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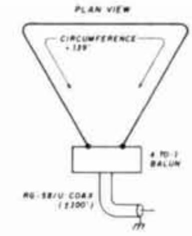

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See page 74 for the winners of February's Weekender contest.

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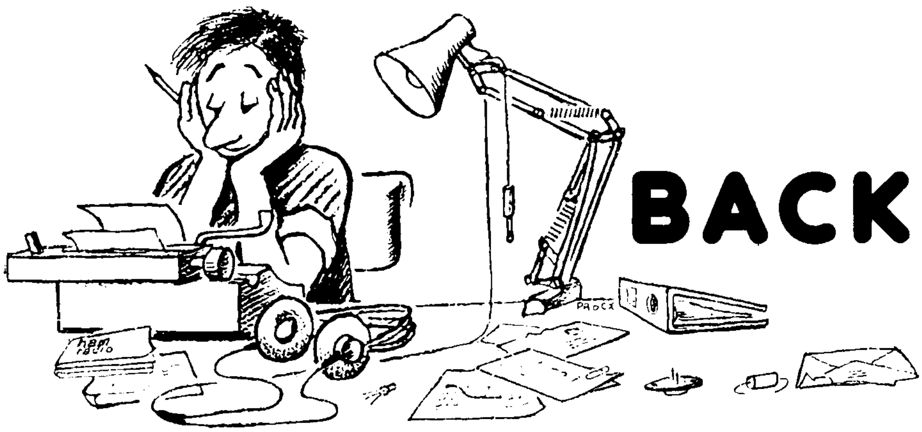

BACKSCATTER

Changes...1989 update

Close to a year ago, we set out to make *Ham Radio* the number one magazine in the Amateur Radio field. It's been a long, difficult process fraught with pitfalls and setbacks, but we are well on our way.

It will take time to reach our goal, but we can do it with your help. The children's story "The Little Engine That Could" reflects HR's aspirations. The competition is tough. We know we must work very hard at tailoring the magazine's content to please you. That's why we've been asking you, our readers, what you think of our changes. The responses to our reader surveys and evaluation cards have been outstanding. Over 95 percent of you approve of what we've been doing. To be fair, there are those of you who aren't happy. We hope that in time, we can win you over too!

To our effort to serve you, we pay strict attention to all reader comments. In the past two years, your letters to us have asked for MORE PROJECTS and CONSTRUCTION please! And so we began the process of redirecting HR to fill your needs in that area. This process isn't easy. As many of you already know or are learning, it's often difficult to get parts. It's also difficult to get authors to write about their construction projects. We do feel that we have an excellent group of authors writing for us now, but there's always room for more.

HR is a reflection of you, our reader. While a significant number of you are technically oriented and look to HR for electronic information, you're also Hams — men and women who take their love of radio and communications home every night. Some of you do little but tinker and test. Others are "die-hard" contesters who can't wait for the next major event. Some of you bemoan the departure of tubes. Others are immersed in the latest digital state-of-the-art electronics. In short, your interests run from Alpha to Omega.

When Jim Fisk, W1DTY and Skip Tenney, W1NLB, started *Ham Radio* in 1967, their goal was to mail a magazine that stayed away from politics and delivered nothing but the best in technical Amateur Radio subjects. During it's first ten years, HR met that goal. Unfortunately, Jim's untimely death in 1980 upset the formula and it's taken us a few years to get back on track. Under Rich Rosen's, K2RR, guidance HR once again re-established itself as the Amateur's technical magazine. Now Marty Durham, NB1H, Bob Wilson, WA1TKH, and Terry Northup, KA1STC, are working very hard to ensure HR includes only the very best technical articles every month.

Our new look, created by local graphic artist Ann Desmarais, is designed to make HR more readable. While consistency is safe, a design change was necessary. HR looked like it was locked in a 1968 time warp. The new logo is a bold statement of HR's commitment to quality. The inside layout is clean and easy to read. The type was selected to compliment the text and other material, not fight it. The page layout was modified to take maximum advantage of the space on each page. The only complaint we've received about our graphics changes is that some of you find them too drastic, too bold. The bars over the figures are distracting to a few readers. Others have told us they find the bars help them locate and identify figures and schematics. We'll keep working to refine these changes to meet your needs.

So what's the bottom line? You've asked us to not become a clone of the other magazines. HR has met that goal. By staying in our niche of construction and projects, HR can continue to deliver what you want. But we need and want your comments. Write, call, look us up at Hamfests — TALK to us! Keep letting us know what you like and dislike. This is your magazine. Tell us how can we make it better for ***YOU***!

Craig Clark, N1ACH

COMMENTS

Another satisfied customer

Dear HR

I just received January, 1989 — a superior piece of work that is as good as any you have ever published. The article mix had something for most enthusiasts (HF synthesizer, 3456-MHz through ATV) and the articles had some guts. Not everyone is going to run out and build Dave's (WA3JUF) 3456 rig, but almost everyone reading an article like that is bound to at least learn something new. Nice job by John Shelley, WA1IAO on ATV — get some more pieces like that out of him.

As difficult as it is to avoid the standard cliches, keep that kind of material coming. Could be your best issue ever — I have them all.

John W. Molnar, WA3ETD,
Milford, New Hampshire 03055

Points to ponder

Dear HR

I'd like to make a few observations. First, even though the "Short Circuit" (page 35, October issue) does appear at the end of an article in the series to which the correction applies, it would be a thoughtful touch to include the information reference on the "Contents" page. This is of future help when your memory says there was one, but you don't remember where for certain.

I note an apparent shift to computer program coverage relating to the "clones." There is usually a statement or at least an inference that no great problem should exist in converting BASIC programs to other machines, and this is probably true. However, in view of the popularity of the C-64 in the ham fraternity, would it not be thoughtful to include an already "converted" C-64 version?

Thanks for listening.

John E. Runninger, WB2LCP,
Rome, New York 13440

Gremlins?

Dear HR

A gremlin somehow must have snuck into The Weekender column "Get the Most From Your NiCads" (December 1988). The caption for Photo A is on Photo C; Photo B's caption is on Photo A; and Photo C's caption is on Photo B. Otherwise it was a very interesting article!

Bill Wornham, WA1CRE,
Townsend, Massachusetts 01469

Information for all

Dear HR

I wish to congratulate you on the improvement of your *Ham Radio* articles this past year. They are more informative for the new hams as well as the older ones.

I am not going to single out any writer, but I feel the articles for the younger hams are important these days too and I think some of the other ham magazines have forgotten this fact.

I want to draw your attention to the odd article that should have been checked for accuracy or edited.

Keep up the good work.

E. W. Forster,
Blaine, Washington 98230

Great February Cover

Dear HR

The February *Ham Radio* cover was great. Haven't seen anything like it since the days of Phil Gildersleeve and Clyde Darr of early QST days...

Congrats!

Bruce Kelley, W2ICE,
American Wireless Association, Inc., Holcomb, New York 14469

The last hurrah

Dear HR:

It isn't often one hears a ham on the air performing outstanding services for other hams. I know of one who gives of himself tirelessly, without letting up; without regard to his personal health or equipment he's steadfastly at his key, carrying out his mission. Most surely, the deity had called upon him to fulfill his destiny at the controls of his station.

It happened early one January morning around 1300 GMT on 7005 kHz during the Mellish Reef DXpedition operation. His signal was strong and his fist rang out in flawless CW, "UP 5..UP 5!" And occasionally, to remind us of our humble beginnings in radio, he would embellish, "UP 5..UP 5 LID!" Oh, if only to have had him for an Elmer in another time. I could tell he was becoming fatigued; this monumental task was taking its toll. His timing became ragged and he was not coming down on his key precisely when the DX operator started sending, resulting in many operators being able to hear Mellish Reef coming back to their call. I knew he wouldn't be able to keep up the frantic pace. It was kind of like the death throes of Kipling's Gunga Din, the immortal regimental bugler. In a last hurrah of "UP 5..UP 5", with tongue lolling, finals red hot, his hand slipped off the key and his signal drifted off.

Seldom can we pay tribute to such an operator, an enduring essence of QRM, virtually a pure flux of Hertzian generated disturbance. Wherever you are, out there in the QSB, here's to you, "traffic cop!" You're a better man than I am!

Don Longacre, NW2V
Caledonia, New York 14423

MFJ TUNERS

Here is the finest 3 KW PEP Tuner money can buy with roller inductor, dummy load, *new* peak reading meter, antenna switch, balun and more ...

The MFJ-989C is not for everyone. **However,** if you do make the investment you get the finest 3 KW PEP tuner money can buy - one that will give you a lifetime of use, one that takes the fear out of high power operation and one that lets you get your SWR down to absolute minimum.

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MFJ-989C **$349.95**

You get a **new** lighted **peak** and average reading Cross-Needle SWR/Wattmeter with a **new** more accurate directional coupler.

You get a giant two core balun wound with teflon wire for balanced lines and a 6-position antenna switch with extra heavy switch contacts.

Its compact 10¾x4½x15 inch cabinet fits right into your station.

You get a 50 ohm 300 watt dummy load for tuning your exciter, a tilt stand for easy viewing and a 3-digit turns counter plus a spinner knob for exact inductance control. Add $10 s/h.

2-knob *Differential-T*™ Tuner

MFJ-986 **$269.95** The **new** MFJ-986 Differential-T™ 3 KW PEP 2-knob Tuner has a differential capacitor to make tuning foolproof and easier than ever. It ends constant retuning with broadband coverage and gives you minimum SWR at only **one** best setting. Covers 1.8-30 MHz.

The roller inductor lets you tune your SWR down to absolute minimum. A 3-digits turns counter lets you quickly return to your favorite frequency.

You get MFJ's **new** peak and average reading Cross-Needle SWR/Wattmeter with a **new** directional coupler for more accurate readings over a wider frequency range. It reads forward/reflected power in 200/50 and 2000/500 watt ranges. Meter lamp is front panel switched and requires MFJ-1312, $9.95.

A **new** current balun for balanced lines reduces feedline radiation and forces equal currents into antenna halves that are not perfectly balanced for a more concentrated, stronger signal. Add $10.00 s/h.

MFJ's *Fastest Selling* Tuner

MFJ-941D **$109.95** **The MFJ-941D is MFJ's fastest selling 300 watt PEP antenna tuner. Why? Because it has more features than tuners costing much more and it matches everything continuously from 1.8-30 MHz.**

It matches dipoles, vees, verticals, mobile whips, random wires, banlanced and coax lines.

SWR/Wattmeter reads foward/reflected power in 30 and 300 watt ranges. Antenna switch selects 2 coax lines, direct or through tuner, random wire, balanced line or tuner bypass. Efficient airwound inductor gives lower losses and more watts out. Has 4:1 balun. 1000 V capacitors. 10x3x7 inches.

MFJ's *Random Wire* Tuner

MFJ-16010 **$39.95**

You can operate all bands anywhere with any transceiver when you let the MFJ-16010 turn any random wire into a transmitting antenna. Great for apartment, motel, camping operation. Install a wire anywhere! Tunes 1.8-30 MHz. 200 watts PEP. Ultra small 2x3x4 in.

