 0.101 |
| 15 | 0.0422 | 0.0935 |
| 16 | 0.0390 | 0.0869 |
| 17 | 0.0363 | 0.0810 |
| 18 | 0.0338 | 0.0758 |
| 19 | 0.0317 | 0.0712 |
| 20 | 0.0297 | 0.0670 |
| 21 | 0.0279 | 0.0633 |
| 22 | 0.0263 | 0.0599 |
| 23 | 0.0249 | 0.0567 |
| 24 | 0.0235 | 0.0539 |
| 25 | 0.0223 | 0.0513 |
| 26 | 0.0212 | 0.0489 |
| 27 | 0.0201 | 0.0466 |
| 28 | 0.0192 | 0.0445 |
| 29 | 0.0183 | 0.0426 |
| 30 | 0.0174 | 0.0408 |
| 31 | 0.0167 | 0.0391 |
| 32 | 0.0160 | 0.0376 |

data sheet tells us that we should maintain the input voltage between 7 and 35 volts. If we use a bridge rectifier the circuit might look like **fig. 1**. If we convert the 7 and 35 volts to rms, then for the bridge rectifier these voltages would correspond to a transformer voltage (rms) range of 5 to 25 volts.

Although any transfomer within this range would work, the only common values are 6.3 and 12.6 volts rms. Either will work; however, the 12.6 volt rms transformer would probably be more economical since an increase in voltage decreases the filter-capacitor value.

Assume we'll use the 12.6 volt transformer, transformer. The current rating for the transformer would be

$$I_{dc} \geqslant \frac{1}{0.8} = 1.25 \text{ ampere}$$

A transformer with a 1.5-ampere rating should do nicely.

The diodes should be capable of supplying

$$I_{dc} \geqslant \frac{1}{1.6} = 0.625 \text{ ampere}$$

*and have a reverse voltage rating of*

$$E_{PIV} \geqslant \frac{(12.6)(1.414)}{0.8} = 23 \text{ volts}$$

Diodes rated at 1 ampere at 50 volts should work well for CR1-CR4 in **fig. 1**; for example the type 1N4001.

Since the peak voltage across the capacitor will be about 18 volts, or 12.6 x 1.414, and any capacitor that will maintain the negative ripple peaks above 9 volts would be adequate. (Some ripple will appear at the output, however, and this value will be proportional to the ripple voltage across the filter capacitor.)

The ripple voltage, $E_r$, can be converted to per cent ripple by

$$\text{per cent ripple} = \frac{E_r}{E_{c(peak)}} \cdot (100) \qquad \textbf{(15)}$$

(See **fig. 2**) If $E_r$ is taken as maximum, the negative ripple peaks will be $V_I/0.8$ and the positive peaks will be

$$E_{c(peak)} - (12.6)(1.414) = 18 \text{ volts}$$

(See **fig. 3**). The per cent ripple will then be

$$\text{per cent ripple} = \frac{E_{c(peak)} - 9}{E_{c(peak)}} = \frac{18 - 9}{18} = 50 \text{ per cent}$$

Since the per cent ripple exceeds the values listed in the tables, we can use any value of capacitance determined from the tables, since these values will produce capacitor values with ripple less than 50 per cent. The voltage rating for the capacitor would be

$$WVDC \geqslant \frac{E_c}{0.8} = \frac{18}{0.8} = 23 \text{ volts}$$

Choose capacitors with a maximum rating of at least 25 volts. Usually in a case such as this, the most difficult problem is determining the per cent ripple that can be tolerated. In the example above, the maximum ripple was 50 per cent. The amount of ripple we can allow in our power supply is anything between zero and 50 per cent. The only difference between using a capacitor that will produce 50 per cent ripple and one that will produce 10 per cent ripple is the amount of ripple appearing across the regulator output.

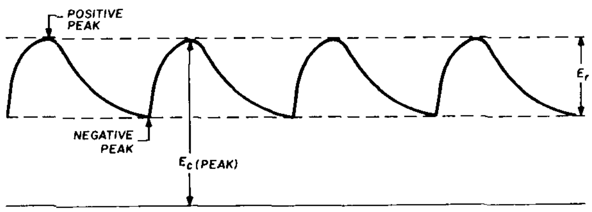


**fig. 2. Typical waveform showing ripple voltage, $E_r$, and voltage across filter capacitor, $E_c$.**

The regulator acts as a filter (if $V_{in} < 7$ *volts*); however, some ripple will be conducted to the output. This value of ripple will be in the millivolt range in both extremes, with a higher value of output ripple for an input ripple of 50 per cent. The best suggestion is to use a capacitor that produces the higher value of ripple when the supply is to power large-signal, low-gain circuits. Smaller values of ripple are dictated by higher gains and smaller signal levels. Ripple levels of 10 to 30 per cent will be adequate for all but the most stringent applications.

Increasing the ripple voltage above 30 per cent or decreasing the ripple by using capacitors that produce less than 10 per cent ripple, usually results in

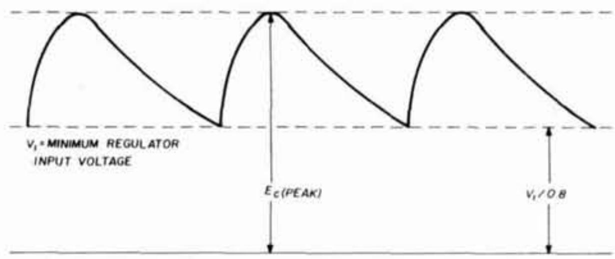


**fig. 3. Waveform showing relationship between positive and negative ripple-voltage peaks with respect to the minimum regulator input voltage.**

less-than-desired performance. The value of capacitance for 10 per cent ripple would be

$$C \geqslant \frac{XI_1}{E_c} = \frac{0.0677 \cdot 1}{18}$$
$$= 3.761\,(10^{-3})\ farads$$
$$= 3761\ microfarads$$

and the value for a capacitor producing 30 per cent ripple would be

$$C \geqslant \frac{(0.01744)\cdot(1)}{18} = 9.69\,(10^{-4})\ farad$$
$$= 969\ microfarads$$

A good range of values for $C$ would be about 1000-4000 microfarads.

## in summary

Components for the power supply producing 5-volts output and a maximum load current of one ampere would be a 12.6-volt transformer capable of providing 1.5 amperes, four diodes (such as 1N4001s), a capacitor between 1000 and 4000 microfarads with a voltage rating of 25 volts, and a 5-volt regulator. For noncritical applications I would use a 1000-microfarad capacitor, and where ripple may be a problem I would use a 3750 microfarad capacitor.

The procedure above is one I've found useful for the past several years. The ability to design and build one's own equipment is one of the most enjoyable facets of amateur radio. I hope you will find as much enjoyment in the design process as I have.

**ham radio**

# private call system

## for vhf fm

Tired of the blurps and bleeps while listening to your repeater? Try this tone encoder for private and noise-free monitoring

**There are many times** when you might like to monitor your local repeater while waiting for a friend to come on without having to listen to continual chatter or "kerchunking." The system described here is similar to the Motorola paging units wherein a tone is transmitted that disables receiver squelch. With the *Priva-Call* installed in your radio, all your friend has to do is transmit your particular (private) tone. The *Priva-Call* will sense this tone, connect the speaker to the rig, and a CALL light will illuminate. The system is self-contained and is simply plugged into your external speaker jack. A 10-ohm resistor provides a load to your radio at all times.

### circuit description

Audio from your receiver speaker is fed into pin 3 of U1, the NE-567V phase-locked loop (**fig. 1**). When a tone of the correct frequency is received, the voltage on pin 8 will drop from 4 to near zero volts. This causes Q1 to switch off, increasing its collector volt age from zero to 2 volts. When the gate voltage of Q2, the SCR, increases to a voltage higher than the cathode voltage, Q2 triggers on and closes relay K1, which turns on the speaker. The speaker will now remain on until the RESET switch is activated.

When you're finished answering your call, simply switch to RESET, then switch to ON. This will disconnect the speaker, and the *Priva-Call* will remain in the standby mode until the proper tone is again received.

### construction

The circuit was breadboarded and verified for operation using a plug-in type breadboard available through E. L. Company, Continental Specialties, Radio Shack, and others. This saves much time during the debugging stage.

After the circuit was working properly at minimum current drain, it was built onto a piece of Vector board 1 x 1½ inches (3x4cm) in size with hole spacing to match the NE567 PLL.*

Parts layout isn't critical, since the circuit operates at audio frequencies. By making the board size small enough, it was fitted inside my existing *Touch-Tone* box.† An alternative method would be to mount the board, a battery pack (9 or 12 volts), and a small speaker inside a separate box and mount this box next to your rig. The decoder plugs into the speaker jack and the tone generator taps into the microphone input, so the system can be changed easily from rig to rig without destroying the resale value.

The easiest way to construct the *Priva-Call* is to start at the left side of the circuit diagram and just begin wiring parts to the board in the order you get to them. Most component values are uncritical and can be obtained from advertisers in this magazine or through your local Radio Shack store.

R1 can be a small trimmer of 10k-100k ohms. R2 and R3 determine the phase-lock frequency and should total 1k-15k for most audio tones. The values I chose gave a frequency range from 830-1340 Hz. Reducing R2 to 1k and increasing R3 to 10k or 20k will give a much broader range. R4 can be 2k-22k. R5 can be 1k-10k. R6 and C5 provide a 1.5-second time delay to prevent false triggering. R8 can be 50 to 500 ohms; its purpose is to keep the gate current small. R9 and CR2 aren't really needed for proper operation and could be omitted. CR2 does provide a CALL in-

*Etched and drilled printed circuit boards are available from the author; instructions and parts layout are included. The price is $3.95 postpaid. Comments and questions are welcome, but please send a self-addressed stamped envelope for replies.

†Available through D.A.R.T., Post Office Box 201, Clawson, Michigan 48017. (Price as of 1975 was $6.75, postpaid.) For a picture and description, see *ham radio*, November 1973, page 67.

**By Ken Wyatt, WA6TTY,** 12391 Marilyn Circle, Garden Grove, California 92641

dicator, though, and the combination of R9 and CR2 helps to reduce the current drain when the relay is on.

The value of R9 should be small enough so the relay will turn on and off reliably. Start with no resistor (also remove CR2 so it won't burn out), and get the circuit working first. Add R9 and CR2, then start increasing R9 to reduce current drain. By adding that one resistor, the current drain can be reduced from 40 to 25 mA — a valuable saving if your rig is battery operated.

C1 can be a 0.1 to 0.5$\mu$F disk ceramic. C2 determines the frequency and should be of good quality for stability. C3 should be a minimum of twice the value of C4. If C3 is too large, it will delay turn-on and turn-off of the NE567. C4 determines the bandwidth and should be 2.2$\mu$F. C6, C7, and C8 provide rf bypassing to prevent triggering by nearby transmitters.

For those who wish to experiment, the formula for frequency in this case is

$$F = \frac{1.1}{(R2 + R3) \cdot C2} \qquad \textbf{(1)}$$

where $F$ is frequency (Hz), $R2$, $R3$ are in ohms, and $C2$ is in farads.
The formula for per cent bandwidth is

$$BW = 1070\ (V/F \times C4)^{1/2} \qquad \textbf{(2)}$$

where $BW$ is bandwidth (%), $V$ is the input voltage (which equals 0.2 V) $C4$ is in $\mu$F, and $F$ is frequency (Hz).

## encoder circuits

Three simple ways can be used to provide the call ing tone; two are oscillator circuits and the third uses a *Touch-Tone* pad. I used the tone pad since it provides a stable frequency by pushing adjacent buttons. See **table 1** for a listing of all the possible frequencies available.

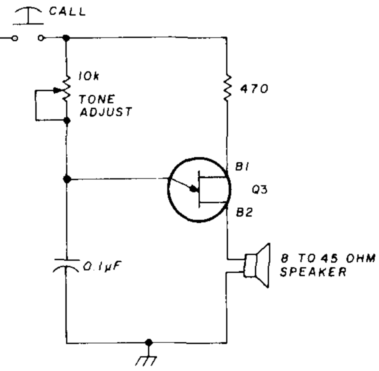


**fig. 2. Encoder system 2, which uses a unijunction transistor (UJT) oscillator. The speaker is held near your microphone to activate the system.**

System 2 is a UJT oscillator, which can be audio-coupled to your transmitter by holding the speaker next to the microphone (see **fig. 2**).

System 3 uses a phase-locked loop IC as the tone generator and is directly connected to the microphone input, **fig. 3**. Also, bear in mind that these are not the only circuits that will work for generating audio tones. For example, many circuits have been devised using the NE555 timer IC.[1]

## system hookup

The *Priva-Call* system is designed to fit between the speaker jack on your transceiver and an external speaker. Note that if the decoder board is mounted inside your radio, you can use the original speaker. I used a Motorola speaker, but there's no reason why

| | | |
|---|---|---|
| C1,C2 | 0.1 $\mu$F | 272-1069 |
| C3 | 4.7 $\mu$F, 15 volts | 272-1001 |
| C4 | 2.2 $\mu$F | 272-1040 |
| C5 | 100 $\mu$F, 15 volts | 272-1005 |
| C6,C7,C8 | 0.01 $\mu$F | 272-131 |
| Q1 | 2N718, 2N2222, 2N3565 | 276-2009 |
| Q2 | small scr | 276-1059 |
| U1 | NE567V | 276-1721 |
| CR1 | 1N4735, 6.2-volt, 1-watt | 276-561 |
| CR2 | Red LED | 276-041 |
| RY1 | *miniature magnetic reed relay* | 275-230 |
| | *or sensitive mechanical relay* | 275-004 |
| SW1 | dpdt miniature toggle switch | 275-1546 |
| R1 | 10k trimmer | 271-218 |
| R3 | 5k trimmer | 271-217 |

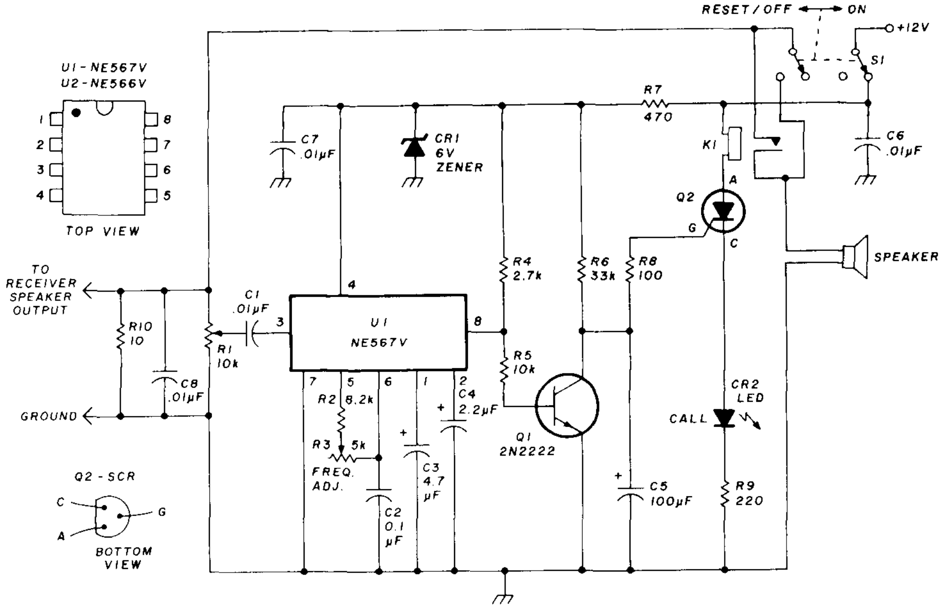


**fig. 1. *Priva-Call* decoder schematic. Capacitors less than 1 $\mu$F are disk ceramics; those over 1 $\mu$F are electrolytics.**

table 1. **Possible tone frequencies available for use with the** *Priva-Call* system using the *Touch-Tone* pad.

| pushbutton numbers | frequency (Hz) |
|---|---|
| 1 and 2 | 697 |
| 4 and 5 | 770 |
| 7 and 8 | 852 |
| * and 0 | 941 |
| 1 and 4 | 1209 |
| 2 and 5 | 1336 |
| 3 and 6 | 1447 |

you couldn't mount a small speaker inside the same minibox as the decoder. See **fig. 4**.

The system I used incorporated both the *Touch-Tone* pad and the decoder board. See **fig. 5**.

## adjustment

You can either use a signal generator set to your tone frequency, or a repeater-group member or friend who will transmit the tone.

**Signal generator method.** Disconnect the *Priva-Call* from the speaker hjack of your radio and connect it to your signal generator. Set the generator for about 1 volt output at the tone frequency you want. Adjust R1 for a reading of 0.1 to 0.2 volt at pin 3 of U1. Now slowly adjust R3 until the system triggers on. The voltage at pin 8 of U1 should decrease to near zero.

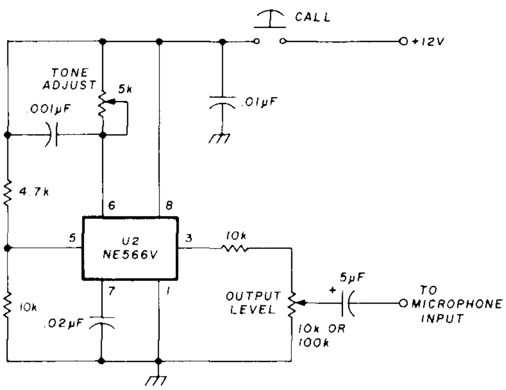


**fig. 3. Encoder system 3. This system uses the NE566V phase-locked loop. Output level is adjusted so that the tone is the same amplitude or slightly less than that of your voice as someone listens to your signal.**

Remove the tone signal and the SCR should remain conducting and the CALL light should remain illuminated. Move switch S1 to RESET then to ON, and the CALL light should turn off, indicating standby mode. If the system triggers falsely when connected to your radio, make sure that the voltage at pin 3 of U1 is not more than 0.2 volt. This is ac voltage, by the way, and *not* dc voltage.

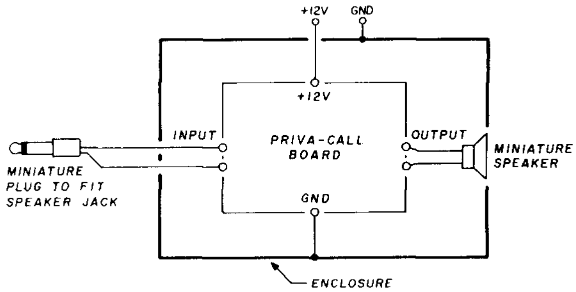


**fig. 4. Self-contained version of the *Priva-Call*.**

**Group-member method.** Instruct your friend to transmit the tone for three seconds then wait for seven seconds repeatedly until proper operation is obtained. Adjust the volume control on your radio for normal listening level. Then adjust R1 and R3 as

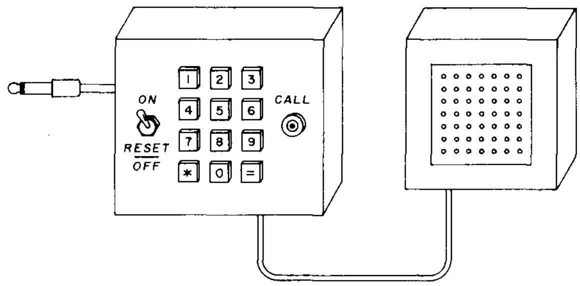


**fig. 5. *Priva-Call* system with external speaker, which is built into a *Touch-Tone*® box (see text).**

described above until your speaker is triggered on every time.

## operation

Place toggle switch S1 in the RESET/OFF position and adjust your radio for normal listening volume. To call a station, press the CALL button or the proper *Touch-Tone* buttons. Hold the CALL button in for at least two seconds so you're sure the other party's speaker has latched on . Now make your call as normal.

To place your *Priva-Call* in the standby mode, move the switch to the RESET/OFF position and adjust your radio for normal volume. Turn on the squelch and move the switch to the ON position. The *Priva-Call* is now ready to receive the proper call tone.

## reference

1. Request a copy of the *LM-555 Timer Application Notes* from Signetics, 811 East Arques Avenue, Sunnyvale, California 94086. See also *The Linear Data Book*, National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051 (price: $3.50). Also available through Radio Shack stores.

**ham radio**


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# measuring resistance values below 1 ohm

A simple, effective circuit for low-value resistance measurements using readily available parts

**While researching the Amateur Radio** literature I found suprisingly few articles on measuring low values of resistance, especially for measurements under 1 ohm. When making a shunt for a typical 0-15 milliammeter so that it will read 0-150 milliamperes (or higher), we usually need a shunt or resistance with a value of less than 1 ohm and probably close to 0.3 ohm. Unless such a shunt is accurately made it's easy to obtain an error of 20 or 30% in the expanded-scale readings of the shunted meter.

A search revealed some significant facts about resistance measurements in general. The Wheatstone bridge, used to measure resistance, measures medium and high resistances but isn't suitable for measuring resistances of less than 1 ohm. Resistances ranging from a few to a few-hundred ohms may be measured by using a constant current of the same value flowing through a known and unknown resistance, then measuring the voltage drop across the unknown resistance.

A method for measuring very low resistance values was found in which large values of current (about 50 amperes) were applied to a low-resistance circuit, then measurements were made of the low value of voltage across the unknown low resistance. Very low values of voltage, divided by high values of current, will give values of resistance in thousandths-of-an-ohm range. This latter method seemed like a good approach, but I decided to use values of current much, much, lower than 50 amperes to measure voltage in the millivolt range.

For these measurements I used a millivoltmeter that reads 0-50 mV on one scale and 0-500 mV on the other, a Simpson model 260 multimeter (to read 100 mA, and a couple of 1-ohm 1% resistors.)

While the next statement may be old stuff to many, it nevertheless bears repeating. The ohm may be defined as the resistance of a conductor through which an emf of 1 volt will maintain a steady current of 1 amperes.* We'll use this principle in a circuit in which the voltage-to-current ratios will be 1 ohm, but the actual values of voltage and current used will be one-tenth of 1 volt and one-tenth of 1 ampere. We will have the following relationships:

$$R = \frac{E}{I}\ ;\ 1\ ohm = \frac{0.1\ volt}{0.1\ ampere}$$

$$\begin{array}{c} unknown\ R \\ (less\ than\ 1\ ohm) \end{array} \leqslant \frac{millivolt\ reading\ (volts)}{0.1\ ampere}$$

## measurement circuit

The circuit used to make these measurements is shown in **fig. 1.** If you make measurements below 1 ohm, you may wish to use eight binding posts and a minibox enclosure (mine measures 4 by 4 by 2 inches, or 102 by 51mm). Use good-quality binding posts; *do not* use Radio Shack no. 274-661, which are made in two pieces and break apart when the hex nut is tightened. A 1-inch (25mm) spacing on centers for the unknown binding posts will allow resistance measurements in terms of ohms per inch or ohms per mm. This circuit is simple. However, the mechanical connections must be tight, joints well soldered, and no. 12 or 14 (2.1 or 1.6mm) copper wire used to make connections.

## procedure

In making resistance measurements, a 1-ohm, 1% resistor (the "standard") is connected in the unknown position and the battery and milliammeter are connected to their posts (**fig. 1**). The 50-ohm pot is adjusted so that milliammeter reads 100 mA. The millivolt meter is connected last, and it will read 100 mV.

