

one dollar

ham **radio**

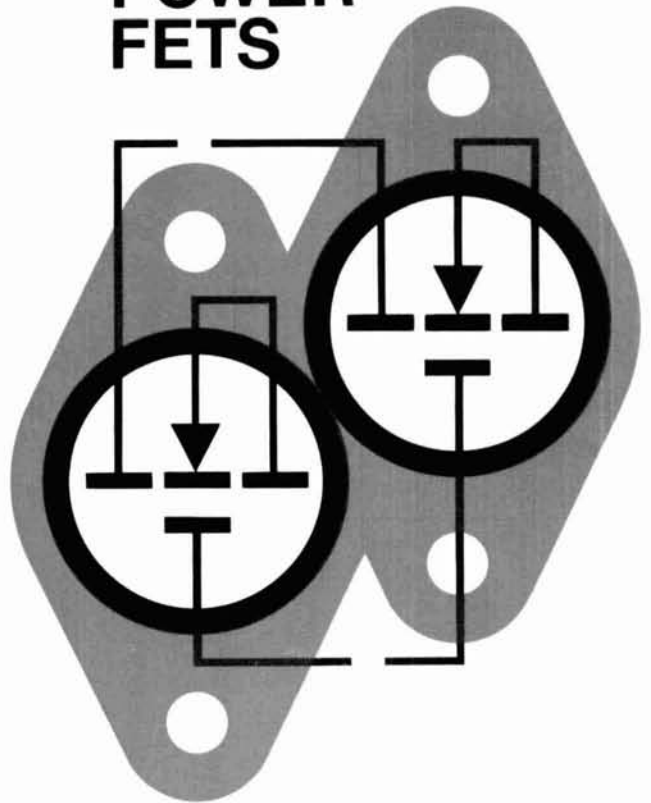
magazine

hr 

SEPTEMBER 1976

- digital frequency readout 16
- morse keyboard 26
- uhf dummy load 30
- audio frequency-shift keyer 45
- troubleshooting solid-state 60
- and much more . . .

TWO-METER TRANSVERTER using POWER FETS



If you own a VHF ONE, a TS-700A or an FT-221

...Tempo's 100AL10 solid state linear is just what you need

Double your pleasure with the first truly linear solid state power amplifier available. The 100AL10 guarantees increased range and clarity in your VHF communications under all operating conditions. It operates in the frequency range of 144-148 MHz with power output of 100W (nom) with 10W (nom) in. Modern solid-state technology is used throughout, along with conservatively rated components to assure the highest possible reliability. Microstrip design on glass epoxy circuit boards give added resistance to damage from shock or prolonged vibration.

Simply plugs into any of the above transceivers (an SSB adaptor is required with the VHF-ONE) and you're on the air . . . loud and clear.

The 100AL10 (12VDC) \$179.00
The PS-1220 (AC power supply) \$129.00
The 100-AL10-B (AC power supply and amplifier in one compact package...ready for AC operation) \$295.00



VERSATILITY PLUS! the TEMPO MR-2

VHF HIGH BAND MONITOR-PAGING RECEIVER

The Tempo MR-2 is a shirt pocket size monitor-paging receiver with hundreds of uses. 12 channel capability...more than any competitive receiver and at an economical price. Excellent selectivity and guaranteed sensitivity across a 4 MHz band spread.

140-170MHz range. Plug-in crystals. Ni-cad batteries and accessory charger included.

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The Tempo Line, now more than ever...solid value

Tempo VHF-ONE Full 2-meter band coverage (144 to 148 MHz for transmit and receive • Full phase lock synthesized (PLL) • Provision for accessory SSB adaptor • 5-digit LED receive frequency display • Automatic repeater split • Solid state • 10 watts output . . \$495.00

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Tempo/CL-146A A mobile transceiver for the 2 meter amateur band • Compact and rugged • Solid state • 144 to 148 MHz (any 2 MHz without retuning). 12 channel possible. One channel supplied, two channels of your choice free \$239.00

Tempo CL-220 Same general specs as CL-146A,

but operates 220 to 225 MHz (any 2 MHz without returning) \$299.00

Tempo FMH Two watt VHF/FM hand held • 6 channel capability • Solid state • 144-148 MHz • Includes 1 pair of crystals, built-in charging terminals for ni-cad batteries \$199.00

Tempo 6N2 Power amplifier for 2 and 6 meter operation • 2000 watts PEP input on SSB & 1000 watts input on CW and FM • Solid state power supply \$795.00

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Tempo's brand new advanced design digital display transceiver...the Model 2020. 80 through 10 meters, SSB. Another solid value in the Tempo line.

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THE "WOW" DESIGN!

YAESU'S NEW FT221 — ENTIRE 2 MTR BAND!

FM-AM-USB-LSB-CW

PHASE LOCK LOOP!

AND WOW! ONLY \$629.

Price and Specifications subject to change without notice.

No crystals needed!

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Phase lock loop circuit!

Full band coverage —
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Pulse noise blanker!

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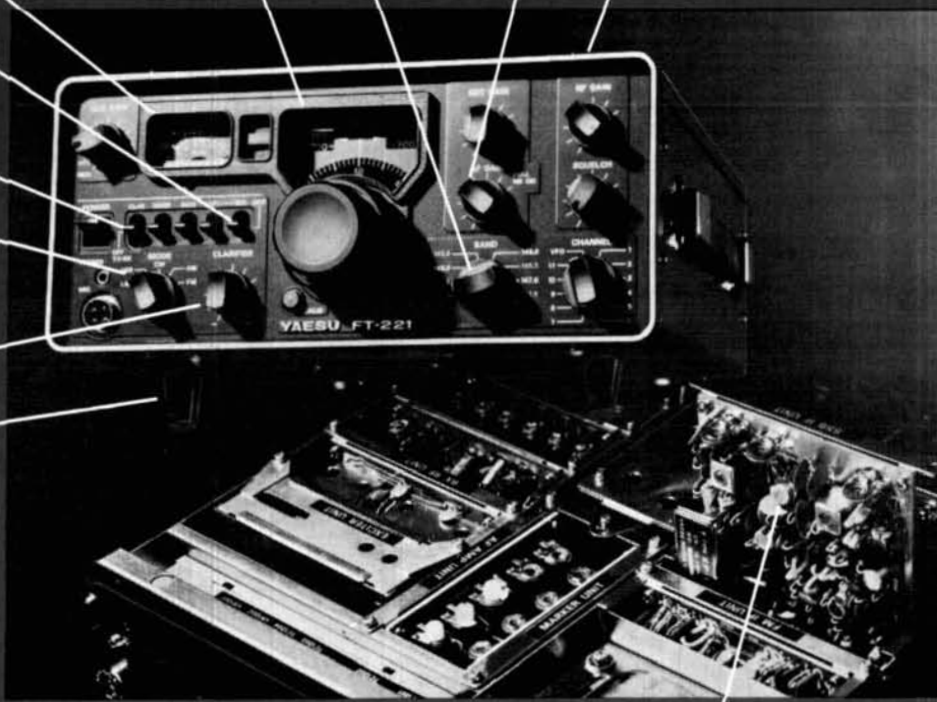
0.5 microvolt receiver
sensitivity!

24 watts SSB PEP input!

PTT or VOX operation!

Mike, plugs, connectors
supplied!

Plug-in computer quality
circuit boards!



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YAESU

The radio.

Stay tuned for future programs.



The HAL ST-6000 demodulator/keyer and the DS-3000 and DS-4000 KSR/RO series of communications terminals are designed to give you superlative TTY performance today—and in the future. DS series terminals, for example, are re-programmable, assuring you freedom from obsolescence. Sophisticated systems all, these HAL products are attractively priced—for industry, government and serious amateur radio operators.

The HAL ST-6000 operates at standard shifts of 850, 425, and 170 Hz. The tone keyer is crystal-controlled. Loop supply is internal. Active filters allow flexibility in estab-

lishing different tone pairs. You can select AM or hard-limiting FM modes of operation to accommodate different operating conditions. An internal monitor scope (shown on model above) allows fast, accurate tuning. The ST-6000 has an outstandingly high dynamic range of operation. Data I/O can be RS-232C, MIL-188C or current loop.

The DS-3000 and DS-4000 series of KSR and RO terminals provide silent, reliable, all-electronic TTY transmission and reception, or read-only (RO) operation of different combinations

of codes, including Baudot, ASCII and Morse. The powerful, programmable 8080A microprocessor is included in the circuitry to assure maximum flexibility for your present needs—and for the future. The KSR models offer you full editing capability. The video display is a convenient 16-line format, of 72 characters per line.

These are some of the highlights. The full range of features and specifications for the ST-6000 and the DS series of KSR and RO terminals is covered in comprehensive data sheets available on request. Write for them now—and tune in to the most sophisticated TTY operation you can have today...or in the future.



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ham radio

magazine

SEPTEMBER 1976

volume 9, number 9

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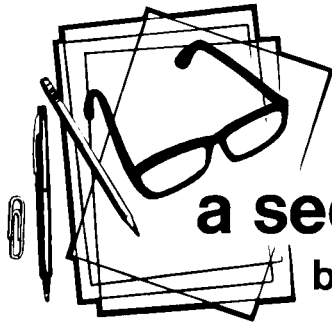
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a second look

by Jim Fisk

If attendance at the microprocessor seminars at the various hamfests around the country is any indication, amateur interest in these versatile machines is growing by leaps and bounds. Although a good deal of this increased interest is due to the drastic price reductions of the past few months, improved support from the manufacturers in terms of hardware and software have been a contributing factor. Whereas last year's computer hobbyist spent the majority of his time developing and building hardware, today the trend is toward the software, or programming, side of computer design. And, as many hobbyists are discovering, software is often more challenging — and rewarding — than wiring up a board full of logic chips.

Another trend that promises to increase the popularity of the home computer is that of designing the basic machine to accommodate future developments in microprocessor technology. Although the direct interface logic is different for each processor chip, with careful circuit design it's possible to retain all of the expensive memory boards of the basic system, as well as most of the input/output circuitry. This takes a good deal more planning, and an understanding of LSI IC design, but the computer manufacturer who is successful will dominate the future market. As it stands now, most computer systems are oriented around a single microprocessor chip. This is unfortunate because it means that each new, improved processor that reaches the marketplace requires a whole new design, an entirely new machine — input/output logic, memory *and* power supplies. At least one company, The Digital Group, Inc., has recognized this basic deficiency and has come up with a computer system that will accommodate a wide range of microprocessor chips. With this design concept you don't have to buy a whole new system each time an advanced processor hits the market; you simply buy a new CPU card (at considerable cost savings) and use your existing memory and input/output logic.

As with all new developments, the microprocessor field has been in a continual state of flux since the first device was announced several years ago, and I see no reason for it to settle down in the near future. If you made a survey of computer hobbyists right now, you'd probably find that most of them use an Intel 8080 or 8080A in their system, with the Motorola 6800 running a distant second. This is an important consideration if you're thinking about buying a computer for home use because it means that there are a large number of programs available which you can put to work as soon as you get your machine. Once you've had some "hands on" experience with existing programs, the task of writing your own programs will look much less formidable. That's when the real fun of owning your own computer begins.

It's important to keep in mind that just because the 8080 is king of the hill right now doesn't mean it's always going to be that way. The new Zilog Z80, for example, operates much like the 8080, but is faster and has a more powerful instruction set; waiting in the wings are yet more powerful processor ICs which will reach the market in coming months. However, if you choose a system that has good software support, and is designed to accommodate future developments in microprocessor technology, you'll have a computer that can be easily updated and expanded as soon as devices become available.

Many amateurs have been watching the home computer market with caution, waiting for the product to mature to the point where they can buy the most computing power for the least cost. Although we'll almost certainly see some further price reductions in the months and years ahead, today you can put together a very good system for about the same cost as an ssb transceiver. If you choose wisely, and spend your money carefully, you can have a system *now* that will meet practically all of your future computer needs.

Jim Fisk, W1DTY
editor-in-chief

Now ICOM Introduces 15 Channels of FM to Go! **The New IC-215: the FM Grabber**

This is ICOM's first FM portable, and it puts good times on the go. Change vehicles, walk through the park, climb a hill, and ICOM quality FM communications go right along with you. Long lasting internal batteries make portable FM really portable, while accessible features make conversion to external power and antenna fast and easy.

Grab for flexibility with the new **IC-215** FM portable.

- Front mounted controls and top mounted antenna
- Narrow filter (15KHz — compatible spacing)
- 15 channels (12 on dial / 3 priority)
- Fully collapsible antenna
- Compatible mount feature for flexible antenna
- Dual power (3 watts high / 400 mw low, nominal)
- External power and antenna easily accessible
- Lighted dial and meter



Your new **IC-215** comes supplied with: 5 popular channels; handheld mic, with protective case; shoulder strap; connectors for external power and speaker; 9 long-life C batteries.

VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

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LONG-AWAITED CB EXPANSION was announced July 27th with 17 new channels added to the existing 11-meter CB band. The expansion to 40 channels won't become effective until January 1 in order to give manufacturers time to develop, and have type-accepted, the new radios. One of the 17 new channels falls between channels 22 and 23 — the remaining 16 are from 23 up.

Tough New Technical Specifications on all new 40-channel CB gear are also a part of the Report and Order on Docket 20120. All transmitter harmonic and spurious radiation must be down 60 dB from the carrier instead of the present 49 dB, and total receiver radiation at the antenna terminals can't exceed two nanowatts. In addition, receiver chassis radiation must be under five microvolts at three meters. As tough as these new specs seem, however, they are likely to get tougher.

TYPE ACCEPTANCE OF AMATEUR RADIO GEAR is still very much under consideration by the FCC. It's not only a result of the misuse of Amateur transceivers by the "HF" groups and the proliferation of "3-30 MHz" broadband linear amplifiers, but is also due to some serious interference problems traced to inaccurately "spec'ed" commercially-made Amateur gear that was being used by Amateurs. Some action along these lines is not far off — perhaps by late Fall.

NOVICE PHONE PRIVILEGES are to be proposed to the FCC by the ARRL. The League Board of Directors voted in Denver to petition the Commission to immediately add 145-145.5 and 222-225 MHz CW, AM and FM with 50 watts DC input to the Novice frequency bands.

EXPERIMENTAL NOVICE LICENSING PROGRAM became an official reality with an FCC Public Notice issued July 21. Only a limited number of organizations will be selected to participate in the experimental phase of the program, which is designed to be a "controlled experiment" leading to improvements in the Novice license examination system.

Organizations Interested In Participating in the FCC's new Novice license examination program should submit a detailed proposal to John Johnston, Chief, Amateur and Citizens Division, FCC, Washington D.C. 20554 for review.

Minimum Course Coverage for the experimental program must include all material in the Commission's Element Two Novice Study Guide but may be taken from any source. Instructors must be experienced and knowledgeable, hold a General or higher class Amateur license and be 21 or older. Course graduates will be required to pass a five wpm code test and a written examination of at least 20 questions covering the nine Element Two Study Guide categories — and some students from each class will still have to take a standard Commission-graded Novice examination.

AMATEURS APPLYING to the FCC for license renewal, modification, or other action should always try to pay by personal check. The returned cancelled check provides assurance that your application made it through the mail, and may even prove you've paid if your paperwork later gets lost in the system.

"Straight Forward" License Processing is now down to 7-8 weeks for most applicants, according to late reader reports. Anyone who has been waiting longer than 12 weeks for an Amateur license should probably call FCC at (202) 632-7175 for help.

1X2 CALLSIGN REQUESTS INCREASED SHARPLY after a very slow beginning. Since 1x2 assignments are hand processed, some delays seem likely — even some pre-July 1 requests for unspecified 1x2 calls will probably be delayed by the influx.

WD8 CALLSIGNS have been issued in quantity and should be showing up on the bands momentarily. A look in the latest Callbook shows WD4, WD9 and WD0 shouldn't be far behind. For bicentennial purposes WD call holders should use "AE" for a prefix.

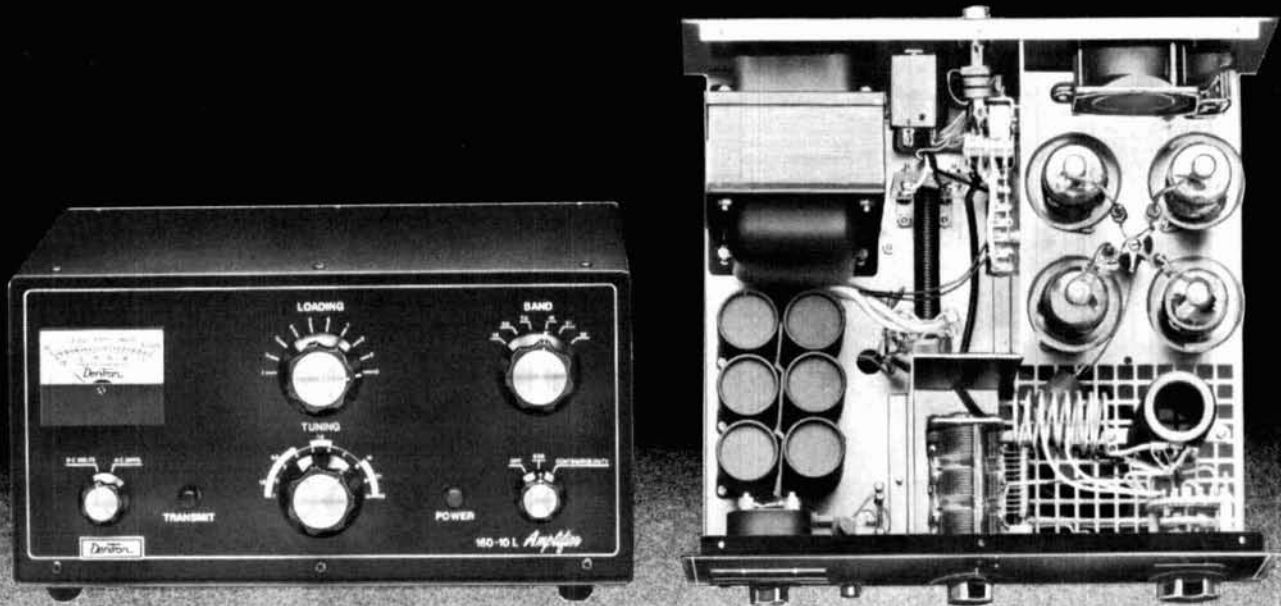
WT-PREFIXED CALLS have been issued to a few Amateur license applicants who've been the victims of an extreme foulup in the FCC's paperwork mill. The WT (for temporary) calls are good only until the computer issues the new Amateur's permanent call, so they should be very good catches for prefix hunters.

OSCAR 8 DELAY now looks like it might extend through 1980 for want of a timely launch vehicle. An interim satellite to supplement OSCAR 6 and 7 is being considered to take advantage of a NOAA launch opportunity in late 1977. Experienced volunteers to work on both hardware and software for the project will be needed.

Coast Guard Cutter planning an extended Arctic tour wants to use OSCARs for crew communications because of HF propagation problems and its being too far north to use synchronous satellites over the equator. AMSAT is looking for volunteers to make coverage plots to determine practicality — W3GEY has details.

WV'S REMAINING PROPAGATION REPORT will be discontinued October 1 unless a tentative decision to disband the Telecommunications Services Center, which supplies the 14 minutes after the hour report, can be reversed. Write Dr. Douglass Crombie, Director ITS/OT, U.S. Department of Commerce, Boulder, CO 80302 or call him at (303) 499-1000, ext. 4215 — a carbon of your letter to the Honorable T.E. Wirth, U.S. House of Representatives, Washington, D.C.

Dentron Proudly Reveals the Secret of the New \$499.50 Super Amp



If the amplifier you're thinking of buying doesn't deliver at least 1000 to 1200 watts output, to the antenna, you're buying the wrong amplifier.

Our New Super Amp is sweeping the country because hams have realized that the Dentron Amplifier will deliver to the antenna, (output power), what other manufacturers rate as input power.

The Super Amp runs a full 2000 watts P.E.P. input on SSB, and 1000 watts DC on CW, RTTY or SSTV 160 - 10 meters, the maximum legal power.

The Super Amp is compact, low profile, has a solid, one-piece cabinet assuring maximum TVI shielding.

The heart of our amplifier, the power supply, is a continuous duty, self-contained supply built for contest performance.

We mounted the 4 - 811 A's, industrial workhorse tubes, in a cooling chamber featuring the on demand variable cooling system.

The hams at Dentron pride themselves on quality work and we fight to keep prices down. That's why the dynamic Dentron Linear Amplifier beats them all at \$499.50.

**The No-nonsense Amplifier
at a No-Nonsense Price \$499.50.**

Dentron

Radio Co., Inc.

2100 Enterprise Parkway
Twinsburg, Ohio 44087
(216)425-3173

When you get tired of compromises...

TS-700A Specifications

TRANSMIT/RECEIVE FREQUENCY RANGE:
144-148 MHz
MODE: SSB, FM, CW, AM
RF OUTPUT: CW, FM: more than 10W output.
AM: more than 3W output. SSB: more
than 20W DC input.
ANTENNA IMPEDANCE: 50Ω (unbalanced)
CARRIER SUPPRESSION: Better than 40 dB
SIDE BAND SUPPRESSION: Better than 40 dB
SPURIOUS RADIATION: Less than -60 db



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

- Operates all modes: SSB (upper & lower), FM, AM, and CW
- Completely solid state circuitry provides stable, long lasting, trouble-free operation
- AC and DC capability. Can operate from your car, boat, or as a base station through its built-in power supply
- 4 MHz band coverage (144 to 148 MHz) instead of the usual 2
- Automatically switches transmit frequency 600 KHz for repeater operation. Just dial in your receive frequency and the radio does the rest... Simplex repeater reverse
- Or do the same thing by plugging a single crystal into one of the 11 crystal positions for

- your favorite channel
- Outstanding frequency stability provided through the use of FET-VFO
- Zero center discriminator meter
- Transmit/Receive capability on 44 channels with 11 crystals
- Complete with microphone and built-in speaker
- The TS-700A has been thoroughly field-tested. Thousands of units are in operation throughout Japan and Europe

The TS-700A is available at select Kenwood dealers throughout the U.S. For the name of your nearest dealer, please write.

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

KENWOOD'S TS-820 *the Pacesetter*



KENWOOD HAS ATTAINED A HIGHER LEVEL OF ACHIEVEMENT IN ITS TS-820 THAN EVER REACHED BEFORE. THE DISCRIMINATING AMATEUR WHO WANTS THE VERY BEST NEED LOOK NO FURTHER NOR WAIT ANY LONGER. THE TS-820 PACESETTER™ WILL PROVIDE SUPERIOR PERFORMANCE, VERSATILITY AND FEATURES FOUND IN NO OTHER TRANSCEIVER.

THE NEW "PACESETTER" IS THE ULTIMATE PROOF OF KENWOOD'S DEDICATION TO OFFERING ONLY THE VERY FINEST.

What makes the TS-820 the Pacesetter: Full 160-10 band coverage, QRM-killing IF shift, true R.F. speech processor, husky AC power supply, state-of-the-art PLL VFO system, rugged final amplifier, RF negative feedback circuit . . . all this and more built in to make the TS-820 the Pacesetter that it is.

We haven't forgotten the other standard Kenwood features either . . . efficient noise blanker, 25 kHz calibrator, built-in speaker, CW Sidetone and semi-break-in circuits.

Let's take a closer look at some of these important features. This month the Digital Readout:

The Digital Display Readout directly

indicates the transmit and receive frequencies by counting the carrier, VFO, and heterodyne signals. Unlike dials using a VFO signal only, it indicates the accurate frequency in any operating mode. The readout accuracy is determined by the standard 1 MHz oscillator which is calibrated to WWV. The counter actually figures the frequency down to 10 Hz and the digital display reads out to 100 Hz. Frequencies are displayed in Kenwood blue digits for long operation without fatigue.

When the Digital Display is installed, the D.H. (display hold) switch is used as a memory device. By pressing the switch, the selected frequency will remain displayed.

TS-820 Specifications

FREQUENCY RANGE: 1.8-29.7 MHz
(160 - 10 meters)

MODES: USB, LSB, CW, FSK
INPUT POWER: 200W PEP on SSB
160 W DC on CW
100 W DC on FSK

ANTENNA IMPEDANCE: 50-75 ohms, unbalanced
CARRIER SUPPRESSION: Better than 40 dB
SIDE BAND SUPPRESSION: Better than 50 dB
SPURIOUS RADIATION: Greater than -60 dB
(Harmonics more than -40 dB)

RECEIVER SENSITIVITY: Better than 0.25uV

RECEIVER SELECTIVITY:
SSB 2.4 kHz (-6 dB)
4.4 kHz (-60 dB)
CW* 0.5 kHz (-6 dB)
1.8 kHz (-60 dB)

* (with optional CW filter installed)
IMAGE RATIO: 160-15 meters: Better than 60 dB
10 meters: Better than 50 dB

IF REJECTION: Better than 80 dB
POWER REQUIREMENTS: 120/220 VAC,
50/60 Hz, 13.8 VDC (with optional
DS-1A DC-DC converter)

POWER CONSUMPTION: Transmit: 280 Watts

Receive: 26 Watts (heaters off)

DIMENSIONS: 13-1/8" W x 6" H
x 13-3/16" D

WEIGHT: 35.2 lbs (16 kg)

Additional Features

FINAL AMPLIFIER: The TS-820 is completely solid state except for the driver (12BY7A) and the final tubes. Rather than substitute TV sweep tubes as final amplifier tubes in a state-of-the-art amateur transceiver, 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. Tubes run cool with the aid of a noiseless fan (standard) mounted on the rear panel. The above tube and power combination minimizes the possibilities of TVI and helps to maintain the Kenwood reputation for excellent audio quality.

Most modern SSB transceivers employ some type of ALC circuit in the final stage. The TS-820 uses R.F. negative feedback from the PA plate circuit to the driver cathode permitting a high degree of linearity at the high power level of the PA tubes. This accomplishes third order intermodulation products 35 db or greater below the output signal . . . you get one of the cleanest signals on the air today.



VFO-820

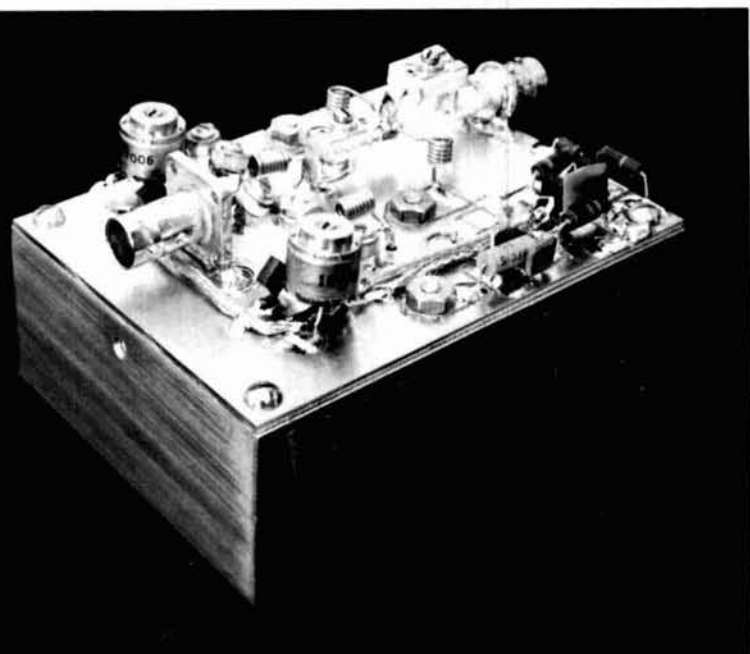
The VFO-820 is a solid state remote VFO designed exclusively for use with the Kenwood TS-820 Pacesetter. The VFO-820 has its own RIT circuit and control switch. It is fully compatible with the optional digital display in the TS-820. The perfect extra to any Pacesetter station.

CW-820

500Hz CW Crystal Filter

TV-502

The TV-502 transverter puts you on 2-meters the easy way. Simply plug it in to the TS-820 (or TS-520) and you're on the air. Operates in the 144.0-145.7 MHz frequency range with a 145.0-146.0 MHz option.



two-meter transverter using power fets

How does 10 watts
PEP output for
1 milliwatt input sound?
Here's a complete transverter
using a new power fet
that gets it all together

This article describes a two-meter transverter which, with approximately 1 milliwatt input, will produce a nominal 10-watt PEP output with all distortion products 28 dB down from one tone of a two equal-tone test signal. The receiving converter, which uses a conventional dual-gate mosfet rf amplifier, compares favorably with a commercial receiver of recent design. These units are designed for use with a 28-MHz transceiver (in my case the Kenwood Twins).

design considerations

I used a modular approach in the design of this transverter. Advantages of this approach are given in an excellent article by Joe Reisert.¹ One of the advantages of the modular approach becomes apparent during initial alignment, because three different output levels are readily available: from the mixer module, a nominal 100 milliwatts; from the first linear amplifier, a nominal 2 watts; and from the final linear amplifier a nominal 5 or 10 watts. The intermodulation specification for the two lower-level modules is a nominal 35 dB down. All modules are designed to work into a 50-ohm load. A block diagram is presented in fig. 1.

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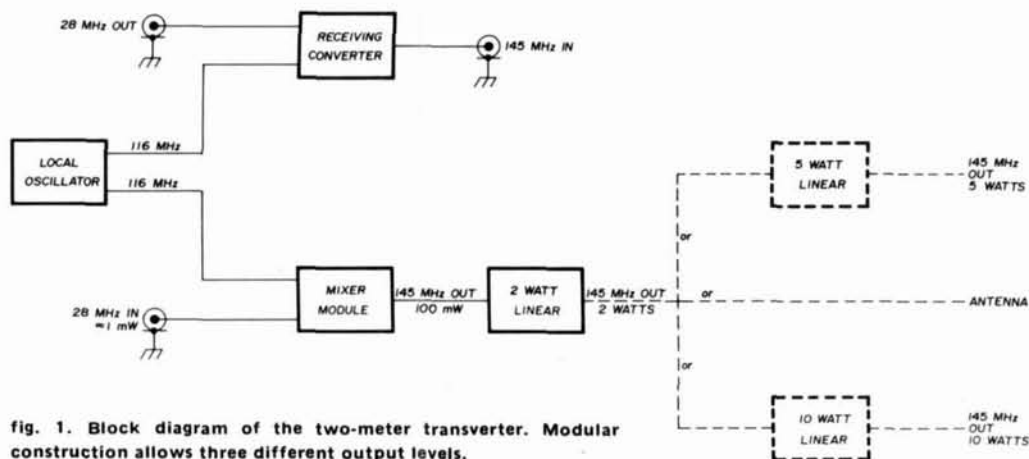


fig. 1. Block diagram of the two-meter transverter. Modular construction allows three different output levels.

Oscillator. This circuit (fig. 2) is described generally in reference 2. It is designed for use with a fifth-overtone 116-MHz crystal. In the past I've experienced difficulty with overtone oscillator circuits but this oscillator circuit is an exception. I've encountered no problems with spurious outputs or hard starting; and with the dual-gate buffer, the output of this module is relatively clean. The inductor in parallel with the crystal is necessary to prevent spurious oscillations. The oscillator module provides two mutually isolated 50-ohm outputs at 116 MHz. Nominal output level is 1 volt rms per output port. Using this approach and a little care, the transmitting converter can be used to tune the receiving converter provided you have a separate transmitter and receiver.

The oscillator output network is a lumped-constant equivalent of a Wilkinson *n*-way combiner, fig. 3. The constants for this circuit can be determined from the following equations.

$$C1 = \frac{1}{2\pi f_o R_o} \quad (1)$$

$$C2 = \frac{C1}{2} \quad (2)$$

$$L1 = L2 = \frac{R_o}{2\pi f_o} \quad (3)$$

$$R1 = 2R_o \quad (4)$$

where:

f_o = frequency (Hz)

$R_o = R_{gen} = R_{load}$ (ohms)

C = capacitance (F)

L = inductance (H)

For example, using $f_o = 116$ MHz and $R_o = 50$ ohms,

$$C1 = \frac{1}{(2\pi)(116 \times 10^6)(50)} = 27 \text{ pF}$$

$$C2 = 27/2 = 13.5 \text{ pF}$$

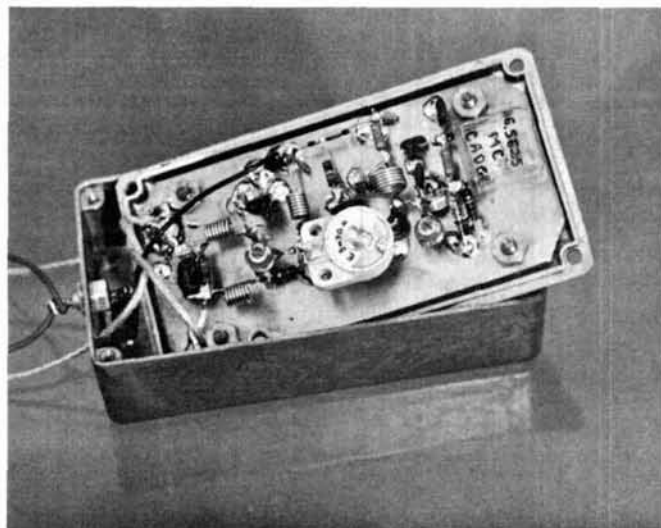
$$L1, L2 = \frac{50}{(2\pi)(116 \times 10^6)} = 69 \text{ nH}$$

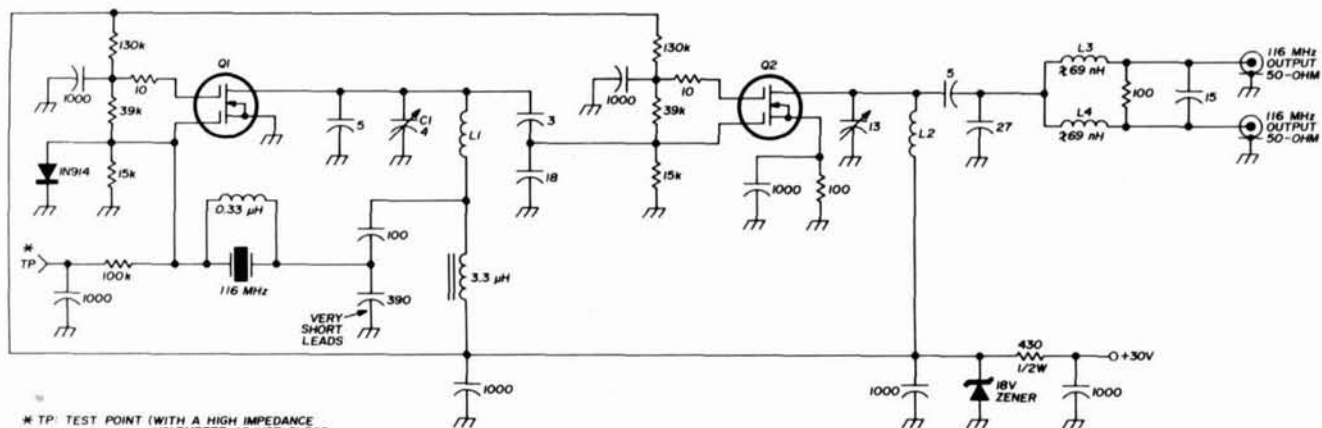
$$R1 = 2 \times 50 = 100 \text{ ohms}$$

Mixer. The mixer circuit (fig. 4) has many advantages over conventional doubly-balanced mixers including low component count, and no requirement for balanced transformers. The mixer portions provides approximately 1 dB conversion gain and has a nominal 50-ohm input impedance at both input ports. The 1k variable resistor is used to minimize the 116-MHz local oscillator signal at the mixer output. While minimizing the 116-MHz local-oscillator signal, the fifth harmonic of 28 MHz is also minimized.

The input signals are cancelled at the mixer output in a manner similar to that of a push-push doubler. The mixer output contains the beat signal plus even-order

Local-oscillator module. Point-to-point wiring is used, with component leads serving as tie points. The trimmer capacitor is adjusted for maximum negative voltage at test point 1 (see fig. 2).





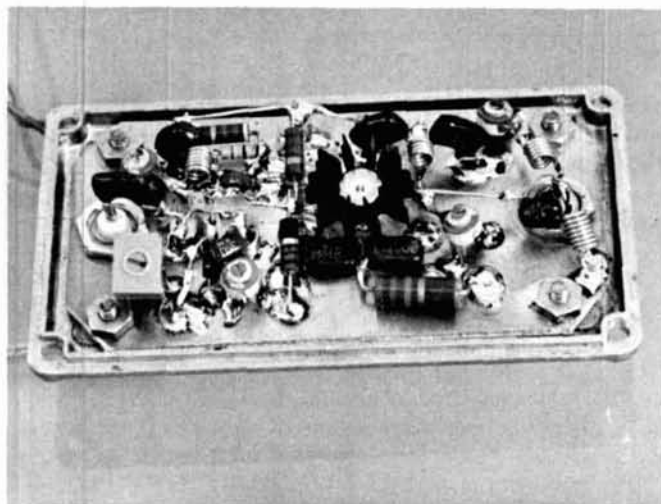
* TP: TEST POINT (WITH A HIGH IMPEDANCE VOLT-METER, ADJUST C1 FOR MAXIMUM NEGATIVE VOLTAGE)

fig. 2. Local-oscillator module provides two mutually independent outputs at 116 MHz. L1 is 5 turns, 1/4" (6.5mm) ID; L2 is 7 turns, 1/8" (3mm) ID; L3, L4 are 4 1/2 turns, 1/8" (3mm) ID. All are close wound using no. 20 AWG (0.8mm) enamelled copper wire. Q1, Q2 are Fairchild FT0601 or RCA 40673.

products of the input signals. The even-order products are attenuated by the output-network Q. The mixer circuit is very flexible. By removing the input matching networks and shunting the fet gates to ground with 10-k resistors, the choice of input frequencies can be changed easily. Only a small loss in conversion gain will be noted, and the input impedances will be something like 200 ohms. If you wish, you can design matching networks to make the input impedance look like 50 ohms again. For a more detailed treatment of this circuit, see reference 3.

The buffer transistor in this circuit draws 40 mA nominal current and dissipates approximately 0.8 watt. Because the transistor is not a high-power device, a clip-on heatsink should be used and some ventilation provided. The filter at the output of this stage is designed to attenuate the local oscillator second harmonic and could be eliminated if a bandpass filter is used at the antenna.

Mixer module. Input connector is at left, with balanced fet stage slightly to the right. The 2N3866 power stage is at the center, mounted in a clip-on heatsink. Output connector is at right.



Amplifiers. The linear amplifiers (figs. 5 and 6) provide three different output levels. One amplifier is designed to be driven directly from the mixer module. With 1 milliwatt input to the mixer module, this amplifier delivers a nominal 2 watts PEP output.

In this configuration, and with some slight changes in biasing networks; operation can be achieved with a

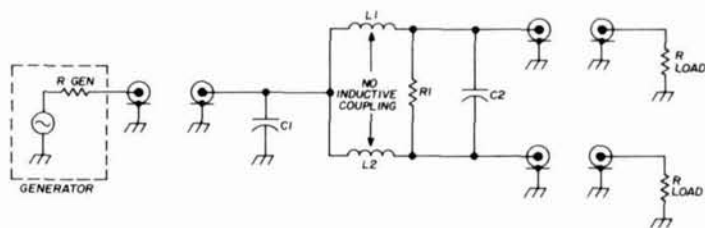


fig. 3. Wilkinson n-way divider or summer used in local-oscillator output as a lumped-constant equivalent circuit. Examples for determining values are given in the text.

24-volt power supply and only a slight decrease in output power. In both power fet circuits, bias resistors are adjusted to set the fet quiescent drain current to 150 mA. After the quiescent drain current has been set, the gate voltage can be measured, and the variable resistors can be replaced with fixed resistors.

The amplifier in fig. 5 will deliver a nominal 5 watts PEP output with a 30-volt supply. With two of these amplifiers in series, mixer drive must be reduced to keep the final amplifier in the linear region.

The amplifier in fig. 6 will deliver a nominal 10 watts PEP output and also requires a decrease in drive at the mixer. Tuning this amplifier is a bit more complicated and requires back-and-forth adjustments between the two input networks for maximum undistorted output. Both amplifiers have a nominal 12.5 dB of gain and are capable of more output than that specified; but in the interest of good operating techniques, output power should not exceed that which is specified.

fig. 4. Mixer module has a minimum of parts and uses no balanced transformers. All coils are 1/8 in. (3mm) ID close wound with no. 20 AWG (0.8mm) enamelled copper wire. L1 6 turns; L2, L3 4 turns; L4 4½ turns; L5 8 turns. Q1, Q2 are n-channel jfets (Siliconix J310); Q3 is a 2N3866 transistor.

