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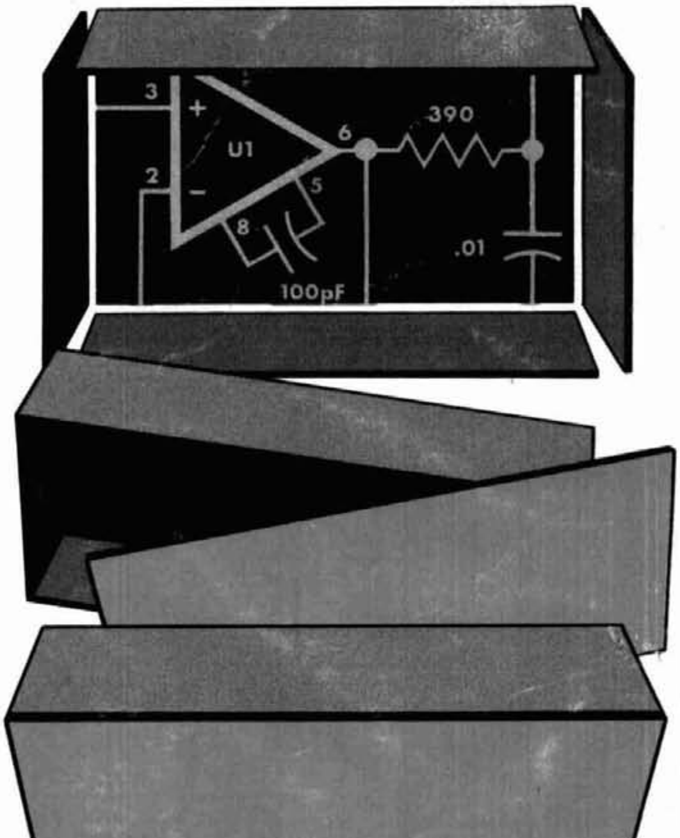
ham radio

magazine

OCTOBER 1979

modular-type



50-MHz SSB EXCITER

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1KD-5

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The 2KD-5 and 2K-4A linear amplifiers completely fulfill the needs of discriminating amateurs who want the very best *and are willing to pay the price*. But we have long felt that many amateurs would be satisfied with less power if they could still have the same high quality and dependability.

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Henry Radio

Prices subject to change without notice.

New MFJ 3 & 1.5 KW Versa Tuners

Run up to 3 KW or 1.5 KW PEP and match everything from 1.8 thru 30 MHz: coax, balanced line, random wire. Built-in balun.

3 KW VERSA TUNER IV's — 1.5 KW VERSA TUNER III's

NEW MFJ KW VERSA TUNERS HAVE THESE FEATURES IN COMMON

These 6 new MFJ KW Versa Tuners let you run up to 3 KW or 1.5 KW PEP (depending on the model) and match any feedline continuously from 1.8 to 30 MHz: coax, balanced line or random wire. Gives maximum power transfer. Harmonic attenuation reduces TVI, out of band emissions.

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Efficient, encapsulated 4:1 ferrite balun. 250 pf, 6000 volt capacitors. 18 position dual inductor, 17 amp, 3000 V ceramic rotary switch (3 KW version). 12 position inductor, ceramic rotary switch (1.5 KW version). 2% meters. SO-239 coax connectors, ceramic feedthru for random wire and balanced line. One year limited warranty. Made in U.S.A.

3 KW VERSA TUNER IV's

1 MFJ-984 3 KW VERSA TUNER IV

$299.95 *EXCLUSIVE RF AMMETER insures maximum power to antenna at minimum SWR. Built-in dummy load.*

This is MFJ's best 3 KW Versa Tuner IV. The MFJ-984 Deluxe 3 KW Versa Tuner IV gives you a combination of quality, performance, and features that others can't touch at this price.

An exclusive 10 amp RF ammeter insures maximum power to antenna at minimum SWR. A separate meter gives SWR, forward, reflected power in 2 ranges (2000 and 200 watts).

Versatile antenna switch lets you select 2 coax lines thru tuner and 1 thru or direct, or random wire, balanced line or dummy load.

A 200 watt 50 ohm dummy load lets you tune your exciter off air for peak performance. Efficient, encapsulated 4:1 ferrite balun.

2 MFJ-981 3 KW VERSA TUNER IV

$199.95 *Accurate meter gives SWR, forward and reflected power in 2 ranges: 2000 and 200 watts. 4:1 ferrite balun.*

The MFJ-981 3 KW Versa Tuner IV is one of MFJ's most popular Versa Tuners. An accurate meter gives you SWR, forward and reflected power in 2 ranges: 2000 and 200 watts. Encapsulated 4:1 ferrite balun.

3 MFJ-982 3 KW VERSA TUNER IV

$199.95 *Antenna switch lets you select 1 coax thru tuner and 2 coax thru tuner or direct, or random wire and balanced line.*

The MFJ-982 3 KW Versa Tuner IV gives you a versatile 7 position antenna switch that lets you select 1 coax thru tuner and 2 coax thru tuner or direct, or random wire and balanced line. Encapsulated 4:1 balun.

If you already have a SWR/wattmeter, the MFJ-982 is for you.

4 MFJ-980 3 KW VERSA TUNER IV

$169.95 *Heavy duty encapsulated 4:1 ferrite balun for balanced lines.*

The MFJ-980 is MFJ's lowest priced 3 KW Versa Tuner IV but has the same matching capabilities as the other 3 KW Versa Tuner IV's.

Features an efficient, encapsulated 4:1 ferrite balun for balanced lines.

1.5 KW VERSA TUNER III's

5 MFJ-962 1.5 KW VERSA TUNER III

$169.95 *SWR, dual range forward and reflected power meter, 6 position antenna switch, encapsulated 4:1 ferrite balun.*

The MFJ-962 1.5 KW Versa Tuner III is an exceptional value.

An accurate meter gives SWR, forward and reflected power in 2 ranges (2000 and 200 watts).

A versatile six position antenna switch lets you select 2 coax lines thru tuner or direct, or random wire and balanced line. Encapsulated 4:1 balun.

Black front panel has reverse lettering.

6 MFJ-961 1.5 KW Versa Tuner III

$149.95 *6 position antenna switch lets you select 2 coax lines thru tuner or direct, or random wire and balanced line.*

The MFJ-961 1.5 KW Versa Tuner III gives you a versatile six position antenna switch. It lets you select 2 coax lines thru tuner or direct, or random wire and balanced line. Encapsulated 4:1 ferrite balun.

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Black front panel has reverse lettering.

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Why not visit your dealer today? Compare these 3 KW and 1.5 KW Versa Tuners to other tuners. You'll be convinced that its value, quality and features make it a truly outstanding value. If no dealer is available, order direct from MFJ and try it. If not delighted, return it within 30 days for a prompt refund (less shipping). Charge VISA, MC. Or mail check, money order plus $10 shipping/handling.

For technical information, order/repair status, in Mississippi, outside continental USA, call 601-323-5869.

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More Details? CHECK — OFF Page 110

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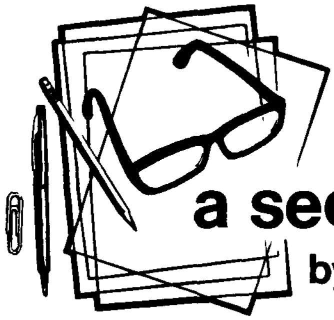
contents



a second look

by Jim Fisk

I've been interested in the history of radio nearly as long as I've been a Radio Amateur, and am continually on the lookout for old wireless equipment to add to my collection. Local ham flea markets and auctions are often the source of unexpected treasures, and I attend as many as I can; not too long ago I *missed* an opportunity of a lifetime when I passed up an auction of surplus electronic equipment at an old, respected New England college. Much of the "surplus" gear dated back to the 1920s and was built into custom-made wooden cases which were then in fashion; most of the buyers, unfortunately, were antique dealers who were interested only in the finely crafted cabinets — the priceless radio equipment inside was destined for the trash heap.

In many respects it was a replay of an event in Oklahoma several years ago: The auction of the electronics equipment and *junk* collection of a prominent local amateur. From all reports, it was quite a collection, filling four large warehouses. Except for the huge volume (and original cost) the collection resembled the typical "hell box" of every amateur who lived through the halcyon days when building your own transmitter was conventional practice and everyone eagerly added to his junk collection at every possible opportunity.

However, there was one big difference in the Oklahoma collection: Where most Radio Amateurs painfully part with dollars, this amateur painlessly parted with thousands of dollars. Think back a few years — what was the most delectable piece of radio gear you remember? It was probably in the Oklahoma collection. And not just one, but several. Parts, radio sets, test equipment, you name it, it was all there in unimaginable profusion. One whole warehouse floor was reportedly crammed full of big transmitters, spark coils, and rotary gaps for 1920-style transmitters, spiderweb coils and thousands of variable capacitors of every possible make and description. A complete inventory would go on for pages.

Now here's the tragedy: These priceless articles, which belong in a museum, were grouped in huge lots with utter junk and sold to junk dealers! The probability that these dealers could differentiate between valuable antiques and valueless junk is frighteningly small. Antique radio equipment that can never be replaced, items not preserved in any museum, were probably bulldozed under at a county landfill dump.

This scene, on a much more modest scale, is probably repeated many times a year all over the country. Without getting morbid, each one of us should realize that we are not immortal. Each of us has a collection of electronic gear that will, if someone doesn't know any better, be bulldozed under with the trash at the city dump when we join the list of *Silent Keys*. Each item, when you acquired it, represented a jewel to be treasured and was carefully put away. If you were ever so careless as to toss out one of these treasures, you almost certainly would have an immediate pressing need for an identical article. I know, because it happens to me every time I clean house!

The point is this: Talk to your heirs. Clue them in as to what items, if any, belong in a museum. Better yet, make arrangements with the executor of your estate to donate certain prized items to a local school or college; antiques should be given to a museum of your choice. The same sort of foresight applies to your newer equipment as well. Give your executor the names of several trusted amateur friends who will help dispose of modern radio gear and test equipment. They will know the fair market value — your executor may not. There have been more than a few cases where an amateur's survivors have been ripped off to the tune of thousands of dollars; don't let it happen to your family.

Jim Fisk, W1HR
editor-in-chief

comments

RTTY demodulator

Dear HR:

I would like to make some comments on the article by KB9AT in the October, 1978, issue: "Digiratt PLL²."

In his third sentence the author states, "The one common drawback to PLL terminal units is that they decode only half the available information present in the RTTY signal." In other words, we could eliminate one of the two tones and still end up with the same results. We could go to a similar signal like CW but Baudot encoded. This would save some bandwidth and let our transmitter finals live longer because of the shorter duty cycle. As far as I know, most if not all TUs use some kind of discriminator, PLL or otherwise, which produces at its output a positive voltage corresponding to one tone and a negative voltage corresponding to the other tone, both with respect to a reference voltage, which might or might not be at ground potential.

These two voltages are then processed through filters and/or a comparator before going to the keyer stage. What if one of these tones is missing? One of these two output voltages is also missing. And the place where the missing tone should be is now filled with noise. When we send that noise through a comparator to the keyer stage, the keyer stage will start switching back and forth on noise pulses. So we see that it's absolutely necessary to have two tones.

My second argument is with the author's poor choice of PLL for his TU. If at any time he had read the data sheets and looked at the graphs that go with this PLL tone decoder, he definitely would have made another choice. First, the data sheet gives a simple equation to calculate the bandwidth, which is

$$BW = \frac{V_i}{F \bullet C2}, \qquad (1)$$

and the minimum detectable signal is 20 mW. Inserting this value into **eq. 1** shows that with the author's choice of a filter capacitor, which also determines the bandwidth, we have a bandwidth of 15 Hz. Going to a more normal input voltage of 2 volts we find a bandwidth of 48 Hz. Now, going with these numbers one step further, on the data sheets we find the graph *Greatest number of cycles before output*. We find that as much as 300 Hz occur before the 567 will lock up on that short 2125-Hz tone.

We know that each bit in our Baudot-encoded machines at 60 wpm is only 0.022 second long. This means that we have, from those 2125 Hz, only available per bit $0.022 \times 2125 = 46.75\ Hz$, far less than we need in the worst-case lockup time. So we lose that bit altogether. When we have an R or a Y, where we have six transitions, we switch back and forth between the two PLLs; and every time each PLL must search and try to lock up.

Agreed, the data sheet also says that "assuming random initial input phase, only during 1/6 of the time will there be a lockup time longer than half the worst-case lockup time." This means that we can transmit all bits in a letter such as R or Y. Furthermore, we should take into account that most machines will print garble when we have a signal distortion (shortening of the pulse) of 30 per cent on a well-adjusted machine!

Now even with the loop filter C completely removed, the worst-case lock up time can still be 27 Hz, which is far more than 30 per cent, and is about 58 per cent.

So with all of this in mind we can see that the 567 is a very poor choice for 60 wpm or more on RTTY, and we can see why this chip was never intended to be used for that purpose. There are many other choices that would have been far better, which I've tried in all the years I've been on RTTY. Other chips that are intended for RTTY have a lockup transient only at the very beginning of each transmission, or when the signal appears at the input of the TU. By careful choice of loop filter C, these loops will almost instantaneously follow each tone deviation that might appear within its capture range.

Joe C. Zegers, WB6PMV
Sunnyvale, California

Dear HR:

Reader Zegers has raised some interesting questions in his letter. I wish to reply to his statements with this letter.

I stand by my statement that phase locked loops decode only one frequency, which in RTTY is one half of the information. Actually, a more correct statement would be that they decode only a small range of frequencies within their detection bandwidth.

It is true that PLL circuits (such as the popular 565 for instance) are often connected to an op-amp, and a positive and negative voltage swing obtained for use in keying circuits. However, both the 565 and the 567

(Continued on page 80)

TS-180S DUAL SSB FILTER

What advantages are provided by the dual SSB filter system in the TS-180S?

The dual SSB filter system in the TS-180S provides the following advantages:

- Improves receiver signal-to-noise ratio (S/N).
- Improves receiver selectivity.
- Allows greater RF speech-processor compression level.

Which filters are supplied as standard features?

The TS-180S operates with these filters:

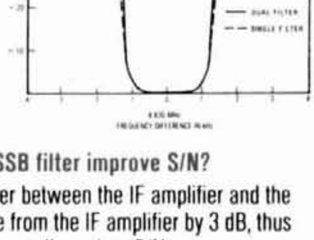
YK-88SSB IF SSB Filter #1	Standard, Built-in
YK-88SSB IF SSB Filter #2 (for dual filter system)	Optional
YK-88CW 500-Hz CW Filter	Optional

How much is selectivity improved by adding the second SSB filter?

Even with just the one standard SSB filter, the TS-180S is very selective. Passband widths with the single and dual filters, as well as with the CW filter, are shown below:

RESPONSE	SINGLE SSB FILTER	DUAL SSB FILTER	CW FILTER
−6 dB	2.4 kHz	2.2 kHz	0.5 kHz
−60 dB	4.2 kHz	3.0 kHz	1.5 kHz

The newly developed MCF type filter, including both the YK-88SSB and YK-88CW, has sharp response characteristics. The newer filters are notable in their lack of response "humps" away from the main portion of the passband curve.



How much does the second SSB filter improve S/N?

Adding a second crystal SSB filter between the IF amplifier and the detector reduces wideband noise from the IF amplifier by 3 dB, thus giving a certain improvement in overall receiver S/N.

How does the dual SSB filter system also improve RF speech-processor compression level?

The following maximum compression levels are available with the TS-180S RF speech processor:

	SINGLE SSB FILTER	DUAL SSB FILTER
MAXIMUM COMPRESSION LEVEL	15 dB	30 dB

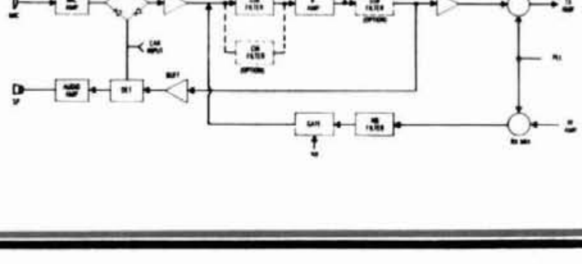
The dual filter system functions in the IF stage, which is common to both the transmitter and receiver. The RF compressor speech processor in the TS-180S is always on, with selectable time constants of SLOW (natural sounding audio) and FAST (more audio punch for the pile-ups). Up to 15 dB of compression in the FAST mode may be achieved without sideband expansion (splatter), using a single filter. With the dual filters, the sideband is filtered again and a high-quality SSB signal of high talk power is obtained, with a maximum compression level of 30 dB without splatter.

Can both the optional second SSB filter and optional CW filter be used for receiving at the same time?

Yes.

Where is the dual SSB filter system located in the TS-180S?

The dual SSB filter system is in the TS-180S IF unit, and the second filter may be installed easily by the user. The general circuit configuration is shown below.



PC-1 PHONE PATCH

Is a matching phone patch available for Kenwood equipment?

After many requests, Trio-Kenwood is introducing the PC-1 phone patch, which may be connected between a transceiver and the telephone-line. (We recommend obtaining a voice connecting arrangement from the telephone company for legal attachment to the telephone line.)

Does the PC-1 use a hybrid circuit for VOX operation?

The PC-1 is able to interconnect the transmitter, receiver, and telephone line voice coupler while accommodating a great difference in voice levels to and from the telephone line, and cancelling the audio level from the receiver at the input to the transmitter's VOX circuit.

Is the PC-1 easy to adjust?

Three easy adjustments are made after a phone call is established:

- NULL control, with a clear, continuous signal tuned in on the transceiver, for minimum deflection of the PC-1 meter.
- RX GAIN control, to about 0 VU on the PC-1 meter, for hearing the signal clearly through the telephone receiver.
- TX GAIN control, for proper VOX operation while the party on the telephone speaks.

presstop

DISASTERS OR EMERGENCIES should not require that all other activity on the Amateur bands cease, the commissioners decided at their last meeting before their annual August recess. The issue was raised in a Petition for Rule Making, RM-2015, which had been filed after a weather emergency that occurred during the 1972 Field Day and resulted in considerable interference between emergency nets and Field Day operators.

The Petition Had Proposed that all but emergency operations be automatically prohibited on all Amateur bands for the duration of an emergency, but the commissioners agreed, in their dismissal of the petition, that Part 97.107 of the Rules already provides the means for doing just that when — and if — it is needed.

Radio Control Enthusiasts would have lost one of their limited channels if another interesting Petition for Rule Making had not also been dismissed by the commissioners. In that petition, RM-2215, the Saf-T-Onics Company had proposed equipping all autos with a transmitter and receiver on a common RC channel so that blowing a car's horn would activate a warning signal in all other nearby vehicles.

A WELL-PLANNED ATTACK on malicious interference, led by ARRL Southwestern Director W6EJJ, has been started on the West Coast. Enlisted in the battle are area congressmen, including Representative James Corman of Van Nuys, a nine-term veteran of the House of Representatives and long-time friend of Los Angeles attorney N6AHU, and Senator Alan Cranston. Both have met with concerned local Amateurs for briefings on the jamming problem as well as rundowns on Amateur Radio's value on the local, national, and international level.

Rep. Corman, a senior member of the powerful House Ways and Means Committee, seems genuinely disturbed over what he has learned of the malicious interference problem, and is quite determined to do something about it.

U.S. AMATEUR POPULATION DROPPED during July for the first time in five years, with the operator total down 100 from the all-time high of 365,985 a month earlier. Most significant is that the falloff comes entirely from a drop of 700 in the Novice Class, which would have been expected to have more than held its own due to the recent extension of Novice licenses to five year, renewable terms.

Other Than Novice Operators, who dropped from 66,992 to 66,285 during July, all other classes showed an increase last month. Extras went from 23,493 to 23,627; Advanced from 84,436 to 84,531; General from 121,743 to 122,066; and Technicians from 69,321 to 69,045. However, Novice losses more than offset those gains.

NEW EAST GERMAN PREFIXES in the Y2-Y9 block have just been announced, with special callsigns for individuals, clubs, and special-purpose stations. Under the new system DM2AAO would become Y21AO, while DM2CAO would be Y23AO. Club stations will begin with Y3 (Y31AA, Y37AB, for example). Short calls are for repeaters (Y21A-Y29Z), contest teams (Y31A-Y39Z), beacons (Y41A-Y49Z) and bulletin stations (Y61A-Y69Z).

THE PROTO-FLIGHT SOLAR PANEL for Phase III Mission A, provided by Solarex Corporation, has been received and has been given thermal vacuum cycling tests. The tests will be followed by vibration tests, after which, if all goes well, more of these panels will be built.

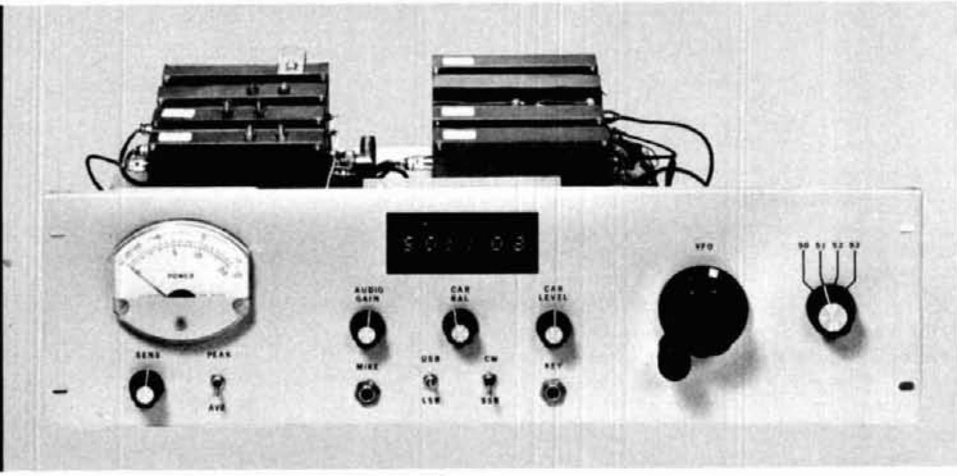
WB5MPU Reports That The Solar Cells for Phase III now total 4,077, and 39 battery cells have been sponsored for this OSCAR program.

COMPLAINTS ABOUT THAT "WOODPECKER" signal that tears up the HF bands still should be phoned in to the FCC's Watch Officer, (202) 632-6975, 24 hours a day. The purported Russian Over-The-Horizon radar is heard from about 5 to almost 30 MHz.

THE FOUNDATION FOR AMATEUR RADIO has announced the six winners of its 1979 scholarships. The winners are WB9LAD, WD8OKD, WB8TDA, WD5GZL, WB5LMZ, and NØAKC. These scholarships are open to all Radio Amateurs holding at least a General Class license. This year, applications were received from 28 states. Information on next year's scholarships will appear in next May's issues of the major Amateur Radio publications.

633 KILOMETERS ON 3 CENTIMETERS is the new DX record set on July 27 by I4CHY/7 and I2FZD/2. I2FZD/2 operated from a mountain top northeast of Milan, while I4CHY/7 was in Testa del Gargano on the Adriatic coast. Both used Gunnplexers and 1-meter dish antennas. I4CHY/7 made 20 contacts on 10 GHz during his two-week operation, including one at 571 km with I3ZJL's homebrew 3-mW rig, and another with YU3JN/2 near Trieste (about 400 km).

A WARC COMMEMORATIVE POSTAGE STAMP has been issued by the Federal Republic of Germany. The 60-pfennig stamp shows the front panel of a Collins KWM-2 transceiver tuned to the 21-MHz CW band. Now that this WARC commemorative has been printed, plans for a separate Amateur Radio commemorative have been dropped.



50-MHz SSB exciter

Construction details of a high-performance, 50-MHz exciter which features CW/SSB operation, digital readout, and modular-type construction for circuit improvement and modification

This article describes an SSB/CW exciter with digital frequency readout. It covers ±100 kHz segments centered on 50, 51, 52, and 53 MHz. The power output has been limited to 50 milliwatts because the primary use of the exciter is to drive solid-state transmitting converters. The wide frequency range allows coverage of all present weak-signal band segments and satellite passbands.

A modular approach was used in building the rig. I was convinced of the flexibility of this technique by Joe, W1JR. The rig could very easily have been built with fewer modules and still retained its testability. However, I wanted to be able to change very small pieces of the rig without pulling the whole thing off the air. I also felt that taking modularity to this somewhat sublime limit would make the exciter more reproducible. There is a disadvantage to the approach though; you do not end up with a small box. But if you are a casual builder or apt to change designs in midstream, then this is the only way to go.

The exciter can be broken down into analog and digital sections. **Fig. 1** shows the block diagram of the analog section, which is made up of ten modules. Each module contains a "complete" function. If you start with the audio preamp, the exciter can be built up from it; that is, all existing modules are used in testing the next. I kept the port impedances of the rf modules at 50 ohms to aid in testing. It also allows easy changes to any given module with minimum impact on the whole project.

Most of the analog portion of the rig was stolen in bits and pieces from the many designs that have appeared in various Amateur Radio journals. Wherever possible, I picked the "cheapest" way to go, consistent with getting the rig to fly with minimum

By Rick Commo, K1LOG, 3 Pryor Road, Natick, Massachusetts 01760

problems. I also imposed the constraint that there would be no hot switching of any rf, in order to facilitate a neat and functional panel layout.

The digital section, shown in **fig. 2**, consists of six modules, or in this case, boards. It was also built from the bottom up starting with the time base. References are included at the end of this article.

The specifications for the exciter, which are tabulated below, are on a par with the majority of commercial low-band rigs advertised in the Amateur journals:

maximum power output	50 mW CW
carrier suppression	>45 dB, with respect to single tone
IM products	−32 dB, with respect to two tones
harmonics responses	−50 dB, with respect to full carrier
nonharmonic responses	−45 dB, with respect to full carrier

audio module

The audio module (see **fig. 3**) is not complicated. Two op-amps provide a voltage gain of about 50 and lowpass filtering. An LM308 was used for the first stage because it has somewhat lower noise than most garden-variety op-amps. Just about any op-amp could be used for the second stage, with appropriate changes in (or deletion of) the compensation capacitor.

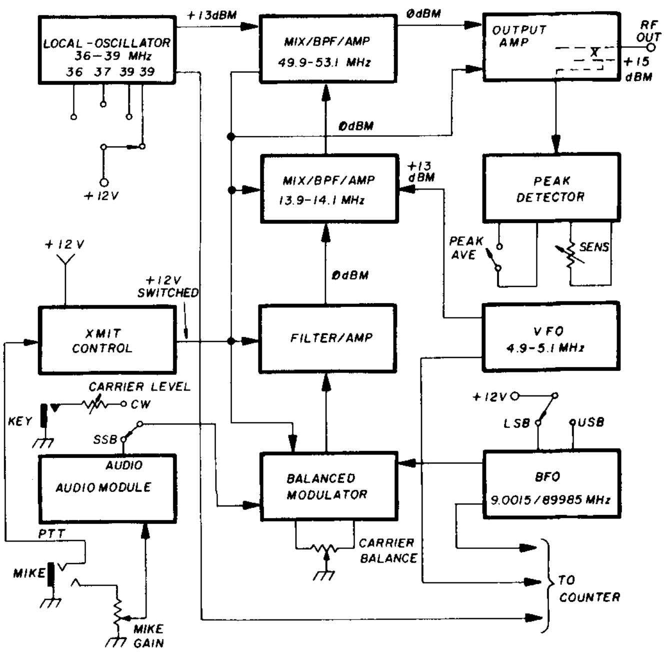


fig. 1. Block diagram of the 50-MHz exciter. To facilitate circuit changes and improvements, each block is built into an individual box, with the input and output impedances set at 50 ohms.

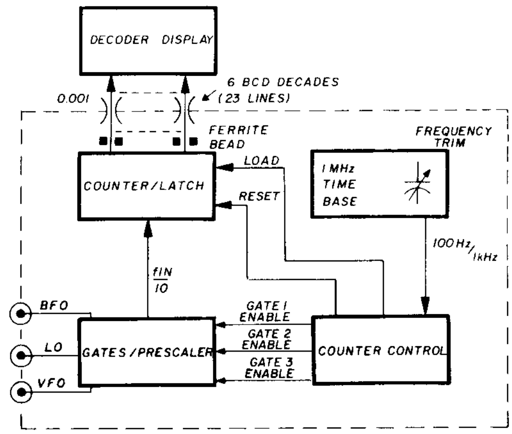


fig. 2. Diagram of the frequency display portion of the exciter. Each oscillator is individually gated through to the main counter, providing a true readout — rather than what would be derived from the less-accurate presetting method.

In this design the first stage has a gain of five and the second a gain of ten. This was more than enough for the microphone that I use. Any gain adjustments the reader feels are necessary in his own case should be done in the first stage. This will preserve the roll-off of the lowpass filter.

Be forewarned: Getting skimpy with audio bypass capacitors is not a good idea, especially in the bias network for the unused inputs. Any hum that appears on these inputs gets amplified right along with the main audio. It doesn't take too much noise to make a poor sounding signal.

BFO module

The BFO module, as shown in **fig. 4**, contains two oscillators and a buffer. The oscillators are pretty standard, the only thing done special being to match the fets for the approximately equal zero bias drain current (I_{dss}). This was done by shorting the gate to the source and measuring the current with 12 volts applied between the source and drain. The buffer amplifier is described in the ARRL *Solid-State Design* manual.[1]

The amplifier was driven directly from the oscillators. This was done to insure a clean waveform. With an input impedance of essentially zero ohms, the amplifier keeps the crystals adequately decoupled from each other.

Two outputs are taken from the amplifier. The high-level output goes to one input of the frequency counter. The low-level output, which is variable (200 mV max) goes to the modulator. The oscillators are adjusted on frequency by C1 and C2. If the counter is built first, it can be used to do the netting. I used the McCoy crystals that came with the filter, although a 9.000-MHz KVG crystal was tried and no problems were encountered.

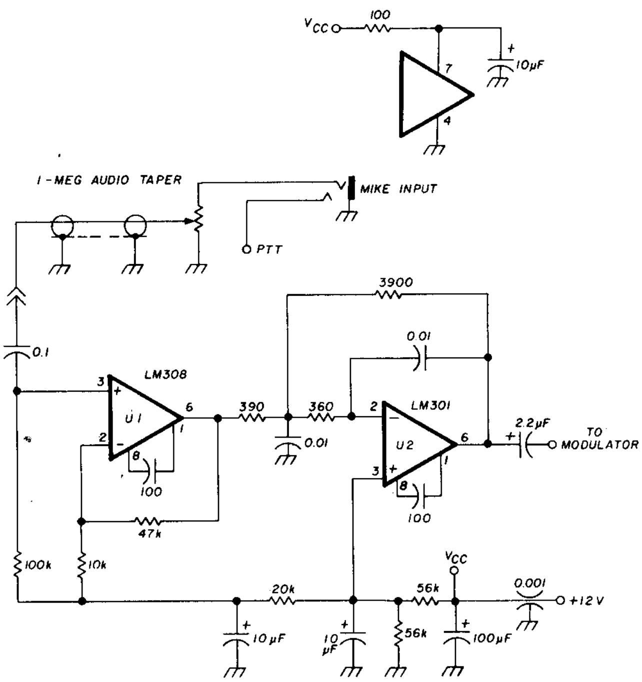


fig. 3. Schematic of the audio module. The filtering in the +12 volt line helps ensure that no hum will be present on the signal.

balanced modulator

The modulator (**fig. 5**) uses an MC1496. This circuit has been around a while,[2] but it's easy to get going and has excellent carrier balance. It is fed with about 60 mV of 9-MHz rf and about 600 mV of audio. A balanced circuit was used in the output. This gives a 3-dB increase "for free." A single-ended design will work as well, and has been used in many other designs. The output of the module is about −10 dBm.

Some thought should be given to the layout of the modulator in order to prevent BFO leak-through and, hence, degraded carrier balance. The initial attempt at building the modulator had all the components stuck in the box. This resulted in some carrier coupling to the audio inputs. Some 200-pF bypass caps cured the problem, but I decided to rebuild the module anyway. The second module was built with many of the modulator pins going to Teflon feedthroughs. In this way, most of the dc and all of the audio was wired on the outside of the box. This resulted in a much cleaner layout and the module worked the first time power was applied.

Care should also be taken to avoid overdriving the modulator with the BFO. Initial efforts with this module were very frustrating because of this problem. The best way to set the modulator up is to null the carrier, then inject an audio tone and reduce the BFO drive level until the output of the transmitter starts to fall off. Leave the BFO set at that level.

The filter-amp module provides gain and matching for the 9-MHz crystal filter (see **fig. 6**). I used a McCoy Golden Guardian, because I got some at a flea market cheap. Other filters may be used, however, if appropriate changes are made in the matching resistors (560 ohms for the McCoy). The gain of the module is controlled via the unbypassed emitter and source resistors. The second gate of Q2 can be used as an ALC input if desired.

Attention should be paid to the supply-line filtering to reduce leakage around the filter. While this is not as important in an exciter as it would be in a receiver, it still pays to be careful.

The variable capacitors on the input and output of the filter are there to resonate out the residual inductance of the filter's transformers, thus reducing passband ripple. This is most easily done by padding the LSB crystal to exactly 9.0000 MHz, and then tweaking the two capacitors for maximum output. This will get pretty close to optimum passband ripple.

VFO module

The 5-MHz VFO (**fig. 7**) is built around an ARC-5 (transmitter) capacitor. This tends to make the VFO quite a bit bigger than it might have been, but it does have the advantage (in VFO design) of mass and built-in gear reduction. The "back wall" of the capacitor was drilled and tapped so that the VFO circuitry could be mounted directly on the capacitor.

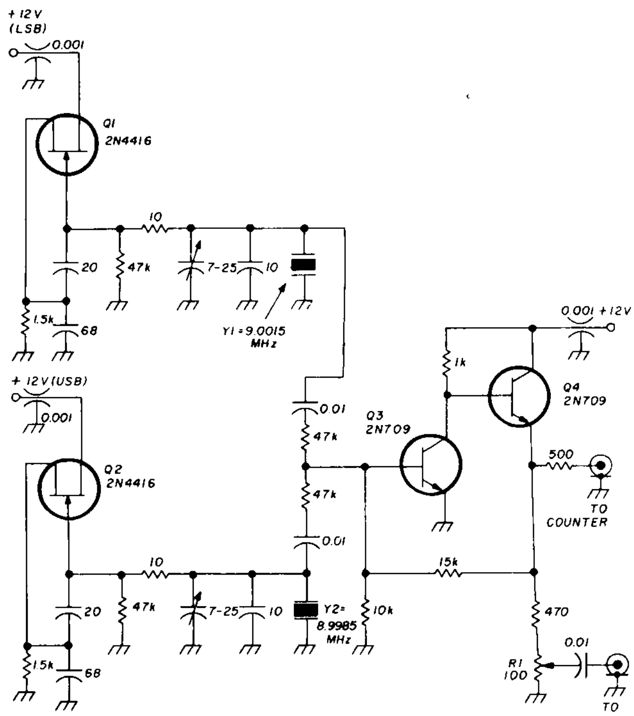


fig. 4. Schematic diagram of the BFO module which supplies the 9-MHz signals to the crystal filter. The level adjust, R1, must be a carbon potentiometer.

The oscillator uses a jfet and is buffered with a dual-gate mosfet. I found that the loading of a mosfet was significantly less than that of a jfet. The output of the buffer goes to an amplifier to raise the output up to a usable level. No compensation has been done on the VFO as yet. However, since the ARC-5 capacitor is made of Invar, the VFO is fairly stable as is. At room temperature, the drift over a two-hour period, starting cold, was on the order of 300 Hz. The frequency variation over wide temperature ranges has not yet been investigated.

Harmonics were a problem with this VFO. Without the half-wave filter, the second and third harmonics were only 15 and 20 dB down, respectively. The third harmonic created a bad spur, since 15 MHz is not that far down on the skirts of the first mixer's filter. Adding the half-wave filter brought the second harmonic down to 30 dB and the third down to 48 dB, at which point the spur problem went away.

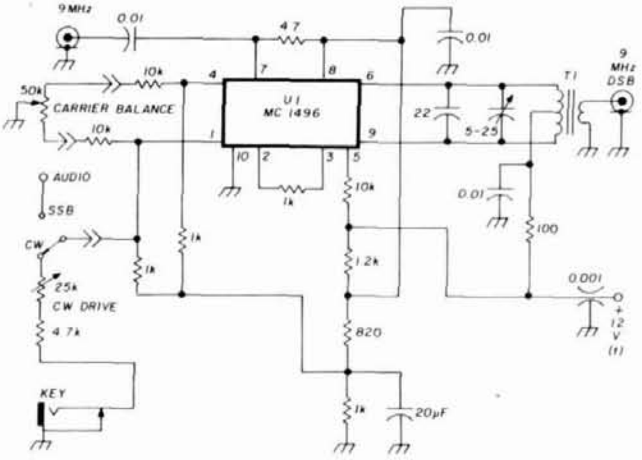


fig. 5. Diagram of the balanced modulator module. C1 is a 5-25 pF trimmer. T1 is wound on a T50-6 core, with the primary twenty turns of no. 24 AWG (0.5 mm) and the secondary five turns of no. 24 AWG (0.5 mm). The two windings are bifilar wound on the core.

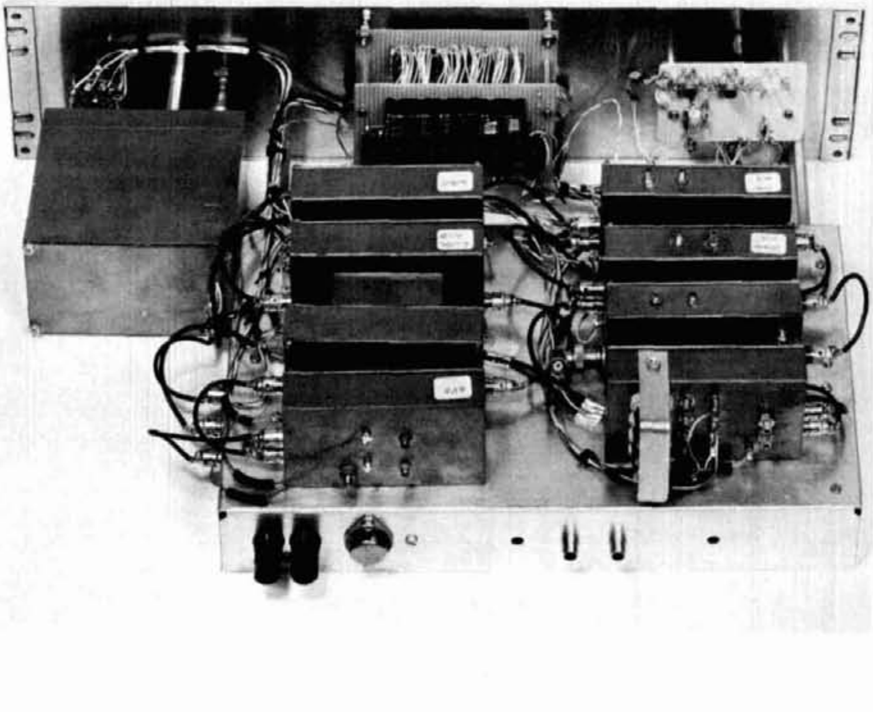
mixer modules

The 14- and 50-MHz mixers shown in **fig. 8** are identical, with the exception of the filters. All ports of the double-balanced mixers are padded to insure that they see 50 ohms. If not, the mixer will most likely not perform properly. The output of the filter is also padded for essentially the same reason, to guarantee that the filters are properly terminated at all frequencies. The post-filter amplifier is a broadband design built around the 2N5179. It has more than enough gain to bring the signal back up to a usable level. The i-f signal into the modules is held to 0-dBm max, with an LO level of about + 13 dBm. This is done to insure that IMD products are at least 30 dB below full output, which runs between 0 and + 3 dBm.

The mixer modules turned out to be the weak link in the chain as far as IMD products were concerned. Since access to a spectrum analyzer was limited, further work on the mixers had to be curtailed. I suspect that substituting a 2N3866 for the 2N5179 and increasing the collector current to 30-50 mA would improve the IMD specs considerably.

LO module

The LO module (see **fig. 9**) consists of four oscilla-



Top view of the 50-MHz ssb exciter showing the individual modules used for the analog circuits. Large enclosure at left houses the VFO; modules on the main chassis include (center) audio, filter amp, balanced modulator, and BFO. At right are the 14-MHz mixer/filter, 50-MHz mixer/filter, output amplifier, and local oscillator modules.

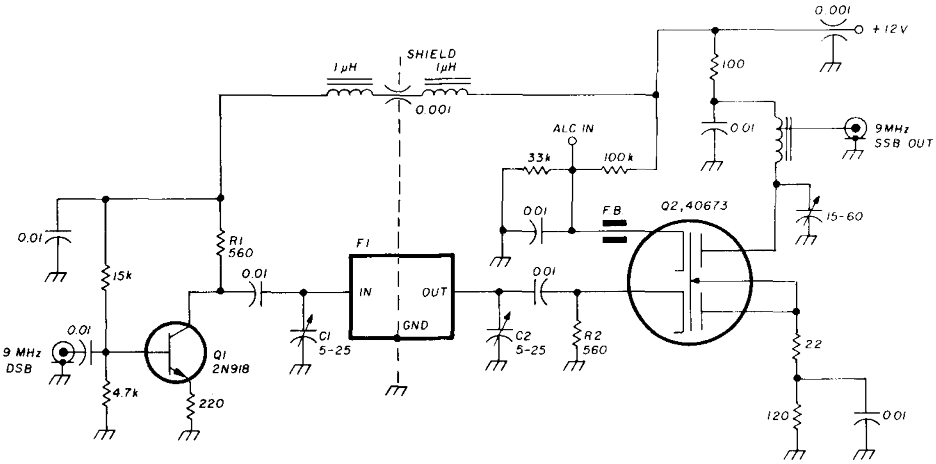


fig. 6. Schematic of the SSB filter and amplifier module. F1 is a KVG 9FA, 9FB, or equivalent, 9-MHz crystal filter. The terminating resistors and trimmers (R1, R2, C1, and C2) must match the filter used. L1 is thirty-eight turns of no. 28 AWG (0.3 mm) wound on a T75-2 core. The tap is located eight turns from the cold end.

tors and an amplifier. I started out by trying to diode switch the crystals but was never really happy with the results. I ended up building four separate oscillators and switching the power to the desired oscillator. The secondaries of the tuned circuits are diode switched so that they would not interact with one another and also to reduce the loading of the active oscillator. While this technique takes more components than other methods of dc switching, it is versatile in that the frequency range of the module is limited only by the bandwidth of the buffer amplifier since no compromises are required on the part of the oscillators. This is significant if you want to steal the circuit for an all-band exciter or receiver where the LO frequencies could vary considerably.