Disconnect one lead of the millivolt meter from its post, remove the 1-ohm, 1% "standard" resistor, and connect the unknown resistor (assumed to be less than one ohm). Gingerly touch the lead of the millivolt meter to its post to see if the millivoltmeter will read on the scale. Observe the millivolt reading

*An interesting but slightly different definition is given in reference 1. **Editor**

By H. J. Stark, W4OHT, 9231 Caribbean Boulevard, Miami, Florida 33189

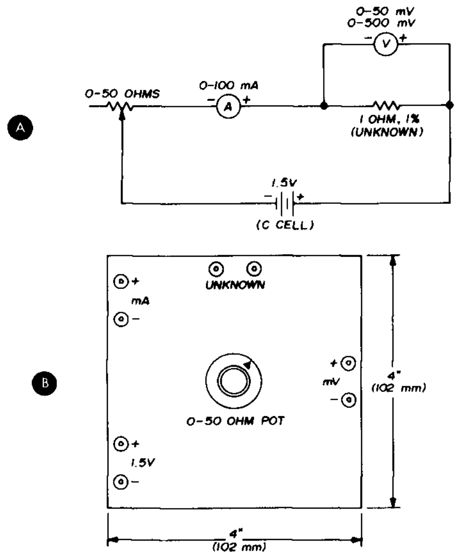


**fig. 1. Schematic, A, and panel arrangement, B, of the low-resistance measuring circuit. Binding posts for the unknown resistance can be spaced 1 inch or 25mm, which allows resistance measurements in terms of unit length. Short lead lengths of large-diameter wire are necessary for accuracy. Insulate binding posts from the chassis.**

and, at the same time, see that the milliammeter reads 100 mA.

The millivolt reading divided by 0.1 is the resistance of the unknown being measured. Remember that if you use clip leads or long wire leads from the unknown resistance to the binding posts their resistance contributes to the value of resistance being measured.

A word of caution. If you are using a sensitive and/or expensive millivoltmeter, be sure the scale or meter setting will accommodate the reading. For example, if you use a 0-25 or 0-50 millivolt range meter and the unknown resistance turns out to be 0.8, 0.9 or 1 ohm, the meter pointer will slam against its stop and meter damage will probably result. Always use the largest millivolt scale first.

Keep in mind also that accuracy is limited by such factors as the accuracy of the 1-ohm, 1% "standard" resistor and the accurracy of the meters and their shunts. Since most good-quality current- and voltage-measuring equipment available to amateurs runs about 1 or 2%, the low-resistance measurement values should also be in that range.

## reference

1. E. A. Mechtly, "The International System of Units, Physical Constants and Conversion Factors," NASA Publication SP-7012, Scientific and Technical Information Division, Office of Technology Utilization, National Aeronautics and Space Administration, Washington, D. C., 1960, page 5. (Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402; price 30 cents.)

**ham radio**

# tone-burst generator for repeater accessing

## Unique, single IC tone-burst generator that can fit inside a microphone case

**As more and more repeaters** are licensed, interference increases when a common input frequency is shared by multiple repeaters. One solution to this problem is tone-burst accessing. This type of accessing usually requires a short burst, about one second in duration, at a specified frequency such as 1800 Hz. Each time the transmitter is energized, a tone is transmitted which is decoded at the proper repeater.

### circuit description

A very simple, inexpensive, and small tone-burst generator has been developed which will fit inside a microphone case and yet is powered from the transceiver without any additional wiring. The tone-burst circuit uses a CMOS quad NOR gate, CD4001AE. These chips are obtainable from parts suppliers listed in the back of this magazine for less than $1.00. The quad NOR gates are connected in a standard astable multivibrator circuit to generate the tone needed for accessing a repeater. The Tone burst on-time is developed by an R-C time constant which is triggered by the PTT switch closure to ground. A large-valued-power supply capacitor is used to power the multivibrator for a time period slightly longer than the tone burst on-time. The capacitor is normally charged to 12 volts through the PTT circuitry during receive.

**Fig. 1** shows the schematic of the complete tone burst generator. The astable frequency is defined from the equation

$$f = \frac{1}{2.2\,R1C1}\ Hz$$

where R1 is in ohms and C1 is in farads. By making R3 greater than 2R1 the tone-burst frequency is essentially independent of temperature effects and power supply voltage. The astable multivibrator is gated on by another section of the quad NOR gate. The on-time is defined by the R2-C2 time constant and is approximately equal to

$$T_{on} = 1.1\ R2\text{-}C2\ seconds$$

where R2 is in ohms and C2 is in farads. C2 is only allowed to charge after the PTT switch closure. When C2 is charging, the oscillator will be turned on until the C2 charging voltage rises above the input threshhold of the NOR gate. Note that voltage is removed from the circuitry when the PTT line is grounded. To provide a supply voltage during the tone burst interval, capacitor C3 is used to store enough charge to power the astable. C3 is a miniature electrolytic capacitor whose value should be greater than 30$\mu$F at 15 Vdc. The series diode prevents the discharge of C3 when the PTT line is grounded.

A simple T-network is used to attenuate the 12-volt oscillator output voltage to a level necessary to drive the microphone input circuitry of the transmitter. The values of the network should be adjusted to provide sufficient drive voltage without unnecessary loading of the microphone element.

### interfacing

**Fig. 2** shows the schematic of the tone-burst generator connected to the microphone and PTT circuitry. Note that only three wires are needed to interconnect the tone-burst generator with the transmitter. The power supply voltage is taken through the PTT relay in the transmitter.

When adjusting the tone-burst frequency, it is helpful to ground pin 1 or 2 of the CD4001 so a tone

**By Gene Hinkle, WA5KPG,** I/O Engineering, 9503 Gambel's Quail, Austin, Texas 78758

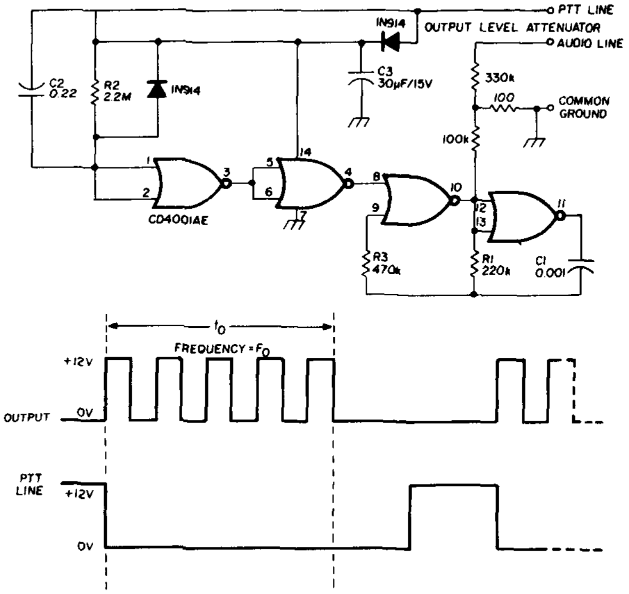


fig. 1. Schematic diagram of the tone-burst generator. A burst is generated each time the microphone switch is closed. Capacitor C3 is used to power the generator.

is generated at all times. The value of R1 should then be adjusted to put the oscillator right on frequency. A pot could be used during adjustment and then replaced after the correct resistance value is found, or if a miniature trimpot is used, it could be left in the circuit at all times.

Since the circuit uses only one IC and a few components, it will easily fit inside the microphone case

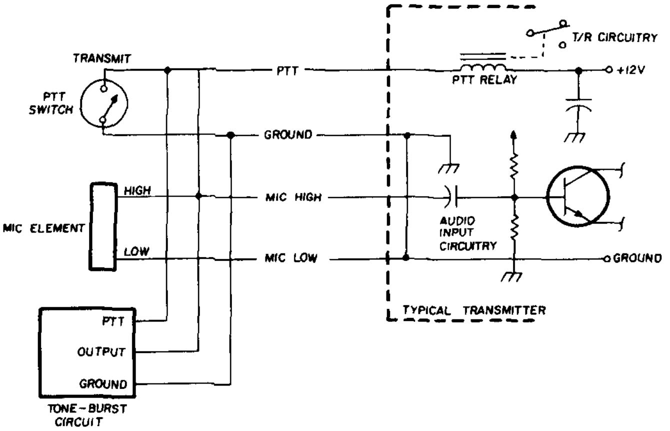


fig. 2. The connections between the tone-burst generator and a transmitter. Power is derived from the PTT circuitry. The generator will easily fit into the transmitter or even the microphone case.

or inside the transmitter chassis at the microphone connector site. If needed, a miniature switch could also be used to disable the circuit when not needed or to change the value of R1 to generate a different frequency.

**ham radio**

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# TS-520S

## AND DG-5 DIGITAL FREQUENCY DISPLAY


**FULL COVERAGE TRANSCEIVER**

The TS-520S provides full coverage on all amateur bands from 1.8 to 29.7 MHz. Kenwood gives you 160 meter capability, WWV on 15.000 MHz., and an auxiliary band position for maximum flexibility. And with the addition of the TV-506 transverter, your TS-520S can cover 160 meters to 6 meters on SSB and CW.

**DIGITAL DISPLAY** DG-5 (option)

The Kenwood DG-5 provides easy, accurate readout of your operating frequency while transmitting *and* receiving.

**OUTSTANDING RECEIVER SENSITIVITY AND MINIMUM CROSS MODULATION**

The TS-520S incorporates a 3SK35 dual gate MOSFET for outstanding cross modulation and spurious response characteristics. The 3SK35 has a low noise figure (3.5 dB typ.) and high gain (18 dB typ.) for excellent sensitivity.

**NEW IMPROVED SPEECH PROCESSOR**

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**VERNIER TUNING FOR FINAL PLATE CONTROL**

A vernier tuning mechanism allows easy and accurate adjustment of the plate control during tune-up.

**FINAL AMPLIFIER**

The TS-520S is completely solid state except for the driver (12BY7A) and the final tubes. Rather than subsitute TV sweep tubes as final amplifier tubes in a state of the art amateur transceiver,

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# TS-820S

## WITH DIGITAL FREQUENCY DISPLAY

We told you that the TS-820 would be best. In little more than a year our promise has become a fact. Now, in response to hundreds of requests from amateurs, Kenwood offers the TS-820S* ... the same superb transceiver, but with the digital readout factory installed. As an owner of this beautiful rig, you will have at your fingertips the combination of controls and features that even under the toughest operating conditions make the *TS-820S the Pacesetter that it is.*

Following are a few of the TS-820S' many exciting features.

**PLL** • The TS-820S employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

**DIGITAL READOUT** • The digital counter display is employed as an integral part of the VFO readout system. Counter mixes the carrier VFO, and first heterodyne frequencies to give *exact* frequency. Figures the frequency down to 10 Hz and digital display reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

**SPEECH PROCESSOR** • An RF circuit provides quick time constant compression using a true RF compressor as opposed to an AF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

**IF SHIFT** • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820S a pacesetter.

*The TS-820 and DG-1 are still available separately.

Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity.

An effective noise blanking cricuit developed by Kenwood that virtually eliminates ignition noise is built into the TS-520S.

The TS-520S has a built-in 20 dB attentuator that can be activated by a push button swich conveniently located on the front panel.

A special jack on the rear panel of the TS-520S provides receiver signals to an external receiver for increased station versitility. A switch on the rear panel determines the signal path . . . the receiver in the TS-820 or any external receiver.

### VFO-520 — NEW REMOTE VFO

The VFO-520 remote VFO matches the styling of the TS-520S and provides maximum operating flexibility on the band selected on your TS-520S.

### AC POWER SUPPLY

The TS-520S is completely self-contained with a rugged AC power supply built-in. The addition of the DS-1A DC-DC converter (optional) allows for mobile operation of the TS-520S.

### EASY PHONE PATCH CONNECTION

The TS-520S has 2 convenient RCA phono jacks on the rear panel for PHONE PATCH IN and PHONE PATCH OUT.

### CW-520 — CW FILTER (OPTION)

The CW-520-500 Hz filter can be easilly installed and will provide improved operation on CW.

### AMPLIFIED TYPE AGC CIRCUIT

The AGC circuit has 3 positions (OFF, FAST, SLOW) to enable the TS-520S to be operated in the optimum condition at all times whether operating CW or SSB.

The TS-520S retains all of the features of the original TS-520 that made it tops in its class: RIT control • 8-pole crystal filter • Built-in 25 KHz calibrator • Front panel carrier level control • Semi-break-in CW with sidetone • VOX/PTT/MOX • TUNE position for low power tune up • Built-in speaker • Built-in Cooling Fan • Provisions for 4 fixed frequency channels • Heater switch.

## TS-520 Specifications

Amateur Bands: 160-10 meters plus WWV (receive only)
Modes: USB, LSB, CW
Antenna Impedance: 50-75 Ohms
Frequency Stability: Within ±1 kHz during one hour after one minute of warm-up, and within 100 Hz during any 30 minute period thereafter
Tubes & Semiconductors:
- Tubes . . . . . . . . . . 3 (S2001A x 2, 12BY7A)
- Transistors . . . . . . . . 52
- FETs . . . . . . . . . . 19
- Diodes . . . . . . . . . . 101

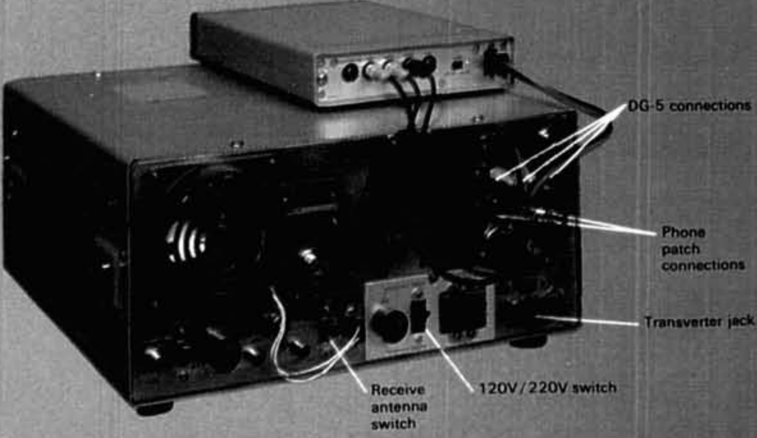
Power Requirements: 120/220 V AC, 50/60 Hz, 13.8 V DC (with optional DS-1A)
Power Consumption: Transmit: 280 Watts Receive: 26 Watts (with heater off)
Dimension: 333(13⅛) W x 153 (6-0) H x 335(13- (13-3/16) D mm(inch)
Weight: 16.0 kg(35.2 lbs)

TRANSMITTER
RF Input Power: SSB: 200 Watts PEP CW: 160 Watts DC
Carrier Suppression: Better than -40 dB
Sideband Suppression: Better than -50 dB
Spurious Radiation: Better than -40 dB
Microphone Impedance: 50k Ohms
AF Response: 400 to 2,600 Hz

RECEIVER
Sensitivity: 0.25 uV for 10 dB (S+N)/N
Selectivity: SSB:2.4 kHz/-6 dB, 4.4 kHz/-60 dB
Selectivity: CW: 0.5 kHz/-6 dB, 1.5 kHz/-60 dB (with optional CW-520 filter)
Image Ratio: Better than 50 dB
IF Rejection: Better than 50 dB
AF Output Power: 1.0 Watt (8 Ohm load, with less than 10% distortion)
AF Output Impedance: 4 to 16 Ohms

## DG-5

SPECIFICATIONS
Measuring Range: 100 Hz to 40 MHz
Input Impedance: 5 k Ohms
Gate Time: 0.1 Sec.
Input Sensitivity: 100 Hz to 40 MHz . . . 200 mV rms or over, 10 kHz to 10 MHz . . 50 mV or over
Measuring Accuracy: Internal time base accuracy ±0.1 count
Time Base: 10 MHz
Operating Temperature: -10° to 50° C/14° 122° F
Power Requirement: Supplied from TS-520S or 12 to 16 VDC (nominal 13.8 VDC)
Dimensions: 167(6-9/16) W x 43(1-11/16) H x 268(10-9/16) D mm(inch)
Weight: 1.3 kg(2.9 lbs)





## DG-5

The luxury of digital readout is available on the TS-520S by connecting the DG-5 readout (option). More than just the average readout circuit, this counter mixes the carrier, VFO, and heterodyne frequencies to [illegible] your exact frequency. This handsomely-styled accessory can be set almost anyplace in your shack for easy to read operation . . . [illegible] it on the dash-board during mobile operation for safety and convenience. [illegible] display your operating frequency while you transmit and receive. Complete with DH (display hold) switch for frequency memory and 2 position [illegible] selector. The DG-5 can also be used as a normal frequency counter up to 40 MHz at the touch of a switch. (Input cable provided.)
NOTE: TS-520 owners can use the DG-5 with a DK-520 adapter kit.

# TS-600



## TV-506

An easy way to get on the 6 meter band with your TS-520/520S, TS-820/820S and most other transceivers. Simply plug it in and you're on . . . full band coverage with 10 watts output on SSB and CW.

Experience the excitement of 6 meters. The TS-600 all mode transceiver lets you experience the fun of 6 meter band openings.

This 10 watt, solid state rig covers 50.0-54.0 MHz. The VFO tunes the band in 1 MHz segments. It also has provisions for fixed frequency operation on NETS or to listen for beacons. State of the art features such as an effective noise blanker and the RIT (Receiver Incremental Tuning) circuit make the TS-600 another Kenwood "Pacesetter".

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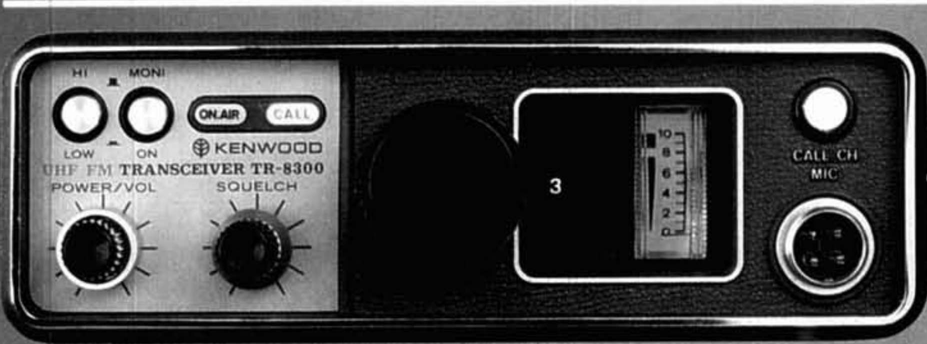


# TR-8300

Experience the luxury of 450 MHz at an economical price.

The TR-8300 offers high quality and superb performance as a result of many years of improving VHF/UHF design techniques. The transceiver is capable of $F_3$ emission on 23 crystal-controlled channels (3 supplied). The transmitter output is 10 watts.

The TR-8300 incorporates a 5 section helical resonator and a two-pole crystal filter in the IF section of the receiver for improved intermodulation characteristics. Receiver sensitivity, spurious response, and temperature characteristics are excellent.

# KENWOOD
*...pacesetter in amateur radio*

# TS-700S
## WITH DIGITAL FREQUENCY DISPLAY


**Check out the new "built-ins": digital readout, receiver pre-amp, VOX, semi-break in, and CW sidetone! Of course, it's still all mode, 144-148 MHz and VFO controlled.**

Features: Digital readout with "Kenwood Blue" digits • High gain receiver pre-amp • 1 watt lower power switch • Built in VOX • Semi-break in on CW • CW sidetone • Operates all modes: SSB (upper & lower), FM, AM and CW • Completely solid state circuitry provides stable, long lasting, trouble-free operation • AC and DC capability (operate from your car, boat, or as a base station through its built-in power supply) • 4 MHz band coverage (144 to 148 MHz) • Automatically switches transmit frequency 600 KHz for repeater operation. Simply dial in your receive frequency and the radio does the rest . . . simplex, repeater, reverse • Or accomplish the same by plugging a single crystal into one of the 11 crystal positions for your favorite channel • Transmit/Receive capability on 44 channels with 11 crystals.

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Features Kenwood's unique Continuous Tone Coded Squelch system, 4 MHz band coverage, 25 watt output and fully synthesized 800 channel operation. This compact package gives you the kind of performance specifications you've always wanted in a 2-meter amateur rig.

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Shown with the PS-8 power supply

(Active filters and Tone Burst Modules optional)


# TR-7500

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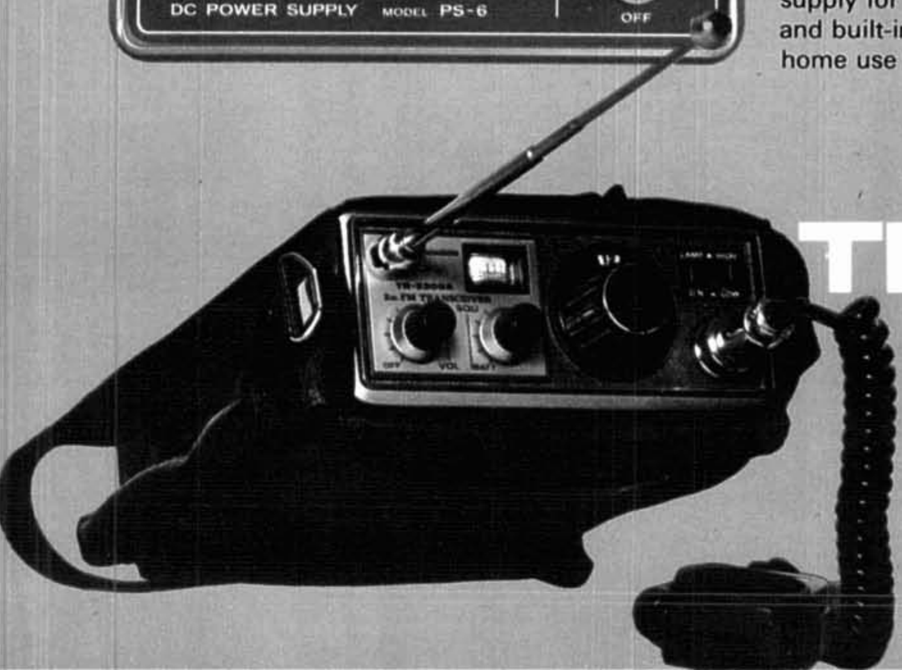

# TR-2200A

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## R-599D T-599D

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# *Fine equipment that belongs in every well equipped station*

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- TS-820 . . . . 10-160 M Deluxe Transceiver
- DG-1 . . . . . . Digital Frequency Display for TS-820
- VFO-820 . . . Deluxe Remote VFO for for TS-820/820S
- CW-820 . . . 500 Hz CW Filter for TS-820/820S
- DS-1A . . . . . DC-DC Converter for 520/820 Series

**520 Series**

- TS-520S . . . 160-10 M Transceiver
- DG-5 . . . . . . Digital Frequency Display for TS-520 Series
- VFO-520 . . . Remote VFO for TS-520 and TS-520S
- SP-520 . . . . External Speaker for 520/820 Series
- CW-520 . . . 500 Hz CW Filter for TS-520/520S
- DK-520 . . . . Digital Adaptor Kit for TS-520

**599D Series**

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- T-599D . . . . 80-10 M Matching Transmitter
- S-599 . . . . . External Speaker for 599D Series
- CC-29A . . . . 2 Meter Converter for R-599D
- CC-69 . . . . . 6 Meter Converter for R-599D
- FM-599A . . FM Filter for R-599D

## SHORT WAVE LISTENING

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- TS-700S . . . 2 M All Mode Digital Transceiver
- VFO-700S . Remote VFO for TS-700S
- SP-70 . . . . . Matching Speaker for TS-600/700 Series
- TR-2200A . 2 M Portable FM Transceiver
- TR-7400A . 2 M Synthesized Deluxe FM Transceiver
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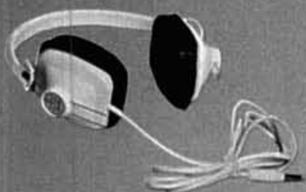
| Telescoping Whip Antenna | T90-0082-05 | TR-2200A |
| Ni-Cad Battery Pack (set) | PB-15 | TR-2200A |
| 4 Pin Mic. Connector | E07-0403-05 | All Models |
| Active Filter Elements | See Service Manual | TR-7400A |
| Tone Burst Modules | See Service Manual | TS-700A, TR-7400A |
| AC Cables | Specify Model | All Models |
| DC Cables | Specify Model | All Models |



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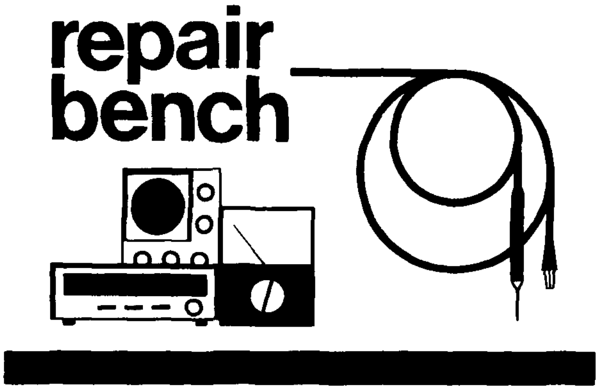


# Joe Carr, K4IPV

## troubleshooting the power supply

**It's probably safe to say** that few circuits fail as often, in almost every type of equipment, as the power supply. In fact, a dictum often given younger electronics people by more experienced hands is to look for the power supply problem before attempting to find any others. I know this is a rather large claim, but it's supported by almost two decades of electronic service experience and will probably be corroborated by others who have such experience.