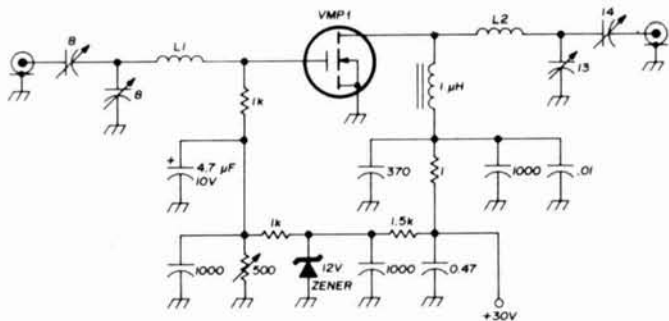
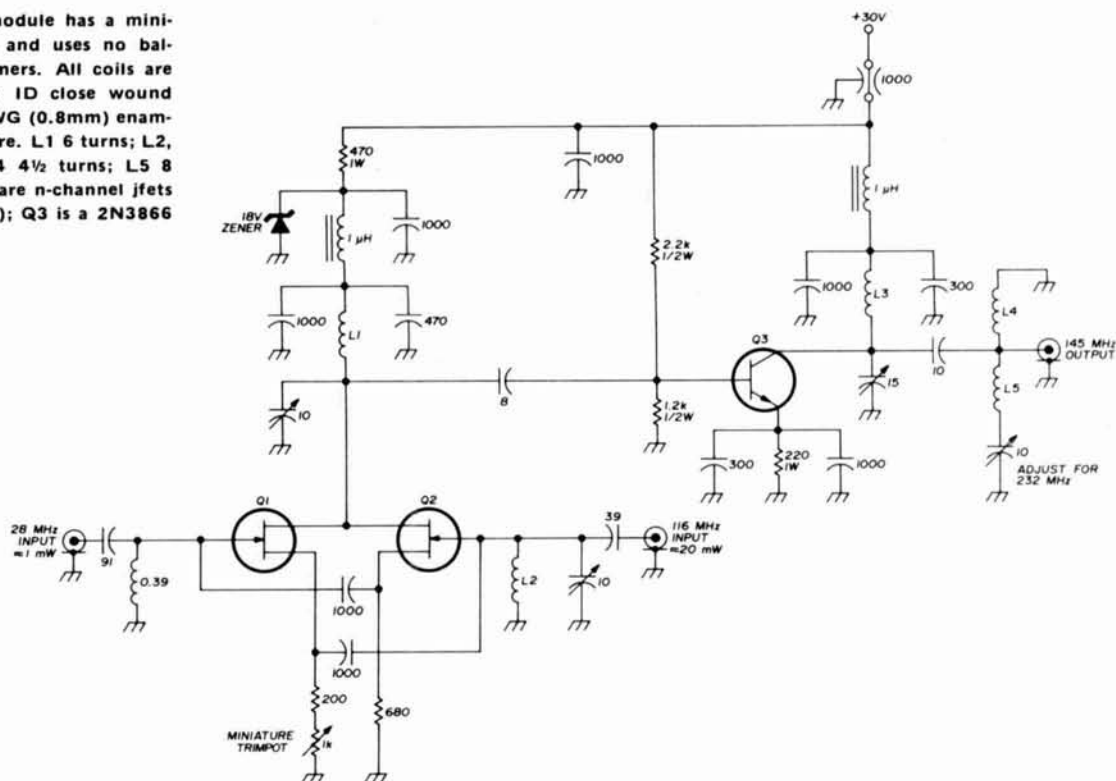


fig. 5. Two- or five-watt linear amplifier uses a Siliconix VMP1 fet. Although designed for switching service, this device works well as a linear rf amplifier. L1 is 8 turns 1/8" (3mm); L2 is 5 turns, (3mm) ID close-wound with no. 20 AWG (0.8mm) enamelled copper wire.

the power transistor

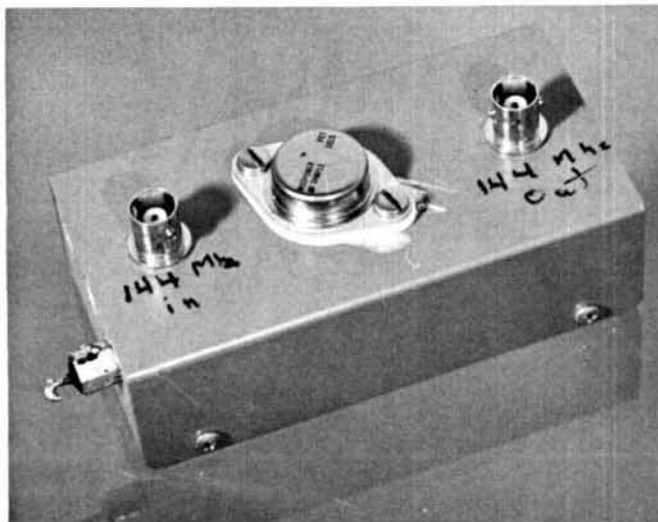
Recently Siliconix announced the availability of a high-current, high-speed switching transistor known as the VMP1 *Mospower* FET.* Although no rf specifications are available, the VMP1, designed to switch 1 ampere in 5 nanoseconds, works very well as a linear amplifier.

The VMP1 has some very desirable features compared with bipolar transistors in this application: a) no

thermal runaway, b) no secondary breakdown, and c) input and output impedances are relatively high.

As with all fets, gain decreases slightly with increased temperature. Thermal runaway is no problem with the VMP1 which outweighs the disadvantage of the slight gain decrease. All three amplifiers were run for one-half hour continuously at full rated output with less than 0.5 dB decrease in output power with input level held

Five-watt linear amplifier module using a Siliconix VMP1 Mospower fet. Construction of the two-watt linear amplifier is similar.



*For ordering information on the Siliconix VMP 1 Mospower Fet, write to Ed Oxner, Siliconix, Incorporated, 2201 Laurelwood Road, Santa Clara, California 95054.

constant. At the end of these tests, the fets were only warm to the touch.

After tuning and optimizing the matching networks, I disassembled them and measured the component values. With these values and the appropriate formulas, I determined that, for best performance at 7 watts PEP output, the source impedance is 12 ohms in series with an inductive 25 ohms and remains relatively constant for

tor without introducing too much additional capacitance. In this case, I used a beryllium-oxide heatsink insulator 0.062 inch (1.6mm) thick. In this configuration, the fet shunt output capacitance was calculated at approximately 20 pF, and that of the heatsink insulator 26 pF, for a total shunt capacitance of 46 pF. At 145 MHz this presents no problem. The VMP1 can be used with circuit Q_s as low as 2 using the above technique.

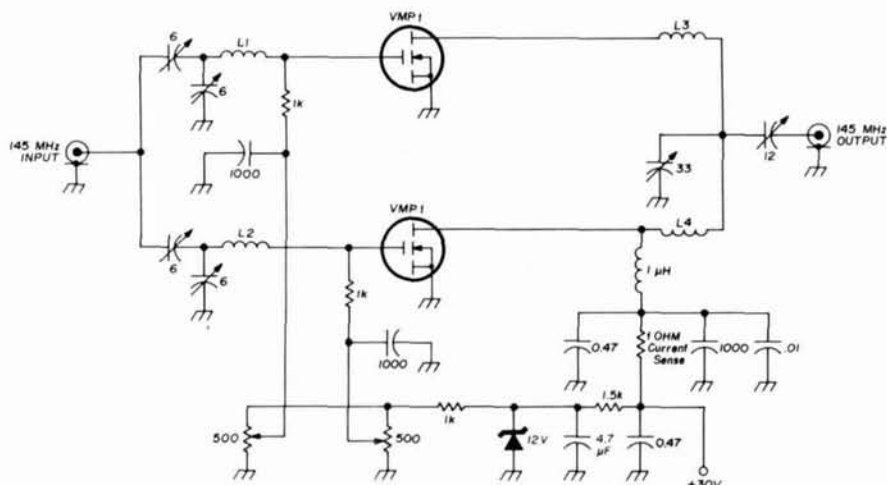
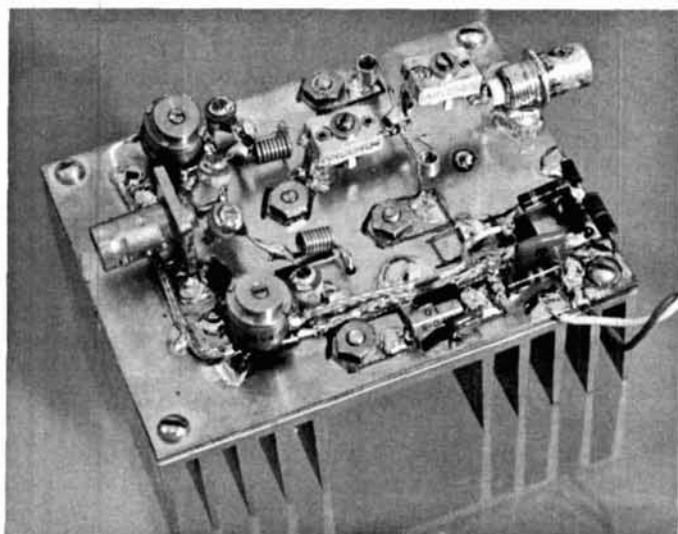


fig. 6. Ten-watt linear amplifier uses two Siliconix VMP1 for a nominal 10 watts PEP output. These amplifiers have excellent stability and minimal gain decrease with increased temperature. L1, L2 are 8 turns; L3, L4 are 5 turns, all 1/8" (3mm) ID closewound with no. 20 AWG (0.8mm) enamelled copper wire.

smaller drive levels. The load impedance for the same conditions is 12 ohms in series with 14 ohms inductive reactance.

Note that the largest contribution to output capacitance is the result of mounting the fet. Because the drain of this fet is connected to the transistor case, it's necessary to develop some means to heatsink the transis-

Ten-watt linear amplifier module uses two Siliconix VMP1 Mos-power fets on a finned heatsink. In this photograph the input is at left, output at right. Bias adjust pots are at left.



The two higher power output stages have efficiencies of 30 to 40 percent and require adequate heatsinks. For the 10-watt unit, I used a 4 x 3 x 1-1/2 inch (10x7.6x4cm) fin-style heatsink with a beryllium-oxide heatsink insulator 0.062 inch (1.6mm) thick. If you don't use this style heatsink insulator, you must change the matching networks to compensate. I strongly recommend this style of insulator. For the 2-watt unit I used the recommended heatsink insulator but used the module chassis for the heatsink. (Care must be used when working with beryllium-oxide insulators. Pulverized particles are poisonous if breathed).

receiver

The receiving converter (fig. 7) has a lightly coupled interstage bandpass filter and is rather narrowband. For full coverage of the 2-meter band, the inductors in the interstage bandpass filter should be tightly coupled. This receiving converter will oscillate unless terminated properly at the input, which means that either the voltage to the dual-gate mosfet must be removed while transmitting, or the receiving converter input must be terminated while transmitting.

construction hints

As with any vhf project, lead lengths should be as short as possible. Circuit layout is important; if you use the schematics and photos as guides for component placement, you shouldn't have any difficulties. The values for variable capacitors are nominal. That is, these

values must be within the range of the capacitors. This allows some flexibility during parts procurement. I recommend high-quality capacitors in the linear amplifier output networks.

Initial adjustments should be made with reduced input drive. Then the input drive should be increased slowly until final adjustments can be made. In any case,

should show a slight dip when the output shunt capacitor is tuned to resonance.

Any of these configurations will allow full coverage of the 2-meter band. The output in the 10-watt configuration was measured on a Hewlett-Packard spectrum analyzer. Three frequencies were visible on the display. The local oscillator output was 35 dB down from the

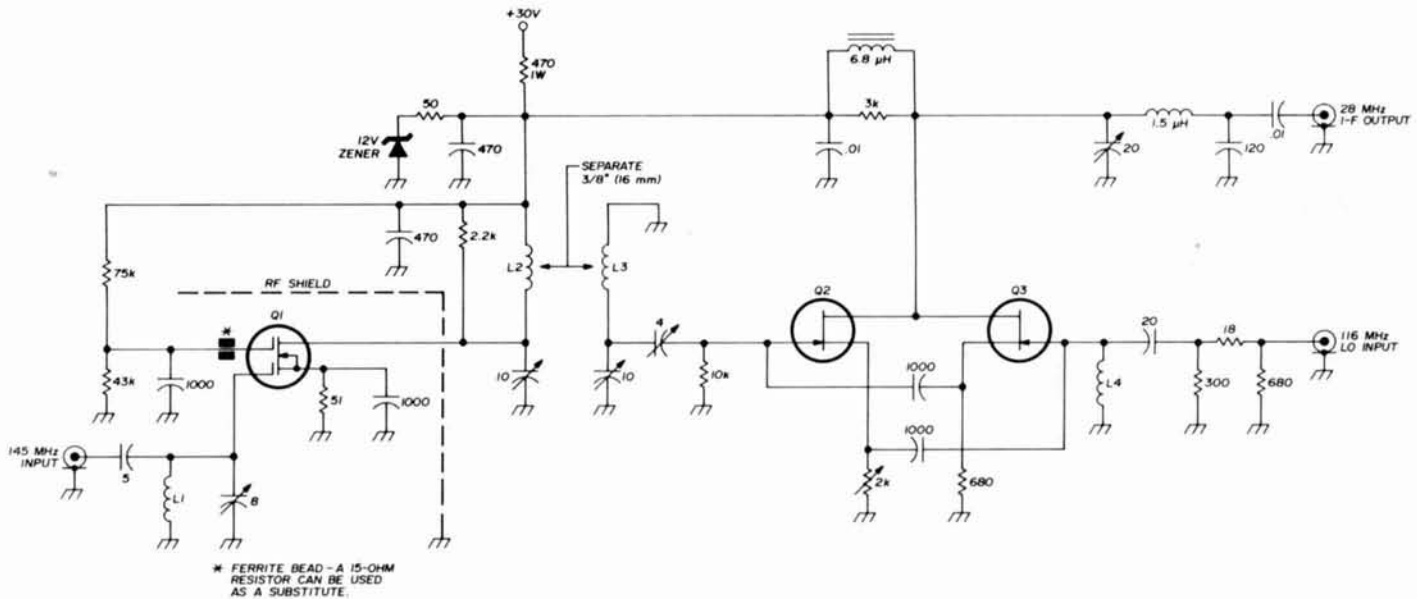
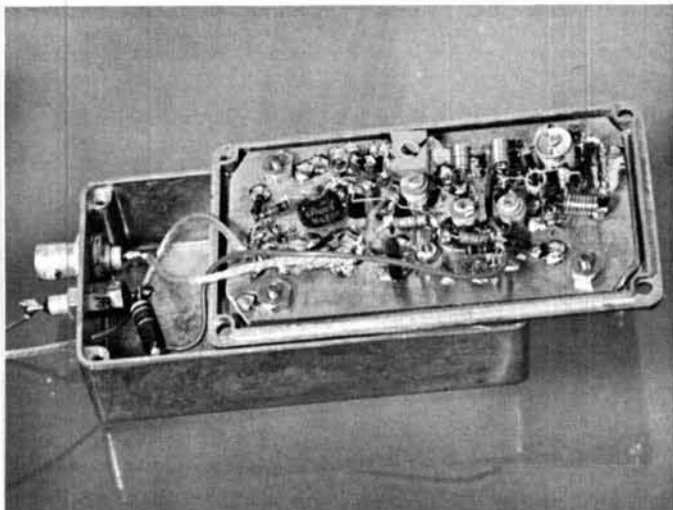


fig. 7. Receiving converter is relatively narrowband. For full coverage of the two-meter band, L2 and L3 should be tightly coupled. L1, L4 are 6 turns; L2, L3 are 8 turns. All are 1/8" (3mm) ID close-wound with no. 20 AWG (0.8mm) enamelled copper wire. Q1 is a Fairchild FT0601 or RCA 40673; Q2, Q3 are n-channel jfets (Siliconix E300, J310, or 2N5485, 2N5486).

with one exception, all variable capacitors are tuned for maximum output. If you have the proper test equipment, the two output capacitors can be adjusted for maximum undistorted output rather than maximum power output. In both procedures, the drain current

Receiving converter module uses point-to-point wiring and is mounted in small Pomona cast-aluminum chassis.



145-MHz output, and the second-harmonic was 45 dB down. I didn't have the opportunity at this time to balance the mixer, so it's conceivable the local oscillator could have been adjusted so that it was greater than 35 dB down. An appropriate antenna bandpass filter should significantly improve these figures.

Although I wouldn't recommend this project to a beginning vhf enthusiast, I can say I've had few problems with the project. I've built two complete transverters of the 2-watt variety, one 5-watt linear, and two 10-watt linears with the same good results. Both transverters are on the air and work very nicely.

In conclusion, I'd like to thank WA6COB and WA6VAB for their help on this project. Special thanks go to Ed Oxner of Siliconix, and Will Alexander, WA6RDZ, for their enthusiasm and technical support and to WA6RNC for the photography.

references

1. Joe Reiser, W1JAA, "VHF/UHF Techniques," *ham radio*, March, 1976, page 44.
2. George D. Hanchett, "Insulated-Gate Field-Effect Transistors in Oscillator Circuits," RCA Electronic Components and Devices, Somerville, New Jersey.
3. Harold T. McAleer, "Mixer Circuit Has Clean Output," General Radio Company, Engineering Department (reprinted from *Electronic Industries* October, 1960).

ham radio



digital frequency display for amateur communications equipment

Although designed for
Heath SB-series equipment
this compact
frequency display
is easily adapted
to most amateur gear

During the past few years a number of frequency displays have been offered by manufacturers or described in the amateur literature.¹⁻³ I found that most had some undesirable feature: cost, complexity, or difficulty in setup and adjustment. The design I finally arrived at satisfied my needs and hopefully it will be useful to others.

Although this display was designed for the Heath SB series, it will work well with nearly any receiver, transmitter, or transceiver. Construction cost should be less than \$50 even if you have a barren TTL junkbox. No exotic parts are required, so it should be no problem obtaining everything required from the popular parts distributors.

theory of operation

Let's begin by looking at a typical amateur transceiver, such as the Heathkit SB101, to see what's required to make a digital frequency display. Fig. 1 shows a simplified block diagram of the SB101 in receive mode. As you can see, there are four signals to consider in computing the received signal frequency: the first heterodyne oscillator, the vfo, the carrier/product oscillator, and the audio output frequency. There are at least

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three different ways of combining these signals to yield the correct frequency, and I've seen all of them used in the past.

The first method is to build a mixer to combine all the signals and come up with an rf signal to count. However, unless you go to great pains to shield everything, it's likely your frequency readout system will sneak enough signal back into the receiver to cause havoc.

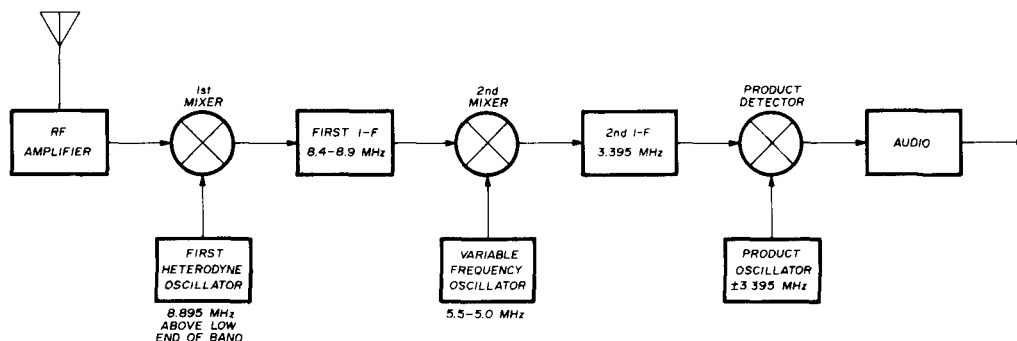


fig. 1. Simplified block diagram of the Heath SB101 in the receive mode showing signal sources that can be used for a frequency display. The vfo frequency is used as the variable to implement the frequency counter in the design described here.

The second approach is to combine the four signals digitally by using an up/down counter. The counter adds by counting upward and subtracts by counting downward. For any particular mixing scheme in a rig, this method is workable, but the counter must be reprogrammed for a different rig using a different combination of oscillator signals.

Finally, the third approach takes advantage of the fact that two of the four signals are crystal-oscillator signals and are fairly stable. These are the first heterodyne and carrier/product oscillators. The third signal is the audio output and, in most cases, can also be considered to be constant. This leaves only one variable -- the vfo.

Realizing this, all you need do now is determine the vfo frequency at some given frequency and later determine the offset from the original vfo frequency. For example, if you measure the vfo at 4995 kHz when the receiver is tuned to 14.000 MHz, and then measure 5003 kHz when tuning an unknown frequency, you know the unknown frequency is $14.000 + (5.003 - 4.995)$ or 14.008 MHz. Remember that in the Heath SB series the vfo is tuned backward up the band (because the second i-f is the difference between the vfo and the first i-f).

implementing the theory

The next problem to solve is, how do you accomplish the subtraction of frequencies? Also, how do you determine and store the vfo frequency at the band edge? It

proper choice of the digital counter. The 74192 programmable up/down BCD counter is a handy device to use in this and many other applications. This device has been described in other articles so I'll briefly outline its operation.

Frequency subtraction. As shown in fig. 2, this counter has *up/down* inputs and *carry/borrow* outputs. When a pulse appears on the *up* input, the counter advances to

turns out that both problems can be easily solved by the the next higher state (i.e., from state 7 to 8). Likewise, for the *down* input, the counter goes to the next-lower state. When the counter is in state 9 and an *up* signal comes along, the counter goes to state zero and signals the next stage, through the carry line, to advance. Corresponding events occur when the counter is in state zero and receives a *down* signal.

Two other useful inputs are *clear* and *load*. Independen-

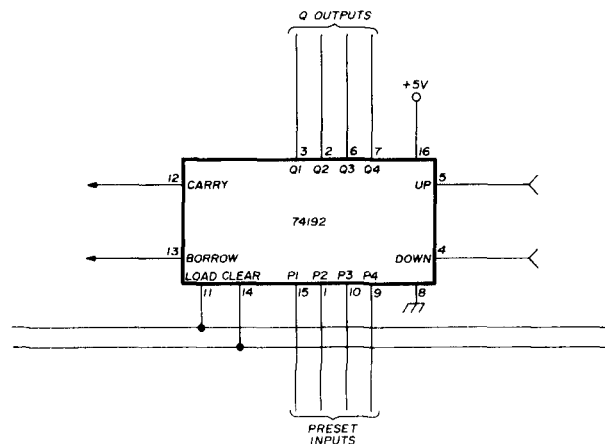


fig. 2. Heart of the frequency display is the 74192 programmable up/down BCD counter. UP/DOWN and CARRY/BORROW inputs and outputs are used to subtract frequencies and store the vfo frequency at the band edge in the counter display.

dently of whatever else the counter may be doing, when a pulse appears on the *clear* input, the 74192 goes to state zero. Also independent of other inputs, when a load signal is received the data present on the *preset* inputs are loaded as the new state of the counter. For example, if the 74192 were in state 7 and a load pulse

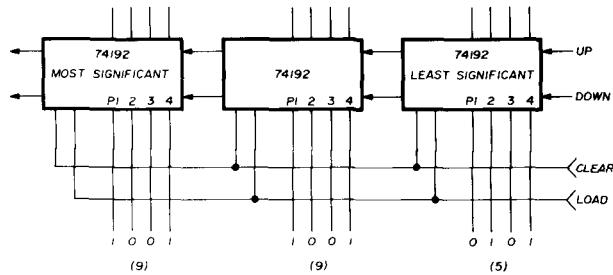


fig. 3. Three 74192s in cascade form a counter that will count to 999.

occurred, and if the *preset* inputs were 0101 (5 in decimal), the counter would go immediately to state 5.

There are certain restrictions in the use of this counter, but they are logical. Telling the counter to simultaneously count up and down is ambiguous; likewise, telling the counter to load a *preset* and *clear* at the same time does not make sense.

Now, how is this device useful? Suppose you had three 74192s cascaded to form a counter that will count to 999, as shown in fig. 3. Assume you initially loaded the counter with 995. Now you gate the vfo into the counter through the *down* input for 1 ms. Initially you are at 14.0 MHz so the vfo is at 4995 kHz. In 1 ms, 4995 pulses get through to the counter. Well, 995 (the initial state) minus 4995 (the number of *down* pulses) equals -4000. What state is the counter in at the end of the counting interval? Is it -4000? Not really, because the counter only remembers the three least-significant digits. The -4 showed up as four borrow pulses from the last stage. Therefore, you are tuned to 14.000 MHz and the counter displays 000. When you tune to 14.008 MHz, the vfo will be oscillating at 5003 kHz, and a 1-ms gating signal will admit 5003 pulses. The final state of the counter is now $995 - 5003 = -4008$. Again, only the three least-significant digits are seen and you see 008, corresponding to 14.008 MHz. It's easy to see that a four-digit counter and a 10-ms gate would display to the nearest 0.1 kHz.

Calibrate sequence. It looks like the first question is now answered: to subtract frequencies you just load the counter with the *preset* for the band edge and count down. But now for the second problem. How do you determine the frequency at the band edge and save it for future presets? This question can be answered in terms of what you already have — a device that will start at zero or any preset number and count up or down from there. Normally you start at some *preset* and count

down. What if you started at zero and counted up to some final state? If you then saved that final state for your new *preset*, everything would be solved. You would start at zero, count up to a final state, then count back to zero. This "calibrate" sequence could be initiated by pushing a button to activate the proper control logic. The vfo would be initially set to the low edge of the band (while tuning in the rig's 100-kHz calibrator), and the counter would display all zeros. As the vfo is tuned away from the band edge, the counter will read the operating frequency accurately.

Let's look at a diagram of one decade of the counter circuit required. Fig. 4 illustrates what is needed. For those who can understand a timing diagram better than my word description, see fig. 5, which also shows the control signals the counter requires.

In fig. 6, I've put the whole counter together in a block diagram. The set pushbutton initiates the calibrate sequence described above. Finally, fig. 7 shows what is required for control and timing logic. As described under

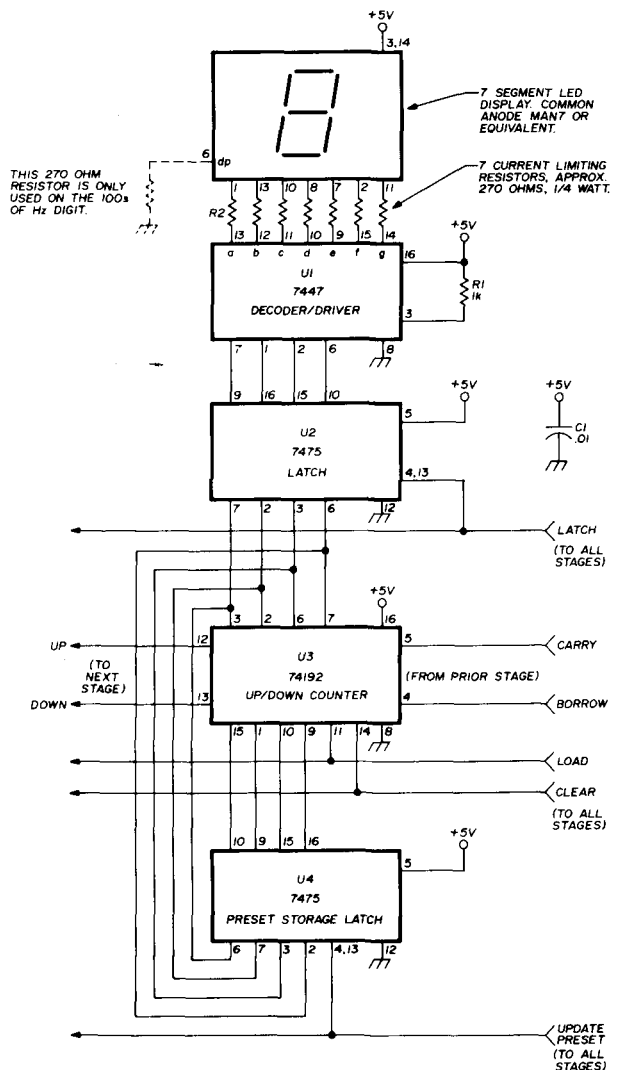


fig. 4. One decade of the counter used in the frequency display.

construction and adjustment, this board contains the only variable element: the crystal oscillator. As shown in **fig. 7**, two options are available for this oscillator. Initially I used a simple and reliable CMOS oscillator circuit. The circuit is, however, difficult to trim (I had to open up the crystal can to do so!). If you decide to use

that doesn't tune backward, simply reverse the *up/down* lines that come out of the control board to the first decade.

construction

I chose to put all control logic including the time-base

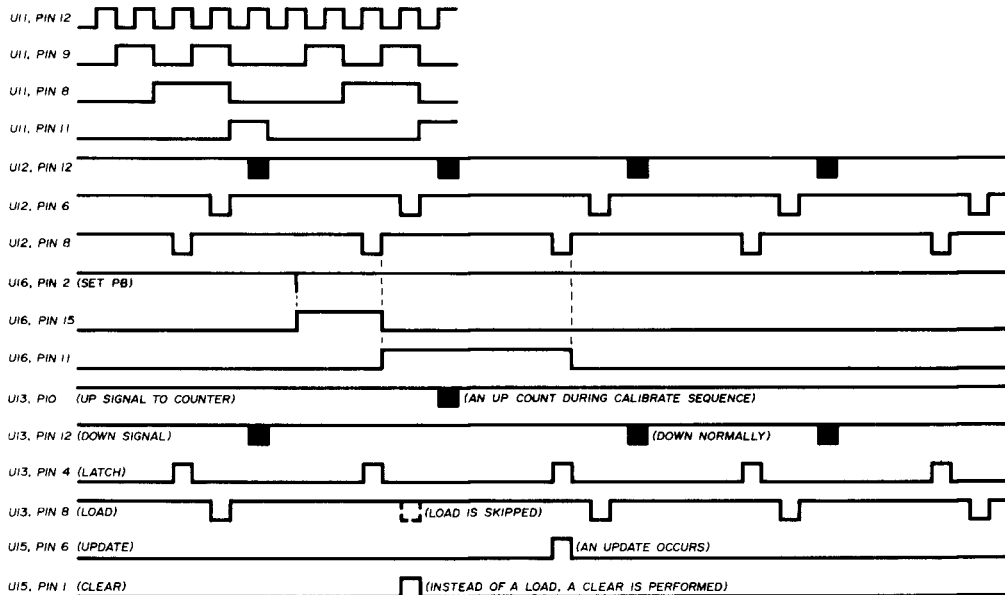


fig. 5. Timing diagram of the digital-frequency display including control signals.

the alternative oscillator shown on page 21, it will have to be external to the control board but will be much easier to adjust.

As described, the frequency display will operate with nearly any rig in which the vfo tunes backward and will indicate frequency within 10 Hz. If your rig uses a vfo

oscillator and count-down circuitry on one board. Each decade of the counter occupies its own board. This method seemed to give the most compact layout when using printed-circuit boards. It also made it five times easier to design the counter board(s)! **Fig. 8** gives the foil pattern used for the control board, and **fig. 9** shows

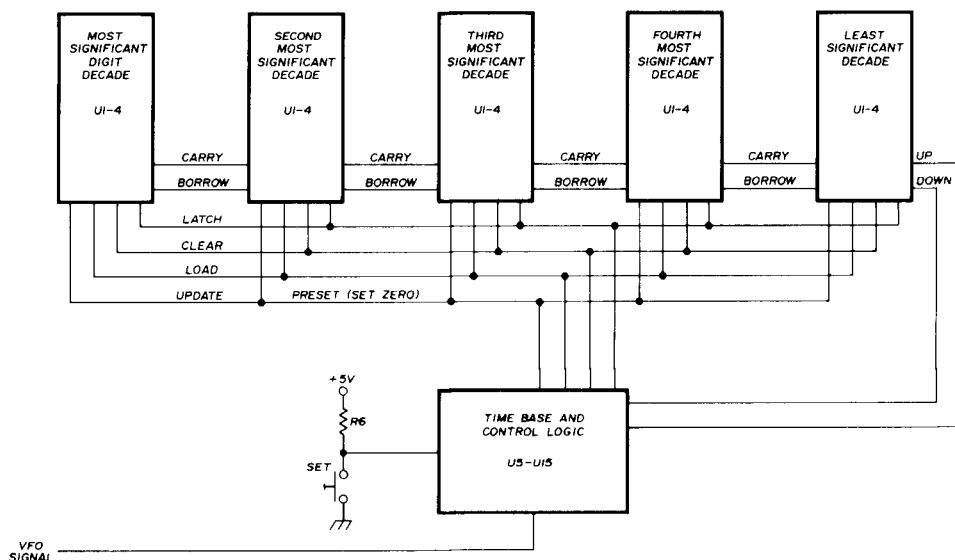


fig. 6. Block diagram of the frequency-display counter showing counter decades and time base and control-logic relationships.

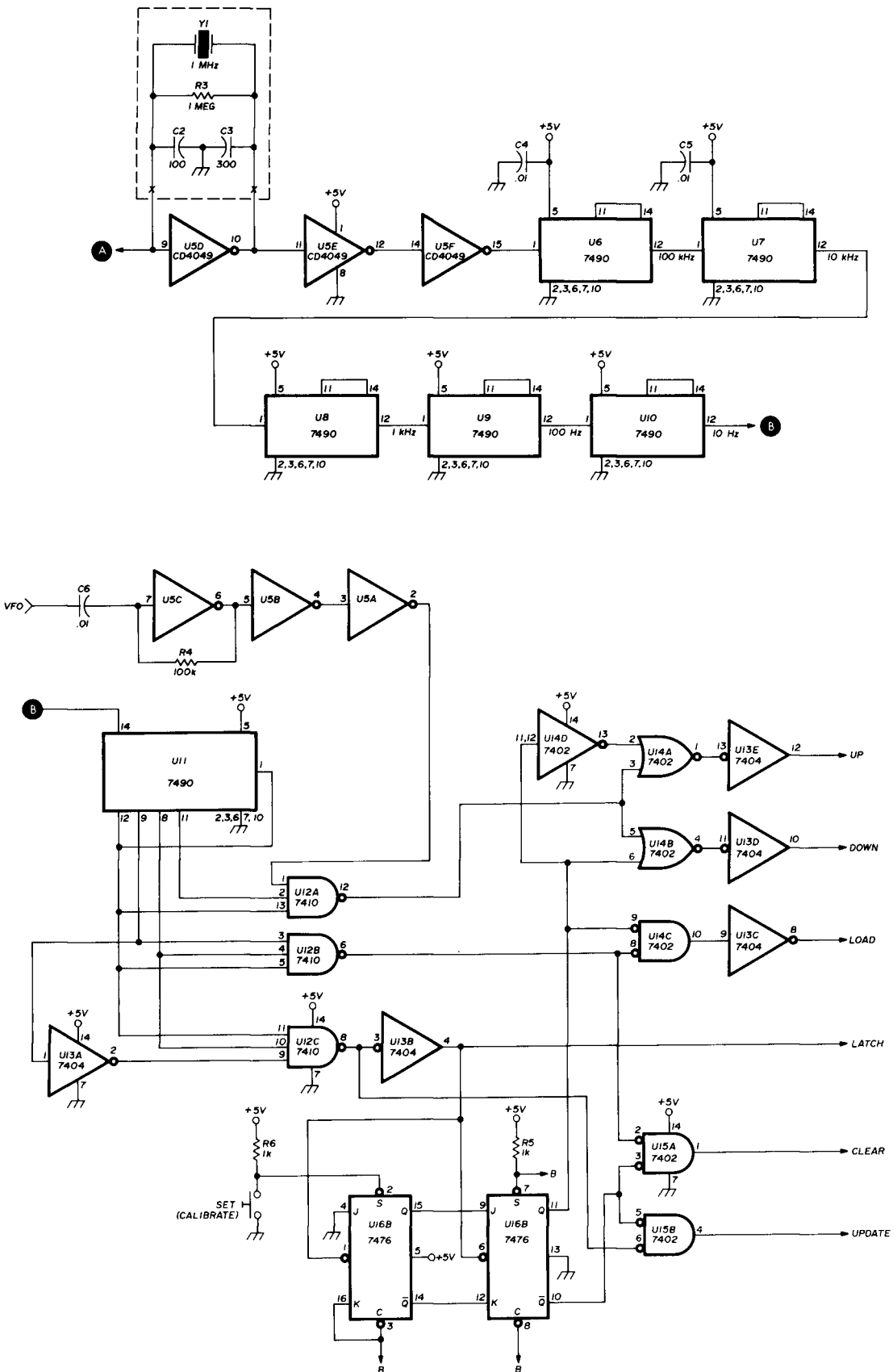
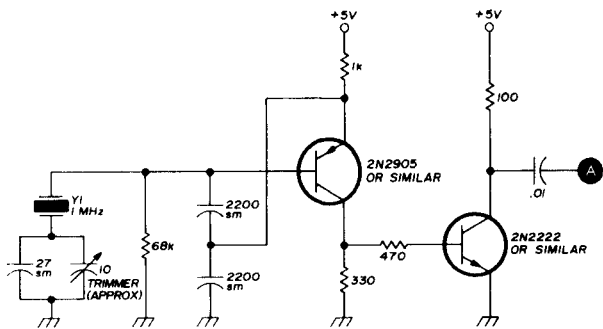


fig. 7. Control and timing logic. An alternative time-base oscillator, shown on the opposite page, must be external to the control board but is much easier to adjust than the circuit shown for U5.



ALTERNATIVE TIME-BASE OSCILLATOR

the part and jumper layout. To avoid the use of jumpers on the five decade boards, I used a double-sided board, illustrated in fig. 10, with component layout in fig. 11. Note that if you wish to avoid double-sided boards, the component side of this board is really just a number of jumpers and could be eliminated. I have tried to show my chassis layout in the photographs, but realize that almost *nothing* is critical about the layout.

George Oliva, WA2UOA, used an approach that may interest some people trying to duplicate this circuit. He used two separate chassis, one for all logic — hidden away under the rig and a tiny LMB chassis for the

you have or feel like buying some 74LS low-power Schottky logic (especially for the 74192s) the load on the supply will be eased considerably.

I decided to save my 74LS192s for a project requiring more speed and now live with a rather warm three-terminal regulator.⁴ I chose to power all five decade boards from one 7805 regulator in a TO3 case mounted on the rear panel and to power the control board with its own 78M05 mounted on the board in a TO5 case. In both cases, unregulated dc was 11 volts dropped to 7 volts through a series resistor (R7 and R8 in fig. 12) to prevent the regulators from overheating because of a 6-volt internal drop. Make sure any three-terminal regulator you use is well decoupled on both the input and output. At least 0.1 μ F is required to prevent oscillation under load or at higher temperatures.

If you'd like to stay with a single regulator, it will be necessary to use an external series pass transistor to handle the current. All these ideas are shown in fig. 12.

installation

I hope I haven't given the impression that this digital-frequency display works only on receive — it was just easier to describe that way. For the Heath SB101 and most other sideband transceivers, the first heterodyne oscillator and the carrier/product oscillator are common

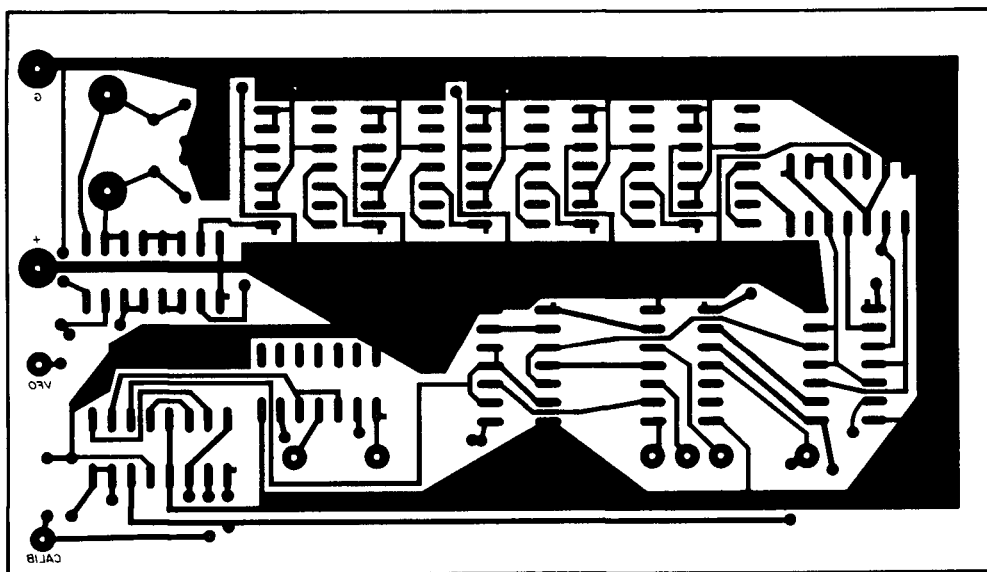


fig. 8. Foil side of the control board.

displays and *set* pushbutton, both sitting on top of the rig.

power supply

Since all circuitry is TTL (or CMOS running at TTL levels) the logic needs a fairly well regulated 5-volt supply. Current consumption, if you use standard 7400-series TTL, will be about 1.5 amperes, with each board (control and decade) drawing 220 to 230 mA. If

to receive and transmit. With my SB101, I can read transmit and receive frequencies with an inboard or outboard vfo without any switching. This is the installation I describe, but any other should become obvious.