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MFJ-949C **$149.95** The MFJ-949C gives you more precise matches than any tuner that uses two tapped inductors. Why? Because you get two **continuously** variable capacitors that give you infinitely more positions than the **limited** number on switched coils.

This gives you the precise control you need to get your SWR down to a minimum. After all, isn't that why you need a tuner? Covers 1.8-30 MHz.

You also get MFJ's lighted 2-color Cross-Needle SWR/Wattmeter, 6-position antenna switch, 50 ohm 300 watt dummy load and a built-in balun - all in a compact 10x3x7 inch cabinet that fits right into your station. Meter light requires MFJ-1312, $9.95.

With MFJ's **best** 300 watt PEP tuner you get an MFJ tuner that has earned a reputation for being able to match just about anything - one that is highly perfected and has years of **proven** reliability.

MFJ's *Mobile* Tuner

MFJ-945C **$89.95**

Don't leave home without this **mobile** tuner! Have an uninterrupted trip as the MFJ-945C **extends your antenna bandwidth** and eliminates the need to stop, go out and adjust your mobile whip.

You can **operate anywhere in a band and get low SWR.** You'll get maximum power out of your solid state or tube rig and it'll run cooler and last longer.

Small 8x2x6 inches uses little room. **SWR/ Wattmeter and convenient placement of controls make tuning fast and easy while in motion.** 300 watts PEP output, efficient airwound inductor, 1000 volt capacitors. Mobile mount, MFJ-20, $3.00.

144/220 MHz VHF Tuners

MFJ-921 **$69.95**

MFJ's new VHF tuners cover both 2 Meters and the 220 MHz bands. They handle 300 watts PEP and match a wide range of impedances for coax fed antennas. SWR/Wattmeter. 8x2½x3 in. **MFJ-920, $49.95.** No meter. 4½x2½x3 inches.

MFJ

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MFJ's *Artificial* RF Ground

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You get two husky **continuously** variable capacitors for maximum power and minimum SWR. And lots of inductance gives you a wide matching range.

You get MFJ's **new** peak and average reading Cross-Needle SWR/Wattmeter with a **new** directional coupler for more accurate readings over a wider frequency range. It reads forward/reflected power in 200/50 and 2000/500 watt ranges. Meter lamp is front panel switched and requires MFJ-1312, $9.95.

Has 6-position antenna switch and a teflon wound balun with ceramic feedthru insulators for balanced lines. 10¾x4½x14 7/8 inches. Add $10.00 s/h.

MFJ's *smallest* Versa Tuner

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BUILDING A DIGITAL FILTER

FIR filter features guaranteed phase linearity

By **Paul Selwa, NB9K,** 61 East Tilden Drive, Brownsburg, Indiana 46112

Digital filters provide high-performance designs with properties that can't be provided by analog filters. These properties include: stability, no tweaking, repeatability, insensitivity to temperature, and the guaranteed linear phase response of Finite Impulse Response (FIR) filters. This last characteristic is required in narrow bandpass filters for phase-shift encoded digital data like that used on the Mode-S transponder in the Phase 3C satellite.

Digital filters aren't new, but it's only recently that the inexpensive ICs needed to build them have become available. The main hardware impediment has been the lack of low-cost digital multipliers. In software, the problem has been the lack of inexpensive programs to determine the filter's coefficients. Optimal filter designs require extensive iterations and aren't practical for manual calculation.

This article provides information about the construction of FIR digital filters. You can construct the hardware if you have a general knowledge of digital techniques. I can provide you with a program which calculates the coefficients for FIR filters of up to 128 taps.

FIR filters

There are various types of digital filters; the FIR filter is the most useful. This filter is unconditionally stable and has guaranteed linear phase response. It's resistant to the effects of noise, because any noise components are in the filter only until a new set of data samples has been taken. It's also the type of digital filter least sensitive to the effects of the precision (length) of the filter coefficients.

IIR filters

The other popular digital filter is the Infinite Impulse Response (IIR) filter. Because a portion of an IIR filter's output is fed back into the filter, any disturbance at the output is partially present in all subsequent outputs until the filter is deliberately cleared and the process is repeated. Another concern with IIR filters is their highly nonlinear phase response. For phase-dependent modes of communication, like phase-shift encoded data in digital transmission, the data may be garbled and no subsequent filtering will completely remove the distortion.

FIR filter construction

A FIR filter consists of the following sections:

- A low-pass filter (LPF) limits the bandwidth of the signal. This is called an anti-aliasing filter.
- An analog-to-digital converter (ADC). It may need to be preceded by a sample-and-hold circuit if its conversion time is long.
- A data memory that saves the digitized samples of the signal. Data is often saved in two's complement (2C) form for compatibility with hardware multipliers.
- A set of filter coefficients that are used to multiply the data memory's samples. These are often called filter taps and are usually stored in 2C form.
- An accumulator that contains the sum-of-product terms that are generated by multiplying the data memory contents by the filter's coefficients.
- A multiplier chip, or a processor with multiplying capability. Multiplier accumulators (MACs) are common.
- A digital-to-analog converter (DAC) to change the filter's digital output word to an analog signal.
- A low-pass filter to remove clock noise from the DAC's output. It is called a reconstruction filter and has the same bandwidth as the anti-aliasing filter.
- A controller to coordinate the actions of these pieces of hardware. It can be as simple as a PROM, containing control bits with a counter to read out the PROM's words sequentially, or it can be an actual digital signal processor like the Texas Instruments TMS32010 with its own program.

You can build a compact system, like the TI-based system shown in **fig. 1**, with a few LSI chips. This version requires an assembled program for the TMS32010 processor. The coefficients are in the program PROM and the data memory is on the processor chip. The anti-aliasing filter, the ADC, the DAC, and the reconstruction filter are in the TLC32040.

A more efficient implementation for home assembly consists of two GE chips made for FIR applications. The ISP9128 is a FIR controller and the ISP9210 is a MAC. These two chips do most of the work for you. The approximate cost of this pair is $80.

Aliasing

Any digital filter has a bandwidth limitation that's set by the sampling rate of the input ADC. To prevent aliasing, the sampling frequency must be at least twice the bandwidth of the anti-aliasing filter. The folding frequency is defined as exactly one-half the sampling rate and is theoretically the maximum frequency that the filter can handle without aliasing problems. This frequency is often referred to as the Nyquist frequency or rate. It's called the folding frequency because the sampler's output frequency components have mirror symmetry around that frequency.

When a signal is being sampled at a given rate, the signal's components are duplicated above and below each harmonic of the sampling frequency, just as they would appear as sidebands of AM transmitters operating at those frequencies.

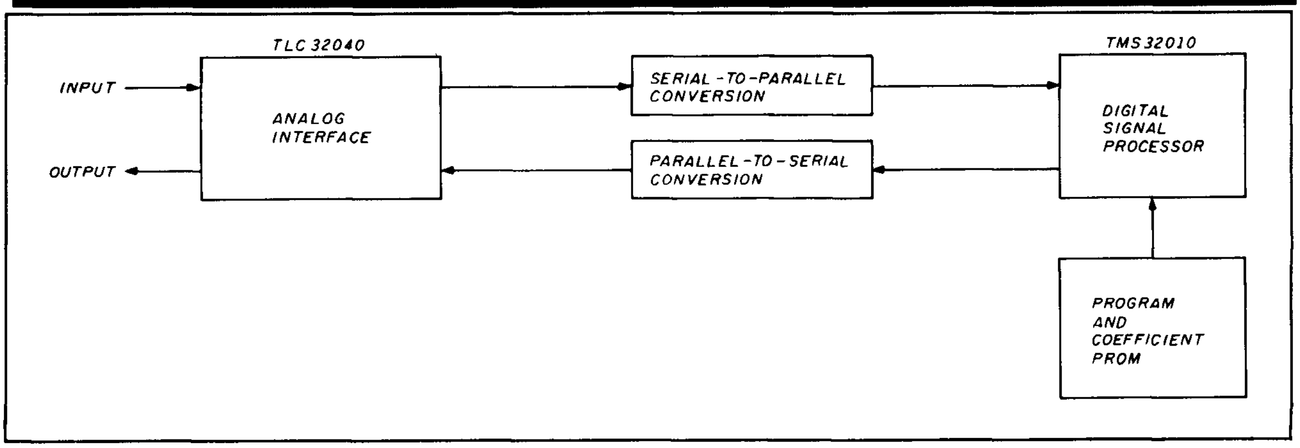
The only one you need to worry about is the fundamental sampling frequency. If you have a sampling rate of 10,000 Hz and a signal of 1000 Hz you'd get spurious outputs from the sampler at 9000 Hz (10,000 – 1000 Hz) and at 11,000 Hz (10,000 + 1000 Hz), in addition to the baseband signal of 1000 Hz. If you raised the input signal's frequency to 4999 Hz, the sampler would produce sideband components at 5001 Hz and at 14,999 Hz, and also preserve the 4999-Hz baseband signal. At an input frequency of 5000 Hz you'd be unable to distinguish between the real signal and the sideband of 5000 Hz (10,000 – 5000 Hz) from the sampling signal's carrier. As you further increase the input frequency, the lower sideband copy of the input signal takes on the alias of a lower frequency input signal. That's why the LPF precedes the ADC.

Anti-aliasing filters

These filters can be passive or active. While the theoretical cut-off frequency of the LPF can be at the folding frequency, any practical filter has finite rolloff. You can't get away with using a sampling rate that's barely twice the highest frequency component you pass through the LPF. Practical anti-aliasing filters have cut-off frequencies of approximately one-third the sampling rate, so the LPF's response will be down 40 dB or more at the folding frequency. For voice communications that require bandwidths of 2500 Hz, you'll see sampling rates of 8000 Hz or greater. For other modes, like CW which needs no more than 1000-Hz response, you can get away with a sampling frequency of 3000 to 5000 Hz.

A poor choice of anti-aliasing filter can upset your FIR system's operation. If you depend on the inherent linear phase response of the FIR structure, use a linear phase (flat group delay) LPF for anti-aliasing and for the reconstruction filter. An easy way to obtain flat group delay is to use the EXAR XR-1003/1004 — a switched-capacitor low-pass Bessel filter. These filters preserve the information in phase-shift encoded data. Another advantage of using switched-capacitor filters is that you can divide the sampling clock to drive the LPF and you'll automatically be in the correct ratio with respect to the sampling rate. That may not be important in a system using a single sampling rate, but for a dynamically reconfigurable system you won't have to worry that the anti-aliasing LPF is at the wrong bandwidth.

FIGURE 1

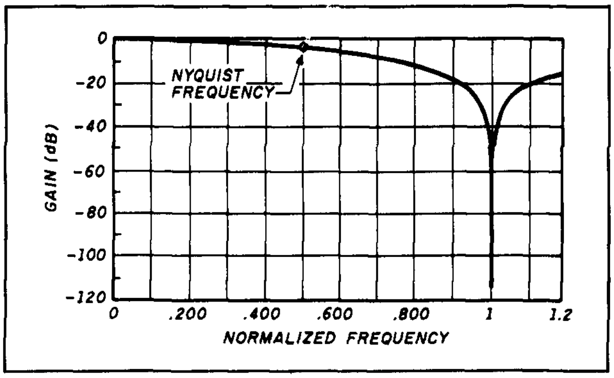


One-chip digital signal processor implementation.