In this month's *repair bench* we'll discuss the troubleshooting techniques appropriate to receivers, transceivers, low-to-medium-power transmitters, and other items of station equipment. It's assumed that the reader is limited as to available test equipment, so the procedures are given in terms of simple voltmeters and ohmmeters, although it's recommended that you also obtain at least a low-cost oscilloscope.

### full-wave supply

Consider the rather ordinary full-wave supply of **fig. 1**. This circuit is of a type frequently encountered in amateur radio equipment. We'll not spend any time describing the operation of this type of circuit because this is an article on troubleshooting, not theory. If you want a review, see the *Radio Amateurs Handbook* and the other appropriate amateur literature.

**By Joseph J. Carr, K4IPV,** 5440 South 8th Road, Arlington, Virginia 22204

The rectified output voltage waveform, without filtering, resembles a series of pulsating dc waves (or inverted parabolas). But with capacitor C3 connected the waveform more nearly resembles that of **fig. 2A**. The output waveform taken across bleeder resistor R1 should be very close to a straight line and be ripple-free.

### common problems

Several different types of problems will be found in power-supply circuits. Those most often found are:

1. Hum or ripple on the dc output.

2. No output voltage, but the fuse is okay.

3. Fuse blows.

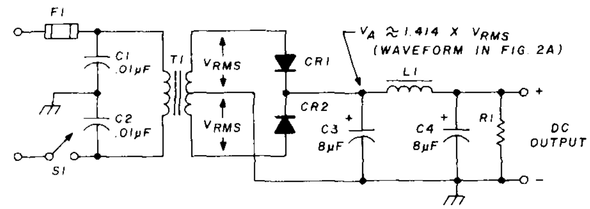


**fig. 1. Typical dc power supply using full-wave rectification. The text describes methods for troubleshooting problems that cause ripple or hum in the output.**

Ripple appears in any number of ways, depending mostly on the nature of the circuit drawing power from the affected power supply. In a communications or broadcast receiver, for example, the hum will most likely be heard in the speaker or earphones; while in a transmitter, the hum will most likely modulate the output and be heard by others. It doesn't only affect ssb/a-m transmitters, incidentally, so also suspect ripple in many types of problems in CW and fm transmitters. On a television screen, ripple will usually show up as either single (60 Hz) or double (120 Hz) horizontal black bars, sometimes of low contrast, that seem to migrate vertically up the screen.

In almost all cases where ripple or hum originates in the power supply, it's reasonably safe to "pre-indict" the filter capacitors. These components are the most frequent source of trouble. Realize, however, that not all sources of hum or apparent ripple are the fault of the power supply. There are several other sources for such spurious signals.

One of these is a resistive short circuit in a vacuum tube. The heaters, and sometimes the cathode are powered directly from low-voltage ac and this voltage will either appear on the grid or modulate the cathode-plate current directly in some cases. Another case is low-frequency oscillation with a frequency that approximates that of the power line or its second harmonic. Also, in many types of equipment, the possibility of ground loops must be considered as well as common-mode rejection problems or shielding defects as a source of hum.

One differentiating technique is to examine the frequency of the hum. In all equipment that uses any form of *fullwave* rectification, the ripple frequency in the power supply is 120 Hz (or twice the line frequency for those outside the United States and Canada). If the hum is nearer to the line frequency, then you can suspect one of the other causes and temporarily forget the power supply.

These articles on power-supply servicing contain much useful advice for newcomer and old timer alike. Especially appropriate are the author's remarks on "dos and don'ts" in working with this type of circuit. Joe Carr's remarks are *must reading* for anyone thinking about working on power supplies, regardless of the voltages involved. **Editor**

The waveforms in **figs. 2A** and **2B** were taken from the same power supply, on the same oscilloscope, with the same sensitivity setting, during the same session. The actual power supply circuit was not unlike that of **fig. 1**, but the filter capacitors were higher in value. The waveform of **fig. 2A** was taken at point **A** (in **fig. 1**) with capacitor C3 connected and in good condition. The waveform in **fig. 2B**, on the other hand, represents the waveform at the same point but with C3 disconnected. This exercise effectively simulates an open capacitor as might be found in actual equipment. Note the rather dramatic increase in ripple amplitude.

**table 1. Steps to follow when troubleshooting a power supply when no dc output is obtained.**

| measurement across | approximate value | check for open circuit if no voltage at* |
|---|---|---|
| **1.** T1 primary | 115 Vac | F1, F1 holder; S1; ac power cord |
| **2.** T1 secondary | high-voltage ac | T1 primary; T1 secondary |
| **3.** C3 | high-voltage dc | T1 center tap; center tap grounding; diodes CR1 and CR2 |
| **4.** Across C4 | high-voltage dc | L1 |

*All checks are performed with an ohmmeter and with the ac power plug removed from the wall outlet. Wait a few seconds, then connect an alligator cliplead across the filter capacitors. Connect the negative or grounded end first, then attach the hot end. Leave the cliplead in place for 25 seconds, then remove it. The supply should be safe for both you and the *ohmmeter*. In the last two steps it may be necessary to remove the two diodes before making resistance measurements, as they can give erroneous readings.

Always check the associated wiring and solder connections for each component! Many bad solder connections are difficult to eyeball, so you may want to re-do each one if no other possible cause is found.

## component substitution

If you don't have an oscilloscope, then you'll have to trouble shoot using the component substitution technique. This technique consists of shunting a known good capacitor across each filter capacitor in its turn. It's important to a) use a filter capacitor with the *same* or *higher* ratings and b) scrupulously observe *polarity markings.*

An aluminum electrolytic capacitor might explode if power is applied in reverse of normal polarity. Even if the danger from shrapnel is reduced, the cleanup afterwards and the pure fright involved should be reason enough to take care!

Capacitor bridging must be done with care, not only as mentioned above, but in the actual manner in which you perform the job. You may well be dealing with potentials that can be lethal, so some safety precautions are necessary. In this one respect I advise you to ignore the professional servicer and listen to some expert advice given to beginners:

**1.** Turn the equipment off.

**2.** Using a screwdriver, or preferably an alligator cliplead, ground the filter capacitor for a few seconds.

**3.** Check with a dc voltmeter to make sure all the charge has been *drained off* the capacitor.

**4.** Using either alligator clipleads or solder tacking, connect the known good capacitor across the suspect component.

If the substitute capacitor makes the symptoms disappear, then make the substitution permanent — first go through the capacitor discharge procedure given above.

Many people, even (or perhaps especially) those professionally experienced in electronic servicing, are tempted to solder a new replacement directly across the open capacitor which was used originally. This approach to "repair" seems especially convenient if the bad capacitor is a multi-section chassis-mounted type, and an available replacement is of the tubular type . This is an example of popular, but *extremely poor* practice. It's often the case that the old capacitor will short circuit, which will have a spectacularly bad effect on the future life expectancy of your equipment! This is one of those cases where we

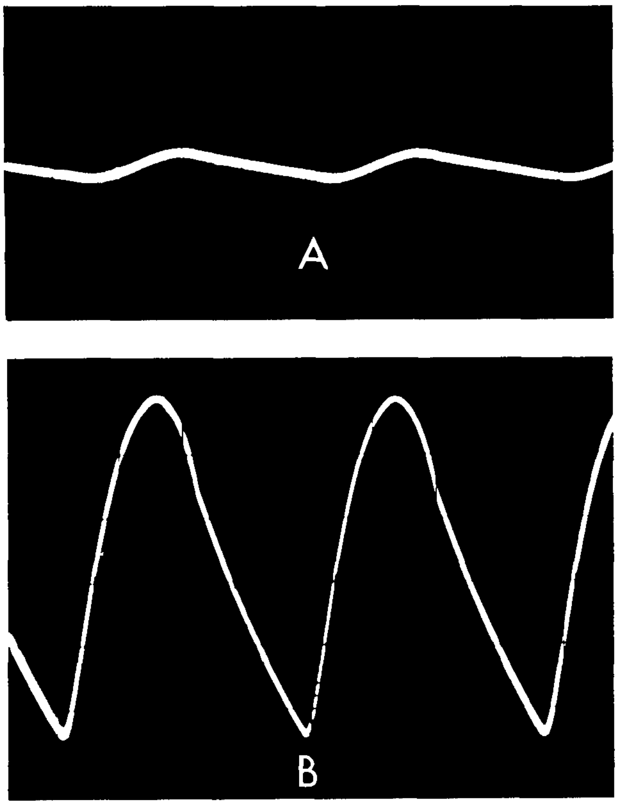


**fig. 2. Oscillograms showing the output waveforms obtained from the supply in fig. 1. Picture A shows the supply output waveform taken with capacitor C3 (fig. 1) connected. Picture B shows the pulsating waves obtained at CR1, CR2 junction (fig. 1), without the succeeding filter, C3, L1, C4 connected.**

can show a good reason for demanding good craftmanship on repair jobs. Shunting a bad capacitor with a good one, then, is only a *diagnostic* method and is definitely **NOT** a *repair* technique!

In cases where there's no dc output but the fuse is intact, or where the fuse blows, it's necessary to use a vom or vtvm. These instruments are so low in cost these days that you should make one or the other a part of your amateur-station equipment. For most amateur work the vom is preferred. Reasons: portability, low cost, and it's not susceptible to rf fields.

But let's get back to our next problem type: no dc output, but the fuse is intact. **Table 1** shows the steps to follow in this type of job. Set your voltmeter to its highest ac scale and connect the probes across the primary of transformer T1. Turn on the power and observe the voltage reading. If it's too far down the scale to be easily read, reduce the voltmeter range, posittion-by-position, until a good reading is obtained. If you get past the 150-Vac scale, however, and still have no reading, then give up.

A good reading (105-125 Vac in the U.S.) indicates that you should go o n to the next step. If, on the other hand, there's no voltage across T1 primary turn off the set, unplug it from the wall outlet, then use ohmmeter continuity checks (*R x 1* scale) to find the open component. Check those items indicated in the right-hand column of **table 1** for continuity.

Similarly, you must check the voltage across the T1 secondary. Again set your ac voltmeter to its highest ac scale and work down until a readable deflection is obtained. If there's no voltage across T1 secondary, suspect either the secondary or primary winding as being open. Use the same procedure as indicated in the first step.

For the last steps in the procedure, it's necessary to use the dc scales of your voltmeter. The same method of starting with the highest scales and working down is necessary to avoid an expensive surprise.

## the open fuse

A somewhat more spectacular type of power supply defect is the case of the blown fuse. It's reasonably true that "fuses don't cause trouble, they *indicate* trouble." Whenever a fuse blows you must assume that there's a root cause, and that does not usually include a surge on the ac line, as many often believe. To be sure, such activity can occur during a thunderstorm, but in most residential areas few truly destructive surges do occur. Something overloaded that power supply, and it bears at least an attempt at diagnosis!

One of my first employers in electronics was fond of saying that, "All electrical troubleshooting involves the finding of an unwanted path for current, or locating a lost but required path for current," and that "The best tactic is to divide and conquer." Good advice 18 years ago and still good advice today. Such is the approach with the case of the blowing fuse.

We want to find an unwanted path for current (a short circuit) and must follow either (or both) of two schools of thought on how to divide and conquer.

One school maintains that the best method is to obtain a good supply of new fuses and keep replacing them as they blow. In the meantime, between fuse changes, you disconnect first one component then another until one is disconnected that causes the fuses to stop blowing. This technique has a certain validity, but can be expensive, especially if there are a large number of options. A better idea is to mount a television receiver-type ac circuit breaker in a plastic box (well insulated). Solder one end of two alligator clipleads to the breaker. The alligator-clip ends are then used to shunt the blown fuse. This can be a little dangerous if not done correctly, so if you have any doubts, then use up a couple of boxes of fuses.

The other school of thought is to use an ohmmeter to locate the short circuit to ground. This is the method of choice if there is some way of knowing the expected resistance to ground at various critical points. This type of information is often given in amateur equipment service manuals, but in many cases you will have to guess. This technique is the more elegant of the two, provided it works, because one must always be aware that operation of an overloaded circuit, even if the fuse is expected to go up in smoke, can further damage the equipment. Under **NO** circumstances may you use a higher-value fuse!

The actual procedure in "divide-and-conquer" servicing of a power supply circuit depends somewhat upon the type of equipment being serviced. In audio circuits you may have a shorted output tube or transistor, shorted output transformer, and so forth. In a transmitter, on the other hand, a final amplifier operated without protective bias may well blow a fuse if the excitation fails. If an ohmmeter check fails to reveal a short circuit in such a case, then suspect a loss of drive, or a sagging filament, as the cause. The latter problem may occur after a few moments normal operation and it is most frequently seen in transmitters where the final-amplifier tubes are mounted horizontally.

If a short circuit does show up on the ohmmeter, however, it can be conquered by first disconnecting the rectifiers (the most frequent single cause of trouble), and then the load, followed by the filter capacitors. Don't overlook the possibility of a carbon path from an arc or dirt to ground, which could cause the trouble.

## power-supply dos and don'ts

**1.** If at all possible, use an isolation transformer to power all instruments and equipment being used or serviced.

**2.** Always use *well-insulated* alligator clipleads and meter probes. If they are in disrepair then repair them before use.

**3.** *Always* unplug the power cord when connecting or disconnecting clipleads or when soldering tacking.

**4.** Work on a bench with a master power shut-off switch and, if possible, a ground-fault interrupter.

**5.** Use the "buddy-system" and inform the buddy where the master shut-off is located and how it's operated. Similarly, inform all members of your family of the master-switch location and under what circumstances it is to be operated.

**6.** If your equipment and instruments don't have three-wire power cords, install them. In this type of power cord a third wire (usually green in color) is grounded to the equipment chassis.

**7.** *NEVER* work outside or in an area with a concrete or dirt floor* unless the equipment is designed for that purpose by reason of *double-insulation* or *three-wire* power line grounding of the equipment case. Many people have been killed by indoor appliances taken out of doors.

**8.** Now for a seeming paradox: *NEVER* defeat or trust interlocks.

**9.** Never service ac/dc equipment unless operated from an isolation transformer. Similarly, never use ac/dc equipment outdoors.

**10.** Always do quality work, use quality components, and *never* button up a piece of equipment cabinet with a temporary or unorthodox repair inside. A Murphy's Law corrollary states that, "Temporary repairs become permanent if there are more than two screws holding the cabinet together."

**11.** Switch to safety, think safe, work safe, be safe, and live.

*The editor of this article, W6NIF, after 40 years as an amateur, was careless recently when testing a 4500-Vdc power supply. He was working in a garage with a concrete floor and the +4500-volt lead accidentally fell onto the concrete. W6NIF was lucky — he survived.

**ham radio**

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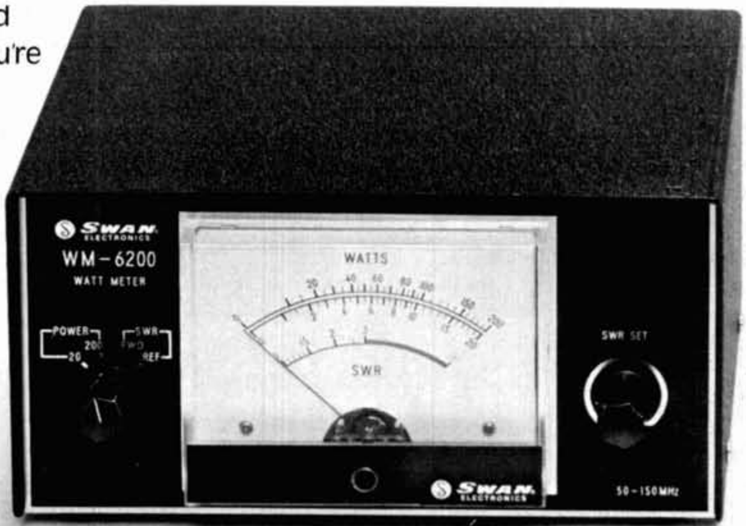


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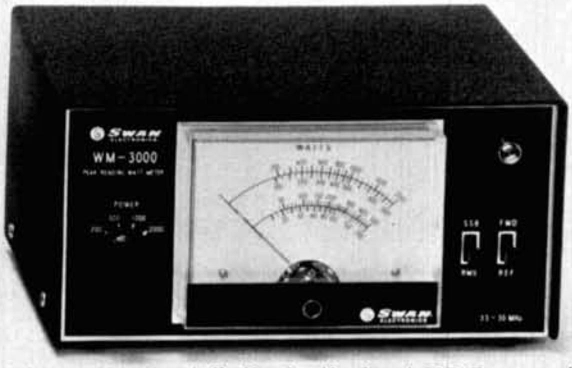


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# remote checking of repeater shack temperature

By **Fred Johnson, ZL2AMJ**, 15 Field Street, Upper Hutt, New Zealand

**Our repeater site** is situated in a hut at 2823 feet (860m) on top of a mountain. The site is sometimes snow covered in winter, and user stations have often discussed the likely temperature at the site. It was finally decided that a very simple addition to the repeater would enable users to know if the temperature was above a preset level. It would then be possible to track the temperature through the day to learn the time when the temperature passes across that level in the morning, and when it passes back across that level in the late afternoon. Variations in the daily times of change enable estimates of the temperature maxima and minima to be made.

The modification to the repeater is simple. A room thermostat and a capacitor have been added to the repeater, increasing the length of the squelch tail when the thermostat contacts are closed. After the temperature drops below the thermostat setting the tail goes to its longer length condition. In our case, the tail lengthens by 2 seconds when the temperature goes below 40 degrees Fahrenheit (4 degrees Celsius). Our thermostat has been changed several times as the knowledge of the situation improved. The site is rarely visited so the setting we decide upon is permanent for long periods. It is a simple matter to measure the tail length and conclude the present temperature zone. No equipment except a watch is required at measuring stations.

The schematic (**fig. 1**) shows the control circuitry between the receiver mute and the keyed transmitter high-voltage line. Q1 and Q2 are connected as a darlington pair to minimize loading on the CA3089E mute circuitry. Q3 and Q4 are a Schmitt trigger producing a delay time before the transmitter drops out. Q5 is the series transistor which turns the transmitter on and off. The tail length is set by the values of C1, R1, R2 and the input characteristics of Q3. With the addition of C2, (by the thermostat) two very distinct tail length conditions are generated.

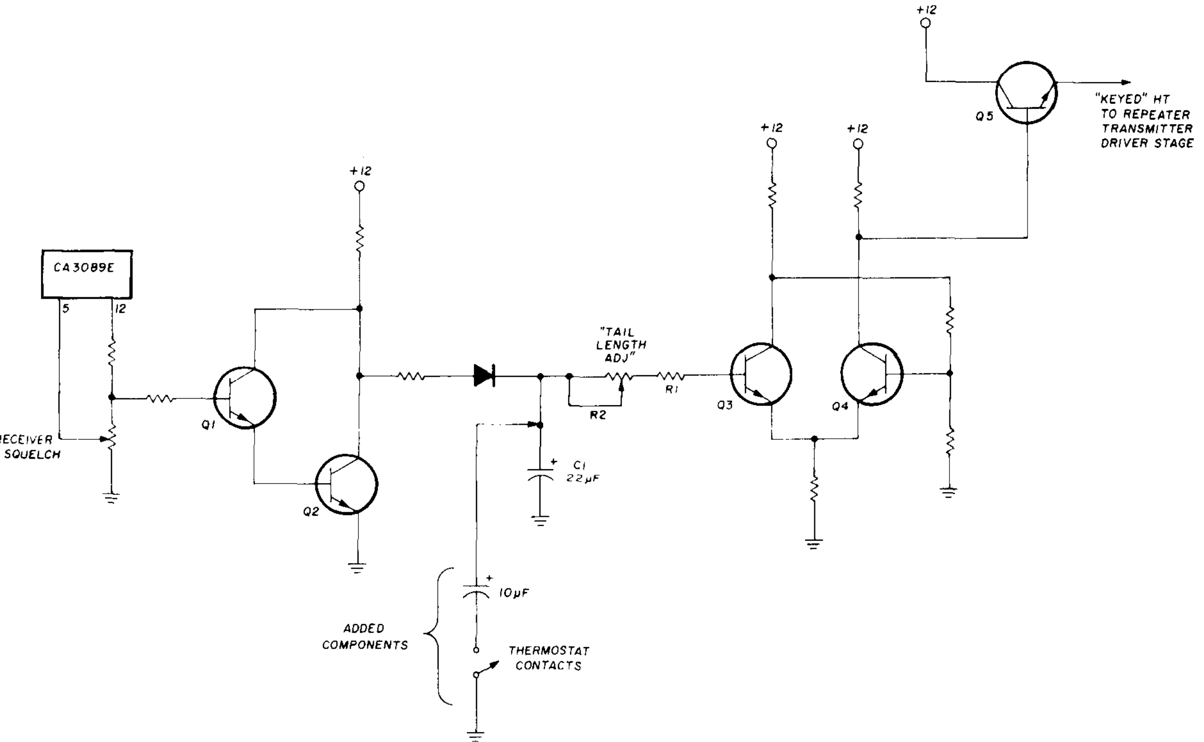


**fig. 1. Schematic diagram of the additions to squelch-tail circuitry that will permit changing the tail length. When the temperature has exceeded some level set on the thermostat, the additional capacitor will increase the length of the squelch tail.**

Although it is unlikely that your repeater will use the same control circuitry as described here, you will probably find some similar points where the addition of an appropriate capacitor and thermostat will cause an increase in the repeater tail length.