On receive, the vfo injection circuit looks like that in fig. 13. The point labelled A on one side of R221 is the best place to pick off the receive vfo signal, whether an internal or external vfo is used. On transmit, the circuit is as shown in fig. 14. The point labelled B on one side

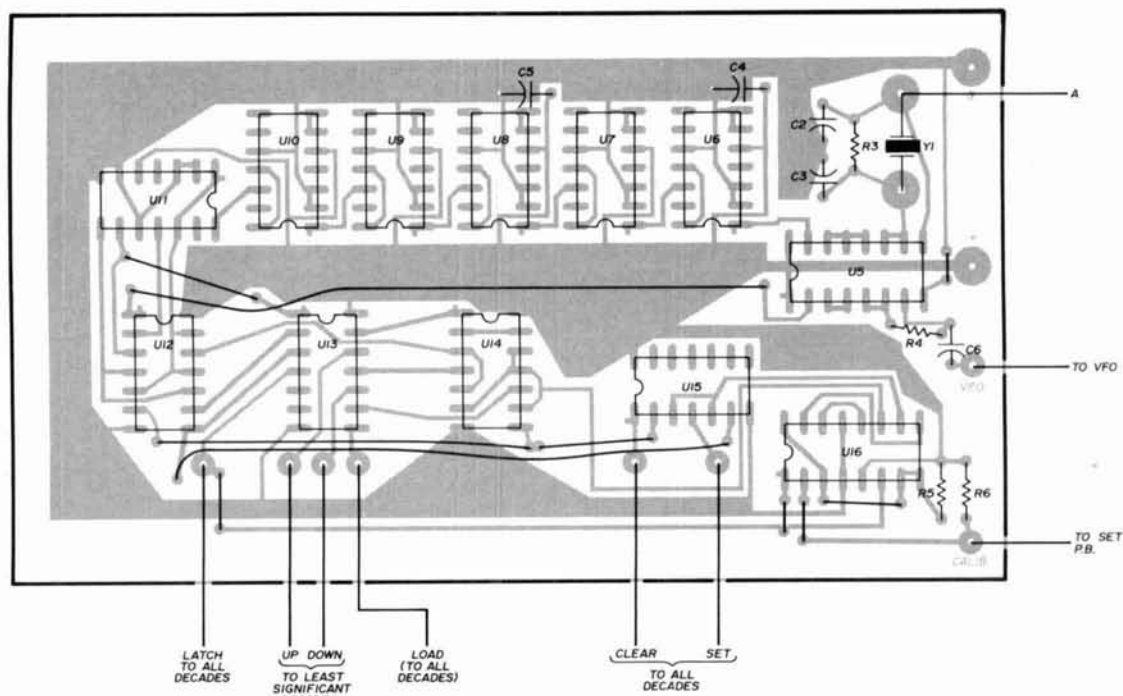


fig. 9. Component location and jumper layout for control board.

of R927 is the best place to take off the transmit vfo signal, also independent of the control mode.

To combine these two signals, I used the simple circuit of fig. 15. If you've built your own external vfo, or are using a different rig, make sure that power is

applied only to one vfo at a time when in the transmit mode, or you may find yourself operating on two frequencies at the same time!

The CMOS circuit used for buffering the vfo signal should be adequate for most rigs. Mine has worked

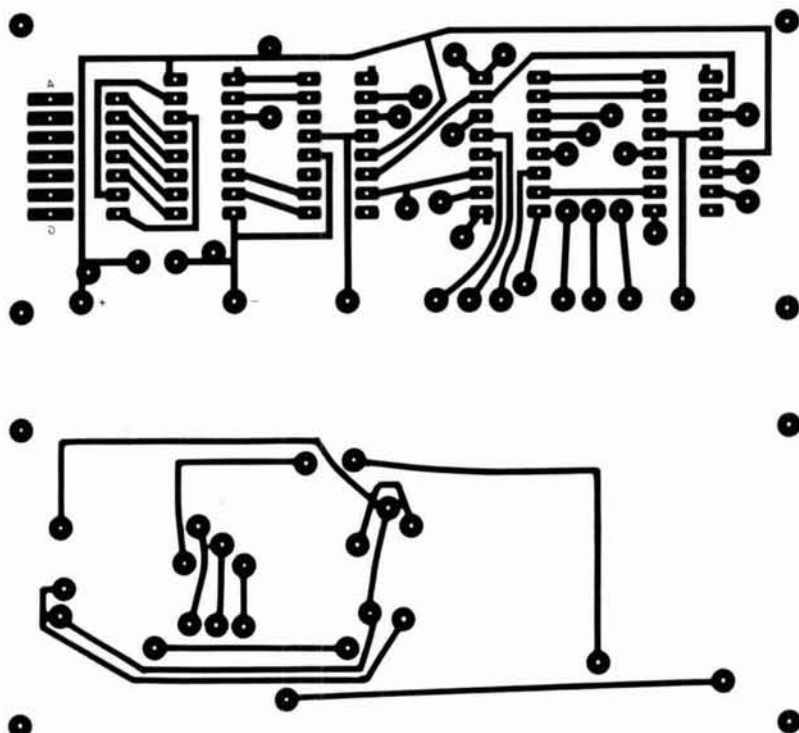
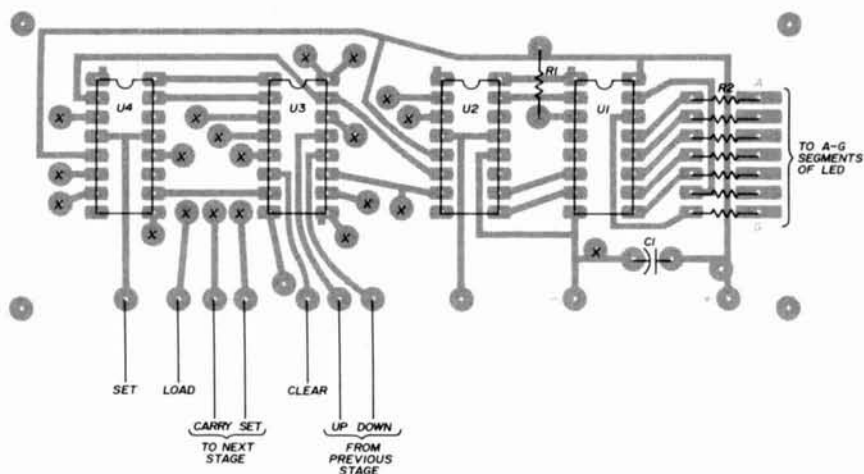


fig. 10. Double-sided board for the decade counter. Foil side is above, component side is below.

fig. 11. Part and solder plug locations for the decade counter board. Symbol X denotes location for connection between foil and component sides of the board. Traces on component side are not shown (see fig. 10); these circuit traces could be eliminated if desired (see text).



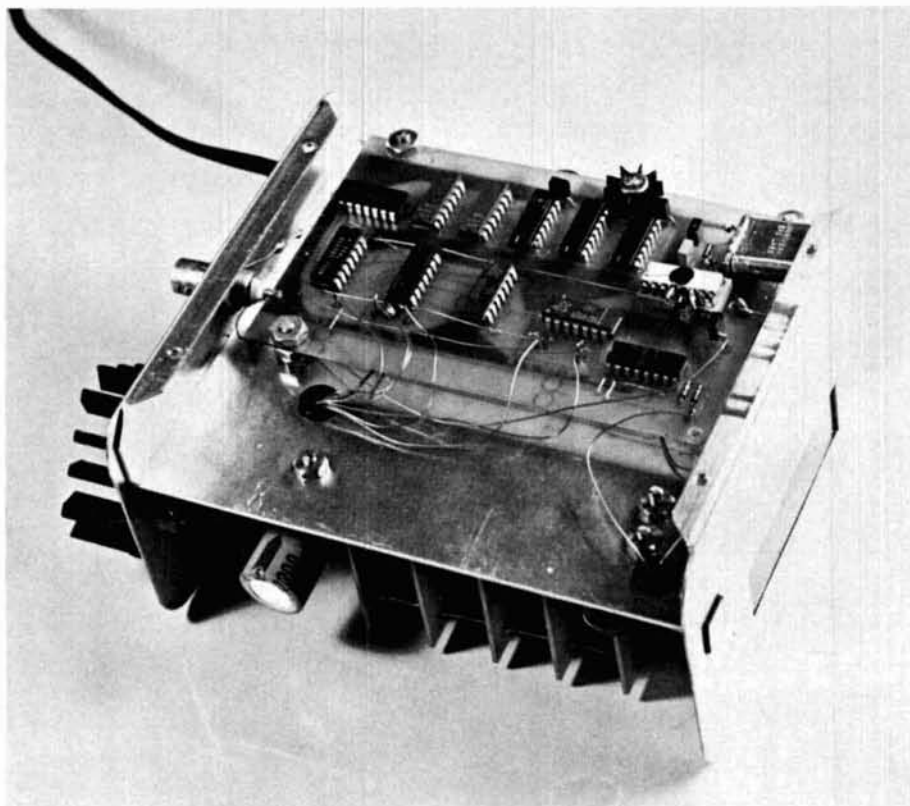
reliably with signal levels of 500 mV at 5 MHz and was good to 50 mV with the breadboard.

The only adjustment is in the crystal oscillator used for the frequency standard. To guarantee accuracy over the entire 500-kHz tuning range of the Heath SB series, when calibrated at one end, the 1-MHz oscillator must be within 5 Hz, which should be easy to ensure. For Collins equipment with a 200-kHz tuning range, the oscillator need be within 12 Hz.

As mentioned above, if you use the onboard crystal oscillator, it will be necessary to open up the crystal (preferably in a HC6/U holder) and make pencil marks

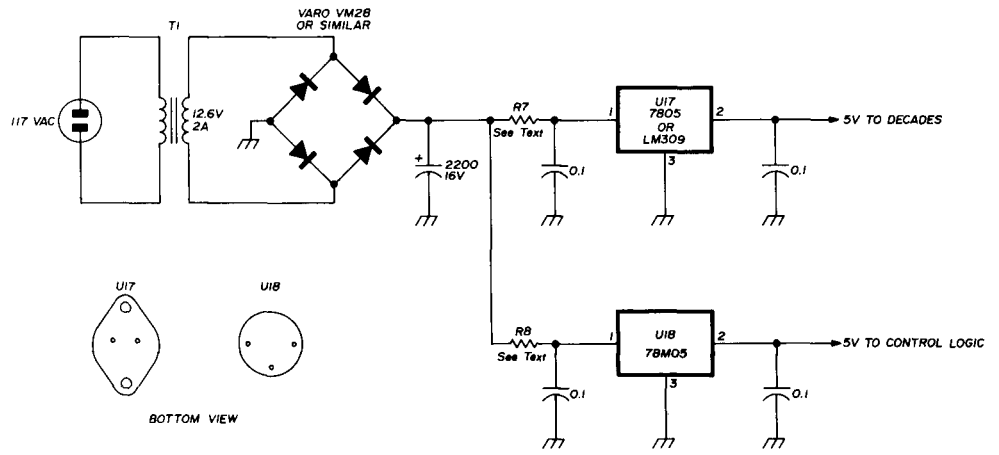
on the center of the crystal to lower its frequency. Do this while listening to WWV for a zero beat or while measuring with a frequency counter. An alternative method would be to zero beat an a-m broadcast station, although the frequency tolerance of these stations is rather poor for this purpose. To zero beat an a-m station, use the 10-kHz output of the 7490 divider. Whatever method of frequency measuring you use, you'll probably find it much easier if you have built the external 1-MHz oscillator that can be trimmed with a capacitor.

The use of this counter should be evident from the

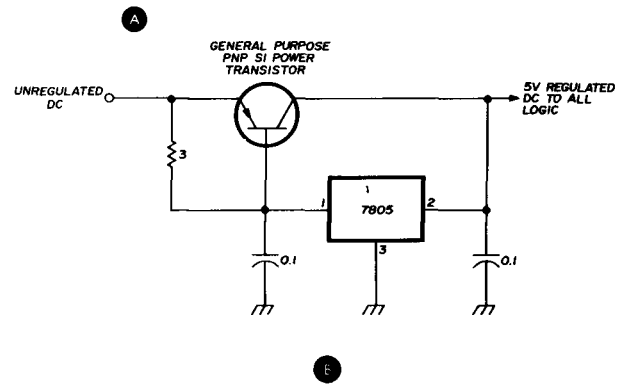


Bottom view of the digital frequency display showing control logic and time-base circuits.

fig. 12. Power-supply suggestions for the frequency display. A separate 5-volt supply is shown in A; B shows a single supply using a series pass transistor to handle the current.



description of its theory of operation, but there are a few things I'd like to point out. First, when tuning CW, remember that the transmitter operates with 1-kHz offset in the carrier oscillator. Therefore, if you want to display both transmit and receive frequencies accurately, it will be necessary to tune in the calibrator with the same offset. Hopefully, this offset will be the point where the CW filter peaks up. For single-sideband operation, it will be necessary to zero beat the calibrator. Remember that the vfo and carrier generator are different for upper and lower sideband; you'll have to recalibrate when switching between them. This shouldn't cause too much inconvenience, since USB and LSB usually are not mixed within any given band. Finally, remember that it will be necessary to recalibrate when switching bands, since you are changing the first heterodyne oscillator crystals. On the same band, when opera-



convenient and more versatile. First is changing from 10-Hz to 100-Hz readout. You may not feel that 10-Hz accuracy is needed in your station. This is actually the easiest change of all: just leave out the least-significant digit decade module and bypass one of the 7490s in the

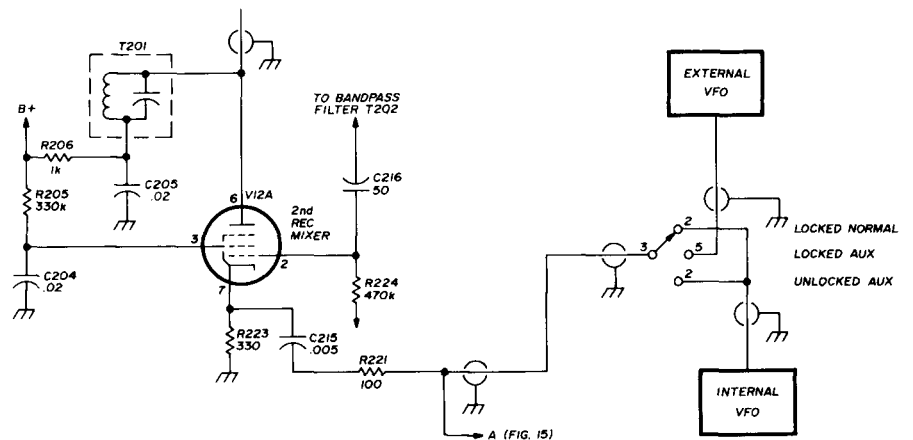


fig. 13. The Heath SB101 second receive mixer circuit showing where to obtain the receiver vfo signal.

ting in the same mode, recalibration normally will not be required.

possible modifications

Let me point out a few simple changes you might consider to make your digital frequency display more

time base divider. The display will then be updated 10 times faster (10 times per second) and some savings will be realized (about \$7 in construction cost and about 200 mA of current consumption). By the way, this change will also relax the requirements for time base accuracy; 1 MHz \pm 50 Hz will be sufficient.

The next possibility is the installation of a double-pole, double-throw switch in the *up/down* signal lines from the control board to the first decade. If this switch is rigged to reverse these lines, you can operate the display with forward and backward tuning vfos.

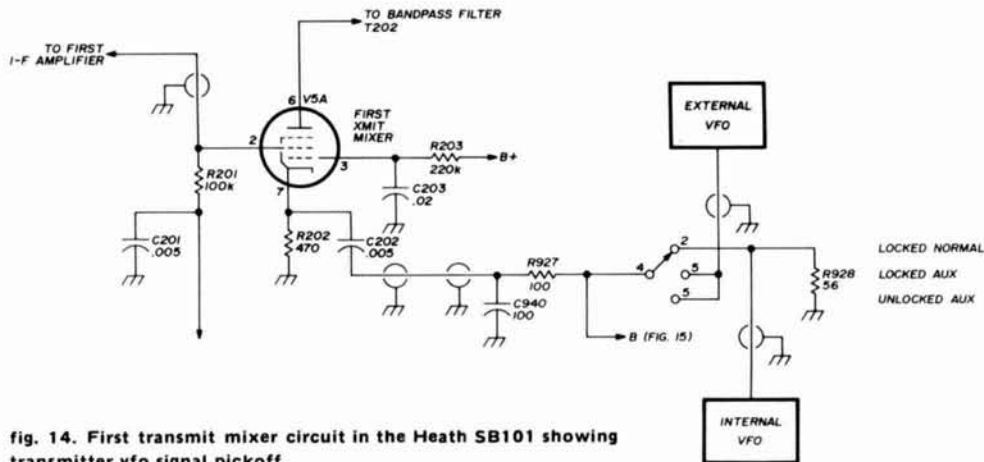
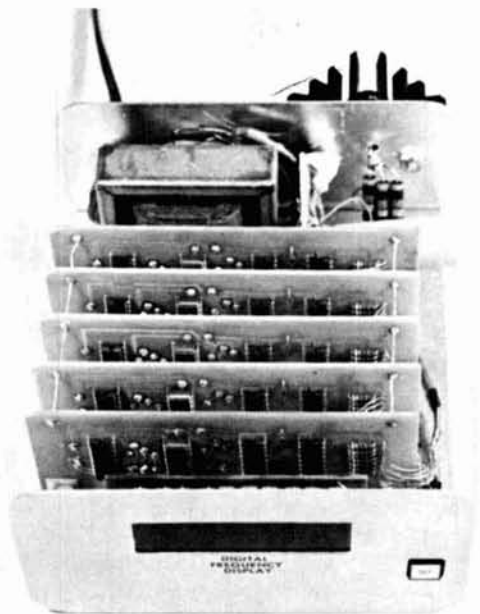


fig. 14. First transmit mixer circuit in the Heath SB101 showing transmitter vfo signal pickoff.

Finally, if you have installed the forward/backward switch, you now have a new piece of test equipment for the shack: a general-purpose frequency counter with direct readout to 1 MHz and 10-Hz accuracy. To make the counter even more versatile, you can build a preamp and bypass the CMOS buffer, yielding a counter usable to at least 20 MHz with the capability of measuring frequency drift and offset automatically (good for checking the drift characteristics of a new vfo).



Digital frequency display showing arrangement of decade counters.

suggested parts sources

A large number of distributors sell the parts used in this project, many of whom advertise in *ham radio*. Two I've had experience with are James Electronics, Belmont, California and Solid State Systems, Columbia, Missouri.

All parts used in this project are stocked by at least one of these suppliers on a regular basis.

conclusion

I've enjoyed designing and building this frequency readout system and hope I've given enough information so that others can duplicate it. I'd be interested in

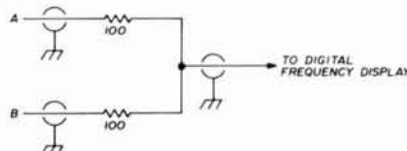


fig. 15. Circuit for combining the signals obtained in figs. 13 and 14.

hearing of any difficulties encountered. I'd also like to hear of any improvements or changes others may come up with.

acknowledgements

I'd like to thank George Oliva, WA2UOA, for his assistance with the photographs and Glenn Williman, WB2DHG, for his constant and occasionally useful criticism.

references

1. Jon Hagen, W7URZ, "A Simple Frequency Counter for Receivers," *QST*, December, 1972, page 11.
2. Kenneth MacLeish, W1EO, "Frequency Counter for the Amateur Station," *QST*, October, 1970, page 15.
3. *Recent Equipment*, "Heath Frequency Display Model SB650," *QST*, August, 1972, page 56.

ham radio

the Accu-Mill

a keyboard interface for the Accu-Keyer

With this circuit and an
ASCII-encoded keyboard
connected to
an Accu-Keyer
you can send
perfect Morse
at 25 words per minute
or better

More than six thousand Accu-Keyers have been built worldwide since the circuit was introduced in the August, 1973, issue of *QST*.¹ The Accu-Mill connects to the Accu-Keyer or to an Accu-Keyer with memory using simple circuitry. With it you can key in your message from a typewriter keyboard, then start sending with your paddle without throwing switches — great for contest operating. The basic Accu-Mill circuit requires a computer-type ASCII-encoded keyboard (many are beginning to show up in the surplus market). You'll also need an Accu-Keyer with an extra-large power supply and a negative 12-volt supply. The following features have been designed into the Accu-Mill:

1. Sixty-four or 128 characters of buffering.
2. Usable with the Accu-Keyer or Accu-Keyer with memory, including provision for external paddles.
3. "Buffer Full" light.
4. Nonbuffered operation with repeating keys and non-buffered operation with non-repeating keys, both switch selected.
5. Speed control by the Accu-Keyer.
6. Easy interface with keyboards having standard or inverted outputs.
7. Only one circuit board.

The Accu-Mill was also designed so that other functions can be added such as:

1. RTTY
2. Radio ASCII when approved.
3. Counter with digital display to let you know how much buffer has been used.
4. A back space function to allow correction of key-stroke errors.
5. Three programmable "vectored" message memories that work with the keyboard buffers to allow automatic insertions in a programmed contest report, so that you can type variables such as callsign, RST and number, for example, and the machine will make insertions while you update the log.

All these extras are now on paper and should be available soon. The memory and backspace features are particularly exciting, because they allow a 10-wpm typist who makes lots of mistakes (like me) to operate in a contest at 25-wpm or better.

logic description

The basic Morse board is presented here. The board uses easy-to-obtain 7400-series TTL devices except for the buffers, which are Fairchild OptiMOS devices; and the read-only memories (ROMs), which usually have the 8200-series TTL numbering (8223, 82S23, and 82S123 tri-state), but also have the 7400 designation of 74188.

Most of the devices have standard totem-pole outputs, which provide logic levels of 0 and 1. Some have open-collector outputs, which provide logic levels of 0 and not-0. These special types are used to connect to the outside world in places where either another output or another device (such as paddles) will operate an input. For proper operation we provide the logic 1 level with an external pull-up resistor. This resistor provides 5 volts at low current when the device is in the not-0 state. When the device is in the 0 state, the open-collector output shunts the voltage from the resistor, and a 0 logic level occurs.

The buffers are 3341 types: first-in first-out (FIFO) shift registers, the same as used in every popular buffered Morse or RTTY keyboard. Here's how they work: A short *shift-in* pulse commands data to enter. Data goes into the input and "falls through" to the last unoccupied slot of 64 positions. Data is output by a *shift-out* pulse of any length. By analogy, imagine a long, tilted gutter with a man at the top dumping in tennis balls as fast as he can and another man at the bottom, who takes them out when he needs them. As long as the man at the top is faster than the man at the bottom, there will always be a supply of tennis balls in the gutter. That's how

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Fairchild explains it. If you can type fast enough you'll get ahead of the output and your sending will be very smooth, or you can load up the registers and go out for coffee while the machine works your contact.

The read-only memories are of the field programmable type. You can easily program them to your code with a very simple circuit. They are used here as look-up tables. Each time a binary address is placed on their inputs, the ROMs "look up" the proper code associated with that binary address and present that code to their output lines. The 74151s are data selectors or multiplexers; they act something like single-pole, 8-throw switches, and scan the ROM outputs.

functional description

Buffer. The Accu-Mill logic diagram is shown in fig. 1. U1 is used only for ASCII keyboards with inverted outputs. U2 and U3 condition the signal from the keyboard that says a key has been pressed (KP). U2 and U3 provide the very short pulse needed for the buffer *shift-in* command and the control needed to disable the buffer for non-buffered operation.

U10-U13 are the 3341 buffers. Each buffer contains a channel four bits wide. We need a six-bit data channel, so the buffer is configured as two channels of data buffering, each four bits wide (two unused bits). It is probable that each channel will operate at a different natural speed, which would result in bad data output, so U14 synchronizes the two channels.

The buffers retain stable data on the output pins after *shift-out* returns low. If stable data were to remain on the input to the next stage, the keyer would lock up on one character. U15, U16 are NAND gates. When *shift-out* returns low, the gates stop data, and the next stage gets an acceptable signal (binary 111111), which prevents lockup.

So far we've looked at the first stage of the Accu-Mill. In this stage we input data from the keyboard and subject it to buffering so that we can get ahead of the transmitted output and type at our own speed. The next stage contains the magic that makes Morse code.

Morse-converter. This stage includes seven devices. U17-U20 are the read-only memories, which contain the ASCII-to-Morse conversion logic. U21, U22 are data selectors, which read the Morse code. U23 is the control counter, which drives the data selectors.

Data at the buffer output is presented to the memory address lines. Since each key has a different binary number, each key addresses a different place in memory, and the memories output a different Morse code bit for each key pressed. The Morse information appears at the memory outputs in parallel form: all dots and dashes appear at once. U21, U22 are data selectors, which put the Morse information in serial form. The data selectors start by looking at Morse bit one and sequentially scan all output bits until the character is complete. The memories are wired so that U17, U18 are dot memories, and U19, U20 are dash memories.

Accu-Keyer interface. This stage includes U24, U25. These gates provide control signals and interface to the Accu-Keyer. U24A, U24B replace the paddles. The

changes in the Accu-Keyer called for in the wiring of the paddle jack (fig. 1) will greatly increase rf noise immunity in the Accu-Keyer. The use of 74132 Schmitt triggers in place of U1, U2 in the Accu-Keyer should cure even the most severe rf problems. Similarly, a 7414 hex Schmitt trigger could be used in high-noise environments in place of U1 in the Accu-Mill.

data flow

The letter A. The letter A is a good example to use in describing data flow through the Accu-Mill, because it has just one dot and one dash. So press A. The keyboard generates 1000001, a seven-bit binary number. But a six-bit number is sufficient to describe all 64 possible characters in memory, so ignore bit seven and leave that wire disconnected.

The six-bit code 000001 is presented to the buffer stage. KP generates *shift-in*. 000001 is entered into the buffer and falls through to the output. U14 senses valid output data and opens gates U15, U16, which invert the data. Now the data is 111110, a six-bit code that is presented to the memory section.

Each memory has only five address lines, so it would appear that there's another unused bit. The extra bit, bit six, is used to select which 32 of the 64 characters is being addressed, letters or numbers. Bit six, which is high (1), is fed to, but does not enable, memories U17, U19, which are programmed for numbers and punctuation. Bit six is also inverted by U25A, and fed to U18, U20. This low (0) signal enables U18, U20, and the memory is ready to make a letter.

The remaining five bits, 11110, address U18 (dot) and U20 (dash) to the places where Morse information necessary to make A is stored. Dot memory U18 outputs 10000000; dash memory U20 outputs 01000000. Data selectors U20, U22 are looking at position one (far left). Dot data selector U21 sees a high bit in position one and causes inverter U24A to ground the dot input of the Accu-Keyer, and a dot is sent. On the dot falling edge, control counter U23 is clocked up by a signal fed back from the Accu-Keyer output.

The output count of U23 changes and drives both data selectors up to the next output lines in the memory. Now dash data selector U22 sees a high bit in position two and causes inverter U24B to ground the dash input of the Accu-Keyer, and a dash is sent. Again control counter U23 is clocked up, and the data selectors are driven up to position three. Neither sees a high bit, so neither sends a dot or a dash. The Accu-Keyer assumes end-of-character and sends a character space.

Spacing considerations. A special condition exists for the seven-baud word space. The keyboard has a space bar, but the Accu-Keyer is capable of sending character-spaces only — not word spaces, so the Accu-Keyer needs to be tricked. A word space always follows a character which has a character space. The character space will be the first three of the seven-baud word space. The space bar will be programmed to send the letter E through the Accu-Keyer. The letter E is one baud, which totals seven baud with the previous character space.

To avoid letting the E get to the transmitter, the

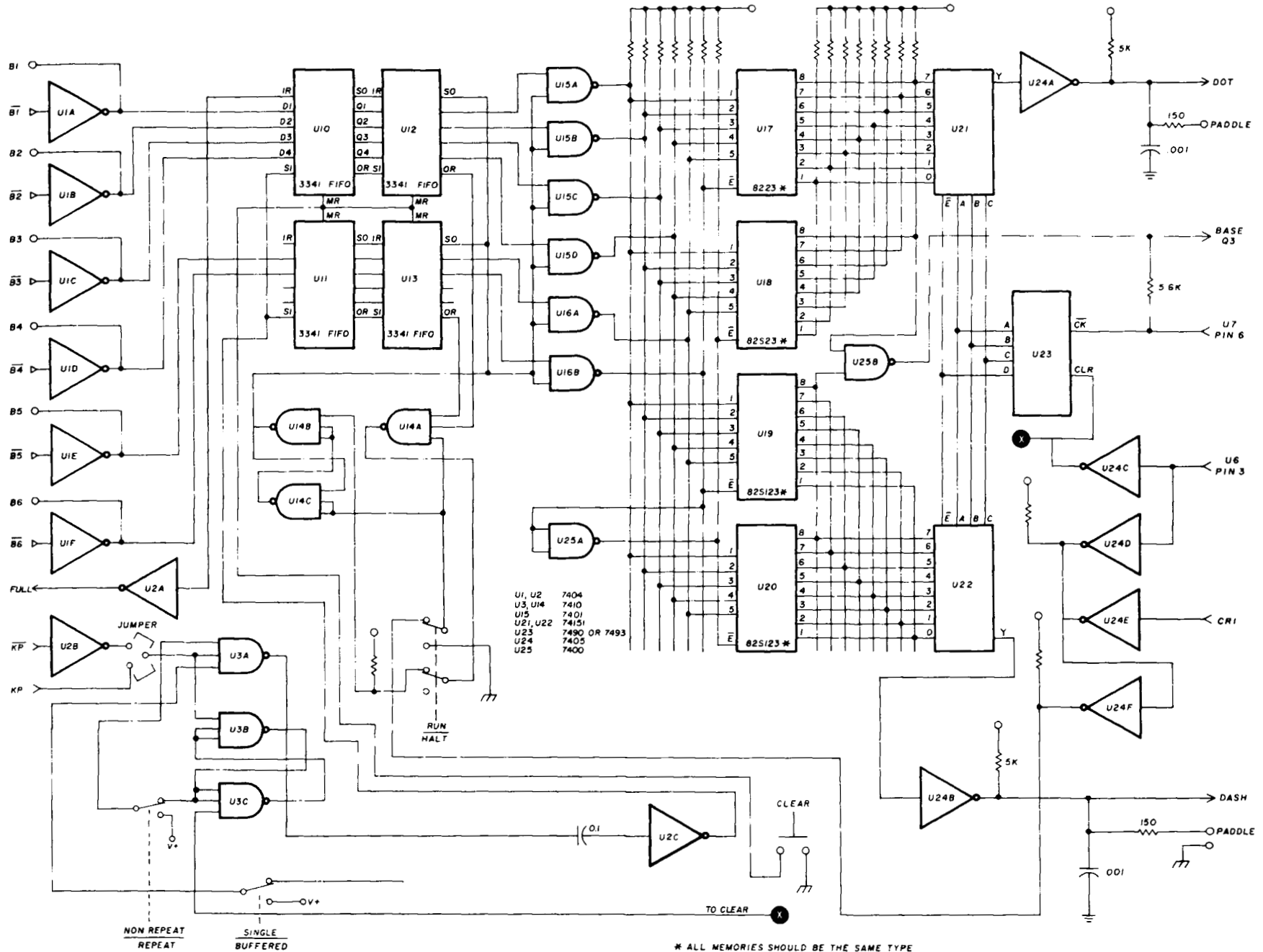


fig. 1. Logic diagram for the Accu-Mill. Shown are methods for connecting three different PROM ships, though all should be of the same type. A complete memory programming chart is supplied with the circuit board, or 825123s are available preprogrammed. In this circuit all resistors are 2200 to 3300 ohms, 1/4 watt, terminated with V+ unless indicated otherwise. All power-supply connections are assumed, as is proper bypassing of V+. Numbered wires are for logical reference, not pin numbers. Keyboard connections are on the left, Accu-Keyer connections are on the right.

memory is programmed differently for this special E to make it seem transparent at the transmitter. The dot memory will be 10000001; dash memory will be 00000001. Note that the first bit (left) in the dot memory will send a dot; the second bit is empty, which signals end of character. A character space is sent, the counter is cleared, and the next character begins. Note also that the data selectors never get to position eight to read the extra ones — this is the trick. These two extra bits are fed to NAND gate U25B. Its output goes low and swamps the keying signal before it gets to output transistor Q3 or Q5. As far as the Accu-Keyer is concerned the letter E was sent, but it never gets to the transmitter.

Using the same logic, a 36-baud pause can also be generated by programming a dot, 00000001, and a dash, 11111111. The keyer sends ... Including the character spaces, that's 36 baud of data, but it never gets to the transmitter. This feature can be put on the # key. The other upper case keys are used for signals such as $\bar{A}\bar{R}$, $\bar{S}\bar{K}$, $\bar{K}\bar{N}$. The only key that cannot be used is the @ key. This space must be programmed in memory with all zeros since this space has the address 111111, which is the same as the resting code put out by U15, U16 between characters. If this space is programmed, the keyer will lock up. The @ will halt the keyboard when pressed. This may be cleared by the halt switch.

A ready made PC board is available for the basic circuit of the Accu-Mill.* It's double-sided and measures 3 x 8 inches (76x203mm), so it should fit in just about any enclosure. A parts-placement guide and step-by-step instructions are supplied with each board. Buffers and memories are also available. This project should not be attempted on vector or perf board.

Several companies sell ASCII-encoded keyboards. These keyboards are usually used or surplus items, but one company, at least, sells inexpensive new kits. New or used, as long as the keyboard works and looks good you're in fine shape. Many keyboards have square keys with no spaces between them, which makes the enclosure easy to build since you cut only one large hole instead of many small ones. Rf has never been a problem for me, but it makes good sense to keep the wiring clean.

Interface to the Accu-Keyer is easy and requires only about six wires. The Accu-Keyer controls the keyboard speed, so you may want to move the Accu-Keyer into the keyboard enclosure and mount your paddle jack on the side of the enclosure. If your Accu-Keyer has a keying monitor, remove the RC network from pin 4 of the 555 timer and connect pin 4 directly to Q3 or Q5 base. C4, C5, R11, and R12 on the Accu-Keyer inputs should also be removed and placed on the paddle jack, as indicated on the schematic.

U1 of the Accu-Mill is used only for ASCII keyboards with inverted outputs. To test for this condition just power-up the keyboard and press A. Test the outputs. Standard boards have bits 7 and 1 high (more than 2.4

*An etched and drilled, double-sided, glass-epoxy circuit board is available for \$15 from W.E. Smith, Post Office Box 544, Hoffman Estates, Illinois 60194. Prices for 3341 buffers and 82S123 memories (preprogrammed) are available upon request.

volts); in this case don't use U1. Inverted boards have bits 7 and 1 low and everything else high; in this case use U1.

A note of caution: keyboards are available with codes such as BCDIC, EBCDIC, and Hollerith. These keyboards can be used but the programming in the memories is much different. A keyboard with separate contacts for each key is suitable only if an ASCII encoder is added to it.

The 3341 buffers are MOS devices and may be sensitive to static charges. Install these last and handle them carefully. Use two 3341s for 64 characters of buffering, or all four for 128 characters of buffering. It's possible to build either a nonbuffered board by using jumpers or a board with an outrageous amount of buffering (like 512 characters or more), but neither serves much useful purpose.

The memories can be the obsolete 8223 or the newer 82S23. Both require pull-up resistors (¼ watt, 2.2k). The very new 82S123 tri-state devices don't require resistors. Fig. 1 shows how to handle each type. A complete memory programming chart is supplied with the circuit board, or 82S123s are available preprogrammed.

IC sockets cannot be used since this is a double-sided board without plated-through holes. This type of board requires some soldering on the top side, and the plastic body of the IC socket will be in the way. Use Molex pins or solder the ICs directly.

In some places this circuit board has conductors running between adjacent pins, which means that the circuit pads are very small. A very fine-tipped soldering pencil is mandatory. Try grinding a spare tip down to a 1/32 x 1/2 inch (0.8x13mm) taper. Use very small-diameter solder. A soldering gun will ruin the board.

The 5-volt power supply should be capable of at least 2 amps. Use a 12.6-volt transformer, a bridge rectifier, and a zener diode with pass transistor and heatsink. Filter it well and use a transformer with about a 3 to 4 amp secondary rating.

The minus 12-volt supply should be capable of supplying 200 mA. Use a transformer with a 600-mA secondary rating, a bridge rectifier, and a zener with a current-limiting resistor. Filter the supply with 2500 μ F at 25 Vdc ahead of the resistor and a 1 μ F tantalum and 0.001 μ F disc ceramic after the resistor.

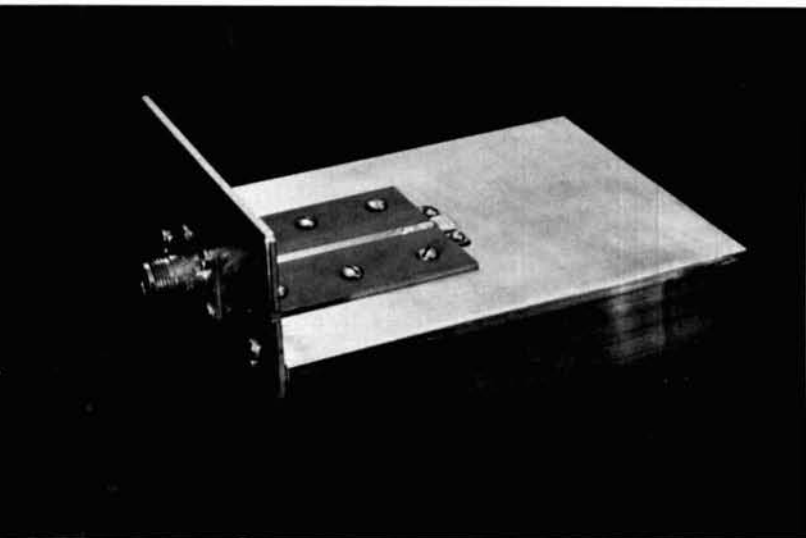
The enclosure can be made of aluminum, wood, or even plexiglass. A flat piece of plexiglass with switches and keyboard mounted on top of a plexiglass or wooden box shaped like a typewriter looks good.

To operate the Accu-Mill, turn it on, select buffered or nonbuffered operation, and start typing. To use the paddle, just plug it in and wait for the Accu-Mill to finish, then start sending. You can change over without throwing any switches. The paddle may remain connected if desired. The HALT switch may be used at any time and will stop the machine at the end of the present character.

reference

1. James M. Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.

ham radio



150-watt uhf dummy load

Details of a 50-ohm,
150-watt dummy load
that exhibits less than
1.2:1 vswr through
1500 MHz —
total parts cost
is less than \$40

Although most amateurs have a dummy load that is suitable for use on the high-frequencies, most low-cost, high-power dummy loads are quite reactive at vhf and present anything but a 1:1 vswr. Occasionally good quality commercial loads are available on the surplus market at reasonable prices, but off-the-shelf vhf dummy loads that will handle 100 watts or more are priced out of the reach of most amateurs. The rf load described here, which is rated at 150 watts, and provides less than 1.2:1 vswr through 1500 MHz, can be put together for less than \$40.

The heart of this unit is the CTC TA150-50 microstrip termination which looks much like a high-power uhf transistor. The device, which is only about 1/4-inch (6.5mm) wide and an inch (25.5mm) long, is attached to an aluminum heatsink as shown in the photographs. The input coaxial connector is connected to the load through

a 50-ohm microstripline that allows close contact to the termination (fig. 1).

construction

Construction of the 150-watt load is simple, but a moderate amount of care is required to assure good uhf performance. The first step is to prepare the heatsink by milling a small indentation, about 0.1 inch (2.5mm) deep, in the center of the heatsink as shown in fig. 2. This allows the lead of the TA150-50 termination to be at the proper height to match the microstrip feedline. Installing the TA150-50 so its input lead is too high or too low may break the lead or crack the ceramic insulation. The correct mounting is shown in fig. 3.

Make sure that the indentation milled into the heatsink is reasonably smooth and flat. Any irregularities in the mounting surface for the TA150-50 termination, or bowing of the heatsink, may crack the BeO ceramic when the mounting screws are tightened. An imperfect mounting surface can also result in poor thermal transfer characteristics which will lower the power rating of the completed dummy load.

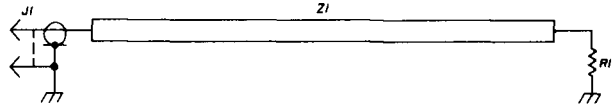
Although Teflon-glass circuit board was used in the author's model shown in the photographs, epoxy-glass circuit-board can be used if you do not expect to use the load above 300 MHz. This is not because of the higher loss of epoxy-glass circuit board (which is good to over 1000 MHz), but because of variations in thickness from one manufacturer to another which affect the impedance of the microstrip transmission line. In addition, voids in epoxy-glass circuit board can cause difficulties. If all you have is G-10 circuit board, by all means use it, but don't be surprised if the vswr above 300 MHz is substantially greater than 1:1.

Circuit-board dimensions for both materials are given in fig. 1. After the circuit board is etched and cut to size, six holes are punched in the board for mounting on the heatsink (see fig. 4). Do not use less than six mounting

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screws because they provide the ground for the 50-ohm microstrip feedline.

Temporarily place the termination in the indentation and mark the position of the two flange-mounting holes. Remove the termination and drill and tap the heatsink for 4-40 (M3) screws. Temporarily install the termina-



- J1 UG-58/U type-N flange mount chassis connector
- R1 CTC TA150-50 50-ohm, 150-watt microstrip termination (available from Webster Radio, 2602 East Ashlan, Department H, Fresno, California 93726)
- Z1 50-ohm microstripline, 2.9" (7.4cm) long, width determined by board type as follows:
 - 1/16" (1.5mm) Teflon-glass circuit board: 0.173" (4.4mm) wide
 - 1/16" (1.5mm) fiberglass-epoxy board: 0.107" (2.7mm) wide

fig. 1. Schematic diagram of the 150-watt dummy load which exhibits less than 1.2:1 vswr from dc through 1500 MHz. The CTC TA150-50 rf termination must be mounted on a heatsink as shown in the photographs.

tion and line up the microstrip circuit board with the lead of the TA150-50. Position the board as close as possible to the termination and mark the six mounting holes for the circuit board. Remove the board and drill and tap the six locations for 6-32 (M3.5) screws.