A "broadband" class-A amplifier is used to buffer the oscillators and raise the signal level. The 4:1 balun normally expected in the output has been replaced with a 2-pole filter in order to reduce oscillator harmonics. The harmonics were all better than −55 dB with respect to the LO signal.

A single stage of amplification was used in the 50-MHz PA module (see **fig. 10**). This was all that I needed to get the signal up to the 50-mW level. It uses a broadband, class-A amplifier into a 2-pole filter. The output is sampled and rectified for use in a peak detector.

I used an MSC CATV transistor because I had some on hand and I preferred to use a stud mount package. A 2N3866 would probably work just as well at a lower cost if you use adequate heat sinking.*

The transistor is biased for approximately 100 mA of collector current. The output filter is similar to the

*MSC transistors are available in stud mount (H002) or T05 package (H003) for $5 plus $1.50 handling for one H002 or two H003s. Send a certified check or money order and your callsign to Ham Trans, Box 383, South Bound Brook, New Jersey 08880. No phone orders.

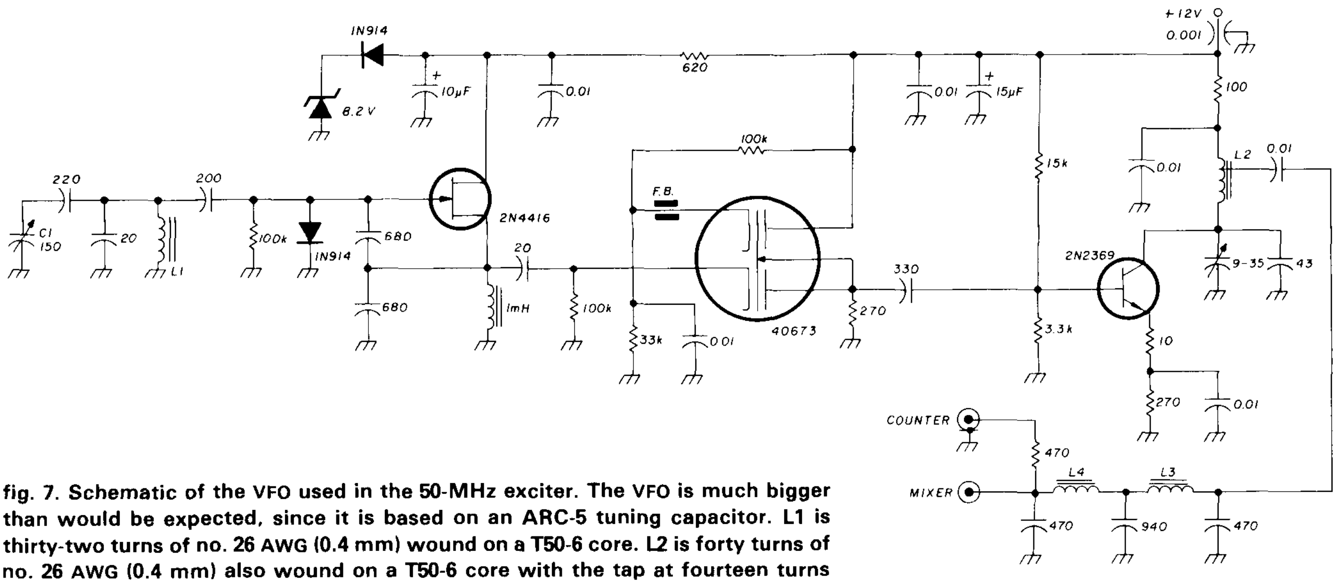


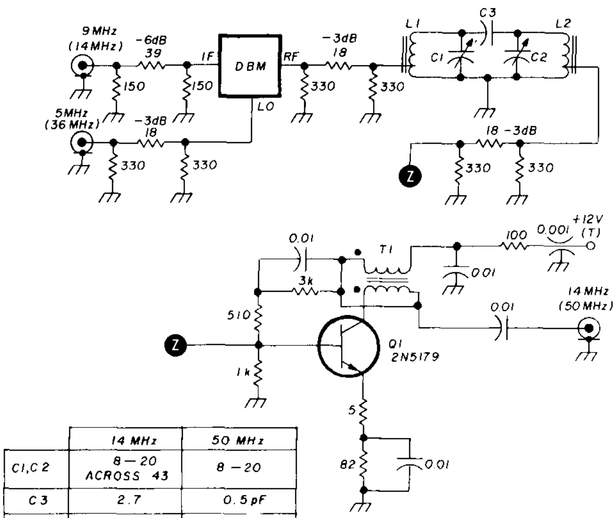
fig. 7. Schematic of the VFO used in the 50-MHz exciter. The VFO is much bigger than would be expected, since it is based on an ARC-5 tuning capacitor. L1 is thirty-two turns of no. 26 AWG (0.4 mm) wound on a T50-6 core. L2 is forty turns of no. 26 AWG (0.4 mm) also wound on a T50-6 core with the tap at fourteen turns from the cold end. The inductors in the half-wave filter, L2 and L3, are both seventeen turns of no. 24 AWG (0.5 mm) wire wound on T50-6 cores.

one used in the second mixer except that the coupling capacitor was increased to reduce losses. It is tuned for maximum signal at 51 MHz.

peak detector

A peak detector is used in place of the usual output detector. This allows the meter to "catch" the voice peaks on sideband so that the operator can tell if he is exceeding the drive-level limit. The output voltage as seen in the schematic, **fig. 11**, from the detector is fed into U1, a unity-gain follower. As the voltage rises, the output of U1 follows and charges up the capacitor through the diode. As the input drops below the voltage across the capacitor, the diode becomes back biased, preserving the voltage on the capacitor. Since the op amps have mosfet inputs, their input resistance is on the order of 10^{12} ohms and the discharge time constant is determined by the resistor across the capacitor and the capacitor's internal leakage. If a Mylar capacitor is used, the time constant can be extended into the minutes range. I used a time constant of 30 seconds because my meter is a heavily damped instrumentation meter and it takes a while to get to full scale. I would recommend a time constant of about 10 seconds (which requires a resistance of 10 megohms). Do not substitute a different op amp for the CA3130s. They were picked because their inputs will operate right to ground and their outputs will go to within millivolts of the supply rails.

In use, the operator tunes up the transmitting chain with the exciter in the CW mode and the peak detector switch set to the "average" position. The meter is set to a convenient reference point with the



	14 MHz	50 MHz
C1, C2	8 – 20 ACROSS 43	8 – 20
C3	2.7	0.5 pF
L1, L2	24t #24 TAPPED AT 4t	14t #24 TAPPED AT 3t

fig. 8. Schematic of the mixer and bandpass-filter module. The mixer is an SRA-1. T1 is ten turns of no. 26 AWG (0.4 mm) wire wound on a Ferroxcube 266T125-4C4 core.

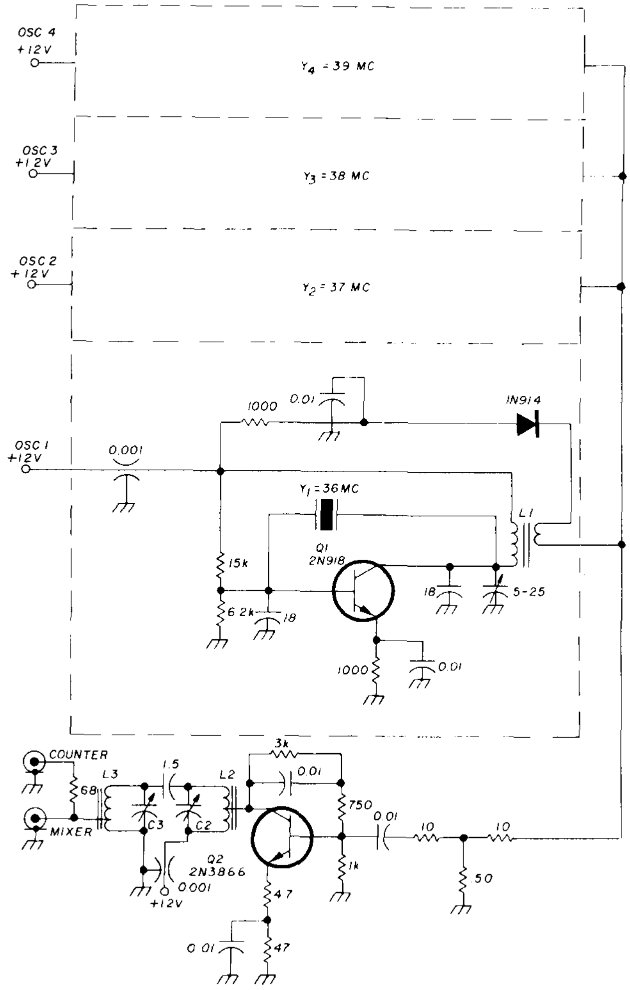


fig. 9. Diagram of the local oscillator module which provides four crystal-controlled frequencies. Each oscillator is tuned by the small trimmer in the collector circuit. L1 is twenty-five turns of no. 24 AWG (0.5 mm) on a T37-10 core. The secondary is two turns wound over the cold end. L2 and L3 are both wound with twenty-five turns of no. 24 AWG (0.5 mm) wound on a T37-10 core. The tap on L2 is eight turns from the cold end, with the tap on L3 at five turns from the cold end. The resistors in the T-type attenuator are selected to provide a 20-mW output.

sensitivity pot and then switched to the "peak" position. The meter will then catch the peaks of the sideband, giving the operator a fairly accurate indication as to whether or not he is exceeding the limit.

PTT control

The exciter is turned on by either the PTT switch on the mike or by a PTT input jack on the back of the chassis (for a foot switch). If either jack shorts to ground, the transmit relay is energized and the supply voltage is applied to the modulator, mixer, and PA modules (see **fig. 12**). I used a relay instead of a solid-state switch for compatibility with other devices in my transmit chain. However, there is certainly no

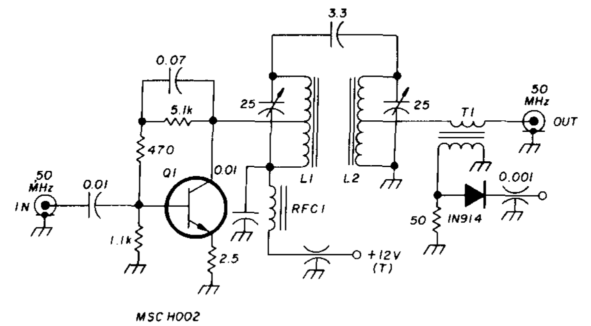


fig. 10. Diagram of the final amplifier transistor and the associated circuitry. L1 and L2 are both fifteen turns of no. 24 AWG (0.4 mm) wire wound on a T50-6 core and tapped three turns from the cold end. T1 is formed by sliding a Fer-ramic CF101 core over the output lead. The secondary is ten turns of no. 24 AWG (0.4 mm) wire.

reason why a power transistor couldn't be used in place of the relay.

counter overview

The digital counter counts each of the oscillators in sequence and then displays their sum. Since the heterodyne scheme for the exciter is all additive, the sum of the oscillators is also the final signal frequency. The counter was broken down into a five functional module as an aid in troubleshooting. All of the modules except the displays and their decoders are mounted under the chassis and all power and signal leads associated with the digital circuitry are well filtered.

A single LM309K is used to regulate the counter. It runs hot and should be well heat sunk. Most of the chips, with the exception of the oscillator and the front-end ICs, could probably be replaced directly with their low-power Schottky (74LS) equivalents without any problems and with a very significant savings in power dissipation. It is one of the things I plan to do in the future.

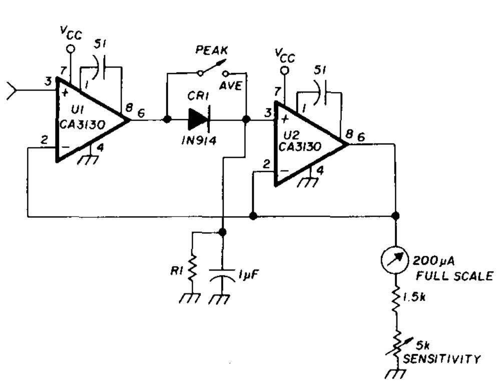


fig. 11. Schematic of the peak detector. C1 should be a Mylar or styrene capacitor. R1 is approximately 1 megohm per second of hold time.

time base

A 1-MHz TTL oscillator is used to drive four decade dividers (see **fig. 13**). The output of either U5 or U6 is selected by the state of TP2. If this point is grounded, the counter will display to the nearest 1 kHz and the update rate will be twenty-five times a second. If this point is high, then the readout will be to the nearest 100 Hz and the update rate will be 2.5 times a second.

The exact frequency of the time-base crystal is set by a trimmer, C1. I had the advantage of owning a precision counter which I used to count the time base frequency at TP1. An alternative approach would be to loosely couple TP1 to your receiver and

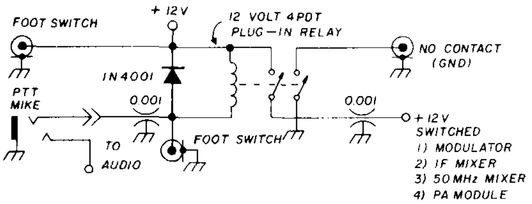


fig. 12. Transmitter control is via a double-pole, double-throw relay which controls 12 volts throughout the exciter.

then beat one of the harmonics to WWV. The crystal I use is one that came from a digital communications board, but it works well. If I were starting from scratch, I would add a divide-by-four stage and use a good quality 4-MHz crystal. For an exciter though, the counter is accurate enough.

control logic

The control logic takes the reference signal from the time-base generator and creates all the control signals for the entire counter. The circuit is more complex than most for two reasons. The first is that the counter must gate in three separate signals and add them together. The second is that I have had some bad experiences using differentiators as sequential pulse generators, as is sometimes done for the load and reset pulses. This type of circuit can often lead to noise problems and I preferred to avoid them. With the illustrated control circuit (see **fig. 14**) there is a finite "quiet" time between all of the gating pulses, the load, and the reset pulses (see **fig. 15**).

The time-base input is inverted by U5 and also divided by two in U2A. Clock 2 is fed to U1, a modulo-six divider. When the fifth state is decoded by U6, pin 9 of U2B goes high, resetting the divider. The next clock 2 pulse causes pin 9 to return low. The result is that pin 8 of U2 creates a gating pulse equal to clock 1 divided by ten with a "quiet" time equal to one clock 2 period.

U3 is wired as a modulo-4 divider. Each of the states of U3 is used for one of the counter functions shown below:

state	U3:3	U3:5	action
1	high	low	G1 high during GE
2	low	high	G2 high during GE
3	high	high	G3 high during GE
0	low	low	load high during (GE-not and CK1-not and CK2-not) reset high during (GE-not and CK1-not and CK2)

U3 is updated to its next state by the clock pulse from U6B. By using a state counter and the four clocking phases, race conditions were avoided and the counter worked the first time it was turned on (wiring errors excepted!).

prescaler

The counter front-end board contains the count enable gates and a prescaler (**fig. 16**). While it is a simple board, caution should be taken in its layout

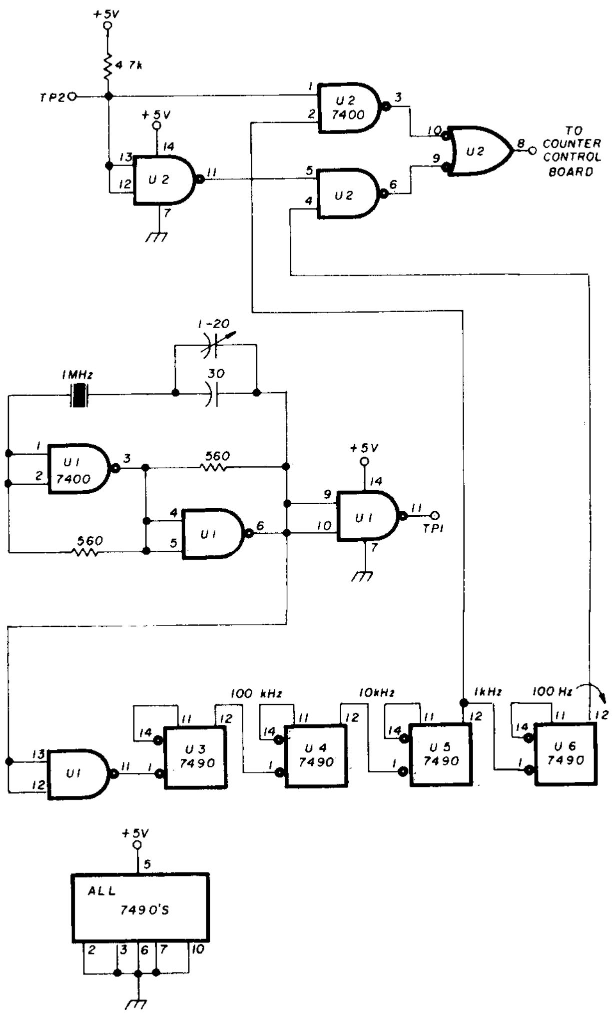


fig. 13. Schematic of the time base oscillator and associated countdown circuitry.

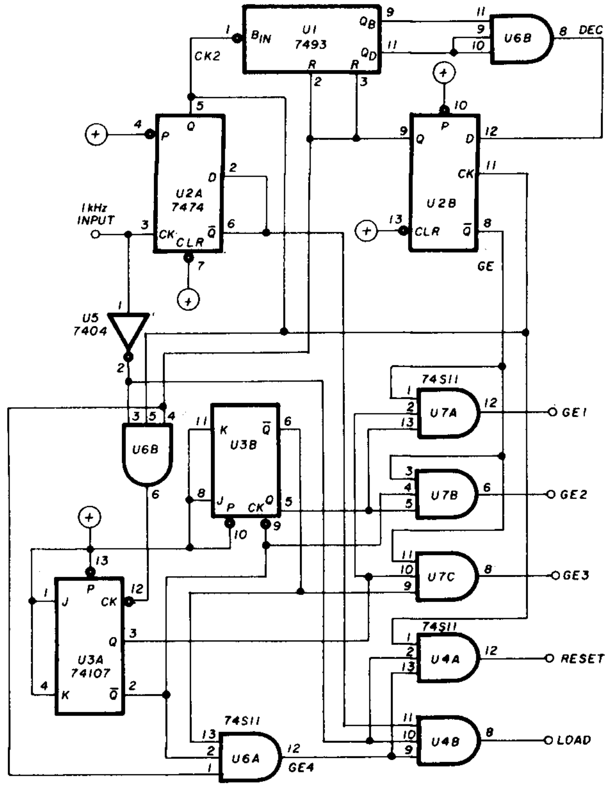


fig. 14. The gating circuitry which generates the pulses and gates for the digital readout. The "plus" sign denotes a common 4.7k pull-up.

and construction. Don't forget, it will have a 39-MHz signal applied to one of the inputs. Each of the oscillators is applied to a section of U1 for squaring up and buffering. The logic signals are then gated and ORed before being prescaled. In order to use the 50-MHz clocking rate of the first stage, U3 is wired divide-by-two, then five. Although pin 12 U3 is no longer symmetrical, it still has a period equal to ten times the input period. That's all that really matters since the 7490s used in the main counter are edge-triggered.

The signals from the oscillators are buffered by sections of U1. These buffers are biased so that their outputs just start to go low. This minimizes the amount of rf voltage needed to toggle them. The analog inputs are decoupled from the digital circuitry by the baluns in order to limit the chance of ground loops reflecting digital noise onto the transmitted signal.

There is some digital noise, however. I believe it is the result of not using high-impedance buffers to drive the timing gates. The noise is way down though; it couldn't be seen on the spectrum analyzer used to measure the transmitter's performance.

main counter

The main counter board, as seen in **fig. 17**, uses a

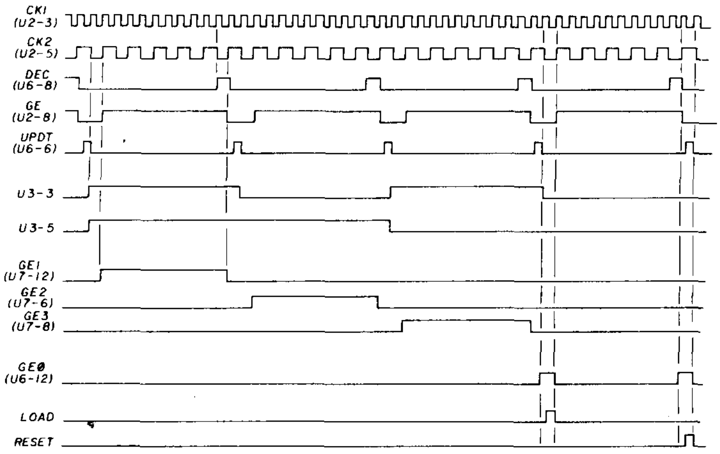


fig. 15. Control logic timing diagram for the circuit shown in fig. 14.

six-digit, latched counter. The 7490s were used because they are cheap and the maximum input frequency of 4 MHz is well below their maximum clock rate. The outputs of the counters are latched to maintain a steady display during each count cycle. Hex latches were used in order to reduce parts count, but any of the 4-bit latches available would do the job with the appropriate wiring changes.

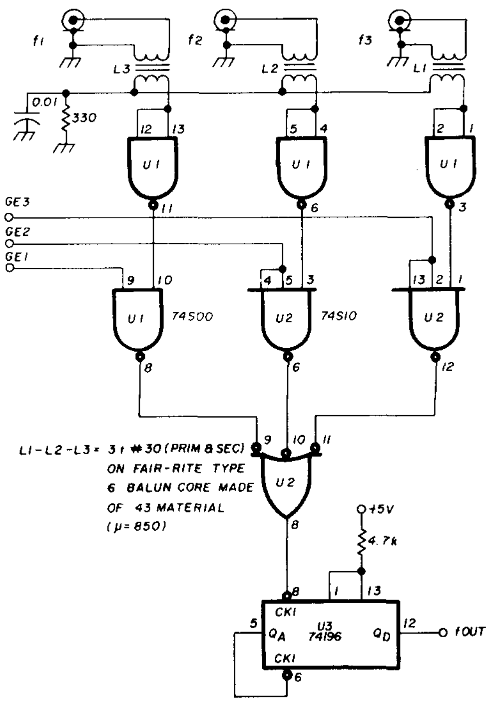


fig. 16. Diagram of the preamp/scaler circuit. Individual sections of the 74S00 and 74S10 provide the buffering and gating of each signal. The 74196 acts as a prescaler, dividing each frequency by ten prior to the main counter. L1, L2, and L3 are wound of Fair-Rite type six balun core. The primary and secondary are both three turns of no. 30 AWG (0.25 mm) wire.

display module

This module consists of two boards, one for the displays and one for the decoders and the current limiting resistors (see **fig. 18**). Common-anode displays were used; any of the MAN-1 compatible types should work.

The ripple-blanking feature was used to disable the leading zero when the counter is gated for a 1-kHz

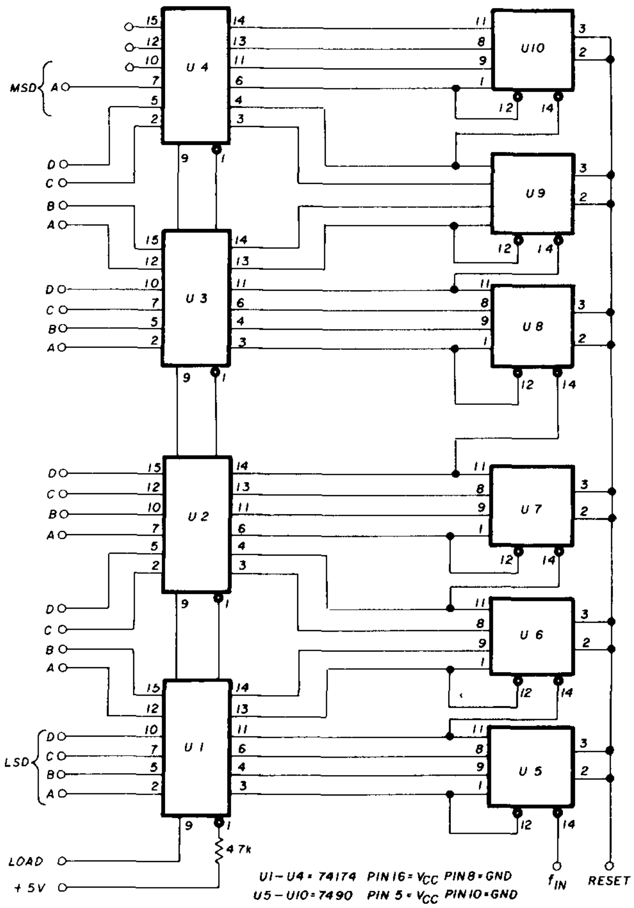


fig. 17. Schematic of the main counter and data latches. Each latch IC provides six latches, reducing the number of ICs by two.

LSD. I set up the display with two decimals to simulate the commas between the MHz, kHz, and Hz digits. This was done for convenience only, since I always have the display reading out to 100 Hz.

module construction techniques

All the analog modules, except the VFO, are 10 x 6.4 x 2 cm (4 x 2.5 x 0.75 inch); the VFO is 11.5 x 8.9 x 7.6 cm (4.5 x 3.5 x 3 inches). See **fig. 19**. They are all constructed from double-clad circuit board which is soldered into a box. A 4-40 (M3) brass screw (with

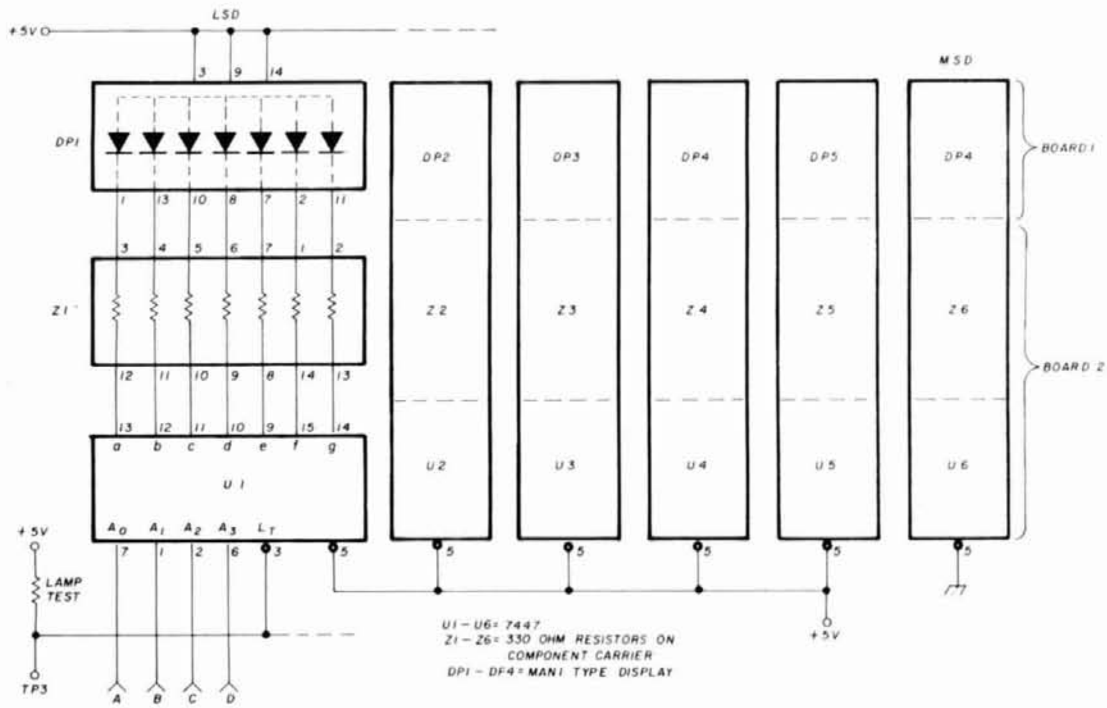
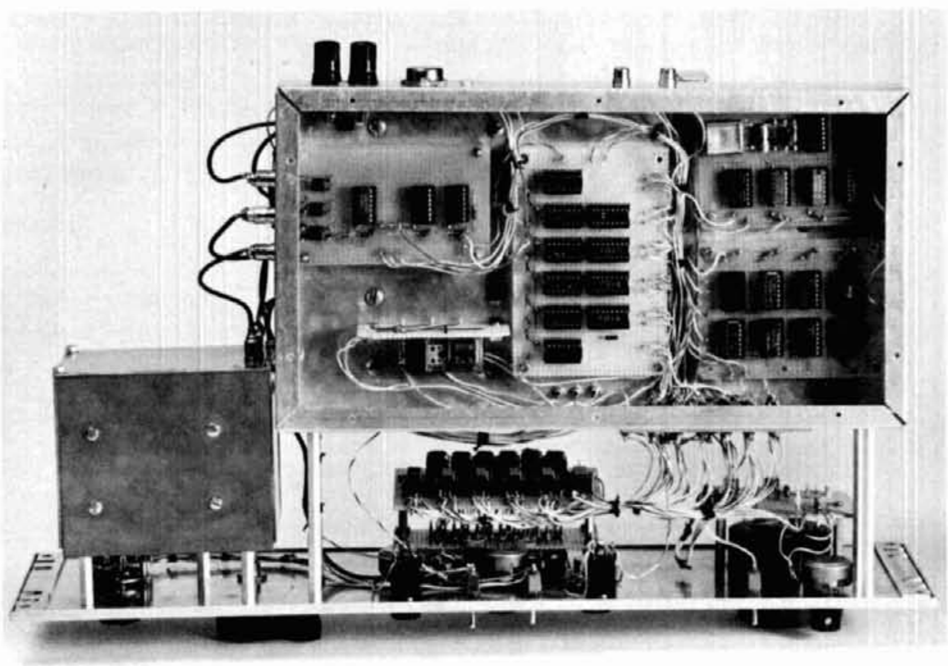


fig. 18. The display module contains the LEDs, limiting resistors, and data decoders. The MAN-1 type LEDs are mounted on a separate board behind the exciter's front panel. The limiting resistors are mounted on component carriers.

the head removed) is soldered into each corner of the box as a means of attaching the cover. For mounting, 8-32 (M4) brass nuts are soldered on the inside (bottom) of the box and the box is then screwed onto the main chassis with 8-32 (M4) screws. I made all the boxes by hand using a hacksaw, a nibbling tool, and a file. It takes about an hour to make up a box. I finally had a friend punch out a bunch of covers and sides for me, which saved a lot of time and made the whole project much more enjoyable.

I use a "standard" bread-boarding chassis which has a row of holes that allows the modules to be



Bottom view of the 6-meter exciter showing construction techniques for the digital counter circuitry.

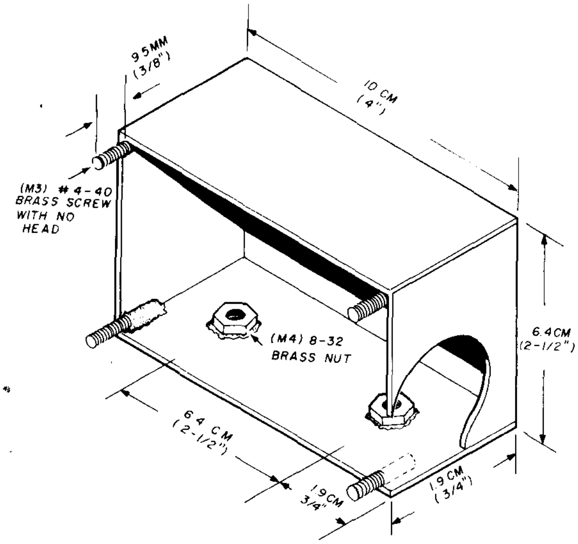


fig. 19. Construction details of the analog modules. Each box is constructed from pieces of circuit board soldered into the desired shape and size.

mounted on 3.8-cm (1.5-inch) centers. The front of the chassis has a piece of angle with 4-40 (M3) clearance holes every 1.3 cm (0.5 inch). Whenever a pot or switch is needed, a small piece of printed circuit board is cut out and attached to the angle to form a "panel." This may seem like a lot of extra work, but it does have the advantage of keeping all the boxes "glued" together. When everything works, the modules are transferred to the final chassis and the breadboarding chassis is ready for the next project.

The modules are interconnected with hook-up wire or RG-174 coax, depending on the type of signal. A couple of ferrite beads were slid over each of the analog power leads. I used phono connectors on

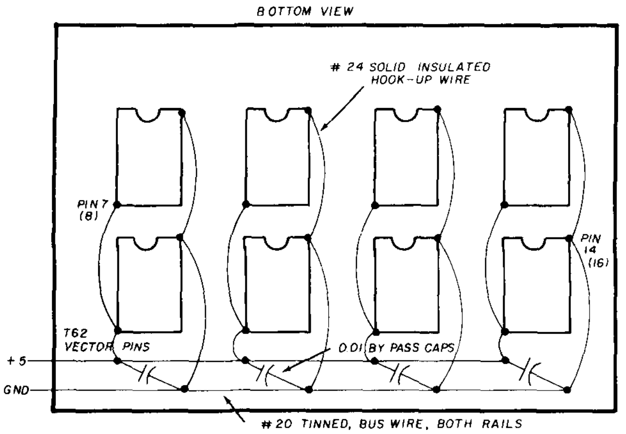


fig. 20. The ICs in the counter circuitry use wire wraps for the point-to-point, with the supply lines bypassed by a 0.01-μF capacitor at each IC. Vector pins are used for the capacitor connection points.

all but the output of the final amplifier module in the interest of cheapness and availability. I used a BNC as the final output connector for compatibility with my switching relays. I believe the phono connectors are fine for low-level work up to about 144 MHz. Beyond that, I prefer to use BNC connectors.

The exciter is built on a 33 x 17.8 x 5 cm (13 x 7 x 2 inch) chassis which is mounted to a 48.3-cm (19-inch) rack panel on 10-cm (4-inch) standoffs. This was done to allow plenty of room for controls. Most of the mechanical work was done with commonly available hand tools. The exception was the red display filter which was machined so that it would look nice when mounted on the chassis.

digital construction techniques

The digital modules were built on perforated G-10 fiberglass boards (**fig. 20**). Power and ground rails are wired with no. 20 AWG (0.8-mm) wire on the bottom of each board. Individual IC sockets are wired into the rails with no. 24 AWG (0.5-mm) solid hookup wire. All signal wiring was wire wrapped.

The power rail is bypassed to the ground rail at each row of sockets with a 0.01-μF ceramic capacitor. The power and ground rails of all the boards are brought back to a common power and ground point. Interboard wiring is done with hookup wire. The outputs from the counter latches were connected to the decoders via 0.001-μF feedthrough capacitors. Ferrite beads were also used on the latch side of the caps.

The story not usually told in most construction articles is the grief encountered in building the equipment. I have had my share with this exciter. There was a growing pile of copper clad boxes as I tried out different and not so successful ideas. The modular approach saved me a lot of time by allowing the development and comparison of different circuits which performed the same function.

acknowledgments

I would like to acknowlege the helpful comments of Joe Reisert, W1JR, and Hank Cross, W1OOP. Many of their suggestions were incorporated into the final design of the exciter. Thanks also to Javed Bukhari, AP2JB/W1, for manuscript critiques.

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ham radio

compact loop antenna

for 80 and 40 meter DX

Quad loops make good low-band DX antennas for those with restricted space — a look at several loop configurations and their advantages

No question about it: the challenge of the five-band DXCC award has created great interest in low-band antennas and has inspired experiments with a wide variety of vertical and horizontal antennas including dipoles, monopoles, delta loops, quad loops, and slopers. Antennas with good performance on 80 meters are typically too large for a city lot. For example, vertical monopoles require extensive ground systems, and horizontal dipoles should be at optimum height. For low-angle radiation, optimum height is on the order of a half wavelength. On 80 meters this is clearly out of the question for most Amateurs.

My home is on a suburban lot where high towers and an effective ground system are impossible. These constraints led to the development of a compact, horizontally polarized loop antenna which has demonstrated competitive performance on both 80 and 40 meters.

loop antenna close to ground

Fortunately, the quad loop offers promise of reasonably good DX performance at low height. Experience has shown that the performance of a Yagi and a quad are roughly the same with respect to height.* There is some evidence, however, that at very low heights the quad may outperform the Yagi.[2] The reason may be that loops contain the electromagnetic field better than dipoles.[3] For whatever reason, the closed loop configuration is relatively immune to nearby objects.[4] The loop configuration also may be relatively immune from some of the effects of nearby ground. For these reasons, the quad loop appears to be a good choice for low band antennas if used with supporting structures within the means of most Amateurs.

L.V. Mayhead, G3AQC, described the performance of loop antennas at low heights in an excellent article, "Loop Aerials Close to Ground," in the RSGB journal, *Radio Communications*.[5] In his article, Mayhead described experiments with a variety of full-wavelength loop antennas close to ground. He modeled the antennas at 470 MHz for radiation-pattern measurements, then constructed two of the best

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*Wayne Overbeck, N6NB, in his article "Quads vs Yagis Revisited," (reference 1), states on page 17: "The result was conclusive: the relative performance of the quad and Yagi was exactly the same at both 7.6 meters (25 feet) and 21.3 meters (70 feet)! This was true on zero-angle line-of-sight signals, high-angle 'short skip,' and on long-haul DX signals." *There was no height at which the quad's relationship to the Yagi changed.* (Italics mine). **Editor.**

configurations for 75 meters and compared them with a dipole at comparable height. Serious low-band DXers should read this article. It offers further evidence that loops make good low-band DX antennas when height is restricted.

evolution of a two-band loop

An 80-meter quad loop is shown in **fig. 1**. The total distance around the loop is a full wavelength. The feedpoint is at the bottom. When used on 80 meters, the current maxima are at the center of the top and bottom spans of the loop (solid circles). Maximum radiation occurs from these two in-phase current maxima. The radiation is horizontally polarized.

When the loop in **fig. 1** is operated on 40 meters, four current maxima appear (open circles). The antenna is resonant on the second harmonic; however, the 40-meter current maxima tend to cancel. The radiation pattern deteriorates into many vertical-

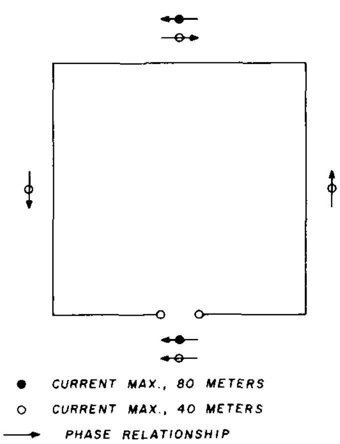


fig. 1. Full-sized 80-meter quad loop showing current maxima for 80 meters (solid circles) and current maxima for 40 meters (open circles). Arrows show relative phase.

ly and horizontally polarized lobes. For this reason, two-wavelength closed loops perform poorly, so quad loops are rarely used on the second harmonic.

Now consider the loop of **fig. 1** distorted into the shape shown in **fig. 2**. The lower left-hand corner folds upward to the right, and the lower right-hand corner folds upward to the left. This forms a half-size loop plus a length of open-wire transmission line. The total length of wire in the loop and the open wire line has not changed. The loop, now reduced in size, presents a capacitive reactance to the open-wire line, which is cancelled by the inductive reactance of the short length of line. Thus the loop and line are still resonant on both 80 and 40 meters.

Fig. 2 shows the positions and relative phase of the current maxima on both bands. Now distort the loop into the familiar delta configurations shown in **fig. 3**. One 80-meter current maximum is still at the top center of the antenna, and on 40 meters all three

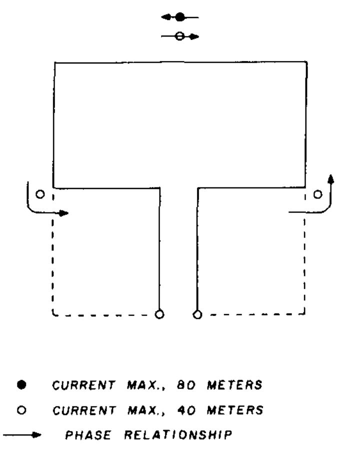


fig. 2. Lower corners of the full-sized loop folded toward the center, forming a 1/2-area loop plus an open-wire line.

current maxima add in phase. Radio-frequency current flowing in opposite directions on the open-wire line cancels radiation from the current maximum at the feedpoint on both 80 and 40 meters. For these reasons, a compact loop antenna of the general shape shown in **figs. 2** or **3** will be a good radiator on two adjacent harmonically related bands.

radiation resistance

The area of the loop shown in **fig. 2** is half the area of a full wavelength 80-meter quad loop. It is twice the area of a 40-meter quad loop. For this reason, on 40 meters, the radiation resistance is high, the efficiency is high, and the bandwidth is broad. The measured impedance at the open-wire line terminals is about 120 ohms. On 80 meters the loop is only half the area of a full-wavelength 80-meter quad loop. Therefore, the radiation resistance is lower and the bandwidth is narrower. On 80 meters the impedance at the open-wire line terminals is about 50 ohms, thus presenting a good match for standard 50-ohm coaxial cable.