**ham radio**

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MICROPROCESSORS

# microcomputer interfacing: the 8080 logical instructions

**Last month we discussed** the concept of, and important use for multi-bit logical instructions such as AND, OR, Exclusive-OR, and COMPLEMENT. This month we'll summarize twenty-eight logical instructions in the 8080A instruction set. It is very important to note that in the case of each logical instruction, *the result is stored in the accumulator*. The previous contents of the accumulator are one of the logical variables in the two-variable logical operation, or in the case of the complement instruction, the only logical variable.

The eight different logical AND instructions, each with the mnemonic ANA S, have the following general form:

| 1 0 | 1 0 0 | s s s |
|---|---|---|
| Arithmetic and logical class of instructions | AND operation | 3-bit binary code for source register |

The three bits designated by sss correspond to the register or contents of a memory location that logically operate on the accumulator contents,

| register | octal code | 3-bit register code |
|---|---|---|
| B | 0 | 000 |
| C | 1 | 001 |
| D | 2 | 010 |
| E | 3 | 011 |
| H | 4 | 100 |
| L | 5 | 101 |
| M | 6 | 110 |
| A | 7 | 111 |

The OR and Exclusive-OR instructions, which have the mnemonics ORA S and XRA S, respectively, have the same general form as the ANA S instruction byte. Thus, for the XRA S instruction the instruction byte is,

| 1 0 | 1 0 1 | s s s |
|---|---|---|
| Arithmetic and logical class of instructions | Exclusive-OR operation | 3-bit binary code for source register |

and for the ORA S instruction,

| 1 0 | 1 1 0 | s s s |
|---|---|---|
| Arithmetic and logical class of instructions | OR operation | 3-bit binary code for source register |

Some examples are:

| logical operation | mnemonic | octal instruction code |
|---|---|---|
| B•A→A | ANA B | 240 |
| M•A→A | ANA M | 246 |
| A•A→A | ANA A | 247 |
| C+A→A | XRA C | 251 |
| L+A→A | XRA L | 255 |
| A+A→A | XRA A | 257 |
| D+A→A | ORA D | 262 |
| E+A→A | ORA E | 263 |
| M+A→A | ORA M | 266 |
| A+A→A | ORA A | 267 |

Another logical instruction, the complement accumulator instruction, has the mnemonic CMA A and the octal instruction byte 057.

In preceding columns,[1,2] we discussed the con-

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

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

cept of an *immediate instruction*, a multi-byte instruction that contains the desired data within the instruction. The three immediate logical operations can be summarized in the following way:

| logical operation | mnemonic | octal instruction code |
|---|---|---|
| <B2>•A→A | < ANI B2 > | < 346 B2 > |
| <B2>+A→A | < XRI B2 > | < 356 B2 > |
| <B2>+A→A | < ORI B2 > | < 366 B2 > |

In the two tables, the symbol → means "is replaced by". Thus, the notation B•A→A means that we AND the variable B with the variable A, and then replace the original contents of A by the result of the logical operation. Within the 8080A microprocessor chip, the logical operation is performed in a temporary accumulator, with the logical result in the temporary accumulator being *copied* into the accumulator register, A.

In last month's column we demonstrated one use for logical instructions, the testing of flag or comparator bits associated with the on/off state of external devices. The AND multi-bit operation is particularly useful when it is desired to clear, filter, or *mask* specific bits in an input data byte. For example, consider the ASCII code for the numeric characters 0 through 9:

| character | octal ASCII code | binary ASCII code |
|---|---|---|
| 0 | 260 | 10 110 000 |
| 1 | 261 | 10 110 001 |
| 2 | 262 | 10 110 010 |
| 3 | 263 | 10 110 011 |
| 4 | 264 | 10 110 100 |
| 5 | 265 | 10 110 101 |
| 6 | 266 | 10 110 110 |
| 7 | 267 | 10 110 111 |
| 8 | 270 | 10 111 000 |
| 9 | 271 | 10 111 001 |

Once the ASCII code is in the microcomputer, the most significant four bits are of little use and can be *stripped* away from the data byte. A simple program that accomplishes such a task is:

| LO memory address | octal instruction code | mnemonic | comments |
|---|---|---|---|
| 000 | 333 | IN | Input ASCII numbers from the following device |
| 001 | 015 | 015 | Device 015 |
| 002 | 346 | ANI | AND the accumulator contents with the following data byte |
| 003 | 017 | 017 | Mask byte that *masks* the most significant four bits in the ASCII word |

The program accomplishes the following Boolean operation for ASCII 5:

| ASCII 5 | | Mask byte | | BCD data of interest |
|---|---|---|---|---|
| 10110101 | • | 00001111 | = | 00000101 |

This logical result of the AND operation is, 00000101. This form contains a single BCD digit per input data byte, with the BCD digit being the least significant four bits in the byte, D3-D0. The remaining four bits, D7-D4, can be used to store another BCD digit provided there's some means to position this second digit in these open bit positions. If the four bits of storage space are not taken advantage of, 50 per cent of the memory capacity will be washed.

To *pack* two BCD digits into a single data byte, you must have the capability to rotate the contents of your accumulator. As an example, the rotate left instruction, which has the mnemonic RLC, the octal instruction byte 007, and can be described as follows: "The content of the accumulator is rotated left one position. The low order bit and the carry flag are both set to the value shifted out of the high order bit position".[3] The four rotate instructions in the 8080 instruction set have been previously discussed.[4] The accumulator is the only register that can be rotated in an 8080A chip. Other registers are rotated simply by moving them to the accumulator register, performing the necessary rotation operations and then returning the rotated byte back to the original register. Besides shifting BCD digits back and forth in data bytes, important uses for the rotate instructions will appear when discussing decision-making operations.

A simple program that can be used to pack two BCD digits into a single data byte is listed below.

| LO memory address | octal instruction code | mnemonic | comments |
|---|---|---|---|
| 000 | 333 | IN | Input ASCII 5 from the following device |
| 001 | 015 | 015 | Device 015 |
| 002 | 346 | ANI | Mask off the four most significant bits |
| 003 | 017 | 017 | Mask byte |
| 004 | 007 | RLC | Rotate the BCD digit |
| 005 | 007 | RLC | into the four most |
| 006 | 007 | RLC | significant bits that have |
| 007 | 007 | RLC | just been cleared |
| 010 | 107 | MOV B,A | Store this result in register B |
| 011 | 333 | IN | Input next ASCII character, in this case ASCII 7, from the following device |

| | | | |
|---|---|---|---|
| 012 | 015 | 015 | Device 015 |
| 013 | 346 | ANI | Mask off the four most significant bits |
| 014 | 017 | 017 | Mask byte |
| 015 | 260 | ORA B | OR contents of register B with contents of accumulator |
| 016 | 167 | MOV M,A | Store packed data into memory, the location being specified by the contents of the H,L register pair |

The result of this sequence of steps is the data byte, 01010111, stored in memory. The four most significant bits are BCD 5, and the four least significant bits are BCD 7. Observe the use of the ORA B instruction, which permitted the combination of two data bytes into one, without changing either. Special 8080 microcomputer programs, called simulators, are available that permit you to follow the execution of an 8080 program step by step by observing the changes in the contents of the internal registers.* If applied to the above program, you would observe the following, *after the execution of the indicated instruction bytes*:

*One such program, called *DEBUG*, has been developed by Tychon, Inc., in Blacksburg, Virginia; it requires the use of a teleprinter or CRT.

| executed instruction bytes | accumulator | register B |
|---|---|---|
| IN 015 | 10110101 | — — — |
| ANI 017 | 00000101 | — — — |
| RLC, RLC, RLC, RLC | 01010000 | — — — |
| MOV B,A | 01010000 | 01010000 |
| IN 015 | 10110111 | 01010000 |
| ANI 107 | 00000111 | 01010000 |
| ORA B | 01010111 | 01010000 |

This completes our discussion of the more important logical instructions in the 8080A instruction set. Additional examples will be used in the following columns, where they will be incorporated into data-manipulation and decision-making tasks.

## references


1. Jonathan A. Titus, David G. Larsen, and Peter R. Rony, "Microcomputer Interfacing: The MOV and MVI 8080 instructions," *ham radio*, March, 1977, page 74.
2. David G. Larsen, Peter R. Rony, and Jonathan A. Titus, "Microcomputer Interfacing: Register pair instructions," *ham radio*, June, 1977, page 76.
3. Intel Corporation, *Intel 8080 Microcomputer Systems User's Manual*, Intel Corporation, Santa Clara, California , 1975.
4. Paul E. Field, David G. Larsen, Peter R. Rony, and Jonathan A. Titus, "Microcomputer Interfacing: A Software UART," *ham radio*, November, 1976, page 60.


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| 50-54 | PA10-160AL◇ | 5-15 | 160 | 10 | 28 | C |
| 144-148 | PA2-25B | 1-4 | 25 | 3 | 13.5 | A |
| " | PA2-70B | 1-4 | 70 | 10 | " | C |
| " | PA2-70BL◇ | 1-4 | 70 | 10 | " | C |
| " | PA2-140B | 1-4 | 140 | 20 | " | D |
| " | PA10-40B | 5-15 | 40 | 5 | " | B |
| " | PA10-40BL◇ | 5-15 | 40 | 5 | " | B |
| 144-148 | PA10-70B | 5-15 | 70 | 8 | " | C |
| " | PA10-70BL◇ | 5-15 | 70 | 8 | " | C |
| " | PA10-80BL◇ | 5-15 | 80 | 10 | " | C |
| " | PA10-140B | 5-15 | 140 | 18 | 13.5 | D |

**SIZES: Inches:** "A", 6.5×2×2. "B", 6.5×5×2. "C", 6.5×7×2. "D", 6.5×10×2
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| FREQ. MHZ | MODEL NUMBER | PWR. INP. (watts) | NOM PWR. OUTPUT (watts) | NOM. CUR. (amps.) | NOM. VOLTS | SIZE |
|---|---|---|---|---|---|---|
| " | PA10-140BL◇ | 5-15 | 140 | 18 | " | D |
| " | PA10-160BL◇ | 5-15 | 160 | 22 | " | D |
| " | PA30-140B | 15-45 | 140 | 15 | " | D |
| " | PA30-140BL◇ | 15-45 | 140 | 15 | " | D |
| 219-226 | PA2-70BC | 1-4 | 70 | 10 | " | C |
| " | PA10-60BC | 5-15 | 60 | 8 | " | C |
| " | PA30-120BC | 15-45 | 120 | 15 | 13.5 | D |
| 400-470 | PA2-40C | 1-4 | 40 | 7 | " | C |
| " | PA10-35C | 5-15 | 35 | 6 | " | B |
| " | PA10-35CL◇ | 5-15 | 35 | 6 | " | B |
| " | PA10-100C | 5-15 | 100 | 15 | " | D |
| " | PA10-110CL◇ | 5-15 | 110 | 20 | " | D |

**NOTE:** NEW STYLE DIMENSIONS WILL BE 7.0×2.375 inches (178×60.3mm) instead of 6.5×2.0 inches (165×50.8mm)

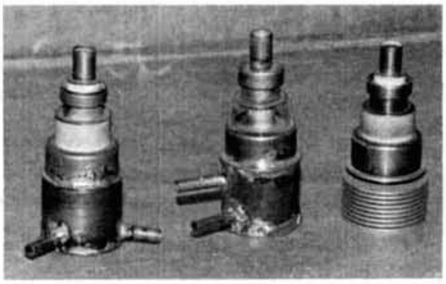
More Details? CHECK — OFF Page 142


## water-cooled 2C39

Why water cool a 2C39 tube? The answer is to prolong its life. This is written with the intent of using 2C39s in a Motorola T44 converted for ATV. T44s were not made for long periods of transmitting, as in TV but with use, watercooling the 2C39 tubes never even get warm. Also, with water-cooled tubes, 900 volts on the plate of the amplifier will give you a healthy output and yet the tube will not be working hard. The 6146 or 2E26 tubes (whichever model you have) should have some air because the box they are in will get very hot without it.

I have put quite a few of these tubes together and the best method I have found is to use a water tank 5/8 or 1 inch (16 or 25mm) long and 1-1/8 inch (28.6mm) in diameter. I use a piece of 1-1/8 inch (28.6mm) O.D. copper tubing cut to the length I want. Then I cut a piece of copper flashing (any thin piece of copper sheet can be used) to cover one end of the tubing. The short tank is for the later model T44 which uses a vane for tuning, while the larger tank is for the early T44 using a plunger on top of the tube for tuning. Note: the vane type must have the inlet and outlet on top and the plunger type has the inlet and outlet on the side.

For the inlet and outlet, I use a short piece of 3/16 inch (4.75mm) tubing about 1/4-inch to 3/8-inch (6.35 to 9.5mm) long, just long enough to put a plastic hose on. The brass tubing can be found in most hobby shops that carry model airplanes and supplies. The plastic tubing is the same as used for tropical fish tanks. After the inlet and outlet tubes have been soldered in place, the next step is to take the heat sink off the 2C39. There are two types of heat sink. One has an Allen screw while the other has a right hand thread. On the type with the thread, I hold the heat sink in a vise and hold the plate of the tube with a pair of pliers (not too tight) and gently turn it off. With the heat sink off, all that remains to finish the job is to solder the tank to the plate

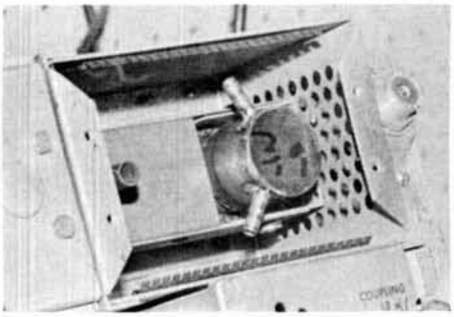


**Three 2C39 tubes include an unmodified tube (right) with original finned heat sink in place. Tube on left is from early T44 (plunger tuning) and tube in center shows "dry run" or first try at modification. Note slightly different placement of water inlet and outlet tubes.**

connection of the tube. I use a 250-watt electric solder bolt and soft solder, being very careful not to get the tube too hot. After a little soldering, I put it under running water to cool, then I solder some more and let the tube cool until the job is done. Don't solder for "looks." Solder for a tight job without too much heat on the tube. I do not use acid core solder, just regular rosin core solder.

Now don't get carried away as I did. I had the T44 tuned, so I made both tubes, put them in and filled them with water. I was so far out of tune by making all of the changes that, no matter what I tried, I couldn't get any output; so it was back to the drawing board for me.

The way that seems to work the best here is to peak the unit up at the frequency I plan to use, then take output readings in two positions, write them down and use them for reference. I use the original power supply for this. Then I pull out the 2C39 tripler, modify it, reinstall it and retune the input and output stages to get the same or better output. On the later T44, it may take a little adjusting of the Z2 and Z4 shorting bars, but keep in mind not to let the tube get too hot. At this point in the procedure there is still no water in the tube. When the output is again satisfactory treat the 2C39 amplifier the same, but keep in mind not to test a long time as you will ruin the tubes. I also mounted one tank a little off-center, putting it somewhat closer to one side of the cavity. The result was that I increased the output from 10 watts to 15 watts. This does differ from the



**Water-cooled 2C39 in place T44 final amplifier compartment. Plastic tubing for admitting and carrying away coolant not yet attached to short pieces of brass tubing on water jacket.**

tube-to-tube, so you may not get exactly the same readings.

Now the tubes are ready for the water but, again, take the tripler first and retune it, as the water will make a big difference (use only distilled water). After the tripler stage is in tune, run the water through both the tubes and retune every stage from the 6146 (or 2E26) through the final. Once the tubes are filled with water and the circuits tuned, you should have no more detuning troubles.

I use a "Little Giant" lawn ornament pump in a plastic three-gallon container. Half an hour of continuous running doesn't even begin to warm the water. We now run our amplifier with 900 volts on the plates. Air cooling the 6146 (or 2E26) is a very big help, and removing the cover also helps without causing any output loss.

My thanks to K9CZI for the photo work.

**Daniel J. Smies, WA9RPB**

## inter-band calibration stability for the Collins R-388 (51-J)

The Collins R-388 is a marvelously accurate piece of gear. It is possible to read frequency to an accuracy of about 400 Hz between 0.5 and 30.5 MHz. The heart of the receiver is a very linear and very stable permeability tuned oscillator. If you follow the technical manual for calibrating band-by-band — and there are thirty of them — you can maintain this accuracy. There can develop, however, a small problem connected with calibrating the receiver. This problem does not affect accuracy if proper procedure is followed each time the band is changed, but it slows calibration process and detracts from the receiver's tidiness of operation.

Calibration of an even band holds very well for all the even bands, but is off by a few kHz on each of the odd bands. For example, as you go from band-to-band you hear almost perfect zero-beating on even bands and tones of approximately the same pitch, *e.g.*, 2 kHz on alternate bands. If you don't use the bfo to read precise frequency, there is no problem for you can read frequency quite closely just by using the MHz and kHz dials and tuning by ear. Except for the vfo, all the tuned circuits in the receiver are in the same position before and after you follow the procedure to make odd and even bands calibrate (index) at the same point.

There are four frequency-determining elements in the calibration circuits: The calibration crystal, the crystals associated with the first mixer (selected one at a time by the band-selector switch), the vfo, and the bfo. I checked each of these to see if any pulling occurred when I rotated the band selector switch band to band. There was none. I therefore ruled out circuit design as a cause of the calibration differences between odd and even bands.

Instead, I found the problem to be a matter of adjustment not covered in the manual. The problem was located in the relationship between the vfo and the bfo, the only *adjustable* frequency-determining elements.

On even bands, the oscillator crystal frequency is subtracted from the vfo frequency; and on odd bands, the vfo frequency is subtracted from the oscillator crystal frequency. Therein lies both the problem and its solution. Below is a chart which shows what happens, for example, on band 7 (6.5 to 7.5 MHz) and band 8 (7.5 to 8.5 MHz).

### Calibration on Band 8

| | |
|---|---|
| 10 MHz | (output from local crystal oscillator) |
| -8 MHz | (harmonic of 100 kHz calibration crystal) |
| 2 MHz | |

Therefore, the vfo mid-scale frequency *should* be 2.5 MHz in order to produce the 0.5 MHz final i-f, but let's assume that it is *actually* 2.49 MHz. Then

| | |
|---|---|
| 2.49 MHz | (vfo frequency) |
| -2.00 MHz | (difference frequency: oscillator crystal frequency minus calibration crystal frequency |
| 0.49 MHz | to final i-f |
| -0.49 MHz | (bfo frequency to produce zero beat and indexing at 8.00 MHz). |

Now, without touching either bfo or vfo, change to band 7 and note:

### Calibration on Band 7

| | |
|---|---|
| 10 MHz | (output from local crystal oscillator) |
| -7 MHz | (harmonic of 100 kHz calibration oscillator) |
| 3 MHz | |

### Subtracting vfo frequency

| | |
|---|---|
| 3.00 MHz | (difference frequency: local crystal frequency minus calibration crystal frequency) |
| -2.49 MHz | (vfo frequency) |
| 0.51 MHz | (to final i-f) |
| 0.49 MHz | (bfo frequency unchanged from band 8) |
| 0.02 MHz | (beat frequency audible on band 7) |

A very simple solution exists. Place a pickup loop near the calibration oscillator tube and connect it to another receiver capable of tuning the frequency range between 2-3 MHz. A small multiband radio can be used with good results. Tune for a harmonic of the calibration crystal. Switch on the bfo and listen for a beat note. Rock the bfo knob slightly, and make sure you are hearing the bfo, not some spurious signal. Line up the bfo knob index with the indexing mark on the cabinet. Adjust the bfo coil for zero beat. This will set the bfo to 0.5 MHz and cure the difficulty.

**George Hirshfield, W5OZF**

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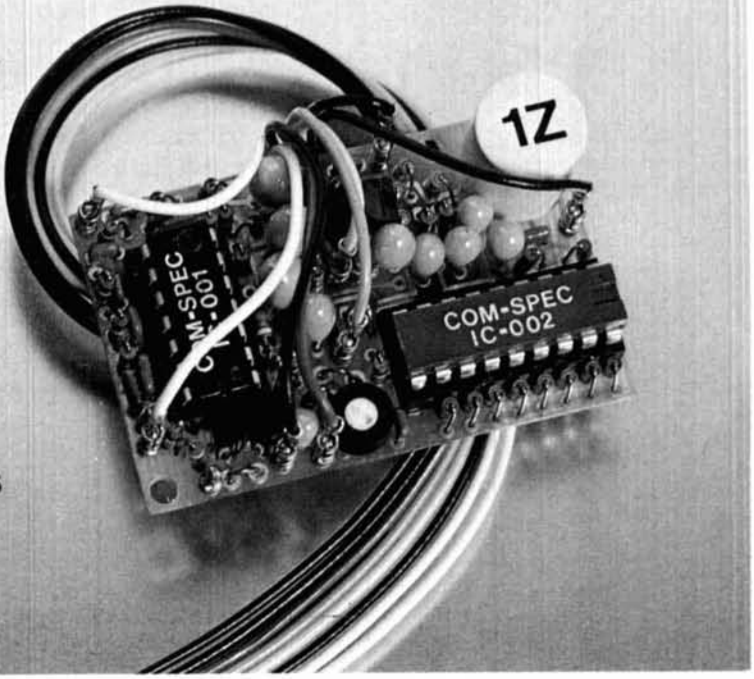


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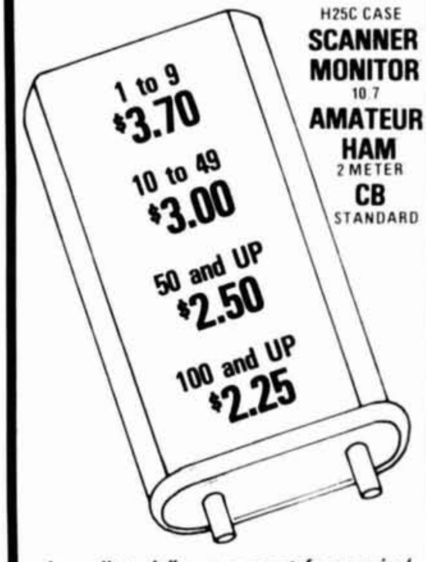


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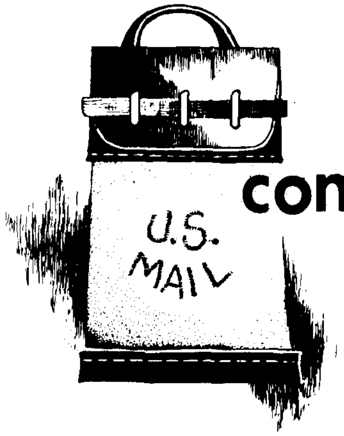

# comments

## microwave amplifier design

**Dear HR:**

I feel compelled to correct what I consider to be a serious error in Paul Shuch's otherwise well written article on "Solid State Microwave Amplifier Design" in the October, 1976, issue of *ham radio.*

Under the heading "Gain and Stability Analysis," Paul states that "If $K$ (Rollet's stability factor) is greater than 1, the amplifier will be stable under any combination of input and output impedances or phase angles." This statement is incorrect, although it is understood how it is easy to make such a sweeping statement from a reading of HP Application Note AN-154 (Paul's reference 5) alone.