Before permanently installing the termination and the microstripline, carefully clean the heatsink to make sure it is completely free of any oil or grease. Apply a small

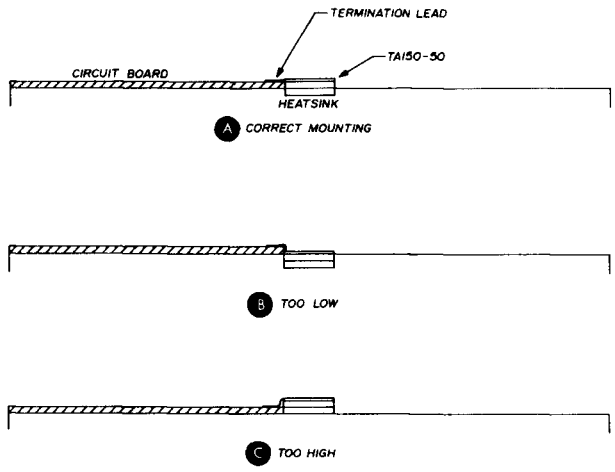


fig. 3. Correct installation of the TA150-50 is shown at (A). If the milled indentation in the heatsink is too deep (B) or too shallow (C), the termination lead will not match the height of the microstripline and may result in damage to the device. Correct depth is 0.1" (2.5mm).

amount of zinc-based heatsink compound on the flange of the TA150-50, place it in the heatsink indentation, and install the two 4-40 (M3) screws. Alternately tighten each screw, but don't use too much torque or you may strip the threads in the heatsink. Now install the microstrip circuit board and the six 6-32 (M3.5) mounting screws.

Install the end-plate assembly on the heatsink and adjust the position of the plate until the center pin of the coaxial connector rests on the top of the microstripline. Tighten the two 6-32 (M3.5) mounting screws and solder the connector to the microstripline. Now solder the TA150-50 lead to the microstripline. This completes the assembly.

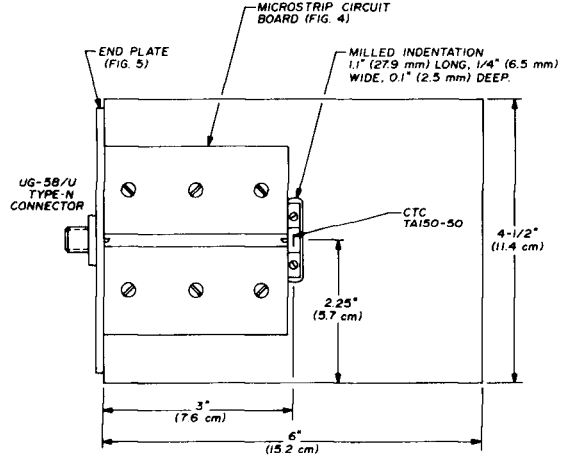


fig. 2. Heatsink layout for the 50-ohm 150-watt dummy load.

amount of zinc-based heatsink compound on the flange of the TA150-50, place it in the heatsink indentation, and install the two 4-40 (M3) screws. Alternately tighten each screw, but don't use too much torque or you may strip the threads in the heatsink. Now install the microstrip circuit board and the six 6-32 (M3.5) mounting screws.

The type-N UG-58/U chassis connector is attached to

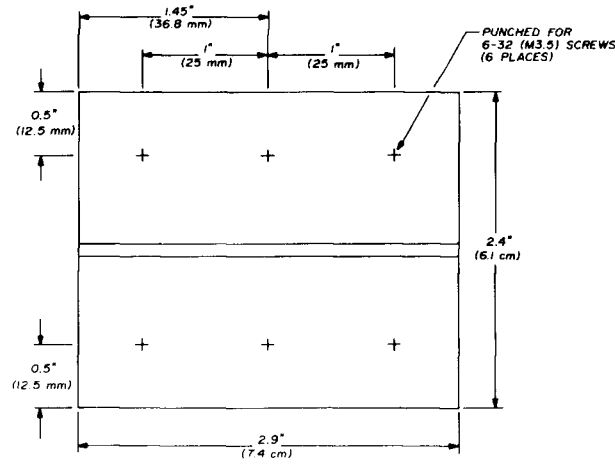
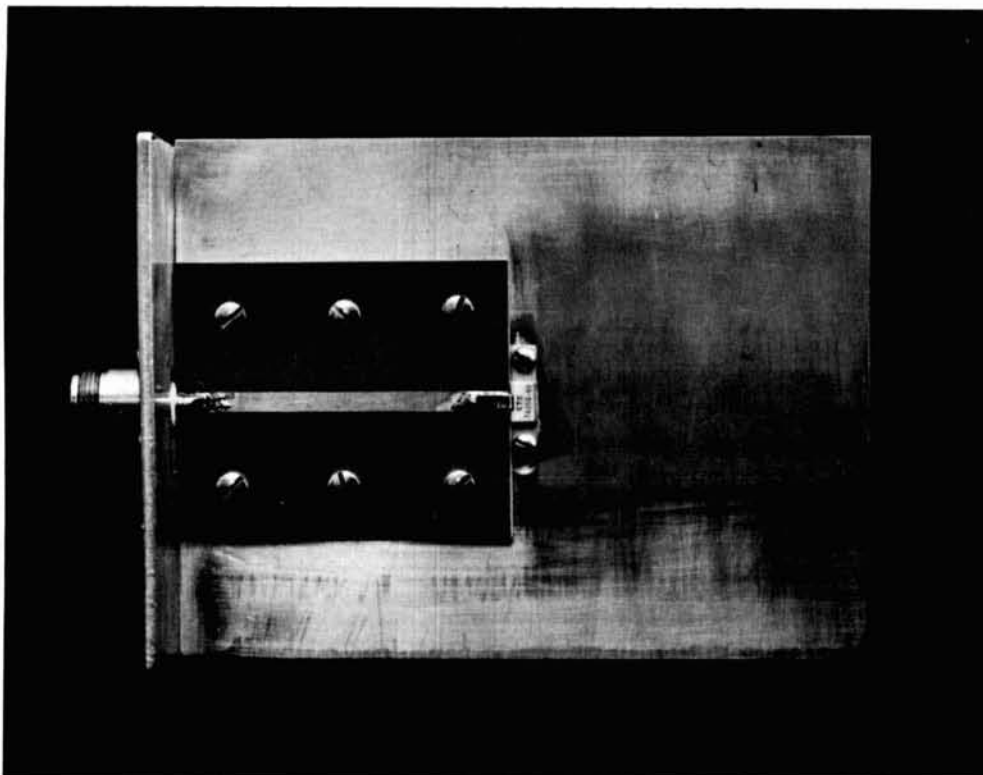


fig. 4. Drilling layout for the microstrip circuit board. Six mounting screws are required to provide good electrical contact with the heatsink. Printed-circuit layout is for 1/16" (1.5mm) double-clad, Teflon-epoxy circuit board, which is recommended for this application. Dimensions for fiberglass-epoxy board are listed in fig. 1.



Construction details of the 150-watt uhf dummy load.

checkout and performance

Connect an rf power source to an accurate vhf swr meter and the completed rf load as shown in fig. 6. Make sure the swr meter is accurate at the frequency of the power source (a Bird model 43 *Thruline* rf directional wattmeter with the correct plug-in element is a good choice). Gradually apply power to the rf load and look for any indication of high swr — this could indicate a poor solder joint, a short, or other assembly problem. If everything looks okay, go ahead and increase power up to the 150-watt maximum.

The maximum case temperature of the TA150-50 is 100°C (212°F). Since case temperature is difficult to measure, heatsink temperature can be used as an indica-

tion of safe operation. If a good grade of thermal compound is used when mounting the TA150-50, this will provide a case-to-heatsink thermal resistance of 0.3°C per watt.¹ This means that, at 150 watts dissipation, the heatsink temperature will be 55°C (131°F). If you cannot measure the heatsink temperature or are in doubt, force-air cool it (that's what I did). At lower power levels, 35 watts or less, the heatsink should be okay for *continuous* use without any external cooling.

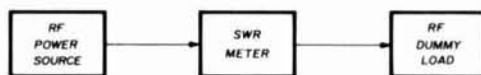


fig. 6. Test setup for checking the performance of the 150-watt vhf dummy load. Swr meter should be accurate at the frequency of interest (Bird model 43 with appropriate slug is recommended).

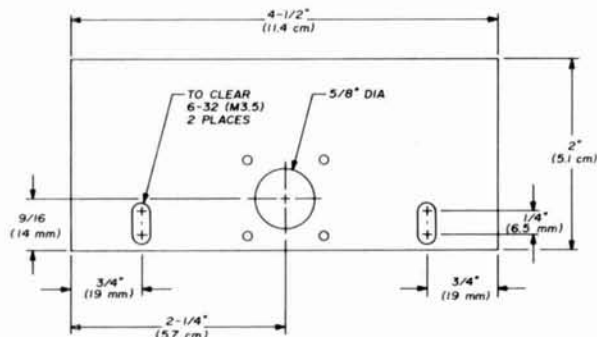


fig. 5. Layout of the end plate. The UG-58/U chassis connector is mounted with short 4-40 (M3) screws. Elongated mounting holes make it easy to align the center pin of the connector with the microstrip line.

Note that the power limitation of the TA150-50 is 150 watts *maximum* — exceeding this rating, for either CW or PEP, may damage the termination.

The measured vswr of this dummy load is less than 1.2:1 all the way from dc to 1500 MHz. A somewhat similar device, the CTC TC250-50, is rated at 250 watts, but the maximum frequency rating for 1.2:1 vswr is only 1000 MHz.

reference

1. Courtney Hall, WA5SNZ, "How to Solve Transistor Heatsink Problems," *ham radio*, January, 1974, page 46.

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the hand-held electronic calculator: solving problems

This article is the second in a series on the hand-held electronic calculator. The first article¹ described the operating principles of the four-function machine, gave examples of how to use it in handling basic arithmetic operations, and touched on the operations that can be performed with the more expensive and elaborate machines, including the use of constants, chain operations, and memories.

Despite its simplicity and low cost, the four-function calculator has as much potential calculating power as the more sophisticated machines, providing you're willing to accept slower operating speed and the occasional use of a scratch pad. The key to this power is in using approximations as a substitute for special calculator functions, using problem-organization techniques, and using a scratch pad as a substitute for calculator memory. With these tools, the simplest four-function calculator becomes usable for all radio calculations. The following text reviews many of the approximations that can be used and gives examples of problem solution. Clearly, the small calculator can be an instrument of great power.

calculator logic

As a first step it's desirable to spend a little time learning about the logic of the calculator. Sometimes the internal logic can be used to simplify a step; occasionally the logic will force a particular procedure. The major elements to understand are:

Rounding: Drop digits, round to nearest value, or hold internally.

Overflow, underflow: Signal used, calculation locked out or error possible.

Chain: How to interrupt; how to change from + - to $\div \times$.

Constant: Switchable, automatic, chainable.

Sign: How to use; how to enter negative divide.

Memory: Self accumulate, overflow, sign.

Function keys: Determine logic (example: % is the same as = times 100 on divide, or as = divided by 100 on multiply).

These processes are best understood by working sample problems. For example, rounding can be checked by

dividing 27 by 99 then multiplying by 2 (answer is 0.545454, rounds to 0.55).

problem organization

Most of the elements of problem organization concern arrangement of parentheses. For example, on the smaller calculators it's usually necessary to solve $Ax(B+C)$ by the steps $(B+C)xA$, the key strokes now being simple. Sometimes it's desirable to write the problem as $AB+AC$ to eliminate inner parentheses. Again, it's sometimes desirable to combine parentheses. For example, the form $(AxB) + (Cx D)$ can't be solved directly on small calculators lacking memory but can be when rewritten in the form $\frac{Ax B}{C} + D \times C$. Quite often it's necessary to repeat a calculation several times using different values of the unknown. (An example would be the calculation of a set of half-wave filters for TVI elimination). For problems of any complexity it's worthwhile to lay out a tabular calculating form with the successive numbers across the top of the page and successive values of the unknown down the page. It's best to arrange unknowns *in order* to simplify a check for mistakes. This process can compensate for memory deficiency of the less-expensive calculators by providing a convenient place for recording intermediate results. The preparation of such a table has another benefit — it can be filed for a permanent record and as future reference.

accuracy and rounding off

The fact that even small calculators have 6 or 8 digits encourages the bad habit of regarding all digits as important. Sometimes they are, as when an expression of the form $(A-B)$ is encountered and A and B are nearly equal. But more often, only the first few digits have significance — the others may as well be zeros.

Many small calculators have provisions for rounding to two decimal places, which takes care of small numbers. For large numbers, or in the general case, calculator rounding is possible by temporarily converting to a small number then scaling back.

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If n is the number of digits to be rounded off, and m is the digit capacity of the calculator, divide first by $10^{(m+n)}$ then multiply by $10^{(m+n)}$. On most small calculators, m is the number of digits displayed; for rounding decimals, regard n as minus.

If the calculator truncates or cuts off the result instead of rounding, rounding can be obtained by first adding $0.5 \times n$ to the number then proceeding as above.

It's rare for radio calculations to require accuracies of more than a few percent, since this is the usual measuring accuracy. For short calculations two significant figures are sufficient; three should take care of nearly all complex problems. An unnecessary number of digits gives a false impression of accuracy.

double precision

Despite the remarks above, there are times when the accuracy needed is greater than the number of digits provided by the calculator. Such problems can be handled by dividing the numbers into halves, performing a few operations, then combining the results — a process used in computer work called *double precision*. (Triple precision is possible but it's too complex to use).

Suppose a number 0123456789 is to be added to another number on a six-digit calculator. The first number can be divided into two parts, 01234 and 56789 . Denote the first part by A and the second by a . To add two such numbers Aa and Bb , compute the sums $C = A + B$ and $c = a + b$. Write the result as Cc . (There may be a carry from c to C or a borrow on subtract).

Example: Add 0123456789 to 1212121212

First number, Aa	$A = 01234$
	$a = 56789$
Second number, Bb	$B = 12121$
	$b = 21212$
Add $A + B$:	$C = A + B$
	$= 01234 + 12121$
	$= 13355$
Add $a + b$:	$c = a + b$
	$= 56789 + 21212$
	$c = 78001$

Write the result as Cc : 1335578001
(sum of 0123456789 and 1212121212).

If either number, say Aa , has more digits than the other number, say Bb , add zeros to the left of the smaller number. For example to add 0123456789 to 0123456 , the numbers would be segmented as follows:

$A = 01234$	$B = 00001$	$C = 01235$
$a = 56789$	$b = 23456$	$c = 80245$
$Cc = 0123580245$, the sum		

To multiply two such numbers Aa and Bb , first compute the four products $Cc = A \times B$, $Dd = A \times b$, $Ee = a \times B$ and $Ff = a \times b$. Compute the sums, $c + D + E = G$, and $d + e + F = H$. The final result is written as $CGHf$. (There may be a carry from f to H , from H to G , and from G to C). A little practice will help keep the partials straight.

Example: Multiply 1234 times 5678 (answer 7006652)

$Aa = 1234$	$A = 12$	$a = 34$
$Bb = 5678$	$B = 56$	$b = 78$
$Cc = A \times B = 12 \times 56 = 0672$		
$Dd = A \times b = 12 \times 78 = 0936$		
$Ee = a \times B = 34 \times 56 = 1904$		
$Ff = a \times b = 34 \times 78 = 2652$		
$G = c + D + E = 72 + 09 + 19 = 100$		
$H = d + e + F = 36 + 04 + 26 = 66$		
$CGHf = 06\ 100\ 66\ 52 = 7006652$		

Note the carry when the second number, 100 , is combined with the first, 06 . An easy way to keep the carry straight is to write the numbers as

$$\begin{array}{r} 06 \\ 100 \\ 66 \\ \hline 52 \\ \hline 07006652 \end{array}$$

For division it's easiest to perform long division, which can be done by direct operations. Enter the left-most digits of the dividend until the number in the display is greater than the divisor. Subtract the divisor and repeat until the remainder is less than the divisor, recording the number of subtractions as the first digit of the quotient. Multiply this remainder by 10 , which is the same as a *shift operation*. Add the next digit of the dividend and repeat the subtraction to obtain the next digit of the quotient. Repeat the shift-enter-subtract sequence until all digits have been entered. The remainder can be expressed as a fraction, or the division can be continued by entering zeros. If memory is available, the number of keystrokes needed is greatly reduced.

Example: Divide 987654321 by 12345 (answer: $80004.400243+$).

A. Enter 98765 (dividend) into calculator, then successively subtract 12345 (divisor) until remainder is less than the divisor:

98765	
$- 12345$	1st subtraction
$\hline 86420$	
$- 12345$	2nd subtraction
$\hline 74075$	
$- 12345$	3rd subtraction
$\hline 61730$	
$- 12345$	4th subtraction
$\hline 49385$	
$- 12345$	5th subtraction
$\hline 37040$	
$- 12345$	6th subtraction
$\hline 24695$	
$- 12345$	7th subtraction
$\hline 12350$	
$- 12345$	8th subtraction
$\hline 5$	

Since 8 subtractions were required, first (left-hand) digit of the quotient is 8 .

- B. Multiply remainder by 10 and add next unused digit of the dividend: $(10 \times 5) + 4 = 54$

Since this number is still smaller than the divisor, no subtraction can be made so the second digit in the quotient is 0

- C. Multiply the remainder by 10 and add the next unused digit from the dividend: $(10 \times 54) + 3 = 543$

Since this number is still smaller than the divisor, no subtraction can be made so the second digit in the quotient is 0.

- D. Multiply the remainder by 10 and add the next unused digit from the dividend: $(10 \times 543) + 2 = 5432$

This number is still smaller than the divisor, no subtraction can be made, and the fourth digit in the quotient is 0.

- E. Multiply the remainder by 10 and add the next unused digit from the dividend: $(10 \times 5432) + 1 = 54321$

This remainder is larger than the divisor so successive subtractions can be made, as before:

$$\begin{array}{r} 54321 \\ - \underline{12345} \quad \text{1st subtraction} \\ 41976 \\ - \underline{12345} \quad \text{2nd subtraction} \\ 29631 \\ - \underline{12345} \quad \text{3rd subtraction} \\ 17286 \\ - \underline{12345} \quad \text{4th subtraction} \\ 4941 \end{array}$$

Since four subtractions were required, the fifth digit in the quotient is 4.

- F. This same procedure can be used to as many decimal points as required, or the numbers (which are now small enough to be handled by most hand-held calculators), can be divided directly: $4941 \div 12345 = 0.400243$
Quotient is written from steps A through F:

$$ABCDEF = 80004.400243$$

table lookup

Because the small calculator doesn't have provisions for special functions or constants, these must be entered as needed. One way to do this is to keep a small set of tables with the calculator and look up values as needed. Small volumes of four-place tables of all common functions are often sold at school bookstores. Larger volumes are available, with greater accuracy, up to the 15-place tables issued by the U.S. Government. *Tables of Functions* by Jahnke and Emde is the standard volume for special functions.

Table lookup is also needed for typical constants and

conversion factors. If several of these are needed often, it's convenient to make up a short table on *Dymo* tape or on a card and fasten it to the calculator case. Typical constants would be π , g , ft-lbs to ergs.

The second way of securing the functions needed is to compute them directly. Usually a full computation is too complex and time consuming to be practical, but many functions and constants can be generated by simple relationships that give approximately the correct value. Since most radio work doesn't require high accuracy, these approximations are extremely useful. The following material shows approximations and error for the commonly needed functions.

numerical values:

$$\begin{array}{ll} \pi = 22/7 & \text{error 0.04\%} \\ e = 19/7 & \text{error 0.15\%} \\ 1/M = 16/7 & \text{error 0.73\%} \end{array}$$

M is the natural log of 10, used to convert from Naperian (base e) to common or Briggsian logarithms (base 10).

log functions:

$$\begin{array}{ll} e^x = 1 + x & \text{error less than 1\% for } x < 0.15 \\ e^x = 1 + x + \frac{x^2}{2} & \text{error less than 1.5\% for } x < 0.50 \end{array}$$

Convert e^x to 10^x by multiplying by $1/M$ (x positive):

$$\log_e x = 2 \left(\frac{x-1}{x+1} \right) + \frac{2}{3} \left(\frac{x-1}{x+1} \right)^3 \quad \text{error less than 1\% for } x < 2.5.$$

Convert to $\log_{10} x$ by dividing by $1/M$.

trigonometric functions:

In the following, x is in radians or (degrees/57.296).

$$\begin{array}{ll} \sin x = x & \text{error less than 1\% for } x < 14^\circ \\ \sin x = x - x^3/6 & \text{error less than 1\% for } x < 57^\circ \\ \cos x = 1 & \text{error less than 1\% for } x < 8^\circ \\ \cos x = 1 - x^2/2 & \text{error less than 1\% for } x < 38^\circ \\ \tan x = x & \text{error less than 1\% for } x < 10^\circ \\ \tan x = x + x^3/3 & \text{error less than 1\% for } x < 30^\circ \end{array}$$

For large values of x , or any value if desired, calculate from

$$\begin{array}{l} \sin(A \pm x) = \sin A \pm x \cos A \\ \cos(A \pm x) = \cos A \pm x \sin A \end{array}$$

The values of $\sin A$, $\cos A$ to each 10° can be kept on a small card or attached to the calculator case. The error will be less than 0.5%.

inverse trigonometric functions:

$$\begin{array}{ll} \sin^{-1} x = x & \text{error less than 1\% for } x < 0.24 \\ \sin^{-1} x = x + x^3/6 & \text{error less than 1\% for } x < 0.58 \end{array}$$

$\cos^{-1} x = \frac{\pi}{2} - \sin^{-1} x$	exact
$\tan^{-1} x = x$	error less than 1% for $x < 0.17$
$\tan^{-1} x = \pi/2 - 1/x$	error less than 1% for $x > 3.0$

It appears that all of the small calculators allow chained operation. This makes it easy to secure integer powers. Simply enter the number and press the times key the number of times of the power. Note that some calculators have automatic constant: for these it's best to press the times key once and the equals key the remaining number of times. If this isn't done, the calculator will retain the constant in a way that can cause errors. If the power is large it's faster to factor the power then take powers of powers. For example $x^{16} = \{(x^2)^2\}^2$, which saves eight key strokes.

Reciprocals, or any negative integer power, can be secured easily with any calculator having constant or memory, since $x^{-n} = 1/x^n$. Place the calculator in the constant mode, enter the value of x , press divide twice to secure a one, then press it n times for the desired value. For simpler calculators, the one must be entered, followed by a divide, then the number.

Non-integer powers are occasionally needed. Sometimes the unknown can be written as a difference, giving the approximations:

$$y^n = (1 \pm x)^n = 1 \pm nx$$

$$y^{1/n} = (1 \pm x)^{1/n} = 1 \pm x/n$$

$$1/y = \frac{1}{1 \pm x} = 1 \pm x$$

For values not close to unity use the approximation:

$$x^n = 1 + n \log_e x.$$

roots

Square roots are easily secured by a method of successive approximation developed by Newton. The value is obtained from:

second estimate of root =

$$\left[\frac{\text{number}}{\text{first estimate}} + \text{first estimate} \right] \times 1/2$$

This is repeated until the digit requiring the desired accuracy doesn't change. This expression is one case of a general rule for any root, which can be written as

$$Z^r = \frac{A^{\frac{Z}{r-1} + A(r-1)}}{r} = A'$$

For example, for the cube root,

$$\frac{\frac{Z/A}{A} + A + A}{3} = \text{new estimate}$$

In these relationships, the number of operations is reduced if the first estimate is close to the true value.

A second way of securing integral roots is by trial. For example, if a cube root is needed, guess a number, cube it, and adjust the original guess. It's not difficult to

secure two- or three-digit accuracy this way, but more accuracy becomes time consuming.

Non-integral roots can sometimes be solved as problems in powers. For example,

$$x^{0.8} = x^{(1-0.2)} = x \cdot x^{-1/5} = \frac{x}{\sqrt[5]{x}}$$

These roots may also be secured from

$$x^n = 1 + n \log_e x$$

hyperbolic functions

In transmission-line calculations, hyperbolic functions are useful. Some approximations for these are:

$$\sinh x = x + x^3/6$$

$$\cosh x = 1 + x^2/2$$

$$\tanh x = x - x^3/3$$

$$\operatorname{arctanh} x = x + x^3/3$$

Note the close relationship to the trigonometric functions.

numerical integration

Integration, which corresponds to finding the area under a curve, is easily done using Simpson's rule. Its formula expression is:

$$\int_a^b F(x) dx = \frac{b-a}{3n} (y_0 + 4y_1 + 2y_2 + 4y_3 \dots + y_n)$$

where y_0, y_1, \dots are the values of $F(x)$ at n equally-spaced intervals between a and b (n even).

To apply, plot the function as a curve, and divide the abscissa range into n equal spaces: ten is often a convenient number. Multiply each ordinate value by Simpson's multipliers, respectively, 1, 2, 4, 2, 4, \dots 1 for the first, second \dots last ordinate. Obtain the sum, and multiply this by the length of each interval divided by three.

concluding notes

These are by no means all the techniques known and used, but they should be ample for all radio work, and much more. The bibliography gives some further data and techniques. Particular attention should be given to the series obtained by expansion using Taylor's and MacLaurin's theorems. These are the basis of most of the approximations above.

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ham radio

automatic beeper

for station control

This simple
one-transistor circuit
improves communications
efficiency on
crowded channels

Amateurs who have heard radio conversations from the Apollo moonwalkers could not have helped but notice that the conversations ended with a beep sound, which indicated transmission termination. This beep sound is an "automatic over" signal. A communications system using such a signal saves time, words, and reduces misunderstanding. The beep-tone frequency is about 800 Hz, which seems to be the frequency most sensitive to the human ear. Proper installation of the beep system will also ensure that transmitter modulation is at a maximum level, just below flat topping.

The "automatic over" system was first used in the Yaesu FT2F 2-meter transceiver. The circuit described here is simpler than that used in the FT2F.

The automatic beep system works in such a way that, when releasing the PTT switch, a time delay occurs in the action of the changeover relay (or relays), which keeps the transmitter on the air just long enough to transmit a tone burst. This tone is generated in a simple one-transistor phase-shift oscillator, **fig. 1**. The circuit uses only a few components and is powered by the voltage present between the PTT terminal and ground in the receive mode. This voltage is commonly 12 Vdc but may be any voltage between 6 and 30 volts dc.

Turning on the transmitter grounds the PTT terminal so that the oscillator supply is shorted on transmit, thereby stopping the oscillator, which is on during receive. The sequence of events is:

1. Receiver on, beep-tone oscillator (BTO) on, relay opens.
2. PTT closes, transmitter on, BTO off, relay closes.
3. PTT opens, transmitter on, BTO on, relay delay effective.
4. Delay time finishes, relay opens, BTO on, receiver on.

construction notes

The 3.9k resistors and 0.01 μ F capacitors should be 5% tolerance or closer. The 0.01 μ F capacitors must be mylar, polycarbonate, polystyrene, or oil. *Do not* use ceramics. The 470 pF and 0.02 μ F capacitors may be ceramic or other types. All resistors can be 1/2, 1/4 or 1/8 watt. The capacitors and resistors marked with an asterisk must be matched within 5%. If matched within 5%, a 20% variation from given values is satisfactory.

The transistor can be any small-signal silicon npn type with a gain of at least 300 at 1 mA. A low-gain transis-

By Earl Hornbostel, WA6URN, Republic Crystal Labs,
P.O. Box 445, Greenhills Post Office, Rizal, Philippines

tor, mismatched resistors or capacitors, or poor-quality capacitors can cause the oscillator to start slowly or not start at all. Hundreds of different types of transistors are available that will work well in this circuit (i.e., 2N930).

There is nothing critical about layout so any method of wiring is acceptable. A small PC board can be made, assembly can be made on a perf board, or terminal lug strips can hold the parts. A convenient way of assembly is to make a small etched board from single-sided copper

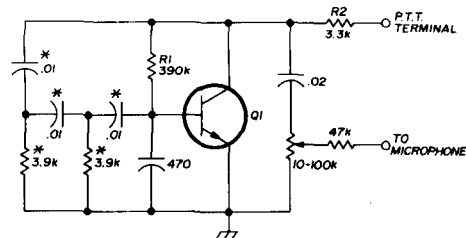


fig. 1. Circuit of the beeper oscillator. Parts marked with an asterisk must be matched within 5 percent. The transistor can be any small-signal silicon npn device with a gain of at least 300 at 1 mA.

clad stock, which is used as one side of a box on which the parts can be soldered on the *etched* side, leaving a continuous copper border. Do not drill any holes. The other five sides of the box can be made from the same material. One of these sides (not an end) can be used as a cover and should be slightly smaller all around, by the material thickness, so that it will fit inside the box formed by the other five pieces.

When the etched board has been wired and tested, the other five sides, with copper facing in, are then soldered together, taking care to line them up straight. Mount the microphone jack and dress the cable, leaving a little slack. Tape the cable inside the box to prevent strain on the soldered joints. The cover plate should have a single grounded wire soldered to it. With copper facing in, push the cover plate into the box about 1/8 inch (3mm), leaving an edge around which Duco cement can be applied. Don't use epoxy cement if you want to open the box later for servicing. This construction method results in a solid, shielded, insulated box that won't cause electrical noise if touched by a stray wire, nor will it be heavy.

installation

Only three connections are needed for this circuit: ground, microphone input, and the hot PTT terminal, all of which are in the microphone cable. The easiest way to install the unit is to use a duplicate microphone jack and plug and a small metal box. Mount the jack on one side of the box. On the opposite side drill a hole for a short piece of microphone cable and wire the duplicate microphone plug to the end of this cable. Mount the volume control to another face of the box. Connect the short length of microphone cable to the microphone jack. If a separate ground is used for the PTT circuit, (sometimes done to avoid switching transients that cause thumps during operation), be sure this ground is the same as that

used for the oscillator. Also be sure the microphone shield does not short to the box or box wiring.

The last thing to do is to install a capacitor across the relay *first* controlled by the PTT switch. The capacitor, in the case of 12-volt relays, must be in the 300-1000 μ F range with at least a 15-volt rating. This capacitor, which is shunted across the relay coil, will charge during transmit causing a delayed release when changing to receive, turning on the beeper. This action occurs because, while the relay is still holding, opening the PTT switch places a potential on the oscillator. The capacitor, in negative-ground systems, should have its negative terminal connected to the PTT-lead terminal of the relay.

No definite value for the capacitor can be given, since this depends on the coil resistance and the length of beep desired. The formula for calculation is:

$$T = RC \quad (1)$$

where R = relay coil resistance (ohms)
 C = capacitance (farads)
 T = time (seconds)

The potentiometer should be set to fully modulate the transceiver without flat topping.

operation

The beeper will operate with any transceiver, a-m or fm, that has a PTT switch with a positive dc voltage of 6 to 20 volts on the PTT terminal during receive. This applies to most modern solid-state or hybrid sets that use a 12-Vdc relay for changeover. Tube sets may or may not have 12-Vdc control relays, so check this before starting the project. Be sure that the control circuit, when open, can pass 1 or 2 mA into the oscillator. In other circuits, such as when bias or the cathode of a tube is controlled, first check the voltage on the PTT terminal in the receive mode. Place a 10k resistor across this terminal and check again. If the voltage across this resistor is not less than 6 volts nor more than 30 volts; and if the receiver continues to operate, the circuit will permit the beeper to work. If negative voltage with respect to ground is present, then use a pnp transistor in the beeper.

Older sets, such as the KWM-2 and the other vacuum-tube equipment, may have the PTT relay in the plate lead of a vacuum tube. The much higher resistance in this case will not only require a lower capacitance, but a higher voltage rating, for the shunt capacitor. Some newer two-meter solid-state transceivers don't use a relay for switching. Instead, diode or regulator-type switching is used. In these cases, it will be necessary to use a much higher value for $R1$ — say 2.7 megohms or higher — and a high-gain (at low current) transistor. Not more than 50 microamperes should pass through $R2$, so that switching is not affected. The transistor is a low-current, high-gain device usually sold for "low noise" preamplifier use.

When the beeper is first used it will be difficult to break the "over" habit, but soon quick exchanges will increase the pleasure of operating and more natural conversation will ensue.

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turn-off timer

for portable equipment

This circuit
prolongs battery life
if you forget
to turn off
battery-operated
instruments

Small battery-operated instruments are nice: no power cords, no heat, instant warmup, and portability. However, if you're like me you'll forget once in a while and leave something turned on with the result that one or more batteries will have to be replaced. So when I converted my vtvm to battery operation,¹ I decided to add a battery-saver circuit to prevent this from happening. The circuit worked out so well I have since added it to two other small pieces of test equipment.

basic circuit

Looking through the literature and reflecting on some recent and past experience, I decided to use CMOS devices and drive the ICvm load directly. There are

several good reasons for this choice. The energized CMOS digital integrated circuit in the quiescent state uses "no power," (typically 0.009 μ W per device at 9 volts),² output impedance is fairly low, input impedance very high, and they are inexpensive.

Using RC timing in a driving circuit to a CMOS gate or in a regenerative one-shot circuit is simple but has a big drawback in this application: the big "knees" in the transfer function. This simply means that voltage from an output gate will drift considerably over an appreciable part of the timing cycle. It's therefore necessary to drive the input gate with a reasonably fast pulse to avoid drifting through the transfer. There are several different ways this can be done, but the 2N6028 programmable unijunction transistor was chosen for the job. This device is stable over an extremely wide range of operating conditions and can be made to operate with practically no battery current. It's also readily obtainable on the surplus market for about 65 cents. Using this little gem with a CD4001 CMOS quad NOR gate resulted in the basic circuit of fig. 1.

operation

Gates G1 and G2 of U1 form a latch circuit or switch, which is operated by the Q1 timer. When S1 is switched to *on*, C2 charges through R2, causing the latch to switch making point A low (ground) and point B high (+9 volts). The timing circuit and the load connected to B are then turned on. R4 and R5 set the operating point of Q1. C1 charges through R1 then discharges through Q1. The discharge pulse across R6 is applied to G2 input, which switches the latch to its opposite state, A high B low. This action turns off both the timing circuit and the load, leaving only U1 in the quiescent state across the battery. Because U1 (the entire package) draws typically only 0.001 μ A in this condition, S1 can remain *on* without decreasing battery life any more than its shelf life.

By Rich Hardesty, W5OXD, 2700 N. Lindbergh — Box 17, St. Louis, Missouri 63114

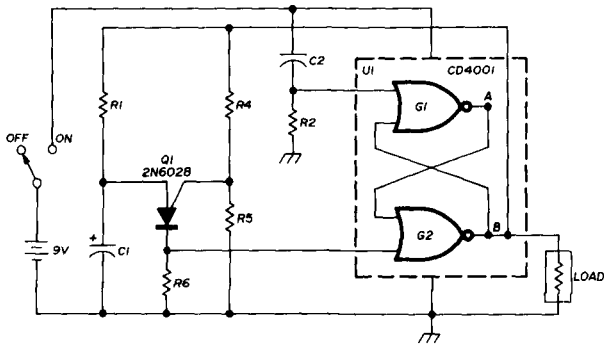


fig. 1. Basic ICvm timer circuit. Q1 is a programmable unijunction transistor, which drives a latch circuit composed of two gates of a CD4001 two-input quad NOR gate. With point A high and B low, both the timing circuit and load are turned off, leaving only U1 in the quiescent state across the battery. U1 current drain is only 0.001 μ A in this condition.

complete timer circuit

Fig. 2 shows the complete turn-off timer for use with the ICvm. Resistor R6 of fig. 1 has been replaced with the primary of T1, a homebrew pulse transformer, the secondary of which is used with the negative supply to the meter. When the timing discharge pulse occurs, it will appear across both windings of T1, switching both latches at the same time to turn off the meter. With the resistor values shown in the Q1 circuit the timer current is maintained below 1 μ A while on.

Diodes CR1, CR2 have been added to provide discharge paths for C1, C2 in the off position of S1 while maintaining timing-circuit isolation in the on position; a direct connection to S1 (negative supply off) forms the discharge path for C3. This allows the circuit to be retriggered at any point in the timing cycle by merely switching S1 off then on again. Note also that the spare

gates in each of U1 and U2 are used to drive the meter circuit. This is done for two reasons — they are there, and paralleling outputs reduces the output impedance and drive losses. The small amount of battery power lost in the output of the drive gates when they are on is not power that can be usefully saved by operating the ICvm directly with the batteries. The output voltages to the meter will be slightly lower than that of the batteries, but the meter is calibrated at whatever voltages are supplied to it. If you want to adapt the timer to a single 9-volt operated device, the positive battery or upper portion of fig. 2 may be used by itself. In this case replace T1 primary with a 10k resistor.

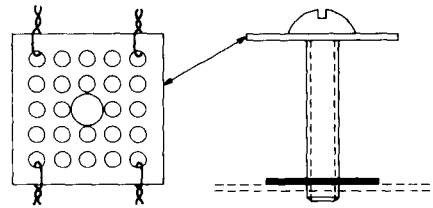


fig.3. Details of pulse-transformer core, which is a piece of 0.6 x 0.6-inch (15x15mm) perf board with 0.1-inch (2.5mm) hole spacing. Mounting screw should be nonmagnetic.

construction

T1 is made as follows: Construct the form as shown in fig. 3 using a 0.6 x 0.6 inch (15x15mm) piece of perf board (0.1-inch or 2.5mm hole spacing) for the top. Use pieces of solid hookup wire run through side holes and twisted to make four terminals. Make the center hole slightly smaller than an 8-32 (M4) screw thread and screw the top against the head of a 3/4-inch-long (19mm) brass or nylon screw. Then force a fiber washer onto the screw, leaving enough thread to mount the

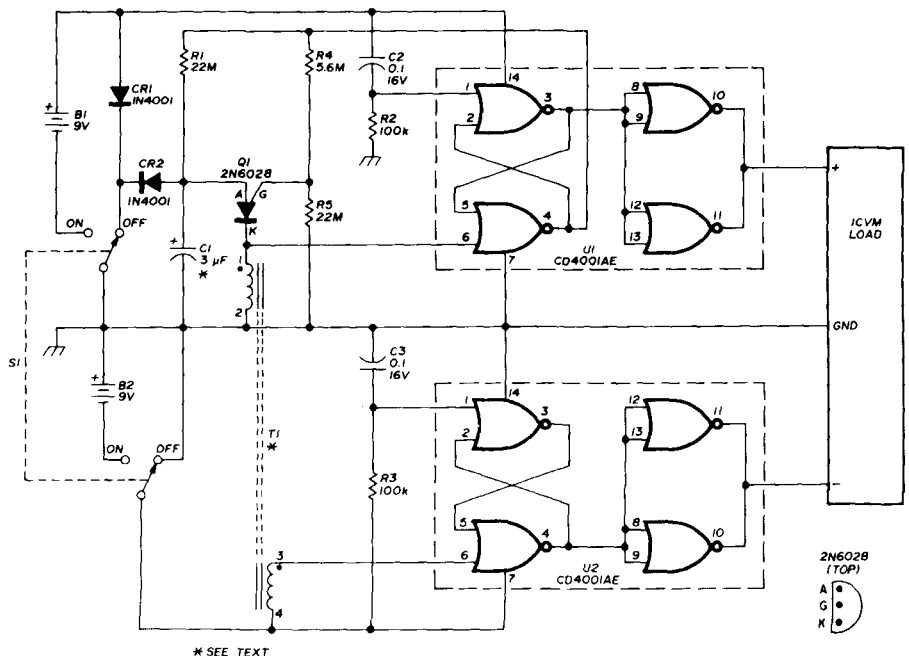


fig. 2. Complete circuit of the turn-off timer. All resistors are 1/4 watt, 5% composition. Resistor R6 of fig. 1, which supplies the timing pulse to U1, has been replaced by the primary of T1, a homemade pulse transformer.

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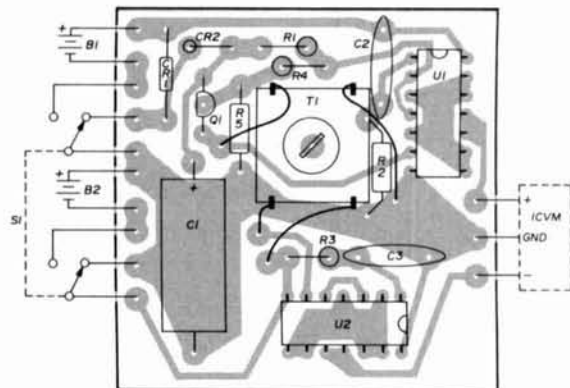


fig. 4. Suggested component layout for the ICvM timer. You can save space by using a lower-voltage capacitor for C1, which is a 3 μF, 50-volt unit.

finished transformer on the circuit board. Next, random wind on the form 600 turns of no. 36 to 40 (0.13 or 0.08mm) enameled wire, soldering the ends to the wire terminals on one side of the perf board top. Mark the start of the winding 1 and the end of winding 2. Repeat for the secondary, using the same number of turns wound in the same direction on top of the primary. Mark the start of winding 3 and the end of winding 4.



fig. 5. PC-board layout (foil side) of fig. 4.