Neither the shape nor size of the loop, nor the length of the open wire line, is of particular impor-

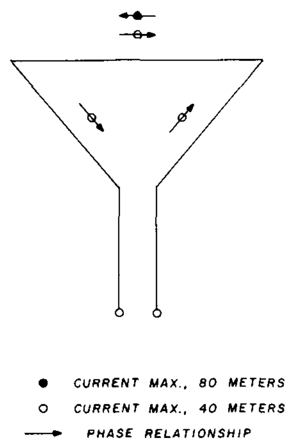


fig. 3. The full-sized loop further distorted into the familiar delta-loop configuration. The 80-meter current maximum is at the top. The 40-meter current maxima add in phase.

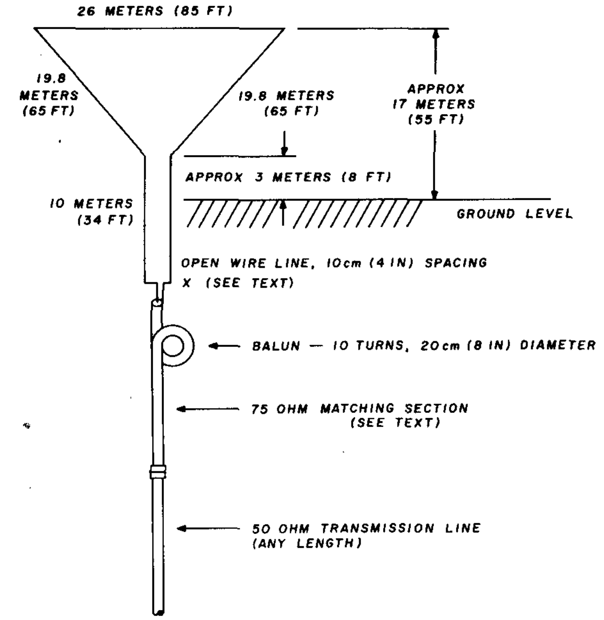


fig. 4. 80/40 meter loop in the delta-loop configuration. Loop can be almost any reasonably open shape. Top should be at least 12 meters (40 feet) high.

tance as long as the loop is reasonably open and the line is between 6 meters (20 feet) and 10.7 meters (35 feet) long. Only the total length of wire, including the loop and the open-wire line, is critical. The total length is best determined experimentally after the antenna is in place; you can resonate the antenna from ground level. Once the antenna is installed, it's unnecessary to take it down again for adjustment.

I built two of these antennas, one at home and the other while on vacation at Lake Tahoe, California. Dick, W3GNQ, also built one at his home in Maryland. All three antennas differ in configuration. The loop antenna at my home is a compromise shape. The top span slopes from an 18-meter (60 foot) tree down to about 12 meters (40 feet). Wires from the

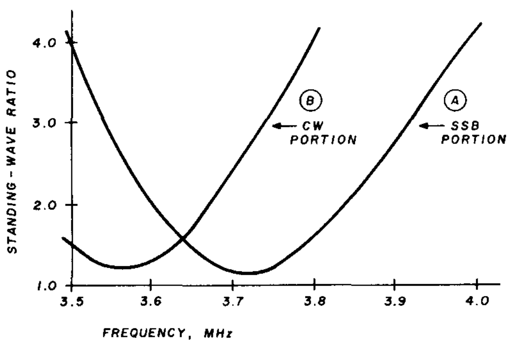


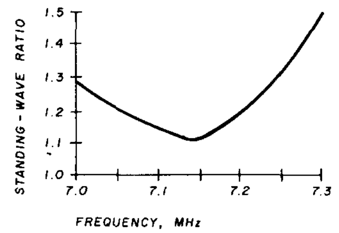
fig. 5. 80/75 meter SWR plots of the delta loop shown in fig. 4. Curve B favoring the CW part of the band was obtained with an extra length of open wire line. See fig. 7.

ends of the top section slant down to the patio overhang and follow the overhang to the feed point. The lengths of wire are in different planes. Last summer, with the beautiful tall pine trees at Lake Tahoe as supports, I built the symmetrical delta loop shown in **fig. 4. Figs. 5** and **6** show the SWR plots.

bandwidth

In general loop antennas have more bandwidth than thin dipoles or monopoles. The antenna described here is no exception. The loop is oversize on 40 meters (1½ wavelengths), so its bandwidth is extremely broad. The SWR doesn't exceed 1.3 over

fig. 6. 40-meter SWR plot for delta loop. SWR is less than 1.5 across the band.



most of the band and doesn't exceed 1.5, even at 7.3 MHz (see **fig. 6**). On 80 meters the loop is only ¾ wavelength. Even with this reduced size, the bandwidth is still satisfactory. The 2.0 SWR bandwidth is 250 kHz, substantially more than the 150 kHz typical of an 80-meter dipole or inverted V. Installing the antenna in a rectangular configuration rather than the delta loop configuration further improves bandwidth.

dual-band feed

A 75-ohm, quarter-wave transformer matches the 50-ohm coaxial transmission line to the 120-ohm input impedance of the loop on 40 meters. On 80 meters, the transformer is only one-eighth wavelength long and doesn't materially affect the 80-meter match. Thus the antenna operates on both bands with a common transmission line.

The two-band feed system (**fig. 4**) consists of any length of 50-ohm line, a quarter wavelength (on 40 meters) of 75-ohm line, and the open-wire line. A simple balun is included in the 75-ohm matching section.

building the 80/40-meter loop

To build the 80/40 meter loop, start with a total length of 87 meters (285 feet) of copper wire. The flat top should be roughly 26 meters (85 feet) long. Make the open-wire transmission line between 6 meters (20 feet) and 11 meters (35 feet) long. The wires should be separated by about 10 cm (4 inches). Spreaders can be made by cutting 1.6 mm (1/16 inch) fiberglass into 1.3 x 11.5 cm (½ x 4½ inch) lengths drilled at each end. Wire these strips onto the open-wire line at roughly one-meter (3-foot) intervals. make the 50-ohm coaxial transmission line from any length of RG-8/U or RG-58/U line, depending on the power level. On 80 and 40 meters RG-58/U is adequate up to several hundred watts input. For a full kilowatt use RG-8/U.

Make the matching transformer with RG-11/U or RG-59/U coax cut to 6.95 meters (22 feet 9 inches), the correct length for solid polyethylene insulation. If you use foam polyethylene insulated coax, the correct length is 8.41 meters (27 feet 7 inches).

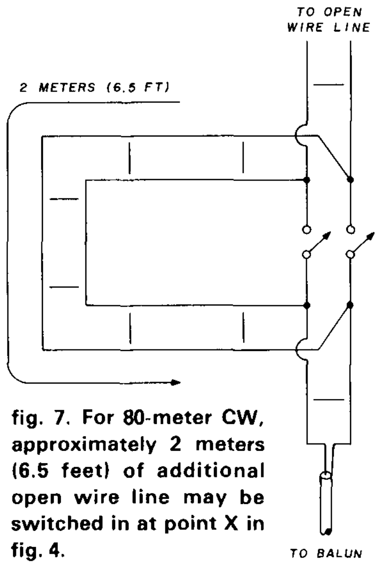


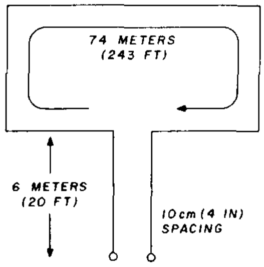
fig. 7. For 80-meter CW, approximately 2 meters (6.5 feet) of additional open wire line may be switched in at point X in fig. 4.

A simple and adequate balun can be added at the loop end of the 75-ohm matching transformer by wrapping ten turns of the coax into a coil. The coil diameter should be ten to fifteen times the outside diameter of the cable used. Place the coil balun as shown in **fig. 4** and use tape to hold it in shape. Connect one end of the quarter-wave transformer to the open-wire transmission line with alligator clips.

Using the alligator clips, adjust the open-wire transmission line length until the SWR curve is well centered for 75-meter SSB. See curve **A**, **fig. 5**. Now plot an SWR curve over the 40-meter band. You'll find it broad and well centered (see **fig. 6**). When you're satisfied with the 75- and 40-meter SWR, remove the excess wire and solder the 75-ohm coax to the open wire line.

From curve **A** of **fig. 5**, notice that the SWR climbs excessively in the CW portion of the 80-meter band. Use the extra length of line and the switch shown in **fig. 7** for 80-meter CW operation and adjust the extra length of line for optimum SWR over the CW part of the 80-meter band. (See **fig. 5**, curve **A**.) Add the

fig. 8. Rectangular loop at W3GNQ. Size and shape of the loop isn't critical. The total length of wire including the loop and the open-wire line must be full-wave resonant on 80 meters. Use two-band feed system shown in fig. 4.



switch and line close to the coax at **X** in **fig. 4**. Use a relay or, because point **X** is near ground level, a switch mounted in a convenient location.

W3GNQ loop

W3GNQ decided to erect his antenna in the general shape of **fig. 2**; his antenna is shown in **fig. 8**. The rectangular shape and short open-wire line result in the SWR curves of **figs. 9** and **10**. The bandwidth of Dick's antenna is broad enough so he can operate on 80, 75, and 40 meters with no switching.

bandwidth and terminal impedance

To gain an understanding of how the input impedance and bandwidth vary with loop size and shape, I made scale models of various loop antennas. All loops were 406 cm (160 inches) in total length including open-wire line. All were resonant between 75 and 90 MHz. I measured terminal impedance and relative bandwidth on a variety of configurations with a Hewlett-Packard RF Vector Impedance Bridge. The curves of **figs. 11** through **14** show the data. **Fig. 11** shows how the terminal impedance and relative bandwidth change with the ratio of square loop size to open-wire line length. When the ratio of the total length of the loop to the length of one side is four, the open-wire line length is zero, and the loop is one wavelength in circumference. The input impedance

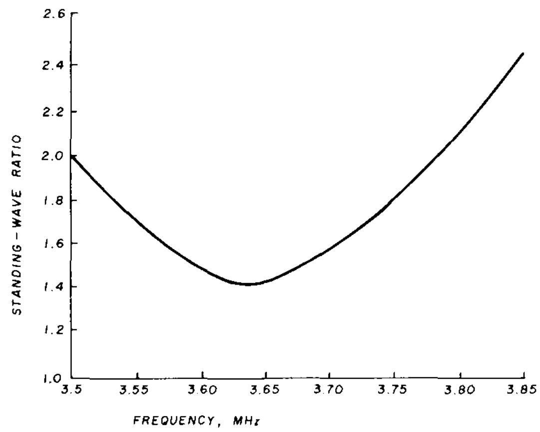


fig. 9. 80-meter SWR plot of quad loop at W3GNQ.

is 145 ohms. As the loop decreases in size, the open-wire line becomes longer and the terminal impedance drops. It reaches 50 ohms at L_t/L_s (total length to side length ratio) between five and six.

I measured the relative bandwidth of the models by recording the impedance-bridge frequency above and below resonance at the +10 and −10 degree points as read on the phase-angle meter. Of course, bandwidth improves as the loop increases in size.

Data taken on a delta loop model is shown in **fig. 12.** Here the open-wire line length was held constant while changing the ratio of top span length to total length. When the terminal impedance is 50 ohms, the bandwidth is the same as that of the square loop when proportioned for the same input impedance (**fig. 11**). The square configuration, however, is capable of greater bandwidth. Furthermore, you can infer from the two sets of curves that a rectangular antenna (**fig. 8**) will have better bandwidth than either a square or triangular loop. The bandwidth

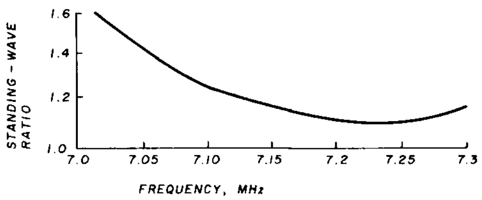


fig. 10. 40-meter SWR plot of the loop shown in fig. 8.

data is only relative and not a measure of the useful bandwidth of the antenna; it's useful only for comparing the scale models.

use on a metal tower

The diamond shape of **fig. 13** is interesting. Because the loop is symmetrical about the vertical axis and is horizontally polarized, it should be a good radiator when supported on a single metal tower. To give some experimental validity to this, during the scale model tests I placed a large metal member near the loop vertical axis, simulating a tower. There was no measurable effect on the terminal impedance, and the resonant frequency changed only one-half per cent. Thus, interaction of a full-scale antenna with a metal tower should be negligible. The inverted delta loop version shown in **fig. 14** also can be used on a metal tower.

diamond vs. square quad loop

On comparing the curves of **figs. 13** and **14,** note the interesting data showing impedance and bandwidth for the diamond quad and the square quad. The full-sized quad loop case is shown on the curves at $L_t/L_s = 4$. The data indicate that a diamond-

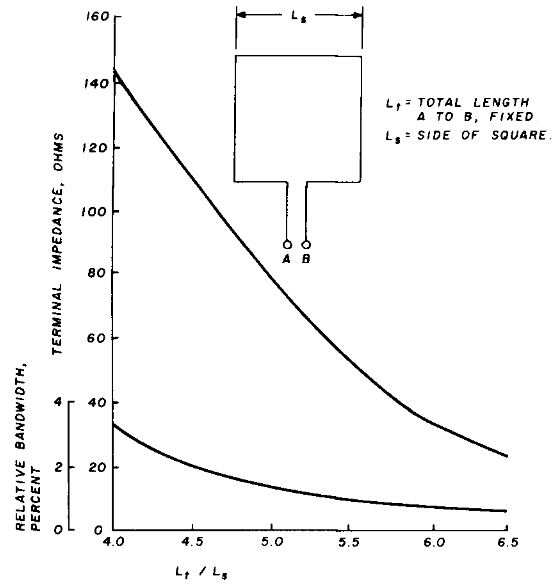


fig. 11. Input terminal impedance as a function of loop side length to total length ratio. Measurements taken on 80-MHz scale model at resonance with an HP Vector Impedance Bridge.

shaped quad is the preferred choice because of higher impedance and greater bandwidth.

Antennas near ground at 3.5 MHz will have a terminal impedance different from that of the scale models because of the effects of nearby ground. I've tried none of the antennas of **figs. 11** through **14** at full scale, so the convenient relationship between 75-

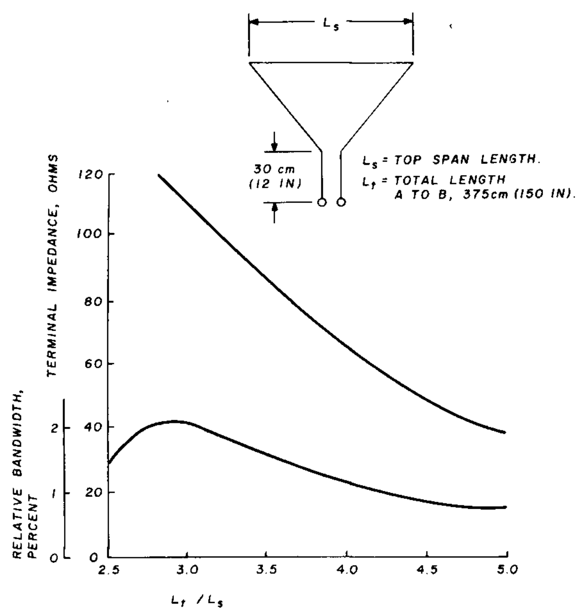


fig. 12. Scale model input terminal impedance as a function of loop top span length for a 375-cm (150-inch) loop including 30-cm (12-inch) open-wire line. Measurements taken at the full-wave resonant frequency near 80 MHz.

and 40-meter resonant length may not hold for these configurations. Therefore, antenna designs based on these curves may require further experimentation.

advantages of the W6TC compact loop antenna

1. The antenna is an excellent radiator on both bands, as theory predicts and as proven in practice.

2. The antenna provides a good match for 50-ohm line on both 80 and 40 meters.

3. The antenna is small compared with other 80 meter antennas. The largest dimension is substantially less than 30 meters (100 feet).

4. The antenna is broadband.

5. The antenna can be supported on relatively low supports and still give reasonably good performance.

6. The shape isn't critical. The antenna can be put in the delta, square, rectangular, or any similar open configuration. It can be installed on a single metal tower in the shape of a diamond or inverted delta.

7. The antenna is horizontally polarized, so a ground system is not required.

8. Only one dimension, the overall length, is critical. This adjustment is made from the ground; it's not necessary to take down the antenna for adjustments.

9. An antenna tuner is not required.

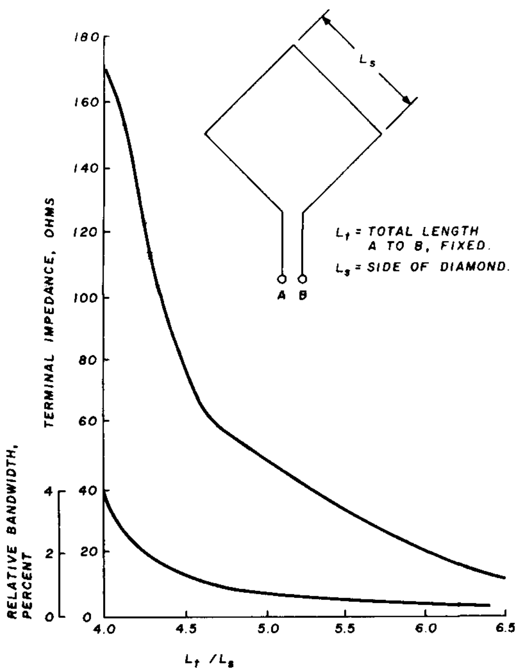


fig. 13. Terminal impedance and relative bandwidth vs diamond side to total wire length ratio. Scale model frequency: 80 MHz. Loop may be mounted on metal tower.

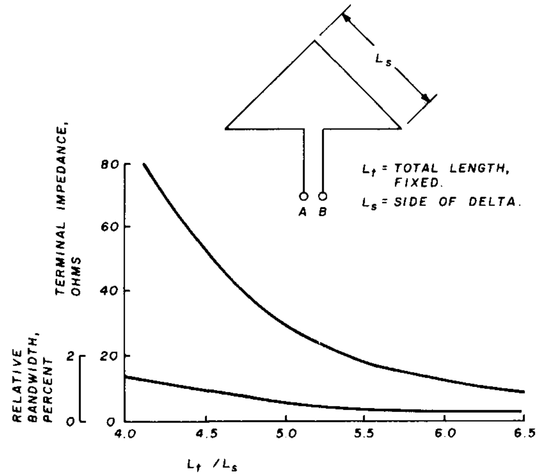


fig. 14. Scale model terminal impedance and relative bandwidth characteristics of inverted delta loop.

10. The center of the long span of the delta-loop version doesn't support a heavy feedline.

conclusion

There's no substitute for full-size antennas supported on tall towers. With low band antennas, "the higher, the better" has always been true. However, if you have room for only one small, low antenna for 80 and 40 meters, this antenna may be your best choice. I hope the examples of full-size antennas and the scale-model data presented here will provide design guidance for your version of the antenna.

Experience with this antenna on the air has been gratifying. While evaluation of low-band antennas is always highly subjective, the W6TC loop appears to be quieter on receive and seems to punch through the pileups better than other low-band antennas tried at W6TC. Working DXCC on 80 meters is difficult from the West Coast. However, after building this antenna, the new countries seemed to come a little easier. Dick, W3GNQ, finds the antenna especially competitive on 75 meters. While direct A-B comparisons were never possible because of space limitations, this antenna, in my opinion, has that extra edge that only on-the-air experience can discern.

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ham radio

the talking clock

An addition to the talking digital frequency readout described in an earlier issue of *ham radio*

It was no time at all after completing the talking frequency readout unit[1] that I recognized the desirability of using its voice for Greenwich Mean Time (or UTC). The investment in the speech synthesis module had already been made and the original readout box was not crowded, so I investigated digital clocks.

clocks

The first clock chip I acquired didn't have BCD output and was meant to drive 7-segment LEDs. Although I located an interesting chip that could have converted the clock data to BCD, I thought its price in unit quantities was too high — above my budget for the whole project. Later I discovered the MM5312 clock chip that sells for $3-$4, which has both BCD and 7-segment data outputs. The MM5312 doesn't read seconds or have all the bells and whistles, but it is a true 24-hour clock on a 24-pin chip. A Radio Shack 5082 miniature 5-digit readout allowed me to get familiar with its operation. (Ignoring the third common cathode makes the middle digit blank.) The visual readout is optional and may be omitted, if desired.

circuit description

The talking clock schematic is shown in **fig. 1**. I planned to use whatever I could for the original circuit to provide the data sequencing immediately after completion of the previous word, regardless of the word time duration. It would have been possible to obtain both frequency and time in response to each inquiry, because the 74193 can control a sequence of sixteen data positions. However, because of the sentence-shortening features of the frequency readout, it seemed unnecessarily complicated to produce a skip past the omitted positions at the end of the sentence. Instead, I chose to provide the clock data in the 0 through 3 (first four) data locations. Stopping after the first four is easiest: merely invert the **C** address line with a spare gate on the original board and substitute its output for the six- or eight-word stopper.

Two other poles of the frequency/time switch are used to make sure the sentence starts at the 0 address. The switching is ahead of the provisions for deleting the first word on the single-digit MHz bands and ahead of the MHz-delete switch, which delays the start past the first decimal point. Thus in the time mode, all four 74193 preset lines are grounded.

The circuit that causes the voice to say *point* in the third and seventh locations (2 and 6) is disabled by switching the fifth data-line input of the voice to ground when in the **time** function; otherwise, the third digit of the time readout would be really strange and come out of the unused vocabulary of the S2A.

switching logic

We must still switch the data itself between the two sources, readout and clock. A 74157 multiplexer must have been designed precisely for this job (**fig. 1**); it acts as a 4-pole, 2-position switch for digital data in TTL form. When its pin 1 is connected high (to +5 volts), the time data at pins 11, 13, 3, and 6 appears at pins 9, 12, 4, and 7 respectively. When it is low (at ground), the data at pins 10, 14, 2, and 5 from the readout is passed through to the same four output pins. Its power pin, no. 16, must have +5 volts present in either mode. Power may be removed from the 7404, 7400, and 7432 while in the readout mode. Power to the 74193 and other chips on the interface board is required in both modes, since the 74193 and gates are required to step from one digit to the next at its command.

data sequencing

The path is now cleared for clock data to reach the speech module, and four defined sequential slots are reserved for it. As is usually the case, the most inter-

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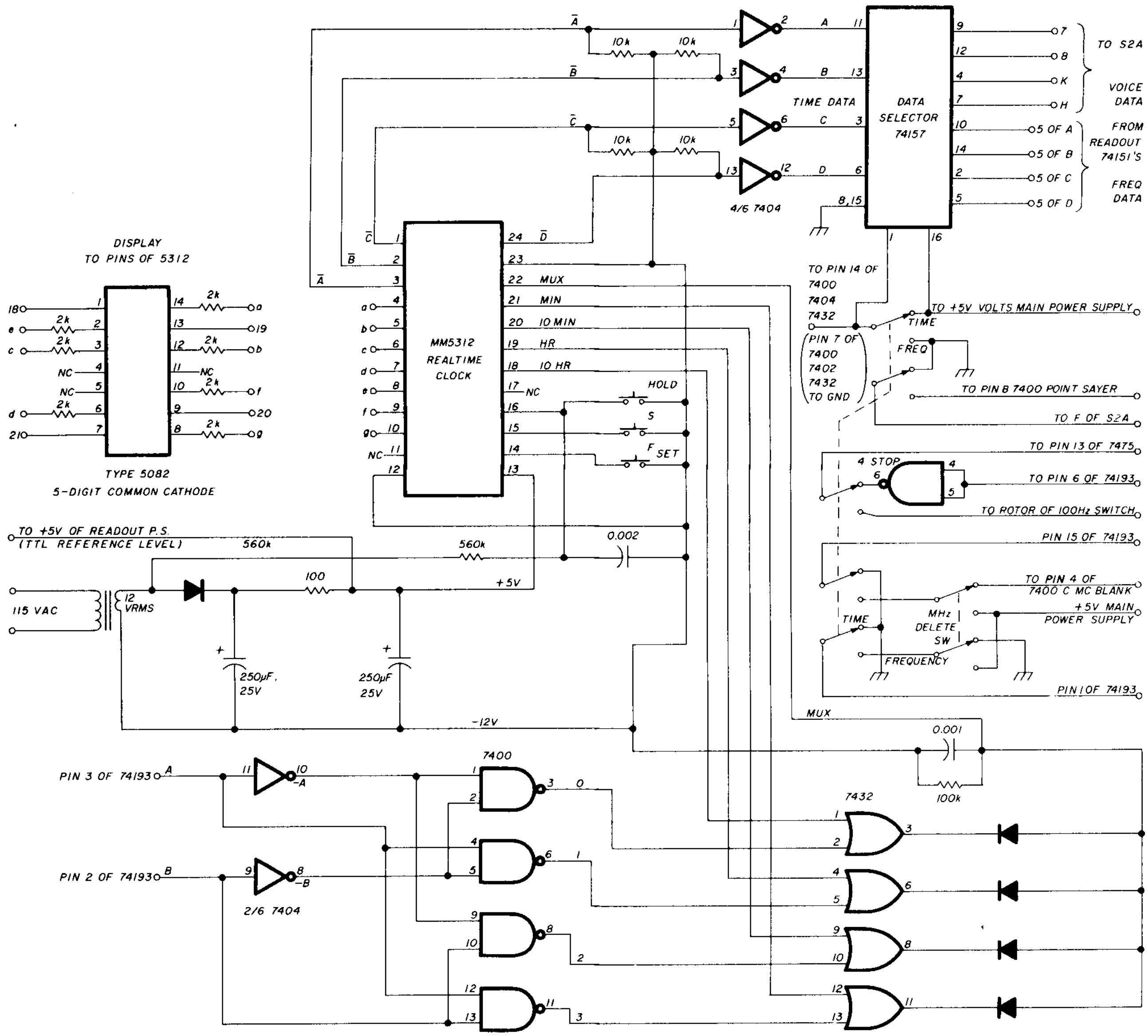

fig. 1. Schematic of the talking clock addition to the talking frequency readout described in an earlier article. It's a useful circuit for the visually handicapped operator.

esting problems come up last. I'd visualized four sets of BCD data available at the same time, which I would have to multiplex, as with the frequency data. But when I examined the 5312 only one set of BCD terminals existed, indicating that the data must somehow be internally multiplexed. Great! That should hold the chip count down. But the problem then was how to control the internal multiplexer. In the normal application, with visual readout, there's no need for this as long as the rate is high enough so that all four LEDs glow simultaneously. But I can't use parallel data for words that have to be said in sequence — and the sequence must be controlled.

The four clock terminals, 18 through 21, go low in sequence so that the appropriate digit LED will glow when the data for that digit is present on the common data lines to all four digits. These four terminals can at least be used to tell which digit's data is appearing on the output BCD data lines at any point in time.

clock mux rate

The clock multiplexing rate is determined by an external RC network connected to pin 22. Looking at this signal on a scope, we see a beautiful repetitive sawtooth waveform. If you use a large capacitor, you'll notice that the four digits light up in sequence, from right to left in backward order. A bit scary. If we ground pin 22, killing the sweep, the readout stops in one of the four positions, more or less at random, but table 1. Truth table defining multiplexer action.

word sequence to read		first 10 hr	second hours	third 10 min	fourth minutes
address	A		1		1
74193	B			1	1
invert	– A	1		1	
7404	– B	1	1		
7400 pin	3	0			
	6		0		
	8			0	
	11				0
5312					
clock pin	18	0			
	19		0		
	20			0	
	21				0
7432					
stop pin	3	0			
	6		0		
	8			0	
	11				0

nevertheless depending on when we do it. A method for controlling the internal multiplexer was evolving. (Maybe I can work out an educated screwdriver to short it out at just the right times.)

A scheme materialized that allowed the multiplexer to scan whenever the clock output data didn't coincide with that requested by the 74193 address position. We want the tens of hours first and the minutes last. When the scanner comes to the correct digit, the multiplexer parks there until it has been pronounced. At the end of the word, the busy line from the voice says, "OK, I'm through," and the 74193 is advanced to the next address. This action releases the scanner lock and it roams (in the wrong direction), looking for the next appropriate digit. It skips over the next two digits presented to it and locks on the third, which is to the right of the last one presented.

Table 1 does a better job of explaining the operation of the circuit. When one of the 7432 positive OR gate outputs goes low, a diode connects it to the scanning waveform and locks it into position. (A positive OR gate has an output low only when both its inputs are low.)

The address is available from the 74193 in BCD form; we need only the **A** and **B** lines to describe the first four addresses. A pair of inverters (7404) and four NAND gates (7400) convert this data to decimal form. Since a NAND gate produces a low output only when both inputs are high, we can play the game four ways and come up with combinations minus **A** minus **B** for 0, plus **A** minus **B** for 1, minus **A** plus **B** for 2, and plus **A** plus **B** for 3.

If we apply each output to a separate NOR gate input, then choose the correct line from the four clock terminals, 18 through 21, the 7432 section that will stop the scanner on tens of hours must have the tens of hours terminal (clock pin 18) as one input and the first address, 0, as the other.

It seemed strange to go to all the trouble of sorting things out through two sets of gates only to wind up connecting all four signals to the same place with diodes. But that was pretty much what I started out looking for — the smart screwdriver. Looking at each 7432 output separately, you should see a square wave that is down one-quarter of the time if you slow it down with a 0.1-μF capacitor across the 0.001-μF.

The visual display stops when the scanner stops, so it's easy to establish what's going on. I used silicon diodes to combine the four signals.

summing up

The gating circuits involving the 7475 latches (reference 1) in the frequency interface board were not modified. I found no error by letting the counter waveform control the start latch, and the reset and address stepping functions were just what I wanted. I added a minimum-design power supply to power the clock chip, which of course is on continuously to maintain time.

Three pushbutton switches permit setting the clock. Upon power interruption, the clock starts running from 0000. When the fast button is pressed, time speeds by at an hour-per-second rate; the slow position advances time at a minute-per-second rate. The hold button permits stopping the clock without resetting.

When listening to WWV, let the clock run to a minute ahead of real time and depress the hold button until the time catches up. On the next minute from WWV, note how many seconds fast you are and hold for a similar period, and you'll find you're right on to the second. The voice repeat switch comes in handy when setting the clock.

Printed circuit boards for the talking readout have been completed and check out. They are available from O.C. Stafford, 427 South Benbow Road, Greensboro, North Carolina 27401. At the time of submission, design of a circuit board for the talking clock addition, incorporating the four chips and diodes shown in the article, has been initiated by O.C. Stafford.

Since the unit now performs two functions rather vital to the visually handicapped Amateur, it's been dubbed the "Second Operator." Let your fingers do the talking.

references

1. Raymond W. Brandt, N9KV, "Talking Digital Readout for Amateur Transceivers," *ham radio*, June, 1979, page 58.

ham radio

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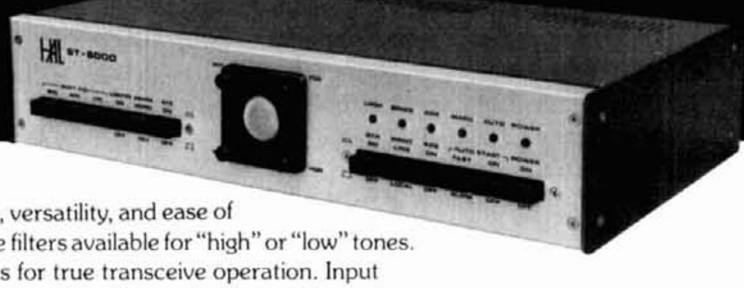

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the handi-counter

A high-frequency counter featuring the Intersil 7216-D built into a hand-calculator case

This is a fun construction article. It involves mating Intersil's new ICM-7216-D 10-MHz counter chip into a small hand calculator case. Frequency limit is ± 550 MHz depending on device options.

I purchased one of the first 7216-D chips. In checking out its many features, I needed an LED display. I had recently purchased two hand calculators in a Poly-Paks penny sale. As I robbed the 9-digit display, the possibility of using the case for a small portable counter evolved into the handi-counter.

design criteria

A small pocket-type counter is designed with sensitivity, frequency range, and accuracy to use for emergency frequency calibration of TR-22 handi-talkies. To meet these requirements, a bare minimum of parts evolved into the circuit of **fig. 1** with the following specifications:

Frequency limits: ± 250 MHz
Sensitivity: reads TR-22 at 0.9 meter (3 feet)
Accuracy: ± 100 Hz or ± 10 Hz
Voltage and current: 5 volts at 137 mA
Readout: seven digits at 1.0-second gating; eight digits at 10.0-second gating

The handi-counter frequency response may be extended to around 600 MHz as shown in **fig. 2**,* in which a 74196 chip (U2) is substituted for the 74LS90 (U2 in **fig. 1**). The specifications for the circuit in **fig. 2** are as follows.

Frequency limits: ± 550 MHz
Sensitivity: 100 mV at 450 MHz
50 mV at 146 MHz
Accuracy: same as the circuit of **fig. 1**
Voltage and current: 5 volts at 185 mA
Readout: same as the circuit of **fig. 1**

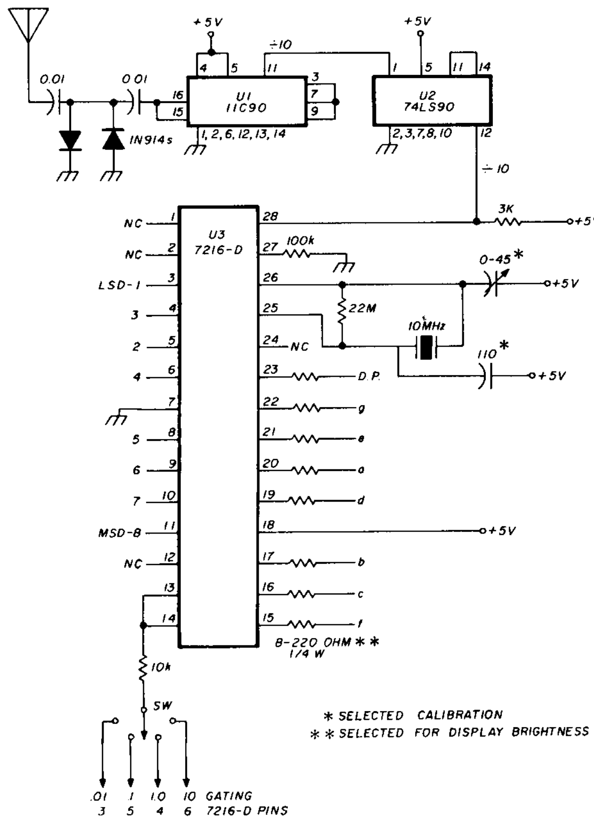


fig. 1. 250-MHz counter using the Intersil ICM-7216-D counter chip.

*A PC-board layout for the 600-MHz version is available from the author. Please send a self-addressed, stamped envelope.

By **R. M. Naglee, K5WKQ**, 2402 Maxwell, Midland, Texas 79701

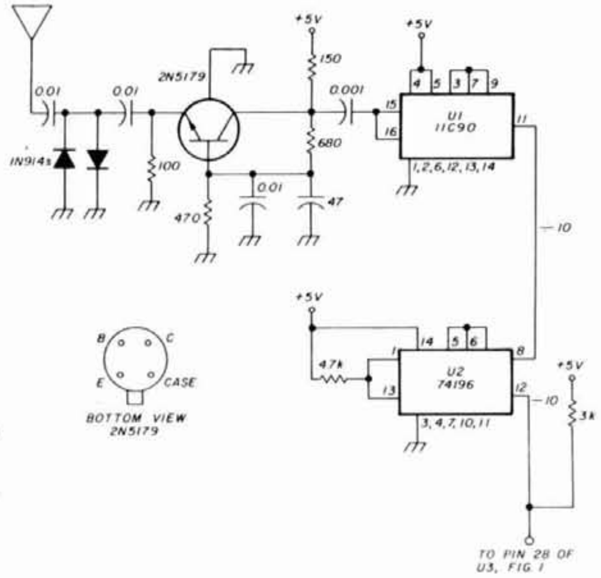


fig. 2. 600-MHz counter, which uses the 74196 chip to replace the 74LS90 divider of fig. 1.

The circuits in **figs. 1** and **2** are the same old standbys that have been used for years, so no credits are given. The 11C90 divides the incoming signal by ten into the 74196 or 74LS90, once more dividing by ten into the 7216-D.

construction

I used the Heathkit laboratory breadboard in the investigation of the many features available in the 7216-D. I used only a few features of the 7216-D (more later about these). Both circuits were thoroughly checked in breadboard fashion. I decided on the circuit of **fig. 1** for my counter; you may wish to do otherwise. I used the small LED readout display from the calculator, **fig. 3**.

The connections for this display were verified in the following manner. I soldered 12.5-mm (0.5-inch) lengths of No. 22 AWG (0.6 mm) wire into each of the pins and plugged the display into the breadboard. I connected a 220-ohm resistor to the 5-volt supply. Then in a trial-and-error method, using a ground wire and the current-limited 5-volt wire, I located each digit and segment. For optimum brilliance and minimum current, 220-ohm current-limiting resistors were used. The frequency-determining capacitors were used for the 10-MHz crystal I had on hand; yours may be different — start out with 39 pF in each.

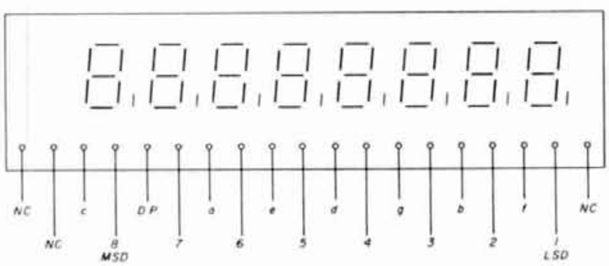
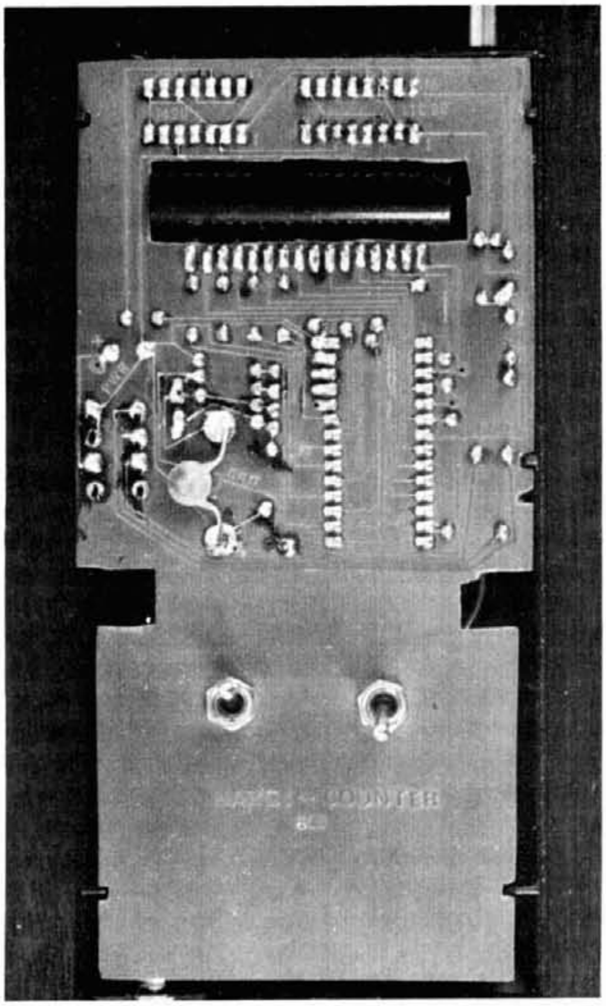


fig. 3. Top view of the 9-digit LED display. (Digit 9 is not used.)

PC board. I used the old PC board with cutout for display from the calculator to get dimensions. I designed the new circuit board in pencil on grid paper in reverse. Then, using a piece of clear Mylar as a base, I used rub-on sheets for all ICs and pads, following the pencilled design. I used a Keuffel and Esser (K&E) size 00 LeRoy pen and India ink to connect the pads. This was my first experience using the positive method in PC work, and I was pleasantly surprised at the results.



Handi-counter board for the 250-MHz unit.

The next step was to flip the clear Mylar base, placing the image next to the emulsion side of a presensitized fiberglass board. I used a piece of clear

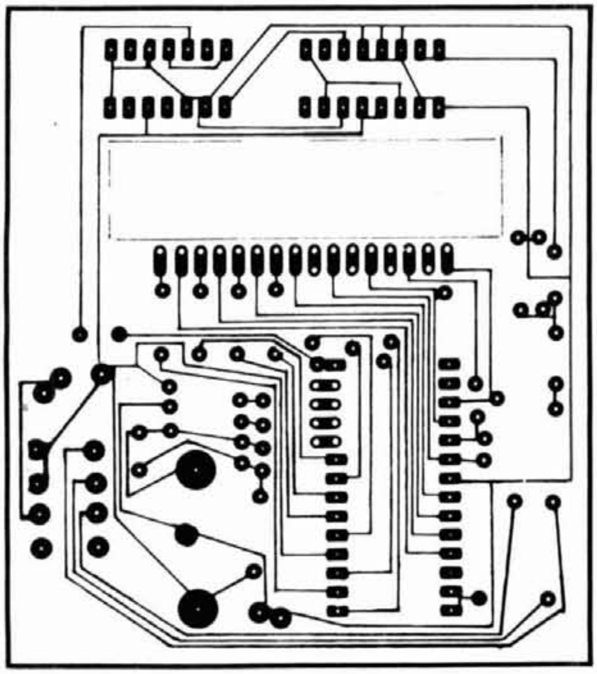


fig. 4. Board layout of the 250-MHz handi-counter. Unit fits nicely into a hand calculator case available from Poly-Paks. A layout drawing is available from the author for the 600-MHz version (see text).

glass about 6.5 mm (0.25 inch) thick to ensure good contact between Mylar and board.