This fundamental error could be the reason why many amplifiers exist today which are only marginally stable, depending on antenna or load connections, despite their designer's belief that the amplifier is "unconditionally stable." The crux of the matter is that $K$ greater than unity is a *necessary* condition for unconditional system stability, but not a *sufficient* one. Stability analysis of uhf amplifiers is far from as simple as Paul suggests.

First, it must be noted that the expression for the *device* stability factor, as I prefer to call it, is *independent* of either source or load impedance. To ensure a stable design, it

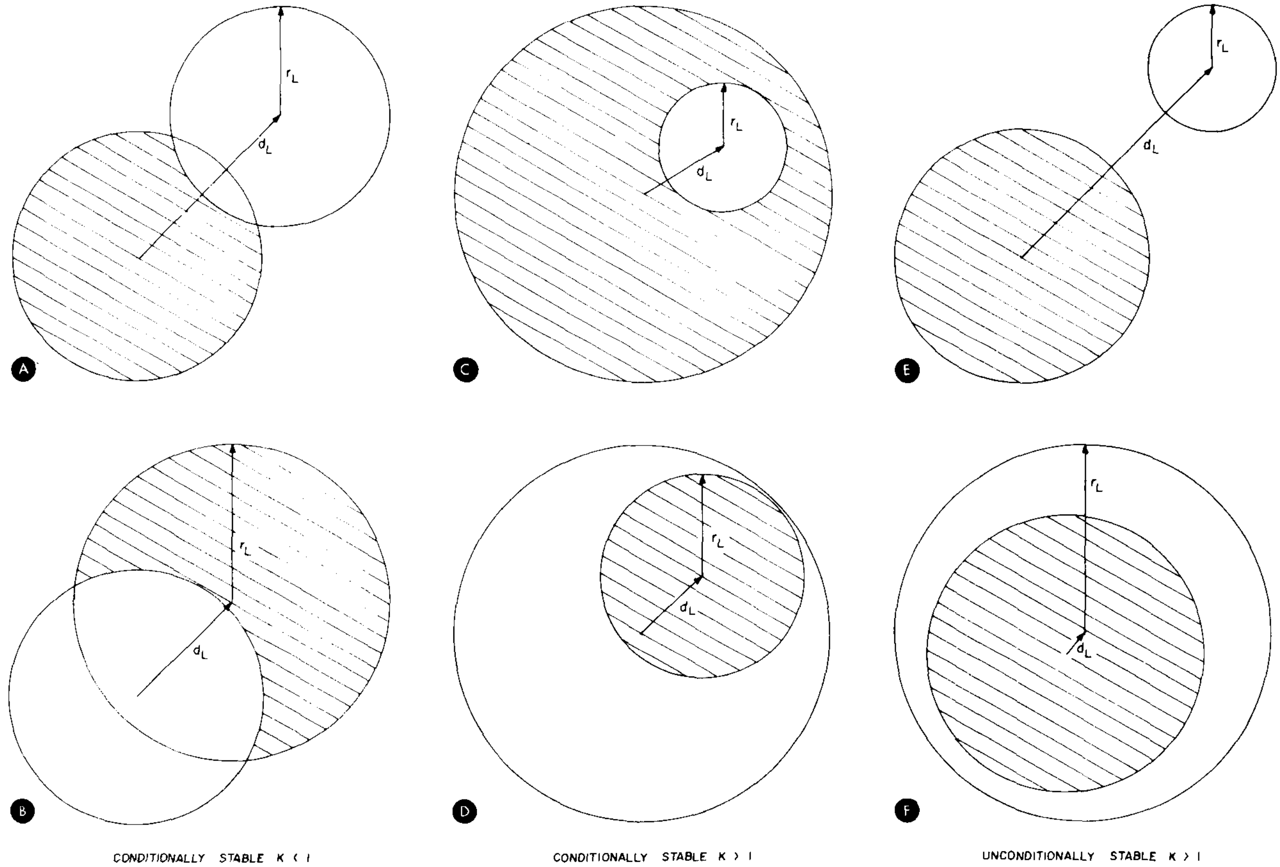


**fig. 1. Stability circle analysis contributed by VK3TK.**

is necessary to know the frequency range over which the system is potentially stable and the load and source impedances which can be used to give stable operation over this frequency range. This information requires that the device stability factor $K$ be known over the frequency range of interest and the reflection coefficients $S_{11}$ and $S_{22}$ for the terminated network (these are not the device s-parameters).*

$$S_{11} = S_{11} + \frac{S_{12} \cdot S_{21}\Gamma_L}{1 - s_{22}\ \Gamma_L} = \frac{S_{11} - \Delta\Gamma_L}{1 - s_{22}\ \Gamma_L}$$

$$S_{22} = s_{22} + \frac{s_{12} \cdot s_{21}\ \Gamma_S}{1 - s_{11}\ \Gamma_S} = \frac{s_{22} - \Delta\Gamma_S}{1 - s_{11}\Gamma_S}$$

for $\Delta$ = determinant of device scattering matrix, *i.e.* $s_{11} \bullet s_{22} - s_{12} \bullet s_{21}$.

Since the source and load terminations being considered are passive networks, their reflection coefficients $\Gamma_S$ and $\Gamma_L$ will be less than unity. For a two-port network to be unconditionally stable, it is necessary that $|S_{11}| < 1$ for all $\Gamma_L$ as $\Gamma_L$ is changed arbitrarily, but kept so that $|\Gamma_L| < 1$. Similarly, it is necessary that $|s_{22}| < 1$ for all $\Gamma_s$ as $\Gamma_s$ is changed arbitrarily, with $|\Gamma_S| < 1$.

Consideration of the $S_{11}$ and $S_{22}$ equations shows that if $|s_{11}| > 1$, then any $\Gamma_L$ will cause $|s_{11}| > 1$ and the network is potentially unstable for all $\Gamma_L$ and the given $\Gamma_S$. Stability with respect to the input port will only then be obtained by ensuring that the positive real part of $Z_s$ is greater than the negative real part of the input immitance. For the condition $|s_{11}| < 1$, the magnitude of $s_{11}$ is less than unity for any passive $\Gamma_L$. Further consideration of the two equations shows that the whole $\Gamma_L$ plane can be separated into two regions, one for which the input immitance is positive real — the stable region, and the other for which the input immitance is negative real — the unstable region. The boundary between these two regions can be defined by solving the relationship

$$|s_{11}| = 1.$$

Using

$$|S_{11}|^2 = S_{11} \cdot s_{11}{}^* = \frac{s_{11} - \Delta\Gamma_L}{1 - s_{22}\Gamma_L} \cdot \frac{s_{11}{}^* - \Delta{}^*\Gamma_L{}^*}{1 - s_{22}{}^*\Gamma_L{}^*} = 1$$

it can be shown, with some algebraic difficulty, that the stable and unstable regions of operation are defined by a circle in the $\Gamma_L$ plane (unit circle) where:

$$center\ d_L = \frac{C_2{}^*}{|s_{22}|^2 - |\Delta|^2}$$

$$radius\ r_L = \frac{|S_{21}S_{12}|}{|S_{22}|^2 - |\Delta|^2}$$

where $d_L$ is located on a line through $S_{22}$* and the origin of the unit circle, and $C_2$ is as previously defined in WA6UAM's article.

Typical examples of stability circles are shown in the diagrams to the left. The region of the $\Gamma_L$ plane which provides a positive real input impedance (*i.e.* $|s_{11}| < 1$) is indicated as follows:

**1.** If the stability circle *includes* the origin of the unit circle, the *inside* of the stability circle (within the unit circle) defines the area in which a selected $\Gamma_L$ will result in a positive real input immitance.

**2.** If the stability circle *excludes* the origin, then the area of the unit circle *outside* the stability circle is the area of positive real input immitance.

The stability of the output port can be investigated wiith respect to $\Gamma_S$ plane being given by:

$$center\ d_s = \frac{C_1{}^*}{|s_{11}|^2 - |\Delta|^2}$$

$$radius\ r_s = \frac{|S_{12} \cdot S_{21}|}{|S_{11}|^2 - |\Delta|^2}$$

The necessary conditions for a two port to be absolutely stable can now be stated: A two-port network is absolutely stable if there exists no passive source or load termination which will cause the system to oscillate. This is equivalent to requiring the unstable regions to lie outside the unit circles in the $\Gamma_S$ and the $\Gamma_L$ planes. This is satisfied if

$$|d_s| - |r_s| > 1$$
$$|d_L| - |r_L| > 1$$
$$|s_{11}| < 1\ |s_{22}| > 1.$$

The establishment of the possible regions of unstable operation inside the unit circle is a necessary prelude to the application of any design technique. Without knowing the constraints imposed on the system by stability requirements, it is pointless to proceed to determine the source and load reflection coefficients to meet some particular gain specification.

I hope this very brief resume has helped in some way to clear the air on this subject.

**Graham J. Clements, VK3TK**
**Technical Director**
**Relcom Engineering**
**Melbourne, Australia**

*Graham Clement's letter is as fine an exposition on stability-circle analysis as I've read since William Froehner's article in the October 16, 1967 issue of* Electronics. *And Mr. Clements goes further than that article by correctly pointing out that $K > 1$ is a necessary, but not a sufficient condition, for absolute stability.*

*Although the stability circle analysis approach outlined by Mr. Clements appears entirely correct, I regard it as frosting on the cake. It is my belief, and confirmed by others, that the only conditions for absolute stability are $K > 1$, $S_{11} < 1$, and $S_{22} < 1$. In other words, an amplifier with $K > 1$ can oscillate* only *at the* design frequency *if either the input or output impedance is negative. Since the rest of my design equations fall apart if $S_{11}$ or $S_2$* are greater than 1, there is little danger of inadvertently designing an oscillator using the formula in my article.

*The key here, of course, is the term "at the design frequency." Any transistor having $S_{11} < 1$, $S_{22} < 1$, and $K > 1$ at a design frequency may well*

*A capital S is used to denote external network S-parameters; a lower-case s is used to describe device parameters.

*exhibit K < 1, $S_{11}$ > 1, or $S_{22}$ > 1 at some far removed frequency. Thus an amplifier which is unconditionally stable over a particular passband may indeed oscillate at some other frequency! This is another reason to use interstage isolators as described in the February, 1977, issue of* ham radio *(page 26), even for "unconditionally stable" amplifiers.*

*Although I have not performed a rigorous analysis to prove that the three conditions for absolute stability are always K > 1, $S_{11}$ < 1, and $S_{22}$ < 1, it has been proven empirically in countless amplifier designs by myself and others. I would be very interested in any careful analysis of this question which* ham radio *readers may care to undertake.*

**H. Paul Shuch, WA6UAM**
**San Jose, California**

## antenna noise bridge

**Dear HR:**

The article on the improved RX noise bridge in the February, 1977, issue of *ham radio* was very well done; authors Hubbs and Doting have come up with an excellent solution to the accuracy problem of the original design by YA1GJM (*ham radio*, January, 1973). When designing and building antennas, RX measurements are a must and, considering the simplicity and accuracy of this improved noise bridge, my advice is, "Don't leave home without it!"

The range-extender idea is a very nice way to get added coverage for this instrument, especially for 80- and 160-meter work. For those using 300- or 600-ohm line the thought occurred to me that another version of the range extender assembly might be made except in this case the resistor would be placed in parallel with the *unknown* impedance instead of in series. For best accuracy the resistor should be nearly equal to the resistance of the pot, say 220 to 240 ohms, and the assembly should be constructed using as physically small a resistor as possible to keep down added stray capacitance.

One word of caution: (especially to hand-held calculator wielders) don't impute any greater accuracy to the computations than that of your original readings. If your reading accuracy was good to within 5%, the computed result isn't going to be any better just because you have it out to eight decimal places. This comment applies to either range-extension computation.

**Forrest E. Gehrke K2BT**
**Mountain Lakes, New Jersey**

*Mr. Gehrke's suggestion for using a 220-ohm shunt range extender with the RX noise bridge is an excellent idea. The 100-ohm series resistor is*

**measured impedance of adapters**

| series adapter (output shorted) frequency (MHz) | $R_p$ | $C_p$ | shunt adapter (output open) frequency (MHz) | $R_p$ | $C_p$ |
|---|---|---|---|---|---|
| 3.5 | 101 | 0 | 3.5 | 165 | 5 |
| 7.0 | 100 | 0 | 7.0 | 165 | 5 |
| 14.0 | 100 | 0 | 14.0 | 165 | 4 |
| 21.0 | 100 | −1 | 21.0 | 165 | 3 |
| 28.0 | 100 | −2 | 28.0 | 165 | 3 |

**Note: The small $C_p$ offsets shown above are used to correct the $C_p$ readings to have a 220-ohm resistor available, I used a 170-ohm resistor in the shunt adapter.**

| frequency (MHz) | $R_p$ | $C_p$ | shunt adapter? | series adapter? | measured series impedance $R_s$ | measured series impedance $X_s$ | actual impedance $R_s$ | actual impedance $X_s$ |
|---|---|---|---|---|---|---|---|---|
| **test load 1 (350-pF capacitor)** | | | | | | | | |
| 3.5 | 203 | 107 | yes | yes | 2 | −131 | 0 | −130 |
| 7.0 | 140 | 102 | no | yes | ~1 | −63 | 0 | −65 |
| 14.0 | 109 | 33 | no | yes | ~1 | −31 | 0 | −32 |
| 21.0 | 103 | 15 | no | yes | ~2 | −21 | 0 | −22 |
| 28.0 | 102 | 6 | no | yes | 0 | −14 | 0 | −16 |
| **test load 2 (14-pF capacitor)** | | | | | | | | |
| 3.5 | 165 | 20 | yes | no | 0 | −3000 | 0 | −3200 |
| 7.0 | 165 | 20 | yes | no | 0 | −1500 | 0 | −1600 |
| 14.0 | 165 | 19 | yes | no | 0 | −750 | 0 | −800 |
| 21.0 | 165 | 18 | yes | no | 0 | −500 | 0 | −540 |
| 28.0 | 165 | 18 | yes | no | 0 | −380 | 0 | −400 |
| **test load 3 (11.6 feet of RG-58/U, open circuited)** | | | | | | | | |
| 3.5 | 237 | 230 | no | yes | −3 | −116 | 4 | −121 |
| 3.5 | 163 | 396 | yes | no | 1 | −115 | 4 | −121 |
| 7.0 | 152 | 433 | yes | no | 1 | −53 | 2 | −50 |
| 7.0 | 122 | 86 | no | yes | 1 | −47 | 2 | −50 |
| 14.0 | 101 | 0 | no | yes | 1 | 0 | 1 | 0 |
| 21.0 | 130 | −27 | no | yes | 8 | −48 | 3 | 50 |
| 21.0 | 150 | −125 | yes | no | 2 | −59 | 3 | 50 |
| 28.0 | 148 | 3 | yes | no | ~1400 | 0 | ~1500 | 0 |
| **test load 4 (1000-ohm carbon resistor)** | | | | | | | | |
| 3.5 | 142 | 5 | yes | no | ~1000 | 0 | ~1000 | 0 |
| 7.0 | 142 | 5 | yes | no | ~1000 | 0 | ~1000 | 0 |
| 14.0 | 142 | 4 | yes | no | ~1000 | 0 | ~1000 | 0 |
| 21.0 | 142 | 3 | yes | no | ~1000 | 0 | ~1000 | 0 |
| 28.0 | 142 | 3 | yes | no | ~1000 | 0 | ~1000 | 0 |

*useful, as explained in our article, for measuring high Q (low resistance) terminations. We offered no suggestion for high resistance terminations; Mr. Gehrke's solution fills this void quite nicely. With a shunt extension device, it's possible to bring these high resistance terminations within the range of the bridge. In fact, using either and sometimes both the series extender and/or the shunt extender, it is theoretically possible to measure* any *impedance at 3.5 MHz and higher. Frank and I have built a shunt range extension assembly to prove the suggestion is practical. Our findings summarized below support that conclusion.*

1. *The shunt range extender can be made physically using the same PL-295 connector and the same SO-239 Motorola pin-plug adapter as suggested in our article for the series device. The only difference is that a short length of wire is used to connect the center terminals together, and the resistor is connected from center pin to shield.*

2. *There is about 5 pF of stray capacitance to ground and about 25-30 nanohenries of series inductances in the finished unit. These strays cause the noise bridge null to shift about 5 pF in the capacitive direction when using the shunt device. This offset can be compensated for with sufficient accuracy (in most cases) by merely subtracting the offset from the readings one obtains.*

*It is interesting to note that these same strays exist in the series range extender. However, nature conspires to make them functionally transparent in this case. The input impedance of the series extender with the output short-circuited is very nearly a pure resistance. This is caused by the fact that 25 nanohenries in series with 100 ohms resistance is functionally equivalent to the same 100-ohm resistor in parallel with a* negative *capacitor. This* negative *capacitor nicely compensates for the stray capacitance in the circuit. The same compensation effect does not exist for the shunt assembly.*

3. *Besides being a* nice *theoretical technique, the shunt extender works in practice as the following data shows.*

*We feel Mr. Gehrke's suggestion is a valuable addition to noise bridge and impedance measuring technology for the ham. Our findings demonstrate the idea is also practical for implementation by the amateur.*

**Bob Hubbs, W6BXI**

## wideband preamp

**Dear HR:**

The Article in the October issue of *ham radio* on the "Wideband Preamp" by W1AAZ was intriguing and yet simple enough for me and two friends to quickly build three models. Unfortunately, the article didn't give us enough indication of the preamp's performance and I thought some readers might be interested in our results.

A Motorola HEP S3013 was used in place of the 2N5109 while the balun was wound using 10 twisted, bifilar turns of no. 30 AWG (0.25mm) wire on a 5//16-inch (8mm) Q-Z core. The balun seemed to be the most critical part of the design. My first attempt with 8 turns of no. 26 AWG (0.4mm) resulted in considerably less gain than the final results. The circuit was laid out on a 1-1/4 x 1-3/4-inch (3.2x4.5cm) printed circuit board. A 22 V battery was used to power the preamp.

The results were quite surprising. With a 50-ohm signal generator on the input and a 50-ohm termination on the output, there was a minimum of 10 dB voltage gain over the range of 2 to 70 MHz. The noise figure was measured to be less than 3dB from 1.5 to 30 MHz. Although no measurements were recorded, a quick check of desensitization and intermodulation distortion showed very good results. My thanks to W1AAZ and *ham radio* for bringing this design to my attention.

**Glenn S. Williams WB2DHG**
**Oakhurst, New Jersey**

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More Details? CHECK—OFF Page 142

# NEW products

For literature on any of the new products, use our *Check-Off* service on page 142.

## 144 and 432 MHz linear transverters

Microwave Modules, Ltd., of Liverpool, England, has introduced a line of transverters (transmitting converters) that are of great interest to Amateurs who want to operate on the vhf bands. Although the term transverter is usually applied to a circuit that only transmits, these units have a receiving converter built in as well. Thus, only a hf-band transceiver need be connected to the Microwave Modules box to enable you to operate on the higher bands with ease.

Three units of primary interest to Amateurs are the MMT 144/28, MMT 432/28, and the MMT 432/28 Mark 4. The first number in the designation indicates the frequency of the band of operation, in this case either 144 MHz or 432 MHz. The second number indicates the frequency of the input (or output) signal required for mixing (or as an i-f output). Thus the 432/28 will allow operation in the Amateur 432-434 MHz range, with an input of 28 MHz for transmitting and an i-f output of 28 MHz for receiving.

The MMT 432/28 Mark 4 is of special interest since it has been broadbanded to cover a 4-MHz range. This feature has been incorporated to allow you to operate both weak-signal (432 MHz) and the future Oscar 8 (436 MHz). Two additional units have also been recently introduced, the MMT 432/50 and the MMT 438/ATV. Power output from the transverters is nominally 10 watts, PEP. Input and output impedance is 50 ohms, with BNC fittings on the enclosure for connection. There is a separate connector for the 28-MHz i-f output to the receiver, marked 28-MHz OUTPUT. A connector is provided for a separate 144-MHz (or 432-MHz, as the case may be) input, but the connector is not wired up. Instructions are given to enable the user to connect this input jack if desired. Normally, the 432- or 144-MHz input jack serves as both transmitting and receiving connections. Separating the two functions would be useful if you wanted to drive a linear amplifier while transmitting. PIN diodes perform the internal switching function.

DC power required for the transverters is in the range of 12 to 14 volts for both units. Quiescent current for the 144-MHz model is 300 mA; for the 432 unit it is 180 mA. Current drain rises to approximately 2 amperes on peaks for both units.

Drive power required for full output on both models is 500 milliwatts, but there is an internal attenuator that may be jumpered out of the circuit to allow the use of an input as low as 5 milliwatts of drive.

Other features worth noting are a receive converter noise figure of approximately 2.5 dB (144 MHz) and 3 dB (432 MHz); a cast-aluminum enclosure for good shielding and mechanical stability; and a crystal oscillator that starts high enough to avoid the need for a large number of multipliers and their spurious products — 101 MHz for the 432 unit and 116 MHz for the 144 transverter. Both boxes measure 7-3/8 inches wide, 2-1/4 inches high, and 5-1/2 inches deep, including connectors (18.7x5.7x13.9cm). Suggested list prices for the transverters start at $199.95 for the MMT 144/28, $229.95 for the MMT 432/28, and $249.95 for the MMT 432/28 Mark 4. The source for this equipment is Spectrum International, Incorporated, Post Office Box 1084, Concord, Massachusetts 01742.

## full-feature frequency counter

Here's a high accuracy frequency counter for those working within the Citizen Band and Amateur disciplines. The counter has recently been made available from Communications Power, Inc. Designated model CPI FC-70, the frequency counter features a bright seven-digit LED readout with anti-glare louvers — great when you're working in a dimly lit environment.

Resolution is within 10 hertz; accuracy is rated at 0.0003 per cent, which is considerably higher than the FCC's 0.005 per cent requirement. The FC-70 accepts 400 watts of throughput power. It has a high-impedance input, which means it's easily used with rf oscillators and grid dippers. It's also useful for testing i-fs, filter characteristics, and crystal response.

The FC-70 operates from either 12 Vdc or 115 Vac. Quick disconnect cables are supplied for both voltages. The FC-70 has a guaranteed upper frequency limit of 40 MHz; 55 MHz is typical. Looks like a nice piece of test equipment for the serious technician working with high-frequency communications equipment.

For more information on the CPI FC-70 counter, as well as information on CPI's complete product line, write Mr. Robert Artigo, Communications Power, Inc., 2407 Charleston Road, Mountain View, California 94043.