Fig. 4 is a suggested component layout on a 2 x 2-inch (51x51mm) perf board or PC board. Fig. 5 is a PC board layout (foil side) of fig. 4. C1 is a 3 μF, 50-volt capacitor. Obviously a lower-voltage type would take up less space. C1 should be a low-leakage type: polystyrene, polycarbonate, or mylar. With R1 of 22 megohms, I had about 3½ minutes-to-turn-off-time. The R1, C1 time constant may be adjusted to your preference.

references

1. Mike Kaufman, K6VCI, "How to Convert your VTVM to an IC Voltmeter," *ham radio*, December, 1974, page 42.
2. RCA Solid State 1974 Databook, Series SSD-203B, *COS/MOS Digital Integrated Circuits*.

ham radio

audio-frequency shift keyer

A stable,
low-cost circuit
designed around
an 88-mH toroid

Many afsk circuits of varying complexity are available, but the circuit described here is the simplest and most satisfactory one I've found. Parts, excluding the relay,* are about \$1.50. I don't know who the originator of the circuit is and claim no credit for it except to bring it to light. It was shown to me by WB6ETJ, who also uses it with complete satisfaction and who is equally in the dark as to its originator.

circuit

The circuit (fig. 1) uses one center-tapped 88-mH toroid tuned to the desired *space* frequency by suitable capacitors. These capacitors are paralleled by additional capacitors to tune the circuit to *mark* frequency. In the completed circuit, *mark* occurs when the relay is closed. For *space* frequency I used two capacitors totalling 0.0628 μF , then carefully removed turns from each side of the toroid center tap until the desired frequency was obtained. With care it's possible to obtain an accuracy of one or two hertz. The *mark* frequency may require three or four values of diminishing capacitance to reach the proper frequency, but with care equal accuracy is

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By John B. Dillon, M.D., KH6FMT, P.O. Box 758, Koloa, Kauai, Hawaii 96756

obtainable. If good quality mylar capacitors are used, the output is a perfect sine wave of equal amplitude.

A 2N404 pnp transistor is quite satisfactory as the oscillator; only 1.5 volts from a flashlight battery are required. The current drain is 100 microamperes, so battery life is very adequate. As I use my unit in a 12-volt system, the Variable Zener¹ set at 1.5 volts works very well. The output, variable from 20 millivolts to 0.08 volt, is controlled by a 10k potentiometer.

The relay coil is plugged directly into my 150-volt, 60-mA loop. When the loop current is turned on, the relay closes, and the afsk is on *mark*. Space frequency occurs when the relay is opened by the teleprinter keyboard.

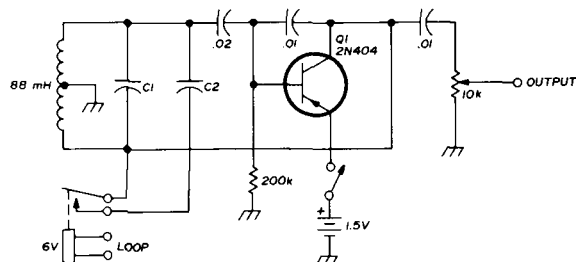


fig. 1. Circuit for simple, stable afsk. Capacitor C1 is tuned to 2295 Hz (approximately 0.0628 μF); C2 is tuned to 2125 Hz with relay closed (approximately 0.0156 μF). Q1 can be practically any pnp transistor. I.D. key may be the battery switch.

No special precautions are required for layout or construction. The unit works as well breadboarded as in a printed circuit I made to match my other gear. I've tried several types of 6-volt relays; all have worked satisfactorily. I've used this unit with an ST-6 and other terminal units. Since it plugs directly into the loop it doesn't interfere with other devices in the loop. All you have to do is plug the output into the transmitter audio input jack, and with a suitable output level you're in business.

reference

1. James McAlister, WA5EKA, "Low-Value Voltage Source," *ham radio*, November, 1971, page 66.

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calibrating ac scales

on the vtvm, icvm and fet voltmeter

A simple circuit
of emf sources
for an indirect
but accurate means
of calibrating
your test equipment
for ac voltages

In the absence of a precision voltmeter, the dc ranges of a vtvm or its solid-state counterpart may be quite accurately calibrated by using a dc source of reliable known open-circuit voltage. The zinc flashlight cell commonly used for this purpose is not a very reliable source, but the readily available P-13 mercury cell is quite reliable.¹ The P-13 cell is well worth the cost of about \$1.35 and possibly it could be stored for later use.*

calibration with the vom

Calibration of the vtvm ac scales to any degree of accuracy is usually not so simple. If you have access to a precision ac voltmeter you're fortunate, but this isn't the usual case. The vtvm ac scales are generally calibrated by the amateur against a vom. The resulting calibration can be, and often is, poor. Even the better vom's usually have an accuracy on ac scales of only $\pm 3 - 5\%$ of full scale.

*It's possible that the P-13 mercury cell could be preserved for a long period by storing it in a refrigerator deep freeze section. I haven't tried this with mercury cells, but common zinc flashlight cells have been stored for a number of years at about zero F. (-18C) with little or no apparent deterioration.

When calibrating one instrument against another used as a standard, the errors of the two instruments are algebraically additive. It is for this reason that laboratories commonly use a standard instrument ten times as accurate as the one being calibrated. For example, to calibrate an instrument to $\pm 1\%$ accuracy, a standard instrument of $\pm 0.1\%$ accuracy is needed. In the worst case, let's assume the vtvm has an inherent accuracy of $\pm 3\%$, is calibrated against a vom with an accuracy of $\pm 5\%$, and the errors are accumulative. The calibrated meter would have an accuracy of not better than 8%.

calibration using ac line voltage

Probably a more common, but sometimes worse (and dangerous) method used by the amateur to calibrate the vtvm ac ranges is to use the ac mains and assume a nominal 117 volts. If the potential across the ac mains is indeed 117 volts calibration will be satisfactory, but how are we to know? The "nominal 117 volts" may very well be anything between 110 and 125 volts, and in some areas where electric power shortage is often critical, the emf at the mains could be 105 volts or less. Let's take a case where the vtvm is calibrated using the ac mains at an assumed 117 volts, but that voltage is actually 125 volts and the errors are accumulative. The voltage error of about 7% and meter error of 3% result in accuracy no better than 10%; not very impressive, to say the least.

calibration circuit

Fig. 1 is a simple circuit of emf sources for an indirect, but more accurate means of calibrating the vtvm ac scales. Ignoring for the moment the part to the right connected by dotted lines to Y1 and Y2, the circuit will be recognized as an ac supply — T1 with a half-wave rectifier, CR1, and a filter, C1. R1 plays no part in the filter and is only used to limit initial surge current through CR1 when power is first turned on; usually it may be omitted. There is no load across C1 except C1 leakage resistance and the backward resistance of CR1, both of which will normally be very high. Having negligible load, capacitor C1 will charge to the peak voltage of the ac emf across X1-X2 minus the forward voltage drop across CR1. T1 may be any step-down transformer. CR1 and CR2 are silicon diodes. R1, if used, may be anything between 22-100 ohms, ½ watt.

By K. F. Hager, W7KQ, Route 1, Box 186, Burton, Washington 98013

C1 and C2 are about 0.5 μF . (More about circuit parameters later).

procedure

Before calibrating the vtvm ac ranges, best possible calibration of the dc ranges should be obtained. The ac ranges are then calibrated as follows: Measure the dc voltage across Y1 and Y2 with the vtvm set for dc measurements, common lead to Y2, probe to Y1. Call this voltage E . Remove the probe from Y1, set the vtvm for ac measurements and connect the probe to X1. The rms potential across X1 and X2, E_{ac} , will be E plus the voltage drop across CR1, E_{cr} , multiplied by 0.707; that is: $E_{ac} = 0.707 (E + E_{cr})$.

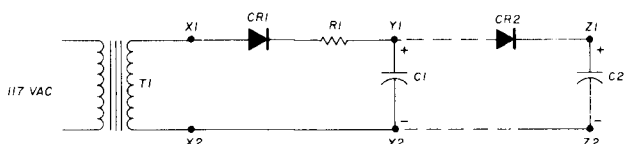


fig. 1. Circuit for calibrating the ac scales on a vtvm or icvm. The rms voltage, E_{ac} , across terminals X1, X2 is determined by $E_{ac} = 0.707 (E + E_{cr})$, where E is the dc voltage measured across Y1, Y2 and E_{cr} is the voltage drop across CR1. Circuit at right of dashed lines is used to determine E_{cr} , as explained in text.

The ac calibration setup should now be arranged to show a meter reading E_{ac} . Example: Potential E is measured at 45 volts and E_{cr} has been determined as 0.3 volt. Therefore, $0.707 (45 + 0.3) = 32.0271$ volts rms. Round this value to 32 volts. With the vtvm set for ac and probes across X1-X2, adjust the calibration so the meter reads 32 volts. Measurements should be performed several times to ensure that line voltage fluctuation doesn't introduce errors.

E_{cr} can't be measured directly with the vtvm but can be determined with a second like diode and a capacitor, CR2 and C2, connected to Y1 and Y2 as shown by the dashed lines in fig. 1. Do not attempt to measure the voltage drop by connecting the vtvm across Y1 and Z1. Shunting CR2 with the vtvm 11-megohm input resistance will cause the potential across Z1-Z2 to eventually reach the same potential as that across Y1-Y2. The speed at which this occurs, of course, depends on the capacitance of C2.

Measure the voltage at Y1-Y2 and the voltage at Z1-Z2. Note the difference in meter reading and let this difference be E_{cr} . CR1 and CR2 should be interchanged and the measurements repeated to determine any difference in voltage drop. Be sure to remove ac power and discharge the capacitors before starting a new set of measurements. In the calculation an ac sine wave is assumed; this will be found to be true where electrical power is from the U.S. and Canadian power grids. It may not be the case with a small, isolated power-generation and distribution system; in this event the waveform should be checked with an oscilloscope. Negligible load across Y1-Y2 is also assumed, and this is the case with a vtvm input resistance of 11 megohms.

circuit parameters

While nearly any available stepdown transformer may be used for T1, one that puts ac voltage across X1-X2, which permits ac and dc voltages to be read high on one scale of the vtvm, is preferable. If the vtvm has typical voltage scales of 0-1.5, 0-5, 0-15, etc., a small 6.3 V_{ac} filament transformer is satisfactory. The open-circuit voltage, which is essentially that across X1-X2, will probably be 7-8 volts or so; this permits reading ac and dc voltages well upscale on the 0-15 volt range of the vtvm. A better choice might be a transformer that places 32-35 volts across X1-X2. In this case, both readings would be taken high up on the vtvm 0-50 volt scale. A transformer placing 12-14 volts or so across X1-X2 would be a poorer choice, since the dc voltage would be read well down on the 0-50 volt scale. Connecting X1-X2 directly across the ac power mains is definitely *not* recommended. Not only would a situation similar to that just cited occur, but the practice is very hazardous.†

circuit constants

C1 and C2 may be almost any capacitors upward of about 0.5 μF . It is important that they have high leakage resistance. This requirement is easily met by tantalum or mylar-paper capacitors. Ordinary electrolytic capacitors may be used if the leakage resistance is high, although there appears little reason to use them. Capacitance is not at all critical. Capacitors between 0.22 and 80 μF have been used with no discernible difference in results. A difference in meter deflection just starts showing when the capacitance is reduced to 0.1 μF . Unnecessarily high capacitance is to be avoided, otherwise the voltage across C1 will change slowly when downward changes in ac line voltage occur. This lag makes calibration more time consuming, and possibly adds a little uncertainty in measurements. R1 may be omitted unless high capacitance is used.

Diodes CR1 and CR2 are International Resistor 170 or HEP 170, but they may be any good silicon diodes. Voltage drop across the HEP 170s, measured as described above, was 0.30 volt, with 45 volts across Y1-Y2. This drop remained constant with decreasing voltages across Y1-Y2 to 10 volts. With 5 volts across Y1-Y2, the CR voltage drop was 0.27 volt. Twelve HEP 170s were tested; 10 showed the same drop of 0.30 volt and two had just slightly less drop, with 45 volts across Y1-Y2.

In conclusion, there are a number of variables and therefore it's not possible to predict the accuracy to be expected after calibrating the vtvm ac ranges as described; however, it's likely to be better than that obtained by the usual methods of calibration.

†The vtvm common input is usually grounded to the chassis and metal case. If the common lead happened to be connected to the hot side of the ac line (a practically even chance), the full line voltage would be between the vtvm case and ground.

reference

1. Daniel A. Gomez-Ibanez, WB9IC1, "Calibrating a DC VTVM or FET VOM," *QST*, September, 1975, page 44.

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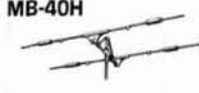
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the MPC1000 — super regulator

This versatile IC
from Motorola
provides up to 10 amps
at any voltage
to 35 volts —
here are some
typical applications

Just a few years ago a 5-volt, 10-amp, regulated power supply boasting 0.1 per cent regulation required many transistors, diodes and resistors. With the advent of power-regulator integrated circuits, the number of components has been reduced to less than a dozen. Now the Motorola MPC1000 reduces the complexity further as the need for an external pass transistor and associated current-limiting circuitry is eliminated.

While there are many applications where several 1-amp three-terminal regulators can be used, many applications simply require 10-amp capability from one regulator. For example, many solid-state power amplifiers require up to 10 amps at 28 volts with excellent

voltage regulation to prevent generation of modulation products which result from changes in V_{CC} . Other uses include large digital projects such as counters, memories, and power supplies at a repeater site.

MPC1000 voltage regulator

The MPC1000 is a positive voltage regulator capable of providing up to 10 amps output current at any voltage to 35 volts. Certainly this device represents a further step in the development of voltage regulator ICs compared with the common 1-amp and 150-mA devices.

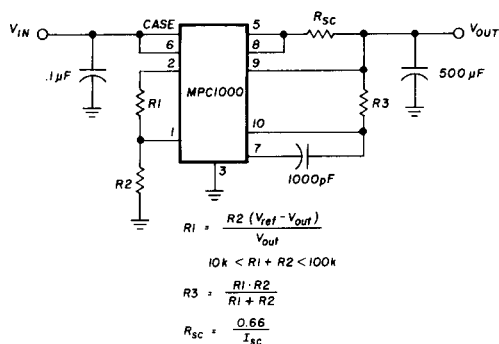


fig. 1. The MPC1000 as a positive voltage regulator for output voltages below the reference voltage, V_{ref} (7.15 ± 0.35 volts), including formulas for choosing the resistors that set the output voltage.

An additional feature of the MPC1000 is that it can be used in applications requiring negative voltages.

Since the MPC1000 can dissipate 100 watts, if you do require the full 10 amps you should choose a power transformer with a secondary voltage that doesn't ex-

By Gary L. Tater, W3HUC, 7925 Nottingham Way, Ellicott City, Maryland 21043

table 1. Electrical characteristics of the Motorola MPC1000 high-power voltage-regulator IC.

parameter	range or value
input voltage, V_{in}	+40 volts max
output voltage, V_{out}	+2 - +35 volts
voltage reference, V_{ref}	7.15 ± 0.35 volts
output current, I_L	10 amps
internal power dissipation at 25C, P_d	100 watts
derate above 25C	$0.667 \text{ W}/^\circ\text{C}$.
quiescent current, I_q	5 mA
line regulation, $V_{in} = 12\text{-}15$ volts	$0.1\% V_{out}$
line regulation, $V_{in} = 12\text{-}40$ volts	$0.5\% V_{out}$
load regulation, $I_L = 0.1\text{-}4$ amp	$0.1\% V_{out}$

ceed the output voltage from the IC by more than 10 volts. Table 1 lists the electrical characteristics needed to use the MPC1000.

The basic positive voltage regulator circuit for voltages below the reference voltage (7.15 ± 0.35 volts) for the MPC1000 is shown in fig. 1. For output voltages

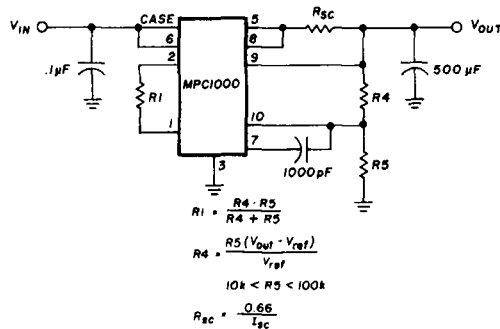


fig. 2. The MPC1000 as a positive voltage regulator for voltages above the reference voltage, V_{ref} .

above 7 volts, the circuit in fig. 2 should be used. Each includes equations for choosing the three resistors that set the output voltage.

Both circuits require a $0.1 \mu\text{F}$ capacitor at the IC input. If the input to the pass transistor (case) and the input to the rest of the regulator (pin 6) are separated, each would require a $0.1 \mu\text{F}$ capacitor. Such a situation would arise when you wish to operate the series pass transistor at a lower voltage than the rest of the IC to minimize heat dissipation within the device.

The current-limiting resistor, R_{sc} , typically runs from 0.66-0.066 ohms. If you have a resistance bridge, you can cut a length of wire to the exact resistance value by successively cutting off wire until that value is reached.

table 2. Data for computing the length of wire for the short-circuit sensing resistor, R_{sc} , in the regulator output circuit. Wire should be cut 50 per cent longer than lengths shown, then trimmed to obtain the required pass current.

copper wire size AWG (mm)	length ft (m)	resistance per 1000 ft (m) (ohms)
16 (1.3)	15.5 (4.7)	4.096 (1.25)
18 (1.0)	10.0 (3.0)	6.510 (1.98)
20 (0.8)	6.6 (2.0)	10.35 (3.15)
22 (0.6)	4.0 (1.2)	16.46 (5.0)

Table 2 lists information to approximate the length of wire needed. If you use this table, I recommend you cut the wire at least 50-percent longer than the calculated amount, then put a resistive load on the completed power supply. If your calculations were correct, the supply will immediately shut down. The short-circuit resistor can now be shortened by small increments until your current requirements are met. Although this procedure may require several cuts, it's the safest method to

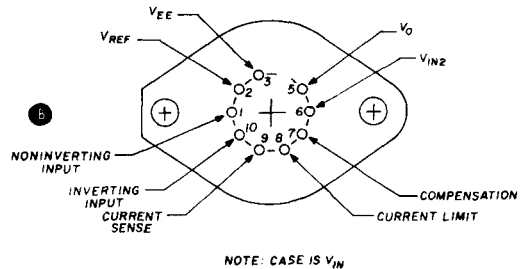
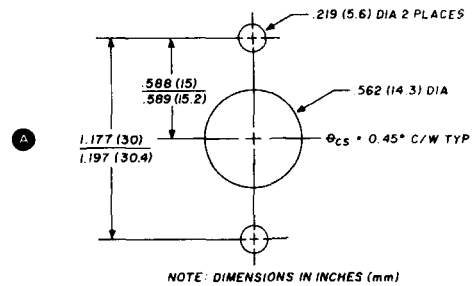


fig. 3. Mounting-hole pattern, A, and base diagram, B, of the MPC1000 voltage-regulator IC. A 9-pin tube socket makes a good mount — but observe pin-number sequence.

use if you don't have an instrument that measures low values of resistance.

mounting

To realize the maximum ratings of this device, the MPC1000 should be mounted on a good heatsink. A simple heatsink mounting-hole pattern is shown in fig. 3A. I didn't have a 9/16-inch (14.5mm) punch, so I substituted a 5/8-inch (16mm) hole, which reduced the thermal path from the IC. A mica washer and socket are available from the manufacturer under the part number MK662.

If you want the regulator on the rear apron of a chassis to dissipate heat, a handy solution for making

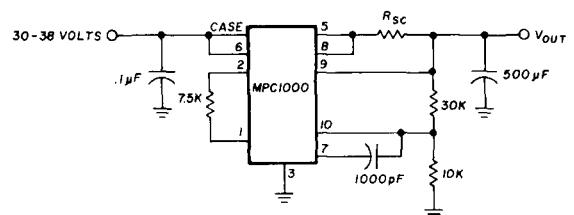
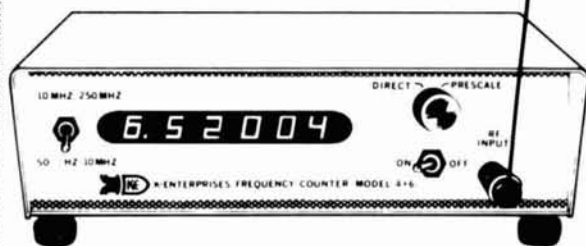


fig. 4. High-current, 28-volt regulator for high-power rf applications.

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contact to the pins is to use a 9-pin miniature tube socket. Fig. 3B shows a bottom view of the pin connections. Note that the pins are *not* numbered sequentially.

practical circuits

I needed a 28-volt, 7-amp supply to power an fm Skyphone that I had converted from 459 to 432 MHz CW for Oscar 7, so I built the circuit in fig. 4 first. I used a 30-volt transformer with a bridge rectifier, which

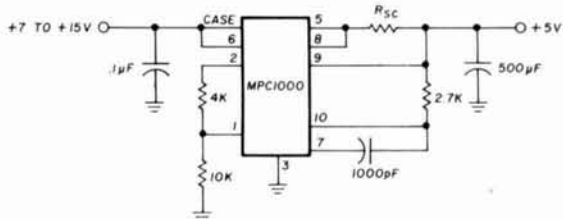


fig. 5. A 5-volt regulator suitable for high-current applications.

worked well when the short-circuit sensing resistor, R_{SC} , was adjusted properly. The initial shunt resistor was too long and caused the IC to shut down during key down. I removed two feet of wire from the homemade resistor, and the power regulator worked as advertised.

If you need several amps at 5 volts for a large TTL project, the circuit in fig. 5 should be useful. For a typical 8-digit frequency counter, which could require 3 or more amps, this one IC and its associated components could replace up to 4 three-terminal regulators.

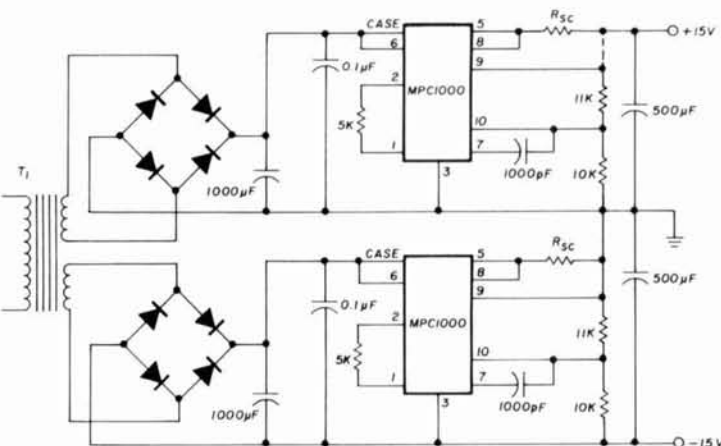


fig. 6. Regulator for providing +15 and -15 volts at 10 amps. T1 should supply 18-24 volts rms from each secondary winding.

The circuit in fig. 6 illustrates another feature of the MPC1000: two can be used to produce negative and positive supply voltages. The example in fig. 6 shows a high-current supply with a positive and negative 15-volt output.

Clearly, the MPC1000 is a versatile IC that can provide a quality high-current regulated power supply for your projects.

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how to clean printed-circuit boards

Here are some
straight forward methods
for cleaning PC boards
after you have installed
the components

There are still many amateurs who despite the efforts in obtaining parts, build their own equipment. The use of solid-state devices makes it mandatory that, at one time or another, the assemblies be done on printed-circuit boards. There has been a good deal of information published in the amateur magazines pertaining to board fabrication — from the original artwork through to the final piece. This short article presents information on the final step in the process and provides some answers to that age old question, "Is a clean board really necessary?"

All of us have noted that commercially manufactured equipment shows no globs of rosin or other soils (if they are there, don't buy it). Since it costs something to obtain that result, we must assume that there is a good electrical reason — as opposed to cosmetic — for the added expense and there is. Further, there is an extensive military specification for board cleanliness.

To fully appreciate the problem and its solution let's talk a little about dirt. Since I have no intention of giving a chemistry lesson, suffice it to say that there are two kinds of soil that remain on circuit boards after you finish etching, drilling, inserting parts (also known as stuffing), and soldering. One is called polar or ionic and consists mainly of the residue from plating baths, etchants and, most important of all, residues of oil from your fingers. The latter is the most insidious. (As a point of information, it is an acknowledged industry fact that the residue from female fingers is different than that from male fingers). All the residues behave differently under varying climatic conditions. If your circuit board is to be used in a humid atmosphere — and where is the place where there is no moisture in the air — the finger

soil should be cleaned off with a solvent that will dissolve ionic material. I'll get into details in a moment because, as you will discover, we really need two different solvents for a perfect cleaning job.

The most noticeable residue found on PC boards and least potentially harmful is the hardened rosin residue of the flux. Rosin-based flux is a necessary evil used in all soldering operations. It is the best and safest remover of oxides of copper we have available and in order to make good solder joints the copper must be clean. Many claims have been made regarding so-called water soluble fluxes, which are highly active ammonium salts; I'm sure their use is advantageous in some instances, but I'm old fashioned and still prefer rosin-based systems. The residue from rosin-based fluxes is non-polar (non-ionic) and requires the use of non-polar or non-ionic solvents to dissolve it. Ionic residue can cause corrosion and shorting between conductors on a board because it can become conductive. On the other hand, rosin residues are insulators when dry and not decomposed; heat with humidity can cause rosin residues to decompose and become conductive.

How then can we insure that all our hard work will result in a working assembly over a long period of time under all conditions of environment? We clean the board with proper solvents using correct procedures. For the two types of soil there are two types of cleaner: polar and non-polar solvents. Water and alcohol are examples of polar solvents; chlorinated and flourinated hydrocarbons are examples of non-polar solvents. Trichloroethylene, trichloroethane, perchloroethylene and trichlorotrifluoroethane are some examples of non-polar solvents. Now that I have impressed you with a lot of fancy words, let's get down to practical cases. It is definitely advisable to clean off your boards, and there are several sources for some of the mouth-crackers listed above. It is certainly not difficult to find water although it is industry practice to buy de-ionized water to reduce contaminating residue contained in tap water. The alcohol is not the drinking kind but ethyl or propyl alcohol; 80% strength rubbing alcohol available in drug stores is suitable. Remember, the finger soil you want to remove is usually not visible, so just clean off the board with a brush dipped in the alcohol.

Obtaining and using a non-polar cleaner is not much more difficult. Trichloroethane, the recommended cleaning agent (also known as Trichloroethane 1,1,1;

By Budd Meyer, K2PMA, 6505 Yellowstone Boulevard, Forest Hills, New York 11375

chloroethene NU; VG), is available in electronic stores and from Miller-Stephenson* in spray cans. Not the least expensive way, but convenient. Freon TE is also available in spray cans. Another source, available in supermarkets in quart cans is *Afta*, a trichloroethylene-based household cleaner. Unfortunately trichloroethylene, as opposed to trichloroethane, can be hazardous if used improperly.

The methodology involved is to flood the area to be cleaned with clean solvent and scrub the area with a brush. I have found that the most effective method is to wet a local area, use a paste brush to scrub the area, then blow on the area or use a fan to assist in rapid evaporation. In industrial use the entire board is either immersed in the cleaner (except as noted below) or placed in a vapor degreaser. The degreaser consists of a large tank of solvent contained in a sump. Heating coils cause the volatile liquid to evaporate rapidly and become a "fog" just above the liquid. The boards are lowered into the fog and the condensate carrying the soil returns back to the sump. This allows the residues to eventually be separated from the fluid, which can be used many times after it has been cleaned up.

You must be cautioned that in recent years it has been discovered that chlorinated hydrocarbons wreak havoc with electrolytic capacitors. The most serious result is that the destruct phase doesn't occur until after many months or years of use. Avoid, with a passion, getting any of these solvents on or around the plugs (insulators) at the positive terminal of electrolytics. Alcohol won't cause any damage as far as is known — but neither will it clean up rosin residues. To emphasize how important this is, electrolytic capacitors that must be cleaned in trichlor now have an additional epoxy seal covering the positive end, and the manufacturers, having recognized the problem, are coming on line with new approaches to sealing the cans with new materials. Also be sure to keep trichlor away from polystyrene parts such as capacitors and trimmer capacitors. They will melt — literally! You should also be cautioned against using trichloroethylene in any place but a well ventilated area and to keep the amount of fluid coming into contact with skin to the barest minimum. If in doubt stick to trichloroethane.

Obviously, the ideal solution would be a mixture of polar and non-polar cleaners. These are available from solder manufacturers, usually under proprietary names, but unless you're willing to buy by the gallon, forget it. Localized cleaning is adequate for the small quantity boards amateurs have to make, and despite all the negative connotations noted above, it can be accomplished safely with care and common sense. Most of your cleaning will be on the copper side of the board away from the components. At the least, removing as much of the residues as possible results in a professional looking board, requires little effort, and will go a long way toward insuring reliability.

ham radio

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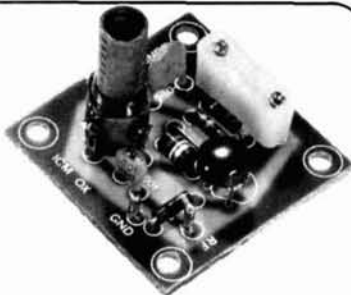
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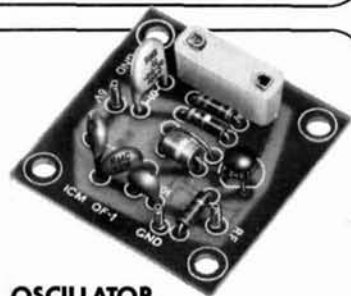
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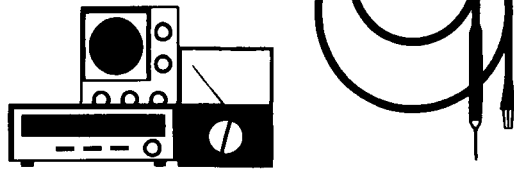
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repair bench



Joe Carr, K4IPV

troubleshooting transistor circuits

In this installment of **repair bench** I'll discuss troubleshooting of bipolar transistor circuits. The principal test equipment will be the vom or vtm and, if you prefer, a transistor tester. First let's review some things about transistors that might affect servicing and troubleshooting.

preliminary considerations

In **fig. 1A** a stylized npn transistor is shown with its base-to-emitter junction connected across a power supply that causes it to be reverse biased. In this condition, charge carriers will be drawn away from the region

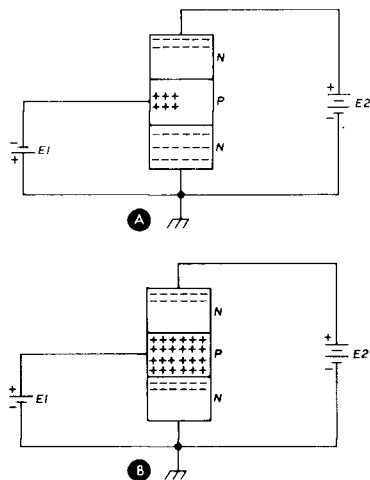


fig. 1. Relationship of charge-carrier propagation across the base-emitter junction in an npn transistor with reverse bias (A), and forward bias (B).

at the junction, creating a relatively wide depletion zone. This allows only a very small current to flow across the junction. In **fig. 1B** the base-to-emitter bias voltage is changed so that the base-emitter junction is forward biased. Charge carriers are repelled by the battery polarity and are driven toward the junction barrier. Here they can combine with oppositely charged carriers from across the junction.

Figs. 2A and **2B** show proper forward-bias-voltage relationships for npn and pnp transistors respectively. In an npn transistor circuit the base is positive with respect to the emitter by approximately 0.7 volt for silicon and 0.2 volt for germanium types. Pnp transistors have about the same values of voltage drop across the base-emitter junction, but it is of opposite polarity. On these transistors the base is more negative (or less positive) than the emitter. (Keep in mind that these polarities are relative quantities).

table 1. Junction voltages to be expected in a normally operating transistor amplifier. Values for silicon devices are shown, followed by those for germanium (in parentheses). Readings 1 and 3 were taken with the minus meter probe on the emitter; reading 2 was taken with the minus probe on the transistor base.

junction	npn	pnp
1. base-to-emitter	+0.7 (0.2)	-0.7 (0.2)
2. collector-to-base	++	--
3. collector-to-emitter	++	--

A pnp transistor, as in the example of **fig. 3**, is still correctly biased despite the fact that the voltages on the elements are positive with respect to ground. Since the base is at 9.3 volts and the emitter at 10.0 volts, the base

will measure - 0.7 volt with respect to the emitter. **Table 1** gives voltage levels to be expected in a normally operating transistor amplifier stage. These voltages may not hold, however, in control circuits (such as squelch) or pulse circuits where the transistor may be reversed biased in one mode or another.

dc voltage checks

Any transistor stage has several dc voltages of interest to the troubleshooter. You want to measure the voltage drop across the emitter and collector load resistors and the base-emitter bias voltage. From these measurements you should be able to spot most faults. Of course, a circuit diagram that shows correct values would be of

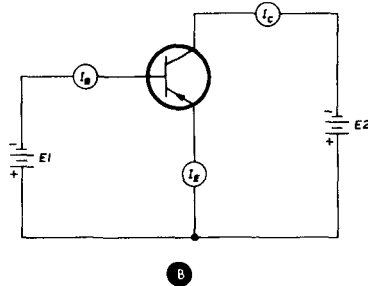
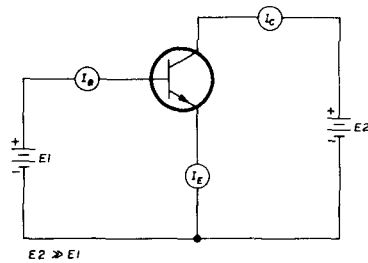


fig. 2. Proper forward-bias-voltage relationships for npn (A), and pnp (B), transistors. In (A) the base is normally positive with respect to emitter by about 0.7 volt for silicon devices and about 0.2 volt for germanium devices.

immense use, but it's not always necessary if you know what "ballpark" levels to expect.

Perhaps the best method for learning the pattern of dc voltages that might be expected in the more common forms of transistor failure is the "case-history" approach. Assume that you have isolated the fault to a stage such as in fig. 4 using signal tracing, signal injection or some other technique. Make the dc voltage measurements shown circled in fig. 4. Note that the emitter voltage is zero. Unless somebody has successfully repudiated Mr. Ohm, you're safe in assuming that the emitter current is also zero. You can also conclude that the collector current is either zero or at a very low value, because the collector voltage is close to the source voltage: a level about $V_{cc}/2$ would be normal. Measuring the base-to-emitter bias voltage, you find 10.7 volts instead of 0.7 volt. These symptoms usually point to an open base-to-emitter junction in the transistor. An ohmmeter or transistor checker will tell the tale if you're still in doubt.

Fig. 5 shows another common defect and its voltage relationships. The emitter voltage is about 0.27 volt, which results in a very low emitter current. Since you again have a collector voltage (17.4 volts) almost equal to V_{cc} (18 volts), you can say that no significant col-

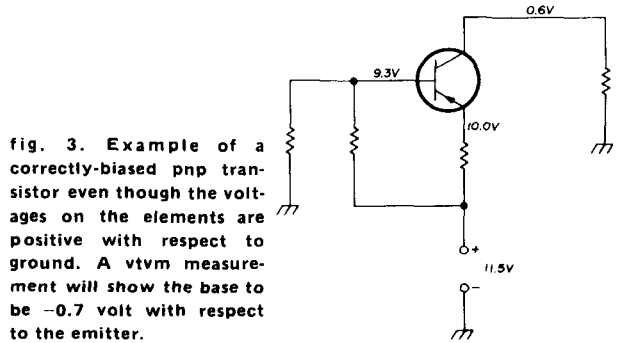


fig. 3. Example of a correctly-biased pnp transistor even though the voltages on the elements are positive with respect to ground. A vtvm measurement will show the base to be -0.7 volt with respect to the emitter.

lector-emitter current is flowing. The base-to-emitter voltage, however, is almost normal, so this junction is probably all right. In this case the collector-to-base junction is open.

A further common fault in transistor circuits is shown in fig. 6. Measurements show a low collector voltage equal or a voltage very close to the emitter voltage. This transistor probably has a collector-to-emitter short circuit. If enough power has been dissipated, this effect may cause collector and emitter resistors to burnout. This condition almost always occurs in class-A audio amplifiers.

transistor testers

Once you've decided that a particular transistor is suspect, you might wish to make further tests using one

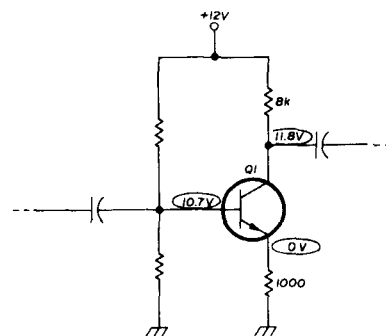


fig. 4. Example of the "case-history" approach to fault isolation in a transistor stage. Circled measurements indicate an open base-to-emitter junction.

of the many transistor checkers on the market. Simple instruments that claim to measure transistor beta are available at low cost, both ready built and in kit form. Be aware that the really inexpensive checkers might be

too simple to give an accurate picture of the transistor's characteristics. The best transistor checker for ordinary service will provide some means for varying base current so you can determine whether the transistor base is able to control collector current.

An ohmmeter can be used as a transistor checker and can tell you quite a bit about the device under test. Certain precautions must be observed, however, as to the types of ohmmeters that are acceptable. Determine what type battery is used in the *ohms* section of your meter. If it's more than 1.5 volts, you may ruin as many transistors as you test! Some older instruments use battery voltages as high as 22.5 volts for the ohmmeter sections.

Alternatively, some modern fet voltmeters have an

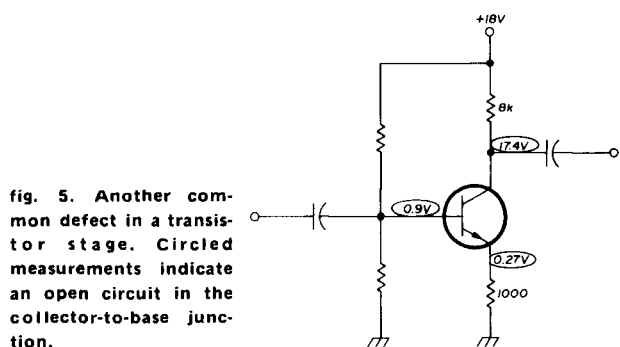


fig. 5. Another common defect in a transistor stage. Circled measurements indicate an open circuit in the collector-to-base junction.

ohmmeter source voltage that is too low for use as a "Transistor tester." This is a double-edged situation, because a desirable feature of such instruments is that they can be used to make in-circuit resistance measurements without removing the semiconductor devices. It is this very feature, however, that eliminates the instrument as a transistor tester. The dc voltage across the ohmmeter probes is too low to forward bias the pn junctions.

Test each junction separately by measuring its resistance twice (fig. 7). Measure the resistance the second time with the probes reversed from the direction used on the first try. Transistor junctions can be viewed as pn diodes and will not pass current in both directions under normal circumstances, so a very high resistance should occur in one direction and a much lower resistance in the opposite direction.

Normally, the reverse-forward ratio should be greater than 10:1. Check both base-to-emitter and collector-to-base junctions in this same manner. On power transistors use the RX1 scale, and on small transistors use the RX100 and RX1000 scales. If too low a resistance scale is used on those small transistors you may blow the junction.

Collector-to-emitter leakage may be checked in the same manner. Make two readings and take the higher one as the leakage resistance. The higher the better, and if it approaches your ohmmeter's idea of "infinity" so much the better. While making this test, you can also ascertain whether the base can control collector current.

Connect the ohmmeter probes between collector and emitter. Next, short the base to the collector and note whether the resistance reading drops. If there is no response, reverse the probes and try again. If again there is no response, assume the transistor is dead.

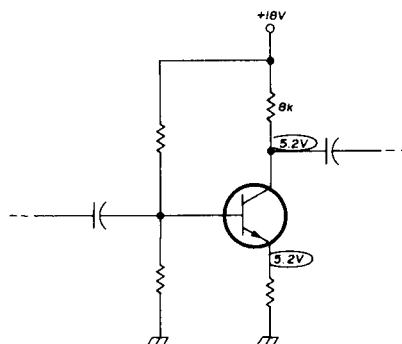


fig. 6. Circled measurements indicate a probable collector-to-emitter short circuit.

which stage is bad?

Signal tracing or signal injection techniques may provide the answer. However, a high-amplitude signal from a signal generator, or a transient generated when connection is made, may shock excite the defective transistor into normal operation. A far better technique would be to use dc analysis initially, then use one of the more traditional techniques only if the dc test fails.

Dc signal tracing requires only a vtvm or high-impedance vom. Fig. 8 shows the transistor lineup in a

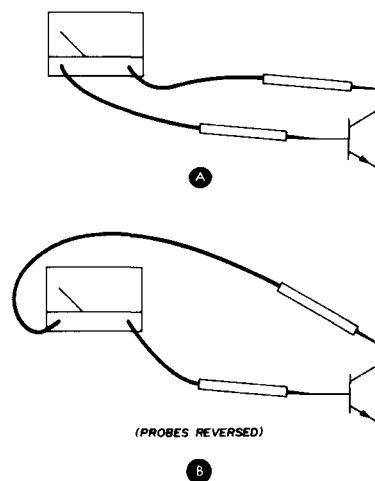


fig. 7. Using an ohmmeter as a transistor checker. Each junction resistance should be measured twice with the ohmmeter probes connected as in (A), then reversed, as in (B). If the transistor is good, the reverse-to-forward ratio should be greater than 10:1.

typical vhf fm receiver. This unit uses npn transistors, so ground the voltmeter minus probe, then use the positive probe to measure the voltage at each emitter in succession. Loss of emitter voltage indicates an open transistor or some defect that causes bias to be removed. The dc level tells you "this is the bad stage," and from there you can ascertain what's wrong. A higher-than-normal

emitter voltage, on the other hand, indicates a leaky or shorted transistor.

Rf amplifiers and some gain-controlled i-f amplifier stages may yield false negative results when this test is used because of agc action. If you can't disable the agc, try rocking the tuning dial back and forth while noting meter readings. The agc-controlled stage will show voltage variations as the dial is tuned across incoming stations. Although the agc can foul you up when troubleshooting, it can nevertheless be used to advantage. If the emitter voltage in this stage (or the collector voltage in some pnp rigs) varies as the dial is tuned across an active band, you can be pretty sure the defect is *not* between the antenna input terminals and the point where the i-f signal is sampled for the agc drive.