Next was the exposure. I used a 250-watt heat lamp (high infrared) placed about 281 mm (11 inches) away. Exposure time was 5 ½ minutes.

After development I rinsed and dried the board, then I put it into the etching tank. After etching I washed the board again, dried it, and scrubbed it with steel wool. The board was then ready for cutting and drilling, after which all jumpers and components were connected.

I used no sockets, but they could be used because the breadboard design showed minimum problems with long wire connections. The board shown in **fig. 4** is an example of how I designed around the calculator case and display. Parts placement is shown in **fig. 5**; circuit boards are available.*

Power supply. Four ni-cad AA cells with 450 milliampere-hour ratings were connected to the existing charger plug in the calculator case. I used a small plastic battery holder.

Antenna. The antenna is a telescoping type, which is available from Radio Shack stores. It's bolted to a Bakelite bracket, which is cemented to the case.

*Circuit boards are available from Whitehouse & Co., Newbury Drive, Amherst, New Hampshire 03031.

ICM 7216-D counter IC

Fig. 1 shows all four available gates. Only two are used in my counter. Pads for additional gates were provided for future use. The pinout of the 7216-D is correct; pins 4 and 5 are digits 3 and 2 as shown. Calibration was for cold starts; that is, no warmup time because for my use the counter is used only for short intervals.

These circuits use only a portion of the capabilities of the 7216-D. During breadboard design all of the features were investigated. The device has such a potential that I've ordered another chip for a counter to be used in my station. It will count between ±0.1 Hz and 600 MHz with a TXCO crystal. The ICM 7216-D features:

1. Frequency measurement from dc to 10 MHz (mine went to 12.5 MHz)
2. Output drivers will drive large common-cathode LED displays plus overflow LED
3. Selectable decimal points
4. Leading zero blanking
5. Eight-digit multiplexing outputs
6. Single 5-volt supply
7. Either 1- or 10-MHz crystals
8. Selectable 0.01, 0.1, 1.0, or 10.0 second gating times
9. Display hold
10. Display blanking

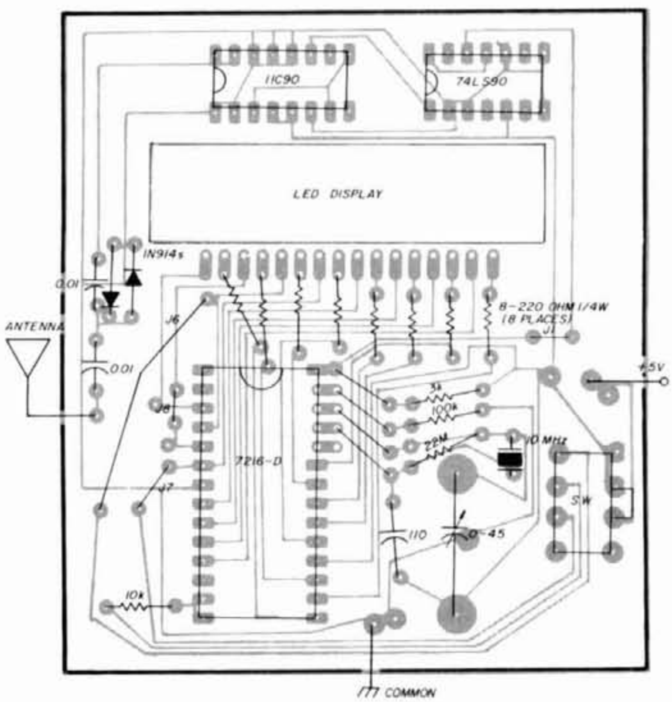
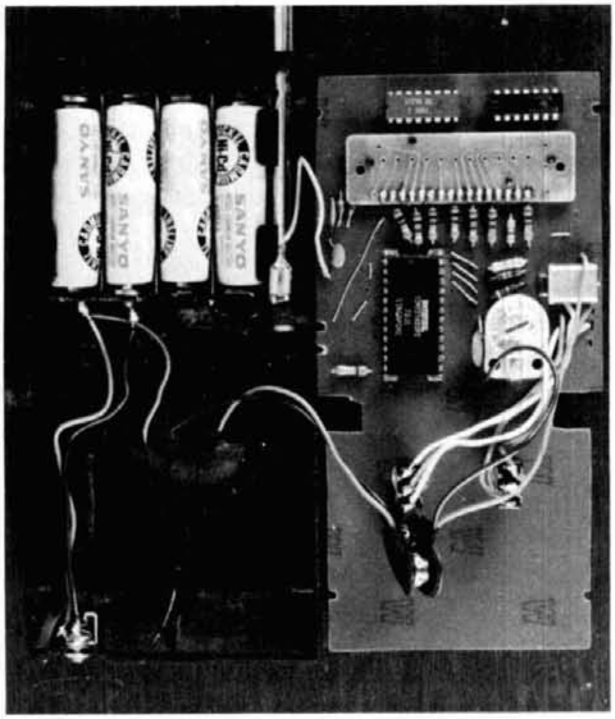


fig. 5. Parts placement for the 250-MHz handi-counter.



250-MHz counter showing component arrangement.

The data sheet accompanying my chip was for the 7216-C, which uses a common anode display. The pinout was *incorrect*. **Fig. 1** pinout is correct.

concluding remarks

I take no credit for any of the designs, only for putting it all together into a small calculator case. I'll be glad to answer all correspondence that includes a self-addressed, stamped envelope. For those interested in cost:

part	source	price
ICM-7216-D	Circuit Specialists	$20.95
11C90	Circuit Specialists	14.95
74LS90	Circuit Specialists	0.40
10 MHz crystal	Circuit Specialists	2.25
Two calculators	Poly-Paks	2.98 each
Four AA nicads		5.95
One battery holder		0.95
One F. G. circuit board		1.95
Miscellaneous resistors and capacitors		1.45
	Total	$51.83.

Watch out for Murphy's Law. The special switch in the calculator board was removed safely but went to pieces. Therefore, two spdt miniature toggle switches, on-off, and 1.0 or 10.0 second gating were needed.

ham radio

repair bench

Joe Carr, K4IPV

building low-voltage dc power supplies

Not many years ago Amateurs and other electronics hobbyists who needed low-voltage dc power supplies used batteries or a simple, unregulated, ac-powered circuit. The most common commercial dc power supplies of that day were unregulated, poorly filtered, and often referred to as "battery eliminators." Such power supplies were used to service car radios and other mobile equipment but were not too good for much else.

Modern solid-state electronic circuits require regulated low-voltage dc power supplies. Many circuits will work best only when the dc power supply voltage is regulated. Oscillators, for example, won't oscillate at the correct frequency unless the power-supply voltage is correct. Even where the absolute operating voltage isn't critical it must remain at the value that existed when the oscillator frequency was adjusted, or the frequency will be different. If the oscillator power-supply voltage changes while the oscillator is running, the frequency will change. Imagine mobile two-way radio if your receiver local oscillator changes frequency enough to move off-channel every time you accelerated away from a traffic light! Sound unreasonable? I've seen many fm broadcast auto radios that shifted 4-6 MHz under acceleration when the internal voltage regulator (8 volts dc) was open.

In digital electronic circuits, especially the very popular TTL, the dc voltage must be regulated. The TTL family of devices will not operate properly or may burn out if the incorrect voltage is applied. TTL devices typically want to see 5 ± 0.25 volts, and in no instance must the voltage rise above 5.6 volts! In reality a narrower range of 5 volts ± 50 mV may be required. It seems that some TTL devices, especially complex or multifunction ICs, become flaky at less than 4.9 or 4.95 volts despite the fact that the manufacturer specified a wider range.

The need for regulated, low-voltage, dc-power supplies, then, is well established. What remains is to determine how to go about making such a supply with a minimum of effort and cost and with little or no sacrifice in utility. Before considering voltage-regulator circuits, let's first review the principles of dc power supplies.

transformers

A transformer (**fig. 1A**) scales the 110-volt ac power main's voltage to that required at the power supply output. In the case of our low-voltage dc supply, the transformer must be a step-down type; *i.e.*, the secondary voltage, E_s, is lower than the primary voltage, E_p. Transformers operate only from alternating current (ac) sources and obey the following relationships:

$$\frac{E_p}{E_s} = \frac{I_s}{I_p} \qquad (1)$$

Note from **eq. 1** that the current ratio is the inverse of

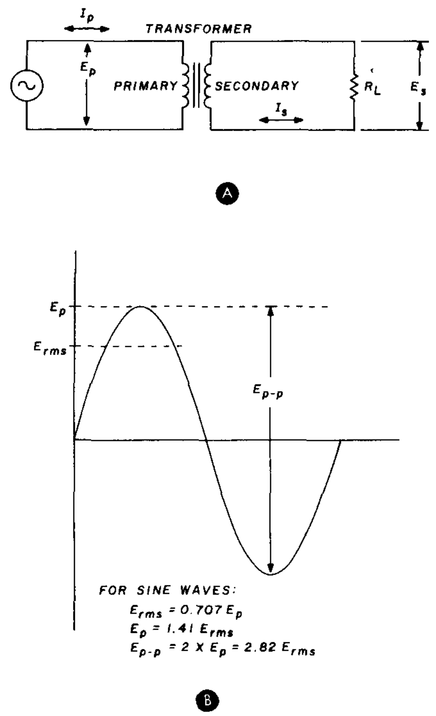


fig. 1. Schematic of a typical dc power supply (A) and the relationships between the ac voltages (B).

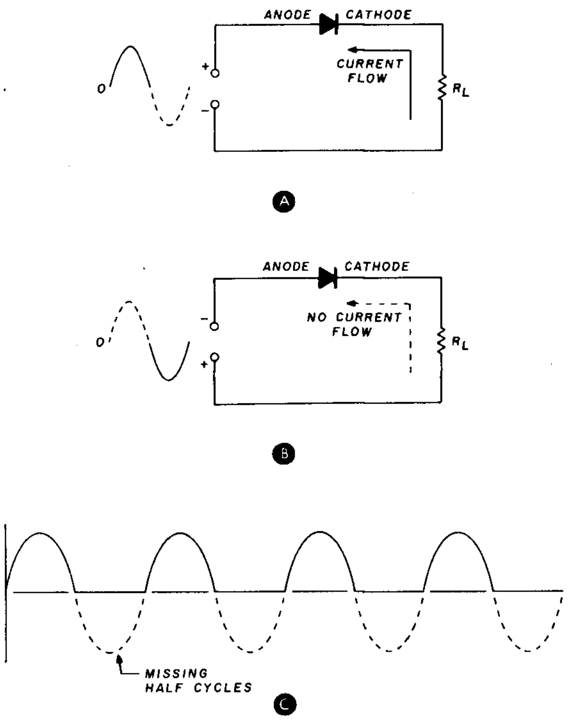


fig. 2. Rectifiers are a necessary ingredient in a dc power supply. (A) and (B) show rectifier current flow in terms of the ac input cycle. The output waveform (C) is unidirectional but pulsating (not pure dc). Because of the missing half cycles, the average voltage at a half-wave rectifier output is only 0.45 times the applied rms voltage, E_{rms}.

the voltage ratio. A transformer that steps voltage down will show an apparently equal step-up of current. This concept can, unfortunately, become confusing at times, because the actual secondary current, I_s, is determined by the secondary voltage, E_s, and the load resistance, R_L, connected across the secondary. The current step-up idea probably arises from the way **eq. 1** is often presented:

$$E_p I_p = E_s I_s \qquad \textbf{(2)}$$

Eq. 2 tells us that I_p will vary as changing load conditions cause I_s to vary; as I_s goes up I_p will also go up to keep the equation constant.

Note that **eqs. 1** and **2** contain no loss terms. Real 60-Hz power and filament transformers are efficient devices; efficiency ratings of from 95 to over 99 per cent are common. This fact justifies our use of simplified equations; the error terms are very small.

Transformers are rated by the primary and secondary voltages, the secondary current, and the primary *VA* rating; *i.e.*, volts time amperes. In most cases the primary voltage will be either 110 volts, 220 volts, or will be selectable between 110 and 220 volts. The secondary voltage is determined by the turns ratio between primary and secondary windings. Both voltages are specified as root-mean-square (rms) values, but both the peak and peak-to-peak voltages become important in dc power supply design. The relationships between E_p, $E_{p\text{-}p}$ and E_{rms} are shown in **fig. 1B.**

Most transformers are built with the primary winding nearest the core. As a result, the primary is more easily overheated. The primary *VA* rating, then, limits the power available from the transformer. The primary *VA* rating cannot safely be exceeded. Some get away with it but this can't be guaranteed. Only transformers built to military specifications are over-specified sufficiently to make the temptation to overrate reasonable.

rectifiers

Rectifiers (**fig. 2**) pass current in only one direction. This features allows them to convert bidirectional ac into unidirectional pulsating dc. **Fig. 2A** shows a simple half-wave rectifier circuit. On the positive alternation of the ac cycle, the diode rectifier anode is positive with respect to the cathode, so current will flow. On negative alternations the rectifier is reverse-biased and no current will flow (**fig. 2B**). The output waveform (**fig. 2C**) although unidirectional is not pure dc; it is pulsating dc. Because of the missing half cycles, the average voltage at a half-wave rectifier output is only 0.45 times the applied rms voltage. To deliver any given level of voltage and current with this circuit requires a transformer with a primary *VA* rating 40 per cent higher.

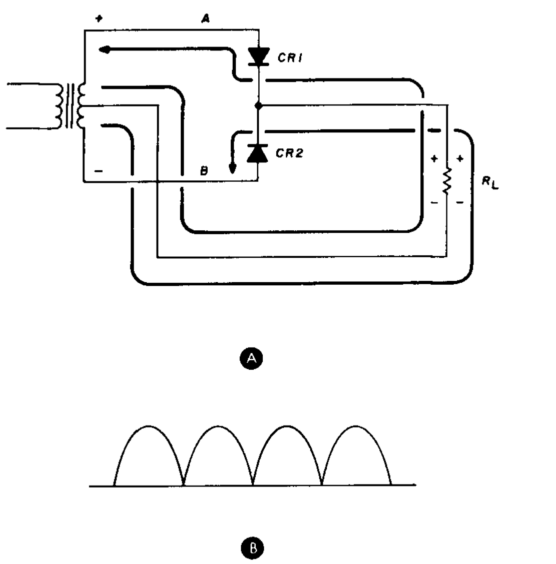


fig. 3. Full-wave rectifier using two diodes and a center-tapped transformer (A) and the double-humped waveform (B), which is characteristic of the full-wave rectifier.

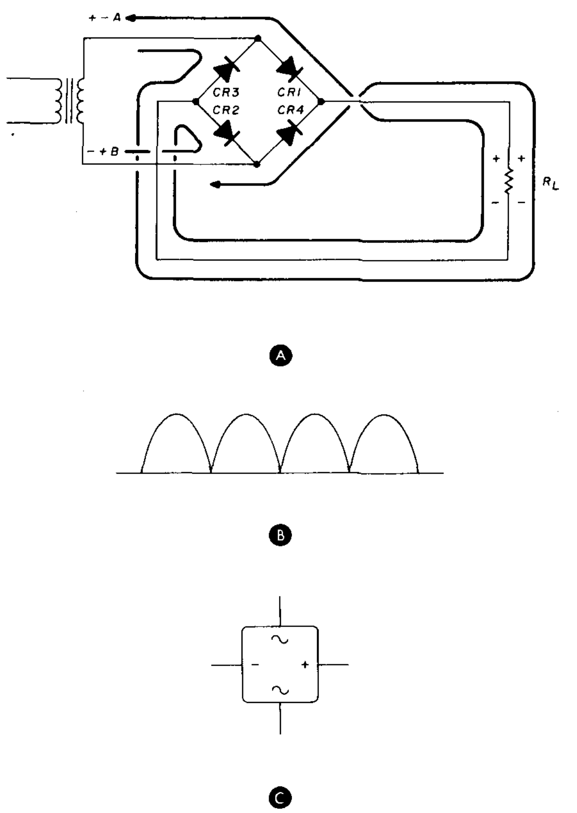


fig. 4. **Full-wave bridge rectifier (A). Output waveform is shown in (B) (as in the full-wave rectifier), but average output voltage is 0.9 times E_{rms}. An example of a prepackaged rectifier showing terminal labeling is shown in (C).**

The half-wave rectifier, then, is not very efficient. Rectifiers that use the entire ac waveform are called full-wave rectifiers, examples of which are shown in **figs. 3** and **4**.

Fig. 3A shows a simple full-wave circuit using two rectifier diodes and a transformer that has a center-tapped secondary winding. The centertap is taken as zero reference, so (on any given half cycle) one end of the secondary will be positive while the other is negative. On one-half of the ac cycle, point **A** will be positive and point **B** will be negative. In this case, diode CR1 is forward biased; diode CR2 is reverse biased. Current flows from the centertap, through load resistor R_L and diode CR1, to point **A**.

On the second half of the applied ac waveform the situation is reversed; point **A** is negative with respect to the centertap and point **B** is positive. In this case, diode CR1 is reverse biased and diode CR2 is forward biased. Current flows from the center-tap, through load resistor R_L and diode CR2 back to the transformer at point **B**.

It is important to note that the current flow through the load is in the same direction on both halves of the ac cycle, which produces the double-humped waveform (**fig. 3B**) characteristic of the full-wave rectifier. The average output voltage produced by the full-wave rectifier is 0.9 times the applied rms potential.

A full-wave bridge rectifier is shown in **fig. 4A**. This circuit doesn't need the transformer centertap — but at the cost of two additional rectifier diodes. On one-half of the ac cycle, point **A** will be positive with respect to point **B**. In this case, diodes CR1 and CR2 are forward biased and CR3, CR4 are reverse biased. Current flows from point **B**, through CR2, R_L and CR1 to point **A** on the transformer. On the second half of the ac cycle the situation reverses; point **A** is negative with respect to point **B**. Diodes CR3 and CR4 are forward biased while CR1, CR2 are reverse biased. Current will flow from point **A**, through CR3, R_L and CR4 to point **B**.

Again we see the current flowing through load resistor R_L in the same direction on both halves of the ac cycle. The output waveform, **fig. 4B**, is the same as in the previous full-wave case. The average output voltage is 0.9 times the applied rms voltage.

The transformer used with the bridge circuit need not be center tapped. The zero potential reference point is designated as the junction of the anodes of CR2 and CR3. This point is labeled −, while the junction of CR1 and CR4 is labeled +. Some prepackaged bridge rectifiers (**fig. 4C**) have the dc terminals labeled with the + and − symbols while the other two terminals are labeled **AC** or have the sine wave symbol as shown.

The bridge rectifier will produce an output voltage two times that of the regular full-wave circuit (from the same transformer) because it uses the entire secondary winding on both halves of the ac cycle. But this is not for free, because the primary *VA* rating must not be exceeded. The secondary current of most center-tapped transformers is rated for the regular full-wave circuit. If a bridge circuit is used, then

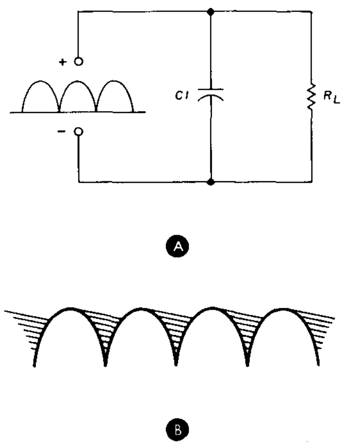


fig. 5. **Simple filter circuit (A) and the filter capacitor action on the pulsating dc input (B).**

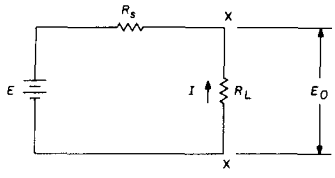


fig. 6. Relationship between R_s (source resistance), R_L (load resistance), I (load current), and E_0 (open-terminal voltage). E_0 may be measured by disconnecting R_L and measuring E_0 when no current flows.

the available current is only one-half the rated current or we'll find that the primary *VA* rating may be exceeded. The full secondary rated current can be obtained only if the transformer is designed for use in *full-wave bridge rectifier circuits.*

Most electronic circuits can't use pulsating dc but instead require pure dc (or nearly so). The pulsations are called ripple. Half-wave rectifiers produce a 120 per cent ripple component and a ripple frequency of 60 Hz (the ac line frequency). Full-wave rectifiers, on the other hand, produce a ripple component of only 48 per cent and a ripple frequency of twice the ac line frequency, or $(2)(60) = 120\,Hz$, in the U.S.A.

filters

A filter circuit smooths the pulsations to produce nearly pure dc. In the simplest case, **fig. 5A**, the filter capacitor *C1* is across the output in parallel with the load. The action of the filter capacitor is shown in **fig. 5B**. The heavy lines indicate the pulsating dc waveform without the filter, while the light lines show the output with the filter. Capacitor C1 will charge to approximately E_p. But after the peak has passed, the charge will return to the circuit. The effect of returning the charge from C1 to the circuit is to fill in the area between pulses (shaded area, **fig. 5B**). The filter reduces the ripple component to a low percentage.

The value of C1 is critical to the performance of this circuit. In general the minimum required capacitance for C1 is higher in half-wave circuits than in full-wave circuits because of the higher ripple factor. For low-voltage full-wave supplies, the value of C1 should be at least 500 μF in small-current supplies (*i.e.*, under 500 mA), and 1000 μF in supplies up to 1 ampere. A general rule of thumb in the over-1-ampere range is to make C1 not less than 1000

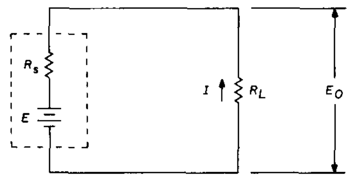


fig. 7. Voltage regulation is a function of output voltage and unloaded and loaded conditions. R_s and R_L form a voltage divider; thus E_0 is only a fraction of the open-terminal voltage.

μF/ampere, with some authorities calling for not less than 2000 μF/ampere. By the second rule, then, a 4-ampere power supply should have not less than 4 times 2000, or 8000, μF of filter capacitance.

The circuit in **fig. 5A** is the simplest dc power supply, but even with a high-value filter capacitor it will show some ripple in the output waveform. A voltage regulator will reduce this ripple to almost zero even though the regulator's main function is to maintain the dc output voltage constant. One power-supply manufacturer emphasized the regulator ripple-reduction feature by claiming that the circuit "amplified"

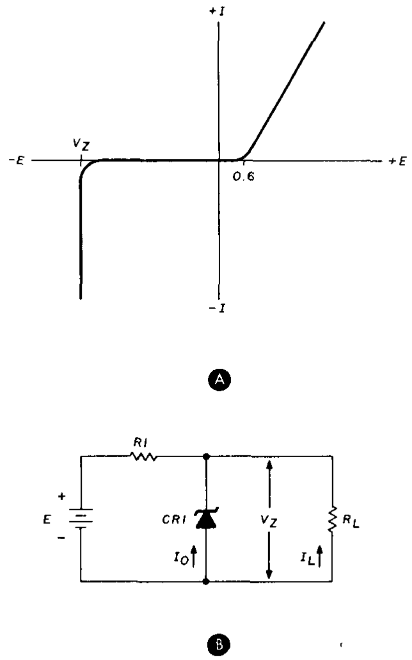


fig. 8. Zener regulator. (A) shows typical current-voltage curve. A common zener regulator schematic is shown in (B).

the 10,000-μF filter capacitance to make it "equivalent" to a 1-*farad* capacitor! What was meant by this over statement is that it would take a 1-farad capacitor to achieve the same ripple reduction obtained from a 10,000-μF capacitor and a voltage regulator.

voltage regulation

All dc power supplies have a certain amount of internal, or source, resistance, R_s. When a load current, I, is drawn from the power supply, a voltage drop, $E = IR_s$, will occur across the source resistance.

The value of the internal resistance can be determined by Ohm's law. The voltage used in this calculation is the power supply open-terminal voltage. This voltage is measured by disconnecting load resistor, R_L, then measuring the power-supply output

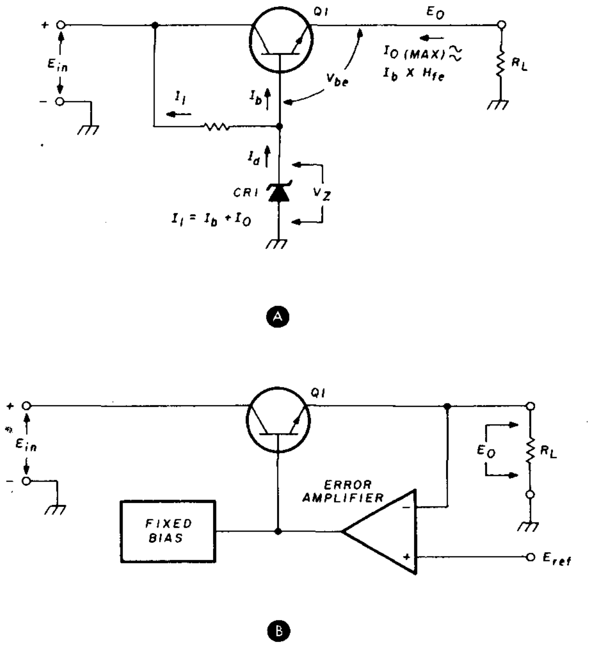


fig. 9. Zener regulator using a series-pass transistor (A). A feedback circuit using an error amplifier IC is shown in (B).

when no current flows (see **fig. 6**). The current used in the calculation is that which will flow when the output terminals are short circuited. Don't try to make this measurement, however! Few real-world power supplies can withstand an output short circuit without damage. An alternative method for determining the internal resistance is this:

$$R_s = \frac{E - E_0}{I} \qquad \textbf{(3)}$$

Where:

- R_s is the internal resistance of the supply (ohms)
- E is the unloaded (*i.e.*, $I = 0$) output voltage
- E_0 is the loaded output voltage (*i.e.*, $I = 0$)
- I is the output current

Voltage regulation is a measure of how stable the output voltage remains between no load and loaded conditions. **Fig. 7** shows the mechanism that causes the output-voltage change. Internal resistance R_S, is effectively in series with load resistance R_L. The output voltage, then, can only be a fraction of the open-terminal voltage because R_s and R_L form a voltage divider. The output voltage at full load will be:

$$E_0 = \frac{E R_L}{R_s + R_L} \qquad \textbf{(4)}$$

Voltage regulation is usually specified in terms of a percentage, which is calculated from:

$$\textit{per cent regulation} = \left(\frac{E - E_0}{E}\right)(100) \qquad \textbf{(5)}$$

regulator circuits

In this article we'll consider three basic forms of regulator circuit: zener diode, zener-referenced series-pass, and feedback.

Zeners have a property that allows them to be used as voltage regulators. **Fig. 8A** shows the curve for a typical zener. In the +E region the diode is forward biased and behaves exactly like any other silicon diode. But in the −E region, in which the diode is normally reverse biased, the zener behavior is somewhat different from that of the ordinary diode. From zero volts to a point called V_z the zener acts like an ordinary diode; current passed is zero. But at V_z the zener "breaks over" and conducts a reverse current. V_z tends to remain constant and is the voltage to which the zener will regulate the applied voltage.

Fig. 8B shows a typical zener voltage regulator circuit. CR1 is connected in parallel with the load. R1 is a series-current limiter that protects the zener from excess current flow. Without R1 the CR1 would burn out.

The simple zener voltage regulator is used for light-duty work only. A general rule of thumb is that the load current should be held to 10 or 20 per cent of the zener current, hence the limitation to low-current applications.

A better solution is to use the zener as a reference source in a series-pass circuit as in **fig. 9A**. In this circuit Q1 is the control device and CR1 is a reference. The output voltage is given as approximately:

$$E_0 \approx V_z - V_{be} \qquad \textbf{(6)}$$

The maximum output current is approximately the normal load current , I_b, allowed by the zener multi-

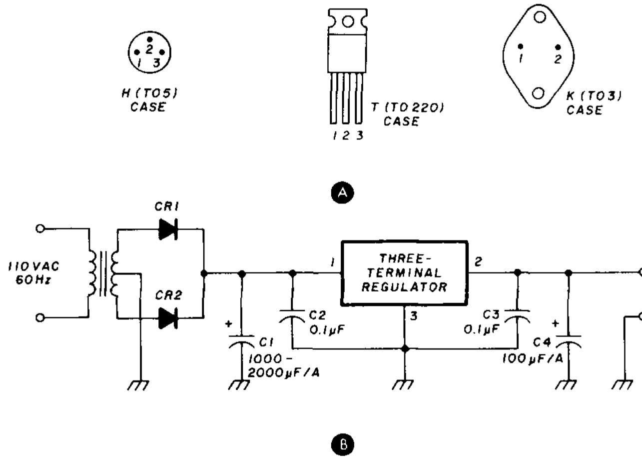


fig. 10. Some case styles for three-terminal voltage regulator devices (A). (B) shows the basic circuit for these regulators. Values for C1 and C4 are minimum (see text).

plied by the beta of Q1; assuming that neither Q1 maximum collector current nor its maximum power dissipation ratings are exceeded.

Another series-pass type regulator is the feedback circuit shown in **fig. 9B**. In this simplified schematic the bias on the series-pass element, Q1, is determined by the output of an error amplifier. This amplifier is a differential circuit, meaning that its output is proportional to the difference between two input voltages (*i.e.*, $E_{ref} - E_0$). If E_0 changes from the value set by E_{ref} (when the load current changes), then the amplifier output changes in a direction that corrects the change.

• Most readers aren't interested in designing complex dc power supplies but want to know how to make supplies that will meet their needs. The supplies in this section will meet the needs of most Amateur Radio applications for either workbench or project use.

The easiest way to obtain supplies up to 5 amperes capacity at a fixed voltage is to use a three-terminal IC regulator. Such regulators can be obtained in most standard voltages up to 24 Vdc.

Several families of three-terminal regulators are available at current levels of 100 mA, 750-1000 mA, 3 amperes, and 5 amperes. **Fig. 10A** shows several case styles used for these devices. The letters denoting the case style are used as a suffix in the regulator type number. An LM309, for example, is a 5-volt regulator, so an LM309H is a 100-mA device in a TO-5 transistor package, while the LM309K is a 1-ampere device in a TO-3 transistor package. The T-style package is generally limited to 750 mA in free air although frequently advertised at 1 ampere.

Often the ratings of these devices are exceeded even though this isn't always good practice. The claim is made that the ratings can be exceeded if proper heat-sinking is applied. I've seen the H-style package devices operated at 150-200 mA, T style at 1 ampere, and the K style at 1.5-2 amperes.

The most common three-terminal devices are the LM340-series and the 78xx-series. For LM340 devices the case style would be denoted by the suffix letter (H, K, or T), while the output voltage is denoted by a hyphen and the voltage; *i.e.*, a 12-volt output 750-mA (T package) device would be given the designation LM340T-12. The 78xx-series devices replace the "xx" in the generic type number with the voltage rating. The 7805, then, is a 5-volt device while the 7812 is a 12-volt device.

The basic circuit for these regulators is shown in **fig. 10B**. T1, diodes CR1 and CR2, and capacitor C1 are the same as in any unregulated supply (a bridge rectifier may be substituted for CR1/CR2). Capacitor C1 is the filter capacitor and should have a value not

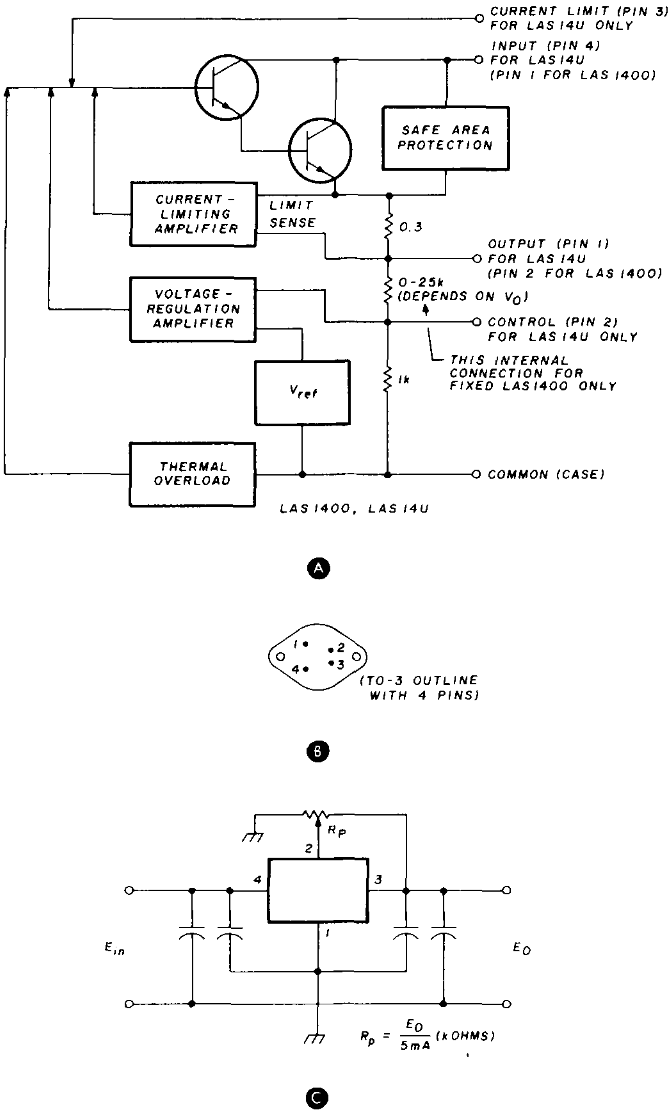


fig. 11. Adjustable four-terminal voltage regulators offered by Lambda Electronics. A simplified circuit is shown in (A). The case (similar to the TO-3) with pinouts is shown in (B). Regulator can be set to output voltages with pot R_p between 4 and 30 Vdc (C).

less than 2000 μF/ampere (I_{max}). Capacitors C2 and C3 improve regulator noise immunity and should be mounted as close as possible to the regulator body. Capacitor C4 is optional but improves the circuit transient response. C4 should have a value of not less than 100 μF/ampere.

Until recently there were few three-terminal voltage regulators on the market for current levels over 1 ampere. The LM323, for instance, would pass 3 amperes at a fixed 5 volts. Fairchild Semiconductor now offers several devices in the 5-ampere range. Lambda Electronics* offers three lines of three-termi-

*Lambda Electronics, 515 Broad Hollow Road, Melville, New York 11746.

nal devices in TO-3 packages. The LAS-15xx series produce 1.5 amperes, the LAS-14xx series produce 3 amperes, and the LAS-19xx series produce output currents up to 5 amperes. As in the 78xx series, the "xx" is replaced by the output voltage. An LAS-1905, then, is a 5-volt, 5-ampere device, while the LAS-1512 is a 12-volt, 1.5-ampere device.

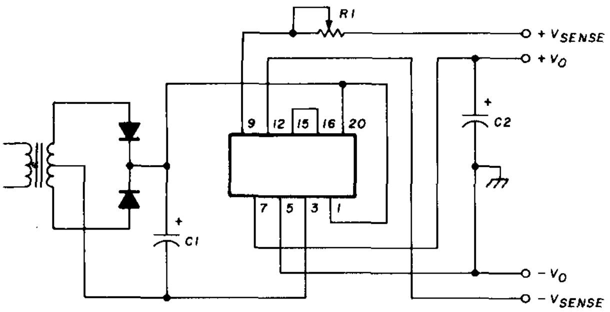


fig. 12. A hybrid voltage regulator offered by Lambda Electronics. R1 minimum value should be $0.25\ E_0$ times 1000 ohms per volt except for 5-volt models, in which case 3000 ohms is used.

An exception to the Lambda numbering scheme is the LAS-19CB, which delivers 13.8 volts dc at the output at up to 5 amperes. This device is designed to power Amateur Radio and CB mobile transceivers on the bench or in a base-station. (Most "12-volt" mobile electrical systems are actually 13.8-volt electrical systems.)

All three-terminal regulators have a certain minimum and maximum input-output differential voltage ($E_{in} - E_0$) rating. A typical number is 2.5 volts for the minimum and a maximum in the 30-40 volt range. The minimum *I/O* differential is the smallest difference that will allow the regulator to operate properly, while the maximum voltage rating is the level that will probably cause device burnout if exceeded.

The *I/O* differential, however, can be a trouble area for the unwary. A 5-volt, 5-ampere device may be rated for a maximum input voltage of 35 volts dc and a maximum power dissipation of 50 watts. The power actually dissipated is:

$$P_d = I(E_{in} - E_0)$$

$$P_d = (5)(E_{in} - 5) \qquad \textbf{(7)}$$

So if the maximum input voltage is 35 volts,

$$P_d = (5)(35-5) = (5)(30) = 150\ watts \qquad \textbf{(8)}$$

Clearly, we can't expect to draw the full current at the maximum input voltage without exceeding the device power dissipation rating. By rearranging **eq. 7** to solve for E_{in} when P_d is 50 watts, the maximum input voltage at full-rated output current is 15 volts. Although the 5-volt device is used as an example, the same reasoning applies to other regulators as well.

Lambda Electronics also offers a line of adjustable four-terminal regulators in packages that are similar to TO-3. A simplified internal circuit is shown in **fig. 11A**. Note that it's a feedback device with thermal, safe operating area and current overload protection. Overload protection is very important in situations where the device being powered shorts out or where the alligator clips on your bench supply come together! The series-pass element in these four-terminal regulators is a Darlington pair to take advantage of the extremely high gain. The case (similar to TO-3) and pinouts are shown in **fig. 11B**. Although standard TO-3 heatsinks will work for this device, it's necessary to drill the extra holes.

The Lambda four-terminal adjustable voltage regulators can be set to any output voltage within their specified range using potentiometer R_p (**fig. 11C** is a typical circuit). The range for most models is 4-30 Vdc. The LAS-15U, LAS-14U, and LAS-19U produce output currents of 1.5, 3, and 5 amperes respectively. With the exception of the control pin and the potentiometer, the four-terminal regulator uses the same general circuit as the three-terminal devices.

High-current power supplies (over 5 amperes) are sometimes tricky to design properly. You can't just slap a zener into the base circuit of a series-pass transistor and make it work reliably. Additionally, ready-built, high-current power supplies are often quite costly. A reasonably simple solution to these problems is a Lambda high-current, hybrid-module device:

Lambda series	ratings
LAS2000	5 amperes/85 watts
LAS3000	10 amperes/140 watts
LAS4000	10 amperes/170 watts
LAS5000	20 amperes/270 watts
LAS7000	30 amperes/400 watts

The LAS5205 is a 20-ampere, 5-volt regulator, while the LAS7215 produces 15 volts at 22 amperes. **Fig. 12** shows an example of a hybrid voltage regulator. The voltage trim pot should have a minimum value of ($0.25E_0 \times 1000\ ohms/volt$) except for 5-volt models, in which case a value of 3000 ohms is used. In practice these are minimum values and the actual value must be found by experimentation. In the case of my own LAS5205, used in a Digital Group Z-80 computer, the required value was 12 kilohms.

Note that both pins 2 and 20 are plus-input-voltage terminals. This can lead you astray in some cases because pin 1 will operate with only 2.5 volt *I/O* differential voltage, while pin 20 must have not less than 7.5 volt *I/O* differential. Pin 1 is the normal high-current terminal leading to the series-pass transistor while pin 20 powers the internal control circuit.

In my computer power supply, E_{in} for the high-current side was 8 volts (obtained from a 6.3-Vac filament transformer), while the control circuit input voltage on pin 20 was derived from the +15 volt supply used with a +12 volt regulator in the computer.

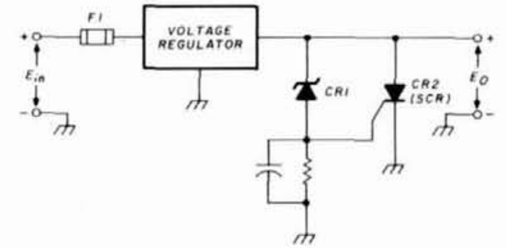


fig. 13. Overvoltage protection scheme using a zener (CR1) and a silicon-controlled rectifier (CR2). The circuit is known as the "SCR crowbar" approach.

overvoltage protection

One aspect of regulated power-supply construction often overlooked by the Amateur is overvoltage protection. Very few electronic circuits can tolerate excessive input voltage for more than a few seconds. TTL IC devices, for example, can burn out if more than 5.6 volts is applied to V_{cc} for an extended period of time. Amateur and CB transceivers that normally operate on 13.8-volt systems will flunk a smoke test when +17 volts is applied, which is the normal voltage obtained from a rectified and heavily filtered 12.6-volt transformer!

The solution is to provide some form of overvoltage protection (OVP); that is, a means of turning off the power supply if the output voltage exceeds a preset limit. **Fig. 13** shows a common approach to OVP design. CR1 is a zener with a breakdown voltage greater than E_0 but less than E_{in}. When E_0 rises to a value higher than the breakover voltage, CR1 conducts and turns on the gate of silicon-controlled rectifier CR2. When CR2 turns on, a short-circuit occurs across the regulator output that blows fuse F1. This a brute-force approach called an "SCR crowbar."

Lambda Electronics offers monolithic SCR crowbar devices in TO-66 and TO-3 packages as well as certain heavy-current devices in custom packages. Information on these devices may be obtained by writing to Lambda Electronics at the address given previously.

ham radio

active antenna coupler for VLF

A discussion of active low-frequency and very low frequency antenna preamps, with some details for extending the frequency range to 10 MHz and above

The goal of this project has been to have a single, electrically short antenna operate over a wide frequency range with a minimum of interference or operational problems. The biggest problems are those of local noise pickup from 60-Hz harmonics and overload from strong, out-of-band signals (above 300 kHz). In general, any jfet, mosfet, or even CMOS inverters may be used to provide high power gain, but some circuits work better than others.