## electronics tools in a roll-pouch kit

This new product, offered by Jensen Tools and Alloys, looks like the answer to the tool-kit problem for field engineers and electronics technicians. It's called the JTK-81 — a tool kit that contains more than 25 essential tools in a roll pouch that's easy to store in drawer or pocket.

The tool complement consists of pliers, cutters, screwdrivers, nutdrivers, wire strippers, hex and spline keys, soldering equipment, hammer, and more. A Triplett model 310 vom is offered as an optional accessory. The tool package fits neatly into a multipocketed 12 by 21 inch (305 by 533mm) vinyl roll pouch.

The JTK-81 kit without vom is priced at $75.00. With meter, the kit price is $127.00. Quantity prices are significantly lower.

If you'd like a free catalog describing more than 3000 hard-to-find tools, as well as other Jensen products, drop a note to Jensen Tools and Alloys, 4117 North 44 Street, Phoenix, Arizona 85018.

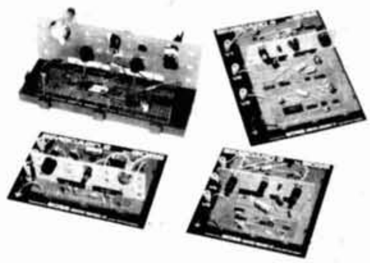
## two-meter transceiver


System 3000, a microcomputer-based two-meter transceiver offered by Edgecom, Inc., provides amateurs with a complete personal communications ystem. It has an on-board computer that provides unusual flexibility. Some of its many features:

- Ten front-panel programmable priority channels
- Priority-channel silent monitor
- Built-in scanner
- Two-frequency subaudible tone encoder/decoder
- Transmitter frequency offset
- Audio alarm

For more information on the System 3000, write Edgecom, Inc., 2909 Oregon Court A3, Torrance, California 90503.

## dip breadboard kits



You can obtain DIP Breadboard Kits in three larger models from Hammond Manufacturing Company. The three new models are Bimboard 2, 3, and 4. They consist of individual Bimboards slotted together and mounted onto a 1/16-inch (1.5mm) thick matte-black aluminum base.

The new Bimboard models provide



More Details? CHECK—OFF Page 142

24, 36, and 48 in.$^2$ (155, 232, and 310 cm$^2$) breadboarding area. Included are 1100, 1650 and 2200 individual sockets.

Aluminum backplates, which are mounted on four nonslip rubber feet, are fitted with four screw terminals. Input power and ground leads may be connected to these terminals. Also included are 2-, 3-, or 4-component support brackets, which provide mounting for larger components. For more information write Hammond Manufacturing Company, Inc., 385 Nagel Drive, Buffalo, New York 14225.

## counter-generator with prescaler

Lunar Electronics presents a new frequency counter-generator with a five-digit display and a seven-digit readout with front-panel scaling. It's the model DX-555P — a basic 30-MHz counter with prescaler. The instrument has a 10-MHz time base, which includes easy zero adjust to WWV. The built-in prescaler extends the count range to 300 MHz (activated by a rear-panel switch).

Featured is a variable-frequency marker oscillator, which covers 440 kHz-30 MHz in three bands. When the marker oscillator is activated (front-panel switch), its output is available from a rear-panel jack and is also displayed on the counter readout.

Marker-oscillator output, which may be amplitude modulated, is of sufficient amplitude for aligning receivers with 455-kHz i-fs up through 30 MHz. The high harmonic output may also be used throughout the lower vhf range with careful attention to frequency, which will preclude aligning your receiver on images.

The Model DX-555P with prescaler lists at $239.95. Without prescaler the price is $189.95. For further information write Lunar Electronics, P.O. Box 82183, San Diego, California 92138.

# BULLET ELECTRONICS

P.O. BOX 19442
DALLAS, TX. 75219
(214) 823-3240

## 6 DIGIT MINI MOBILE ALARM CLOCK KIT

Many of our customers who have bought our other mobile clock kits (MK-03 & MK-04), have requested a small mobile clock for in dash mounting. We put our engineer to work on it and the result is the compact MK-05. Designed to be a mobile clock from the ground up. There has been no compromise on quality. **Take a look at the specs, price, size and compare it with any other clock kit on the market.** We will be waiting for your order!

- Quartz crystal timebase
- Toroid and zener noise & voltage protection
- Magnified .15 inch, 6 digit LED readout with spacing between hours, minutes, & seconds
- Top Quality epoxy glass PC boards are drilled & plated
- No additional components are required
- Complete with presettable 24 hr. alarm (speaker NOT included)
- Can be used as elapsed timer
- Easy, quick assembly
- 9–14 VDC @ 40 to 50 ma
- Readouts can be turned off & the clock continues to keep time
- PC board Clock: 2.6"x2"
  Readout board: 2 3/8"x.75"


**MK-05**

**$12.95**

## Mini Grandfather Clock Kit

**$39.95 kit** **$59.95** (assembled & checked out)

- Completely Electronic
- 100% Solid State
- All CMOS IC Construction
- 2 Quality Plated PC Boards 6.5" x 4.5"
- New, revised easy to follow instructions
- Large ½" LED readout with AM/PM & colon indicators
- Simulated LED swinging pendulum with syncronized tick-tock sound.
- Chimes the hour (ie: 3 times for 3 o'clock)
- Adjustable volume tone and sustain on the chime.
- LOW COST
- Complete with all parts including transformer & speaker.

**We offer a beautiful solid hard wood case in either ash or walnut with front ruby filter. Designed and cut specifically for the mini grandfather clock kit.**
**Unfinished Case** – $15.95
**Finished Case** – $19.95
Please specify type of wood desired. Case is shipped unassembled.

## OVERVOLTAGE PROTECTION KIT $6.95

The OVP-1 is an overvoltage protection circuit designed to protect your expensive gear if the series pass regulators short or unauthorized hands tamper with the voltage setting on a variable supply. Set the OVP-1 for 1 or 2 volts over the normal operation voltage and it will instantly go into current limiting; (if the supply has this feature), or blow the fuse. The kit comes complete with PC board, all components including the 25A SCR and complete easy to follow instructions. Designed specifically for the PS-12 Power Supply Kit.

## PS–12 HIGH CURRENT VARIABLE POWER SUPPLY KIT

A LOW COST WAY TO HAVE A QUALITY VARIABLE BENCH SUPPLY.

ALL ELECTRONICS SUPPLIED
LARGE COMPUTER GRADE FILTER
PLATED PC BOARD
UNIQUE PRE-REGULATOR ALLOWS COOLER OPERATION AT HIGH CURRENTS.
3 to 16V & 15 to 30V (two ranges) @ 10A CONTINUOUS (15A with fan cooling)
ADJUSTABLE CURRENT LIMITING
SHORT CIRCUIT PROTECTION

Regulation: 240mv Load & Line
Ripple: Less than .5V @ 30V & 10A.

**$49.95**

**Add $3.70 for UPS shipping. Outside continental U.S. Add $10.00 for Parcel Post & Insurance.**

## MK–03 AIRCRAFT/CLOCK TIMER KIT.

You don't have to be a pilot to need the MK-03. If you want a mobile clock that offers: six .4" LED readouts, 24 hour real time readout, 24 elapsed time readout, alarm, snooze, display blanking. Timer and clock share same set of readouts but are totally independent of each other. Timer has reset and freeze feature. Many other options are available. Sold less case and switches because of the various mountings and options available.
**$26.95/complete electronics and boards less switches and case.**

## OUR CUSTOMERS WRITE ABOUT OUR CDI KIT:

*"...great kit."*
*"...unbelievable value", "...good design!"*
*"...fantastic kit and service. Send three more."*

**$9.95**

The CDI kit is all these things and more. Get in on a one-time deal. Complete electronics.
Requires heatsink (not included) also works for voltage source for high intensity strobe.

**TERMS: NO COD's** * Send check or M.O. * Add 5% postage Tx. Residents add 5% sales tax * Foreign add 10% (20% airmail) Orders under $10. add 60c handling * Repair service available Accepting phone orders on Master Charge and Bankamericard.

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**$39⁹⁵**

Patent Pending


Model SW-5000

- 52 ohms
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- Available in UHF, BNC, N, F, all series

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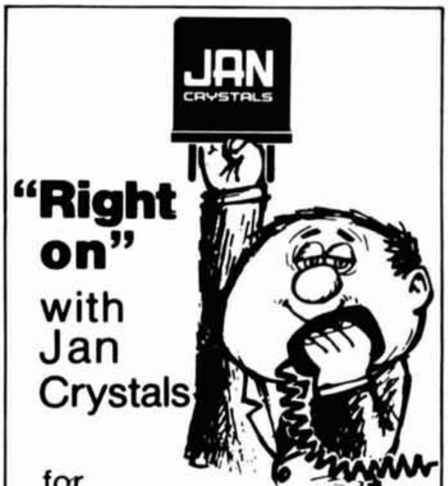


for

- **General Communication & Industry**
- **Citizen's Band (Standard & Synthesized)**
- **Two-Meter - Monitor - Scanners**
- **Marine VHF** • **Amateur Bands**

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More Details? CHECK—OFF Page 142

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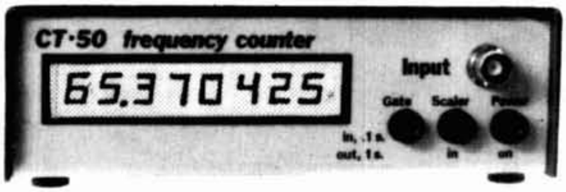
More Details? CHECK—OFF Page 142

# NEW Frequency Counter

## $79.95 kit




## UTILIZES NEW MOS-LSI CIRCUITRY

You've requested it, and now it's here! The CT-50 frequency counter kit has more features than counters selling for twice the price. Measuring frequency is now as easy as pushing a button, the CT-50 will automatically place the decimal point in all modes, giving you quick, reliable readings. Want to use the CT-50 mobile? No problem, it runs equally as well on 12 V dc as it does on 110 V ac. Want super accuracy? The CT-50 uses the popular TV color burst freq. of 3.579545 MHz for time base. Tap off a color TV with our adapter and get ultra accuracy — .001 ppm! The CT-50 offers professional quality at the unheard of price of $79.95. Order yours today!

CT-50, 60 MHz counter kit .......................... $79.95
CT-50 WT, 60 MHz counter, wired and tested ........... 159.95
CT-600, 600 MHz prescaler option for CT-50, add ......... 29.95

**SPECIFICATIONS**

Sensitivity: less than 25 mv.
Frequency range: 5 Hz to 60 MHz, typically 65 MHz
Gatetime: 1 second, 1/10 second, with automatic decimal point positioning on both direct and prescale
Display: 8 digit red LED .4" height
Accuracy: 10 ppm, .001 ppm with TV time base!
Input: BNC, 1 megohm direct, 50 Ohm with prescale option
Power: 110 V ac 5 Watts or 12 V dc @ 1 Amp
Size: Approx. 6" x 4" x 2", high quality aluminum case
Color burst adapter for .001 ppm accuracy available in 6 weeks.
CB-1, kit ................................ $14.95

## CLOCK KIT
### 6 digit 12/24 hour

Want a clock that looks good enough for your living room? Forget the competitor's kludges and try one of ours! Features: jumbo .4" digits, Polaroid lens filter, extruded aluminum case available in 5 colors, quality PC boards and super instructions. All parts are included, no extras to buy. Fully guaranteed. One to two hour assembly time. Colors: silver, gold, black, bronze, blue (specify).

Clock kit, DC-5 .................... $22.95
Alarm clock, DC-8, 12 hr only .......... 24.95
Mobile clock, DC-7 .................. 25.95
Clock kit with 10 min ID timer, DC-10 ... 25.95
Assembled and tested clocks available, add $10.00

## VIDEO TERMINAL KIT $149.95

A compact 5 x 10-inch PC card that requires only an ASCII keyboard and a TV set to become a complete interactive terminal for connection to your microprocessor asynchronous interface. Its many features are single 5 volt supply, crystal controlled sync and baud rates (up to 9600 baud), 2 pages of 32 characters by 16 lines, read to and from memory, computer and keyboard-operated cursor and page control, parity error display and control, power-on initialization, full 64-character ASCII display, block-type see-thru cursor. Keyboard/computer control backspaces, forward spaces, line feeds, rev. line feeds, home, returns cursor. Also clears page, clears to end of line, selects page 1 or 2, reads from or to memory. The card requires 5 volts at approx. 900 ma and outputs standard 75 ohm composite video.

TH3216 Kit $149.95
TH3216, Assembled and Tested 239.95
VD 1, Video to RF Modulator Kit 6.95

## CAR CLOCK KIT $27.95

12/24 Hour 12 Volt AC or DC
- High Accuracy (1 minute/month)
- 6 jumbo 4" LED readouts
- Easy, no polarity hookup
- Display blanks with ignition
- Case, mounting bracket included
- Super instructions

Complete Kit, DC 11 $27.95

**AUTO-DIMMER $2.50**

Automatically adjusts display brightness according to ambient light level. For DC 11 Car Clock.

## CHEAP CLOCK KIT $8.95

DC-4 Features:
- 6 digit .4" LED
- 12 or 24 format

Does not include board or transformer

PC Board $2.95
Transformer $1.49

## 600 MHz PRESCALER

Extend the range of your counter to 600 MHz. Works with all counters. Less than 150 mv sensitivity. Specify ÷10 or ÷100
Wired, tested, PS-1B ..... $59.95
Kit, PS-1B ............ $44.95

## 30 watt 2 meter Power Amp

The famous RE class C power amp now available mail order! Four Watts in for 30 Watts out, 2 in for 15 out, 1 in for 8 out, incredible value, complete with all parts, instructions and details on T-R relay. Case not included.
Complete Kit, PA-1 ......... $22.95

## CALENDAR ALARM CLOCK

Has every feature one could ever ask for. Kit includes everything except case, build it into wall, station or even car!
**FEATURES:**
- 6 Digits, .5" High LED
- 12/24 Hour Format
- Calendar shows mo./day
- Snooze button
- True 24 Hour Alarm
- .7001 chip does all!!
- Battery back up with built in on chip time base

**Complete Kit, less case, DC-9 ........................ $34.95**

| | | LINEAR | | REGULATOR | | TRANSISTORS | |
|---|---|---|---|---|---|---|---|
| 5314 Clock | $2.95 | 555 | $ .50 | 78MG | $1.49 | MRF-238 30W VHF | $11.95 |
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| 74S112 | .75 | 566 | 1.49 | 309H | .99 | PNP 2N3906 type | 10/$1.00 |
| 7447 | .79 | 567 | 1.49 | 340K-12 | .99 | NPN Power Tab 40W | 3/$1.00 |
| 7473 | .35 | 1458 | .50 | 7805 | .89 | PNP Power Tab 40W | 3/$1.00 |
| 7475 | .50 | LED DRIVER | | 7812 | .89 | FET MPF-102 type | 3/$2.00 |
| 7490A | .55 | 75491 | .50 | 7815 | .89 | UJT 2N2646 type | 3/$2.00 |
| 74143 | 3.50 | 75492 | .50 | 7818 | .89 | 2N3055 NPN Power | .75 |

SPECIAL

**DIODES: 1KV,2.5A ......... 5/$1.00  100V,1A ......... 10/$1.00  1N914A type ........ 50/$2.00**

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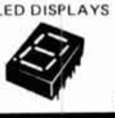

FND 359 ...... .75
FND 510 ...... 1.25
DL 707 ...... 1.25
HP 7730 ...... 1.25
Red Polaroid Filter ... 4.25" X 1.125" ... .59

**741 OP-AMP SPECIAL**
Factory prime mini dip with both Xerox and 741 part numbers
**10 for $2.00**

**SOCKETS**
14 PIN 5/$1.00
16 PIN 5/$1.00
24 PIN 2/$1.00
40 PIN 3/$2.00

**FERRITE BEADS**
with info and specs
15/$1.00
6 hole Balun Beads
5/$1.00

# MINI-KITS

**TONE DECODER KIT**

A complete tone decoder on a single PC Board. Features: 400-5000 Hz adjustable frequency range, voltage regulation, 567 IC. Useful for touch-tone decoding, tone burst detection, FSK demod, signaling, and many other uses. Use 7 for 12 button touchtone decoding. Runs on 5 to 12 volts.
**Complete Kit, TD-1 ..................... $4.95**

## SUPER-SNOOP AMPLIFIER

A super-sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as a general purpose test amplifier. Full 2 watts of output, runs on 6 to 12 volts, uses any type of mike. Requires 8-45 ohm speaker.
**Complete Kit, BN-9 ................ $4.95**

## FM WIRELESS MIKE KIT

Transmit up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9 V. Type FM-2 has added super sensitive mike preamp.
**FM-1 ...... $2.95  FM-2 ...... $4.95**

## COLOR ORGAN/MUSIC LIGHTS

See music come alive! 3 different lights flicker with music or voice. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300 watts. Great for parties, band music, nite clubs and more.
**Complete Kit, ML-1 ................ $7.95**

## LED BLINKY KIT

A great attention getter which alternately flashes 2 Jumbo LEDs. Use for name badges, buttons, or warning type panel lights. Runs on 3 to 9 volts.
**Complete Kit ...................... $2.95**

## POWER SUPPLY KIT

Complete triple regulated power supply provides variable ±15 volts at 200 mA and +5 volts at 1 Amp. 50 mV load regulation good filtering and small size. Kit less transformers. Requires 6-8 V at 1 Amp and 18 to 30 VCT.
**Complete Kit, PS-3LT ................ $6.95**

## SIREN KIT

Produces upward and downward wail characteristic of police siren. 5 watts audio output, runs on 3-9 volts, uses 8-45 ohm speaker.
**Complete Kit, SM-3 ................ $2.95**

## DECADE COUNTER PARTS

Includes: 7490A, 7475, 7447, LED readout, current limit resistors, and instructions on an easy to build low cost frequency counter.
**Kit of parts, DCU-1 ................. $3.50**

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More Details? CHECK—OFF Page 142

# Bearcat® 210 $289.


**The Bearcat® 210** is a sophisticated scanning instrument with the ease of operation and frequency versatility you've dreamed of. Imagine, selecting from any of the public service bands and from all local frequencies by simply pushing a few buttons. No longer are you limited by crystals to a given band and set of frequencies. It's all made possible by *Bearcat* spaceage solid state circuitry. You can forget crystals forever.

Pick the 10 frequencies you want to scan and punch them in on the keyboard. It's incredibly easy. The large decimal display reads out each frequency you've selected. When you want to change frequencies, just enter the new ones.

Automatic search lets you scan any given range of frequencies of your choice within a band. Push-button lockout permits you to selectively skip frequencies not of current interest. The decimal display with its exclusive "rolling zeros" tells you which channels you're monitoring. When the *Bearcat* 210 locks in on an active frequency the decimal display shows the channel and frequency being monitored.

With the patented track-tuning system, the Bearcat 210 automatically aligns itself so that circuits are always "peaked" for any broadcast. Most competitive models peak only at the center of each band, missing the frequencies at the extreme ends of the band.

The Bearcat 210's electronically switched antenna eliminates the need for the long low band antenna. And a quartz crystal filter rejects adjacent stations as well as noise interference.

Call toll-free 800-521-4414 now to place a BankAmericard or Master-charge order. This is our 24 hour phone to our order department and only orders may be processed on this line. To order in Michigan or outside of the U.S. dial 313-994-4441.

Add $5.00 for U.S. shipping or $9.00 for air UPS to west coast. Charge cards or money orders only please. International orders invited. Michigan residents add tax. Please write for quantity pricing.

## Bearcat® 210 Features

- **Crystal-less**—Without ever buying a crystal you can select from all local frequencies by simply pushing a few buttons.
- **Decimal Display**—See frequency and channel number—no guessing who's on the air.
- **5-Band Coverage**—Includes Low, High, UHF and UHF "T" public service bands, the 2-meter amateur (Ham) band, plus other UHF frequencies.
- **Deluxe Keyboard**—Makes frequency selection as easy as using a push-button phone. Lets you enter and change frequencies easily . . . try everything there is to hear.
- **Patented Track Tuning**—Receive frequencies across the full band without adjustment. Circuitry is automatically aligned to each frequency monitored.
- **Automatic Search**—Seek and find new, exciting frequencies.
- **Selective Scan Delay**—Adds a two second delay to prevent missing transmissions when "calls" and "answers" are on the same frequency.
- **Automatic Lock-Out**—Locks out channels and "skips" frequencies not of current interest.
- **Simple Programming**—Simply punch in on the keyboard the frequency you wish to monitor.
- **Space Age Circuitry**—Custom integrated circuits . . . a *Bearcat* tradition.
- **UL Listed/FCC Certified**—Assures quality design and manufacture.
- **Rolling Zeros**—This *Bearcat* exclusive tells you which channels your scanner is monitoring.
- **Tone By-Pass**—Scanning is not interrupted by mobile telephone tone signal.
- **Manual Scan Control**—Scan all 10 channels at your own pace.
- **3-Inch Speaker**—Front mounted speaker for more sound with less distortion.
- **Squelch**—Allows user to effectively block out unwanted noise.
- **AC/DC**—Operates at home or in the car.

## Bearcat® 210 Specifications

**Frequency Reception Range**

| | |
|---|---|
| Low Band | 32—50 MHz |
| "Ham" Band | 146—148 MHz |
| High Band | 148—174 MHz |
| UHF Band | 450—470 MHz |
| "T" Band | 470—512 MHz |

*Also receives UHF from 416—450 MHz

**Size**
10⅝" W x 3" H x 7⅝" D

**Weight**
4 lbs. 8 oz.

**Power Requirements**
117V ac, 11W; 13.8 Vdc, 6W

**Audio Output**
2W rms

**Antenna**
Telescoping (supplied)

**Sensitivity**
0.6μv for 12 dB SINAD on L & H bands
U bands slightly less

**Selectivity**
Better than −60 dB @ ± 25 KHz

**Scan Rate**
20 channels per second

**Connectors**
External antenna and speaker, AC & DC power

**Accessories**
Mounting bracket and hardware
DC cord


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# flea market

**RATES** Non-commercial ads 10¢ per word; commercial ads 60¢ per word both payable in advance. No cash discounts or agency commissions allowed.

**HAMFESTS** Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

**COPY** No special layout or arrangements available. Material should be typewritten or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue

**DEADLINE** 15th of second preceding month.

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

**HW-101, HP-23** — $300; KLM Echo II 2 Mtr. USB/LSB — $235; Heath Twoer, D.C. supply — $30; F.O.B. N6KM 272 Fourth St. East, Sonoma, CA 95476.

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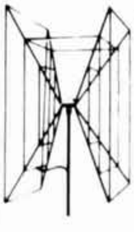

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More Details? CHECK—OFF Page 142

# flea market

## Coming Events

**MEMPHIS IS BEAUTIFUL IN OCTOBER!** The Memphis ARRL-sponsored Hamfest, bigger and better than the 4,500 who attended last year, will be held at State Technical Institute, Interstate 40 at Macon Road, on Saturday and Sunday October 1 and 2. Demonstrations, displays, MARS meetings, flea market, ladies flea market, too! Hospitality room, informal dinners, XYL entertainment, many outstanding prizes. Dealers and Distributors welcome. Contact Harry Simpson W4SCF, PO Box 27015, Memphis, TN 38127 for further information.