ADC

The ADC is one of the simpler system blocks, but distortion is introduced in the converted number — called the (sin X)/X error — where X = pi • input frequency/sampling frequency. The ratio (sin X)/X is equal to 1 for X = 0 (DC signal), and gradually drops to zero when the input frequency is equal to the sampling frequency. The loss at the Nyquist frequency is 3.9 dB, as shown in **fig. 2**. For normal communications work, the relative reponse across the audio band is of little importance; you can ignore this factor without a problem. This is especially true if the sampling rate is high with respect to the anti-aliasing filter's cutoff, because the loss from the (sin X)/X rolloff is small. You can obtain a first-order correction by pre-emphasizing the input signal to the ADC.

FIGURE 2



Sin(X)/X response. Note the Nyquist Frequency is shown at 0.5 on this scale.

Filter coefficients

The stored data samples are all multiplied one-for-one by their corresponding filter coefficients, between the acquisition of each successive data sample. The product of each multiplying operation is accumulated and the resulting sum-of-products is a data word that's output by the filter, until the next output value is calculated.

The FIR design program calculates filter-coefficient sets for up to 128 tap filters. Depending on the sampling rate you choose, you may not be able to do all the multiply accumulate (MAC) cycles between two successive data samples. This means you'll either have to shorten the filter's length or build faster MAC hardware. The design program allows a total of five bands including stopbands plus passbands. The fancier the filter's operation, the longer the time for the filter to define these bands. You'll need fast hardware for the most elaborate types of filters. But it's easy to build the low-pass, single bandpass, notch, and high-pass filters with moderate filter time length.

The program first calculates a coefficient set for a filter having unity gain (zero dB). While these tap weights will produce a working filter, the number set may not use your system's full 8 or 16-bit capability unless it can handle floating point math. After locating the tap weights for the zero-dB filter, the program finds the largest value coeffient and scales them all linearly to gain the best use of fixed-point hardware's mathematical range. For example, the largest coefficient might not require the most significant 2 bits in the system. In that case, you'd get one-fourth the signal level from the filter that the hardware is capable of producing. The scaling process results in a filter with the same frequency response, but with something other than zero-dB gain. The gain figure is printed in the output listing, just ahead of the scaled tap values. In this example the scaled filter would have 12-dB gain.

The results are printed in floating point decimal and in fractional 2C hexadecimal. If you don't want to use the entire 16 bits of the hex coefficients, simply start at the highest (left-most) bit and use the number of bits you want. This 2C notation is used almost universally in computers and in MAC hardware. The 2C part refers to the technique used to encode bipolar binary numbers in which the most significant bit of the number is the sign bit (0 = plus, 1 = minus). The "fractional" part refers to the fact that the total of the remaining bits have a positive value less than 1. This number approaches unity more closely as the length of the 2C number increases. The value of a 2C tap from this filter program will be equal to:

−1 • (sign bit) + (positive value of the remaining bits) with the left-most remaining bit having a value of +0.5, the next having a value of +0.25, and so on.

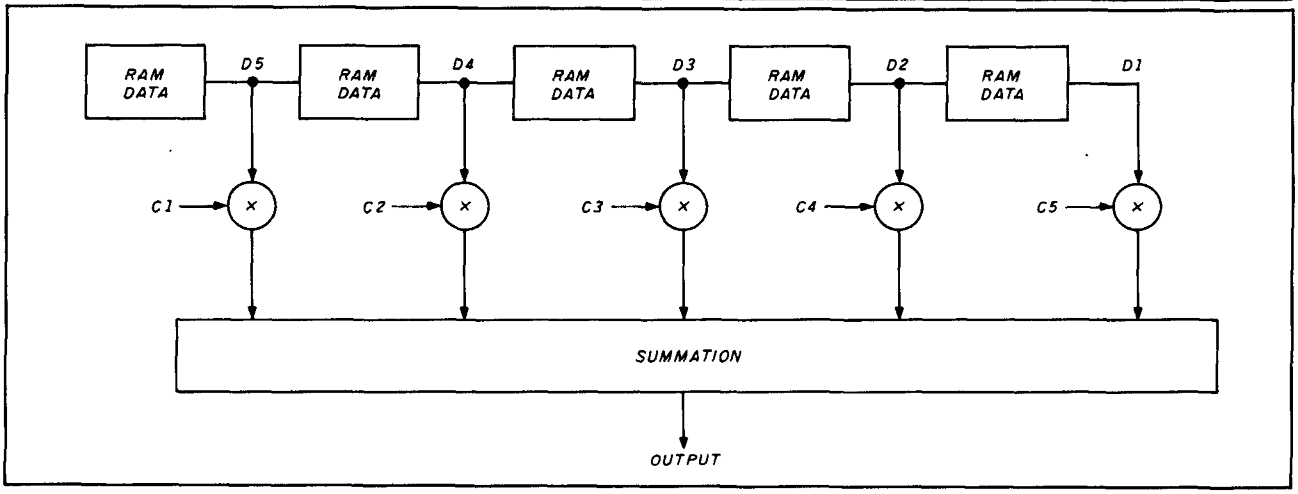
FIR filter operation

Suppose you need a length 5 FIR filter. The program will calculate the filter's coefficients, which are symmetrical around the center value (the third in this case). If you've chosen an even number of coefficients the symmetry will still exist, but without a unique central value. The coefficients are labeled in the program's output and must be used in sequence. In this example, the data memory will be length 5. It will always be the same length as the number of taps in the digital filter. The five most recent data samples will be multiplied by the five coefficients as shown in **eqn. 1**. To make notation easy, I'll refer to the data samples as D1-Dx, to the coefficients as C(1)-C(5), and to the outputs as O1-Ox (see **fig. 3**). The first usable filter output is produced after the fifth data sample is taken.

$$O1 = D1 \cdot C(5) + D2 \cdot C(4) + D3 \cdot C(3) + D4 \cdot C(2) + D5 \cdot C(1) \quad \textbf{(1)}$$

The output value O1 is placed in the output DAC. Calculation stops until the sixth data sample appears. It replaces the sample D1 (i.e., the oldest sample) and then calculates the second output. In all cases, the new data sample replaces the oldest stored data sample.

FIGURE 3



Filter state for output 1.

O2 = D2•C(5) + D3•C(4) + D4•C(3) + D5•C(2) + D6•C(1) **(2)**

Output sample O2 is placed into the output DAC. Again the filter waits for the next data sample (which replaces sample D2), then calculates the third output sample.

O3 = D3•C(5) + D4•C(4) + D5•C(3) + D6•C(2) + D7•C(1). **(3)**

This process is continued, and the filter produces outputs at the same rate as the incoming samples. Note that the filter operates on the most recent data samples only (five in this example), and the older ones are written over in the data memory as more recent samples are taken. No portion of a noisy data sample remains in the filter; the FIR structure, compared with an IIR filter, is insensitive to noise. The process of shifting the data relative to the coefficients doesn't have to be an actual data shift in memory. You can accomplish the same effect by using counters as data pointers to place new samples and to retrieve the samples for the MAC operation.

Output data

The multiplication of two signed 16-bit words produces a 32-bit product in which two identical sign bits appear. Take the top 16 bits as your result, after you perform a left shift of one position to remove the redundant sign bit. Some multiplier chips automatically perform this function. Many times, the accumulator used in building an output value has more than 16 bits of resolution (like our example). Thus an intermediate value that exceeds its 16-bit capacity wouldn't cause overflow and a false result by a "wraparound" from the maximum number, past zero, to a smaller number. When the total sum-of-products is finished for a given output sample, some product terms may have been negative and some positive; this helps prevent overflow. Any filter can be overloaded, so scale your inputs properly to avoid problems.

You may have to change the 2C result back into simple binary code for the output DAC. Do this by inverting the sign bit position of the sum-of-products. This shifts the 2C number to a value between zero and the maximum value your data variable can achieve.

Controlling the filter

If the filter is built of separate pieces instead of a FIR controller chip or a one-chip digital signal processor with its own program, you'll have to generate the control program in a PROM or use some other method to produce a "state machine." This is a little tedious, but not difficult. You must determine how many separate bits are needed to drive the control inputs for the ADC, data RAM, coefficient PROM, MULTIPLIER, DAC and other elements of the system. The PROM data readout will be sequential, because a counter will be used to drive the address inputs of the chip. At each new address, you'll program 1 bits to perform the control functions required at that time interval. As the counter runs through its range, the logic signals to control the various parts of the filter will be read out. To avoid problems from address or data skew, use a register at the PROM data outputs to clean up the data. This will cause a one-clock cycle delay in the filter activity, but that's no problem. The first two locations in the PROM can be all zeros to get everything set up. Think of the bits as a method of defining sequential events, without consideration of active high or active low control states. Make all bits represent active high events inside the PROM; if you need an active low output, invert the bit outside the PROM. This technique is less prone to error than if the PROM contents directly

Reader Service CHECK—OFF Page 118 ✓ 194

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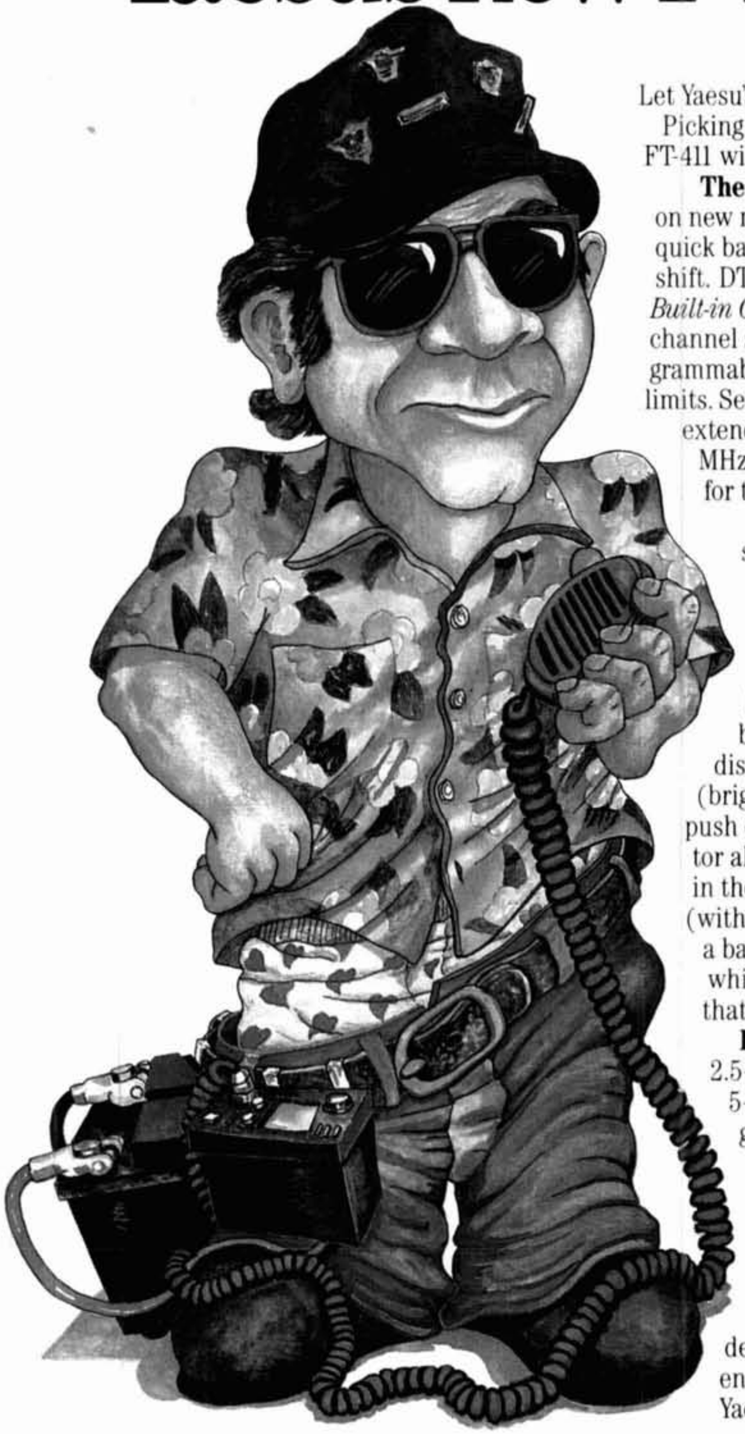