The primary purpose of a vlf receiving antenna coupler is to convert the low-level signal at the high-impedance pickup point on a short antenna to a low-impedance level for driving the feed cable back to the receiver. The use of bipolar transistors has invariably resulted in problems due to intermodulation distortion or cross modulation from nearby broadcast-band transmitters. A jfet is far less susceptible to this problem over a wide dynamic range. One of the most common jfets available is the MPF102, which I used in the preamplifier circuit shown in **fig. 1**.

circuit description

The input lightning arrester is of obvious value when a good low-impedance ground system is provided at the antenna mounting. The series input resistors, with the capacitance of the neon bulb and trigger diode, serve as double RC filters to help reduce broadcast-band and high-frequency signals. They also provide static discharge protection. The choice of trigger diode for the low-voltage limiter is critical. Some diacs and thyristors are quite nonlinear and have appreciable resistance/capacitance variations. Some General Electric and Japanese diodes, apparently constructed as back-to-back 14-volt zeners, appear to work best and will prevent burnout of the preamplifier in all but the worst-case, direct-hit situation. You should never use parallel, opposed polarity silicon or germanium diodes in place of a trigger diode, because these produce an almost ideal crystal detector for broadcast-band signals with direct audio signals flowing down the cable!

The output transformer in **fig. 1** is operated in a step-down mode from the jfet drain terminal to provide a higher current driver for the cable at a 150- to 350-ohm impedance level. Fifty-ohm cable is not a perfect match, but at these low frequencies the cable looks like a capacitor and there is no VSWR problem because of the very short electrical length of the cable. The transformer is a standard 600-ohm, center-tapped, line-to-line type. Some UTC subouncer models work just as well and will pass frequencies to 300 kHz or more when terminated with a 330-ohm resistor at the receiver end. Power for the preamplifier flows up the cable from the 330-ohm isolating resistor at the receiver end. The cable capacitance helps limit the high-frequency response. In fact, additional capacitance directly in parallel with the coaxial cable may be used to restrict the preamplifier response for use below 100 kHz.

The coupling capacitor to the receiver should be fairly large if you are interested in signals down to the 10-kHz range or below. The preamplifier will drive 50-ohm cables up to 30.5 meters (100 feet) long and still provide adequate response up to 200 kHz. Seventy-five ohm cable can be used to reduce the cable capacitance for longer runs.

The input impedance and sensitivity of the preamplifier are limited by the input RC protective networks and the relatively high-current operating level. It is a good idea to check the current with a meter temporarily connected in series with the 330-ohm power supply isolating load resistor. Current should be about 4.5 mA at +5 Vdc. If you observe a drastically different current, try changing the 330-ohm load resistor, but be sure to check the preamp operation. In testing dozens of MPF102s, a bad one with too

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low an I_{DSS} specification could be found. You should be able to generate a 50-mV rms output signal, with no distortion at the receiver end, when a 50-mV rms, 100-kHz input signal is connected to the antenna terminal through a 100-pF capacitor. A 100-pF antenna input capacitor will roughly simulate a 2-meter (6-foot) whip antenna for testing purposes with a low-impedance signal source.

Limiting will start at about 100-mV rms, which is

receivers like the Radio Shack DX-300 which tunes down to 10 kHz.

antenna-mounted preamp

A standard 2-3/4 meter (108-inch) CB whip is used for the antenna, with the preamplifier mounted as shown in **fig. 3.** The antenna should be vertical and in the clear above the immediate terrain if possible. The higher the antenna is mounted, the less will be

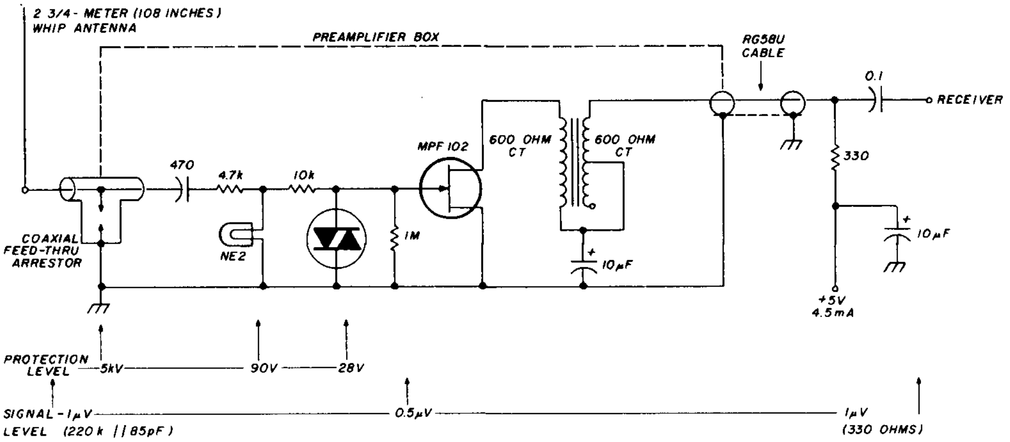


fig. 1. Schematic diagram of one version of a vlf antenna preamplifier. The amplifier's voltage gain is 6 dB, with a noise figure of 3 dB. The −3 dB frequency response, while feeding 15 meters (50 feet) of RG-58U, is 300 Hz to 300 kHz. The maximum signal level without distortion is 100 mV rms. A GE ST-2 or equivalent diode is used as the trigger diode. The coupling transformer is a Mouser TL016.

more than enough range for most receivers. When the input signal is strong enough to start limiting, the output is reasonably symmetric because of the grounded source and high current operation of the MPF102. The noise figure of about 3 dB is adequate for most uses, since the antenna noise is quite high. Typically, in the 100-kHz region, the atmospheric noise level will be over 10 μV/kHz/meter. With a 3-dB noise figure, the preamp generated noise is about 0.1 μV/kHz.

receiver coupling

The simplest way of coupling the preamp to a receiver is shown in **fig. 1**. Other methods using another transformer to drive two receivers or a tuned input circuit are illustrated in **fig. 2**. The wideband, two-receiver circuit is of value in operating a low-frequency, 10.2-kHz Omega receiver in parallel with a wide tuning range receiver with the same antenna.

The tuned-circuit coupling method has been used for a number of experimental receivers with Polyakov's detector[1] and a direct-conversion method with a balanced mixer.[2] These input circuits might also be used with some of the surplus RAK-RBA receivers, the Palomar Engineers vlf converter, the new Elmek LXK 60-kHz receiver, and with various modern

the ac ground noise pickup problems. The arrangement shown is mounted on a cast iron sewer vent pipe which serves as a good low-impedance ground. A small plastic crutch-tip cap at the end of the antenna whip helps reduce corona discharge problems in turbulent weather. I usually seal all joints, including the preamp box, with silicone rubber sealing compound to prevent moisture from entering. However, in the past, water has sometimes entered the box or antenna connectors. A small bleed hole is drilled in the very lowest or bottom part of the box assembly to drain away any moisture that runs into the assembly.

My only bad experience with lightning was when one of the systems failed due to a strike on a tree nearby. The antenna system apparently suffered a side streamer discharge, but the preamplifier itself was not damaged. The coax cable shield was burned to a crisp inside the jacket with not much obvious damage to the plastic outer jacket. There was a burn point where the cable bent over the roof at a well-grounded rain gutter. The receivers connected in the lab were not damaged.

other antennas

The preamplifier of **fig. 1** can be used with hori-

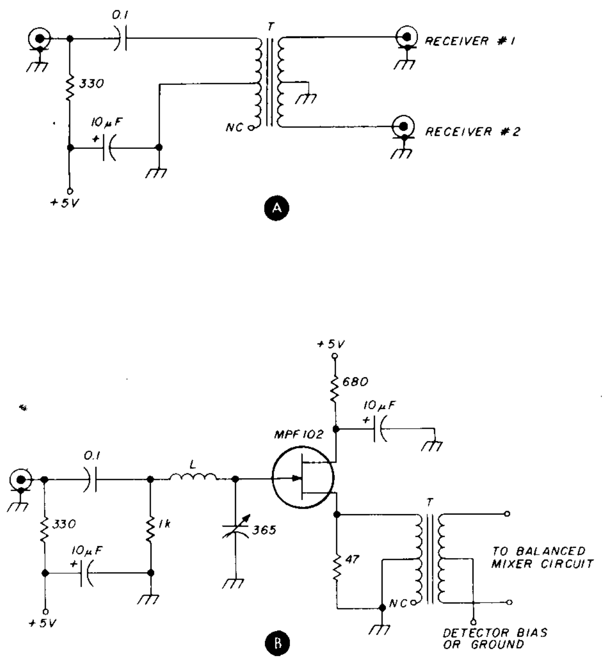


fig. 2. Diagram (A) shows a method for connecting two receivers to a single preamplifier. The transformer is a Mouser TL016. (B) is a tuned input circuit for use with a direct-conversion type of receiver. The inductor is chosen to resonate at the input frequency.

zontal antennas up to 30 meters (100 feet) long, if desired. However, I do not recommend antenna lengths of 150 meters (500 feet), which some DX hunters have used. In many cases, there is not much advantage in long wires over a good vertical radiator. The problem with the long wire is a good ground, underneath the length of the antenna, which will not have fluctuating 60-Hz ground currents. A big problem with long-wire vlf antennas for Amateur users is that the wire picks up 60-Hz harmonics along the entire length of the antenna, which tends to cancel the effectiveness of the length. For a simple installation, a single vertical antenna mounted reasonably in the clear will provide a better signal-to-noise ratio than a long wire strung out over the landscape.

An E-field whip antenna with a wideband preamplifier has one big advantage in that all tuning is done at the receiver end of the circuit. A tuned circuit antenna has to be adjusted for each new frequency range and this becomes a major problem when the antenna is mounted remote from the receiver shack. Loop antennas have a similar restricted bandwidth, compared with this wideband system. H-field loop antennas do have another advantage in that they may be rotated to reduce noise pickup. With an E-field antenna whip, there is no easy way of reducing noise pickup from nearby power lines and varying ground currents except by changing the antenna location, moving it higher, or providing better ground systems directly under the antenna.

audio interference

Audio rectification problems sometimes develop as a result of strong broadcast signals. This does not appear to affect the receiver's signal-to-noise ratio as long as the audio signals do not pass directly into the detector. Some experimental direct conversion receivers have exhibited direct audio feedthrough. This can sometimes be cured with a highpass filter at the receiver input instead of the 0.1-μF coupling capacitor. Tuned transformer or link-coupled input circuits can also be used to reduce direct audio interference feedthrough.

Audio rectification is caused by some nonlinear element or corroded joint and a parallel ground loop where some of the dc current for operating the preamp is being modulated. In one case, on a flat roof building, connecting the antenna mounting to a supposedly conducting member of the roof structure resulted in high broadcast noise pickup at the receiver. The problem was solved by isolating the preamp ground return from the antenna-mount lightning arrester ground such that there is no direct dc connection at the roof. The preamp box "floats" at the end of the coax cable and there is no chance of the roof truss ground providing parallel ground currents along the cable to generate additive or cross modulation effects. This can be done in **fig. 3** by substituting a tight jam-fit plastic pipe coupling for the

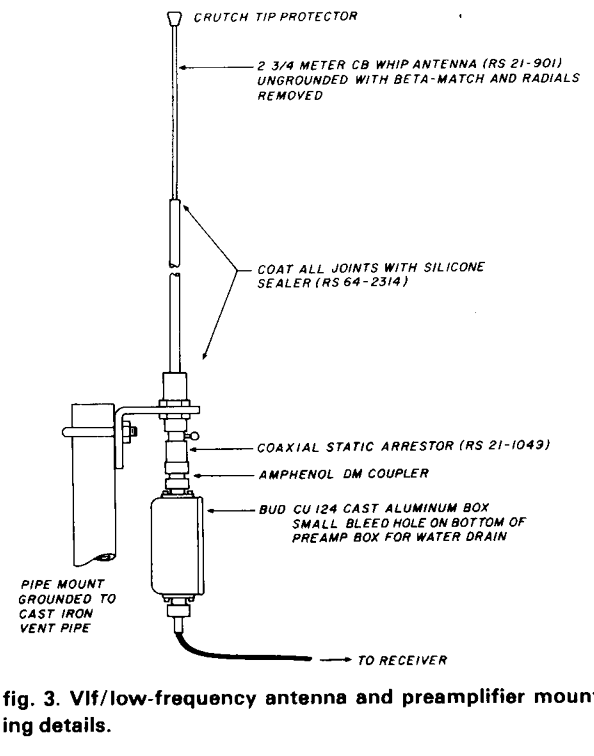


fig. 3. Vlf/low-frequency antenna and preamplifier mounting details.

Amphenol DM (double male) fitting with only the center conductors of the uhf fittings connected with a short length of threaded rod. Thus, the antenna mount is insulated from the preamp and cable with the common ground point at the receiver end of the circuit.

wideband modifications

Attempts to operate these jfet preamps over a wider bandwidth results in many problems. One circuit which has been used up to 10 MHz is illustrated in **fig. 4**. The input protection is reduced to provide less attenuation. The trigger diode will typically contribute 12 to 25 pF of added capacity. At vlf, this is not of much consequence, but at 10 MHz this results in about a 5 dB signal loss. **Fig. 4** uses feedback to provide high current gain and unity voltage gain. The gain is adjusted for the I_{DSS} of a particular 2N5457 by changing the value of the 680 ohm to 1-kilohm resistor. I usually try to adjust for unity voltage gain at 100 kHz. This provides the best linearity and a dynamic range of up to 200,000 μV rms. The output impedance of this amplifier is 80 ohms. There will be a VSWR ripple at the higher frequency range when driving a 50-ohm cable as illustrated *in* **fig. 4B.** VSWR effects at the high end are noted in both cases. The transformer preamp has a still higher output impedance, but this is of little consequence since I was not interested in performance above 200 kHz. Vlf receivers usually look like a 300- to 600-ohm load to the preamp cable with the preamp of **fig. 1.**

With conventional high-frequency receivers, the input may look like a 50-ohm load, which also produces a VSWR effect. The circuit of **fig. 4** has been used for WWV reception at 10 MHz with performance often better than that obtained using an untuned short length of antenna wire. Thus, while there is an apparent 16 dB voltage loss at 10 MHz, the preamp still has some power gain at this frequency when used with a short antenna. Most high-frequency receivers have excess rf gain and a low enough signal-to-noise performance to be used with this preamplifier up to about 10 MHz. The circuit of **fig. 4** is better matched to 75-ohm or 95-ohm cable providing slightly fewer VSWR effects and somewhat better frequency response.

A number of other variations have been tried, including use of two or more transistors in the preamplifier box configured as a source follower driving an emitter follower. None of these have provided

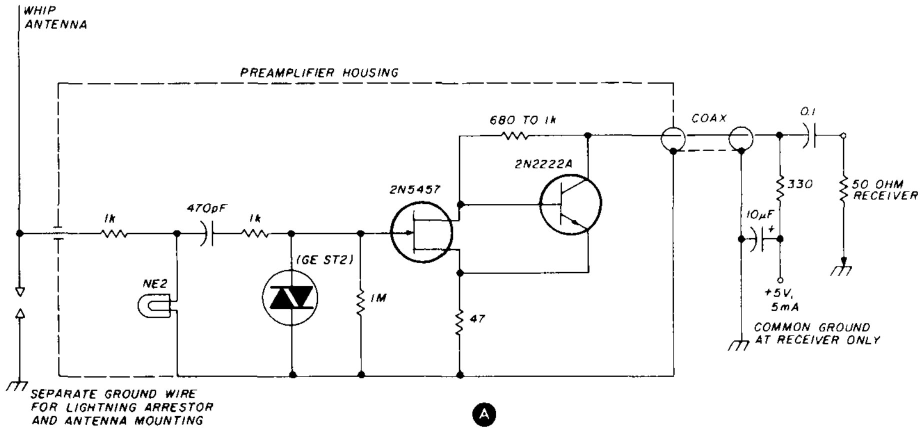
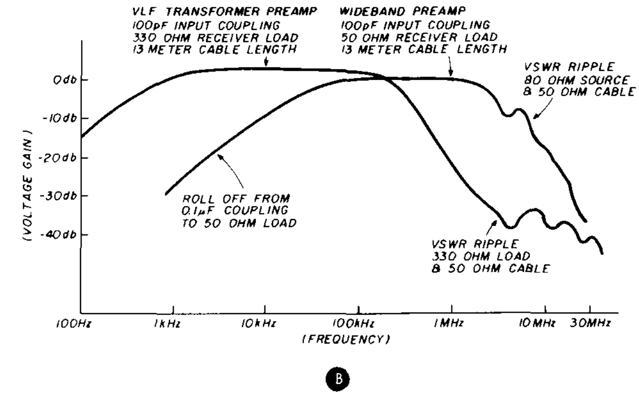


fig. 4. Diagram of a wideband active antenna preamplifier (A). The graph (B) shows the difference between this active preamplifier and that shown in fig. 1.



much better performance than the circuit illustrated in **fig. 4A**. One interesting possibility for those who like to wind their own toroidal transformers would be a bifilar-wound toroid connected as a 4:1 unbalanced step-down transformer from the jfet drain terminal. An inductance of about 1 to 4 mH should provide a wideband device over the range from 60 kHz and up. Surplus pulse transformers have been used in this manner with some success, but it's difficult to obtain a really wideband circuit without reducing all protection at the input to the jfet. There is an inherent problem in that at vlf frequencies you require a very high input impedance for a short whip antenna, but at higher frequencies like 10 MHz, the antenna is a much lower impedance and should be terminated with a lower-impedance circuit.

Still another thought for the experimenter is to consider the methods used in the input circuits of wideband oscilloscopes covering up to 30 MHz. The difficulty here is dynamic range and the circuit complexity, usually requiring a separate dual power supply lead to the preamplifier and perhaps even balanced shielded cable at the output.

High impedance circuits require low capacitance at the input to provide a really high frequency response. One of the most common problems is that of the capacitance to ground of the antenna mount and lightning arrester. This has a big effect on the sensitivity of a short antenna at frequencies like 10 MHz when coupled to a high-Z circuit.

high-gain preamplifier

For very short antenna systems, such as used in mobile or airborne systems, a high-gain preamp is desirable to make up for the low-level signal received on antennas less than 1 meter (3 feet) in effective height. Some vlf receivers are designed such that a low level of 1 μV or so is required for minimum detectable signal. With an electrically short antenna, there may not be enough signal developed to activate the receiver threshold properly, hence, some more gain is often desirable. A preamplifier with 20 dB gain over a frequency range of 100 Hz to 1 MHz is shown in **fig. 5**. This circuit uses the same 2N5457 jfet as in **fig. 4**, but is operated as a voltage amplifier instead of a source follower. The emitter follower provides a low output impedance. This preamp will also work up to about 20 MHz, but the gain drops off to 0 dB or unity at this frequency. The circuit is more susceptible to overload than the previous preamps so some input RC filtering is used to restrict the range.

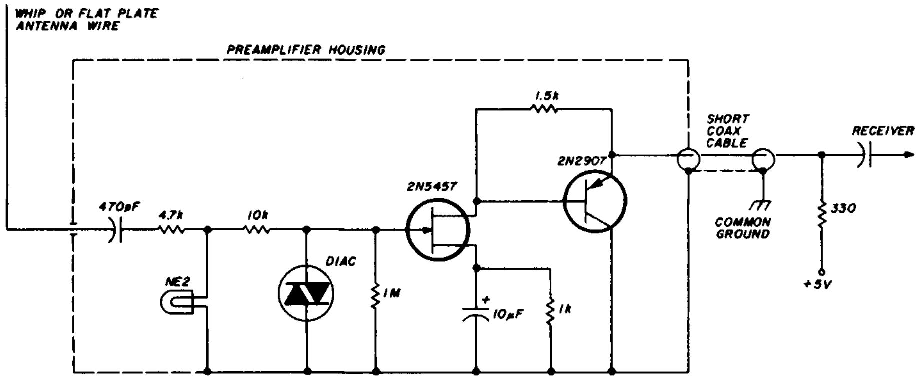


fig. 5. Schematic diagram of a preamp capable of 20 dB gain over the frequency range of 100 Hz to 1 MHz.

Other variations are of course possible, including the use of the output transformer coupling method of **fig. 1** and other biasing schemes for operating the jfet at higher gain. In portable/mobile use, there is not so much concern for a low output impedance cable driver since the receiver can be located close to the preamp with a short length of cable. Circuits like **fig. 5** have been used in general aviation aircraft with good results in the 100-kHz Loran-C range. Marine users are cautioned against using these high-gain preamplifiers because of ground-loop interference problems caused by rusty hulls and poor grounding practice in many boats. A conventional preamplifier more like **fig. 1**, mounted up on a mast well away from the superstructure, will usually provide satisfactory performance, particularly when the coax cable is not grounded to the antenna mount, as discussed previously.

results

This antenna and preamplifier system has been used to receive the 10.2-kHz Omega signals on all eight stations including LaReunion Island, halfway around the world. In Ohio, I regularly receive twelve different Loran-C transmissions from the East Coast, Northeast, and Gulf Coast 100-kHz chains. At night, I observe Loran-C skywave signals from the West Coast chain over 4000 km (2500 miles) away. WWVB puts in a strong 150-μV signal in Ohio, but is often interfered with by MSF in England on the same 60-kHz frequency. Other signals noted are the time frequency standard stations in Switzerland on 75 kHz, Japan on 40 kHz, as well as numerous communications and military FSK-type signals in the 14 to 150 kHz range. The system works well in the 1750-meter Amateur band (160 kHz to 190 kHz), but I have not yet made any serious attempt at DX hunting. The most interesting DX received is on 15.625 kHz, part of the USSR Alpha vlf navigation system.

Harmonics of 60 Hz and TVI from harmonics of the 15.75-kHz horizontal oscillator in nearby TV sets are the most common interference observed in urban locations. In my receiving shack, the 60-Hz troubles usually do not start until the mercury vapor arc lights in front of my home start operating, and other 60-Hz uses increase during the prime evening hours.

In some installations, BCI from nearby transmitters can be a problem. These can usually be cured with an additional low-pass filter or trap inserted in the receiver input circuit, with better grounds on the antenna pole mounting, and with proper care in design of the receiver input circuits to minimize cross modulation problems. Common-mode 60-Hz pickup is sometimes a problem caused by combinations of poor ground connections at the antenna coupler box and the receiver location. If this cannot be cured by relocating the antenna, then another method is to use a balanced, twisted-pair, shielded transmission line. The unused half of the preamp output transformer and a similar balanced input transformer at the receiver with a 330-ohm current limiting resistor connected to the center tap can be used to reduce common mode pickup problems. In general, balanced transmission lines have not been used because it is difficult to obtain suitable lines and weatherproof fittings that will pass frequencies to 300 kHz without excessive expense. It is easier to cure these problems by antenna location or ground changes.

acknowledgments

The effort on vlf/low-frequency antenna couplers has been part of a study of low-cost methods for producing receiving systems for the general aviation community, sponsored by the NASA Langley Research Center. This paper is a direct result of that work. The help of student assistant Edwin Jones is appreciated in testing some of the most recent preamplifier systems.

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ham radio

connectors for CATV coax cable

How to beat the high cost of connectors for popular "1-inch" CATV coaxial cable

Large quantities of "1-inch" CATV coax cable *have recently become available from various* sources. The electrical characteristics of this cable make it attractive for Amateur vhf-uhf applications, particularly for long transmission lines. The cable is offered at modest cost, from tag ends to full-reel lengths of up to 732 meters (2400 feet).

The "1-inch" CATV cable, however, is not without its drawbacks, and this article suggests ways to circumvent these with ordinary construction practices using shop tools and readily available materials.

hardline "1-inch" CATV cable

The CATV cable is shown in **fig. 1**. **Table 1** gives *physical and electrical properties. Perhaps the* cable's major disadvantages are 1) its handling properties below room temperature, at which it has the ductility of gas pipe; 2) its relatively large bend radius; and, most of all, 3) the high cost of end connectors.

Fig. 2 shows, from left to right, an expensive commercially available end connector; an Amateur design in the raw; and the Amateur design in a moisture-proof final configuration. Relative costs for the two Amateur designs are quite low.

For the obvious reason of cost, and because of the relative bulk of the commercial connector, I evolved the Amateur design, which can be made with fairly common materials, and, to a large degree, common hand tools.

These were the other major considerations achieved in the Amateur design:

1. No electrolytic action between dissimilar metals
2. Resistance to moisture penetration
3. Minimum discontinuity bumps in line impedance introduced by the connector

materials and tools

Tables 2 and **3** show the materials and tools you'll need for making the connectors. **Fig. 3** illustrates the raw parts needed for the suggested Amateur design, denoted A, B, and C, D, and G. **Fig. 3** also suggests not only the assembly steps, but interrelated with the following text, features and mechanics of fabrication, treatment, and parts use to the point of final assembly, as shown in the connector at the right-hand side of **fig. 2**.

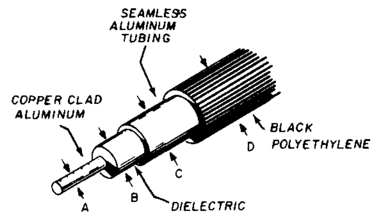

fig. 1. Makeup of typical "1-inch" CATV cable.

The tools should be available to the average builder or his friends, or they can be rented from local outlets.

fabrication

Steps for making your coax connector are given below. Refer to **fig. 3** as you proceed.

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1. Using a tubing cutter, make a cut through the vinyl cable jacket and seamless-tubing shield about 15-25 cm (6-10 inches) from the cable end.* Then, using a fine-blade hacksaw, cut through the dielectric and inner conductor. Make the cut flush with the outer surface of the cable. Remove aluminum filings from the dielectric surface. **E** of **fig. 3** shows what it should look like.

table 1. CATV "one-inch" coax cable characteristics.

CATV cable makeup (fig. 1)

part	material	nominal OD mm (inch)
A-conductor	solid bare copper-clad aluminum	5.8 (0.227)
B-insulation	extruded foam polystyrene	22.6 (0.9)
C-shield	seamless aluminum tubing	25.4 (1.0)
D-jacket	extruded polyethylene (black)	28.4 (1.1)

physical properties

maximum pulling force	261 kg. (575 lbs.)
minimum bending radius	10 times cable diameter
nominal weight	641 kg./km. (430 lbs./1000 ft.)

electrical characteristics

maximum attenuation, 20C[1]		maximum attenuation, 68F[2]	
frequency MHz	dB/100 meters	frequency MHz	dB/100 feet
5	0.26	5	0.08
30	0.66	30	0.20
50	0.85	50	0.26
216	1.9	216	0.59
240	2.0	240	0.63
260	2.1	260	0.65
270	2.2	270	0.68
300	2.3	300	0.7

1. Attenuation varies ±2 per cent nominal per 10C variance in ambient temperature.
2. Attenuation varies ±1 per cent nominal per 10F variance in ambient temperature.

2. Find the precise center of the copper-pipe-cap outer face. Center punch the cap center, and drill a hole using a sharp no. 42 (2.4-mm) bit. Remove burrs from the pipe cap inside.

3. Force the pipe cap firmly over the square end face of the cable.

*The foam dielectric is not particularly hygroscopic, but some moisture will inevitably accumulate near the exposed end. Remove the section of contaminated cable before installing the connector.

†Use of the drill guide requires temporary cut and removal of about 6.5 mm (1/4 inch) of the black polyethylene jacket to allow the guide to slip down over the aluminum shield (**C** or **fig. 1**).

table 2. Materials for making the coax-cable connector.

quantity	description
1	4-40 x 1/2-inch (M3 x 12.5 mm) BH or RH nickel-plated screw
1	83-378 bulkhead vhf female receptacle (Amphenol)
1	copper end cap for 1-inch (25.5-mm) rigid copper water tubing
4	6-32 x 1/4-inch (M3/5 x 6.5-mm) hex-head sheet-metal screws
1	bottle of Liquid Tape (General Cement)
1	end of CATV cable to attach to connector

4. Clamp the cable vertically in a vise. Using the pipe-cap center hole as a guide, carefully drill a no. 42 (2.4-mm) tap hole *straight down* to a depth of 1/2 inch (25.5 mm) into the copper clad center conductor of the cable. For quantity jobs, get a machinist friend to make a drill guide as shown in **fig. 4.**† Then tap the center conductor 4-40 (M3) screw and remove chips from the tap and hole after each turn of the tap.

5. Remove the hex nut and lockwasher from the bulkhead connector (Amphenol 83-879) and discard the lock washer. Mount the connector upright in a vise. Carefully drill down from the top, through the solder tip, with a no. 33 (2.9-mm) drill. Set the connector with its new short tip aside.

6. Reduce the head diameter of a 4-40 x 1/2-inch (M3 x 12.5-mm) screw to about the same outside diameter (see **A**, **fig. 3**) as the male tip of a PL-259 connector. This can be done by inserting the screw into a drill and rotating the screw head against a flat fine-

fig. 2. Standard commercial CATV-cable connector, left, and the Amateur design.

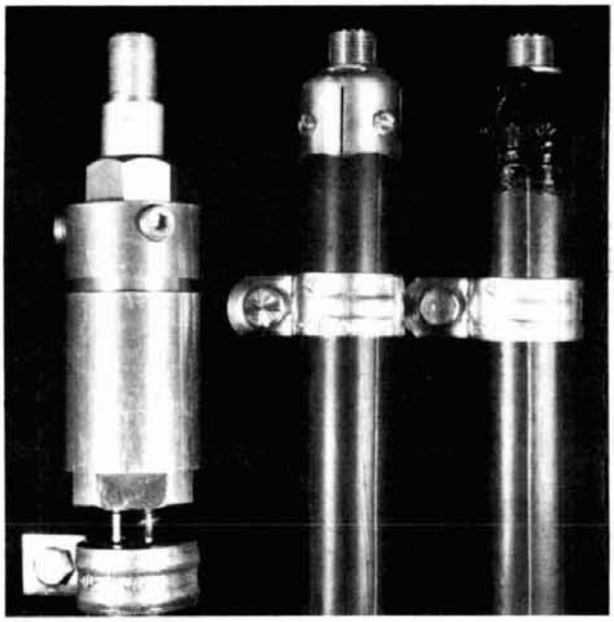


table 3. Tool requirements.

quantity	description
1	1-inch (25.5-mm) tubing cutter for copper or aluminum
1	fine-tooth hacksaw blade and frame
1	3-inch (77-mm) vise
1	1/8-inch (3-mm) wide flat-blade screwdriver
1	fine-tooth flat file and emery cloth
1	150-watt soldering iron or Benzomatic torch
1	center punch
1	electric drill motor with 1/4 or 3/8 inch (6.5-mm or 9.5-mm) chuck
1	4-40 (M3) tap and wrench
1	5/8-inch (16-mm) OD socket punch
1	1/4-20 (M7) bolt, lockwasher, and nut
1	no. 12 SS compression hose clamp
1	high-speed drill bits, nos. 42, 33, 29, and 1/4 inch (2.4, 2.9, 3.5, 6.5 mm)
1	open-end wrench or socket for 1/2-inch (12.5-mm) bolt
1	piece of steel wool
1	corrosion-proof rosin-core solder, about 20 inches (50 cm) long.

mesh file. The final outside diameter should be 0.15 inch (3.8 mm).

7. Using another 4-40 (M3) screw to temporarily block the tapped hole of the center conductor, liberally coat and seal the face of the dielectric, shield, and black vinyl jacket of the cable with General Cement liquid tape or equivalent material.

8. Drill out the hole in the face of the pipe cap to 1/4-inch (6.5-mm). Using an upside down 1/4-inch (6.5-mm) bolt and nut to secure the cap in a vise, make four fine hacksaw cuts 90 degrees apart about 3/4 inch (19 mm) down from the lip of the cap. (See **F**, **fig. 3**). Between the slots drill four 0.09-inch (2.4-mm) holes about 1/4 inch (6.5 mm) back from the same lip about 90 degrees apart.

9. Remove the cap from the vise and the superfluous 1/4-inch (6.5-mm) hardware. Insert a 5/8-inch (16-mm) diameter chassis punch. Tighten the bolt on the punch. You should have a clean 5/8-inch (16-mm) hole in the copper cap face.

10. Burnish the cap surface with steel wool. Insert the body of the bulkhead receptacle from the inside of the cap. Tighten the flat nut. (See **F**, **fig. 3**).

11. With the torch and minimum flux, solder the flat nut onto the cap surface. Use care to fill the void on the flat, keyed side of the receptacle body.

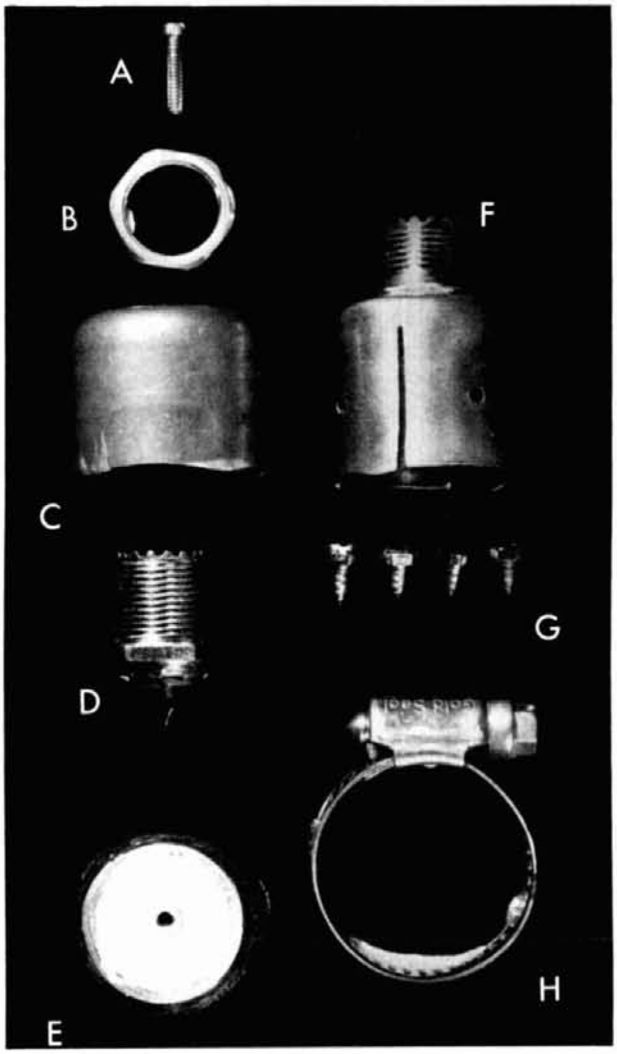
12. Insert the 4-40 (M3) screw, threads down, into the female flange fingers of the receptacle. Push the cap connector assembly down onto the face of the coax, then tighten the screw into the tapped center conductor. Slip the hose clamp over the cap to the cap lip.

13. *Very carefully* drill through the guide holes in a) the copper cap; b) through the black jacket; and c) just deep enough to puncture the outer seamless aluminum jacket of the coax cable. Use the no. 42 (2.4-mm) drill.

14. Carefully enlarge the four copper cap holes with a no. 29 (3.5-mm) drill just enough to allow the 6-32 x 1/4-inch (M3/5 x 6.5-mm) screw shanks (see **G**, **fig. 3**) to pass through the cap material.

15. Install the sheet-metal screws (four each) through the copper cap, vinyl, and into the cable outer aluminum jacket. Make sure the screws are hand-tool tight, no more.

fig. 3. Raw materials needed for the Amateur design of a coax connector for the hardline CATV cable. Assembly steps are shown for the final connector (extreme right, fig. 2).



16. Remove the hose clamp. Check for short circuits or high leakage between inner and outer conductor. If all is well:

17. Coat the cap body, hex-head screws, and junction of the vinyl jacket with G.E. "Liquid Tape," "Tool Dip," heat-sensitive tape, or 1-1/2 inch (38 mm) heat-shrink tubing treated with the torch. Make sure the connector threads are nice and clean.

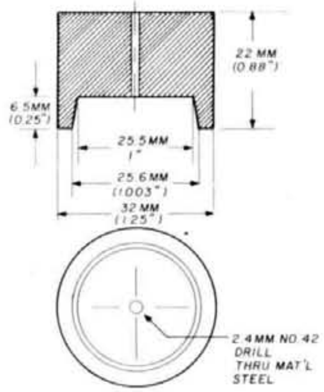


fig. 4. Drill guide for quantity production. The guide can be made by a machinist. (See step 4 in the fabrication procedure.)

This completes the assembly procedure for the Amateur-design CATV-cable connector.

final notes

Metal-to-metal contacts will be reasonably non-electrolytic; that is, silver-plated connector (inner), to stainless-steel 4-40 (M3) screws, to aluminum inner conductor. Also this applies to the stainless-steel sheet-metal screws, from copper cap to aluminum jacket.

The nominal impedance of the completed connector is about 65 ohms. It will show a small impedance bump at about 146 MHz. For matching considerations using 50- or 75-ohm sources, see references 1-5.

acknowledgments

I wish to express my thanks to the following Amateurs for help on this project: W1SCS, W1WME, K2TJZ, K1MOQ, W1TXK, WA1YRQ, and W1IBF.

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ham radio

TS-520SE

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GENERAL:	
Frequency Range:	1.8- 2.0 MHz (160 m) 3.5- 4.0 MHz (80/75 m) 7.0- 7.3 MHz (40 m) 14.0-14.35 MHz (20 m) 21.0-21.45 MHz (15 m) 28.0-28.5 MHz 28.5-29.1 MHz } (10 m) 29.1-29.7 MHz 15.0 MHz, receive only (WWV)
Modes:	SSB (USB, LSB), CW
Antenna Impedance:	50-75 ohms
Frequency Stability:	Within ±1 kHz during one hour after one minute of warm-up, and within 100 Hz during any 30-minute period thereafter.
Power Requirements:	120 VAC, 50/60 Hz; 280 W (transmit)
Dimensions:	13-1/8 inches wide, 6 inches high, 13-3/16 inches deep
Weight:	35.2 pounds
TRANSMITTER:	
Input Power:	200 W PEP (SSB), 160 W DC (CW)
Carrier Suppression:	Better than 40 dB
Unwanted Sideband Suppression:	Better than 50 dB
Spurious Radiation:	Better than -40 dB
Microphone Impedance:	50 k ohms
AF Response:	400-2,600 Hz
RECEIVER:	
Sensitivity:	0.25 μV for 10 dB (S + N)/N
Selectivity:	SSB: 2.4 kHz/-6 dB; 4.4 kHz/-60 dB CW: 0.5 kHz/-6 dB; 1.5 kHz/-60 dB (with optional CW filter)
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IF Rejection:	Better than 50 dB
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end-of-transmission "K" generator

An easy-to-build circuit for sending the Morse character "K" at the end of a transmission

Ever since the Apollo moon shots, Amateurs have been aware of the advantage of a tone at the end of a transmission to indicate that the "over" has finished. Under poor conditions this tone indicates unequivocably to the other station that it's his turn to transmit. There's a growing fashion now in Britain to use not just a single tone but a "dah-di-dah" sequence, making the Morse character "K", meaning "over" in telegraphy. The circuit described here will perform this function using only two standard ICs and a handful of other components.

the "K" generator

The heart of the unit is U2, an IC type CD4017 (**fig. 1**). This device is a decade counter with decoded outputs, which means it has ten outputs: zero, one . . . nine. Initially the zero output is high and all the others are low. When a clock pulse is applied to the clock input, the zero output goes low and the one output goes high. After the next clock pulse, only the two output will be high. This sequence continues until the nine output is high; after that, the zero output goes high again and the sequence repeats.

Also provided on U2 are a reset and a clock inhibit input. When a high is applied to the former, the counter goes straight to the state of having the zero output high. Applying a high to the clock inhibit input freezes the counter in its current state, and further clock pulses have no effect until the clock inhibit input goes low again.

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In this application a free-running clock is connected permanently to the clock input and the clock inhibit is connected to the zero output. Consider the effect of this if the counter is in the zero state: the zero output is high; therefore the clock-inhibit input is high. Thus clock pulses have no effect on the counter and it remains in the zero state, seemingly permanently. However if the clock inhibit is forced briefly low, the counter will cycle through its outputs, one to nine. When it overflows to zero, the clock inhibit is again high and no further counting occurs.

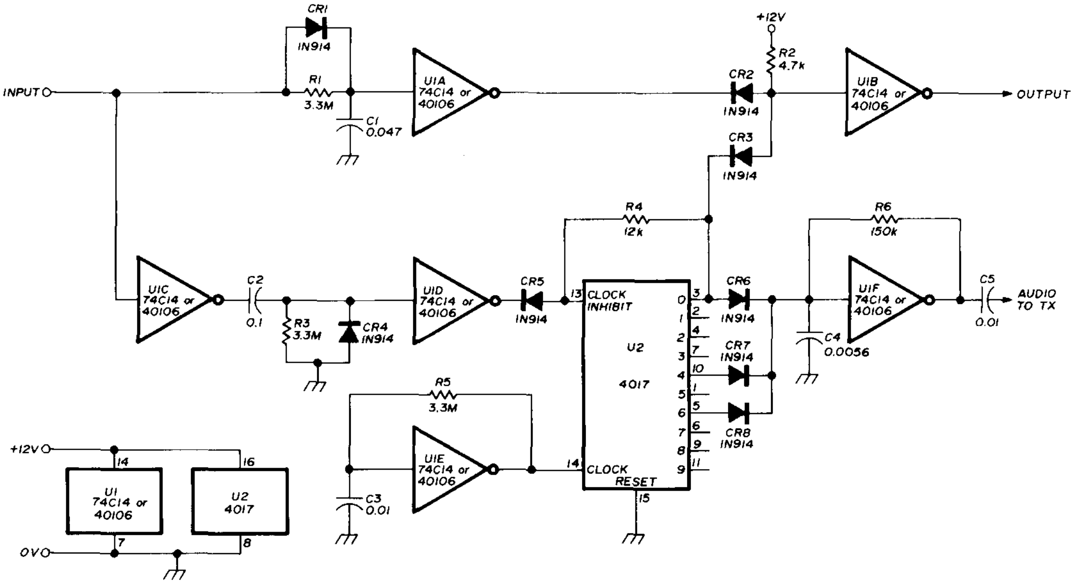

fig. 1. Schematic of the "K" generator. Circuit is designed around U2, a CD4017 decade counter with outputs between zero and nine. Also included in U2 are a clock input, clock-inhibit input, and reset.