An S-meter can be used instead of a voltmeter as an overall check. Note whether the S-meter deflects normally as the receiver is tuned across the band. If it does then look elsewhere; if no S-meter deflection occurs, a problem exists within the agc loop.

A similar technique may be used to troubleshoot receivers that use pnp transistors, with modifications in procedure to account for the difference in transistor polarity. (In both cases assume that negative grounding is used — a fair assumption in most mobile equipment, but one possibly tinged with errors in some home equipment). In a pnp stage, connect the voltmeter positive probe to the B+ line and use the minus probe to measure the emitter resistor voltage drop (fig. 9). Most receivers use a fairly hefty electrolytic capacitor to decouple the B+ line; this component may often be used as a point of identification if no schematic is available. As in the case

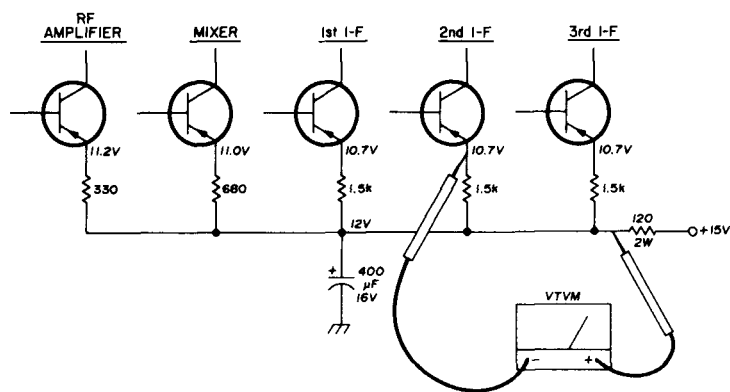


fig. 9. Using a vtvm for dc signal tracing in a vhf-fm receiver with pnp transistors. As in the circuit of fig. 8, the voltage measured at the emitter resistor will give clues as to device malfunction.

of npn stages, the voltage drop at the emitter resistor can give clues as to device malfunction.

The oscillator stage can be checked using dc analysis techniques as an indicator of oscillation (but not of oscillation frequency). Connect a voltmeter across the emitter resistor, using whichever procedure is applicable to the transistor polarity. Tune the dial from one end of

the band to the other. The emitter-resistor voltage drop will vary as the dial is tuned. This change will be greater on general coverage-receivers than on amateur-band-only models; but, even in the latter, some change will be noted. In crystal oscillators, sometimes a change in

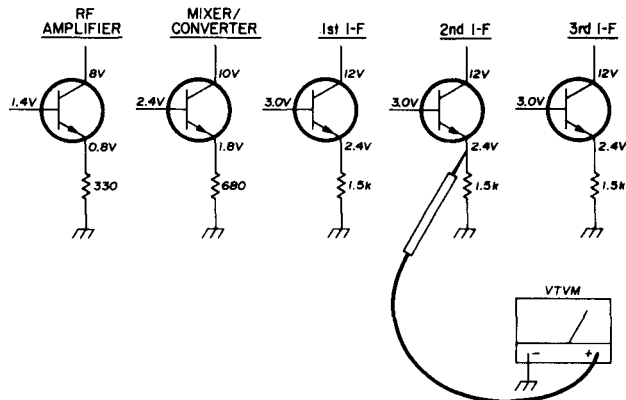


fig. 8. Dc signal tracing with a vtvm in a typical vhf-fm receiver using npn transistors. The probes should be connected as shown. Loss of emitter voltage indicates an open transistor or some defect that causes loss of bias.

emitter-resistor voltage drop will occur when the crystal is removed from the circuit. In either case, the change identifies oscillation.

caution note

Vacuum-tube test equipment is tolerant of some abuse, but transistorized equipment is not always so forgiving. Use of ungrounded ac-powered test equipment can easily generate both transient and steady-state voltage levels, which are quite capable of destroying transistors. Ground the cases of your test equipment. Two-wire power cords always identify ungrounded test equipment. For safety reasons it's wise to convert to three-wire power cords, in which the third wire is grounded to the chassis and cabinet. Of course, this only applies to equipment which is *not* ac/dc.

Grounded test equipment can create problems when troubleshooting, as in fig. 9, where the grounded case might be connected to the voltmeter minus probe. In that case, you must use either a battery-operated voltmeter such as a vom or fetvm, or a voltmeter which, although ac powered, isolates both input probes from chassis. This, incidentally, seems to be the way many modern digital voltmeters are being made.

conclusion

The material presented here is intended for the average amateur who likes to service his own equipment. I've tried to cover the most likely problems that may be encountered. The procedures given should prove useful and will allow you to get back on the air as soon as possible without spending a lot of money for a repair bill.

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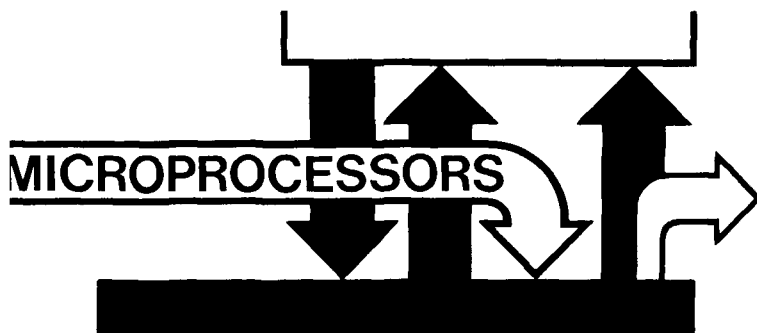
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interfacing a digital multimeter with an 8080-based microcomputer

This month we'll discuss the interfacing of an 8080-based microcomputer with a very versatile laboratory instrument, the Keithley model 160B digital multimeter with model 1602B digital output. We purchased this multimeter one year ago and found it to be an excellent example of what manufacturers can do to facilitate the interfacing of their instruments.

The Keithley model 160B is a general-purpose 3½-digit multimeter that can function as a dc voltmeter, dc ammeter, or ohmmeter. Twenty-six different ranges exist for the multimeter in its three modes of operation. The lowest range scales provide maximum readings of 1.999 mV, 19.99 nA, and 1.999 ohms. The 1.999 mV scale has an accuracy of $\pm 0.1\%$ of reading ± 1 digit. Thus, a display reading of 1.000 mV will have an uncertainty of ± 0.002 mV, or $2 \mu\text{V}$. The highest possible readings associated with the three different modes of operation are 1200 volts, 1999 mA, and 1999 megohms, with the megohm reading accurate to only $\pm 30\%$. This multimeter can be viewed as the digital complement of the ubiquitous multirange chart recorder.

The multimeter is basically a sophisticated analog-to-digital converter (ADC) that can handle most laboratory

requirements for a digital data acquisition provided the data acquisition rate is no greater than one data point per second.* Switching between the 26 different ranges is performed manually. We would expect that, in the future, such switching will be performed by a built-in microprocessor operating under the control of an external computer.

The basic point of this month's column is the full interface circuit, shown in fig. 1, between the Keithley model 160B and a small development 8080-based microcomputer. The two OR gates and the SN74154 decoder generate the three different *device select pulses*¹ required to input data from the Keithley meter to the 8080 microcomputer. Note the $\overline{\text{IN}}$ input at pin 18 of the SN74154 decoder. This interface circuit takes advantage of the fact that all outputs from the 1602B digital output board are *open collector* and can be *bussed* together as in fig. 1. The noun, *bus*, can be defined as follows:²

A path over which digital information is transferred, from any of several sources to any of several destinations. Only one transfer of information can take place at any one time. While such transfer is taking place, all other sources tied to the bus must be disabled.

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

*The settling time of the multimeter is about two seconds. Although five data conversions can be made per second, it may take about one second for the precision of a typical data point to reach 0.1% or 0.2%.

Notice how pins 16, 12, and 10 on the Model 160B are connected to the same input, D7, of the 8080 microcomputer. These three pins are said to be bussed together. Pins 35, 31, and 28 are bussed together to input D6; pins 17, 13, and 9 to input D5; pins 36, 32, and 27 to input D4; and so on. The eight inputs to the 8080, D0 through D7, comprise an eight-bit data bus over which information passes, one group at a time, from the Keithley multimeter to the 8080 microcomputer.

of data from the multimeter to the microcomputer over a set of eight data bus lines labeled D0 through D7.

A simple program that accomplishes the data transfer from the multimeter to the microcomputer is provided in table 1. The entire data acquisition and movement of data to registers C, D, and E occurs in 21 microseconds, a time that is fast when compared to the rate of five conversions per second by the multimeter. Clearly, considerable time is still available to the microcomputer

table 1. Microcomputer program that demonstrates the acquisition of 20 bits of data over the eight-bit data bus between the Keithley multimeter and the 8080 microcomputer shown in fig. 1.

10 memory address	instruction byte	mnemonic	clock cycles	description
000	333	IN 5	10	Generate device-select pulse that strobes the 10^0 and 10^1 digits into the accumulator
001	005	—	—	Device code for strobe inputs 1 and 2
002	117	MOV C,A	4	Move accumulator contents to register C
003	333	IN 4	10	Generate device-select pulse that strobes the 10^2 digit, the 10^3 bit, and the overload and polarity outputs into the accumulator
004	004	—	—	Device code for strobe inputs 3 and 4
005	127	MOV D,A	4	Move accumulator contents to register D
006	333	IN 3	10	Generate device-select pulse that strobes the Flag, $\overline{\text{Flag}}$, DP1, DP2, and DP3 outputs into the accumulator
007	003	—	—	Device code for strobe inputs 5 and 6
010	137	MOV E,A	4	Move accumulator contents to register E

At this point, 20 data bits are stored in registers C, D, and E. The microcomputer can now take this information and manipulate it in different ways. With the aid of the BCD digits and DP1, DP2, and DP3, it can determine the magnitude of the input decimal number. With the aid of the polarity input, the sign of the decimal number can be determined.

In the definition of a bus, it is indicated that only one transfer of information can take place at any one time. In fig. 1, this transfer is accomplished with the aid of the three sets of two strobe inputs. When a logic 0 is applied at strobes 1 and 2, the BCD codes corresponding to the 10^0 and 10^1 digits are transferred to the 8080 accumulator. The strobe signal for strobe inputs 1 and 2 is provided as a negative device-select pulse from channel 5 of the SN74154 decoder chip. In a similar manner, strobes 3 and 4 and also 5 and 6 permit the acquisition by the microcomputer of the remaining output data from the Keithley multimeter. In summary, three device-select pulses permit strobing twenty output bits

to manipulate the acquired data before new data is input into the accumulator.

Some additional explanation of fig. 1 is appropriate. Not shown in the figure are eight 4700-ohm resistors that are the *pull-up resistors* for the eight open-collector bus lines. One pull-up resistor is required for each of the eight data bus inputs. One end of the resistor is tied to +5 volts and the other end to the bus line. These resistors are not shown in the diagram because they can be added to the circuit board within the Keithley multimeter. The 8080 data bus normally employs an alternative bussing technique called *three-state bussing*. The interface circuit of fig. 1 represents a marriage of the two bussing techniques, open-collector and three-state. The 4700-ohm resistors do add a load to the data bus, but this does not prevent other devices from being tied to the bus provided each bus connection in the other devices can sink, in the logic 0 state, the additional 1 mA current produced by the 4700-ohm pull-up resistor.

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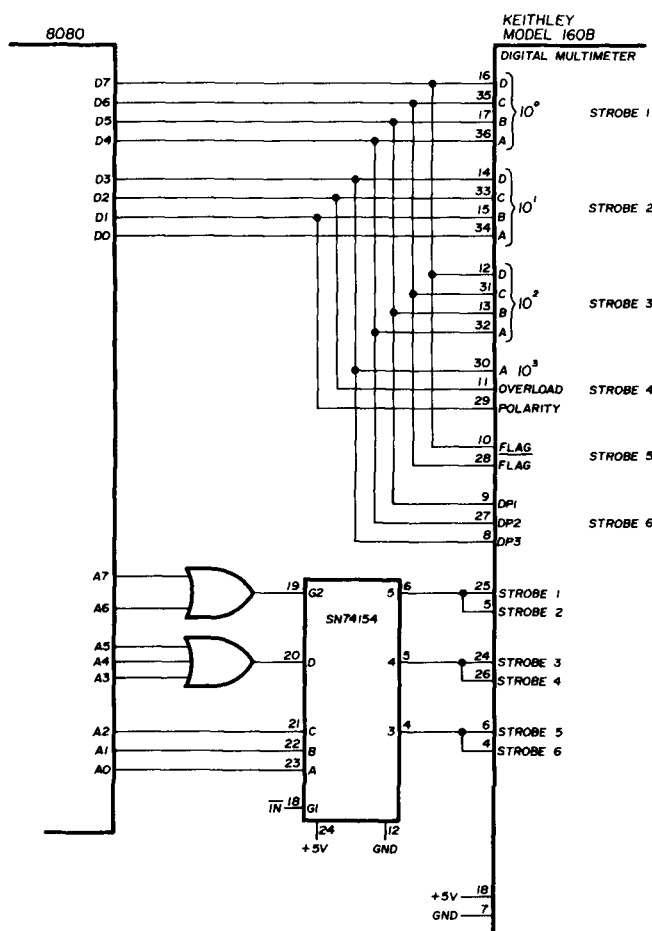
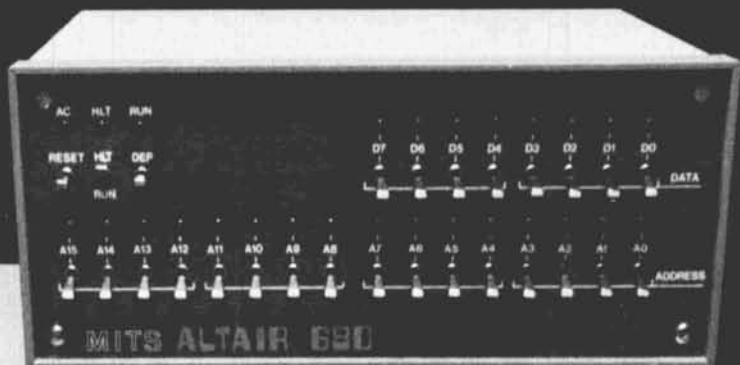


fig. 1. Interface circuit for a Keithley Model 160B multimeter and an 8080-based microcomputer.

At the beginning of this column, we stated that the Keithley multimeter is an example of what manufacturers can do to facilitate the interfacing of their instruments. In this case, what Keithley did was to provide open-collector outputs for all 20 output pins on the model 1602B digital output board. The added cost was small compared to the added value of the instrument. We expect future instruments to be microcomputer oriented in the sense that data bus outputs will be provided to permit direct interfacing of the instruments to microcomputers through simple wire interconnections. We hope these columns will encourage manufacturers to provide minicomputer- and microcomputer-oriented digital outputs and document such outputs as well as Keithley has done with their model 160B.

references

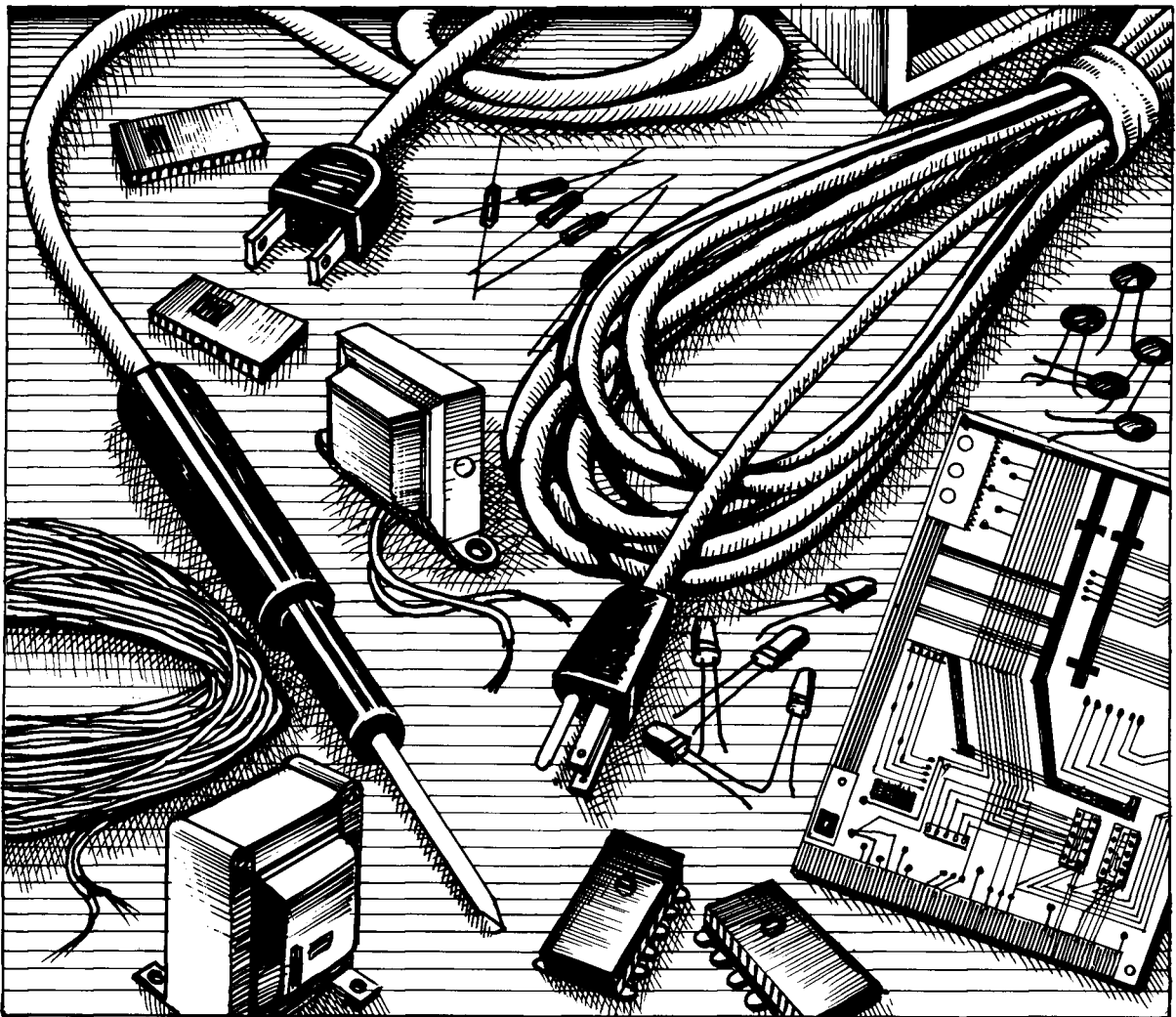
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2. *Bugbook III. Microcomputer Interfacing Experiments Using the Mark 80 Microcomputer, an 8080 System*, E&L Instruments, Inc., Derby, Connecticut, 1975.



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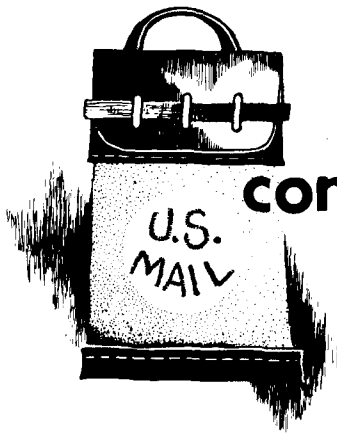
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comments

fet-bipolar amplifiers

Dear HR:

I would like to comment on Irving Gottlieb's article, "A New Look at Solid-State Amplifiers," which appeared in the February, 1976, issue. The transconductance of all bipolar transistors is basically the same and equal to $1/r_e$ which explains why the spec sheets do not bother to mention it. The emitter resistance, r_e , has a value of 26 ohms at room temperature and 1 milliamperes. This is because KT/q , the average energy of the current carriers, is 26 millivolts at this temperature. The bipolar G_m is thus $1/26$ or 38,461 micromhos. The author by some roundabout calculations arrives at an erroneous figure of 300,000 micromhos for the bipolar G_m because he made the false supposition that the gain of the fet is 4 in his fig. 1B. The gain of the fet is the transconductance multiplied by the load impedance which is the input impedance of the bipolar transistor in this instance. The bipolar input impedance is 26 times beta. For the transistor the author considered, beta (grounded-emitter current gain) is 300 or the input impedance is 26×300 or 7800 ohms. The fet gain is then 4000×7800 divided by a million or 31.2. If the erroneous 4 is removed from the author's G_{m2} calculation and 31.2 substituted, the G_{m2} becomes $4000 \times 300/31.2$ or 38,461 micromhos.

The reader may conclude that the author's fet-bipolar combination produces greater gain than can be realized from a cascade pair of bipolars. The author seems to duck this comparison except to indulge in the debasing rhetoric of the bipolar's "current hun-

gry base-emitter junction," etc. The gain of the author's pair is 1200 times the output impedance in kilohms. Two bipolars would supply a first stage gain of $38,461 \times 7800 \times 10^{-6}$ or 300 times while the second would have 38.46 times the kilohm output impedance. The total gain of the two bipolars is then 300×38.46 or 11,538 times the kilohm output Z . The gain superiority of the bipolar pair is thus $11,538/1200$ or 9.615. We can then afford to lose 9.615 in a matching transformer to feed the "current hungry base" which means the impedance level can be $7800 \times (9.615)^2$ or 7800×92.45 which equals 721,096 ohms. Since the ordinary impedance levels are considerably less than this, the matching can be accomplished with less loss in gain and the bipolar combination will show a substantial superiority.

Since the author considered a bipolar type that is basically an audio transistor, I assume that his basic interest was at the lower frequencies. It should be pointed out, I believe, that as the frequency increases, vacuum tubes and fets can produce "current hungry inputs" of their own. This is because of negative feedback from common lead impedances and coupling capacitances. At 100 MHz, the input impedance of these majority-carrier devices may be no more than the bipolar's and thus with the necessity to match removed, the bipolar's superiority is even more telling.

J.A. Worcester

Worcester Electronics Laboratory
Frankfort, New York

To begin with, it is not correct to say that the transconductance of all bipolar transistors is $1/26$ milliohms, or 38,461 micromhos. If this were so, we would have long ago had a single "universal" transistor, rather than the thousands of types now extant. To bring this statement into a plausible ballpark, one would have to modify it as follows: "All bipolar transistors tend to develop the

parameter of transconductance at the rate of 38,461 micromhos per milliamperes of emitter current." Thus, we can expect to see evidence of my "alleged" 300,000 micromhos with the practically-reasonable emitter (and collector) current of about 7.5 milliamperes. Inasmuch as the silicon transistor tends to develop higher transconductance per milliamperes than do germanium devices, one might obtain a transconductance of 300,000 micromhos with even less current, say in the vicinity of five or six milliamperes. (The current dependency of r_e , and therefore, transconductance, is clearly explained in the seventh edition of the General-Electric Transistor Manual, pages 45 and 46, under "Emitter Diffusion Resistance, r_e ").

Nowhere did I infer any intention to operate the bipolars at one milliamperes. Hopefully, my bias networks will enable operation in the five to ten milliamperes region. In the event the experimenter does not initially attain such operation, he can very easily bring it about by changing any one of the three emitter-base biasing resistors. The reason I mention this is that these inexpensive silicon-transistors often have beta tolerances as great as five to one. However, in a sample quantity of ten 2N3565s I found that seven of them had betas exceeding 250. So, I feel that my "nominal" beta of 300 is not atypical. Because of the current dependency of transconductance, you will find power transistors with transconductances on the order of 500 mhos!

With regard to my phraseology in which I refer to "current-hungry base-emitter junctions", I view such a description as apropos when one compares the input circuits of bipolars with field-effect transistors. This is especially true when one recognizes that to obtain high transconductance from a bipolar transistor, it is necessary to operate at relatively high current levels — and this always tends to lower the input im-

pedance. It is no trick at all to operate fets with gate-source resistors in the tens or hundreds megohm range. This is not readily done with bipolars because of their "current-hungry base-emitter junctions."

Mr. Worcester introduces an interesting point in his discussion of transformer coupling. I acknowledge that transformers do enable one to recover some of the loss in power gain that usually accompanies RC-coupled bipolar stages. Perhaps, somewhat arbitrarily, I decided to exclude the use of transformers in my article. The reason underlying this decision was that the average amateur does not have ready access to such transformers. Also, there can be a lot of headaches associated with coupling transformers. I wanted to provide an easy means of rolling one's own workhorse amplifiers.

I agree with Mr. Worcester that at sufficiently high frequencies, even "infinite input-impedance" devices display dissipative, and other conductive effects. It is true that most of the applications I envisaged involved audio and low rf frequencies, say to several MHz. (Of course, even here, it behooves one to choose his devices carefully. I hope I have provided the readers with reasonable fets and bipolars insofar as concerns frequency capability).

I think Mr. Worcester will find that during the past five years or so, the major semiconductor vendors have included transconductance data in their specs. Below is a sample from Delco literature pertaining to their triple-diffused silicon power-transistor, the 2N5157. RCA, Motorola, and GE provide similar curves. Sometimes, how-

ever, the word "transconductance" is not used; the manufacturers merely depict collector current vs base-emitter volts with collector volts and temperature held constant.

Summarizing I contend that my numbers were reasonable, and that the fet would develop a voltage gain of about four because it "sees" approximately one-thousand ohms of bipolar input impedance. Moreover, the bipolar develops a beta of 300, together with a transconductance of 300,000. However, it operates between five and ten milliamperes, not at one milliamperere. I also concede that there are application areas where the fet-bipolar combo does not necessarily provide the best solution.

Irving M. Gottlieb, W6HDM

old-time television

Dear HR:

Your well-researched article on television in the February, 1976, issue of *ham radio* was fascinating, although the results of K4TWJ's attempts to bring back 1925 TV to the amateur bands were a bit disconcerting. Apparently we haven't come as far on the road to deregulation as we thought.

Allow me one correction on your etymology: "Television" does not mean transmission of pictures over wires any more than "telescope" means seeing the stars by wires. *Tele-* is from the Greek and means "far off." Mr. Jenkins was entitled to call the new medium whatever he wanted, but he was no more correct in his naming than AT&T.

Joe Moell, WA6JFP
Fullerton, California

low-definition television association

Dear HR:

One of our members has sent me a copy of the article "50 Years Of Television," which appeared in the February, 1976, issue of *ham radio*. Clearly, American readers are not all up to date with developments outside the United States in the field of low-definition television (LDTV).

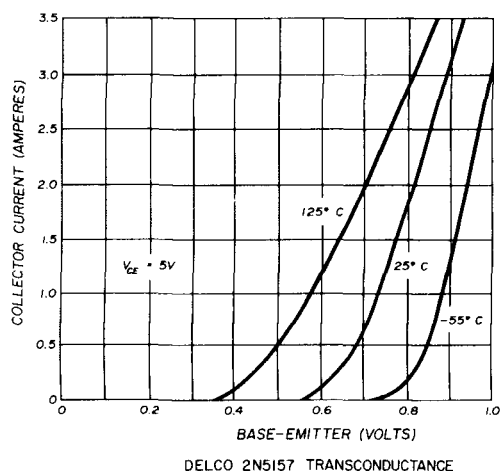
In 1971 I started LDTV experiments in collaboration with S. Kujawinski of Nottingham, unaware that Chris Long of Victoria, Australia, was working along similar lines at the same moment.

A paragraph in the British magazine *Wireless World*, brought us into contact early in 1972. This magazine item revealed that Chris Long, in collaboration with Dan Van Elkan, VK3UI, had broadcast 48-line TV on the shortwaves on January 30, 1972, the first Australian LDTV broadcast since 1929. On the basis of this contact, I started a search for other correspondents and was so successful that on April 26, 1975, a formal LDTV society was formed. The Association is dedicated to reviving the techniques of the 1930s on an improved basis as a serious amateur activity.

Perhaps British experience of the LDTV period was less disillusioning than the briefer U.S. experience. This may be explained by the support given at the time by the giant BBC organization, the provision of an efficient carrier-borne synchronization system, powerful transmitting stations of huge range, daily programs, top-line nationally-known entertainers, and perhaps even the choice of a vertical scanning system. Certainly, to judge by the views expressed in the *ham radio* article, the cessation of the 30-line BBC-Baird system in late 1935, after six years, caused more consternation and anger in the U.K. than the corresponding termination in the U.S.A.

Although I can vaguely remember the old system as a boy, most of our members have only read about it in books, and our younger members (still at school) view it as the *very latest thing* with none of those "old-fashioned" cathode-ray tubes to worry about. The nostalgia mentioned in your article is almost totally absent here (in Europe and Australia). Our system is regarded as highly practical, relevant to present needs, and with synchronous sound, a valuable communication medium.

Members work on any standards they prefer, but for communication purposes the "Nottingham" standards have become widely accepted as a judicious compromise between the requirements of bandwidth and pictorial detail in the context of what can be achieved by reasonably skilled "kitchen table" engineers. Significantly, many of our members are ex-sstv enthusiasts or experimenters with a foot in each camp. The low cost of LDTV equipment and the "live" nature of the images are a tremendous attraction. No broadcasts



have yet been made in the U.K. (most members preferring closed-circuit experiments or "teletape" correspondence through the post, the extra stereo track providing the sound) but it should not be long before the once-familiar *ululation* is again on the air, if only on vhf.

For the information of your readers, the preferred standards of the LDTV Association are as follows: **Lines**, 32, vertical, with upward spot movement; **Frame speed**, 12½ per second; **Aspect ratio**; 3 vertical by 2 horizontal; **Line pulses**, blacker than black, 5 to 10% of line length (no frame synchronization pulses are employed, except for special purposes, e.g., closed-circuit usage); **Tape standards**, speed, 19 cm (7½ inches) per second; **Sense**, no signal equals black; **Tracks**, numbers 1 and 4, video, numbers 2 and 3, sound.

The LDTV Association is still welcoming new members and hopes to have representation in most European countries by the end of 1976.

D.B. Pitt
Chairman, LDTV Association
Nottingham, England

oscar communicators use excessive power

Dear HR:

After many nights and mornings of hearing Oscar 6 shut down because of overload and having myself "sucked out" of both Oscar 6 and 7 on numerous occasions, I feel that I must write to you in hopes that you will help me to make my thoughts known.

I am getting disgusted with the amateurs who completely disregard AMSAT's recommended power levels to hog the satellites for their own use or prevent others like myself, who try to stay close to the suggested power levels, from using the satellites. Face it, guys, you have no more right to use the satellites than anyone else. I imagine that you really do not care about how all that extra ERP affects the satellites' translators and power systems. One day you may find to your amazement that one of the birds does not work any longer.

The fellows in the Amsat organization have done all of us a great favor in getting the birds into orbit in the first place. Let's not blow a good thing. If I were Amsat and saw how the satellites

are being abused, I would think twice about orbiting another Oscar, especially if it were as tremendously advanced as the proposed Phase III satellite.

So please, satellite users, refrain from using excessive ERP; it is not needed. If you are trying to access the birds with around 150 watts ERP and do not hear your downlink signal, you need to do one or more of the following:

1. Determine if you are really transmitting within the translator's receiver passband.
2. Find out just where your transmitter signal would appear on your receiver tuning dial.
3. Check to see that your antenna is pointing in the right direction.
4. Improve your receiver setup.

Notice that none of the above items includes increasing your effective radiated power.

Watson R. Gabriel, Jr., WB4EXW
Kernersville, North Carolina

DT-600 RTTY demodulator

Dear HR:

I always enjoy the projects and the informative articles published in *ham radio*. I just ordered a PC board from Data Technology Associates for the DT-600, and was very pleasantly surprised by the quality of the material and the amount of documentation enclosed with the board. They should receive a medal. And, believe it or not, the demodulator worked the first time I turned it on.

Rick Hall, K5GZR
Bellaire, Texas

two-meter frequency synthesizer

Dear HR:

I am writing to express appreciation for the extremely sensible two-meter synthesizer circuit published in the January, 1976, issue of *ham radio*. I hope to add this to my accumulating list of projects.

It is rather obvious that the state of the art dictates either a digital dial read-out or outright synthesization, in the

transmitting and receiving systems. Toying a bit with the basic control arrangement as a master control for transmitting, a couple of possibilities suggested themselves:

1. Providing a heterodyne crystal to present 140 to 144 MHz, feeding a decade divider, and thus affording the span from 14.0 to 14.4 MHz in 1 kHz increments.
2. Dividing again by two would present 7.0 to 7.2 MHz in 0.5 kHz increments, making a beautiful 40-meter CW unit.
3. Using the original 144 to 148 output, decade dividing to 14.4-14.8, and additive-heterodyning with 6.6 MHz would give 21.0-21.4 in 1 kHz steps.
4. Using the mode suggested in 2 above, and heterodyning the 7.0-7.2 with 5.2 MHz would give 1.8 to 2.0 MHz in 0.5 kHz steps.
5. Maintaining the original 144-148 output, subtractive mixing with 116 MHz would give 28.0-32.0 in 10 kHz steps for complete 10-meter coverage.

With the possibility of additional amateur bands becoming available after 1979, making just about everything but the "modifiable" Heath SB-104 broadband rig obsolete, I believe that a synthesizer useable as a master frequency control, whether it includes the necessary combinations for receiving or not, would be most welcome. My own training, skills and available time do not permit me to do much more than indulge in random periods of very wishful dreaming. I have a few bits and pieces of VHF engineering two-meter gear, and am convinced that they would blend perfectly with the basic synthesizer system to make a truly state-of-the-art transceiver for fm and CW operation.

Lee Clough, W5GQV
Texas State Technical Institute
Waco, Texas

sstv reporting system

Dear HR:

In October, 1966, sstv pioneer Copthorne MacDonald obtained permission to experiment with sstv on amateur radio and on Navy MARS. Since that time considerable effort has gone into technical improvement but not much

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- An honest, rock-crusher [NTL] kilowatt in all modes, like the ALPHA 374. You can lock the key at a full d-c kilowatt and leave town . . . if you have a very husky dummy load!
- Full coverage 10-160 meters - no other [NTL] kilowatt linear (except a '77D) covers 160.
- Standard 45 pound plug-in transformer (1.5 KVA CCS) itself outweighs some so-called 'kilowatt' amplifiers. (The only way we know to make any true [NTL] kilowatt lighter than the '76 is to use special tape-wound Hipersil® transformers like those standard in the ALPHA 77D and '374, and optional in the '76.) \$895 U.S.; factory stock.

Every ALPHA HF Linear Amplifier has a combination of quality and convenience features that's available in no other true kilowatt d-c, 2+ KW PEP linear amplifier: • modern, rugged ceramic grounded-grid triode tubes; • silver-plated copper tubing main tank coils; • a 1.5 KVA CCS (or larger) plug-in transformer; • full-cabinet, ducted air cooling; • self-contained desk-top convenience; and a full year of free factory service for any defect. NEW! Expert factory demonstration, advice, sales, and service is conveniently available in the Midwest and in Southern California. Write or phone ETO direct for full information, illustrated brochure, and personal service.

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progress has been made in instituting a suitable reporting system. One of the projects of the Navy Marine Corps MARS SSTV Specialty Network, which was established in 1972, has been the development of a practical reporting system for general use.

The time-tested R-S-T system was a logical place to start. With readability (R), signal strength (S) and video quality (V) we came up with R-S-V. Several variations of designating the quality of video were tested, commencing with nine gradations. These were soon discarded as too cumbersome. Ken Wood, Jr., K6IIS and NNNØQXJ, eliminated all of the extraneous data and suggested a system that contains the key information you need 95% of the time.

This system has been in use for about two years with very good results on the Navy Marine Corps MARS SSTV Specialty Network which meets at 2100Z on Saturday and Sundays on 13975.5 kHz. It permits many reports to be made quickly and if you are so inclined you can make a chart of the reports and have a record of two-way propagation between a large number of stations scattered over a large geographical area.

The video reporting system varies from conventional R and S in that picture quality is not progressive. It is possible for a V3 picture to be better than a V4 picture. The system is as follows:

- V5 Closed circuit quality pictures
- V4 Good pictures with multipath
- V3 Good pictures with interference
- V2 Readable pictures with multipath and interference
- V1 Mostly unreadable-loses sync-pictures interrupted.

This system is good for reporting radio and video reception on QSL cards, on voice or by video pictures and is particularly valuable for nets or contests where time is of the essence.

Thomas F. Pollock, WB6ZYE
Coordinator
U.S. NAVMARCORPS MARS
SSTV Specialty Network

European vhf-fm repeaters

Dear HR:

In *presstop* last year *HR report* editor W9JUV gave advice to those

hams going to Europe to bring their portable two-meter equipment along with the appropriate crystals for repeater use. As we are using totally different channels for repeaters in Region I, compared to Region II, it might be interesting for your readers to know the correct channel numbers and the input and output frequencies for the European repeaters. Below is a short list which is self explanatory. In addition I can tell you that the international (within Region I) mobile/portable calling frequency is 145.500 MHz and the international mobile/portable traffic frequency is 145.550 MHz. In addition, there are twelve traffic frequencies on two meters (designated S21 through S33).

Gunnar Eriksson, SM4GL
Falun, Sweden

European vhf-fm repeater channels.

	in	out	in	out
R0	145,000--145,600	433,000--437,600		
R1	145,025--145,625	433,025--437,625		
R2	145,050--145,650	433,050--437,650		
R3	145,075--145,675	433,075--437,675		
R4	145,100--145,700	433,100--437,700		
R5	145,125--145,725	433,125--437,725		
R6	145,150--145,750	433,150--437,750		
R7	145,175--145,775	433,175--437,775		
R8	145,200--145,800	433,200--437,800		
R9	145,225--145,825	433,225--437,825		

European two-meter traffic channels.

S21	145,525	S28	145,700
S22	145,550	S29	145,725
S23	145,575	S30	145,750
S24	145,600	S31	145,775
S25	145,625	S32	145,800
S26	145,650	S33	145,825
S27	145,675		

microprocessor definitions

Dear HR:

I wish to note a peculiar inconsistency in the definitions given by Rony *et al* in their February, 1976, microprocessor article. On page 51, they correctly define "synchronous operation" as "operation of a system under the control of clock pulses." Yet, immediately above that, they define "synchronous computer" to mean "a digital computer in which all ordinary operations are controlled by equally-spaced signals from a master clock." In fact, as implied by the definition of "synchronous operation," there is no require-

ment for any synchronous machine to use *equally-spaced* clock pulses. Similarly, their definition of "synchronous states" . . . in which the performance of a sequence of operations is controlled by equally-spaced clock signals. . ." Again, while most (but certainly not all) synchronous machines use equally-spaced clock pulses, there is no switching-theoretical requirement for them to do so. (I believe that practical considerations almost invariably weigh on the side of using equally-spaced clock pulses).

Perhaps part of the explanation for this discrepancy lies in the fact that the correct definition of "synchronous operation" references the authors' *Bug-book III*, while the inaccurate definitions of "synchronous computer" and "synchronous" reference Graf's *Modern Dictionary of Electronics*. Rony *et al* bear partial responsibility for Graf's error by printing it, especially when they put it next to their own correct definition. This is not much ado about nothing: a misunderstanding of such fundamentals can foster much confusion; your readers depend on your accuracy, and you owe them no less.

E. Douglas Jensen
Sr. Principal Engineer
Computer Systems Research
Honeywell

Mr. Jensen is entirely correct in his observation: there is no switching-theoretical requirement for equally spaced clock pulses in synchronous machines. The definition given for a synchronous computer applies to most existing computers, minicomputers, and microcomputers, and therefore should be a valid working definition for most individuals. The definition emphasizes the rule, rather than the exception. A more general definition would be as follows:

Synchronous computer

A digital computer in which all ordinary operations are controlled by clock pulses from a master clock.

Peter R. Rony
David G. Larsen
Jonathan A. Titus

Hy-Gain verticals stand alone.

Hy-Gain multi-band vertical amateur antennas are entirely self-supporting. They require no towers or guys and go up in just a few square feet yet they offer remarkable performance. Their omnidirectional pattern means no rotator is required. Hy-Gain verticals go up easily with just a few hand tools and their cost is surprisingly low.

See your Hy-Gain dealer for the antennas that give you the performance you want, take minimum space and have your kind of price. Hy-Gain verticals.

18HT 6-80 meters.

The only vertical antenna on the market offering multi-band performance without traps. The Hy-Gain 18HT utilizes a unique stub decoupling system to maximize efficiency, frequency stability and band isolation. It also offers a 50 ohm input impedance for all bands.

The 18HT features automatic band switching, 1/4 wavelength performance on 40 and 80 meters, 1 3/4 wavelength on 10 and 15 meters. Maximum legal power rating on all bands. It is entirely self-supporting and requires no guys. Heavy duty, slotted, taper swaged, aircraft quality aluminum with full circumference compression clamps is used for radiators. The 24' tower is all rugged, hot-dip galvanized steel and all hardware is iridited for corrosion resistance. Special hinged base for easy raising and lowering. **Order No. 182**

18AVT/WB 10-80 meters.

The Hy-Gain 18AVT/WB gives you true wide-band performance in limited space. And now we've made it even better. The 18AVT/WB now has an improved 80 meter coil and an over-size corona ball on the whip to eliminate wasteful and noise corona discharge.

This antenna is rated in excess of maximum legal power 10-40 meters and up to 1 KW PEP on 80 meters. Entirely self-supporting, requires no guys. All tubing is slotted, taper swaged, aircraft quality aluminum with full circumference compression clamps.

The 18AVT/WB has automatic band switching and utilizes three air dielectric Hy-Q

traps for exceedingly stable performance and true 1/4 wave resonance on all bands. May be roof mounted with Hy-Gain 14RMQ kit. Recessed SO-239 connector prevents moisture deterioration. 12" heavy duty mast support bracket.

Order No. 386

14AVQ/WB 10-40 meters.