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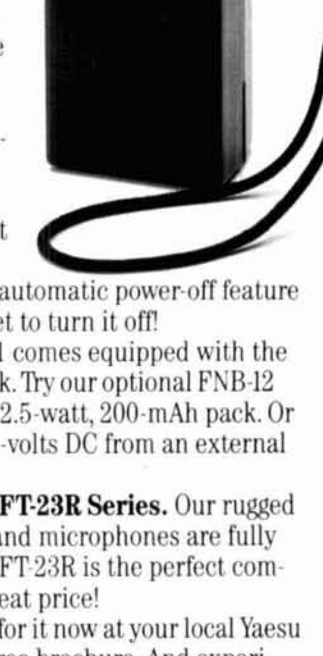

Not bad for a handheld measuring just 55(w) x 32(d) x 139(h) mm (the same size as our FT-23R Series HTs)!

Friendly operation. For operating convenience, the FT-411's keypad features a "do-re-mi" audible command verification. Both the display and keypad can be backlit (brightly!) for night operation at the push of a button. A rotary channel selector allows fast manual tuning. Or key in the frequency directly. Operate VOX (with YH-2 headset option). Plus you get a battery saver to conserve power while monitoring. And a (defeatable) automatic power-off feature that shuts down your radio if you forget to turn it off!

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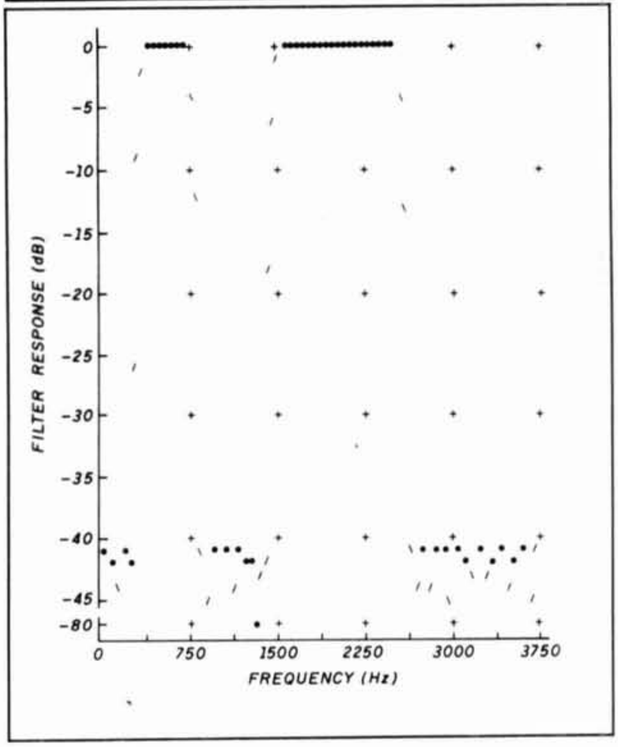
create both high and low active logic. In practice, this method takes several PROMs operating in parallel to create enough control bits.

Using the FIR design program

After the program starts, it prompts you for a file name so it can store the filter's parameters on disk. Entries are made in an interactive mode. The file includes all your entries, and all numeric and graphic outputs. There's a compressed graph to give you an idea of the filter's response curve. This curve covers one CRT screen, with a vertical scale of 5 dB per line. A detailed graph in 1-dB steps is also available. A portion of a sample problem output is shown in **fig. 4**.

FIGURE 4



Frequency response of the 5-band sample problem.

Sample problem

As an example of the type of filter you can build, consider a filter of length 128, which passes the first three voice formants. The bands are defined as 0-250, 375-700, 825-1400, 1525-2500, and 2625-3750 Hz. The sampling rate is 7500 Hz. The maximum of the stopband response is below −40 dB, with the deepest notch reaching −80 dB. The numeric outputs and stopband data below −45 dB are deleted to compress the figure.

A smaller version of this program is available from Public Brand Software, Inc., P.O. Box 51315, Indianapolis, Indiana 46251. This version, on their disk HR11.0, will create filters of maximum length 10. The full-featured version is available only from the author, for $45.00. (Indiana residents add 5-percent state sales tax.)

Parts sources for FIR filters

Texas Instruments parts
- TMS32010NL
- TLC32040NL

General Electric parts
- ISP9128CP64
- ISP9210CP6465

EXAR parts
- XR-1003CP
- XR-1004CP

Parts Suppliers

TI and EXAR parts can be obtained from Marshall Industries. Call 1-800-522-0084 for the nearest location.

GE parts can be obtained from:

Hamilton Avnet Electronics
485 Gradle Drive
Carmel, Indiana 46032
(317)844-9333

Article A **HAM RADIO**

THE WEEKENDER

Easy antenna access for urban apartment dwellers

This article is dedicated to those urban HF operators who, because of security or other restrictions, have been unable to have constant access to a good receiving antenna.

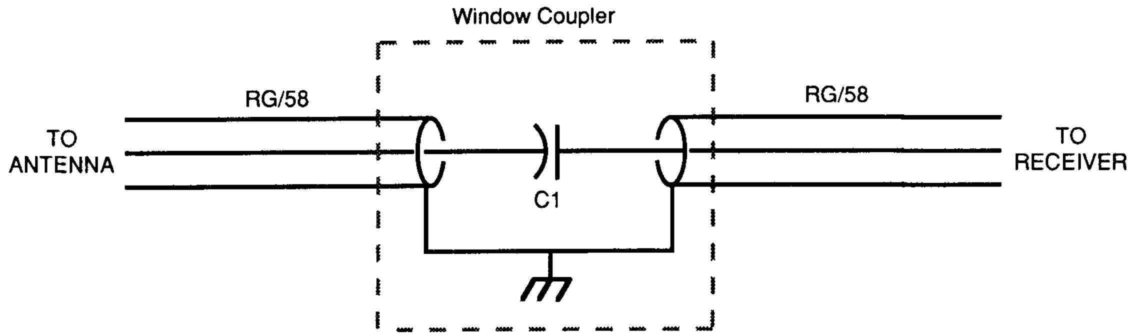
My typical operating procedure on the HF bands is to listen to the activity on each band, then attach the appropriate loading coil to a loaded vertical antenna mounted on a pipe on my balcony. Sometimes I simply want to hear the latest solar activity forecast on WWV or catch the news from the BBC. Because I live in an apartment building with brick walls and aluminum-framed windows, this operation normally requires several trips through a sliding-glass door that leads to the balcony. Blasts of cold air entering my small apartment are side effects in the winter.

By Bryan Bergeron, NU1N, 30 Gardner Road, Apartment 1G, Brookline, Massachusetts 02146

Confronted with this dilemma (and complaints from my XYL), I sought a solution that would eliminate the outdoor excursions for *receive only* applications or at least limit the ones required to begin HF operation. The most direct solution, drilling holes in either the brick wall or an aluminum window frame for a coaxial feedthrough, isn't allowed by my landlord.

I tried using a window antenna, but the it proved unsatisfactory. It was impossible to secure the window properly against burglars with the antenna installed. Anyway, the antenna I tried is designed for wooden window frames, and must be insulated from an aluminum window mount. I tried using a block of wood drilled to accommodate coaxial cable and wedged in the window frame, but this also resulted in an unacceptable security risk. Because of my location on the ground floor and the construction of the apartment building (an effective Faraday shield!), an indoor antenna proved useless — even for WWV reception.

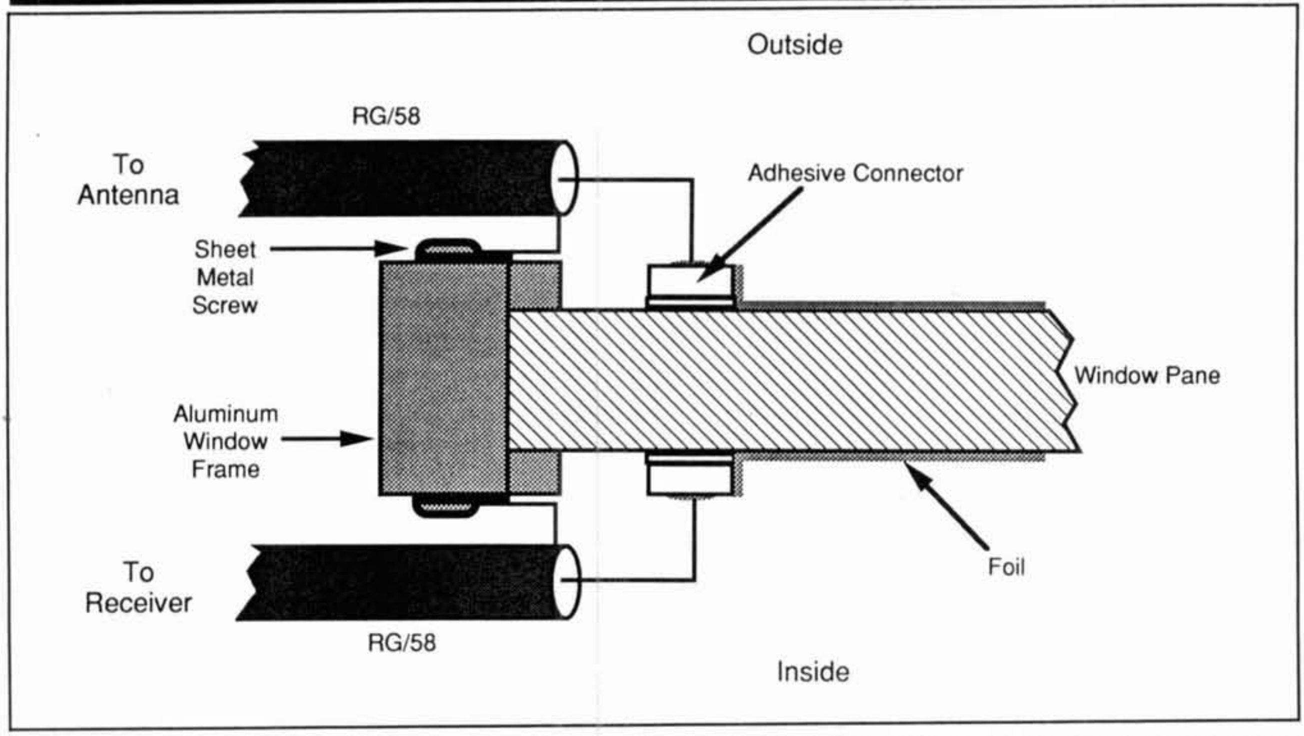
FIGURE 1



Schematic diagram of the window coupler. An effective RF connection is provided through coupling capacitor C1.