**ADRIAN HAMFEST**, Adrian, Michigan. Sunday, September 25, 1977 at Lenawee County Fairgrounds. Prizes every hour! Flea Market, trunk sales. Advance tickets $1.50; $2.00 at door. Tables available. Contact Adrian A.R.C., Box 26, Adrian, MI 49224 (517) 265-8016.

**MELBOURNE, FLORIDA, SEPTEMBER 10-11.** The 12th Annual Melbourne Hamfest will be held Saturday and Sunday, from 9 a.m. to 5 p.m. each day in the airconditioned Melbourne Civic Auditorium located on Hibiscus Boulevard. Donation is $2.50 per person. Full program includes forums, meetings, auction, swap tables, commercial exhibits, awards, prizes, etc. Contact K4HPT, 2749 Herford Road, Melbourne, FL 32935 for swap table reservations. FCC exams on Saturday, donation not needed for exams. Form 610 must be filed with FCC, Room 919, 51 S.W. First Avenue, Miami, FL 33130, not later than August 31, 1977. Hamfest talk-in on 25/85 and 52/52. Sponsored by Platinum Coast Amateur Radio Society. For more info write P.O. Box 1004, Melbourne, FL 32901.

**"GREATER LOUISVILLE HAMFEST** Sunday Sept. 25, 1977. Kentucky Fair and Exposition Center, West Wing Pavilion. Indoor exhibitors area. Indoor and Outdoor Flea Market. Admission $2.00. Vendors, admission plus $2 indoors space or $1 outdoors space. For further info, or hotel, motel or camping reservations contact K4GOU, Denny Schnurr, 2415 Concord Dr., Louisville, KY 40217, phone #(502) 634-0619."

**SANGAMON VALLEY** Radio Club Second Annual Hamfest on Sunday, September 25th, at the Sangamon County Fairgrounds, New Berlin, Illinois, 16 miles west of Springfield. Indoor display area and covered pavilion. Exhibits, food and ladies activities. Overnite camping! Tickets: $1 advance, $1.50 at gate. First Prize — Wilson HT. Talk-in: 146.28/.88 and .52 MHz. Information: WB9-QWR, Carole Churchill, 622 Magnolia, Rochester, IL. 62626.

**NORTHEASTERN STATES** 160 Meter Amateur Radio Association annual election and banquet, Saturday, October 8, 1977 at Kozel Tavern, 5 miles northeast of Hudson, NY on Rt. 9H. Flea market in rear parking lot starting at 1 PM. Dinner at 6 PM. For any further information, write or contact W1EUB, Sec. Treas. on 160 meters.

**HAMARAMA** '77 & Mid-Atlantic States VHF Conference. Conference to be held Oct. 1, Treadway Inn on Easton Rd., Willow Grove, PA 19090. Flea Market to be held Oct. 2, Bucks Country Drive-In Theater, Easton Rd., Warrington, PA. For further info contact Ron Whitsel, WA3AXV, P.O. Box 353, Southampton, PA 18966. Phone: 215-355-5730.

**CLEVELAND, OHIO** Hamfest, Saturday, Sept. 10th at the German Central Farms (Deutsche Centrale), 7863 York Road at Sprague. Mobile check-ins and info on 146.52 from 0600 with W8QV. Large Picnic area, Family and Y.L. Activities, large Flea Market, indoor Commercial Displays. Eats for all. Grand Prize at 1530. Donations $2.00 at Main Gate, opening at 0700. Flea Market add'l $1.00 per car space — Gold Rush at 0600. For info write: Cleveland Hamfest Association, Box 43413, Cleveland, Ohio 44143.

**NEW YORK** Radio Amateurs of Greater Syracuse (RAGS) Hamfest Saturday, October 8 from 9 A.M. to 6 P.M. at the Syracuse Auto Auction, 4 miles south of Syracuse, N.Y. on U.S. Route 11 between Nedrow and LaFayette. Flea market, CW and wiring contests, forums, panels and eyeball QSOs. Lunch counter, nearby campsite and Apple Festival for the family. Talk-in on 31/91. Tickets are $1.50 before October 1 and $2.00 at the gate. For further information, contact Roger Hamilton, WA2AEW, c/o RAGS, P.O. Box 88, Liverpool, New York 13088.

**HAMFEST** Lima, Ohio, October 9. The Northwest Ohio ARC 3rd annual hamfest at the Allen Country Fairgrounds. Two large buildings, tables and table space available. Dealers welcome. For information and reservations write, N.O.A.R.C., P.O. Box 211, Lima, Ohio 45802. Phone 640-1433 or 991-2716.

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| CD4022 | 1.25 | CD4069 | .45 | 74C161 | 3.25 |
| CD4023 | .25 | CD4071 | .45 | 74C163 | 3.00 |
| CD4024 | 1.50 | CD4081 | .45 | 74C164 | 3.25 |
| CD4025 | .25 | CD4511 | 2.50 | 74C173 | 2.60 |
| CD4026 | $3.95 | CD4518 | 2.50 | 74C193 | 2.75 |
| CD4027 | .69 | MC14566 | 3.00 | 74C195 | 2.75 |
| CD4028 | 1.65 | 74C00N | .39 | MC4044 | 4.50 |
| CD4029 | 2.90 | 74C02N | .55 | MC14016 | .56 |

# LINEAR

| | | | | | |
|---|---|---|---|---|---|
| LM300H | .80 | | | LM1351N | 1.65 |
| LM301H | .35 | | | LM1414N | 1.75 |
| LM301CN | .35 | 78MG | 1.75 | LM1458C | .65 |
| LM302H | .75 | LM370N | 1.15 | LM1496N | .95 |
| LM304H | 1.00 | LM373N | 3.25 | LM1556V | 1.85 |
| LM305H | .95 | LM377N | 4.00 | LM2111N | 1.95 |
| LM307CN | .35 | LM380N | 1.39 | LM2901N | 2.95 |
| LM308H | 1.00 | LM380CN | 1.05 | LM3065N | .69 |
| LM308CN | 1.00 | LM381N | 1.79 | LM3900N | .55 |
| LM309H | 1.10 | LM382N | 1.79 | LM3905N | .60 |
| LM309K | .99 | NE501K | 8.00 | LM3909 | 1.25 |
| LM310CN | 1.15 | NE510A | 6.00 | LM5556N | 1.85 |
| LM311H | .90 | NE531H | 3.00 | MC5558V | 1.00 |
| LM311N | .90 | NE536T | 6.00 | LM7525N | .90 |
| LM318CN | 1.50 | NE540L | 6.00 | LM7535N | 1.25 |
| LM319N | 1.30 | NE550N | .79 | 8038B | 4.95 |
| LM320K-5 | 1.35 | NE555V | .39 | LM75450 | .49 |
| LM320K-5.2 | 1.35 | NE560B | 5.00 | 75451CN | .39 |
| LM320K-12 | 1.35 | NE561B | 5.00 | 75452CN | .39 |
| LM320K-15 | 1.35 | NE562B | 5.00 | 75453CN | .39 |
| LM320T-5 | 1.75 | NE565H | 1.25 | 75454CN | .39 |
| LM320T-5.2 | 1.75 | NE565N | 1.25 | 75491CN | .79 |
| LM320T-8 | 1.75 | NE566CN | 1.25 | 75492CN | .89 |
| LM320T-12 | 1.75 | NE567H | 1.95 | 75494CN | .89 |
| LM320T-15 | 1.75 | NE567V | 1.50 | RCA LINEAR | |
| LM320T-18 | 1.75 | LM703CN | .45 | CA3013 | 2.15 |
| LM320T-24 | 1.75 | LM709H | .29 | CA3023 | 2.56 |
| LM323K-5 | 9.95 | LM709N | .29 | CA3035 | 2.48 |
| LM324N | 1.80 | LM710N | .79 | CA3039 | 1.35 |
| LM339N | 1.70 | LM711N | .39 | CA3046 | 1.30 |
| LM340K-5 | 1.95 | LM723H | .55 | CA3059 | 3.25 |
| LM340K-6 | 1.95 | LM723N | .55 | CA3060 | 3.25 |
| LM340K-8 | 1.95 | LM733N | 1.00 | CA3080 | .85 |
| LM340K-12 | 1.95 | LM739N | 1.00 | CA3081 | 2.00 |
| LM340K-15 | 1.95 | LM741CH | .35 | CA3082 | 2.00 |
| LM340K-18 | 1.95 | LM741CN | .35 | CA3083 | 1.60 |
| LM340K-24 | 1.95 | LM741-14N | .39 | CA3086 | .85 |
| LM340T-5 | 1.75 | LM747H | .79 | CA3089 | 3.75 |
| LM340T-6 | 1.75 | LM747N | .79 | CA3091 | 10.20 |
| LM340T-8 | 1.75 | LM748H | .39 | CA3102 | 2.95 |
| LM340T-12 | 1.75 | LM748N | .39 | CA3123 | 2.15 |
| LM340T-15 | 1.75 | LM1303N | .39 | CA3130 | 1.39 |
| LM340T-18 | 1.75 | LM1304N | 1.19 | CA3140 | 1.25 |
| LM340T-24 | 1.75 | LM1305N | 1.40 | CA3600 | 1.75 |
| LM350N | 1.00 | LM1307N | .85 | RC4194 | 5.95 |
| LM351CN | .65 | LM1310N | 2.95 | RC4195 | 3.25 |

# 74LS00 TTL

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

## CLOCK CHIPS

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

## DATA HANDBOOKS

| | | |
|---|---|---|
| 7400 | Pin-out & Description of 5400/7400 ICS | $2.95 |
| CMOS | Pin-out & Description of 4000 Series ICS | $2.95 |
| Linear | Pin-out & Functional Description | $2.95 |

ALL THREE HANDBOOKS $6.95

# Timeband by FAIRCHILD — Watches —

**Men's & Ladies**

- Solid State
- Displays hour, minute, second, month & day
- Free set of replacement batteries
- Choose LED or LCD styles
- One year factory warranty

T249 White w/bracelet $19.95
T248 Yellow w/bracelet $22.95
LED

Ladies LCD

TC625 White w/strap $29.95
TC624 Yellow w/strap $34.95
LCD

T237 White w/bracelet $22.95
T236 Yellow w/bracelet $25.95
LED

TC437 White w/bracelet $29.95
TC436 Yellow w/bracelet $34.95
LCD

LADIES LED

T325 White w/strap $24.95
T324 Yellow w/strap $27.95

# CHANNEL F

FAIRCHILD VIDEO ENTERTAINMENT SYSTEM

**$159.95**

- Freeze Action • Speed Option
- Automatic time and scorekeeping
- Battery-free AC operation
- Dual controls with 8-way action
- Built-in Pro Hockey and Tennis games
- Easy hook-up on any B/W or Color TV
- Factory warranty

**Channel F — additional cartridges — $17.95 ea.**

0811 — Tic-Tac-Toe/Shooting Gallery Quadra-doodle/Doodle/
0812 — Desert Fox/Shooting Gallery
0813 — Blackjack (1 or 2 players)
0814 — Spitfire (1 or 2 players)
0815 — Spacewar (2 players)
0818 — Magic Numbers (computer logic)
0819 — Drag strip (1 or 2 players)
0820 — Maze (2 players)
0822 — Baseball (2 players)

# DISCRETE LEDS

| .125" dia. | | | .190" dia. | | |
|---|---|---|---|---|---|
| XC209 | Red | 10/$1 | XC111 | Red | 10/$1 |
| XC209 | Green | 4/$1 | XC111 | Green | 4/$1 |
| XC209 | Orange | 4/$1 | XC111 | Yellow | 4/$1 |
| XC209 | Yellow | 4/$1 | XC111 | Orange | 4/$1 |

| .200" dia | | | .185" dia. | | | .200" dia. | | |
|---|---|---|---|---|---|---|---|---|
| XC22 | Red | 10/$1 | XC526 | Red | 5/$1 | XC556 | Red | 10/$1 |
| XC22 | Green | 4/$1 | XC526 | Green | 4/$1 | XC556 | Green | 4/$1 |
| XC22 | Yellow | 4/$1 | XC526 | Yellow | 4/$1 | XC556 | Yellow | 4/$1 |
| XC22 | Orange | 4/$1 | XC526 | Orange | 4/$1 | XC556 | Orange | 4/$1 |
| SSL 22 | RT | 4/$1 | XC526 | Clear | 4/$1 | XC556 | Clear | 7/$1 |

.085" dia. MV50 - Red - 6/$1

INFRA-RED LED ¼" x ¼" x 1/16" Flat 5/$1.00

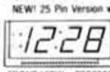
# DISPLAY LEDS

DL707 DL338

| TYPE | POLARITY | HT | | TYPE | POLARITY | HT | |
|---|---|---|---|---|---|---|---|
| MAN 1 | Common Anode | 270 | 2.95 | MAN 3640 | Common Cathode-orange | 300 | 1.75 |
| MAN 2 | 5 x 7 Dot Matrix | 300 | 4.95 | MAN 4710 | Common Anode-Red | 400 | 1.95 |
| MAN 3 | Common Cathode | 125 | 3/1.00 | DL701 | Common Anode-red ± | 300 | .99 |
| MAN 4 | Common Cathode | 187 | 1.95 | DL704 | Common Cathode | 300 | .99 |
| MAN 7 | Common Anode | 300 | 1.25 | DL707 | Common Anode | 300 | .99 |
| MAN 7G | Common Anode-green | 300 | 1.95 | MAN 4740 | Common Anode-Red | 400 | .99 |
| MAN 7Y | Common Anode-yellow | 300 | 1.95 | DL741 | Common Anode | 600 | 1.50 |
| MAN 52 | Common Anode-green | 300 | .99 | DL 747 | Common Anode | 600 | 2.25 |
| MAN 64 | Common Anode-red | 400 | .99 | DL 750 | Common Cathode | 600 | 2.49 |
| MAN 74 | Common Cathode | 300 | 1.50 | DL 338 | Common Cathode | 110 | .50 |
| MAN 82 | Common Anode-yellow | 300 | .99 | FND70 | Common Cathode | 250 | .75 |
| MAN 84 | Common Cathode-yellow | 300 | .99 | FND503 | Common Cathode | 500 | 1.00 |
| MAN 3620 | Common Anode -orange | 300 | 1.75 | FND507 | Common Anode | 500 | 1.00 |

## FCS 8000A — 3½ Digit — .8" Display

NEW! 25 Pin Version with colon & am/pm indicator



FRONT VIEW - FSC8000

**SPECIAL $4.95 EA.**

- Connects almost one for one with 3817, 3817A or D. (3817 available at $5.00 each)
- Typical segment current 8mA except colon, 10 hrs. b & c and 10 min. a & d which are 16 mA.
- MAXIMUM FORWARD CURRENT — 25 mA
- Forward voltage drop 1.5 volts

## HP 5082-7300 Series — Multi-Digit

- ⅛" Ht. • Common Cathode • Dip Package
- 3 to 5 volts @ 5 mils per segment
- 7 segment Monolithic • Red Display

| | |
|---|---|
| 2 Digit | $ .79 |
| 3 Digit | .89 |
| 4 Digit | .99 |
| 5 Digit | 1.19 |

## IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

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

## SOLDERTAIL STANDARD (TIN)

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

## SOLDERTAIL STANDARD (GOLD)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 pin | $.30 | .27 | .24 | 24 pin | $ .70 | .63 | .57 |
| 14 pin | .35 | .32 | .29 | 28 pin | 1.10 | 1.00 | .90 |
| 16 pin | .38 | .35 | .32 | 36 pin | 1.75 | 1.40 | 1.26 |
| 18 pin | .52 | .47 | .43 | 40 pin | 1.75 | 1.59 | 1.45 |

## WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

# 50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

SPECIAL

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

**ASST. 8R** Includes Resistor Assortments 1-7 (350 PCS.) **$7.49 ea.**

SPECIAL

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax
Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
Dealer Information Available

NOW OPEN SATURDAYS

# James ELECTRONICS

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru September

# WIRE WRAP CENTER

## HOBBY-WRAP TOOL-BW-630

**$34.95** (batteries not included)

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch) Complete with built-in bit and sleeve

## WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP

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

**$11.95**

## WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

## WIRE WRAP WIRE — 30 AWG

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

## WIRE DISPENSER — WD-30

- 50 ft. roll 30 AWG KYNAR wire wrap wire **$3.45 ea.**
- Cuts wire to desired length
- Strips 1" of insulation **Specify** — Blue-Yellow-White-Red

## HEAT SINKS

205-CB 680-.75A

| | | |
|---|---|---|
| 205-CB | Beryllium Copper w/Black finish for TO-5 | $ .25 |
| 291-.36H | Aluminum for TO-220 Transistors & Regulators | $ .25 |
| 680-.75A | Black Anodized Aluminum for TO-3 | $1.60 |
| 401-A | Black Anodized Aluminum — predrilled mounting holes for TO-3 | $1.75 |

## DIP SWITCHES SPST Slide Action

| | | | |
|---|---|---|---|
| #206-4 | (8 pin dip) | 4 switch unit | $1.75 ea. |
| #206-7 | (14 pin dip) | 7 switch unit | $1.95 ea. |
| #206-8 | (16 pin dip) | 8 switch unit | $2.25 ea. |

## TV GAME CHIP SET — $14.95

Includes AY-3-8500-1 chip and 2.010 mhz crystal — if purchased separately would cost $18.95.

## ZENERS — DIODES — RECTIFIERS

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

## SCR AND FW BRIDGE RECTIFIERS

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

## TRANSISTORS

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

# CAPACITOR CORNER

**50 VOLT CERAMIC DISC CAPACITORS**

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

**100 VOLT MYLAR FILM CAPACITORS**

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

**+20% DIPPED TANTALUMS (SOLID) CAPACITORS**

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

**MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS**

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

# flea market

**CINCINNATI HAMFEST:** 41st Annual — Sunday September 18, 1977 at the improved Stricker's Grove on State Route 128, one mile west of Ross (Venice) Ohio. Flea Market, Contests, Model Aircraft Flying, Food and Beverages all day. Advance Ticket Sales $7.50 — Tickets at the Gate $8.00 — covers everything. For further information: Lillian Abbott K8CKI, 1424 Main Street, Cincinnati Ohio 45210.

**CHICAGO'S RADIO EXPO '77,** September 17 & 18. Manufacturer's exhibits, seminars on amateur radio and microprocessors, thousands of dollars in door prizes. QCWA banquet Friday night at Mundelain Holiday Inn. Indoor/outdoor flea market open for set-up Friday evening. Tickets $2 advance, $3 at gate. Radio Expo, P.O. Box 1014, Arlington Heights, IL 60006.

**BLOSSOMLAND** annual fall Swap-Shop, October 2nd, Berrien County Youth Fair Grounds, Berrien Springs, Michigan. Large, convenient facilities. Prizes, refreshments, fun. Open all night for set-up. Table space restricted to radio and electronic items. Advance ticket donation $1.50. Tables $2. Write: John Sullivan, P.O. Box 345, St. Joseph, Mich. 49085. Make checks payable to Blossomland Hamfest.

**IOWA** Cedar Valley Amateur Radio Club Hamfest, Sunday, October 2, 1977. Top prizes are Atlas 210X XCVR, Wilson 1402 SM H/T, Heathkit HW-8 QRP CW XCVR, Clegg FM-76 XCVR, plus much more. Technical talks featuring Doug DeMaw W1FB. Manufacturers and Dealers welcome. Talk-in on 146.16/.76, 146.52, 3.970, and 223.5 MHz. Advance tickets $1.50, $2.00 at the door. Write CVARC Hamfest, Box 994, Cedar Rapids, Iowa 52406.

**NORTHWEST GEORGIA ARC** annual Rome hamfest will be held at the Cossa Valley Fairgrounds, Oct. 9. Gates open at 9:00 A.M.. Talk-in 146.34/94. For more info contact WB4AEG, H.D. Dale, Box 274, Adairsville, GA 30103.

**ANNUAL GABFEST,** Uniontown Amateur Radio Club, at the Club Grounds, on the Old Pittsburgh Road Uniontown, PA., September 10, 1977, the Saturday after Labor Day.

**AMSAT** annual meeting Saturday, October 8, 1977 at the Goddard Space Flight Center Employees Recreation Center in Greenbelt, MD. Everyone is invited. The afternoon session of technical and general interest talks, initiated last year, has been greatly expanded and will begin at 1 P.M. The meeting location is easily accessible by major highways, and parking is at the door. For a map and a list of talks please send an SASE to AMSAT, Box 27, Washington, DC 20044.

**LAST SPECIAL EVENTS CALLSIGN (KC3F)** issued to Keystone Country Festival, Sept. 10 & 11 in Altoona, PA. The callsign is issued to the Horseshoe Amateur Radio Club of Altoona. The Keystone Country Festival is a large arts & crafts festival held at Lakemont Park, 4 miles south of Altoona. Horseshoe A.R.C. will be operating KC3F from a portable setup both days from 1400 UTC until 2300 UTC. Special QSL cards issued to each two-way confirmed contact. All frequencies with 20-40-75-80 getting most preference. VHF on simplex as well as 146.01/.61 and .147/75/.15 2m repeaters. SASE for QSLing to W3TEF via Callbook address.

**NEW YORK CITY FLEAMARKET** Sunday, September 25, 9 A.M. to 4 P.M. Raindate — October 2nd at the Hall of Science, 111th St. and 48th Avenue, Queens, N.Y. Raffle, Museum, Fun. Sellers $2.00. Buyers $1.00. Parking $1.25. Info. (212) 699-9400. Talk-in .40/.00.

**THE SEMARA ANNUAL PICNIC AND FLEA MARKET** will be held on September 11 at the Stackhouse Street Fair Grounds, South Dartmouth, Massachusetts. Talk-in on 147.60/147.00.

**LANIERLAND A.R.C.** Fourth Annual Hamnic will be held on September 18, 1977 at the Dogwood Pavillion of Lake Lanier Islands. Main prize ICOM 22-S. Talk-in on .07/.67. Please contact Terry Jones WB4FMJ for further information.

# Stolen Equipment

**STANDARD SRC 826M** 2-meter FM Transceiver. SN; 104207. Stolen from Bill Meyers WBØMCS, 303-777-3353, 27 June 1977. 942 E. Mississippi, Denver, Colo. 80210. Has following Frequencies installed. 1.) 146.94-94, 2.) 52-52, 3.) 16-76, 4.) 34-94, 5.) 28-88, 6.) 88-88, 7.) 31-91, 8.) 148.01-01, 9.) 37-97, 10.) 19-79, 11.) 25-85, 12.)91-31. Has KØKGA scribed on receiver board, receiver crystal board has been rebuilt. Channel 12. 91-31 transmit is 450 cps. high in frequency, transmit trimmer for this channel is different from others.