The Hy-Gain 14AVQ/WB uses the same trap design as the famous Hy-Gain Thunderbird beams. 3 separate air dielectric Hy-Q traps with oversize coils for superb stability and 1/4 wave resonance on all bands. Automatic band switching.

An extremely low angle of radiation is utilized for superior DX performance. Taper swaged, slotted aircraft quality aluminum tubing. Entirely self-supporting, no guys required. Recessed SO-239 connector prevents moisture damage. 12" heavy duty mast support bracket. Roof mount with Hy-Gain 14RMQ kit.

Order No. 385

12AVQ 10, 15 and 20 meters.

The 12AVQ also uses Thunderbird design air

dielectric traps for extremely Hy-Q performance. This is the way to go for inexpensive tri-band performance in limited space. Entirely self-supporting, requires no guys.

For superior DX transmission, the 12AVQ uses a very low radiation angle. Has automatic band switching. Aircraft quality, slotted taper swaged aluminum tubing. Recessed SO-239 connector prevents moisture damage. Heavy duty 12" mast bracket. Roof mount with Hy-Gain 12RMQ kit. **Order No. 384**

18V 10-80 meters.

High performance air dielectric traps, high quality construction and low cost make the 18V an exceptional value. Easily tuned to any 10-80 meter band by adjusting feed point at the base inductor.

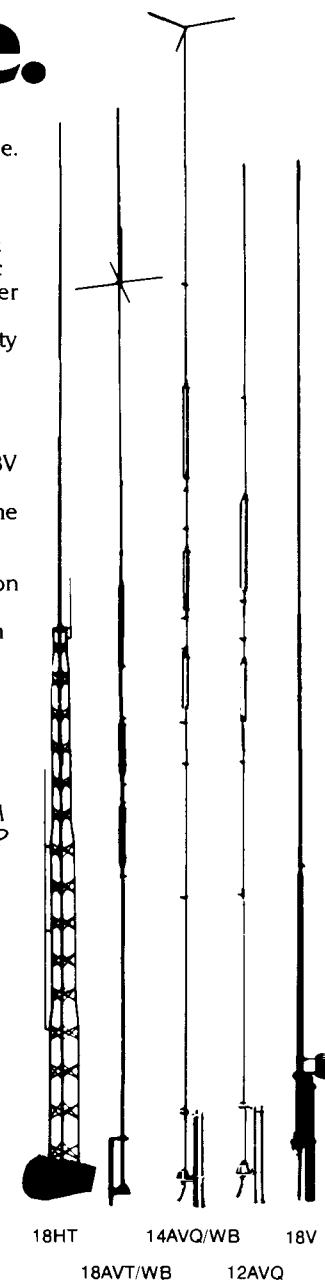
All aircraft quality, slotted, taper swaged aluminum with full circumference compression clamps. Self-supporting, requires no guys. 12" heavy duty mast bracket. Roof mount with Hy-Gain 14RMQ kit. Easily portable. **Order No. 193**

HY-GAIN VERTICAL ANTENNA SPECIFICATION COMPARISON

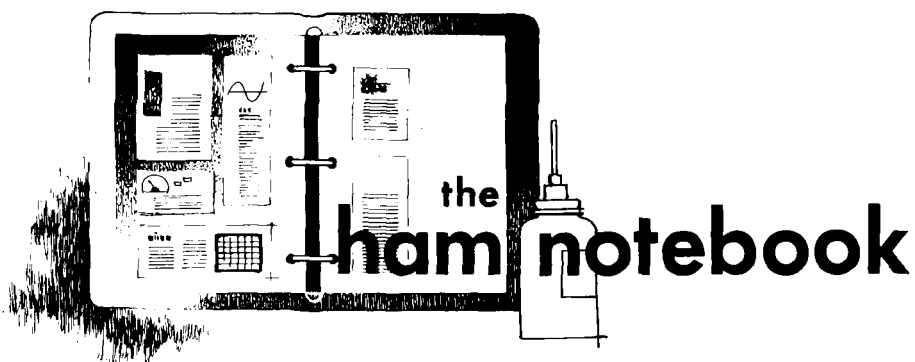
	18HT	18AVT/WB	14AVQ/WB	12AVQ	18V
Electrical					
Max. power input	1 KW AM 2 KW PEP	1 KW AM 2 KW PEP (1 KW PEP on 80)	1 KW AM	1 KW AM	250 watts AM 500 watts PEP
VSWR					
Impedance	2:1 or less	2:1 or less	2:1 or less	2:1 or less	2:1 or less
Mechanical					
Height	50'	25'	18'	13'6"	18'
Shipping Weight	96.7 lbs.	10.7 lbs.	8.2 lbs.	7 lbs.	4.6 lbs.
Mast Diameter	None required	1 5/8"	1 5/8"	1 5/8"	1 5/8"



Hy-Gain Electronics Corporation 8601 Northeast Highway Six; Lincoln, NE 68505
Distributed in Canada by Lectron Radio Sales 211 Hunter Street; Peterborough, Ontario



18HT 18AVT/WB 14AVQ/WB 12AVQ 18V



IC-230 mods: adding splinter channels

The ICOM IC-230 is a frequency-synthesized two-meter fm transceiver capable of operating on sixty-seven channels spaced 30 kHz apart, from 146.010 to 147.990 MHz. Four spare crystal sockets are provided to add 40 splinter channels. Each crystal adds ten channels spaced 30 kHz apart. The first of the four crystals are selected by placing the 146/147 switch in the 146 position and the 100 kHz switch in the A position. That is, 146.AX, where X is any of the ten positions of the 10-kHz switch.

The second crystal is selected with the B position of the 100-kHz switch; i.e., 146.BX. In a like manner, the last two crystals are selected with the 147.AX and 147.BX positions. The only difficulty is that the ten channels associated with each crystal are selected according to a strange coding scheme of the 10 kHz switch. The lowest-frequency channel is selected with the 1 position of the 10-kHz switch, and each successively higher-frequency channel is selected according to the following scheme: 1,4,7,0,3,6,9,2,5,8. Thus, the highest-frequency channels of the first splinter crystal would be selected by placing the controls to 146.A8.

You can select any number of crystals to give you any particular splinter channel. I have my favorite set of crystal frequencies to give complete coverage of all repeater splinters plus all direct splinter channels. If you don't want to spring for all four crystals for complete coverage, you can select your own. The formula for calculating the lowest frequency channel to the ten

channels provided by a crystal is

$$f_x = \frac{f_L - 21.965}{9}$$

where f_x is the crystal frequency (MHz) and f_L is the desired lowest channel frequency (MHz). For example, if you want ten additional channels beginning at 146.415 MHz (the lowest direct splinter channel frequency), the crystal frequency would be $(146.415 - 21.965)/9 \approx 13.82778$ MHz. When you install this crystal you'll add ten channels, from 146.415 to 146.685 MHz.

table 1. IC-230 splinter channels.

frequency (MHz)	setting	use	frequency (MHz)	setting	use
146.415	146.A1	direct	147.015	147.A1	repeater outputs
146.445	146.A4		147.045	147.A4	
146.475	146.A7		147.075	147.A7	
146.505	146.A0		147.105	147.A0	
146.535	146.A3		147.135	147.A3	
146.565	146.A6		147.165	147.A6	
146.595	146.A9		147.195	147.A9	
146.625	146.A2		147.225	147.A2	
146.655	146.A5		147.255	147.A5	
146.685	146.A8		147.285	147.A8	
146.715	146.B1	repeater outputs	147.315	147.B1	repeater outputs
146.745	146.B4		147.345	147.B4	
146.775	146.B7		147.375	147.B7	
146.805	146.B0		147.405	147.B0	
146.835	146.B3		147.435	147.B3	
146.865	146.B6		147.465	147.B6	
146.895	146.B9		147.495	147.B9	
146.925	146.B2		147.525	147.B2	
146.955	146.B5		147.555	147.B5	
146.985	146.B8		147.585	147.B8	

If you wish to omit the direct splinters and receive only the repeater splinter frequencies, you'd start at 146.625 MHz and your crystal frequency would be 13.85111 MHz. This crystal would provide ten channels from 146.625 to 147.195 MHz. For full

coverage I recommend the following four crystals:

crystal freq. (MHz)	crystal socket (LO Module)	coverage (MHz)	setting
13.82778	8	146.415-655	146.AX
13.86111	9	146.715-985	146.BX
13.89444	10	147.015-285	147.AX
13.92778	11	147.315-585	147.BX

A decoding chart (table 1) is provided for using these crystals. When ordering crystals, be sure to specify 0.0025%, 20 pF in HC-25/U holders.

automatic offset switching

When operating the IC-230 two-

meter fm transceiver, it is necessary to change the A/B switch to offset the transmitter either 600 kHz below or above the receiver frequency. Since most all "600-kHz low" repeaters are 146 MHz machines and most all "600-kHz high" repeaters are 147 MHz

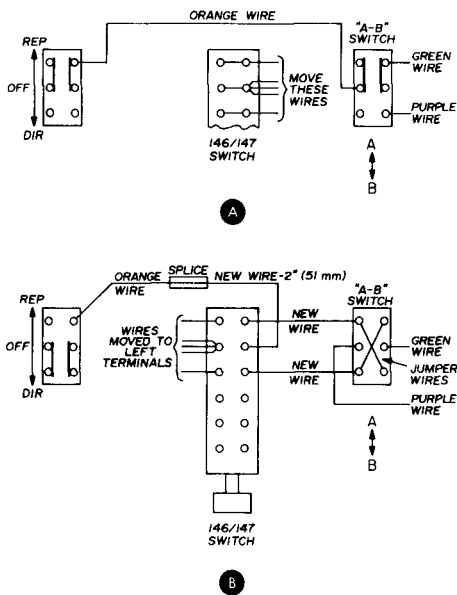


fig. 1. Existing wiring (A) and modifications for automatic offset switching (B) in the ICOM IC-230.

machines, it would be convenient to provide this switching automatically by the 146/147 switch. Fortunately, spare switch contacts are available that allow such a wiring modification to be made. The A/B switch then becomes a *normal-invert* switch, which operates as follows:

MHz switch position	A (normal)	B (invert)	transmitter offset (kHz)
146	X		-600
147	X		+600
146		X	+600
147		X	-600

After you make this mod you never need use the A/B switch unless you want to work "upside down" or work a 146.40/147.00 or 147.60/147.00 machine. Wiring details are shown in fig. 1. Here are the steps for making the changes:

1. Locate the 146/147 MHz switch and note that the rear set of terminals are wired in parallel. Remove the red wires, one at a time, and move them to the three left terminals thus making free the right set of three terminals. Clean the three right terminals.
2. Remove the A/B switch from its bracket. Remove the purple, green, and orange wires and clean the six terminals. Carefully install the jumper wires as shown in fig. 1B. Use AWG 26 (0.3mm) wire. Do not solder at this time.
3. Splice a 2-inch (51 mm) piece of wire

to the orange wire that was removed from the A/B switch. Insulate the splice with heat-shrink tubing. Connect the free end to the terminal on the 146/147 switch (fig. 1B).

4. Connect two new no. 26 AWG (0.3 mm) wires from the two spare terminals of the 146/147 switch to the appropriate terminals of the A/B switch (fig. 1B). Solder the *outer* (corner) terminals only.

5. Reconnect the green and purple wires to the A/B switch center terminals as shown. Solder and check all connections. Reinstall the A/B switch.

Rod Cauvel, WA1OJX

tuning aid for the sightless

This audio tuning device is uncomplicated by connections other than those required to sample transmitter or exciter output at the coax transmission line. It uses no batteries and may be

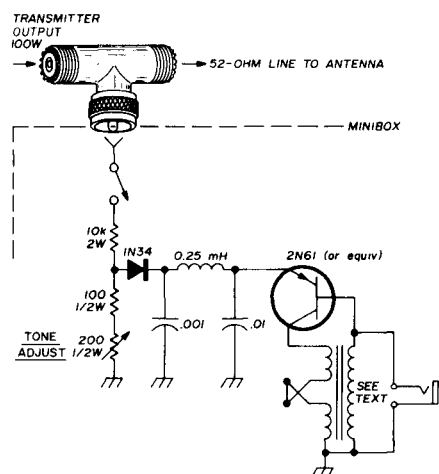


fig. 2. Audio tuning aid for determining maximum rf output power.

switched off after maximum rf output is determined. The circuit may also be used as a tone generator for monitoring CW keying; another possible use is a monitor for determining the condition of your transmission line (e.g., a short circuit between center conductor and shield).

The circuit is shown in fig. 2. A high-resistance voltage divider samples rf from the coax. The rf is rectified by a diode. This rectified voltage, which varies during transmitter tuning, is fed to a form of relaxation oscillator. Output varies in tone pitch as a function of

voltage on the line: low voltage causes a high-pitch tone and high voltage causes a low-pitch tone, which indicates maximum transmitter or exciter output. The tone indication is similar to a dip in transmitter plate current.

The input voltage divider uses about 1 watt for 100 watts into a 50-ohm line. For higher power, the divider may be switched to higher values. For 1 kW, the input resistor should be about 100k, 2 watt. The schematic shows a voltage divider suitable for 100 watts output.

The 1N34 diode feeds about 2 volts to the transistor emitter, which draws less than 2 mA at maximum transmitter output. Any audio-type transistor may be used. If an npn device is used, diode connections should be reversed. The transformer is from a 5-watt transistor amplifier. Base and collector connections to the transformer can be reversed for needed feedback voltage. The color code on the transformer I used is: green to collector, red to base. The other connections in the collector circuit are: green/white to brown; brown/white and blue to ground. The transformer windings measure 22 ohms dc (high impedance); the other two, in series aiding, are each 4 ohm dc. Any transformer with similar resistance measurements should work. Audio output can be heard several feet from high-impedance phones.

D.H. Atkins, W6VX

HW-202 lamp replacement

To decrease the time and trouble of transceiver disassembly, try the idea shown in Fig. 3 the next time the dial light on your HW-202 fails. This lamp provides good illumination and has a prolonged life. Use caution when breaking glass on a burned-out bulb.

H.C. McDonald, W5UNF/6

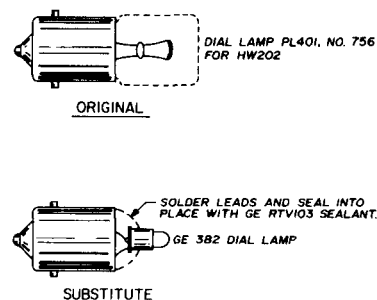


fig. 3. Simple lamp replacement for the Heathkit HW202.

SpecComm Introduces THE DYNAMIC DUO!

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NEW products

hf ssb transceiver



Trio-Kenwood has announced a new addition to its line of amateur radio equipment, the TS-820 "Pacesetter." Some features of this new rig are i-f shift, rf speech processing, digital readout (optional), digital hold (for the readout), rf monitor, monoscale vfo dial, PLL circuitry, rf negative feedback, RTTY, 160 through 10 meter coverage, vox controls, and rf attenuator. Probably the most unusual feature of the TS-820 is the use of a phase-lock filter in the local oscillator circuit, resulting in a very clean injection signal to the mixer. Speech processing is achieved at the rf level and is adjustable from zero to 50 dB through the use of a single, front-panel control.

A complete line of accessories will be available for the TS-820 including a plug-in digital kit, dc-dc converter (for mobile operation), 500 Hz CW filter, deluxe remote vfo, MC-50 microphone, two-meter transverter, and more.

The new TS-820 transceiver sells for \$830.00 and is available from Trio-Kenwood Communications, Inc., 116 E. Alondra, Gardena, California 90248. Write for more information or use check-off on page 126.

all-mode active audio filter



The QF-1 "infinitely variable" filter from Autek Research is designed to combat shortwave interference with features never available to the amateur before. Peak, notch, and lowpass positions, all *continuously* adjustable over the range 250 to 2500 Hz, are provided for use in all communications modes.

The *lowpass* position rejects ssb and a-m hiss and splatter; the *notch* position rejects whistles, CW and carriers. The *peak* position provides superior CW reception with adjustable frequency for easy peaking, and bandwidth continuously variable from 50 Hz to flat. Skirts are steep and exceed 80 dB.

The notch tracks the *peak* frequency and is continuously variable from very wide to very narrow via the selectivity control. Notch depth is to 70 dB. The QF-1 drives a speaker or phones with room-filling volume (1 watt) and also includes a 117-Vac supply so there are no batteries to replace. It works with any receiver or transceiver by simply plugging it into the headphone jack. No impedance matching is necessary.

Selling for \$54.65 postpaid, the QF-1 includes eight IC op amps plus power amplifier and metal cabinet. Order direct, or write for brochure to Autek Research, Box 5127E, Sherman Oaks, California 91403.

high power broadband isolator

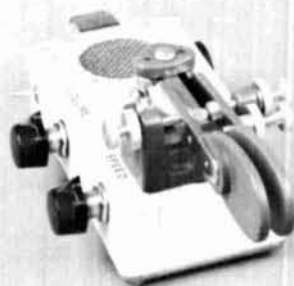
Telewave, Inc. has recently introduced a new series of high power, broadband isolators which feature exceptionally low prices and require no tuning.

The T-1004 series operates in the 400 to 512 MHz bands and provides 30

dB of isolation over a 20 MHz bandwidth with only 0.3 dB insertion loss. The unit provides 60 dB isolation using two junctions and can be shipped standard single junction (30 dB), dual junction (60 dB), and triple junction (90 dB) in one module which eliminates cables and allows for extremely low insertion loss. All loads are removable and can be supplied in powers from 25 through 400 watts.

For more information contact Telewave, Inc., at 2166 Old Middlefield Way, Mountain View, California 94943 (415) 968-4400 or use *check-off* on page 126.

electronic keyer



Palomar Engineers has introduced a new IC keyer that takes less space on your operating table than the old semi-automatic mechanical key. The new keyer sends semiautomatic, full automatic, self completing, dot memory, iambic, or as a straight key. It has built-in sidetone oscillator and speaker, volume and speed controls, weight adjustment and battery holder. Any desired speed from 5 to 50 wpm can be selected while you send.

The IC keyer will key any transmitter, whether grid-block, cathode keyed or plate keyed, up to 500 volts and up to one ampere keyed current. Keying contacts are silver and withstand heavy surge currents and voltage spikes. The built-in paddle is fully adjustable for spacing and tension. A diecast metal case provides full rf shielding.

The clip-in 9-volt transistor battery will power the keyer for about 75 hours of normal operating, making the keyer ideal for portable operation. At the

home station, a lantern battery will last for about two years.

The keyer sells for \$87.50 postpaid in the U.S. and Canada (California residents add sales tax). For more information write to Palomar Engineers, P.O. Box 455, Escondido, California 92025 or use check-off on page 126.

push-to-talk microphone

New from Astatic is the D104 *Silver Eagle* microphone with push-to-talk efficiency. The push-to-talk bar has been added to the D104 "grip-to-talk" desk stand for convenience. A slide lock clamp provides easy "no hands" transmission.

Factory wired for universal hook-up application, the *Silver Eagle* can be converted to electronic or relay operation. The microphone is wired with an open audio line on receive and comes with a coil cord with single-conductor shielded plus 4 unshielded. Switching requirements are determined by the proper hook-up at the cable plug end. All external parts, including the base, are chrome plated.

Information on the D104 microphone can be found by writing Astatic, Conneaut, Ohio 44030, or by using the check-off on page 126.

ARRL electronics data book

The new *ARRL Electronics Data Book* has been written for all technical levels from the beginner to the graduate engineer. Edited by Doug DeMaW, W1CER, it contains a compilation of essential data which is normally scattered among several reference books that an amateur or professional person would maintain in his library.

Among the many subjects treated in depth are RF Circuit Data, L, C and R Networks, Broad- and Narrow-Band Transformer Design, Modern Filter Design, Antennas and Feed Systems and a Catalog of Practical Solid-State Circuits. All chapters include pertinent simple equations with examples worked out to illustrate how the solutions are obtained. The section on transformer design deals mainly with toroidal broad-band components of the conventional

and transmission-line varieties. Schematic and pictorial diagrams are furnished for each transformer type. The chapter on modern filter design covers two- and three-pole Butterworth derivations for most of the frequencies of interest to amateurs. Tables of practical filter values are also included.

This book is an essential adjunct to the *Handbook* and other ARRL technical publications. Soft cover, 8 1/4 x 11 inches (21x28cm), 128 pages. \$4.00 in the U.S.A. and Possessions, \$4.50 elsewhere. Order your copy from Ham Radio Books, Greenville, New Hampshire 03048.

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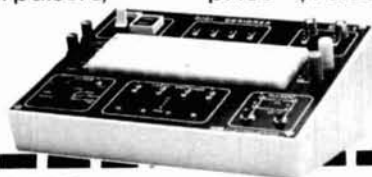


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● **More Sensitivity, Less Interference.**

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35 watts nominal with a minimum of 30 watts across the band

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Amateur Net


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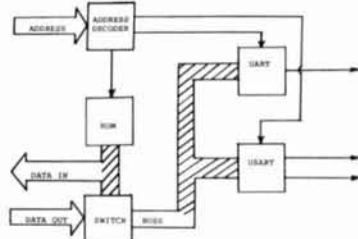
2 METER 

220 MHz 

6 METER 

440 MHz 

I/O board with rom



A new "Turnkey" I/O board is now available for 8080 microprocessors. The user is now able to turn on his computer and "go." All bootstraps, loads, dumps and edits are in a 512-byte ROM on the I/O board.

The board utilizes a UART to interface with a terminal and a USART to interface with one or two cassettes to make a complete computer operating system. Just type in what you require and the ROM executes the program.

The Turnkey I/O board is available in kit form for \$140 or for \$170 assembled and tested from National Multiplex Corporation, 3474 Rand Avenue, Box 288, South Plainfield, New Jersey 07080 or use the check-off on page 126 for more information.

logic probe



A low-cost, pocket-sized, multi-function test instrument known as the model LP-1 *Multi-Family Logic Probe* is available for digital applications from Continental Specialties Corporation. The LP-1 combines the functions of a pulse detector, pulse stretcher and memory circuit, allowing amateurs to get an instant picture of static and dynamic circuit conditions with most popular logic families. LP-1's ability to detect pulses as short as 50 nano-seconds, coupled with its stretching and latching ability, means that one-shot, low-rep-rate, narrow pulses — nearly impossible to see, even with a fast scope — are now easily detectable and visible.

The user simply connects the clip leads to the circuit's power supply, sets the logic family switch to the proper position (TTL/DTL or CMOS) establishing the correct logic level for the family under test and touches the probe tip to the circuit node. Two level detector LEDs plus a blinking pulse detector LED display signal activity at the node under test. At high frequencies, LP-1 will also indicate whether or not signals are symmetrical.

High input impedance on both DTL/TTL and CMOS modes virtually eliminates loading problems in the circuit under test, and input impedance is constant for both logic 1 and 0 states. The LP-1 sells for \$44.95.

For more information, use the check-off on page 126 or contact Continental Specialties Corp., 44 Kendall Street, Box 1942, New Haven, Connecticut 06509.

solderless breadboard kit



Proto-Board^R-6, a low-priced solderless breadboard kit, is available from Continental Specialties Corporation. This compact kit can be assembled in minutes and offers six 14-pin DIP IC capacity for basic breadboarding, testing and building applications.

The PB-6 includes one QT-47S solderless breadboarding socket, two QT-47B bus strips, four 5-way binding posts, a metal ground and base plate, rubber feet, all nuts, bolts, and screws, plus complete easy-assembly instructions.

The PB-6 lets the user test and build circuits without soldering or patch cords; all interconnections between components are made with common no. 22 AWG hook-up wire. Measuring 6 inches long by 4 inches wide (15cm x 10cm), the PB-6 sells for \$15.95 from local distributors or direct from Continental Specialties Corporation, 44

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Illustrated . . . Larsen JM-150-K Kūlrod Antenna and mount for 2 meter band. Comes complete with coax, plug and all mounting hardware. Easy to follow instructions. Handles full 200 watts.



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2 METER FM TRANSCEIVER



Size 9 1/2" x 10 1/2" x 3 1/4"

- ★ 143 to 149.99 MHz in digitally dialed 5 KHZ steps without buying a single crystal! 142 MHz coverage optional.
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- ★ Completely independent transmit/Receive frequency control, yet simplex with the flip of a single switch.
- Includes dynamic microphone and mobile mounting bracket

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- ★ TWO YEAR WARRANTY!
- ★ Very low transmitter spurious output
- ★ Beryllium copper printed circuit card guides provide SOLID retention of plug in modules, as well as excellent ground connection to the modules.

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Touch Tone® — trademark of the Western Electric Co.

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- ★ 650 MHZ PRESCALER KIT
- Why pay \$75.00 to \$100.00 or more for a 250 MHz prescaler when you can get one that goes all the way to 650 MHz for just
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- ★ TOUCH-TONE KEY BOARD
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Kendall Street, P.O. Box 1942, New Haven, Connecticut 06509; 351 California St., Box 7809, San Francisco, California 94104. For more information use check-off on page 126.

National TTL Data Book

A new TTL Data Handbook describing National Semiconductor's complete line of bipolar logic devices has just been published. The new handbook gives full specifications and electrical performance characteristics on standard 54/74 TTL, low-power 54L/74L, high-speed 54H/74H, ultrahigh-speed Schottky 54S/74S, low power Schottky 71LS/81LS, Series 9000 TTL, Series 10,000 ECL, and Series 930 DTL. An industry cross reference guide and a functional index are also included, as well as package outlines.

The TTL Data Handbook may be obtained by sending a \$4 check (California residents add 6% sales tax) to the Marketing Services Department, National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, California 95051.

concealable antenna mount



A steel antenna mount which stops radio antenna theft, trademarked *Tuk-A-Way*, has just been introduced. Sold as an accessory for citizens-band radio, mobile radio and car telephone users, *Tuk-A-Way* installs easily on the trunk lip of most car models, and provides complete antenna concealment inside the trunk when not in use. It accepts antennas designed for either roof or trunk mounting.

Tuk-A-Way offers three essential benefits for car radio and telephone users: the added protection against theft; the convenience which allows use of automatic car washes and covered parking facilities; and the elimination of

paint chipping and scratching or permanent holes in the roof or trunk by use of a clamp for installation.

For durability, the antenna mount is constructed of 12-gauge, cold-rolled steel, and is coated with zinc chromate. The hinge is of stainless steel and is spot-welded to the clamp to provide positive ground contact. In addition, the hinge is fitted with a stop which holds the antenna suspended and off the trunk floor while stored, allowing for short-range reception from inside the trunk.

Tuk-A-Way is available for \$15.95 from Deep South Marketing Corp., 2828 Telephone Road, Houston, Texas 77023.

logic monitor



Logic Monitor 2, a digital test instrument incorporating a fully isolated power supply and selectable trigger threshold which matches the precise characteristics of the logic family under test, has just been introduced. The LM-2, which lists at \$125.00, consists of two units; a connector/display unit which clips over the IC, and a power-supply module, which contains the precision reference power supply and logic family selector switch. Because it simultaneously displays 16 channels of information, it can show the user far more than an oscilloscope, and it's always automatically in synchronization.

LM-2's self-contained power supply means that there is no loading of a circuit under test, avoiding the problem of logic level shifts, false triggering and power-supply loading which sometimes occurs with other types of equipment.

6 Digit LED Clock Kit - 12/24 hr.

\$950 IN QUANTITIES
ea. OF 1 TO 5

\$850 IN QUANTITIES
ea. OF 6 OR MORE

KIT INCLUDES:

- INSTRUCTIONS
- QUALITY COMPONENTS
- MONEY BACK GUARANTEE
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

- 6 — LED Readouts (FND-70 .25 in. Red, com. cathode)
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- 13 — Transistors
- 3 — Switches
- 6 — Capacitors
- 5 — Diodes
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- 24 — Molex pins for IC socket

ORDER KIT #850

AN INCREDIBLE VALUE!

"Kit #850 will furnish a complete set of clock components as listed. The only additional items required are a 7-11 VAC transformer, a circuit board and a cabinet, if desired."

Printed Circuit Board for Kit #850 or #850-4 (etched & drilled Fiberglass) \$2.95
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"Mini-brite" discrete LED's (for colon in clock display) pkg. of 5 for \$1.00

KIT #850-4 SAME AS #850 BUT .4" LED'S \$11.95

60 HZ XTAL TIME BASE KIT — Use your digital clock from any 12 Volt DC source: Car—Boat—Etc. **\$5.95 ea.**

Power req: 5-15 VDC/2.5 mA @ 12 VDC KIT #TB-1
Accuracy: (adjustable) 2 PPM/3.6 MHz xtal
Size: PC board approx. 1" x 2"
Complete - Single IC kit with info for easy hook-up to most IC clock.

\$4.95 purchased with any clock kit

NOW AVAILABLE — TB-IC (wired, tested & calibrated) \$9.95

JUMBO DIGIT CONVERSION KIT — For LED Clocks. Kit provides a multiplex display PC board and six .5" brite LED's, (FND-503's or FND-510's). LED's require only 5 mA/seg and can be driven by most any LED clock circuit. Data for displays and hook-up included. (This PC board will mate point to point with kit #850 circuit board) specify Common Cathode or Anode **\$9.95**

JUMBO DIGIT CLOCK KIT COMPLETE — Kit features six .5" red LED's, all components, PC boards, plug transformer, line cord, etc. 50/60 Hz op., 12 or 24 hr, MM5314 IC. (Will fit Cab. I) **Kit #5314-5 Complete Less Case \$19.95**

6 Digit LED Clock - Calendar - Alarm Kit

• 12/24 HR TIME • JUMBO DIGITS (MAN-64) • 28-30-31 DAY CALENDAR • AC FAILURE/BATTERY BACK-UP • 24 HR ALARM — 10 MIN. SNOOZE • ALTER-NATES TIME (8 SEC) and DATE (2 SEC) OR DISPLAYS TIME ONLY AND DATE ON DEMAND • 50/60 Hz OP. • THIS KIT USES THE FANTASTIC CT-7001 CHIP. FOR THE PERSON THAT WANTS A SUPER CLOCK KIT (TOO MANY FEATURES TO LIST)! THIS IS A COMPLETE KIT (LESS CASE) including Power Supply, Line Cord, Drilled PC Boards, etc. **39.95** ORDER KIT #7001B (CASE NOT INCLUDED)

KIT #7001-C SAME AS #7001-B BUT HAS DIFFERENT LED'S. USES FOUR .63" DIGITS & TWO .3" DIGITS FOR SECONDS. COMPLETE KIT, Less Case. **\$42.95**

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout. Specify for #7001B or #7001C. (Set of 2) **\$7.95**

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3" HIGH
6 1/4" WIDE
5 1/2" DEEP
GREAT FOR CLOCK & Clock-Calendar Kits
White Plexiglas Case
Specify RED or GRAY Plexiglas Chassis
Chassis Serves As Bezel To Increase Contrast of Digital Displays. Use Gray With Any Color — Red With Red Displays Only (Red LED's with Red Chassis Brightest)

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CABINET II

2 1/2" HIGH
4 1/2" WIDE
5 1/2" DEEP
GREAT FOR SMALLER CLOCK KITS. (Ideal for Kit #850 or #850-4 above)
All Plexiglas Red Chassis, White Case.
Red Chassis Serves As Bezel To Increase Contrast of LED Displays

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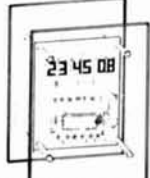
CT-7001 — CLOCK-CAL-I.C. \$7.95
MM5314 — CLOCK I.C. \$3.95
MM5316 — ALARM CLOCK I.C. \$3.95
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- o Input impedance = 50 ohms
- o Output TTL, Fan out of 1
- o Sensitivity 14 mv @ 150 MHZ, 150 mv @ 300 MHZ



\$32.95
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2 Meter FM Transmitter

- o 2 Channels, 144-148 MHZ
- o Power Output 2 watts typical, 1 watt min @ 12.5 VDC
- o 50 ohm output impedance
- o Narrow band FM ± 5 KHZ
- o Rugged balanced emitter output transistor
- o Small size 1 7/8" w x 1" h x 3 3/4" L



Input Watts	Output Watts	
	Min.	Typical
1	15	20
2	20	25
4	30	30

\$39.95
LA-144

30 Watt 2 Meter Power Amplifier

- o Frequency range 144-148 MHZ
- o Maximum RF output power 30 watts
- o Maximum RF input power 5 watts
- o Supply voltage 13.6 VDC
- o Small size 1 7/8" w x 5/8" h x 3 3/4" L
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Send Self-Addressed Stamped Envelope For More Information

In use, the LM-2 visually displays gate inputs rising and falling, passing pulses from circuit to circuit. Flip-flops may be seen changing states; decoders and encoders can be seen accepting and recoding information.

Further information on the LM-2 can be obtained from Continental Specialties Corp., 44 Kendall Street, Box 1942, New Haven, Connecticut 06509, or by using the check-off on page 126.

hand-held ssb transceiver

The MM-2C is a hand-held, single-channel ssb transceiver recently introduced by Northern Radio Company of Seattle, Washington. Rated at 5 watts peak envelope power, the MM-2C operates in the 1.6-10 MHZ range. It's completely solid state and is powered by self-contained rechargeable batteries. The transceiver can be used with a variety of antennas and is protected against antenna mismatch. A temperature-compensated crystal oscillator assures optimum frequency stability between -22 and 122F (-30 and 50C).

The MM-2C transceiver is ideally suited for applications requiring portable communications capability in areas where the range with hand-held vhf fm equipment is limited by terrain or dense foliage. Although the unit is specifically designed for longer-range portable communications required by industries such as Petroleum, Mining, Geological, and Forestry, it is also suitable for amateur radio applications. For more information contact Northern Radio Company, 4027 21 Avenue West, Seattle, Washington 98199, or use *check-off* on page 126.

short circuit

Much to our embarrassment, the so-called NASA speech filter which appeared in *circuits and techniques* in the June issue did not originate from NASA, but from a jokester who published the circuit in a French amateur radio magazine in April, 1971. The only clue to the spoof, which we didn't catch, was the name of the NASA engineer who supposedly developed the circuit — Schertz — which is German for joke. The only thing the circuit does is provide a very large insertion loss.

SWTP 6800

#1

IN PERFORMANCE

The word is getting around. There is simply no better processor available for general purpose computer work than the Motorola MC6800. This memory oriented processor is easier to program and makes possible more efficient, shorter and faster running programs than the old fashioned bus oriented processors. Have you been convinced that machine language, or assembler programs are only for the experts? Well not with a modern 6800 based computer. Anyone can learn very quickly with this simple straightforward hexadecimal notation processor. When you add to these advantages the unique programmable interfaces and the Mikbug® ROM you truly have a "benchmark" system.

Mikbug® eliminates the tedious and time consuming job of loading the bootstrap program from the switch console each time the computer is turned "On". With Mikbug® this is automatic and you simply don't have switches and status lights. It has been said (not by us) that a switch console is essential for "hardware development," (perhaps they meant "hardware debugging"). Anyway the SwTPC 6800 system has no need for either. This is a fully developed, reliable system with no strange habits. All boards have full buffering for solid noise immune operation. One crystal type clock oscillator drives everything, processor interfaces and all; so there are no adjustments and no problems.

FOR VALUE

The SwTPC 6800 in its basic form comes complete with everything you will need to operate the computer except an I/O device. This may be either a teletype of some kind, or a video

terminal. You get a heavy duty anodized aluminum case, a 10 Amp power supply large enough to power a fully expanded system, a mother board with seven memory/processor slots and eight interface slots, a 2,048 word static memory and a serial control interface. This kit is now only \$395.00. It was introduced at \$450.00, but when processor prices went down we reduced the price of the kit accordingly.

As an owner of our 6800 computer you will get copies of our newsletter with helpful information and software listings. We have a library of software including all the common computer games and our fantastic BASIC. This is available to you for the cost of copying, you don't have to buy anything to get this material.

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- American Microprocessors, Equipment & Supply Corp. at Chicagoland Airport, P.O. Box 515, Prairie View, Illinois 60069 (312) 634-0076
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Adjusts 10 sec. to 3 min. 2 Hz, pulsed dc output.

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\$7.95 assembled,
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1000Hz TONE
IC oscillator for use with TG-970. Drives your speaker.

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\$4.50 assembled,
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Use with W.E., etc. Touchtone pads. Carrier hold delay with indicator; LED pilot; variable pad gain, hold delay and pad-mic isolation. Zener regulated. Sinks 300 ma.

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TT-980 & TT-979

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\$21.25 assembled,
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Gain: 3.4 db. compared to
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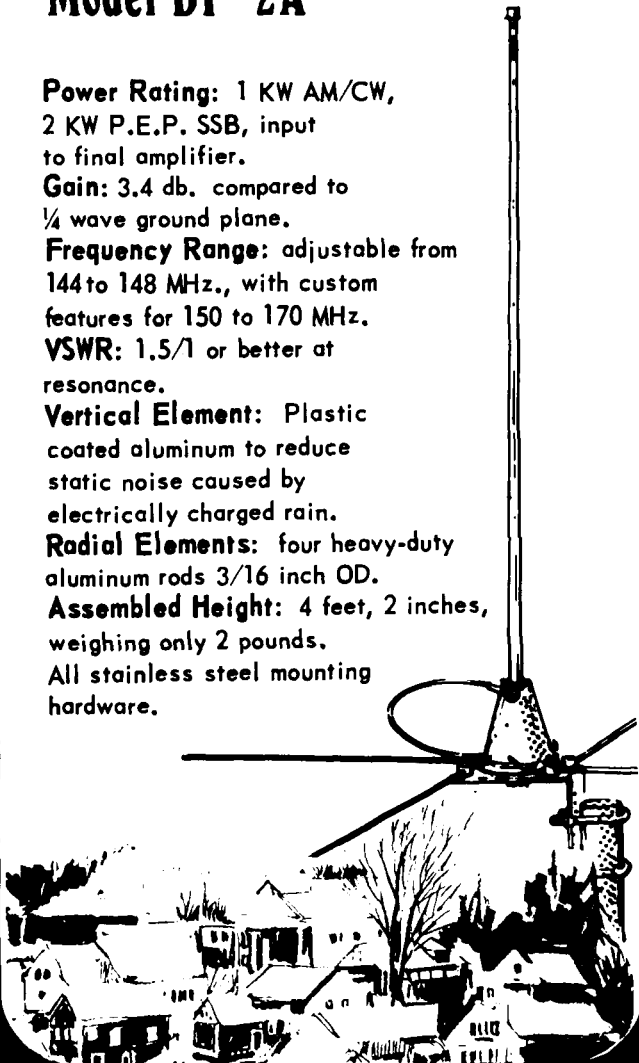
VSWR: 1.5/1 or better at
resonance.

Vertical Element: Plastic
coated aluminum to reduce
static noise caused by
electrically charged rain.

Radial Elements: four heavy-duty
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Assembled Height: 4 feet, 2 inches,
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All stainless steel mounting
hardware.



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Power Rating: 250 watts AM/CW,
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Gain: 3.4 db. compared to
1/4 wavelength.

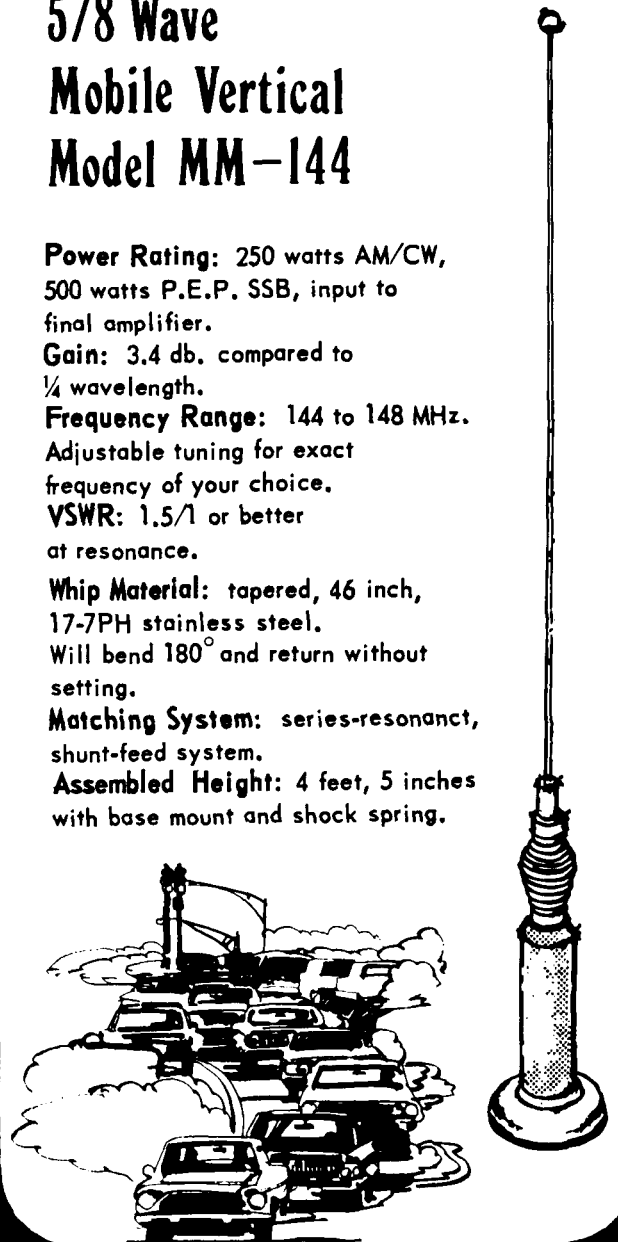
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VSWR: 1.5/1 or better
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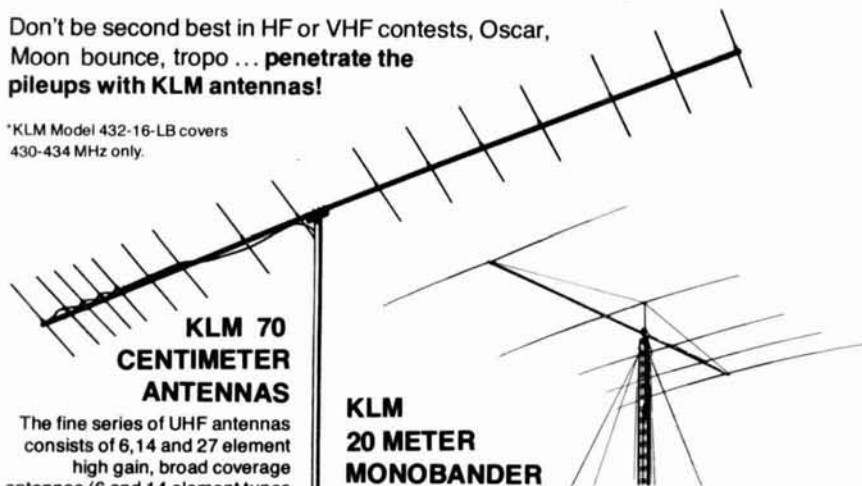
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A typical antenna: (KLM-420-470-14)
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Gain: 11.5db (dipole reference)
Beam width: 18 degrees @ 3db pts.
Diameters: Boom: 1" (25.4mm)
Elements 3/8"D (9.5mm)

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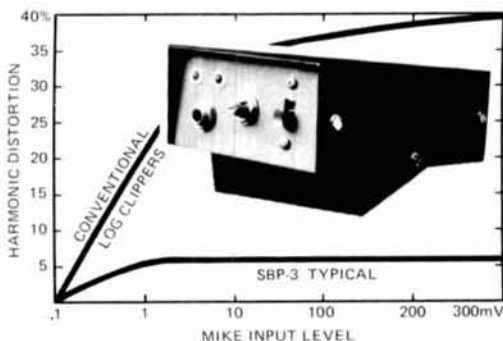
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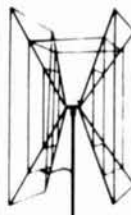
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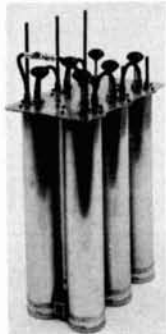
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3 inch 4 ohm VC Square frame speaker 0.3 watt with 4 mounting holes. \$1.45 each ppd.