We thus have a method of making the counter cycle once through its complete set of outputs. Not counting the zero waiting state, nine counter states remain, and it so happens that the sequence for "K" in Morse is nine dot units long (on-on-on-off-on-off-on-on-on). Arranging the outputs correctly we can make the unit send "K" when wanted.

The other chip used in this project is U1, a 74C14 (40106), which contains six inverting Schmitt triggers. By judicious use of diodes, these triggers are sufficient to complete the required logic functions. The first building block to be constructed from a Schmitt inverter is a relaxation oscillator (**fig. 2**). Operation is as follows: the capacitor charges through the resistor until the trigger input reaches its upper triggering voltage. The output then goes low, and the capacitor discharges through the resistor until the lower triggering voltage is reached. Then the output goes high, and the capacitor starts to charge again. The output is thus a square wave.

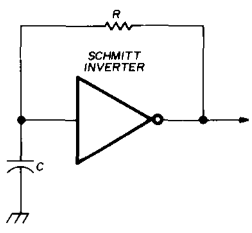

fig. 2. An oscillator may be easily made during a Schmitt inverter IC. This example is seen in U1E, the clock driver for U2 (fig. 1).

In the circuit of **fig. 1**, two of the Schmitt inverters are used as oscillators. U1E is a free-running oscillator, which clocks the counter. U1F is a gated oscillator working in the audio range, which generates the tone. Diode gating is arranged so that the tone is inhibited if any of the diode inputs are high. These diodes are connected to the zero, four, and six outputs of U2 so that the tone is off when the counter is in its resting state and also during the gaps between the dots and dashes.

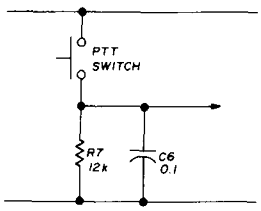

fig. 3. Switch debouncing and interfacing circuit.

The input to the unit is in two paths. The first triggers the counter at the end of the transmission. The input signal is inverted and fed to a differentiator C2, R3 (**fig. 1**). The pulse generated on the leading edge of the input signal is suppressed by CR4, but that generated on the trailing edge is fed to U1D where it's squared. For the pulse duration, the counter clock inhibit input is pulled low through CR5.

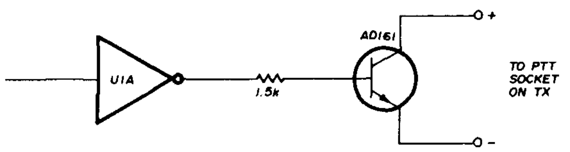

fig. 4. Circuit for interfacing the "K" generator to a transmitter.

Because R4 is relatively high in value, this action will occur regardless of the state of the zero output. Once the clock inhibit input has been pulled low, the counter starts and the zero output goes low, which forces the clock inhibit input low regardless of the U1D output state.

The input voltage is also fed to integrating network R1, C1. On the leading edge, C1 charges up quickly through CR1; but on the trailing edge, a delay occurs while C1 discharges through R1. The voltage on C1 is squared and inverted by U1A and fed to the diode AND gate CR2, CR3. Its other input is the counter zero output. If either of these is low, the output is low and U1B output is thus high, feeding the transmit/receive switching.

Thus, as the press-to-talk switch is released, U1A output will be low because of the delaying action of C1. A moment later, the counter zero output will go low, which keeps the transmitter switched on, even though C1 has discharged. Only when the counter has cycled completely will the zero output go high again. Now both inputs to the diode AND gate will be high and the transmitter is switched off.

interface circuits

This completes the description of the logic part of the circuit, but the unit will, at this stage, only work with CMOS input and output levels. Clearly some kind of interfacing is needed in any real situation. For the input side, the circuit of **fig. 3** will suppress any contact bounce generated by the press-to-talk switch and provide the appropriate input levels to the unit. Because of the time constant of R7, C6 the spikes generated by the contact bounce aren't fed to the input. The value of R7 is smaller than either that of R1 or the on resistance of CR1, so the charging and discharging of C1 is not affected. Clearly, a normally closed switch could be used by interchanging the positions of the switch and R7.

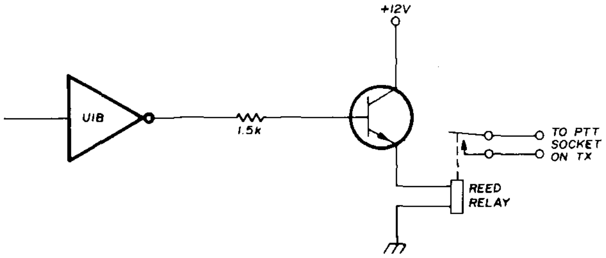

fig. 5. Alternative interfacing arrangement where circuit isolation is essential.

For the output interfacing, the situation is rather more complicated by the variety of circuits with which the unit could be required to operate. I used the arrangement shown in **fig. 4**. The transistor was an old germanium power device, but any variety of NPN transistor with adequate voltage and current ratings will probably work. In my home-brew transmitter, one of the PTT lines was connected to the supply rail so that the transistor operated in common-collector mode. The same circuit will operate just as well in common-emitter mode where one of the PTT lines is at zero potential.

Where the transmitter switching arrangement is unusual, or the unit is to be used with a variety of transmitters with differing switching methods, it's best to isolate the unit by a relay. **Fig. 5** shows a circuit for driving a reed relay; again the transistor type isn't critical. It is, however, important to make sure that the relay is adequately rated for the current drawn through the PTT line since, if overloaded, the contacts tend to weld together and leave the transmitter permanently on — to the potential embarrassment of the operator!

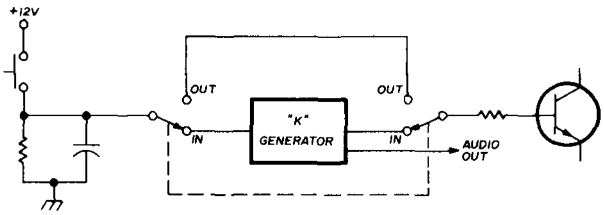

fig. 6. Using a dpdt switch, the "K" generator may be removed from the circuit when desired. The trigger is no longer connected to the circuit so that the audio signal can be retained.

construction

With circuits of this type layout isn't critical. Construction can be in just about any form desired. The circuit can then be either hidden in a spare corner of the rig or built into a separate box. Where the relay driver is not used, the current drain is very low, so a separate battery supply is quite feasible if a suitable voltage isn't available in the transmitter. If you go this route, a common connection must be made to the transmitter chassis, probably through the PTT line, to allow the switching transistor bias current to flow.

Finally, for local contacts, the "K" can be suppressed as shown in **fig. 6** if you wish. Operation is then as normal.

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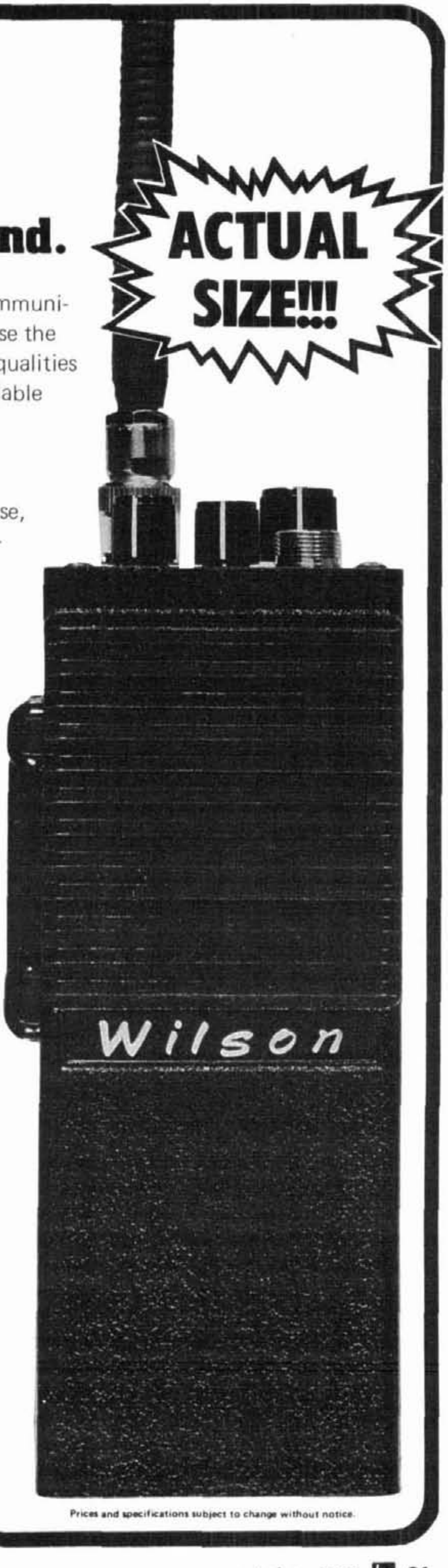

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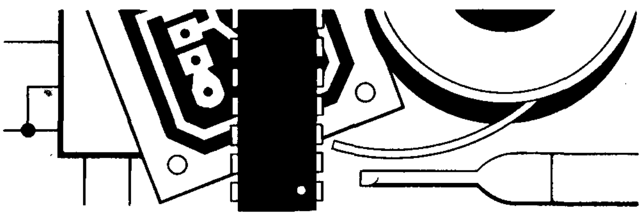

capacitance measurements with a frequency counter

A digital capacitance meter has been on my shopping list for some time, but it's been difficult to justify the expense of the single-function instruments available. An article in *QST*[1] followed by investigation of the literature on the NE555 led to the design of a frequency counter attachment that allows capacitance to be read from the counter display. Using a 7-digit counter, capacitance values from 1 pF to 1 μF may be read with an accuracy of about 2 per cent ± 2 pF. A range switch isn't required.

design

The NE555, when used as a one-shot, produces a pulse of width

$$T = kRC \qquad (1)$$

where k is inherent in the 555, R is the charging resistor, and C is the capacitance being measured. By ANDing an oscillator output with this pulse, a burst of pulses is produced each time the 555 is triggered. The pulse frequency in the burst is that of the oscillator, while the number of pulses in the burst is determined by the length of the pulse produced by the 555. The value of R may be adjusted so that when a 1-pF capacitor is measured, the 555 output causes exactly one oscillator pulse to appear in the burst. Increasing the capacitor to 100 pF will make the 555 output 100 times longer and allow 100 oscillator pulses in the burst. Counting the pulses in one burst will then indicate the capacitance in pF.

To ensure that exactly one burst occurs per frequency-counter gate time, the 555 is triggered by the opening of the frequency counter gate as shown in the block diagram, **fig. 1**.

The effects of stray capacitance are compensated for by providing a third input to the AND gate which forms the burst, nulling the first part of the pulse from the 555. Typical waveforms are shown in **fig. 2**.

circuit description

The design is implemented as shown in **fig. 3** using a 4009A and a NE555. The functions are shown in the same relative positions in the block diagram and schematic for clarity.

The crystal oscillator is standard and provides a stable square-wave output. The crystal frequency isn't critical but should be greater than 1 MHz to allow measuring 1-μF capacitors using a 1-second

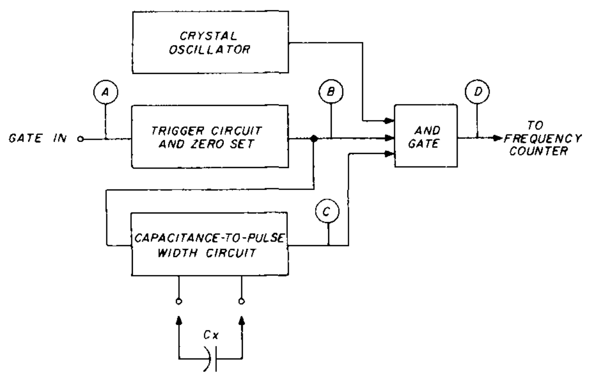

fig. 1. Block diagram of the capacitance measurement attachment for a frequency counter.

By John Moran, 8 Newfield Lane, Newtown, Connecticut 06470

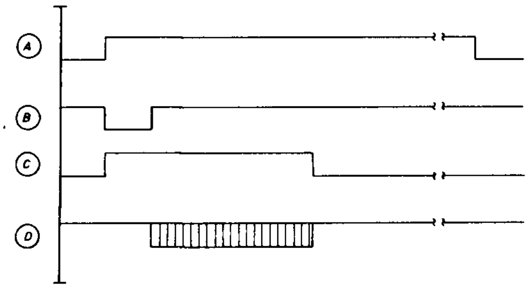

fig. 2. Typical waveforms. Letters at left key the waveforms to both the block diagram and the schematic.

gate time. CMOS speed is restricted when operating from 5 volts, so frequencies above 2 MHz may not work too well.

The trigger circuit consists of a one-shot started by the leading edge of the gate pulse. The output pulse width is adjustable to allow compensation for the effects of stray capacitance, as described earlier. The one-shot is followed by an inverter, which cleans up the pulse shape and provides the proper polarity to trigger the 555 and drive the AND gate. The capacitance-to-pulse width conversion is done by the trusty NE555 in a standard one-shot configuration.

The AND gate is home-grown CMOS/diode logic, which works well and avoids the need for a third IC. The voltage divider on the output reduces amplitude and, more important, the output impedance, thus avoiding stray pickup from the oscillator.

construction and calibration

Perf board construction is adequate if the ICs are bypassed with 0.01-μF capacitors directly at the V_{cc} pins and if the output voltage divider is located a short distance from the crystal.

A metal box should be used to house the unit, since it's sensitive to 60 Hz pickup. This phenomenon is evidenced by a slow variation of about one-half per cent in the reading as the counter gate beats with the line frequency. A variation of over 2 per cent occurs without an enclosure.

The 100-pF capacitor at the oscillator output affects starting and should be adjusted for reliable

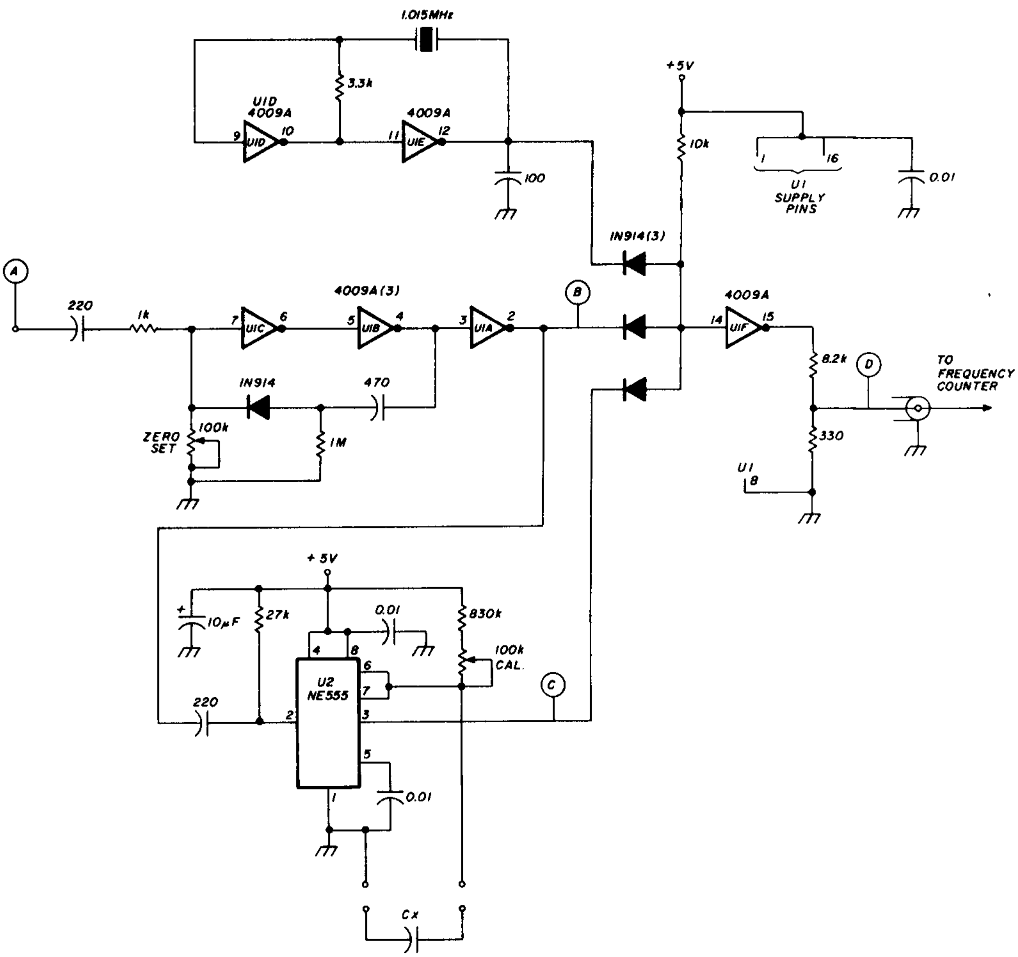

fig. 3. Schematic diagram. Relative position of functional sections matches the block diagram.

operation. The 830k resistor in series with the calibration pot is actually two resistors in series to get a nonstandard value. Using a higher-frequency crystal may require this value to be reduced for calibration.

The frequency-counter gate signal must be made accessible to allow triggering the unit. I installed two pin jacks in the back of my counter to provide both the gate and +5 volts. I used a 200-pF series capacitor to bring the gate line out, to prevent damage to the counter in the event that the line is inadvertently shorted.

Calibration is best done using a one per cent capacitor with a value of several thousand pF as a standard. Lacking this, several silver-mica capacitors in parallel will probably be adequate, since the deviations from the marked values should average out.

Begin calibration by adjusting the ZERO SET control to the maximum resistance setting. Then, without a capacitor in the measurement socket, adjust ZERO SET until a reading is obtained on the counter. Back off slowly until a zero reading is obtained again. Connect your standard capacitor and adjust the CAL control to obtain the correct reading. Then repeat the procedure to correct for adjustment interaction.

If your counter has 0.1-second and 1-second gate times, be sure to use the 1-second gate when measuring capacitors above 0.01 μF.

variations on the theme

It's possible to add a second range by paralleling the charging resistance (830k + CAL) with values that are a factor of 1000 smaller to allow reading capacitors between 0.001 μF and 1000 μF. Note, however, that capacitor leakage causes artificially high readings, so electrolytics with an internal resistance of 1 megohm or less can't be read accurately.

Much of the circuit is also applicable to using the 555 as a direct-reading ohmmeter covering 1 ohm to 1 megohm in a single range.

concluding remarks

A frequency counter attachment has been described that measures capacitance. My hope is that frequency counters will soon be replaced by multifunction instruments incorporating voltage, current, resistance, capacitance, and frequency-measurement capability, much as the voltmeter was replaced by the VOM. Until that time, the versatility of your frequency counter may be increased with devices such as that described here.

reference

1. D.A. Blakeslee, "An Inexpensive Capacitance Meter," *QST*, December, 1978.

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Power:	4 'AA' cells, 12 V AC/DC
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cross-guide coupler for 10-GHz

Design and construction details of the cross-guide coupler, an easy to build directional coupler for 10 GHz

When it becomes necessary to sample a portion of the transmitted power from a signal source or transmitter, a directional coupler is normally used. A great variety of commercial couplers are available, but they are beyond the means of most Amateurs. Once in a while, surplus dealers have sales of X-band equipment, but these pieces can still be quite expensive. Sometimes at a ham auction or flea market pieces can be purchased quite reasonably. However, directional couplers are hard to come by, so building one is an alternate approach.

The simplest type of directional coupler is the cross-guide design shown in **fig. 1**. Many commercial cross-guide designs have cruciform hole coupling which make the coupling ratio and directivity frequency independent.[1] Broadwall directional couplers also have broadband performance, but it is at the expense of long length and precision machining. The round hole cross-guide coupler has the advantage of short length and good performance over a limited bandwidth. It is the easiest form to design and build.

design

The practical range of coupling in a round hole cross-guide coupler varies between 20 and 45 dB down from the incident power. **Fig. 2** shows the hole arrangement relative to the coupler ports; also shown is a graph of how the coupling varies as ratio of hole diameter to guide width.[2,3]

The following is an example of a design procedure to build a cross-guide coupler using the graph in **fig. 2**. First, the center of the 10.0 to 10.5 GHz Amateur band is 10.25 GHz. Since the bandwidth of the round hole cross-guide coupler is approximately 10 per cent, the coupling coefficient should not change more than a few per cent in the 10.0 to 10.5 GHz band. The second step is to decide on the desired coupling ratio. Sources such as reflex klystrons and Gunn diodes, which have an output power in the 10 to 20 mW range, require a sampling coupler to have a coupling ratio of 25 dB or greater. This will keep the power level into the detector in the square-law region. Referring to the graph in **fig. 2**, the D/a ratio for 26 dB is 0.335, where a is the broad dimension of the waveguide. For WR-90 waveguide (*i.e.*, X-band guide), the broad dimension, a, is 22.86 mm (0.900 inch). The large hole diameter is:

$$D = 0.335\,(22.86)\ mm\ [0.335(0.9)\ inch]$$

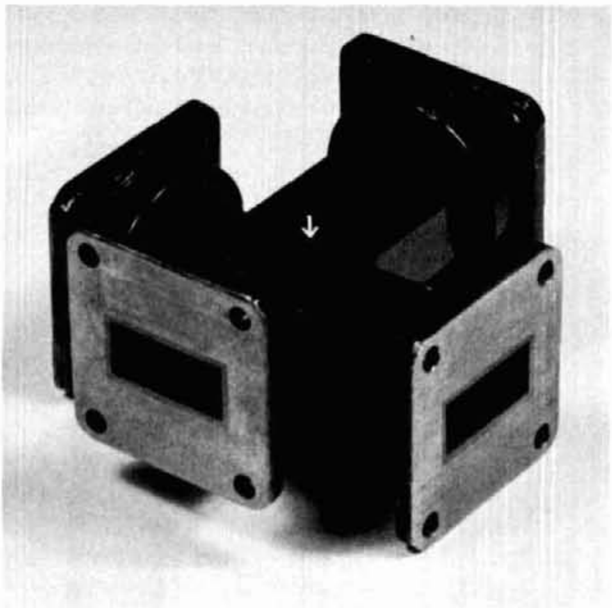
$$D = 7.66\ mm\ (0.3015\ inch)$$

The smaller hole is $2D/3$, so:

$$2D/3 = 2(7.66)/3mm\ [2(0.3015)/3\ inches]$$

$$= 5.11\ mm\ (0.201\ inch)$$

Finished directional coupler.



By Richard A. Bitzer, WB2ZKW, 3 Ray Street, Milltown, New Jersey 08850

Now that the hole diameters are known, their distance from the center line of each guide must be $\lambda_g/8$. To calculate λ_g, the quantities λ_o and λ_C must be known.

$$\lambda_o = \frac{C}{f}$$

$$\lambda_o = \frac{3 \times 10^8 m/sec}{10.25 \times 10^9 Hz} \quad \left(\frac{1.18 \times 10^{10} in/sec}{10.25 \times 10^9 Hz}\right)$$

$$= 0.02927 \text{ meter } (1.152 \text{ inches})$$

$$= 29.27 \text{ mm}$$

where λ_o = free space wavelength
C = velocity of light in free space
f = frequency of operation

For TE_{10} propagation mode down WR-90 waveguide, the cut-off wavelength is:

$$\lambda_C = 2a$$
$$= 2\,(22.86)\text{ mm } [2(0.9)\text{ inches}]$$
$$= 45.72\text{ mm } (1.8\text{ inches})$$

The guide wavelength, λ_g, for TE_{10} mode is:

$$\lambda_g = \frac{\lambda_o}{\sqrt{1 - \left(\frac{\lambda_o}{\lambda_C}\right)^2}}$$

$$= \frac{29.27}{\sqrt{1 - \left(\frac{29.27}{45.72}\right)^2}}\text{ mm} \quad \frac{1.152}{\sqrt{1 - \left(\frac{1.152}{1.800}\right)^2}}\text{ inches}$$

$$= \frac{29.27}{0.768}\text{ mm} \quad \left(\frac{1.152}{0.768}\text{ inches}\right)$$

$$= 38.10\text{ mm } (1.5\text{ inches})$$

The hole centers are $\lambda_g/8$ from the center lines of both guides, therefore $\lambda_g/8$ is 4.76 mm (0.0187 inch).

The above example can be repeated for any desired coupling ratio between 20 dB and 45 dB, useful over the bandwidth of the 10-GHz Amateur band.

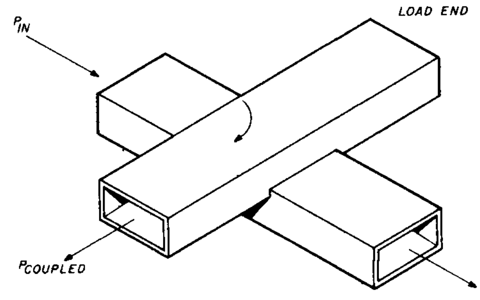


fig. 1. Diagram of the cross-guide coupler configuration. Note that the one end of the coupled arm can be terminated.

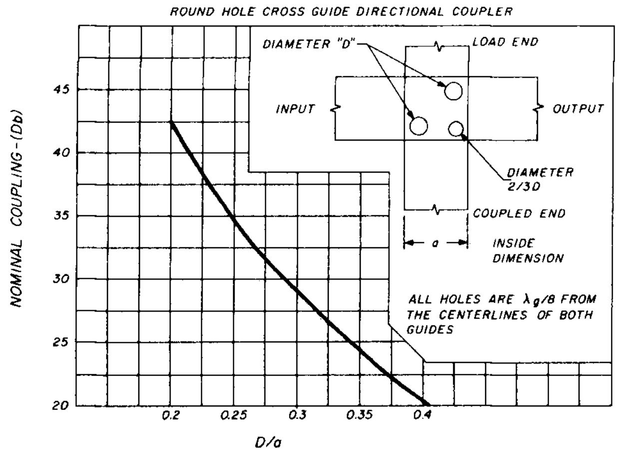


fig. 2. Graph of the relationship between the coupling factor and the physical dimensions of the waveguide and coupling holes.

construction

The directional coupler uses two 76.2 mm (3-inch) pieces of WR-90 waveguide and four UG-39/U cover flanges. **Fig. 3** shows an exploded view of the coupler. From a length of waveguide, cut two pieces 76.2 mm (3-inches) long and file the ends square and smooth. On piece number 1, scribe and drill the hole locations according to the design data. File off all burrs, since it is important not to have any obstruction inside the waveguide. With piece number 2, a slot is to be cut so that this piece fits centrally over the holes in piece number 1. One way to do this is to cut a piece of wood to fit the inside dimensions of the guide and insert it into the guide. Scribe the slot dimensions on the guide and cut on the inside of the scribe marks with a fine hack saw. Do not cut too deep, for the depth of the cut is the wall thickness dimension. The sawdust from the wood should tell you when to stop. The two pieces are placed over one another as shown in **fig. 3** and soldered together. Use a torch rather than a heavy duty soldering gun or iron. Be careful not to let any solder run into either guide. If it does, it can be carefully filed out.

The next step is to solder the flanges onto the waveguide sections. Use a piece of flat aluminum sheet to work on. Place the flange face down. Wrap the guide assembly with a damp cloth to keep the two pieces from coming unsoldered while soldering on the flange. Place the waveguide into the flange, supporting the waveguide while soldering. Repeat this step for the remaining flanges. An alternative procedure in soldering the pieces together is to use a higher temperature solder for the cross pieces and a lower temperature solder for the flanges. To complete the job, use emery cloth to smooth finish the flange faces. For appearance, the coupler can be painted and labeled, giving a commercial looking appearance.

results

The cross-guide coupler was designed to have the coupled power down 26 dB from the incident power. The measured value of the coupled arm is −26.2 dB. The directivity was measured to be 22.6 dB, about

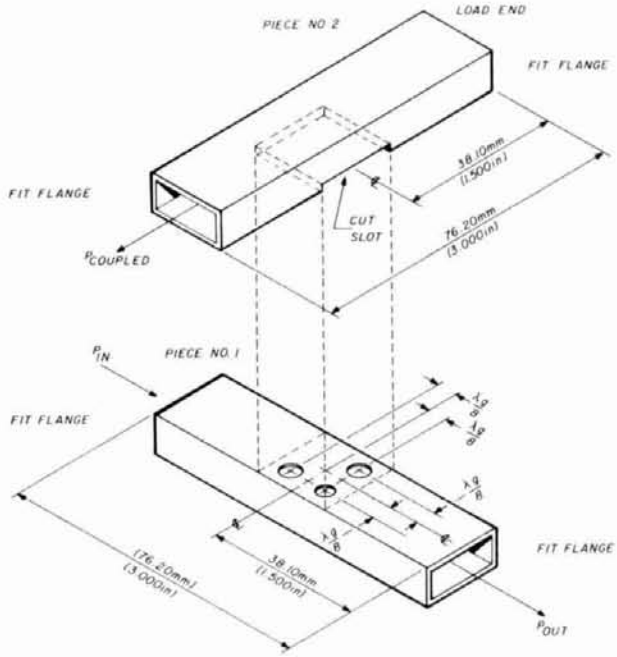


fig. 3. Assembly view of the cross-guide coupler.

average for cross-guide couplers. Referring to **fig. 1**, directivity is the ratio of the power down the coupled arm to that coupled into the load arm from the source. The main arm VSWR is 1.03 to 1, and the insertion loss is 0.05 dB. The coupler was used to sample power from a 10-GHz signal source test bench set up. For this application, the decoupled, or load end, arm has to be terminated with a load, which can be easily made by using a 76.2-mm (3-inch) long guide, flange on one end and a copper sheet across the opposite end. Inside, glue a wedge of 3.16-mm (1/8-inch) thick Masonite coated with Aquadag across the center of the narrow dimension of the guide. The VSWR of such a load measured 1.03:1.

references

1. A. F. Harvey, *Microwave Engineering*, Academic Press, London, 1963, page 107.
2. D. G. Fink, *Electronic Engineer's Handbook*, First Edition, McGraw-Hill, New York, 1975, section 9-7.
3. T. S. Saad, *Microwave Engineer's Handbook*, Artech House, 1971, volume 2, section 1.

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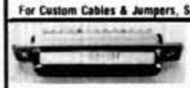

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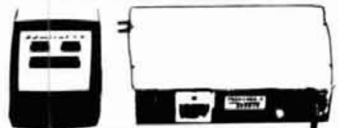

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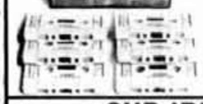

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DIGITAL TECHNIQUES

gate arrays for pattern generation

Gate array structuring has been the subject of many papers, and a number of methods have been devised to simplify design. All the methods have one thing in common: pattern recognition by examination. This is true whether you have a static or dynamic pattern.

All large gate structures take a bit of time to design regardless of the examination method. Simple methods can be used in most Amateur designs. The example for this part of the series is a digitial *CQ* generator for perfect CW keying of those two letters.

organization

The basic time period in CW is dot length. Dashes are three dot lengths. Since the letters *CQ* are familiar, spacing can be shortened to three dot lengths with five dot lengths between groups. (It's assumed that a letter group will be repeated a selected number of times.)

Dot length will be the clock for a binary counter that times the pattern. Each *CQ* letter group requires eighteen clocks for key down, fourteen for key up. The total is thirty two, and a five-stage binary counter (2^5) will take care of timing.

Timing generator lines are labeled A through E (**fig. 1**), A being the least-significant bit and the fastest. The first step is to tabulate the timing-generator states and fit them with the desired pattern. **Table 1** shows this.

Both letters are nearly the same length. The E timing line can be used as a letter selector. This simplifies state examination to only four timing lines. Note that the first two states in **table 1** are not used.

The timing generator has not been specified, but some assumptions are made. All zeroes will be in a reset condition and must be key up. A binary 00001 may or may not have the same length from all zero as between other states; this is determined from the case where the timing generator clock is not synchronous with manual pattern start.

pattern breakdown

Table 1 indicates that six states of the first four lines are common to both letters. This simplifies gating, because timing line E doesn't have to be considered for those six states. Only two states are exclusive for letter *C*; four are exclusive for letter *Q*.

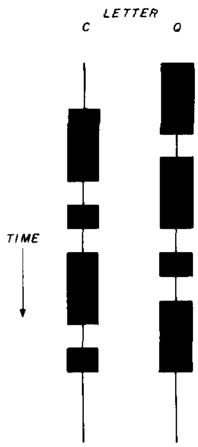
Common letter states of lines A through D are all even decimally. A will be low for all six. Concentration now narrows to B, C, and D lines for the common states, which allows a detailed breakdown as shown in **table 2**.

Common states can be reduced to three: $\bar{C}B$, $\bar{D}C$, and $D\bar{B}$. The X is a don't-care bit state; that bit can be either 1 or 0. Some further examination of don't-cares will show three other combinations: $\bar{D}B$, $C\bar{B}$, and $D\bar{C}$.

Either of the three state combinations can be used. It's also possible to set up inhibits from $\bar{D}\bar{C}\bar{B}$ and DCB. The choice depends on the exclusive letter states. Only letter *Q* seems to have don't-cares, with combinations of $\bar{D}\bar{C}\bar{B}$ or $\bar{D}\bar{B}\bar{A}$.

table 1. Patterns and truth table for digital *CQ* generator.

TABLE 1



D C B A	DECIMAL STATE	DESIRED STATES BOTH	E=0	E=1
0 0 0 0	0			0
0 0 0 1	1			1
0 0 1 0	2	2		
0 0 1 1	3		3	
0 1 0 0	4	4		
0 1 0 1	5			5
0 1 1 0	6	6		
0 1 1 1	7			
1 0 0 0	8	8		
1 0 0 1	9		9	
1 0 1 0	10	10		
1 0 1 1	11			11
1 1 0 0	12	12		
1 1 0 1	13			
1 1 1 0	14			
1 1 1 1	15			

State combinations should now be tried in a gate array. Remember that inverted, or NOT, bits must have inverters in the array, because the AND operation is possible only with high states. These could

By **Leonard H. Anderson**, 10048 Lanark Street, Sun Valley, California 91352

also come from the timing generator if inverted states are present.

a gate array pattern decoder

Fig. 1 shows one configuration. Common letter states are generated by using the inhibit states from **table 2** and creating them in G10 and G11. NAND-gate outputs will be low when all inputs are high (the *Nand Rule*).[1] G10 and G11 will thus inhibit G12 on states $\bar{D}\bar{C}\bar{B}$ and DCB; G12 is enabled on the other six states.

Choice of inhibit gating allows using $\bar{D}\bar{C}\bar{B}$ for letter *Q*. An inverter restores the high state for AND operations. State $\bar{C}$BA is common to both letters, as is $\bar{B}$A. Use of common partial states allows a reduction in total package count, although it may appear to use more gates. Packages have quadruple 2-input gates and dual 4-input gates; it may be that use of more 2-input gates will result in fewer packages.

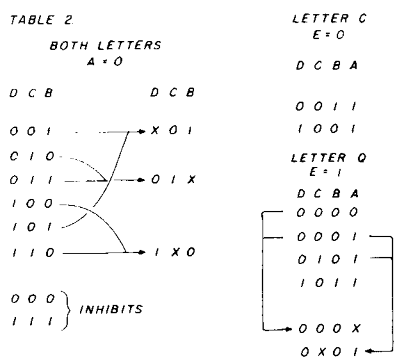
G14 and G15 AND the two states for letter *C*. G19 ANDs the $\bar{D}\bar{B}$A don't-care state from **table 2**, while G20 and G21 AND the remaining two states. G16 and G22 are ORs. G17 and G23 AND each state combination with E and $\bar{E}$ respectively. G24 ORs everything, and key down occurs when the output is high.

Total package count for the circuit of **fig. 1** is six: one hex inverter, two dual 2-input NANDs, and three triple 3-input NANDs (two gates connected as inverters). This isn't very economical or simple in layout — two other digital devices can help simplify things.

decoders and multiplexers

A decoder (sometimes called demultiplexer) will provide a single low output on one of two, four, eight, or sixteen output pins depending on one, two, three, or four data select lines. It can be thought of as a rotary switch with a grounded arm and all stator contacts as the outputs. Binary-data-select input will determine switch position.

table 2. Detailed breakdown of pattern states for common and exclusive conditions.



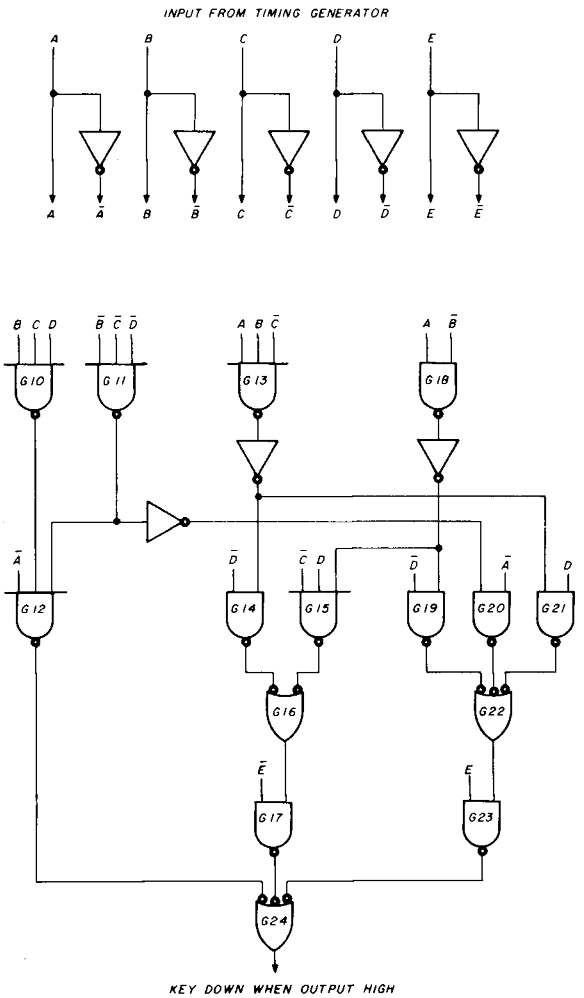


fig. 1. Gate array decoder for *CQ* generator using NAND gates.

A multiplexer will select one of two, four, eight, or sixteen inputs based on binary-data-select lines and transfer this information to a single output. The multiplexer can also be thought of as a switch: all inputs go to stator contacts, and the arm is the output. Position is determined by data-select control inputs.

a simple pattern decoder

Fig. 2 applies a 74L154 TTL decoder package with other low-power TTL NAND gates to the pattern-decoding task. The 74L154 has sixteen outputs active low and fits the sixteen states of **table 1**. Its outputs can be ORed as required.

G30 ORs the two exclusive states for letter *C*, while G31 ANDs them with $\bar{E}$. G35 is connected as an inverter to generate $\bar{E}$ high. G32 ORs the four exclusive letter *Q* states, ANDing them with E in G33. G34 ORs the six common letter states plus the two ANDed exclusive letter states.

U1 has two chip select pins marked G_1 and G_2.

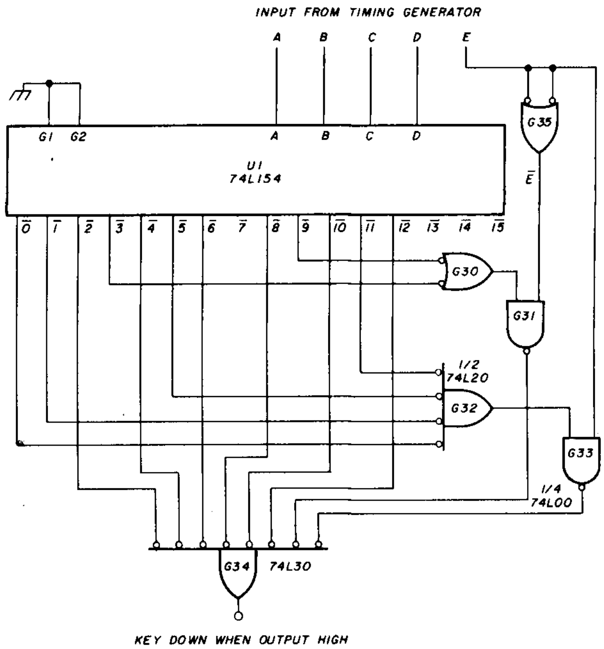


fig. 2. Simpler decoder for digital *CQ* generator.

These pins are used in arrays of decoders for enabling only one out of many. This circuit has only one chip, so it's enabled all the time by tying both pins low.

simplest decoder

This circuit uses a 74150 TTL multiplexer, or mux, and a single inverter as shown in **fig. 3**. The switch analogy describes operation. Timing lines A through D switch the inputs from E0 through E15 to output W. Inputs are high for key down; low for key up.

Common states of key down are wired to V_{CC}, while unused states (7, 13, 14, 15) are wired to

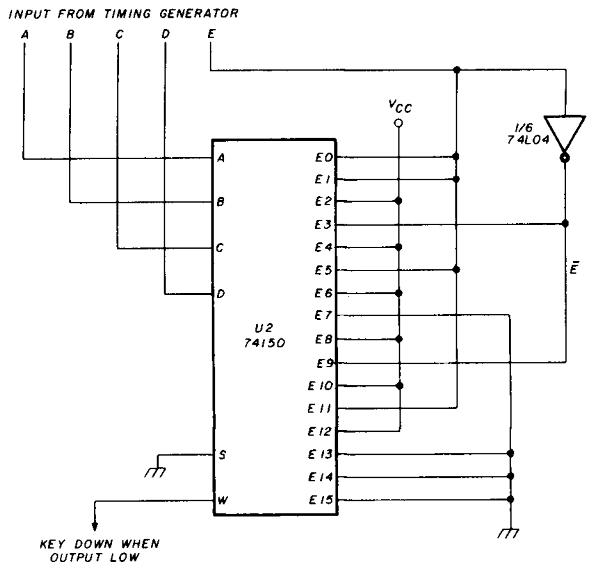


fig. 3. Simplest decoder for the digital *CQ* generator.

ground; if unconnected in TTL, those inputs will go high. Exclusive letter states are obtained from E directly or from the inverter for $\bar{E}$.