It occurred to me that I might try coupling RF from an external antenna through my window, adapting a method similar to those used in some mobile window-mount VHF antennas. The schematic in **fig. 1** shows the basic concept involved in what I call the "window coupler." The coaxial cable from my receiver (an ICOM R-71A) is connected, through coupling capacitor C1, to an external coaxial cable that feeds a "stealth" dipole antenna. The window cross section in **fig. 2** shows the details of the window coupler. Notice that coupling capacitor C1 is formed by two strips of aluminum foil mounted exactly opposite each other, on either side of and along the width of the window. The single-pane glass of the window forms the dielectric of C1. The two parallel foil strips, each 3/8″ × 48″, form the capacitor's plates. The braids of both the internal and external coaxial cables are connected to

FIGURE 2



Window cross-section showing the details of coupling capacitor construction. The center conductor of each coaxial cable is connected to parallel foil strips with the aid of adhesive connectors designed for connecting the foil to burglar alarm systems. The braids of each cable are connected to the aluminum window frame.

Parts list

Adhesive-backed foil—Radio Shack part no. 49-502 (120 foot roll—$5.99)

Adhesive connectors—Radio Shack part no. 49-504 (3 pair for $2.59)

Krylon Acrylic Spray Coating, Crystal Clear no. 1301 (about $3)

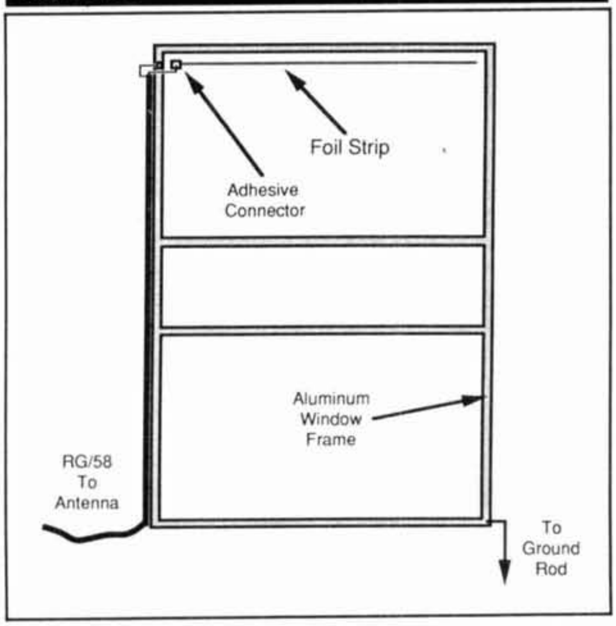
Silicone sealer

the aluminum window frame by the existing sheet metal screws. The frame is grounded through a short length of coaxial braid connected directly to a 6-foot copper ground rod (see **fig. 3**).

Both the adhesive-backed aluminum foil and adhesive-backed connectors used for building the coupling capacitor are available from Radio Shack. Adhesive foil and connectors, designed orginally for burglar alarm systems, make for a quick and aesthetically pleasing installation (see **fig. 3**). To keep the outside connections clean and free of corrosion, make sure that you cover the coaxial connection with a small amount of silicone sealer. To prevent the foil from deteriorating, I sprayed the outside strip with a thin layer of clear acrylic spray coating. Clear fingernail polish or clear enamel will work as well.

The window coupler performs magnificently as a means of providing a connection to an external receive antenna. There's no detectable degradation in received signal strength on the HF bands when using it, com-

FIGURE 3



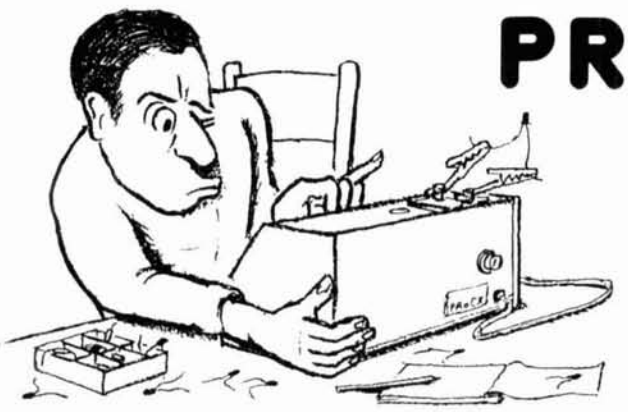
The window coupler as seen from the outside. The foil strip along the top edge of the window provides for an inconspicuous installation.

pared with a direct connection to my dipole antenna. Now I have constant access to WWV and the short-wave bands. I can listen for band openings at the wee hours of the morning or late at night without disturbing my family, compromising the security of our apartment, or incurring the wrath of my landlord.

Now the obvious question: Is the window coupler any good for transmission? Well, I've made several contacts through the coupler with a QRP rig (an HW-8) on 15 meters. With an MFJ-900 Transmatch and a long-wire antenna attached immediately to the outside foil strip, I've been able to achieve an SWR ratio of less than 1.3:1 across the CW segment of the 15-meter band. Because the foil strips are so thin, I haven't tried to transmit through the window coupler with my Swan 500 — for fear of vaporizing the aluminum foil! For high-power applications, you might want to try extending the strip in an "L" shape, or use several strips in parallel.

I hope that you enjoy this simple and easy to build window coupler. Let me know if you have any questions and/or enjoy using the system.

Article B **HAM RADIO**



PRACTICALLY SPEAKING

Joe Carr, K4IPV

Light metal and other topics

The oscilloscope (shown in **photo A**) is an instrument that lets you examine a waveform appearing on the screen of its cathode ray tube (CRT). Most of you are aware of the oscilloscope's usefulness in examining low-frequency waveforms, but you may not know that the instrument is also helpful at RF frequencies. At one time, most oscilloscopes were limited to frequency responses of 500 kHz or less.

Just a decade ago high-frequency oscilloscopes were costly items that found extensive use only in commercial applications. Few Amateur Radio operators owned scopes at all — much less high-frequency ones. But that situation is changing. A number of manufacturers offer low-cost oscilloscopes that provide vertical bandwidths of 20, 50, or even 100 MHz. While not exactly in the "low-cost" category, these instruments are well within the range of many Amateurs.

This month I'll look at a method for placing either detected or raw RF on the input of an oscilloscope. I used an Amateur HF dummy load, a Drake DL-1000 (see **photo B**), as the basis for my measurement system. The modified internal circuit of the DL-1000 is shown in **fig. 1**. The main load is a 1000-watt, 50-ohm non-inductive resistor element mounted between the center pin of an SO-239 "UHF" coaxial connector (J1) and ground. The 1000-watt rating of the DL-1000 is based on a relatively short duty cycle, and that's appropriate for most Amateur Radio applications. If you need to run more power, or to operate into the load for more than a couple of minutes, Drake provides a cutout on the rear panel of the dummy load to accommodate a blower fan for forced air cooling.

I added two sampling elements to the internal circuitry of the DL-1000. I constructed both of 1/8-inch (3.18 mm) brass tubing. This tubing, available in hobby and model shops, is inexpensive and easily worked with a hacksaw or jeweler's saw. I terminated each sampling element in a 220-ohm, 1-watt resistor at the "cold" end. I connected the sampling element used to drive the RF sample port directly to the BNC jack (J3).

It's possible to use a wire loop, instead of the brass rods, for the sampling element. Build a 1-inch (2.54 cm) loop consisting of several turns of no. 14 solid insulated wire. Connect one end of the loop to the output jack (J2 or J3), and the other end to the resistor termination. (I've found that resis-

PHOTO A

Standard 5-inch dual-trace oscilloscope with 20-MHz bandwidth and triggered sweep. (Courtesy B&K Dynascan Corporation.)

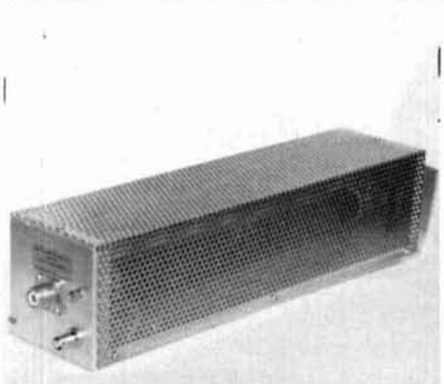
tor terminations aren't strictly necessary when using loops, so you might want to try connecting the loops between the output jack and ground first.)

You also connect the detected output (J2) to a brass rod sampling element, which is terminated in a 220-ohm resistance. However, there's a detector/rectifier network at the output end that demodulates the RF signal to produce a DC signal proportional to the RF power level. You can use this port for measuring RF power in CW (sinusoidal) waveforms, or looking at the waveform modulation on a low-frequency oscilloscope.

Photos C and **D** show the construction of the modified DL-1000. The internal structures appear in **photo C**, while the connectors at the output end are shown in **photo D**. The detected output connector is an RCA phono jack; the raw RF sample is a BNC jack. I used two different connectors; this makes it easier to tell them apart. But there's no reason why you can't use the same connector — either BNC (preferred) or RCA phono jack — for both. I wouldn't try an SO-239 UHF coaxial connector (used for the RF input to the load) for either the RF sample or detected outputs. It's possible that it could be mistaken for the main RF power input, with potentially disastrous results. A ground connector is also provided on the end plate. I haven't used it for anything yet, but it seemed like a good thing to have available.

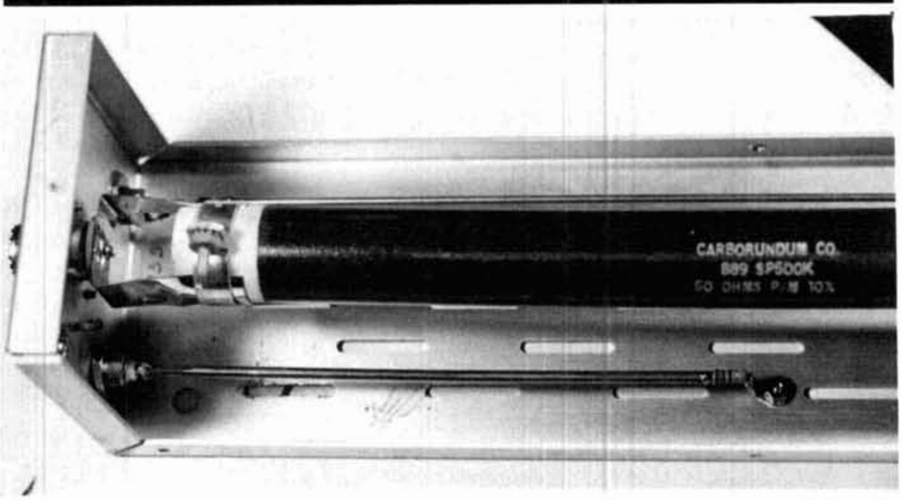
Photos E, F, and **G** show several outputs from the RF sampling jack. These waveforms were taken from the

PHOTO B



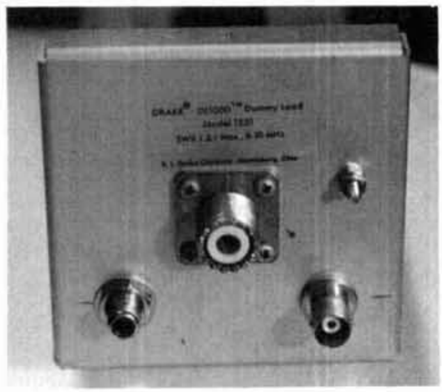
Drake DL-1000 dummy owned and modified by the author.