More Details? CHECK—OFF Page 142

More Details? CHECK — OFF Page 142

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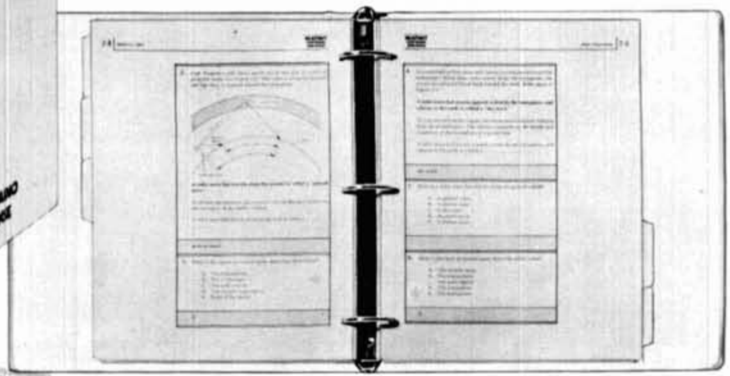

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ED-107

## DIODES/ZENERS

| | | | |
|---|---|---|---|
| 1N914 | 100v | 10mA | .05 |
| 1N4004 | 400v | 1A | .08 |
| 1N4005 | 600v | 1A | .08 |
| 1N4007 | 1000v | 1A | .15 |
| 1N4148 | 75v | 10mA | .03 |
| 1N753A | 6.2v | z | .25 |
| 1N758A | 10v | z | .25 |
| 1N759A | 12v | z | .25 |
| 1N4733 | 5.1v | z | .25 |
| 1N5243 | 13v | z | .25 |
| 1N5244B | 14v | z | .25 |
| 1N5245B | 15v | z | .25 |

## SOCKETS/BRIDGES

| | | | | |
|---|---|---|---|---|
| 8-pin | pcb | .25 | ww | .45 |
| 14-pin | pcb | .25 | ww | .40 |
| 16-pin | pcb | .25 | ww | .40 |
| 18-pin | pcb | .25 | ww | .75 |
| 22-pin | pcb | .45 | ww | 1.25 |
| 24-pin | pcb | .35 | ww | 1.25 |
| 28-pin | pcb | .35 | ww | 1.45 |
| 40-pin | pcb | .50 | ww | 1.95 |

Molex pins .01 To-3 Sockets .25

2 Amp Bridge 100-prv 1.20

25 Amp Bridge 200-prv 1.95

## TRANSISTORS, LEDS, etc.

| | | | | |
|---|---|---|---|---|
| 2N2222 | NPN | | | .15 |
| 2N2907 | PNP | | | .15 |
| 2N3740 | PNP | 1A | 60v | .25 |
| 2N3906 | PNP | | | .10 |
| 2N3054 | NPN | | | .35 |
| 2N3055 | NPN | 15A | 60v | .50 |
| T1P125 | PNP | Darlington | | .35 |

LED Green, Red, Clear .15

D.L.747 7 seg 5/8" high com-anode 1.95

XAN72 7 seg com-anode 1.50

FND 359 Red 7 seg com-cathode 1.25

## C MOS

| | |
|---|---|
| 4000 | .15 |
| 4001 | .20 |
| 4002 | .20 |
| 4004 | 3.95 |
| 4006 | 1.20 |
| 4007 | .35 |
| 4008 | 1.20 |
| 4009 | .30 |
| 4010 | .45 |
| 4011 | .20 |
| 4012 | .20 |
| 4013 | .40 |
| 4014 | 1.10 |
| 4015 | .95 |
| 4016 | .35 |
| 4017 | 1.10 |
| 4018 | 1.10 |
| 4019 | .70 |
| 4020 | .85 |
| 4021 | 1.35 |
| 4022 | .95 |
| 4023 | .25 |
| 4024 | .75 |
| 4025 | .35 |
| 4026 | 1.95 |
| 4027 | .50 |
| 4028 | .95 |
| 4030 | .35 |
| 4033 | 1.95 |
| 4034 | 2.45 |
| 4035 | 1.25 |
| 4040 | 1.35 |
| 4041 | .69 |
| 4042 | .95 |
| 4043 | 1.25 |
| 4044 | .95 |
| 4046 | 1.50 |
| 4049 | .80 |
| 4050 | .60 |
| 4066 | 1.35 |
| 4069 | .40 |
| 4071 | .35 |
| 4082 | .45 |

## — T T L —

| | |
|---|---|
| 7400 | .15 |
| 7401 | .15 |
| 7402 | .20 |
| 7403 | .20 |
| 7404 | .15 |
| 7405 | .25 |
| 7406 | .35 |
| 7407 | .55 |
| 7408 | .25 |
| 7409 | .15 |
| 7410 | .10 |
| 7411 | .25 |
| 7412 | .30 |
| 7413 | .45 |
| 7414 | 1.10 |
| 7416 | .25 |
| 7417 | .40 |
| 7420 | .15 |
| 7426 | .30 |
| 7427 | .45 |
| 7430 | .15 |
| 7432 | .30 |
| 7437 | .35 |
| 7438 | .35 |
| 7440 | .25 |
| 7441 | 1.15 |
| 7442 | .55 |
| 7443 | .85 |
| 7444 | .45 |
| 7445 | .80 |
| 7446 | .95 |
| 7447 | .95 |
| 7448 | .95 |
| 7450 | .25 |
| 7451 | .25 |
| 7453 | .20 |
| 7454 | .25 |
| 7460 | .40 |
| 7470 | .45 |
| 7472 | .45 |
| 7473 | .25 |
| 7474 | .35 |
| 7475 | .35 |
| 7476 | .30 |
| 7480 | .55 |
| 7481 | .75 |
| 7483 | .95 |
| 7485 | .95 |
| 7486 | .30 |
| 7489 | 1.35 |
| 7490 | .55 |
| 7491 | .95 |
| 7492 | .95 |
| 7493 | .40 |
| 7494 | 1.25 |
| 7495 | .60 |
| 7496 | .80 |
| 74100 | 1.85 |
| 74107 | .35 |
| 74121 | .35 |
| 74122 | .55 |
| 74123 | .55 |
| 74125 | .45 |
| 74126 | .35 |
| 74132 | 1.35 |
| 74141 | 1.00 |
| 74150 | 1.00 |
| 74151 | .75 |
| 74153 | .95 |
| 74154 | 1.05 |
| 74156 | 1.15 |
| 74157 | .65 |
| 74161 | .85 |
| 74163 | .95 |
| 74164 | .60 |
| 74165 | 1.50 |
| 74166 | 1.35 |
| 74175 | .80 |
| 74176 | 1.25 |
| 74180 | .85 |
| 74181 | 2.75 |
| 74182 | .95 |
| 74190 | 1.75 |
| 74191 | 1.35 |
| 74192 | 1.65 |
| 74193 | .85 |
| 74194 | 1.25 |
| 74195 | .95 |
| 74196 | 1.25 |
| 74197 | 1.25 |
| 74198 | 2.35 |
| 74221 | 1.00 |
| 74367 | .85 |
| 75108A | .35 |
| 75110 | .35 |
| 75491 | .50 |
| 75492 | .50 |
| 74H00 | .25 |
| 74H01 | .25 |
| 74H04 | .25 |
| 74H05 | .25 |
| 74H08 | .35 |
| 74H10 | .35 |
| 74H11 | .25 |
| 74H15 | .30 |
| 74H20 | .30 |
| 74H21 | .25 |
| 74H22 | .40 |
| 74H30 | .25 |
| 74H40 | .25 |
| 74H50 | .25 |
| 74H51 | .25 |
| 74H52 | .15 |
| 74H53J | .25 |
| 74H55 | .25 |
| 74H72 | .55 |
| 74H101 | .75 |
| 74H103 | .75 |
| 74H106 | .95 |
| 74L00 | .35 |
| 74L02 | .35 |
| 74L03 | .30 |
| 74L04 | .35 |
| 74L10 | .35 |
| 74L20 | .35 |
| 74L30 | .45 |
| 74L47 | 1.95 |
| 74L51 | .45 |
| 74L55 | .65 |
| 74L72 | .45 |
| 74L73 | .40 |
| 74L74 | .45 |
| 74L75 | .55 |
| 74L93 | .55 |
| 74L123 | .55 |
| 74S00 | .55 |
| 74S02 | .55 |
| 74S03 | .40 |
| 74S04 | .35 |
| 74S05 | .35 |
| 74S08 | .35 |
| 74S10 | .35 |
| 74S11 | .35 |
| 74S20 | .35 |
| 74S40 | .25 |
| 74S50 | .25 |
| 74S51 | .45 |
| 74S64 | .25 |
| 74S74 | .40 |
| 74S112 | .90 |
| 74S114 | 1.30 |
| 74S133 | .45 |
| 74S140 | .75 |
| 74S151 | .35 |
| 74S153 | .35 |
| 74S157 | .80 |
| 74S158 | .35 |
| 74S194 | 1.05 |
| 74S257( 8123) | .25 |
| 74LS00 | .45 |
| 74LS01 | .45 |
| 74LS02 | .45 |
| 74LS04 | .45 |
| 74LS05 | .55 |
| 74LS08 | .45 |
| 74LS09 | .45 |
| 74LS10 | .45 |
| 74LS11 | .45 |
| 74LS20 | .40 |
| 74LS21 | .25 |
| 74LS22 | .25 |
| 74LS32 | .40 |
| 74LS37 | .40 |
| 74LS40 | .55 |
| 74LS42 | 1.75 |
| 74LS51 | .65 |
| 74LS74 | .75 |
| 74LS86 | .75 |
| 74LS90 | 1.30 |
| 74LS93 | 1.00 |
| 74LS107 | .95 |
| 74LS123 | 1.00 |
| 74LS151 | .75 |
| 74LS153 | 1.20 |
| 74LS157 | .85 |
| 74LS164 | 1.90 |
| 74LS367 | .85 |
| 74LS368 | .70 |

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| | |
|---|---|
| 9301 | .85 |
| 9309 | .35 |
| 9322 | .85 |
| 95H03 | .55 |
| 9601 | .75 |
| 9602 | .50 |

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| | |
|---|---|
| 74S188 (8223) | 3.00 |
| 1702A | 7.95 |
| MM5314 | 3.00 |
| MM5316 | 3.50 |
| 2102-1 | 1.75 |
| 2102L-1 | 1.95 |
| TMS6011NC | 6.95 |
| 8080AD | 15.00 |
| 8T13 | 1.50 |
| 8T23 | 1.50 |
| 8T24 | 2.00 |
| 2107B-4 | 4.95 |

## LINEARS, REGULATORS, etc.

| | |
|---|---|
| 8266 | .35 |
| 8836 | .95 |
| MCT2 | .95 |
| 8038 | 3.95 |
| LM201 | .75 |
| LM301 | .25 |
| LM308 (Mini) | .75 |
| LM309H | .65 |
| LM309K(340K-5) | .85 |
| LM310 | 1.15 |
| LM311D(Mini) | .75 |
| LM318 (Mini) | .65 |
| LM320K5 (7905) | 1.65 |
| LM320K12 | 1.65 |
| LM320T12 | 1.25 |
| LM320T15 | 1.65 |
| LM339 | .95 |
| 7805 (340T-5) | .95 |
| LM340T-12 | 1.00 |
| LM340T-15 | 1.00 |
| LM340T-18 | 1.00 |
| LM340T-24 | .95 |
| LM340K-12 | 2.15 |
| LM340K-15 | 1.25 |
| LM340K-18 | 1.25 |
| LM340K-24 | .95 |
| LM373 | 2.95 |
| LM380 | .95 |
| LM709(8,14 PIN) | .25 |
| LM711 | .45 |
| LM723 | .50 |
| LM725 | 1.75 |
| LM739 | 1.50 |
| LM741 8-14 | .20 |
| LM747 | 1.10 |
| LM1307 | 1.25 |
| LM1458 | .95 |
| LM3900 | .50 |
| LM75451 | .65 |
| NE555 | .50 |
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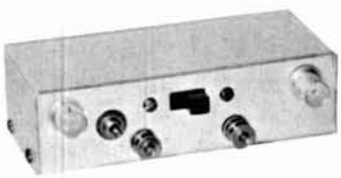

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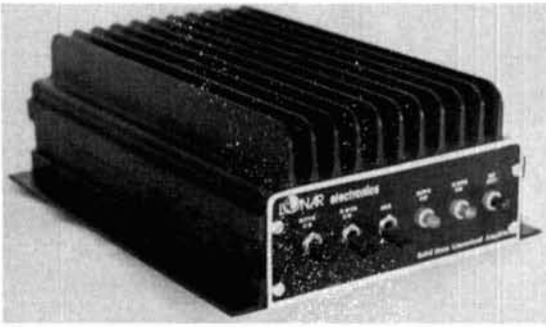
# LUNAR

## proudly announces a NEW 2-Meter AMPLIFIER/PREAMPLIFIER the *2M10-80P*

The Marriage Between Power Amplifiers and Receiving Preamplifiers is Finally Consummated! Lunar Offers an SCS **2M10-80L** Power Amp and an "Anglelinear" **144W** Preamp in a Single, Functionally-Designed Package that Combines Two Superior Products Into One!



**Features:**

- ★ Ten watts input — eighty watts output
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- ★ Variable T-R Delay for CW/SSB
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  (Including Relay Losses)
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**Introductory Price: . . . . . . . . . . . Lunar Model 2M10-80P . . . . . . . . . . . $189.95**

Please add $3.00 shipping and handling

*Also From Lunar:*

Available Now: Complete Line of Separate Preamplifiers 50-450 MHz

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| **Model DGA 4075** | **$59.50** |

Please state portion of band you wish to have pre-cut.

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**MOBILE CB ANTENNA:** 5/8 Firestick **$14.95**

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No CODs. Please add $1.50 handling charge.

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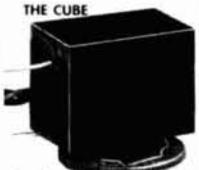
THE CUBE



.5 x .6 x .8 in.

- Inexpensive multi tone encoder
- Compatible with PL-CG-QC
- Low distortion sinewave
- Input 8-18 VDC unregulated
- Rugged, plastic encased with leads
- Adjustable frequency (98-250 Hz), Lower available
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Price $19.95

Freq. set at factory $5.00 extra

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specify 80 or 40 meters with order

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*Larsen Antennas to fit Any Mobile Unit*

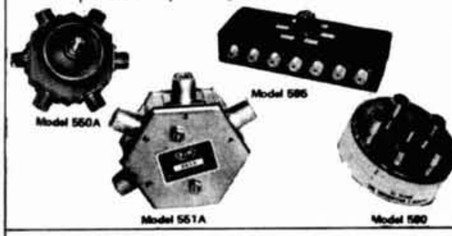
## Larsen Antennas

Magnetic Mount or Gutter Clamp 5/8 wave – $38.50
Specify, 2 meters, 220, 450. 1/4 wave – $18.50

3/8" single hole mount 5/8 wave $31.50
1/4 wave 11.50

## COAXIAL SWITCH SELECTOR CHART – BARKER & WILLIAMSON, INC.

| Model | PRICE | Outputs | Connector Placement | Remarks |
|---|---|---|---|---|
| 375 | 18.95 | 6 | Axial | PROTAX switch. Grounds all except selected output circuit. |
| 376 | 18.95 | 5 | Radial | PROTAX switch. Grounds all except selected output circuit. Sixth switch position grounds *all* outputs. |
| 550A | 14.00 | 5 | Radial | |
| 550A-2 | 12.50 | 2 | Radial | |
| 551A | 17.50 | 2 | Radial | Special 2-pole, 2-position switch used to switch any RF device in or out of series connection in a coaxial line. See figure (over) |
| 556 | .95 | – | – | Bracket only, for wall mounting of radial connector switches. |
| 590 | 17.95 | 5 | Axial | |
| 590G | 17.95 | 5 | Axial | Grounds all except selected output circuit. |
| 592 | 16.50 | 2 | Axial | |
| 595 | 18.50 | 6 | In-line | Grounds all except selected output circuit. |


## MODEL 104R


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

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

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

**$49.95**

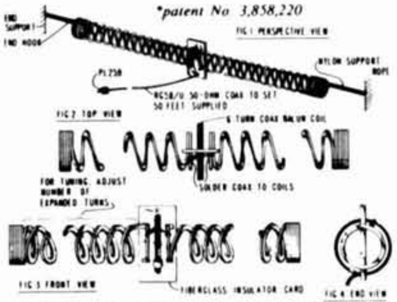
Case: 3½" (H) x 5½" (W) x 6½" (D). Shipping Weight: 6 lbs

## SLINKY!® $39.95 kit

**A LOT of antenna in a LITTLE space**

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

**patent No. 3,858,220*




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

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| 702B | 1-4W | 60-80W | 1 in/70 out | 143-149 MHz | $169.00 |

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

For prices and specifications please write for our Amateur Products Summary! FCC type accepted power amplifiers also available. Please call or write for a copy of TPL's Commercial Products Summary.

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**160-10AT SUPERTUNER™**
Want an antenna tuner to match everything between 160 and 10 through balanced line, coax line and random line. Super-tuner™ is the one for you at just $129.50

**160-10AT-3K SUPER SUPERTUNER™**
Designed and engineered to be compatible with the full-power highly efficient modern amplifiers now available to the amateur. In our opinion the finest tuner on the market today. $229.50

**80-10AT SKYMATCHER™**
Here's an antenna tuner for 80 through 10 meters, handles full legal power and matches your 52 ohm transceiver to a random wire antenna. 80-10AT is yours for only $59.50

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$4.50 @ Lifetime Guarantee

Novice Crystals (Specify Band Only)

NOW! Motorola HT 220 Crystals In Stock!

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# SPECIALS FROM MHz electronics

**Fairchild VHF Prescaler Chips**

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

**Batteries**

Gel-Cell 12 volts at 1.5 Amp Hr. #GC-1215 $19.95

**Crystals**

| | |
|---|---|
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| 5.000000 MHz | 4.95 |
| 3579.545 KC | 2.95 |
| 10 MHz | $4.95 |

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

| | |
|---|---|
| Motorola U43 GGT | $49.95 |
| GE TPL | $99.95 |
| GE MT-33 | $39.95 |
| GRC10 Radio Set | $169.95 |

**Motorola MC14410CP CMOS tone Generator** uses 1 MHz Crystal to produce standard dual frequency telephone dialing signal. Directly compatible with our 12 key Chomeric pads. Kit includes the following.

1 MC14410CP
1 1 MHz Crystal
1 Printed Circuit Board (From Ham Radio Sept. 1975)
And all other parts for assembly. NOTE: Touch Tone Pad not included! $15.70

**Fairchild 95H90DC Prescaler** divide by 10 to 350 MHz. Will take any 35 MHz Counter to 350 MHz. Kit includes the following.

1 95H90DC
1 2N5179
2 UG-88/u BNC's
1 Printed Circuit Board
And all other parts for assembly.
$29.95

**Fairchild 11C90DC Prescaler** divide by 10 to 650 MHz. Will take any 65 MHz Counter to 650 MHz or with a 82S90 it will divide by 10/100 to 650 MHz. This will take a 6.5 MHz counter to 650 MHz. Kit includes the following.

1 11C90DC
1 2N5179
2 UG-88/U
1 MC7805CP
1 Bridge
1 Printed Circuit Board and all other parts for assembly.
82S90 add $5.70 to total.
$59.95

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

**I.C.'s**

| | |
|---|---|
| 8223B | $3.00 |
| 2102 | $1.99 |

MuRata 10.7 MHz Ceramic Filters #SFW-10.7MA $3.95
10.7 *Narrow Band Crystal Filters* Type 2194F $7.95 each

**Johanson and Johnson *Trimmer Capacitors***

| | |
|---|---|
| 1 to 14 pf. | $1.95 |
| 1 to 20 pf. | $1.95 |

**Ferrite Beads**
12 for .99 or 120 for 9.99

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

## TUBES

| | | | | | |
|---|---|---|---|---|---|
| 2E26 | 5.00 | 572B/T160L | 25.00 | 7377 | 40.00 |
| 3B28 | 4.00 | 811A | 9.95 | 8156 | 3.95 |
| 4X150A | 15.00 | 931A | 11.95 | 8908 | 9.95 |
| 4X150G | 18.00 | 5849 | 32.00 | 8950 | 5.50 |
| 4CX250B | 24.00 | 6LQ6 | 4.50 | 4-400A | 29.95 |
| 4CX350A/8321 | 35.00 | 6146A | 5.25 | 4-250A | 24.95 |
| 4CX15000A | 150.00 | 6146B/8298A | 6.25 | 4-125A | 20.95 |
| DX415 | 25.00 | 6360 | 7.95 | 4-65A | 15.95 |
| | | 6907 | 35.00 | | |

## TRANSFORMERS

| | | |
|---|---|---|
| F-18X | *6.3vct at 6 amps* | 3.56 |
| F-93X | 6.5v to 40v at 750 ma. | 3.53 |
| F-92A | 6.5v to 40v at 1 amp | 4.59 |
| N-51X | Isolation 115vac at 35va. | 2.80 |
| Model D-2 | 6.5v at 3.3 amps<br>6.5v at 3.3 amps | 4.95 |
| BE-12433-001 | 30v at 15 ma. | .49 |
| BGH-9 | 6.3vct at 10 amps. | 6.95 |
| F-107Z | 12V @ 4A or 24 V @ 2A | 7.80 |
| P6377 | 12v @ 4a or 24v @ 2a | 6.31 |
| P6378 | 12v @ 8a or 24v @ 4a | 10.31 |
| P8196 | 80vct @ 1.2a | 6.28 |

**New Motorola Carbon Microphone Model P-7255A.**
This unit is a "noise cancelling" palm type microphone. These mikes come with or without cables. Price without $19.95 — with $29.95.

## FANS

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

## DIODES

1N270 Germanium Diodes $7.95/c
Semtech SFMS 20K, 20KV, 10 ma, fast recovery $1.26 ea.

H. P. 623B Microwave test set, 6565 MHz to 7175 MHz $900.00
Beckman to Beckman Model 6127 Eput meter with Model 607 Heterodyne plug in DC to 1 GHz. $900.00
H.P. TS510 A/U/H.P. 608D UHF Signal Gen. 10 MHz to 420 MHz. $500.00
H.P.H03-624C / KS16647 Microwave Signal Gen. 10.7 GHz to 11.7 GHz. $900.00
Motorola MR510 Diodes 1000 piv @ 3 amp. $9.90/20 pcs.

## RF TRANSISTORS

| | | | | | |
|---|---|---|---|---|---|
| 2N1561 | 15.00 | 2N3927 | 11.50 | 2N5641 | 4.90 |
| 2N1562 | 15.00 | 2N3948 | 2.00 | 2N5643 | 20.70 |
| 2N1692 | 15.00 | 2N3950 | 26.25 | 2N5764 | 27.00 |
| 2N1693 | 15.00 | 2N3961 | 6.60 | 2N5841 | 11.00 |
| 2N2631 | 4.20 | 2N4072 | 1.70 | 2N5842/MM1607 | 19.50 |
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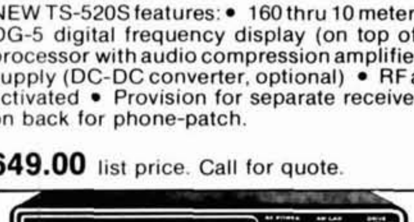

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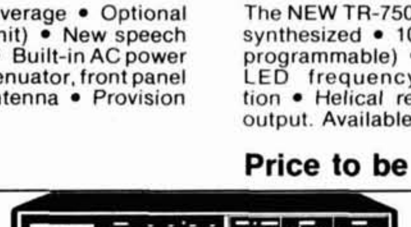

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