The S pin is a strobe, similar to a chip select. It is also used for mux array selection. Note that output W is active low from the inversion bubble (**fig. 3**).

timing and polyphase clocks

Dot rate is quite slow in the *CQ* generator, so small difference in delay through an array won't be noticed. If the pattern were faster, say for a TV sync generator, the propagation delay differences would be very apparent.

The gate array has propagation delays of three to six gates depending on the path. The decoder delay is slightly shorter but variable. The mux circuit of **fig.**

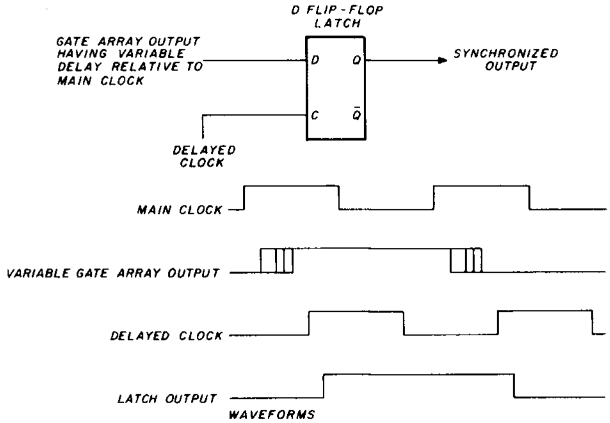


fig. 4. Variable gate array synchronization with delayed clock.

3 can be considered even; it's dependent on the internal structure of U2, which is usually symmetrical.

A way to even up differences in delay (some may be from the timing generator) is to use a delayed phase clock line and a D flip-flop for each output. This is shown in **fig. 4** and could be used anywhere in a large array.

Very large arrays can use several clock phases or a polyphase clock generator. Five or more phases are not unusual. In the polyphase clock, the different phases have even increments of time delay in the clock period. Each D flip-flop is a latch for a particular line and is clocked by a phase with a differential equal to the maximum of all gate arrays plus setup time of the D flip-flop itself. Delays may differ in the array, but the latch output is synchronized by the delayed clock.

reference

1. Leonard Anderson, "Digital Techniques: Basic Rules and Gates," *ham radio*, January, 1979, page 77.

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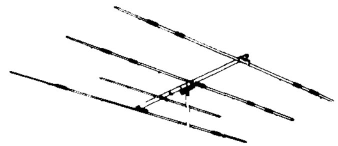

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TH6DXX	Super Thunderbird	$329.95	$259.95	18HT	Hy-Tower 80-10M vertical	$359.95	$289.95
TH3MK3	3 el. 10-15-20M beam	222.95	179.95	18AVT/WB	80-10M Trap vertical	105.95	84.95
TH3JR	3 el. 10-15-20M beam	169.95	139.95	14AVQ/WB	40-10M Trap vertical	69.95	57.00
Hy-Quad	2 el. 10-15-20M Quad	274.95	219.95	12AVQ	20-10M Trap Vertical	42.95	34.95
205BA	5 el. "Long John" 20M beam	329.95	259.95	14RMQ	Roof Mounting kit (verticals)	33.95	29.95
155BA	5 el. "Long John" 15M beam	199.95	159.95	5BDQ	80-10M Trap doublet	109.95	89.95
105BA	5 el;"'Long John" 10M beam	129.95	109.95	2BDQ	80-40M Trap doublet	59.95	49.95
204BA	4 el. 20M beam	249.95	199.95	66B	6 el. 6M beam	119.95	99.95
204MK5	5 el. conversion kit	99.95	79.95	203	3 el. 2M beam	15.95	
153BA	3 el. 15M beam	89.95	79.95	205	5 el. 2M beam	21.95	
103BA	3 el. 10M beam	74.95	59.95	208	8 el. 2M beam	29.95	
402BA	2 el. 40M beam	239.95	189.95	214	14 el. 2M beam	34.95	
BN-86	Balun for beam antennas	15.95	15.95	LA-1	Deluxe lightning arrestor	59.95	49.95
TH2MK3	2 el. 10-15-20M beam	149.95	119.95	TH5DX		269.95	209.95

MOSLEY

		Regular	Special
Classic 33	3 el. 10, 15, 20 Mtr. beam	304.75	209.95
Classic 36	6 el. 10, 15, 20 Mtr. beam	392.75	249.95
TA-33	3 el. 10, 15, 20 Mtr. beam	264.00	189.95
TA-36	6 el. 10, 15, 20 Mtr. beam	392.75	249.95
TA-33 Jr.	3 el. 10, 15, 20 Mtr. beam	197.00	149.95
TA-40KR	40 Mtr. Add On	119.95	89.95

CUSHCRAFT

ATB-34	4 ele. 10, 15, 20 Mtr. beam	289.95	219.95	A147-11	11 ele. 146-148 Mhz. beam	36.95	30.95
ATV-4	10, 15, 20, 40 Mtr. Vertical	89.95	69.95	A147-22	22 ele. Power Pack	109.95	89.95
ATV-5	10, 15, 20, 40, 80 Mtr. Vertical	109.95	89.95	A144-10T	2 Mtr. "Twist" 10 ele.	42.95	34.95
ARX-2	2 Mtr. Ringo Ranger	39.95	32.95	A144-20T	2 Mtr. "Twist" 20 ele.	62.95	52.95
AR-6	6 Mtr. Ringo	36.95	32.95	A147-20T	2 Mtr. beam	62.95	52.95
ARX-220	220 Mhz. Ringo Ranger	39.95	32.95	A430-11	432 Mhz. 11 ele. beam	34.95	29.95
ARX-450	435 Mhz. Ringo Ranger	39.95	32.95	A432-20T	430-436 Mhz. Beam	59.95	49.95
A144-11	11 ele. 144-146 Mhz. beam	36.95	30.95				

HUSTLER

3-TBA	3 ele; 10, 15, 20 Mtr. beam	259.95	189.95
4-BTV	10-40 Mtr. Vertical	99.95	79.95
5-BTV	10-80 Mtr. Vertical	134.95	99.95
RM-75	75 Meter Resonator	16.95	14.50
RM-75S	75 Meter Super Resonator	31.95	27.50
G6-144B	2 Mtr. Base Colinear	79.95	59.95
G7-144	2 Mtr. Base Colinear	119.95	89.95

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the ham notebook

Drake TR-22C sensitivity improvement

A simple modification to the TR-22C has resulted in a significant improvement to the receiver sensitivity. The modification consists of the removal of the built-in telescopic antenna. The antenna is secured to a small plastic block by a single machine screw. To remove the antenna, simply unscrew the antenna from the plastic block and remove it from the transceiver chassis, along with the protective vinyl sleeving covering the antenna. Leaving the plastic block and coaxial cable intact will permit easy reinstallation of the antenna and sleeving should "over-the-shoulder" operation be desired at a later time.

Following removal of the antenna, perform the rf-alignment procedure as follows:

1. Connect a signal generator set at 146.52 MHz to the rear panel antenna connector. Set the level for approximately half-scale deflection on the signal strength meter. I used a friend's signal on 146.52 MHz in lieu of the signal generator.

2. Adjust Ls1, Ls2, Ls4, Ls9, Ls10, and TCt3 for a maximum signal strength meter reading. Tct3 is located on the transmitter circuit board. The individual trimmers should be peaked several times to ensure optimum performance.

The results of this simple modification have been quite gratifying. Several stations heard prior to the removal of the telescoping antenna were usually in the noise level, if heard at all. After removal of the antenna, these same stations were either full quieting or well above the noise level. It appears that the 0.059-wavelength open-circuited line (*i.e.*, the collapsed telescopic antenna) introduces enough capacitance to the receiver front end to detune it, thereby lowering the sensitivity.

Since I do not have the appropriate test instruments but wanted to verify the much improved receiver performance, I repeated the following tests several times: I contacted several stations using local repeaters or direct simplex operation with both my 5/8-wavelength mobile whip and my J-Pole base station antenna. Signal strength readings were taken before and after the removal of the telescopic antenna (including rf alignment of the receiver). In all tests, the TR-22C showed significant improvement in sensitivity when operated without the built-in antenna.

Further improvements can be made in the receiver's performance by replacing the jfet, Qs7, with a 2N3823, replacing the cable between terminal "RA" on the transmitter circuit board and terminal "RA" on the receiver board, and making sure to solder the braid and center conductor close to the circuit boards rather than on top of the "pins" serving as circuit-board terminals. Replace the existing coax cables with RG/174/U or equivalent.

G. A. Herlich, K7OR

S-line backup power supply

Recently I acquired a Collins 516F-2 power supply with an open circuit high-voltage winding in the transformer. After the initial enthusiasm of rewinding the transformer* had subsided, I sought other means of providing a backup supply for my 32S-1/S3.

Replacement or rewound transformers are available from independent sources as well as Collins, but even then the cost is approximately $100. A good, used, 516F-2 transformer costs around $150; therefore I decided to homebrew a spare supply using readily available parts.

The price of the transformer used in the backup supply (**fig. 1**) is less than $25 — considerably less than the replacements already mentioned. If a transformer with a higher secondary voltage rating is used (no more than 750 Vac is recommended), a third filter capacitor and bleeder resistor should be added to provide a sufficient safety margin for the plate-supply string. The low-voltage filter as well might be changed from the capacitive input shown to a choke input by eliminating C3 to keep the low voltage supply within the 300-volt range required. A separate 6.3-volt filament transformer connected in reverse supplies the bias voltage. Under full-load conditions, the supply delivers 660 Vdc at 230 mA, 300 Vdc

*A. Wilson, W6NIF, "Repairing High-Voltage Transformers, *ham radio*, March, 1969, page 66.

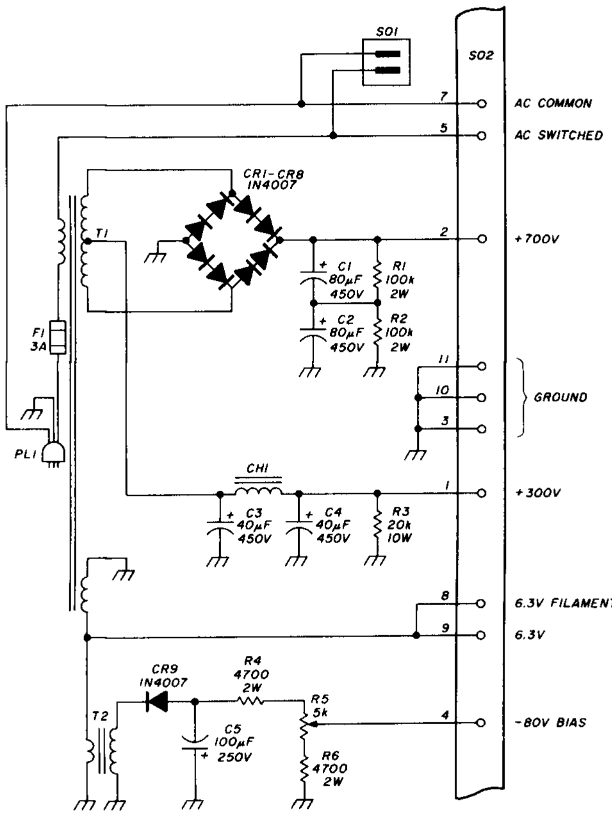
at 175 mA, 6.3 Vac at 8A, and −80 Vdc for bias.

The supply is contained on a 180 × 230 × 51 mm (7 × 9 × 2 inch) aluminum chassis, which is compatible with the 516F-2 cabinet. If you wish to install the supply in the cabinet, the front and rear chassis lips should be reinforced with flat aluminum stock. A paper or cardboard template may be used to transfer the mounting hole locations to the reinforcements.

Socket SO-1 was included on the chassis rear lip to provide a switched ac source to power a cooling fan used on the 32S-( ). Instead of using the standard ac receptacle (Radio Shack 270-642), a 2-pin male cable/female chassis connector (Radio Shack 274-201 and 274-203 respectively) may be used. The female chassis connector requires a 16-mm (5/8-inch) hole. The female cable power socket (SO-2) is an 11-pin Amphenol 78S-11 with a protective cap and cable-strain relief clamp.

The power drawn by the 32S-( ) is well within the transformer's capabilities. After hours of operation on CW, the transformer was only comfortably warm to the touch.

Paul K. Pagel, N1FB



C1,C2	Sprague TVA 1716, 80 MF/450 Vdc	SO-1	Radio Shack 270-642 (or 274-203 — see text)
C3,C4	Sprague TVL 2764, 40 MF/450 Vdc	SO-2	Amphenol 78S-11 with cap and strain relief
C5	Sprague TVA 1718, 100 MF/250 Vdc	T-1	Stancor P-8334, Triad R-77BC or similar
CR1-CR9	1N4007 silicon rectifiers		
CH-1	TV power supply choke, 2-H, 200 mA or similar	T-2	Radio Shack part number 273-050, 6.3V, 1.2 A

fig. 1. S-line backup power supply.

audio modification for Horizon/2

I have an early-model Standard Horizon/2 two-meter rig. I've noticed a lot of audio distortion when stations with very bassy audio come on. Also, PL tones come right through when a larger external speaker is used. The low-frequency rolloff in the receiver audio section is not adequate to keep the audio amplifier IC from being driven into clipping. By replacing the 1-μF coupling capacitor (C134) with a 0.02-μF capacitor unit, the problem was eliminated.

Roy H. Davis, WB9RKN

cliplead carousel

After many frustrating encounters with tangled test leads and several complaints from the YL about "that ball of spaghetti and alligators" hanging from the end of an otherwise neat workbench, I decided there had to be a better way. Encouraged by a sensible system I had admired at the junior college I attend in Rhode Island, I began my improvisation. The method used in school was a long board with slots cut into its edge to accept the ends of the test leads. This was functional, but it took a lot of wall space I didn't have, what with QSL cards, world map, bookshelves, and all. So I "borrowed" a wheel from my son's bicycle parts pile and cut slots into one side of the rim all the way around the wheel. Thinking ahead, I cut some of the slots wider than the rest to accommodate coaxial-type patch cords. The wheel's axle was then secured to the end of a wall bracket with the wheel horizontal at about eye level with the slotted side up. I used a piece of 5-cm (2-inch) aluminum for the bracket, but a standard shelf brace would do as well. Clip leads and patch cords can now be passed up through the inside of the rim and dropped into the slots. This holds them firmly and neatly, easy to see and to get at.

Robert E. Best, WB1AQM

comments

(Continued from page 6)

have DTL/TTL compatible outputs and the 567 will sink a 100-mA TTL load at its pin 8 port. This is a low to high logic change, not a positive and negative voltage change in the case of the 567.

Further, Mr. Zegers' statement that "the place where the missing tone should be is now filled with noise" is not supportable by fact. When a PLL, such as the 567, no longer detects a signal within its passband, it simply changes logic states. If this were not so, the Touch-Tone® decoder circuit using the 567 would not work.

Perhaps Mr. Zegers should examine my keying circuit in more detail. There is no ± V keying used, and while not Mil spec or RS232, it works quite well.

It is not, therefore, "absolutely necessary" to have two tones decoded from a RTTY signal, but it is desirable and that's why I designed the PLL².

With regard to the reader's statement indicating I did not read the data sheet, I suggest he reread his. The National Semiconductor Corporation and the Signetics Corporation both list the bandwidth equation as:

$$BW = 1070\sqrt{\frac{V_1}{f_0 \cdot C_2}}$$

Also, they list the minimum detectable signal as 20 mV, not 20 mW as Mr. Zegers does.

Also they specify the measurement at 20 mV/RMS and further state in the National Semiconductor Linear Data Book *that the equation is an* approximation *only usable to ≤200 mV, so therefore, the 2-volt example given is not valid.*

In actuality, the detection bandwidth is 15.1416 percent, *not 15* Hz, *at 20 mV/RMS input, which indicates that the reader erroneously assumed the resultant of the above equation to be Hz since he indicated that the bandwidth was 15 Hz. The resultant of the bandwidth equation is the percentage of f_0 that the PLL will detect and lock onto. At 20 mV/RMS, the detection bandwidth is ± 160.8795 Hz, not 15 Hz, and the greatest number of cycles before output at 15.1416 percent bandwidth is 28 Hz not 300 Hz.*

Obviously, since bandwidth will widen out between 20 mV/RMS and the saturation point of 200 mV/RMS, an overlap will result between mark (2125 Hz) and space (2295 Hz), and that is why in the PLL² article it was necessary to slew the two PLLs capture frequencies so as to make a "hole" between the two signals. The 2-stage active filter also helped narrow the response envelope to a more acceptable curve.

Finally, I disagree that the 567 was never intended for FSK demodulation. I'm not alone. National Semiconductor agrees with me on page 9-40 of their Linear Data Book, *where they list among other uses for the 567 "wideband FSK demodulation."*

John Loughmiller, KB9AT
Greenville, Indiana

Yagis vs quads

Dear HR:

I imagine you have received a great deal of correspondence concerning N6NB's article in the May issue on the quad vs Yagi controversy. At the risk of adding to the bulk of mail you have already received, I would like to make some comments and offer a suggestion.

N6NB developed an excellent article based upon his experiments using the two portable towers and a triband two-element Yagi as a reference. However, the methods used to provide an accurate standard of comparison were not developed in such a manner that would lead me to conclude that a Yagi is better or worse than a quad. Since N6NB did not isolate and control his variables (such as boom spacing on the two-element quad) he really can't make an objective analysis on the relative performance of each antenna. The question of antenna feedlines for example, was not discussed, yet this variable can be of critical importance in evaluating any antenna array's performance.

While Mr. Overbeck has shed some light on the quad-Yagi controversy, additional research is required before one can draw the conclusions developed by N6NB.

I would like to suggest that N6NB and his associates continue these experiments using tighter controls on the experimental process with the objective of publishing a follow-on article; then we might be able to objectively decide whether a quad is better or worse than a Yagi, and more importantly, under what conditions.

Dr. Kenneth Jenkins, WB6MMV
Portland State University
Portland, Oregon

Dear HR:

As Dr. Jenkins points out, there is no question that ignoring feedline loss variables could invalidate comparative antenna gain measurements such as those reported in my article. However, that variable was considered in all of my tests.

Since I had described my experimental procedures in an earlier article (which I footnoted), I did not repeat the full description in this particular article. I assumed that anyone wishing to critically analyze my procedures would read my previous article on the subject.

Dr. Jenkins is correct in stating that I tested only one two-element quad design. It would be interesting to test other two-element quad designs, but I did test all of the most popular designs using three or more elements; reporting how those antennas fared in comparison to Yagis of similar size was the main point of the article. Dr. Jenkins has suggested no experimental errors that would invalidate those results.

Wayne Overbeck, PhD, N6NB
Malibu, California

NEW products

For literature on any of the new products, use our *Check-Off* service on page 110.

microcomputer-based morse code transceiver from Xitex

Xitex Corporation in Dallas, Texas, has just introduced a Morse code transceiver designed around a pre-programmed single chip microcomputer for the generation and reception of Morse code signals using a standard ASCII or Baudot terminal (such as Xitex Model SCT-100). Applications include military, Amateur, plus certain commercial systems.

The microcomputer's on-chip 2048-byte memory contains both the send and copy algorithms, plus a software UART with multiple ASCII and Baudot baud rates. All timing signals are generated internally from a single external 4-MHz crystal. This not only reduces system costs, but also virtually eliminates RFI generation or susceptibility.

The copy portion of the device provides automatic synchronization from 1 to 150 wpm while it is continuously computing and displaying the corresponding wpm value.

The send mode features include precise control of the output Morse wpm rate in unit increments from 1 to 150 wpm, plus a 32-byte FIFO buffer which can be edited prior to transmission.

Another feature permits both send and copy operation in a unique "RTTY Emulate" mode. This permits the transmission of a 60-character ASCII subset using standard Morse codes plus "new" codes designed for special symbols and control characters (such as line feed, space, carriage return, etc.).

The MRS-100 Morse Transceiver will be available in October from authorized distributors or directly from Xitex. It will be offered in three basic configurations: a partial kit including the microcomputer and blank printed-circuit boards for $95; a full kit including an enclosure, power supply and all other components necessary to configure a complete system (less terminal) for $225; plus an assembled and tested unit for $295. For more information, write Xitex Corporation, 13628 Neutron, Post Office Box 402110, Dallas, Texas 75240.

replacement antennas for handhelds

Centurion International has just introduced a comprehensive line of flexible replacement antennas for handheld radios. Until now, Centurion has been supplying these products exclusively to original-equipment manufacturers and have expanded the line to fit all units.

Four styles are available, one each for low-band and high-band, and a 15-cm (6-inch) whip, or a 5-cm (2-inch) "shorty" for uhf. All styles are available on any of thirteen different connector terminations to fit virtually any model.

The antennas are factory-tuned for high performance and minimum VSWR. Impedance is 50 ohms, and they have a 35-watt power rating. All units are encapsulated and are moisture-resistant.

For more information, contact Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501.

TR-110 Isopack

The new TR-110 Isopack isolation transformer, which eliminates a shock hazard in the testing of transformerless equipment, is now available from B&K Precision Dynascan Corporation. Ruggedly designed for use in industrial, school, or shop-testing applications, the TR-110 Isopack features both direct voltage and dual isolated outputs to ensure operator safety during testing. In addition, the unit also reduces the possibility of damage to ac-powered test instruments due to improper ground connections.

The TR-110 Isopack has an adjustable, isolated, ac output from 90 to 140 volts in nine steps, an important feature for uncovering voltage-sensitive and intermittent faults in TV and audio sets, or for quality control tests to observe the degree of regulation provided by a power supply. In addition, the adjustable output feature allows the user to select a specific line voltage, as often required for standard procedure testing, even when normal line voltage is low.

The isolated output function has a power rating of 350 VA continuous and 500 VA intermittent, and is convenient for connecting both test equipment and the unit to be serviced. An on-off switch and a pilot lamp are provided for the isolated output. The direct outlets are rated at 500 VA continuous.

The TR-110 is available immediately from local distributors at the suggested resale price of $75. For further information on TR-110 and other precision test instruments, contact B&K Precision, 6460 West Cortland Street, Chicago, Illinois 60635.

triband beam

Hustler announces the new Model 3-TBA triband beam antenna. This Amateur beam antenna covers the 10, 15, and 20-meter bands. Longest overall element length is 23 feet 10 inches, and the antenna is designed and tuned for a 24-dB front-to-back ratio. A unique design permits the elements to be much shorter than other beams on the market today. Boom length is 14 feet and the antenna provides better than 8 dB gain. The 3-TBA handles power inputs of 1 kilowatt and is easily matched to 50-ohm cable.

The antenna is constructed of 100 per cent heavy-anodized aluminum with stainless steel hardware, yet weighs only 36 pounds. The all new Hi-Q trap design uses 12-gauge aluminum wire, requires no capacitors, and, once tuned at the factory, is permanently weather sealed for years of reliable operation. This antenna is sure to be a favorite with those operators entering DX contests.

The 3-TBA has a suggested list of $259.95 and is available now. For further information on this or other Hustler antenna products, write Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, Ohio 44142.

10-meter mobile antenna

With the 10-meter band now wide open, Hustler recently announced the introduction of a new, center-loaded, mobile 10-meter antenna. The new Hustler Model HOT-10 has a tapered, 17-7 PH, 53-inch stainless-steel mast, center-loaded to 10 meters.

The trunk lip mount includes a 180-degree swivel adjustment for vertical positioning. Supplied with 17 feet of top-quality RG-58 coaxial cable and factory-installed connectors, the antenna is ready to use. No tools are required for quick installation.

The HOT-10 has a suggested list price of $39.95 and is available now. For further information on this and other Hustler antenna products, write Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, Ohio 44142.

new 10-MHz oscilloscope

Two 10-MHz oscilloscopes recently introduced by Leader Instruments Corporation feature up to 1-mW sensitivity, a capability until now unavailable in low-cost instruments.

William Brydia, vice president of the firm, notes that "this combination of high performance and low cost was made possible by a much simplified design using integrated circuits for many functions. The result is an instrument that is efficient to manufacture, reliable, and very serviceable."

The LBO-513 Single Trace and LBO-514 Dual Trace oscilloscopes are both equipped with 8 × 10 cm displays, Z-axis modulation, X5 magnifier, and complete trigger controls. The LBO-514 Dual Trace unit also provides front panel x-y operation, CH-1/CH-2 trigger selection, and alternate or chopped display modes.

The LBO-513 Single Trace 10-MHz oscilloscope will be priced at $499, and the LBO-514 Dual Trace 10-MHz oscilloscope will sell for $649. Delivery is from stock.

All Leader Instruments carry a two-year warranty backed by conveniently located factory service centers on the East and West Coasts.

For further information, contact Leader Instruments Corporation, 151 Dupont Street, Plainview, New York 11802.

Basic Electricity and Electronics

This is a pair of books published by John Wiley and Sons of New York. They are written in a clear, easy-to-understand manner, and use a self-teaching format throughout each section, followed by a test at the end. You're involved in the text as you go through each subject, and the test provides a check on your performance. The illustrations in each book are well done, and enough of them are used to make each point clearly. There's plenty of room to make notes if you wish.

Basic Electricity is the book to start with, unless you already have a firm foundation in that subject. Even so, a review might just show up a few weak areas in what you thought you already knew. *Electronics* is the volume of greater immediate interest to the beginning Radio Amateur, but it depends upon the student having a working knowledge of electricity — in fact, the introductory pages in the book states that you should have *Basic Electricity* first.

Basic Electricity begins with an explanation of what electricity is, starting with the relationship of atoms and electrons, charges that attract and repel, and continues through conductors and insulators. Other chapters delve into voltage, current, resistance, magnetism, inductance, capacitance, and more. Although the list seems long, each chapter is done so well that you seem to breeze right through them, and emerge at the end with a working knowledge of a particular segment of the electrical world.

Electronics follows the same format, starting with a review and test of what you know (or should have learned from *Basic Electricity*). This is followed by an introduction to some simple electronic components and an explanation of how they work. Diodes, transistors, ac circuits, transformers, oscillators, and amplifiers are among the subjects covered in the eleven chapters.

Anyone who conscientiously follows the lessons in these books will have the groundwork necessary to handle all but the most exotic of electrical or electronic problems he might encounter. Certainly, the theory part of any Amateur exam should hold no fears for one who has completed these two courses.

Both books are a part of what Wiley calls their Self-Teaching Guide, designed to be used by individuals. However, they would also be excellent for anyone who is conducting a class on electrical and electronic theory. At a price of $5.95 each, they'll earn their keep many times over.

Basic Electricity by Charles W. Ryan, and *Electronics* by Harry Kybett are available from Ham Radio's Bookstore, Greenville, New Hampshire 03048; $5.95 each, plus $1 for shipping and handling. Order JW-74787 (*Basic Electricity*), and JW-01748 (*Electronics*).

2-meter magnetic mount antenna

The new model Hustler BBLM-144A 2-meter magnetic mount antenna was recently announced by New-Tronics. This base-loaded, 52-inch antenna offers a unique magnetic mount design with much stronger grip per square inch of magnetic surface than normally available in magnetic mounts.

Careful design of the shunt-fed matching system guarantees maximum signal radiation with a low SWR. The tapered stainless-steel radiator provides maximum protection against flutter and detuning at freeway speeds. Power capacity exceeds 200 watts.

The BBLM-144A includes 17 feet of top-quality RG-58 coaxial cable with factory-installed connectors. The unit has a suggested list of $39.95 and is available now. For further information on this and other Hustler antenna products, write Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, Ohio 44142.

4½-digit high-accuracy DVM

The Model MC-545 is a 4½-digit bench-type multimeter that features five function modes (dcV, acV, dcmA, acmA, and ohms) and provides automatic zero adjustment and polarity indication. The modes appear on the LED display. As an option, a BCD output (8, 4, 2, 1) can be provided for connecting the multimeter between a CPU and a digital recorder.

This highly accurate instrument has (1) a voltage measurement range of 2 to 1000 volts ac and dc; (2) a current measurement range (both ac and dc) from 2 to 1000 mA; and (3) a resistance measurement range to 200 megohms. Maximum indication is 19999 or − 19999.

For more information, write Soar Electronics, 200 13th Avenue, Ronkonkoma, New York 11779.

PE-100 sequential encoder

Communications Specialists announces the introduction of the PE-100 Two-Tone Sequential Encoder.

This desk-top encoder is capable of producing up to one-hundred individual paging codes, or it may be programmed for ninety paging codes and ten group-call codes. Measuring 22 × 18 × 10 cm (8.5 × 7.0 × 3.75 inches) this unit features a high-visibility LED readout display, a twelve-button miniature keyboard, and automatic transmitter keying with a LED indicator.

This encoder is completely solid state and uses digitally synthesized tone frequencies for high stability and accuracy. It is powered by low-voltage ac, which is obtained from an external step-down transformer furnished with the unit, or it may be powered by any unregulated 8 to 16 Vdc source capable of supplying 400 mA.

It is available in all EIA tone frequencies from 268.5 Hz to 3906.0 Hz, with a frequency accuracy of ± 10.1 Hz throughout the full operating range. Frequency stability is 0.1 Hz from − 30 to + 85 degrees C.

This unit is compatible with most two-tone sequential systems, such as Quick Call II, Type 99, and 1 + 1. Output connections include isolated double-pole, double-throw relay contacts rated at 1 ampere.

A one-year warranty is given, provided the unit is returned to the factory for repair. Wired, programmed, tested, and complete with all tones, the PE-100 is available for immediate delivery at $224.95. For additional information contact Communications Specialists, 426 West Taft Avenue, Orange, California 92667.

tunable subaudible tone encoder-decoder

Vega, of El Monte, California, has just introduced a new subminiature, subaudible tone encoder-decoder for handheld radio as well as routine mobile-radio applications. The Model 185 is *completely tunable* to any EIA CTCSS frequency without adding or changing any components. Measuring just 25 × 39 × 14 mm (1 × 1.5 × 0.55 inches), the unit includes a high-pass voice filter and adjustable output level. A unique self-squelching feature eliminates external squelch-circuit connections in most applications, making installation simple and quick. The Model 185 exceeds all EIA specifications, including frequency stability. The Model 185 is available for immediate delivery and comes with Vega's three-year warranty. Suggested dealer net price is $69.95 in quantities of one to nine. For further information, contact VEGA, 9900 Baldwin Place, El Monte, California 91731.

QuikSnip shears

Jilson QuikSnip Cutting Shears eliminate distortion, burrs, and curling when used to cut sheet metal. This modern, unique tool cuts aluminum, brass, and copper sheets up to 15 gauge and mild steel to 18 gauge.

Cutting can be started in the center of work simply by drilling a 1/4-inch hole to accommodate the patented QuikSnip cutting jaws. Four models are available to cut all materials from sheet metal to plastic sheeting in any desired pattern. Model J1252WC has a special wire cutting feature.

Requiring less effort than regular tin snips, QuikSnips are especially useful for aluminum siding, ductwork, metal cabinet fabricating, and auto-body repair. They prove indispensable in flammable environments where cutting torches and power tools are hazardous.

Jilson QuikSnips are constructed of heavy-duty hardened steel with a tough, corrosion-resistant nickel finish, and they have easily replaceable cutting jaws for extended use. QuikSnips feature a return action spring to reduce fatigue and a locking latch for compact storage and jaw protection.

QuikSnips save time, work, and money. Distributor's inquiries invited. For detailed information, contact The Jilson Corporation, 291 South Van Brunt Street, Englewood, New Jersey 07631.

nonmetal tower guys brochure from Phillystran

A new, free brochure explains ten major advantages of nonmetallic, nonconducting tower guys for radio and TV broadcasters, and for CATV and other signal-reception applications. In addition to dielectric integrity — which eliminates the problems of white-noise arcing and electromagnetic interference (EMI) — these new corrosion-resistant tower guys combine high strength, light weight, and inherent flexibility for installation ease. They also are essentially maintenance-free, even around salt-laden, corrosive atmospheres.

Phillystran tower guys eliminate pattern distortion and white-noise arcing at transmitting tower installations. For tower installations where extreme corrosion of steel guys is an especially severe problem, the new Phillystran guys will provide extremely long life, and, on an installed-cost comparison, will be competitive with conventional metal guys.

For more information, ask for your free brochure from Philadelphia Resins Corporation, 20 Commerce Dr., Montgomeryville, Pennsylvania 18936.

Shure 526T series II microphone

Shure Brothers has announced the new Shure Model 526T Series II Super Punch® microphone with new design features that improve its overall versatility for base-station transmissions and make it compatible with virtually all transmitters and transceivers.

The new 526T Series II can be connected to a wide assortment of transceivers with input impedances of 500 ohms or higher. A new six-wire coiled cord and triple-pole, double-throw switch are arranged for universal compatibility with most transceivers. The new microphone can be used to replace original equipment microphones, either ceramic or dynamic, low or high impedance.

Important performance features of the new microphone include a dynamic element and a transistorized preamplifier that operates for hundreds of hours on a standard 9-volt battery. Volume control allows adjustment for optimum transmitter modulation and maximum intelligibility. A "million-cycle" transmit/receive switch closes with a self-cleaning wiping action for noise-free switching with momentary or locking operation. This same switch allows for connecting accessories such as speech processors, antenna relays, and on-the-air lights. For additional information, write Shure Brothers Inc., 222 Hartley Avenue, Evanston, Illinois 60204.

Hustler Five-Band Trap Vertical Antenna

Hustler recently introduced their new model 5-BTV, a five-band trap, fixed-station antenna. The unit covers 10, 15, 20, 40, and 80 meters (tunable to 75 meters). The 5-BTV consists of the popular Hustler model 4-BTV, RM-80-S resonator and spider assembly.

The Hustler 5-BTV delivers top signal performance, consistent contacts, five-band operation, and complete coverage. Use one feedline — any convenient length; switching or matching devices are not required.

The antenna is 7.7 meters (15 feet 5 inches) long, constructed of the finest-quality, heat-treated seamless aluminum tubing, with all stainless-steel hardware. VSWR is better than 1.6:1 at all band edges. Power capability is full legal limit on SSB and CW.

The 5-BTV has a suggested list price of $134.95 and is available now. For further information on this and other Hustler antenna products, including CB, professional, and monitor, write: Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, Ohio 44142.

CSC logic probe kit

Continental Specialties Corporation, a well-known manufacturer of professional digital troubleshooting instruments, has introduced their first kit-style test instrument, which emulates their line of logic probes.

The kit instructions are well-written, offering step-by-step assembly procedures. Solder, wire, and all miscellaneous hardware are included in the kit — along with the printed circuit board, case, and all components, leaving no extras to buy. Even beginning-level kitbuilders can assemble the LPK quickly.

Once assembled, the LPK offers respectable performance as a logic probe. It is circuit powered through attached clip leads. HI, PULSE and LO LEDs display logic states and transitions. The high gain logic state is defined as 70 per cent or more of the supply voltage, the low state as 30 per cent less, making the probe compatible with most digital logic technologies or families. With its high (300,000-ohm) input impedance, circuit loading is reduced.

With the LPK, even very narrow pulses can be detected. Internal circuitry stretches pulses as short as 300 *nanoseconds into 1/10th-second* flashes of the PULSE LED: pulse trains at repetition rates up to 1.5 MHz keep the PULSE LED flashing.

The LPK includes self-protecting circuitry which permits the power leads to be connected in reverse or to as much as 25 Vdc without permanent damage; the probe tip, similarly, can contact ±50 volts continuously, or 110 Vac for up to 15 seconds without permanent damage to the probe.

As a troubleshooting tool, the LPK *holds it own against any logic probe* in all but very high speed applications. As an educational venture for the kitbuilder, it should be noted that the LPK, while a digital tool, is based on analog circuitry — offering a unique opportunity to see how the two disciplines merge.

For more information, or for the name of your nearest CSC stocking distributor, call Continental Specialties Corporation toll-free at 1-800-243-6077.

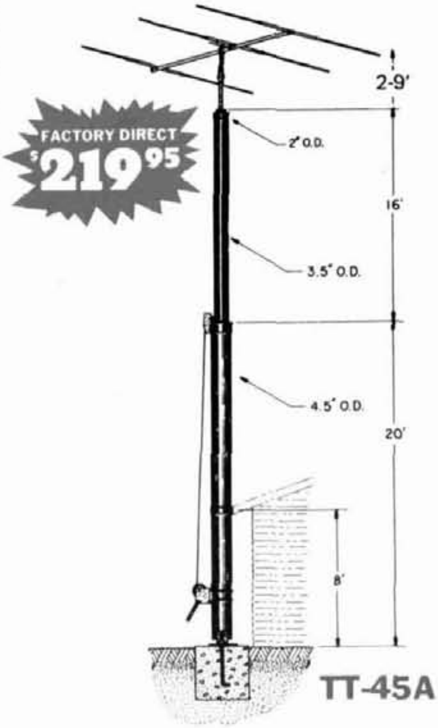
More Details? CHECK — OFF Page 110

New, Improved Wilson Towers

Hinged Base Plate - Concrete Pad, Heavy Duty Winch

Mounting the House Bracket

The Hinged Base Plate allows tower to be tilted over for access to antenna and rotor from the ground.



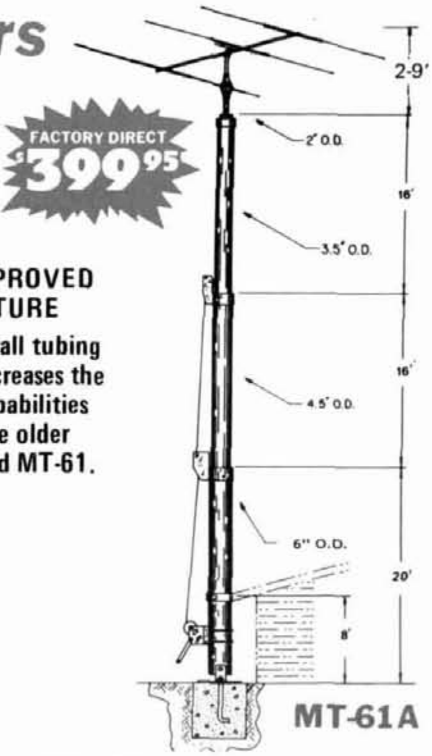
TT-45A

FEATURES:
- Maximum Height 45' (will handle 10 sq. ft. at 38') @ 50 mph
- 800 lb. winch
- Totally freestanding with proper base
- Total Weight, 189 lbs.

The TT-45A is a freestanding tower, ideal for installations where guys cannot be used. If the tower is not being supported against the house, the proper base fixture accessory must be selected.

NEW IMPROVED FEATURE

Heavier wall tubing greatly increases the stress capabilities over the older TT-45 and MT-61.



MT-61A

FEATURES:
- Is freestanding with use of proper base
- Maximum Height is 61' (will handle 10 sq. ft. at 53') @ 50 mph
- 1200 lb. brake winch
- 4200 lb. raising cable
- Total Weight, 350 lbs.

Recommended base accessory: RB-61A, FB-61A.

The MT-61A is our largest and tallest freestanding tower. By using the RB-61A rotating base fixture the MT-61A is ideally suited for the SY33 or SY-36. If you plan to mount the tower to your house, caution should be taken to make certain the eave is properly reinforced to handle the tower. If not, one of the base accessory fixtures should be used.

GENERAL FEATURES

All towers use high strength heavy galvanized steel tubing that conforms to ASTM specifications for years of maintenance-free service. The large diameters provide unexcelled strength. All welding is performed with state-of-the-art equipment. Top sections are 2" O.D. for proper antenna/rotor mounting. A 10' push-up mast is included in the top section of each tower. Hinge-over base plates are standard with each tower. The high loads of today's antennas make Wilson crank-ups a logical choice.

TILT-OVER BASES FOR TOWERS

FIXED BASE

The FB Series was designed to provide an economical method of moving the tower away from the house. It will support the tower in a completely free-standing vertical position, while also having the capabilities of tilting the tower over to provide an easy access to the antenna. The rotor mounts at the top of the tower in the conventional manner, and will not rotate the complete tower.

FB-45A . . . $ 79.95
FB-61A . . . 109.95

ROTATING BASE

The RB Series was designed for the Amateur who wants the added convenience of being able to work on the rotor from the ground position. This series of bases will give that ease plus rotate the complete tower and antenna system by the use of a heavy duty thrust bearing at the base of the tower mounting position, while still being able to tilt the tower over when desiring to make changes on the antenna system.

RB-45A . . . $119.95
RB-61A . . . 179.95

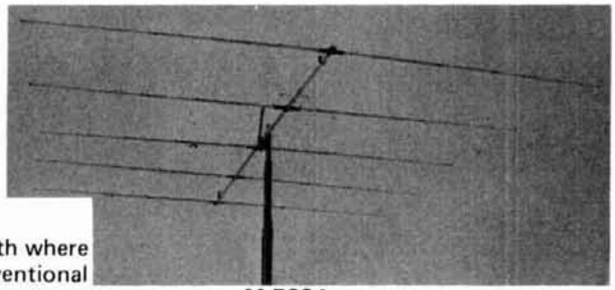
Tilting the tower over is a one-man task with the Wilson bases.
(Shown above is the RB-61A.)

WSI **WILSON SYSTEMS, INC.**

4286 S. Polaris Avenue
Las Vegas, Nevada 89103
(702) 739-7401
Factory Direct Toll Free 1-800-634-6898

Prices and specifications subject to change without notice.