PHOTO C



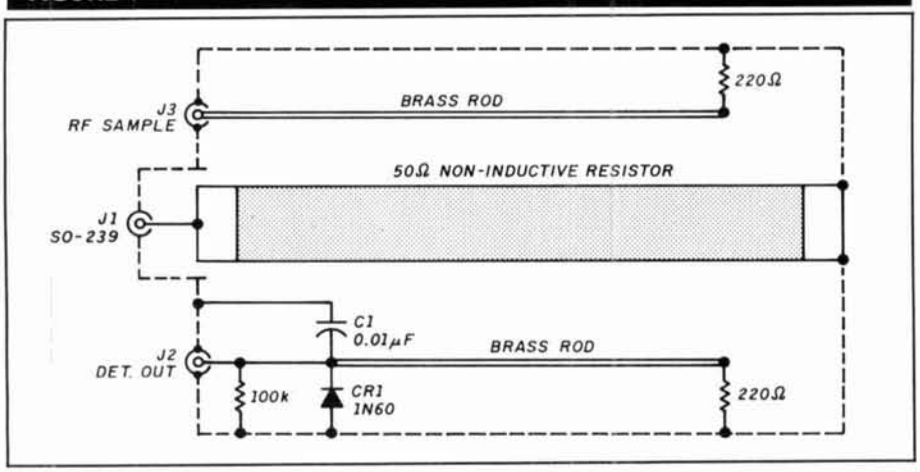
Construction of the sampling loop inside the DL-1000.

PHOTO D



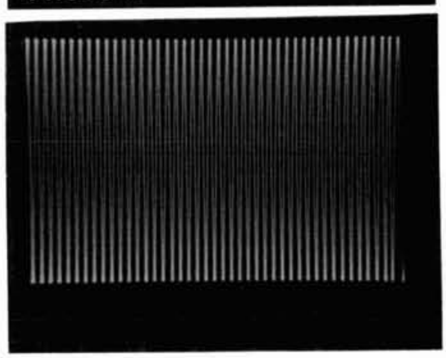
End panel showing the coaxial connector plus added RCA phono and BNC jacks.

FIGURE 1



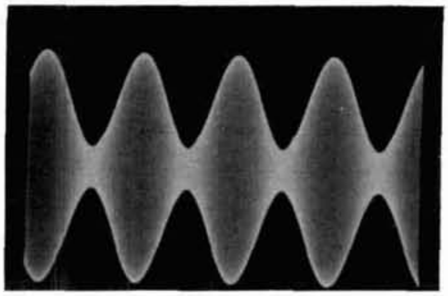
Schematic of the modified DL-1000.

PHOTO E



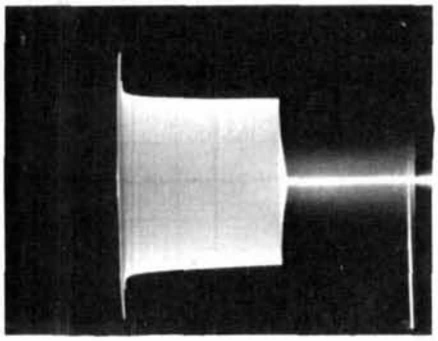
CW waveform.

PHOTO F



AM waveform.

PHOTO G



Keyed-CW waveform.

modified DL-1000 while it was excited by a 65-watt old-fashioned AM/CW HF transmitter. The oscilloscope has a 50-MHz vertical bandwidth. **Photo E** is a CW signal with key down. This signal was on the 75/80-meter band. Notice that the horizontal sweep is fast enough that individual cycles are resolved on the screen. **Photo F** shows an amplitude modulated (AM) signal. The AM signal was single-tone modulated at 400 Hz, and the scope was adjusted to show several cycles at that frequency rather than the higher RF frequency. A keyed CW signal is shown in **photo G**. There are two methods for producing this signal. One is to turn on an electronic keyer and adjust the oscilloscope timebase to trigger on the repetition rate. Alternatively, you can use the scope's single-trace setting (if available) and take the photo at one shot.

Other uses for the brass rods

The preceding section discussed one application of brass stock in an electronics construction project. If you're into construction, especially RF projects, check out your local hobby shop. There are a lot of supplies, tools, and vision aids for those who do their building from the ground up. Of particular interest to electronic builders is the light metal brass stock. These are hollow rods, solid rods, square rods, rectangular rods, and flat plate sheets from strips of only 1/4 inch to sheets 4 inches wide.

Photos H and **I** show an application for the hollow brass rods mentioned earlier. In fact, the small rods in **photos H** and **I** were cut from the same piece of stock as the rods used in the dummy load. The project is a monimatch type of VSWR coupler. It was intended for use inside an antenna tuning unit that I'm building.

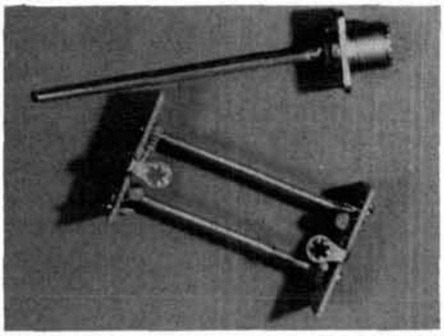
A monimatch uses two short transmission line segments parallel to, and coupled with, the main transmission line segment. Pieces of ordinary perfboard support the transmission line segments at either end. One end of each coupler section is terminated in carbon composition resistors, while the other ends are terminated in 1N60 germanium diodes and 0.001-μF feedthrough bypass capacitors. There's nothing unusual about the design, except for the use of the brass rods as the transmission line and coupler segments.

I selected two sizes of brass stock. To determine the larger one, I took an SO-239 coaxial connector to the hobby shop and found a size that fit snugly over the solder connector of the center pin.

Sheet stock solders well, and can be worked easily with ordinary tools. I use scissors, lightweight sheet metal shears, and assorted other tools to work the brass. In one of my other lives I'm an amateur jewelry maker, and have found some interesting metalworking tools in jewelers' supply catalogues and local lapidary stores. Two of the best are the jeweler's saw and the parallel jaw pliers. The jeweler's saw is like a jigsaw with a very fine blade. (Buy a sleeve of spares — they break easily!) It lets you make very precise cuts and oddball shapes in metals. The parallel jaw pliers look like other pliers, but the jaws are designed to remain parallel to each other through the entire range of motion. This feature allows you to bend metal easily in straight lines, with straight edges. These pliers are especially nice when making shields for RF projects. On one project, I bent a 1-inch strip of brass stock at three points to form a rectangular shield around an RF receiver front-end circuit. I was then able to use a piece of wider sheeting for the shield cover.

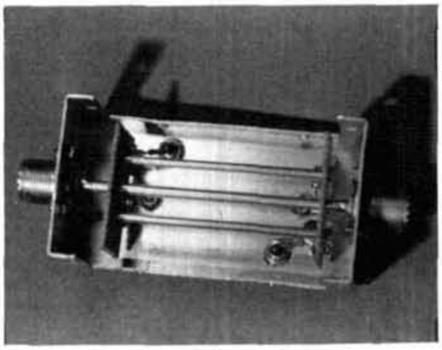
An RF shield is most effective when it's continuous. I know an electronics engineer with a lot of experience in microwave design. He once designed a transmitter and specified cabinet screws every 3/8 inch. But the wizened mechanical engineer who worked for the company felt he had used too many, and reduced the num-

PHOTO H



Disassembled view of the monimatch sensor.

PHOTO I



Assembled view of the monimatch sensor.

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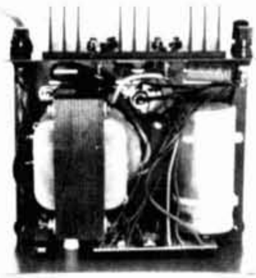

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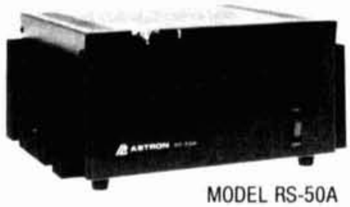
- RIPPLE Less than 5mv peak to peak (full load & low line)
- **Also available with 220 VAC input voltage**

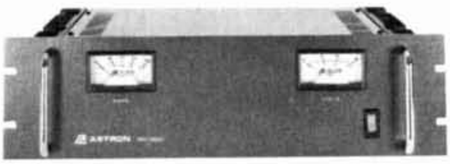


MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

RM SERIES



MODEL RM-35M

19″ × 5¼ RACK MOUNT POWER SUPPLIES

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H × W × D	Shipping Wt. (lbs.)
RM-12A	9	12	5¼ × 19 × 8¼	16
RM-35A	25	35	5¼ × 19 × 12½	38
RM-50A	37	50	5¼ × 19 × 12½	50
• Separate Volt and Amp Meters				
RM-12M	9	12	5¼ × 19 × 8¼	16
RM-35M	25	35	5¼ × 19 × 12½	38
RM-50M	37	50	5¼ × 19 × 12½	50

RS-A SERIES

MODEL RS-7A

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H × W × D	Shipping Wt. (lbs.)
RS-3A	2.5	3	3 × 4¾ × 5¾	4
RS-4A	3	4	3¾ × 6½ × 9	5
RS-5A	4	5	3½ × 6⅛ × 7¼	7
RS-7A	5	7	3¾ × 6½ × 9	9
RS-7B	5	7	4 × 7½ × 10¾	10
RS-10A	7.5	10	4 × 7½ × 10¾	11
RS-12A	9	12	4½ × 8 × 9	13
RS-12B	9	12	4 × 7½ × 10¾	13
RS-20A	16	20	5 × 9 × 10½	18
RS-35A	25	35	5 × 11 × 11	27
RS-50A	37	50	6 × 13¾ × 11	46

RS-M SERIES

MODEL RS-35M

MODEL	Continuous Duty (Amps)	ICS* (Amps)	Size (IN) H × W × D	Shipping Wt. (lbs.)
• Switchable volt and Amp meter				
RS-12M	9	12	4½ × 8 × 9	13
• Separate volt and Amp meters				
RS-20M	16	20	5 × 9 × 10½	18
RS-35M	25	35	5 × 11 × 11	27
RS-50M	37	50	6 × 13¾ × 11	46

VS-M AND VRM-M SERIES

MODEL VS-35M

- Separate Volt and Amp Meters • Output Voltage adjustable from 2-15 volts • Current limit adjustable from 1.5 amps to Full Load

MODEL	Continuous Duty (Amps) @13.8VDC	@10VDC	@5VDC	ICS* (Amps) @13.8V	Size (IN) H × W × D	Shipping Wt. (lbs.)
VS-12M	9	5	2	12	4½ × 8 × 9	13
VS-20M	16	9	4	20	5 × 9 × 10½	20
VS-35M	25	15	7	35	5 × 11 × 11	29
VS-50M	37	22	10	50	6 × 13¾ × 11	46
• Variable rack mount power supplies						
VRM-35M	25	15	7	35	5¼ × 19 × 12½	38
VRM-50M	37	22	10	50	5¼ × 19 × 12½	50

RS-S SERIES

MODEL RS-12S

- Built in speaker

MODEL	Continuous Duty (Amps)	ICS* Amps	Size (IN) H × W × D	Shipping Wt. (lbs.)
RS-7S	5	7	4 × 7½ × 10¾	10
RS-10S	7.5	10	4 × 7½ × 10¾	12
RS-12S	9	12	4½ × 8 × 9	13
RS-20S	16	20	5 × 9 × 10½	18

*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off) ber to one every 4 inches. Hal ordered the new cabinet drilled and tapped according to original specifications. When the work was done, he set up a spectrum analyzer near the transmitter and called the mechanical engineer over for a little demonstration. With each screw he removed, the level of the signal on the spectrum analyzer rose higher and higher. Hal's point (aside from "don't mess with my designs") was that a lot of fasteners are needed to make the shielding effective. Of course, a continuous seam is even better.