OVAL SPEAKER, 2" x 4" x 1 1/4" deep, 8Ω 0.3 watt, anodized with 4 mtg. holes. \$1.75 ea. ppd.

UNPOTTED TOROIDS — center tapped 88MHY Limited Qty's 44 MHY 5/\$2.95 5/\$3.95 ppd.



TUNING METERS — Blue tinted plastic body, 0 to left, graduated scale, 200μA, 1 1/2" W x 1 1/4" H x 3/4" D. Scale can be rear lighted. Sylvania #18148-1 \$2.25 ea. or 4/\$6.95 ppd.

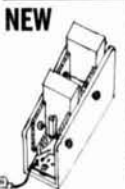


CARBON TRIMMERS Miniature 1/4 watt units for limited-space applications. PC type terminals. Max 500 volts. Ohm ratings are: 200, 500, 700, 1000, 1.5K, 250K, 700K 30¢ ea. or 5/\$1.35 ppd.

NEW MINI Imported vertical pots (1/2"H, 3/8"W, 1/16"D) Values: 1000, 2.5K, 5K, 50K ohms. Slot adj. Also 5K Horiz. Price: 5 for \$1.20 ppd.

MINIATURE SNAP ACTION SWITCHES — SPDT leaf actuator, 10A, 125V AC, 1 1/8" x 1/2" x 3/8" 60¢ ea. or 3 for \$1.55 SPST N.O. Cherry "Button Type" E34, 15A, 125V AC, 1 1/8" x 5/8" x 3/8" 50¢ ea. or 3 for \$1.35 SPST N.C. Acro "Button Type" (tab accessible to make SPDT), 1 1/8" x 5/8" x 3/8" 50¢ ea. or 3 for \$1.35

SPST SLIDE SWITCHES (Red) Made by Stackpole — 4A, 125V A.C. 35¢ ea. ppd.



NEW Transistor and Relay Assembly — consists of (2) MJE3055 and (2) MJE2955 transistors (10 amp, 90w, 60v complementary pairs) mounted in "U" channel heat sink 2 1/2" x 1 1/8" x 1 1/2". (2) XTAL CAN RELAYS, DPDT, 28v, 8000Ω, 5.8 ma DC, 1 amp contacts mounted on PC board with resistors. \$2.85 ea. ppd.

1 1/4 inch miniature alligator clips. Bright vinyl red or black. Nickel plated 9 for \$1.00



CAPACITORS

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3000 MFD @ 30 Volt Capacitors.

Size 1" Diameter x 3" Long. 90¢ Each or 3 For \$2.25 ppd.

3000 MFD @ 20V Capacitors. Same size as above. 80¢ ea. or 3 for \$2.00 ppd.

ALSO 3000 MFD @ 50V 95¢ ea. or 3/\$2.65 ppd

CRL DISC CAPACITORS

.1 MFD, 10V 3/8" dia., long leads. 10 for \$1.00 ppd.

Red 6 foot #18-2 line cord with flanged safety plug — 55¢ ea. or 3/\$1.45 ppd. Gray 6 foot, 7A, plugs into auto litter socket — 95¢ ea. or 3/\$2.55

General Purpose Germanium Diodes. Similar to 1N34a etc. All Cathode banded Full leads. 16 for \$1.00 ppd.

Small, glass, silicon diodes. Fairchild FD-type. Full leads and guaranteed. Price: 16 for \$1.00 ppd.

NEW SIZES — VERTICAL MOUNT

PC BOARD POTENTIOMETERS

American made (CRL) Cermet sizes: 25K, 100K ohms. 5/\$1.30 ppd. CTS Blue wheel. Values: 750, 1K, 1.5K, 50K, 300K ohms. 5/\$1.20 ppd.

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flea market

ICOM 22A, DV-21, Heath P.S. mint \$525 or will trade. Omar, P. O. Box 306, Durand, Mich. 48429.

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

ALL 73 MAGAZINES. From start to date — make offer. J. Strolin, K1REC, 21 Ellen St., Norwalk, Conn. 06851.

15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920's. Amateur station W2AN. Write for information. Antique Wireless Assn., Main St., Holcomb, N. Y. 14469.

COLLINS KWM-2, PM-2, \$900. 312B-5, \$425. IC22, \$150. Crystal pairs, \$6. IC30, 6 crystal pairs, \$250. Excellent condition. Original cartons. 1732 Willow Point, Shreveport, La. 71109.

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

FREE Catalog. LEDs, strobe lights, UARTS, memories, RF transistors, microphones, IC's, relays, rechargeable batteries, precision trimmer capacitors, digital thermometers, unique components. Chaney's, Box 27038, Denver, Colo. 80227.

PC's, Send large S.A.S.E. for list. Semtronics, Rt. #3, Box 1, Bellaire, Ohio 43906.

HEATH HW-7, mint, built by engineer, shipped UPS, \$60. Roger Stachour, WØRL, Grundy Center, Iowa 50638.

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

YAESU OWNERS — Send a dollar (creditable towards dues) for August issue of Newsletter containing detailed chart of US replacements for FT-101 transistors. Or join up and get all 1976 Newsletters plus savings via our Purchasing Service. Still only \$5. International Fox-Tango Club, 248 Lake Drive, W. Palm Beach, FL 33411.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

QSL'S — BROWNIE W3CJ1 — 3035B Lehigh. Allentown, Pa. 18103. Samples with cut catalog 50¢.

EXCLUSIVELY HAM TELETYPE 21st year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. \$3.50 per year. Box 837, Royal Oak, Michigan 48068.

OSCAR 7, SSB-CW TRANSMIT CONVERTERS. For 28 or 50 MHz input at 20 mw. 432 MHz output at 1 watt. Solid state, for 12 volt supply. 35 watt solid state amplifier available for this converter. Units designed and built by WØENC. Write for information. UHF-VHF Communications, 53 St. Andrew, Rapid City, S. D. 57701.

YOUR AD belongs here too. Why not send it in today.

Coming Events

MEMPHIS IS BEAUTIFUL IN OCTOBER! The Memphis Hamfest, bigger and better than the 3,500 who attended last year, will be held at State Technical Institute, Interstate 40 at Macon Road, on Saturday and Sunday, October 2 and 3. Demonstrations, displays, MARS meetings, flea market, ladies' flea market, too! Hospitality room, informal dinners, XYL entertainment, many outstanding prizes. Dealers and distributors welcome, too! Contact Harry Simpson, W4SCF, Box 27015, Memphis, TN 38127, phone 901 358-5707.

HAMFEST — Springfield, Illinois! First. Sangamon Valley Radio Club invites everyone. Sunday, September 26th. Rain-shine. Sangamon County Fairgrounds, New Berlin, Illinois on U.S. 36. Write K9HDZ, 622 Magnolia, Rochester, Illinois 62561.

CINCINNATI HAMFEST: 40th Anniversary Hamfest - Sunday, September 19, 1976 at the New Improved Stricker's Grove on State Route 128, one mile west of Ross (Venice) Ohio. Flea market, exhibits, contests, model aircraft flying, food and beverages all day. Advance ticket sales \$7.00 - Tickets at the gate \$8.00 - covers everything. For further information: Lillian Abbott, 1424 Main Street, Cincinnati, Ohio 45210.

TEST EQUIPMENT

All equipment listed is operational and unconditionally guaranteed. Money back if not satisfied—equipment being returned must be shipped prepaid. Include check or money order with order. Prices include UPS or motor freight charges.

BECKMAN 5750A Counter Freq conv	275
10-1000MHz	275
BOONTON 190A Q-mtr 30-200MHz	325
BOONTON 202B AM-FM sig gen	
54-216MHz	275
DEI TDU-2 30MHz video display	55
GR546C Audio microvoluter	65
GR821A Twin-T imp bridge to 40MHz	165
GR1302A Audio Osc .01-100kHz	75
HP160B (USM105) 15MHz scope with	
norm horiz, dual trace vert plugs	375
HP166B (Mil) Delay sweep for above	130
HP185A Sampling Scope 1 GHz 186B	
xstr rise plug	335
HP202B LF Osc .5Hz-50kHz 10v. out	75
HP205AG Lab Audio Gen .02-20kHz	195
HP212A Pulse Gen .06-5kHz PRR	65
HP430C Microwave Pwr Mtr	40
HP540B Transfer Osc to 12.4GHz for	
use with HP524 type counters	115
HP571B-561B Digital clock/rcdr	245
HP608D (TS10) std sig gen 10-420MHz	425
HP616 Sig gen 1.8-4GHz FM-CW	385
HP686 Sweep Gen 8.2-12.4GHz Sweep	
range 4.4MHz-4.4GHz	595
HP803A VHF Ant bridge 50-500MHz	95
SINGER SSB4 Sideband spec anal	
0-40MHz, res. to 10Hz	685
TEK 181 Time-mark scope calib.	45
TEK 190 Sig gen (const ampl) 50MHz	125
TEK 551 Dual beam 27MHz scope	
less plug-ins	735
TEK 565 Dual beam 10MHz scope	
less plug-ins	525
TS 505 Std VTVM (rf to 500MHz)	65

For complete list of all test equipment send stamped, self-addressed envelope

GRAY Electronics

P.O. Box 941, Monroe, Mich. 48161
Specializing in used test equipment.

SW-5 — \$87.50

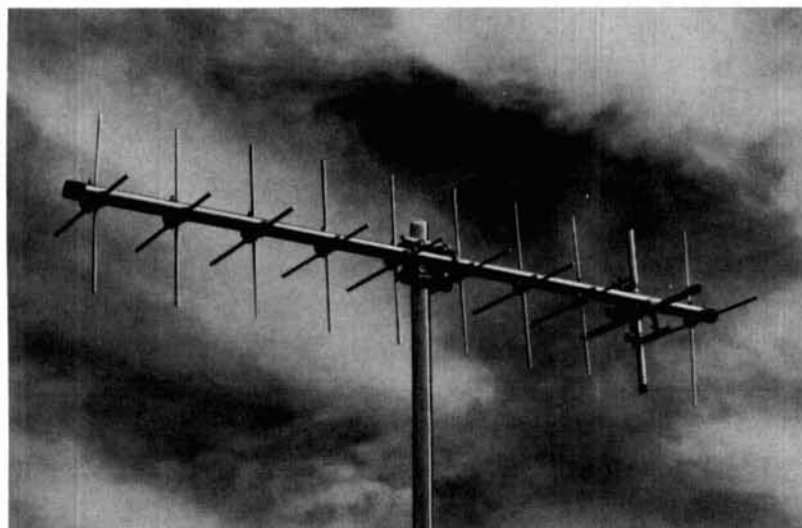


The SW-5 is a remote controlled RF switch with indicator lights telling which antenna is in use. It will handle 4 kW PEP and more. Remote switch is housed in weather tight hinged box. A six wire #18 cable is required to operate the SW-5. Ham M control cable works fine up to 150'. Heavier cable necessary for longer distances. Remote switch operates off 28 VDC built in power supply. No visible effects on SWR. Zero dB insertion loss. Not recommended above 30 MHz. Standard unit is equipped with UHF connectors but BNC, N, HN, C connectors are available at additional charge. Models available are SW3, 4, 5, 6, 7, 8, 9. Also heavy duty 10kW units. Special switching systems are available. Tell us your needs.

ANTENNA MART

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Phone: 515-292-7114

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... *Alive* with activity at *both* ends of the band! Be a part of the total 2 Meter picture with the Cush Craft Twist Antenna. Actually two, easily assembled, 10 element yagis in one — the vertical elements are cut for the high end, the horizontal elements for the low end, and separate feed lines are used. The A147-20T is tailored to meet the demands of the operator who enjoys the best of both worlds

— FM and SSB/CW.

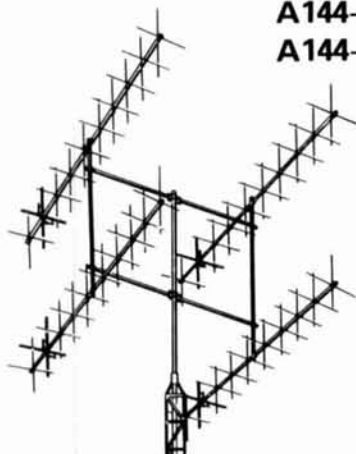
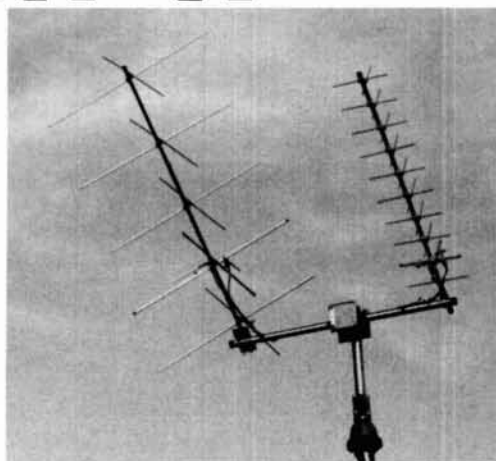
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A144-10T \$32.50 A432-20T \$45.00
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	SPECIFICATIONS			
Model	A147-20T	A144-10T	A144-20T	A432-20T
Center Freq. (MHz)	144.5/146.5	145.9	145.9	432
No. Elements	10/10	10	20	20
Weight (lbs.)	6	3.5	6	3.5
Wind Surf. Area (ft. ²)	1.42	.74	1.42	.37
Mounting	Center	Rear	Center	Rear
Dimensions (Inches)	40x40x140	40x40x70	40x40x140	14x14x57
Front-to-Back Ratio (dB)	22	22	22	22
Forward Gain (dBd) circular	—	10.8	13.6	13.6
linear	12.4	9.6	12.4	12.4

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This Month's Specials

NEW

Fairchild VHF Prescaler Chips

Type	Description	Price
11C01FC	High Speed Dual 5-4 Input OR/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	\$2.60
11C44DC	Phase Freq. Detector	\$2.60
11C58DC	ECL VCM	\$4.53
11C70DC	600 MHz Flip/Flop With Reset	\$12.30
11C83DC	1 GHZ 248/256 Prescaler	\$29.90
11C90DC	650 MHz ECL/TTL Prescaler	\$16.00
11C90DM	650 MHz ECL/TTL Prescaler	\$24.60
11C91DC	650 MHz ECL/TTL Prescaler	\$16.00
11C91DM	650 MHz ECL/TTL Prescaler	\$24.60
95H90DC	250 MHz Prescaler	\$9.50
95H90DM	250 MHz Prescaler	\$16.55
95H91DC	250 MHz Prescaler	\$9.50
95H91DM	250 MHz Prescaler	\$16.50

RF TRANSISTORS

New	Description	Price
RCA 40290	12.5v, Ft. Typ. 500MHz 2 watts min. at p. in 0.5 watts	\$2.48
2N2857	\$1.85	2N6080 \$5.45
2N3375	\$7.00	2N6081 \$8.60
2N3866	\$1.08	2N6082 \$11.25
2N4072	\$1.50	2N6083 \$12.95
2N4427	\$1.20	2N6084 \$13.75
2N5179	\$4.68	2N6166 \$85.00
2N5589	\$4.60	MRF511 \$8.60
2N5590	\$6.30	MCMC918 \$2.50
2N5591	\$10.35	MMT2857 \$2.50
2N5637	\$20.70	

TUBES

IP21	\$19.95	6146B/8298A	\$5.50
2E26	\$4.00	6360	\$5.50
4X150C	\$18.00	6661	\$1.00
4X150A	\$15.00	6680	\$1.00
4CX250B	\$24.00	6681	\$1.00
4X250F	\$22.00	6939	\$5.50
DX415	\$25.00	7984	\$3.95
572B/T160L	\$22.00	8072	\$32.00
811A	\$7.95	8106	\$1.95
813	\$19.00	8156	\$3.95
931A	\$9.95	8950	\$5.50
4652/8042	\$6.95	6LQ6	\$3.95
5894	\$32.00	7289/2C39A 10/	\$12.50
6146A	\$4.25		

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Motorola U43 GGT	\$49.95
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NICAD Batteries, AA, 1.25 volts	49¢ ea.
GEL/CELL #GC1215, 12 volts, 1.5 amp hrs	\$19.95

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MHz electronics

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flea market

ELMIRA, N. Y. HAMFEST: Sept. 25, 1976, Chemung County Fairgrounds. Flea market, dealer displays, technical talks. Talk in 10/70-146.52. \$2.00 advance sale - \$2.50 at gate. For further information, WA2SMM, 320 W. Ave., Elmira, N. Y. 14904.

OHIO: 34th Annual Findlay Hamfest - Sept. 12, Riverside Park, Findlay, Ohio. Talk-in 146.52. For advanced tickets and/or info write: (SASE please for under 5 tickets) Clark Foltz, WBUN, 122 W. Hobart St., Findlay, Ohio 45840.

BLOSSOMLAND SWAP-SHOP, October 3rd, Berrien County Fair Grounds, Berrien Springs, Michigan. Greatly expanded facilities, 150 tables, entertainment, refreshments. Advance ticket donation \$1.50, tables \$2.00. Write: John Sullivan, P. O. Box 345, St. Joseph, Michigan 49085. Make checks payable to: Blossomland Hamfest.

NOW YOU ALL COME, YOU HEAR. Where? Why ARRL Hudson Division Convention, November 13 and 14, Playboy Resort and Country Club at Great Gorge, McAfee, New Jersey. Many exhibits, giant indoor flea market, FCC and ARRL forums, FCC exams, special YL programs, technical sessions and a Saturday night banquet with Jean Shepherd, K2ORS, world traveler, columnist and famed radio and TV personality as the speaker. For information write to Al Piddington, WA2FAK, 4 Acorn Drive, East Northport, N. Y. 11733.

FIRST ANNUAL HAMFEST — Elmira, N. Y. Sept. 25. For details, write WA2SMM, 320 W. Ave., Elmira, N. Y. 14904. Dealer inquiries invited.

EASTERN CONN. AMATEUR RADIO ASSOC. will be holding a flea market and auction on Sept. 19, 1976, starting at 10:00 a.m. and running to 5:00 p.m. at the Rocking 'D' campground, Snake Meadow Rd., South Killingly, Conn. Table space for the flea market will be \$2.00 and commission for auctioned items is 10% (max. of \$10.00). Talk in an 2 mtr FM 52.52. Repeater 1676, CB chan. 14. For more info call Bob, WA100A, 203-774-1465 days or Mike, WA1RLV, 203-774-8254 nites. Dealers invited.

GREATER LOUISVILLE HAMFEST, Sunday, Sept. 26 at the Kentucky National Guard Armory on Crittenden Drive at I-65 in Louisville. Indoor exhibitors, gigantic flea market, free ladies bingo. Registration adults \$2.00, children 12 and under free. Campers only may enter Saturday at 1800z. Write K4G0U — 2415 Concord Dr., Louisville, Ky. 40217.

HAMBURG INTERNATIONAL HAMFEST will be held on Sept. 18, 1976 at the Erie County Fairgrounds, Hamburg, N. Y., near Buffalo. Registration \$3/\$2.50 (adv). Flea market \$1/\$.50. Fri. evening get-together with valuable door prizes, meetings, displays, R/V and picnic facilities, fun, prizes. Talk-in freqs: 146.31/91, 7.255 (ECARS) and 3.925 MHz. Info: Bert Jones, W2CUU, 143 Orchard Drive, Kenmore, N. Y. 14223. Phone (716) 873-3984.

EL PASO-ARRL HAMFEST — Saturday and Sunday, September 4th and 5th. Seminars, Juarez tours, ARRL forum, exotic modes, solar power, computers, flea market. Elegant Vista Motor Inn, I-10 & Lomaland. Write P. O. Box 24050, El Paso, Texas 79914 for information.

ERIE, PENN. Hamfest and Flea Market, Saturday, October 9, 1976. Kuhl Hose Company grounds on Pennsylvania Route 8, 1 1/2 miles south of I-90. Admission is free with a \$1.00 per car charge for the flea market. The times will be from 10:00 a.m. until 4:00 p.m. with a dinner to follow at 6:00 p.m.

SAVE THIS DATE: October 9, 1976 for the 22nd Annual VHF Conference. Western Michigan University, 1 & ET Bldg., Kalamazoo, Michigan. Registration 8 a.m. — full day of activity. Write: Dr. Glade Wilcox, Chm., W9UHF/8, Dept. of Electrical Engineering, Western Michigan University, Kalamazoo, MI 49008. Get on the mailing list for yourself and your club.

CENTRAL KENTUCKY HAMFEST, October 3, 1976 at the Countryworld Convention Center (I-75 between Lexington & Georgetown, KY). Prizes, flea market, talk-in 146.16-76. Admission \$2.50 advance; \$3.00 at door. Info & advance tickets: Hamfest, Box 4411, Lexington, KY 40504.

CALIFORNIA QSO PARTY sponsored by California Contest Club, October 2 & 3. A minimum of 350 W6 stations are hoped to be on the air. SASE for rules to Doug Docherty, WA6DQM, 2306 Monserat Ave., Belmont, CA 94002.

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<input type="checkbox"/> SN7403	.22 .23	<input type="checkbox"/> SN74125	1.29 1.30
<input type="checkbox"/> SN7404	.24 .25	<input type="checkbox"/> SN74126	1.29 1.30
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<input type="checkbox"/> SN7409	.52 .53	<input type="checkbox"/> SN74165	3.75 3.76
<input type="checkbox"/> SN7410	.22 .23	<input type="checkbox"/> SN74150	1.12 1.13
<input type="checkbox"/> SN7411	.27 .28	<input type="checkbox"/> SN74153	1.10 1.11
<input type="checkbox"/> SN7417	.62 .63	<input type="checkbox"/> SN74154	1.53 1.54
<input type="checkbox"/> SN7420	.22 .23	<input type="checkbox"/> SN74157	1.09 1.10
<input type="checkbox"/> SN7421	.55 .56	<input type="checkbox"/> SN74158	1.55 1.56
<input type="checkbox"/> SN7422	.47 .48	<input type="checkbox"/> SN74160	1.59 1.60
<input type="checkbox"/> SN7425	.37 .38	<input type="checkbox"/> SN74163	1.50 1.51
<input type="checkbox"/> SN7430	.22 .23	<input type="checkbox"/> SN74164	1.79 1.80
<input type="checkbox"/> SN7432	.36 .37	<input type="checkbox"/> SN74173	1.69 1.70
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<input type="checkbox"/> SN7447	1.10 1.11	<input type="checkbox"/> SN74184	2.19 2.20
<input type="checkbox"/> SN7448	1.10 1.11	<input type="checkbox"/> SN74185	2.19 2.20
<input type="checkbox"/> SN7450	.22 .23	<input type="checkbox"/> SN74191	2.75 2.76
<input type="checkbox"/> SN7451	.27 .28	<input type="checkbox"/> SN74193	1.29 1.30
<input type="checkbox"/> SN7472	.44 .45	<input type="checkbox"/> SN74195	.89 .90
<input type="checkbox"/> SN7473	1.00 1.01	<input type="checkbox"/> SN74198	2.25 2.26
<input type="checkbox"/> SN7483	.99 1.00	<input type="checkbox"/> SN74199	2.25 2.26
<input type="checkbox"/> SN7485	1.41 1.42	<input type="checkbox"/> SN7490	1.00 1.01
<input type="checkbox"/> SN7486	.47 .48	<input type="checkbox"/> SN7491	.91 .92
<input type="checkbox"/> SN7489	2.25 2.26		
<input type="checkbox"/> SN7490	1.00 1.01		
<input type="checkbox"/> SN7491	.91 .92		

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<input type="checkbox"/> 9H2155-A	MMS203	12.50	12.51
<input type="checkbox"/> 9H2155-B	MMS202	9.95	9.96
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flea market

GREATER SYRACUSE New York Hamfest, Sunday, October 9, 1976, 9 to 6 p.m. at the Syracuse Auto Auction Bldg. (Rt. 11, 4 miles so. of Syracuse). Tickets \$1.50 before October 1st; \$2.00 at door. Lafayette Apple Festival same day — transportation by bus. Info & tickets from: R.A.G.S., Box 88, Liverpool, N. Y. 13088.

PENNSYLVANIA HAMFEST, September 19, 1976, Harrisburg, PA at the Park-n-Shop Parking Garage, 200 Block Walnut St. in Harrisburg. Registration \$3.00 per ham. Talk-in 146.16 WR3ABV .94/.94. Info from W3ABF or WA3AVX.

DXPO 76, McLean, Virginia Ramada Inn (Tysons Corner near McLean — easy access from Interstate 495, September 25 & 26. The most complete DX Convention ever planned. To get on mailing list write: Rosie Lamb, WA3NGS, Rt. 1, Box 297, White Plains, MD 26095. For details on complete DX Technical Session: Paul Rinaldo, K4YKB, 1524 Springvale Ave., McLean, VA 22101.

1976 ARRL DAKOTA DIVISION CONVENTION, October 1, 2, & 3, 1976, sponsored by St. Paul Radio Club. Location is the beautiful, new St. Paul Civic Center, 143 W. 4th St., St. Paul, MN. Biggest & best convention planned since 1933. FCC exams, prizes, awards, forums, technical sessions and more. Write St. Paul Radio Club, P. O. Box 30313, St. Paul, MN 55175. Registration before Sept. 12 is \$4.50, after the 12th, \$6.00.

MIDWEST ARRL CONVENTION, October 8, 9, & 10 in Omaha, Nebraska. Holiday Inn Convention Center at 72nd & Grover Sts., Omaha. Write AKSARBEN Amateur Radio Club, P. O. Box 1173, Omaha, NE 68101.

ADRIAN, MICHIGAN HAMFEST, September 26, 1976 at the Lenawee County Fairgrounds, 8 a.m. to 3 p.m. Tickets \$1.50 advance; \$2.00 at gate. Flea market, large display area. Talk-in 46.46-52-94 MHz. WB2QE.

SHELBY, NORTH CAROLINA Hamfest, Sept. 4 & 5. Display and demonstration of OSCAR 6 & 7 "on" for this event. Amsat station will operate both days. Jim Stewart, WA4MVI, for details.

ANNUAL GABFEST, September 11, Uniontown, ARC. Held on Club grounds, Old Pittsburgh Rd., Uniontown, Pennsylvania.

WRIACT — Worked All Mass Counties Award. SASE to WRIACT, South Shore Repeater Association, Box 284, East Milton, MA 02168 for rules.

PEORIA, ILLINOIS. Hamfest September 19 at the Exposition Gardens (Northmoor Rd., just west of University Ave.). Activities for entire family. Swap, prizes, lunch, overnight camping & dinner available for Sat. 18th. Advance tickets \$1.50 from WA9SCA, Earl R. Kimzey, RFD 1, Hanna City, IL 61536.

Stolen Equipment

DRAKE ML-2 & mounting bracket SN 11446. Stolen on evening of June 17 from James R. Johns, 24 Fairview Dr., Middletown, NJ 07748 (201) 842-8403.

TR22-C SN 850278 and SWAN 350 SN C847975 from my automobile at Northwest Plaza shopping center, St. Ann, Missouri, June 24. If you have information please contact W2ZKE at 1150 Staffler Rd., Bridgewater, NJ 08807.

REGENCY HR2 SN 04-04279 SSN. 313-40-1690 on inside frame. \$50 Reward. Bob Walker, W4LPU, 4713 N.W. 3rd Ct., Plantation, FL 33317. Phone: 305-792-7015.

ICOM IC-230 2 meter FM transceiver SN 2406312, with all 5 west coast "split-split" crystals. Stolen from locked auto. Inscribed on rear chassis: "CA DL- G516583" and "K6ICSS". Taken June 15, 1976. Contact K6ICSS, Dr. Michael K. Gauthier, 9550 Gallatin Rd., Downey CA 90240. Call Collect 213-923-0131.

HW-202 with tone burst encoder and HD-1982 micoder. Transceiver identified inside with K4GET or W1HDL call letters. Micoder low tone oscillator inoperative. Stolen in Utica, NY June 25, 1976. J. F. Myers, 16 Olde Village Dr., Winchester, MA 01890 or notify New Hartford Post, New York State Police.

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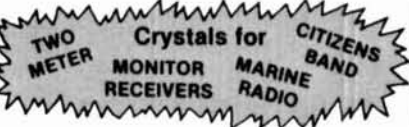
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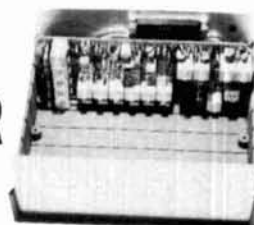
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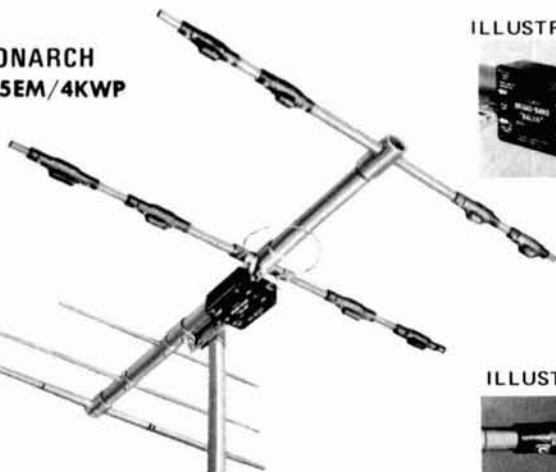


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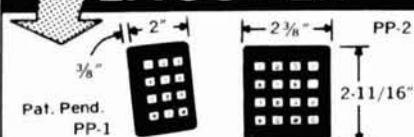
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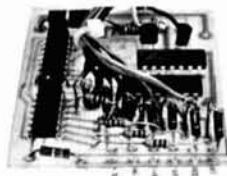
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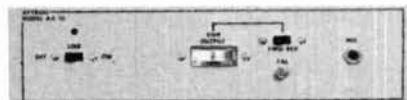
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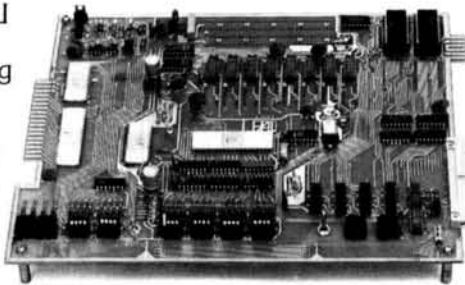
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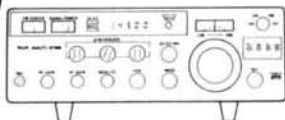
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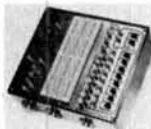
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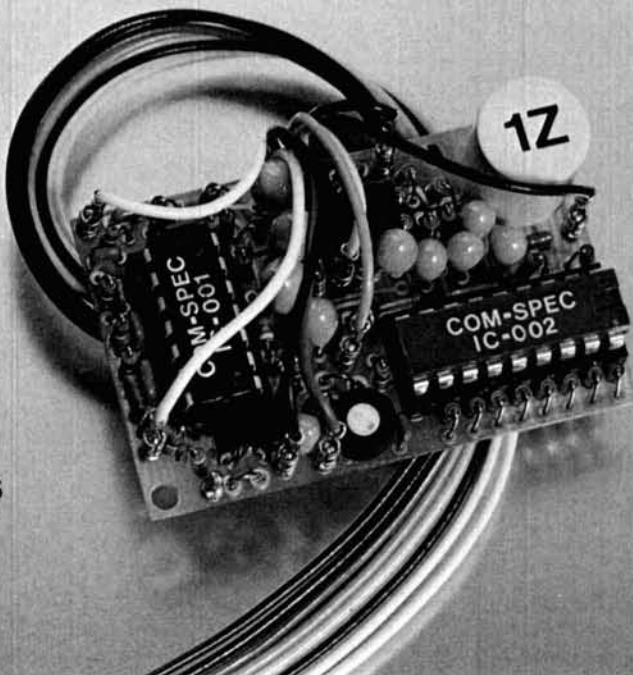
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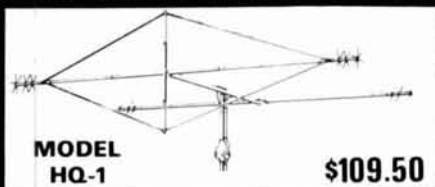


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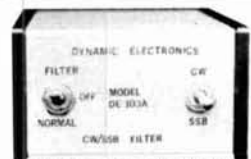
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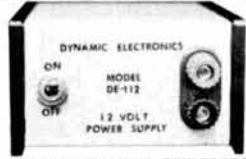


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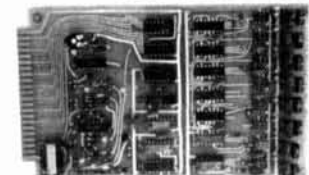
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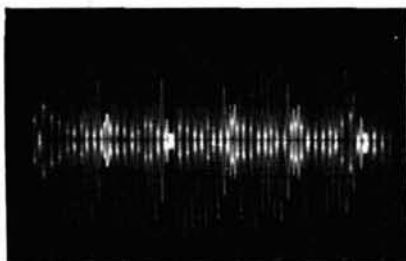


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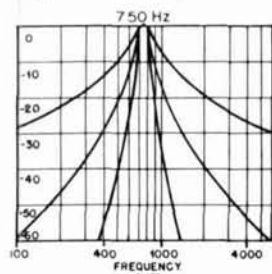


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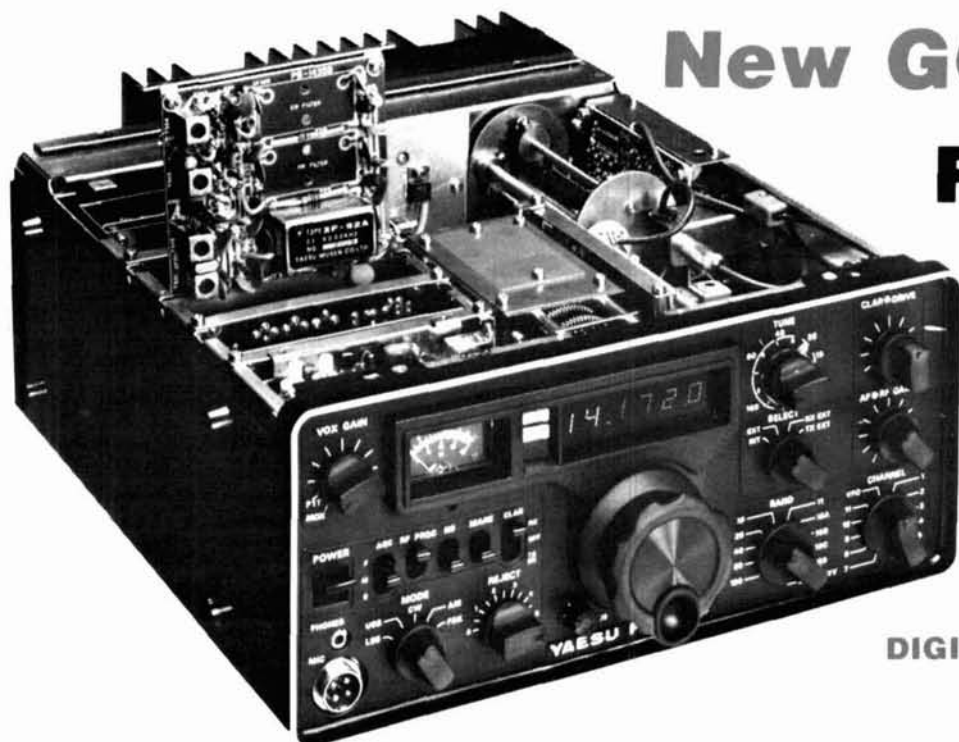
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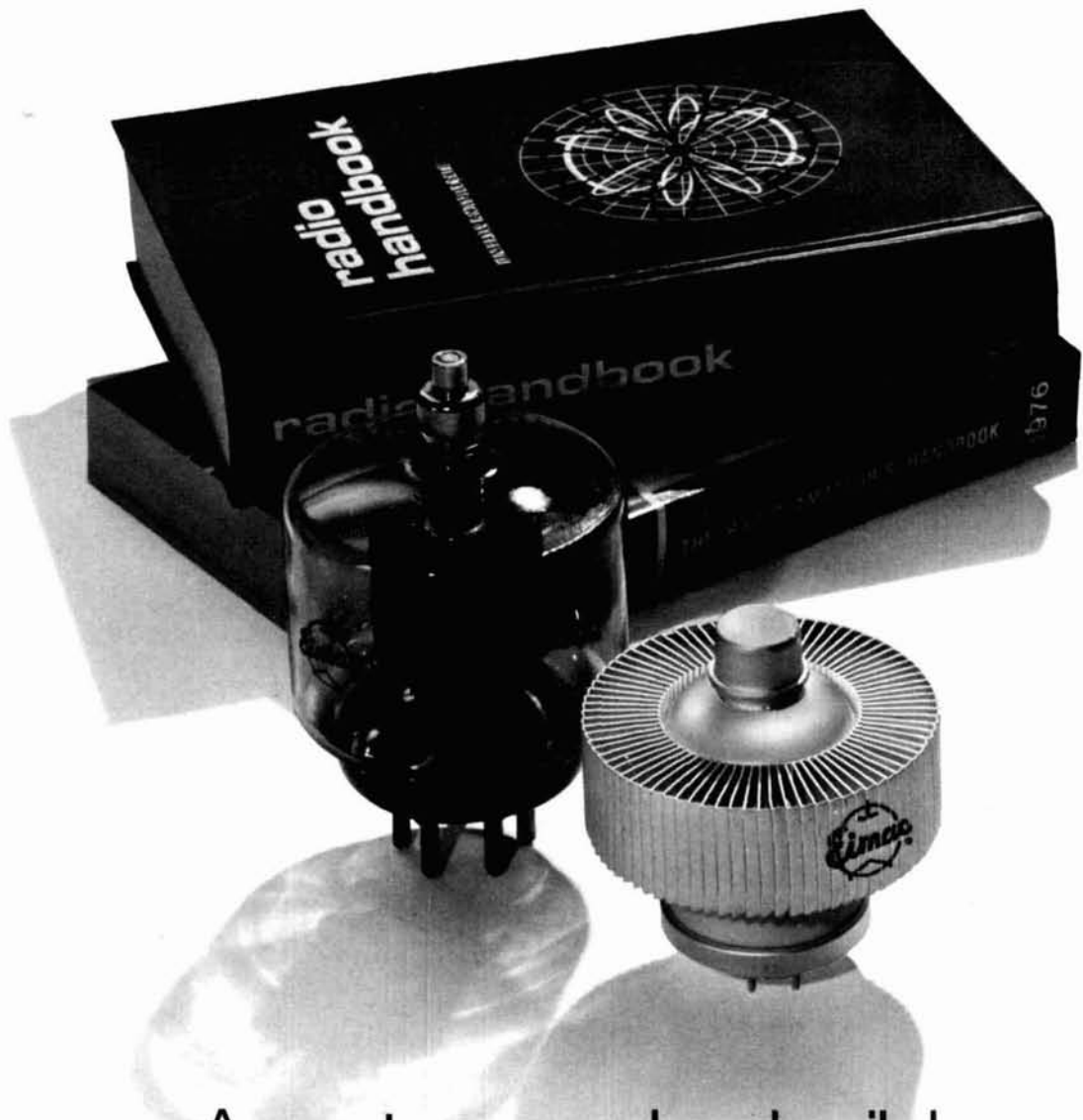
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