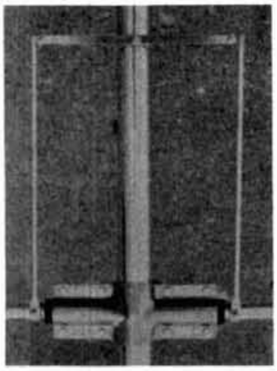
WILSON MONO-BAND BEAMS



M-520A

At last, the antennas that you have been waiting for are here! The top quality, optimum spaced, and newest designed monobanders. The Wilson Systems' new Monoband beams are the latest in modern design and incorporate the latest in design principles utilizing some of the strongest materials available. Through the select use of the current production of aluminum and the new boom to element plates, the Wilson Systems' antennas will stay up when others are falling down due to heavy ice loading or strong winds. Note the following features:

1. Taper Swaged Elements — The taper swaged elements provide strength where it counts and lowers the wind loading more efficiently than the conventional method of telescoping elements of different sizes.
2. Mounting Plates — Element to Boom — The new formed aluminum plates provide the strongest method of mounting the elements to the boom that is available in the entire market today. No longer will the elements tilt out of line if a bird should land on one end of the element.
3. Mounting Plates — Boom to Mast — Rugged 1/4" thick aluminum plates are used in combination with sturdy U-bolts and saddles for superior clamping power.
4. Holes — There are no holes drilled in the elements of the Wilson HF Monobanders. The careful attention given to the design has made it possible to eliminate this requirement, as the use of holes adds an unnecessary weak point to the antenna boom.



Wilson's Beta match offers maximum power transfer.

With the Wilson Beta-match method, it is a "set it and forget it" process. You can now assemble the antenna on the ground, and using the guidelines from the detailed instruction manual, adjust the tuning of the Beta-match so that it will remain set when raised to the top of the tower. The Wilson Beta-match offers the ability to adjust the terminating impedance that is far superior to the other matching methods including the Gamma match and other Beta-matches. As this method of matching requires a balanced line, it will be necessary to use a 1:1 balun, or RF choke, for the most efficient use of the HF Monobanders.

The Wilson Monobanders are the perfect answer to the Ham who wants to stack antennas for maximum utilization of space and gain. They offer the most economical method to have more antenna for less money with better gain and maximum strength. Order yours today and see why the serious DXers are running up that impressive score in contests and number of countries worked.

SPECIFICATIONS

Model	Band Mtrs	Gain dBd	F/B Ratio	Bandwidth @ Resonance 2:1 VSWR Limits	VSWR @ Resonance	Impedance	Matching	Elements	Longest Element	Boom O.D.	Boom Length	Turning Radius	Surface Area (Sq.Ft.)	Windload @ 80 mph (Lbs.)	Maximum Mast	Assembled Weight (Lbs.)
M520A	20	11.5	25 dB	500 KHz	1.1:1	50 Ω	Beta	5	36'6"	2"	34'2½"	25'1"	8.9	227	2"	68
M420A	20	10.0	25 dB	500 KHz	1.1:1	50 Ω	Beta	4	36'6"	2"	26'0"	22'6"	7.6	189	2"	50
M515A	15	12.0	25 dB	400 KHz	1.1:1	50 Ω	Beta	5	25'3"	2"	26'0"	17'6"	4.2	107	2"	41
M415A	15	10.0	25 dB	400 KHz	1.1:1	50 Ω	Beta	4	24'2½"	2"	17'0"	14'11"	2.1	54	2"	25
M510A	10	12.0	25 dB	1.5 MHz	1.1:1	50 Ω	Beta	5	18'6"	2"	26'0"	16'0"	2.8	72	2"	36
M410A	10	10.0	25 dB	1.5 MHz	1.1:1	50 Ω	Beta	4	18'3"	2"	12'11"	11'3"	1.4	36	2"	20

WILSON SYSTEMS, INC. — 4286 S. Polaris
Las Vegas, NV 89103 — (702) 739-7401

FACTORY DIRECT ORDER BLANK

Toll-Free Order Number
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WILSON SYSTEMS ANTENNAS

Qty.	Model	Description	Shipping	Price
	SY33	3 Ele. Tribander for 10, 15, 20 Mtrs.	UPS	$139.95
	SY36	6 Ele. Tribander for 10, 15, 20 Mtrs.	UPS	189.95
	WV-1A	Trap Vertical for 10, 15, 20, 40 Mtrs.	UPS	44.95
	GR-1	Ground Radials for WV-1A	UPS	9.95
	M-520A	5 Elements on 20 Mtrs.	TRUCK	199.95
	M-420A	4 Elements on 20 Mtrs.	UPS	139.95
	M-515A	5 Elements on 15 Mtrs.	UPS	119.95
	M-415A	4 Elements on 15 Mtrs.	UPS	79.95
	M-510A	5 Elements on 10 Mtrs.	UPS	84.95
	M-410A	4 Elements on 10 Mtrs.	UPS	64.95
	WM-62A	Mobile Antenna: 5/8 λ on 2, ¼ λ on 6	UPS	19.95
		ACCESSORIES		
	HD-73	Alliance Heavy Duty Rotor	UPS	109.95
	RC-8C	8/C Rotor Cable	UPS	.12/ft.
	RG-8U	RG-8U Foam-Ultra Flexible Coaxial Cable. 38 strand center conductor, 11 guage	UPS	.21/ft.

Note: On Coaxial and Rotor Cable, minimum order is 100 ft. and in 50' multiples.
Prices and specifications subject to change without notice.
Ninety Day Limited Warranty. All Products FOB Las Vegas, Nevada.

WILSON SYSTEMS TOWERS

Qty.	Model	Description	Shipping	Price
	TT-45A	Freestanding 45' Tubular Tower	TRUCK	$219.95
	RB-45A	Rotating Base for TT-45A w/tilt over feature	TRUCK	119.95
	FB-45A	Fixed Base for TT-45A w/tilt over feature	TRUCK	79.95
	MT-61A	Freestanding 61' Tubular Tower	TRUCK	399.95
	RB-61A	Rotating Base for MT-61A w/tilt over feature	TRUCK	179.95
	FB-61A	Fixed Base for MT-61A w/tilt over feature	TRUCK	109.95
	STB-50	Thrust Bearing	UPS	18.95

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Other popular POWER SUPPLIES also available: (Same features and specifications as above)

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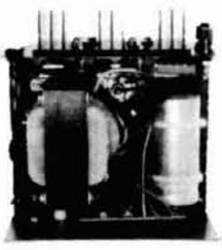
RS-35A	25	35	5 × 11 × 11	29	$138.95
RS-20A	16	20	5 × 9 × 10½	20	$94.95
RS-7A	5	7	3¾ × 6½ × 9	8	$49.95
RS-4A	3	4	3¾ × 6½ × 9	5	$39.95

*ICS — Intermittent Communication Service (50% Duty Cycle)
If not available at your local dealer, please contact us directly.



Inside View — RS-12A

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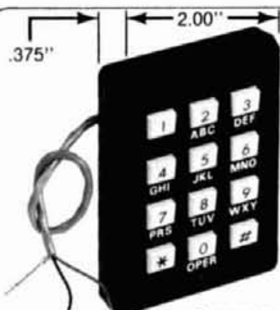
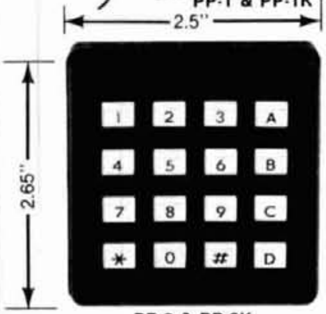


PP-1 & PP-1K



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See page 94 for super value on 1980 Callbooks.

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- **Gives reception of the 1750 meter band at 160-190 KHz where transmitters of one watt power can be operated without FCC license.**
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The converter moves all these signals to the 80 meter amateur band where they can be tuned in on an ordinary shortwave receiver.

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The VLF converter has crystal control for accurate frequency conversion, a low noise rf amplifier for high sensitivity, and a multipole filter to cut broadcast and 80 meter interference.

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- **Learn the truth about your antenna.**
- **Find its resonant frequency.**
- **Adjust it to your operating frequency quickly and easily.**

If there is one place in your station where you cannot risk uncertain results it is in your antenna.

The Palomar Engineers R-X Noise Bridge tells you if your antenna is resonant or not and, if it is not, whether it is too long or too short. All this in one measurement reading. And it works just as well with ham-band-only receivers as with general coverage equipment because it gives perfect null readings even when the antenna is not resonant. It gives resistance and reactance readings on dipoles, inverted Vees, quads, beams multiband trap dipoles and verticals. No station is complete without this up-to-date instrument.

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DEADLINE 15th of second preceding month.

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

WANTED: DEN-35 & AN/FRW-86 demods., TD-687 demux., and FM adapters for Knight TR-106 & 108. C.T. Huth, 146 Schonhardt, Tiffin, OH 44883.

NARDA Model 3002-10 coaxial directional coupler; 0.95-2.0 GHz; 2 type N connectors; brand new, boxed, $25. Arra type 3952-60 variable coaxial attenuator; 1.0-2.0 GHz; 0-60 dB; 2 type N connectors; brand new, boxed, $35. 7 pieces Waveline waveguide components; 2.6-3.95 GHz. List. Edward Halton, W1WB, Providence College, Providence, RI 02918.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

1/2" HARDLINE — 39¢/ft. October special for in stock 1050′ thru 1250′ rolls. 50Ω, with jacket. Solid copper center conductor. 500′ to 1000′ rolls, 45¢/ft. Freight collect. Connectors available. Info — SASE. JRS Electronics, (WA8OGS), P.O. Box 1893-A, Cincinnati, Ohio 45201.

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TECHNICAL MANUALS for Military Equipment. Government classification and nomenclature identification charts included with catalog, $1.00, Colonel Russell, 9410 Walhampton, Louisville, Kentucky 40222.

PORTA PAK — Make your FM mobile a self-contained portable. Models in stock for most popular makes. 4.5 amp hr model $80.00. 9 amp hr $103.00. Charger included, shipping extra. P.O. Box 67, Somers, WI 53171.

HAM MAGAZINES starting with 1940 for sale. QST, HR, 73, CQ. SASE for list. W8QX, Box 452, Birmingham, Michigan 48012.

KITS! ST5X Terminal Unit/Power Supply/AFSK. WRU. Rtty Scope Amplifier. Write for details: Bomark, Inc., Box 7116, Hollywood, Florida 33021. (305) 962-7219.

FIBERGLASS VAULTING POLES. Perfect Quad spreaders or VHF/UHF booms. SASE for info. K5WSE, Box 1032H, Cedar Park, TX 78613. (512) 259-2164.

ROHN RIGID TUBE TOWER, 160 ft., complete except guying $1600. Operational Heathkit HW-2036 2-Meter Transceiver with HD-1984 Micoder II $300. Sectional walk-up tower 4 ft. by 6 ft. by 48 ft. high $600. Jack Lauder, Rt. 3, Box 1, Marble Falls, TX. 78654. (512) 693-3033.

MUSEUM for radio historians and collectors now open. Free admission. Old time amateur (W2AN) and commercial station exhibits, 1925 store and telegraph displays, 15,000 items. Write for details. Antique Wireless Assn., Holcomb, N. Y. 14469.

LUNAR VHF AMPS/PREAMPS. 13.8 VDC (115 VAC input) continuous duty power supplies; 6 amp thru 30 amp models — $44.95 to $124.95. Coax — Times RG-213/U, 50Ω MIL type, 21¢/ft (400′ or more). Towers - Universal aluminum, self supporting. 25% off. Add shipping; COD accepted. SASE for info. JRS Electronics, (WA8OGS), P.O. Box 1893-A, Cincinnati, Ohio 45201.

MOBILE HF ANTENNA, 3.5-30 MHz inclusive, 750 watts PEP, center loaded coil, tuned from the base, eliminating coil changing or removing from mount. Less than 1.5 to 1 VSWR on all ham bands. $119.95 each — contact your local dealer or order from Anteck, Inc., Box 415, Route 1, Hansen, ID 83334. (208) 423-4100. Master Charge and VISA cards accepted. Dealer inquiries invited.

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

SELL: Triton IV w/CW filter, 262G VOX supply, microphone, ammeter and KR50 keyer, 2 yrs., mint condition. J. Smith WA4QOZ, 700 S.W. 16 Pl., Gainesville, FL 32601. (904) 392-4913.

QSL CARDS 500/$10. 400 illustrations, sample. Bowman Printing, Dept. HR, 743 Harvard, St. Louis, MO 63130.

NCX-5MKII, Rare Remote VFO VX-501, No P.S. — $350. WB6RSE. (213) 648-3455.

HAM RADIO REPAIR, alignment. Prompt, expert, reasonable. "Grid" Gridley, W4GJO, 3824 Malec Circle, Sarasota, Florida 33583. (813) 922-1781.

ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-012, Box 762, Plattsburgh, N.Y. 12901. SURPLUS WANTED.

FERRITE BEADS: w/specification and application sheet - 12/$1.00. Assorted PC pots - 10/$1.00. Miniature mica trimmers, 3-40 pF. - 5/$1.00. Postpaid. Includes latest catalog. Stamp for catalog alone. CPO Surplus, Box 189, Braintree, MA 02184.

PC BOARDS FROM HR ARTICLES up to 70% off. SASE's Only. RTC Electronics, Box 2514, Lincoln, Nebr. 68502.

RTTY AFSK Modulator PC board. See Feb. 79 Ham Radio. Drilled $5.00 F. E. Hinkle, 12412 Mossy Bark, Austin, TX 78750.

FOR SALE . . . BIRD model 43 wattmeter in good condition — $80.00. Charlie WD5DEI (915) 565-8174.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

WOULD YOU LIKE to become an Amateur Radio subdealer? We offer good pricing and service on over 50 major Amateur lines. Send letterhead for complete subdealer package. Thomas Communications, 95 Kitts Lane, Newington, CT 06111; or call 1-800-243-7765. (In Connecticut, call 1-203-667-0811).

More Details? CHECK — OFF Page 110

ERC PROMISES UP TO THE MINUTE STATE-OF-THE-ART DESIGN AND PERFORMANCE WE'VE DONE IT FOR 1979

FOUR SIMULTANEOUS FILTERS IN ONE FOR UNPARALLELED QRM FREE RECEPTION (SSB & CW)
PLUS A SPECIAL PATENTED CW PROCESSOR

SL-56
AUDIO ACTIVE FILTER
(3.5 + 5.5 + 7.5 INCHES)

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WARRANTED ONE YEAR FULLY RFI PROOF FULLY WIRED AND TESTED AVAILABLE NOW

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ERC INTRODUCES A BRAND NEW CONCEPT IN THE MEASUREMENT OF VSWR AND POWER ACCEPTED BY THE LOAD

REQUIRES 115 VAC AT LESS THAN 1/16 AMP.

COLLINS GRAY CABINET. WRINKLE PANEL - BRIGHT RED LED DIGITS (.33"). DECIMAL POINT IS THE PILOT LIGHT.

1.8-30 MHz

TWO SO-239 COAX CONNECTORS ARE AT THE REAR PANEL.

DIMENSIONS 3.5 x 5.5 x 7.5 INCHES.

WEIGHT IS 2 POUNDS.

THE MODEL SL-65* (20-2000 WATTS) AND THE QRP MODEL SL-65A* (0.2-20 WATTS) DIGITALLY INDICATE ANTENNA VSWR UNDER ANY TRANSMISSION MODE -- SSB, CW, RTTY, AM Etc. THERE IS NO CALIBRATION REQUIRED AND NO CROSSED METER NEEDLES TO INTERPRET. SIMPLY LOOK AT THE READOUT AND THAT IS THE VSWR. SPEAKING NORMALLY INTO A SSB TRANSMITTER MIC. INSTANTLY CAUSES THE VSWR TO BE DISPLAYED THROUGHOUT YOUR ENTIRE TRANSMISSION. REVERSING THE POSITION OF A FRONT PANEL TOGGLE SWITCH AND THE DISPLAY INDICATES THE NET POWER (FORWARD LESS REFLECTED) THAT IS ACCEPTED BY THE ANTENNA. THE PEAK OF THE NET PEP IS DETECTED AND DISPLAYED WITHOUT FLICKER FOR ANY MODULATION TYPE. DISPLAY UPDATE IS CONSTANT YET FLICKER FREE AS YOU MAY CHANGE THE POWER ACCORDING TO YOUR VOICE. THERE IS NOTHING LIKE THIS QUALITY INSTRUMENT AVAILABLE ANYWHERE ELSE. IT IS THE ONLY VSWR-NET POWER INDICATOR THAT LETS YOU KNOW THE STATE OF YOUR ANTENNAS AND TRANSMITTED POWER AT ALL TIMES WHILE TRANSMITTING. EITHER MODEL IS A SOPHISTICATED DEVICE CONTAINING FOUR CIRCUIT BOARDS AND THIRTEEN INTEGRATED CIRCUITS.

WARRANTY ONE YEAR

SL-65 VSWR INDICATOR

- TWO DIGIT DISPLAY SHOWS VSWR TO AN ACCURACY OF .1 FOR VALUES FROM 1.0 AND 2.2. ACCURACY IS TO .2 FOR VALUES FROM 2.3 TO 3.4 AND TO .3 FROM 3.4 TO 4.0. FROM 4.1 TO 6.2 THE INDICATION MEANS THAT VSWR IS VERY HIGH.
- FOR VSWR VALUES NEAR 1.0, THE POWER RANGE FOR A VALID READING IS 20 - 2000 WATTS OUTPUT. FOR HIGHER VALUES THE UPPER POWER LIMIT FOR A FLICKER FREE VALID READING IS SOMEWHAT LESS (35 - 1000 WATTS FOR VSWR AT 2.0).
- DIVIDE THE ABOVE POWER LEVELS BY 100 TO OBTAIN THE PERFORMANCE OF THE SL-65A QRP MODEL.

SPECIAL AUDIO VERSION AVAILABLE FOR THE SIGHTLESS • WRITE FOR DETAILS •

SL-65 NET POWER INDICATOR

- THE POWER DISPLAYED IS THE DETECTED PEAK OF THE PEP FOR ANY MODULATION. THIS IS THE POWER THAT THE TRANSMITTER IS "TALKED" UP TO. DISPLAY DECAY TIME IS ABOUT ONE SECOND.
- THE POWER DISPLAYED IS THAT WHICH IS ACCEPTED BY THE ANTENNA (FORWARD LESS REFLECTED).
- POWER IS DISPLAYED ON THE SAME TWO DIGITS AS VSWR IN TWO AUTORANGED SCALES. 20 TO 500 WATTS AND 500 TO 2000 WATTS. TRIPOVER AT THE 500 WATT LEVEL IS AUTOMATIC EX: A READING OF 1.2 COULD MEAN 120 OR 1200 WATTS. YOU MUST KNOW WHICH RANGE YOU ARE IN.
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VERY in-ter-est-ing! Next 3 issues $1. "The Ham Trader", Wheaton, IL 60187.

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DX, YOU BET! The DX Bulletin — Best weekly DX info in the world — send for FREE sample copy. K1TN, 306 Vernon Avenue, Vernon, Connecticut 06066.

NORTH AMERICAN DX REPORT — free sample — SASE to Suites R2-R3, 615 S. Frederick Ave., Gaithersburg, MD 20760 — Phone (301) 840-1987.

MOTOROLA — MICOM HF-SSB "consolette" base station. 2-18 MHz, 125 watts, 100-242 VAC (± 20%) 50/60 Hz. Condition: perfect, factory cert. Reg. $3800 — sell at $2300. Tektronix 1401A Spectrum Analyzer Module portable, use w/oscilloscope for spectrum surveillance, rfi testing, etc. Built-in recharger, batteries & 90-272 VAC 48-440 Hz. Cond: factory new. Reg. $4200 — sell at $1900. Commodities Research Corp., 250 W. 99 St., New York City 10025. Tel: (212) 222-3050. Intl. tlx. 420925 (Recov).

HEATH SB-101 TRANSCEIVER, HP-23B Power, SB-600 Speaker — all $395. SB-630 (SWR, Phone patch, Clock, etc.) $95. Sharp Heath CW filter $30. All mint. Also HAL CW keyboard in attractive Univac keypunch case $95. Satisfaction guaranteed on all. W4UKU Jerry Flanders, 411 Urquhart Dr., Beech Island, S.C. 29841. (803) 827-1629.

FOR SALE: Absolutely mint HW101 with CW and SSB filters, 110 VAC power supply and EV619 mic, $375.00. Joe Cecil, W5RIQ, 4908 Broken Bow Pass, Austin, Texas 78745.

RTTY — ST-5, NS-1A owners get increased selectivity with our bandpass active filter 2125/2295 Hz. HR 4/79. Kit $11.95, wired/tested $16.95 postpaid. SASE for info. Nat Stinnette Electronics, Tavares, FL 32778.

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WHO HAS AMATEUR RECEIVERS made by Barrett, Cardwell, Davco, Delft, Galaxy, Guthman, Hatry & Young, Hendricks and Harvey, Lincoln, McCulla, National Pfanstiehl, Postal, Radio Constructors, Ross, Silver, Tobe, Wireless Egert? Or marine receiver by Cardwell, Cutting and Washington, Heintz and Kaufman, Kilbourne and Clark, Simon Radio? Want photos and correspondence. H. L. Chadbourne, 530 Midway Street, La Jolla, CA 92037.

WANTED: TD-687/URR demux., AFSAV-39C keyer, & AN/FRA-86 demod. C. T. Huth, 146 Schonhardt, Tiffin, OH 44883.

CLUB CALL PINS 3 lines 1¼ x 3¼ $1.55 each. Call first, Name and Club. Colors Blue, Black, or Red with White letters. (Catalog) Arnold Linzner, 2041 Linden Street, Ridgewood, N.Y. 11227.

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MANUALS for most ham gear 1937/1970. Send 25¢ for "Manual Catalog." HI, Inc., Box H864, Council Bluffs, Iowa 51502.

More Details? CHECK — OFF Page 110

Coming Events

VIRGINIA: Fourth annual Tidewater Hamfest — Computer Show — Flea Market will be held in the Norfolk, VA Cultural and Convention Center SCOPE October 20 and 21, 1979. 60,000 square feet of airconditioned exhibit and Flea Market tailgating space are available. Doors open at 9:00 AM. ARRL meetings, DX, Traffic forums, plus a CW contest are scheduled. FCC Exams are planned for amateur upgrading Saturday 9-12 AM. A special-feature will be a dinner cruise and banquet on the Spirit of Norfolk Cruiseship Saturday night. Advance registrations $2.50 (SASE), $3.50 at the door. Flea Market tailgate spaces $3/day. Cruise and banquet $16 per person, $30 per couple. Tickets and information — TRC P.O. Box 7101, Portsmouth, VA 23707.

ARROWHEAD RADIO AMATEURS QSO PARTY: open to all Amateurs. Amateurs within 50 air miles of Duluth/Superior are considered Arrowhead Amateurs, and may work anyone. Amateurs outside this area may work only Arrowhead Amateurs for contact points. Call CQ ARAC-50. Frequencies: CW: 3535, 3725, 7035, 7125, 14035, 21035, 21125, 28035, and 28125 kHz. Phone: 3980, 7280, 14280, 21360, and 28560 kHz. Times: 1500 UTC, October 20, 1979 to 0300 UTC, October 21, 1979; and 1500 UTC to 2359 UTC, October 21, 1979. Arrowhead Amateurs exchange RS(T), county and state; all others send RS(T), ARRL section or country. More info from ARAC-50, 123 East First Street, Duluth, MN 55802.

TENNESSEE: Memphis Hamfest and ARRL Tennessee State Convention, Saturday and Sunday, October 13th and 14th, 1979 at Youth Building, Mid-South Fairgrounds. Exhibits, forums, FCC exams at 8 AM sharp on Saturday (bring completed Form 610 and copy of license), flea market ($3/day — tables free), dealers and manufacturers' displays, ladies' activities, and Saturday night party. Hourly prizes, Admission: $3 adults; children 14 and under, free. Trailer hookups available on site. Talk-in 146.34/.94 and 146.25/.85. For information including special motel accommodations, write Memphis Hamfest, P.O. Box 3845, Memphis, TN 38103.

MICHIGAN: 3rd Annual RADAR Swap & Shop, Radio & Electronics Equipment, Sunday, October 7, Kennedy High School, Taylor. Admission $2.00. 9 AM to 3 PM. Door prizes, refreshments. Talk-in 93-33, 52-52, 99-39. Write: RADAR, Inc., P.O. Box 1023, Southgate, MI 48195.

INTERNATIONAL POLICE ASSOCIATION RADIO CLUB contest open to all Radio Amateurs and SWLs for the Sherlock Holmes Award. Saturday, November 10, 1979: 0800-1000, 1400-1700, 1800-2000 UTC; and Sunday, November 11, 1979: same hours. Call CW IPA; mode SSB and CW. No crossband, no crossmode. Members exchange IPA + RS(T) and serial number of contact; non-members exchange RS(T) and serial number. Frequencies: CW: 3575, 7025, 14075, 21075, 28075 kHz +/− 25 kHz; SSB: 3650, 7075, 14295, 21295, 28650 kHz +/− 25 kHz. Information from Vince Gambino, WB4QJO, 7606 Kingsbury Road, Alexandria, Virginia 22310.

QRP A.R.C. INTERNATIONAL QSO PARTY, from 2000 UTC, Saturday, October 6th to 0200 UTC, Sunday, October 7th 1979. Members exchange RS(T), State, Province, Country and QRP Number; non-members exchange RS(T), State, Province, Country and power input. Stations worked once per band and call CQ QRP. Frequencies: CW: 1810, 3560, 7060, 14060, 21060, 28060, 50360; SSB: 1810, 3985, 7285, 14285, 21385, 28885, 50385; Novice: 3710, 7110, 21110, 28110. All frequencies +/− 5 kHz. More information from QRP A.R.C., Contest Chairman, Sandy Blaize, W5TVW, 417 Ridgewood Dr., Metairie, Louisiana 70001.

NEW YORK: LIMARC's Hamfair '79, Sunday, October 14, Islip Speedway, Route 111 (Islip Ave.) 1 block south of Southern State Parkway, Exit 43. 9 AM to 4 PM. Loads of door prizes with special categories. Contests. Admission: $1.50; $3.00 per seller's space (admits one person). All Hams must pay admission, others free. For information: Hank Wener, WB2ALW nights (516) 484-4322 or Sid Grossman, N2AOI nights (516) 681-2194.

INDIANA: Allen County Amateur Radio Technical Society's Fort Wayne Hamfest, Allen County Memorial Coliseum, off U.S. 30 northeast of Ft. Wayne, November 18. Set-up 6 AM. Public admitted 8-4:30 PM. Programs for spouses. Camping facilities, nearby motels. For info: AC-ARTS, Victor M. Locke, 1415 Edenton Dr., Fort Wayne, IN 46804. (219) 432-8047.

MICHIGAN: The Central Michigan Amateur Radio Club and The Lansing Civil Defense Repeater Ass'n's Ham Fair '79, Sunday, October 14, Grand Ledge High School 7 miles west of Lansing. Fly-in service, shuttle service, cafeteria, prizes, computer programs, XYL activities, programs of special interest. Talk-in on 34/94, 22/82, and 52. For information: Ham Fair '79, P.O. Box 138, Bath, MI 48808. (517) 641-4533.

MICHIGAN: 25th Annual VHF Conference, Saturday, October 27, 1979 at the I & ET Building, Western Michigan University. Topics include Non-Yagi VHF Antennas, A New Method of Tuning the Baseloaded VHF Whip, and Microprocessor Basics for Amateurs. Dinner (by reservation only — Deadline date October 24th) at University Student Center. Registration $2, dinner $7. Make checks payable to Electrical Engineering Department, WMU, Kalamazoo, MI 49003.

TEXAS: Confederate Air Force Airsho '79, October 4-7, Harlingen, TX. Airborne mobile operation from WWII B-29 bomber. Try 14,285 and 21,385 kHz between 12 noon and 5 PM Central time. Commemorative QSL card for QSOs.

MASSACHUSETTS: The Framingham Area Radio Association's indoor electronic flea market, Sunday, November 11, Framingham police drill shed behind the police station. Sellers set-up 9 to 10 AM. Doors open 10 AM to 2 PM. Advance table reservations $5.00. Tables at door $7.50 (if available). Talk-in 75-15 and 52 direct. Refreshments available. Information or reservations: Framingham Area Radio Assoc., P.O. Box 3005, Framingham, MA 01701.

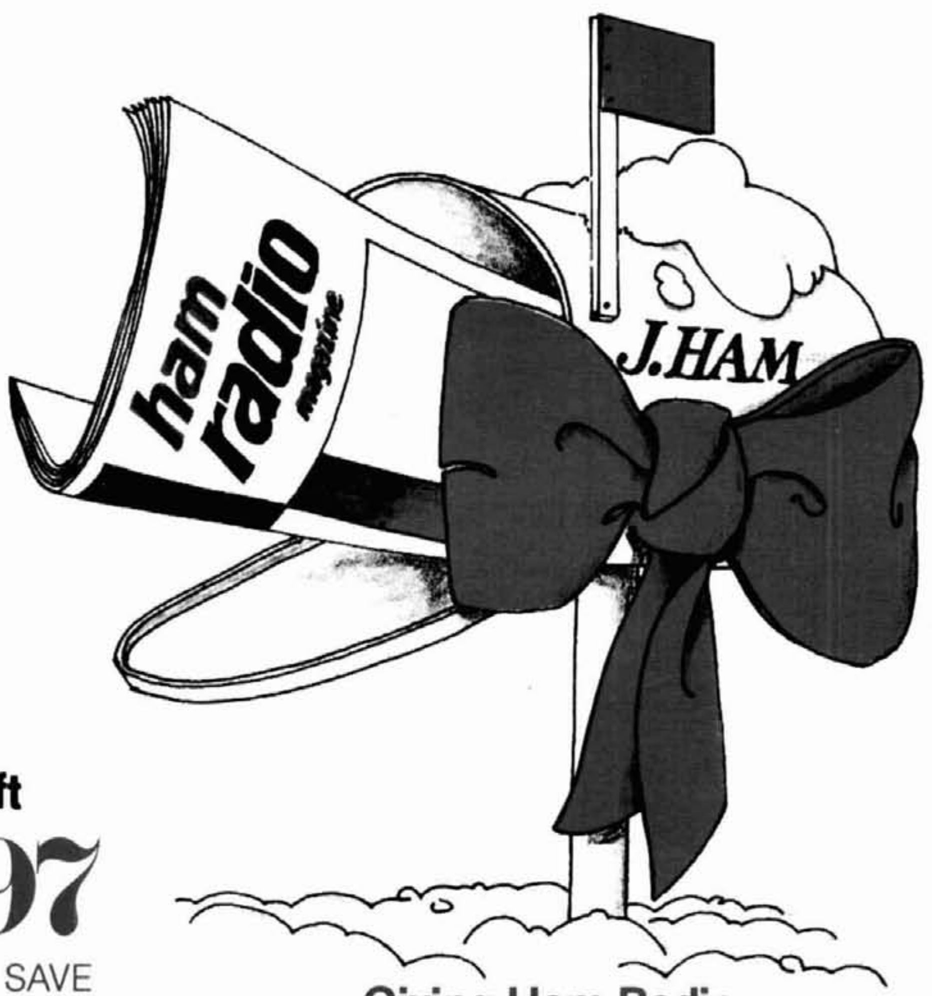
FLORIDA: The Florida Gulf Coast Amateur Radio Council's ARRL State Convention, November 17 and 18, Sheraton Sand Key in Clearwater Beach. Exhibits, forums, technical sessions and more. Ladies' forum, Sunday Luncheon and Fashion Show. Banquet Saturday evening. For information: The Florida Gulf Coast ARC, P.O. Box 157, Clearwater, FL 33517.

PENNSYLVANIA: The Foothills ARC, Greensburg, will be celebrating it's 20th anniversary by holding a Mini-Field Day, Saturday, October 20, 1400 UTC thru 1400 UTC on October 21. Phone and CW operation on 10 thru 80 meters, 5-10 KC up from bottom of General Class portion of each band. Certificates will be awarded to anyone working W3LWW. SASE required.

CALIFORNIA: ARRL Southwestern Division Convention, October 19, 20, 21, 1979 at the Sheraton-Anaheim Hotel located at Ball Road and Interstate 5 in Anaheim, California. Friday, 4 PM - 9 PM; Saturday, 8 AM - 3:30 PM; 4 PM to 5:30 (ARRL Forum); 5:30 - 7:30 PM cocktail party; and 7:30 PM Banquet. Sunday, 00:01 AM P.S.T. the WOUFF HONG Pageant; 9 AM breakfasts, and exhibits until noon. For more information and pre-registration, contact: HAMCON, P.O. Box 1227, Placentia, CA 92670. (714) 993-7140.

More Details? CHECK—OFF Page 110

Gift Ham Radio this year and Save



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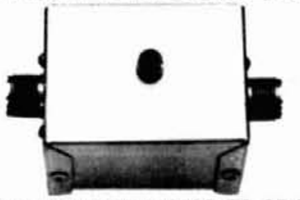

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5600A-W	$179.95									
3550	99.95	50Hz-550MHz	TCXO 1 PPM 17°-40°C	25MV	25MV	75MV	8	.5 Inch	*115 VAC or 8.2-14.5 VDC	2⅛" x 8" x 5"
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					17° - 40°C	0° - 40°C	100 Hz - 25 MHz	50 MHz - 250 MHz	250 MHz - 450 MHz	No.	SIZE IN INCHES	.1 SEC	1 SEC
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CSC‡	MAX-550	$149.95	1kHz-550MHz	Non-Compensated	3 PPM @ 25°C	8 PPM	500 MV*	250 MV	250 MV	6	.1	NA	1 kHz
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* 1 KHz - 50 MHz ‡ Continental Specialties Corp.

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DUNES HOTEL & COUNTRY CLUB

Las Vegas, Nevada

JANUARY 10-13, 1980

BIG HAM SHOW

What's all the chatter and noise we hear?
It's HAMS! Checkin' out mobile gear.
It's SAROC time in the gamblin' State
Send your reservations in, before it's too late.
January 10 thru 13 that's the time to go
To see ham friends and attend a show.
The YL's will love it — so much to do
One arm bandits and a luncheon too.
There's a great first prize — Many others, as well
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You missed the ham convention that's rated best.
So let's get ready, get set and go
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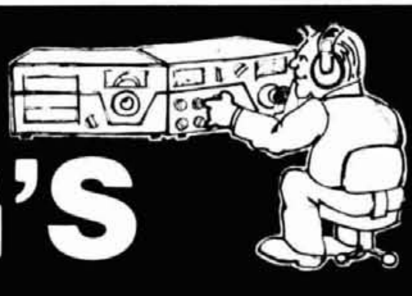

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KENWOOD

KENWOOD TR-7625 25W transceiver

The unit has memory channel with simplex or repeater operation ± 600 KHz transmitter offset, mode switch for switching the transmit freq. up or down, full 4 MHz coverage on 2m (144.00-147.995), 800 channels, 5 KHz offset switch, MHz selector switch, digital freq. display, unlock indicator for transceiver protection.

425.00 List. Call for quote.

KENWOOD RM-76 microprocessor control unit

125.00

List. Call for quote.

KENWOOD TR-7600 2m FM transceiver

Featuring full 4 MHz coverage 144-148, 800 channels, 10W RF output/1W Lo, memory channel with simplex or repeater offset, 13.8 VDC at 3 A continuous. Also LED freq. display, tone pad terminal and band pass filter. RM-76 microprocessor unit avail.

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KENWOOD MC-45 touchtone mic

Touchtone circuit provides PTT (push to talk) with ½ second hangtime after any button is pushed. Dynamic, omnidirectional, 500 ohm impedance mic with adjustable tone output level. Power requirement: 8 VDC, 20 mA. Complete with coiled cord and 5 pin mic connector. Compatible with the TR-7600 and TR-7625 with no modification.

49.95 Call today.

ICOM IC-280 remotable 2m mobile transceiver

The main PLL control head may be detached and remotely mounted. The unit with the microprocessor stores 3 frequencies even after power is turned off. Frequency: 143.90-148.11 MHz, power, 10 watts Hi/1 watt adjustable Low. Power requirements: 13.8 VDC at 2.5 amps. Large easy to read LED's.

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YAESU CPU-2500RK 2m FM transceiver

800 PLL chs. automatic scan over entire 2m band, 4 memories, tone burst, 25 W hi/3W lo @ 13.6 VDC at 8 amps cont. Freq.: 144-148 MHz. Keyboard mic allows remote input of memory or dial freqs., up/down scanning control, aux. repeater split selection to 4 MHz.

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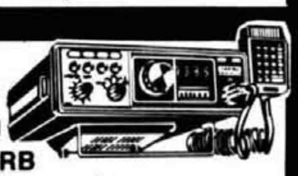

YAESU FT-227RB 2m FM transceiver

This has 4 memory channels, a remote scan from mic, can select to scan clear or busy channel, a frequency coverage of 144 to 148 MHz, 800 channels, power requirements: 13.8 VDC @ 2.5 amps continuous, RF output: 10W hi/1W lo, toneburst ± 600 KHz repeater offset. Complete with YM-22 touch tone mic.

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ICOM IC-215 2m FM transceiver

Features: 15 channel capacity, MOS FET RF amplifier and 5 tuned circuits in the front end for optimum sensitivity and selectivity, S-meter on front panel, dual power level, 3W Hi for long distance, 0.5W Low for local. 13.8 VDC, uses C batteries or rechargeable battery pak, BC-20.

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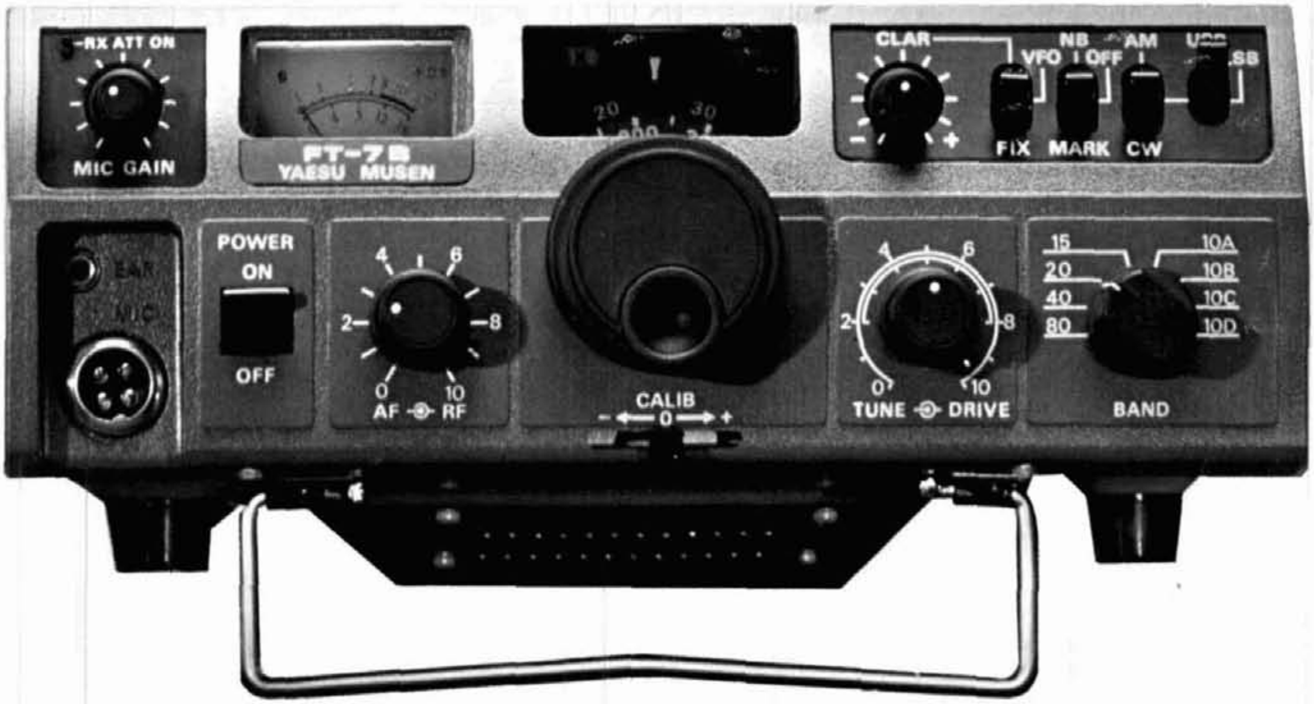

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Sensitivity: 0.5uV for S/N 20 dB
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IF rejection: Better than 50 dB
Selectivity: -6 dB: 2.4 KHz, -60 dB; 4.0 KHz
Cross-modulation: Better than 60 dB immunity at 20 KHz off a 20 dB input signal typical
Audio output: 3 watts @ 10% THD

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Emission: LSB, USB (A3j), CW (A1), AM (A3)
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Spurious emission: Better than -40 dB
Distortion products: Better than -31 dB

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Designed for rugged service.

The new desktop Heathkit SB-221 linear amplifier provides up to 2000 watts PEP input for SSB and 1000 watts input for CW service. Only 100 watts drive power is required to achieve these power levels.

Designed for rugged contest and traffic service, the SB-221 uses the highest grade components including two EIMAC 3-500Z high gain power triodes, well-known for their reliable, efficient performance. One thousand watts of plate dissipation is available from the two tubes, providing ample safety factor for long life service.

The designer's choice.

Top-notch equipment designers, such as Heathkit, choose EIMAC power tubes for commercial as well as amateur products. The 3-500Z power tube used in the SB-221 also serves in many commercial broadcast, FM and point-to-point radio systems where reliability and long life are paramount.

Make sure this fine EIMAC 3-500Z is in your equipment. For full details and a data sheet on the 3-500Z, write Varian, EIMAC Division, 301 Industrial Way, San Carlos, CA 94070. Or contact any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.

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