You can fashion brass sheet stock into a box (or whatever shape you require) for shielding purposes. Instead of solder tacking the thing together, which will work mechanically, use a soldering gun or heavy iron to draw a solder bead along all seams. This makes it essentially RF proof. Doing this is a bit tricky, so be prepared to use alligator clips (or one of those "third hand" bench aids) to hold things steady while you work. If you shop for any of the tools I mentioned, pick up a spool of iron binding wire, too. Jewelers use this wire to bind things together while soldering. Solder tack the pieces of your project together using a small, 25-75 watt soldering pencil. Once the solder-tacked assembly is ready, use a heavier soldering gun (like the Weller D-440) to draw the bead around the edges. Be careful to fill in the gaps in the seam.

Conclusion

The Amateur Radio builder has a large array of electronic components and tools at his disposal. There are also many tools and supplies available from other hobbies and vocations — like the brass stock favored by model builders and the tools used by amateur jewelers. If you like electronic project construction, then go for it!

I can be reached at POB 1099, Falls Church, Virginia 22041; I'd like to have your comments and suggestions for this column.

Article C **HAM RADIO**

EASY MONITOR RECEIVER
FOR 2 METERS

Use weather radio as 2-meter monitor

By Courtney Hall, WA5SNZ, 7716 La Verdura Drive, Dallas, Texas 75248

Want to monitor the 2-meter band and part of the VHF-Hi band on the same receiver? Want to do it for less than $20? Read on.

I've found an inexpensive way to monitor 2 meters. Simply use a modified Radio Shack weather radio; all you need to do is add a jumper wire.

The receiver

I used Radio Shack weather radio catalog no. 12-181B; it's the one housed in a 3-inch cube. It normally sells for $17.95, but sometimes it's on sale for as low as $12.95. Radio Shack also sells some other crystal-controlled weather radios, but this modification won't work on them.

You get a lot of radio for your money in the 12-181B. It's a double-conversion superheterodyne with a fixed-tuned RF amplifier stage. The intermediate frequencies (IF) are 9.7 MHz* and 455 kHz. It's designed for use with narrowband FM signals only. Inside the IF integrated circuit (a Motorola MC3357) there's a five-stage limiter amplifier. This circuit clips off amplitude modulation when the 9.7-MHz IF signal is 5 μV or more. You won't hear any modulation from AM signals, even though their carriers will quiet the background noise. The 9-volt battery must deliver about 20 mA to the receiver during normal listening conditions.

This radio is designed to tune only the frequencies of the National Weather Service broadcast stations which operate on 162.40 through 162.55 MHz. In order to receive the 2-meter band, you must increase the tuning range to cover the frequencies from 163 MHz or higher down to 144 MHz or below.

*I don't know why the first IF is 9.7 MHz instead of the standard value of 10.7 MHz, but the Radio Shack service manual for the weather radio says it's 9.7 MHz.

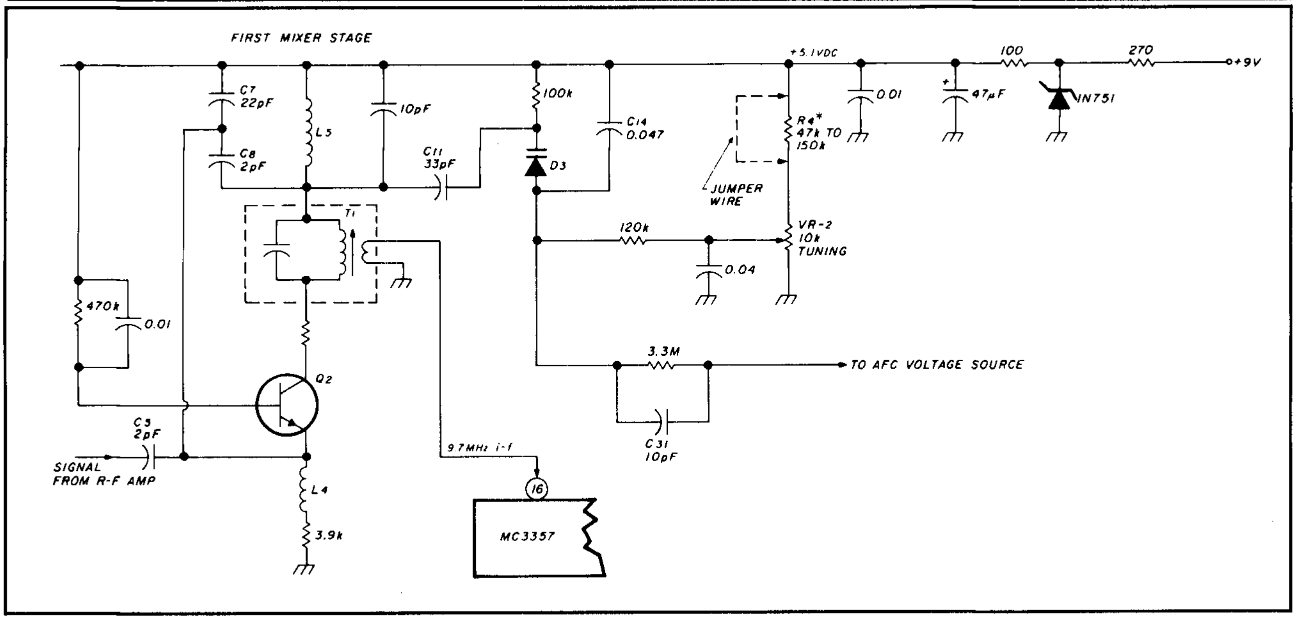
The modification

Receiver tuning is done with a 10-k potentiometer which varies the reverse-bias voltage across a voltage-variable capacitance diode. This diode, also called a tuning diode, is connected across the coil in the first local oscillator. The frequency produced by this oscillator mixes with the incoming signal frequency; the difference between the two frequencies is the first IF of 9.7 MHz. As the reverse-bias voltage across the diode increases, the diode's capacitance becomes smaller. Maximum diode capacitance occurs when the reverse-bias voltage is zero. To make the receiver tune to lower frequencies (down to 144 MHz or below) you must increase the capacitance across the oscillator coil. To do this, decrease the reverse-bias voltage applied to the tuning diode.

Figure 1 is a partial schematic diagram of the receiver circuit showing the first mixer stage, which incorporates the first local oscillator. L5 is the oscillator coil and D3 is the tuning diode. Adjusting VR-2 varies the reverse-bias voltage across D3; this tunes the receiver to different frequencies. R4 is a resistor whose value is selected at the factory to produce the desired tuning range for the weather broadcast frequencies. Connecting a jumper wire across R4 lets you reduce the reverse-bias voltage across the tuning diode to zero volts. This gives the tuning diode its maximum capacitance and tunes the local oscillator frequency low enough for 2-meter reception. The high-frequency end of the tuning range will be the same as it was before the modification.

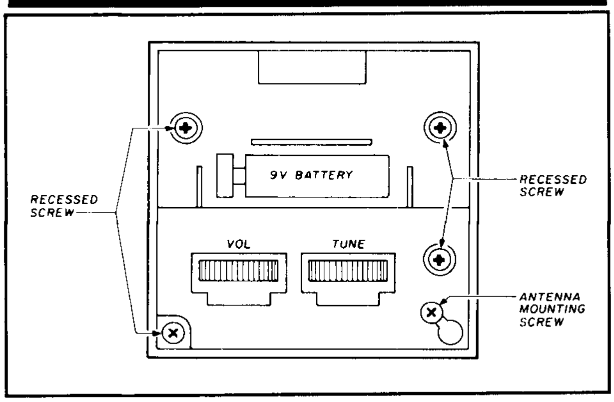
I found a few discrepancies between the schematic furnished with the radio and the actual circuit. Although Radio Shack's schematic shows a range of 47 to 150 k for R4, its value was 27 k in the unit I purchased. The

FIGURE 1



Partial schematic of Radio Shack Weather Radio, showing jumper modification needed for 2-meter hamband reception.

FIGURE 2



Bottom view of Weather Radio with cover removed.

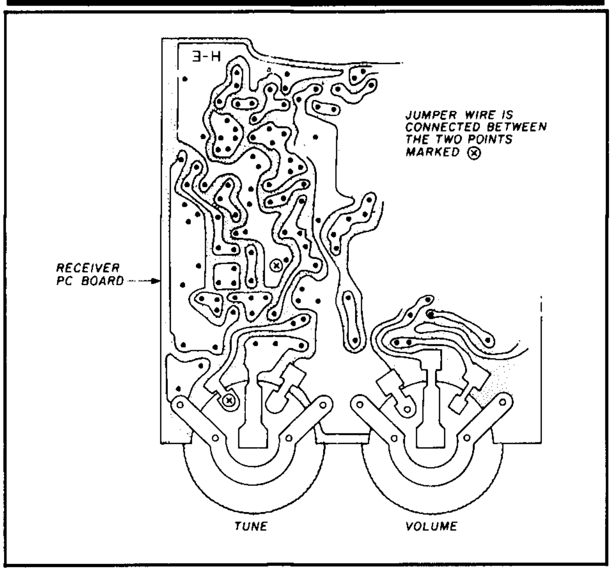
schematic also showed R4 connected to the + 9 volt line instead of to the + 5.1 volt point which is its actual connection.

How to do it

Turn off the radio by pressing the touch bar. Collapse the antenna to its shortest length. Remove the bottom cover by pressing the latch toward the center of the cover and lifting it out. Disconnect and remove the battery.

Next, loosen but do not remove the antenna mounting screw (see **fig.2** for the screw's location). Remove the four screws located in the deeply recessed holes of the case. Push the antenna mounting screw into the corner of the case, so that the head of the screw will pass through the large hole. Then separate the case from the receiver, while guiding the battery connector through the opening provided.

FIGURE 3



Jumper wire is connected between the two points marked "X."

Cut a 1-inch length of hookup wire and remove 1/8-inch insulation from each end. Solder the wire to the circuit side of the printed circuit board as shown in **fig. 3.** Take care that solder points sticking up from the board don't puncture the insulation of the hookup wire.

Put the radio back in its case, while guiding the battery connector and the antenna mounting screw through the appropriate holes. Replace the four screws which hold the case on. Position the antenna mounting screw into its slot and tighten. Connect the battery and place it in its nest. Reattach the bottom cover.

Now extend the antenna and turn on the radio. Tune in a weather broadcast and mark this point on the tuning knob with a dot of paint. This point should be near one end of the tuning range. You should find some 2-meter activity near the other end of the tuning range. When you do, mark the tuning knob with another color dot of paint.

That should do it. The fixed-tuned RF amplifier is still tuned to the 162-MHz weather frequencies, so sensitivity won't be optimum at the 2-meter frequencies. It is, however, adequate for casual monitoring. I believe any improvement gained by adding tuning controls to the RF stage wouldn't be enough to justify the effort. Good listening!

Article D **HAM RADIO**

MULTIBAND SPEECH PROCESSOR

Increase your station's output power at minimal cost

By Robert Wilson, KL7ISA, Box 34298, Bethesda, Maryland 20817

An audio processor is a circuit between the microphone and the radio frequency modulator in a transmitter's audio system. A properly designed processor gives a real boost to your transmitter.[1] A 1.5-kW PEP Amateur station can run an effective 12 kW to its antenna with the addition of a multiband speech processor.

I've designed a simple SSB speech processor built with parts from the local radio store. This processor will give your signal about a 6 to 9-dB increase in signal readability or "punch" in the presence of noise or interference.

Communications speech processors should make the spoken word more intelligible in the presence of noise. These processors don't necessarily need to retain a natural sound, as would a processor designed for broadcast use. According to John Birch, W3JB, Chief of Audio Engineering for the Voice of America, there's a big difference between the various types of processors. Their design is based on the kind of sound a station desires and the particular function it requires.

I found that processing is more efficient if you break the voice down into several different voice bands. This lets you optimize, clip, and adjust each band separately for the required level. Then the signals are added together and clipped once more. The output gain is equalized to the unprocessed microphone level, and the processed audio is sent to the transmitter.

It's easy to build a speech processor like mine. The schematic is shown in **fig. 1**; it's constructed using a "perfboard" layout. I bought all my parts at the local Radio Shack, but sometimes had to series resistors together to get the correct values. I used high quality 0.01-μF film capacitors to determine frequency. I kept all leads as short as possible to avoid RF pickup, and shielded the input and output audio leads for the same reason. My circuit incorporates the well-known "tack together and solder blob" style. A real printed circuit board would speed things up a lot and assure that there are no errors.

Upon completion, I checked the circuit to make sure there were no shorts and that it followed exactly the schematic I had drawn. As a finishing touch, I mounted the speech processor in a metal project box with silicone glue, checking for unwanted grounds to the box.

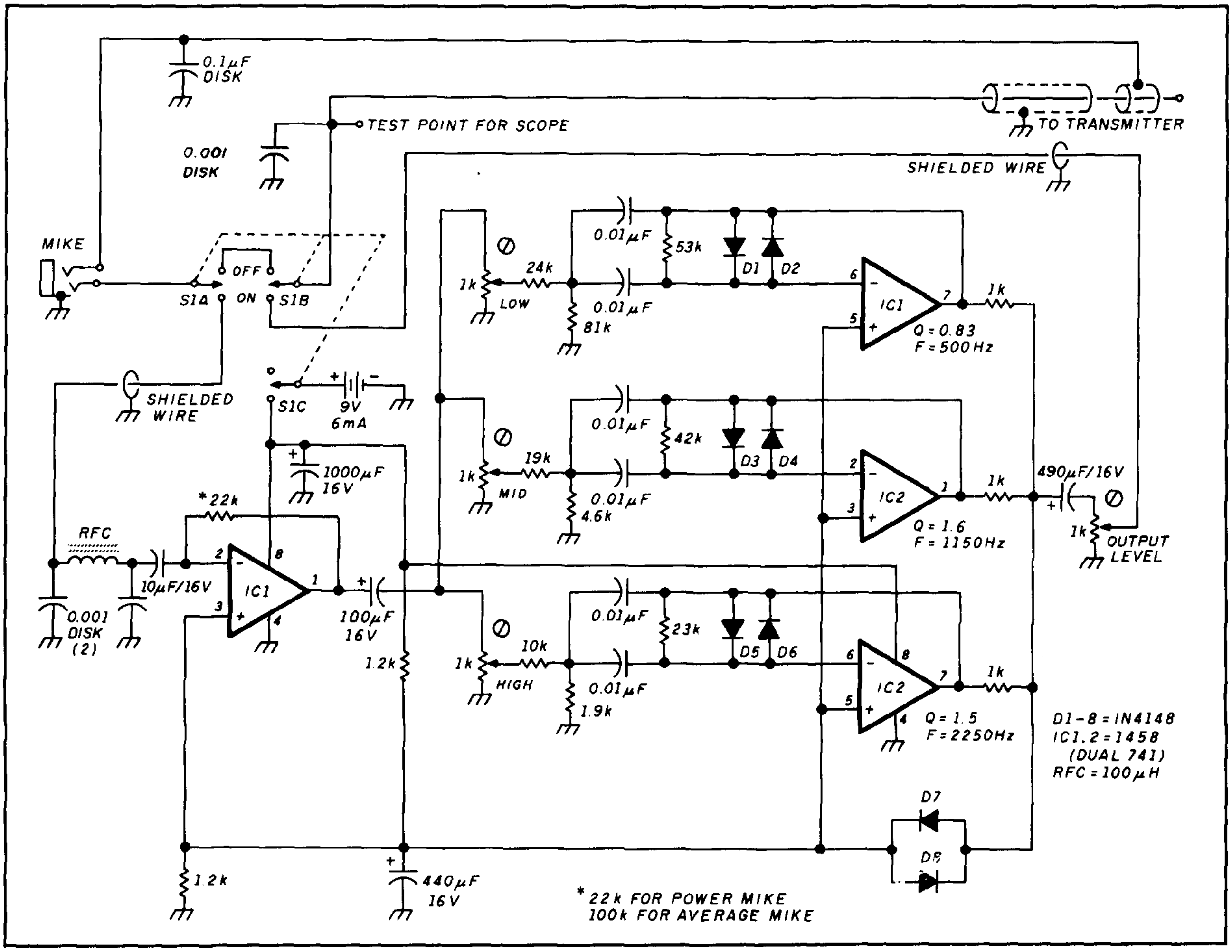
This speech processor is almost foolproof. It's possible to turn all four pots to maximum, plug in any low-impedance mike, and obtain fair results. For best results, get a noise-canceling power microphone (Radio Shack has them) and plan to dedicate it to this processor. The noise-canceling mike prevents background noise from increasing and blanking out the desired weak voice signal sounds. For best operation, tune the processor for your own voice, microphone, transmitter, and same general size of speaker where you expect your signals to be received. After your final tuning, lock the controls and forget them. They are personalized and shouldn't need to be touched again.

I found that the Radio Shack amplified microphone required special RFI suppression to operate in my high-powered mobile station. I opened the case and placed a very small 0.001-μF ceramic disk capacitor between terminals 9 and 10 on the pc board. (This capacitor must clear the side of the case or it will be impossible to reclose the microphone properly.)

The tune-up procedure requires rotating all four controls to maximum. Plug the processor output into your mike jack and your transmitter into a dummy load, or use a dead band for tune-up. Set the modulation control on the transmitter for normal output level on voice peaks. Now with the help of a friend or a second receiver, tune in your own signal. If possible, try a speaker the same size you'd expect most DX operators to use.

Try adjusting the low-frequency band control first, using a standard test sentence like "the quick brown fox jumped..." This band contains most of the power audio frequencies, but it's not the band that contains most of the intelligence. Be very critical of what you

FIGURE 1



Schematic diagram of the multiband speech processor.

hear. Use the criterion, "Can I understand this signal better in the presence of noise?" not "This signal sounds more natural!" Adjust the high-band control using the same criterion. Finally, adjust the mid-band control if necessary. You'll probably need two or three adjustment sessions before final control lockdown.

When you're through tuning the three band level controls, your voice may sound a bit harsh, but not particularly strident. If you have an oscilloscope, you can turn the processor off and measure the microphone audio peaks. Look only for the peaks — the processor will change the audio density greatly. The change shows up clearly on the scope. Now you can compare the results of processed audio with the unprocessed audio simply by switching between the two. The results should be remarkable even to an untrained ear.

At 1 kW my mobile station is considerably larger than most, but I still need lots of effective power to compete with fixed stations running 1.5-kW PEP and using beam antennas. That's why I added the multiband speech processor in line with the microphone. I set the transmitter modulation control to run full power with the processor turned on. Power peaks in this situation are about the same with the processor on or off. When I switch it off, my signals are unusable in the presence of noise or QRM — but with the processor on I can compete with the crowd. I believe it adds a good 6 to 9 dB to the effective power of my station under these conditions. This boost is the equivalent of 8 kW or 3 S-units. It certainly makes a difficult transmitting situation easier and helps me work mobile DX.

Reference

1. W.W. Smith, W6BCX, "Premodulation Speech Clipping and Filtering," *QST*, February 1946.

Article E

HAM RADIO

NEW products

Ultra-compact IC-725 HF transceiver

ICOM has introduced the compact IC-725 HF transceiver. The all-mode IC-725 features:

- USB/LSB/CW transmitting and receiving, AM receiving, optional module no. UI-7 for FM transmit/receive, and AM transmit.
- Twenty-six tunable memories with band stacking registers.
- DDS (Direct Digital Synthesizer) system.
- Built in AH-3 controller. (Optional AH-3 automatic antenna tuner available.)
- Three scanning systems: programmable, memory, and selected mode.
- Priority watch.
- 105-dB dynamic range receiver.
- 160 through 10-meter operation. Short-wave reception from 30 kHz to 33 MHz.

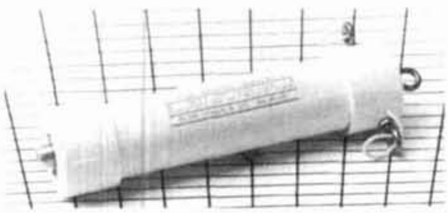
Other features include: panel-selectable RF preamp and attenuator, dual VFOs, noise blanker, RIT, semi-break in CW, selectable AGC, a full-duty cycle, and optional narrow CW filter.

The suggested retail price of the IC-725 is $949. For more information contact ICOM America, Inc., 2380 116th Ave., NE, PO Box C-90029, Bellevue, Washington 98009-9029.

Circle #301 on Reader Service Card.

High power, special purpose baluns

RADIO WORKS has three new types of baluns. The B1-2K and B1-4K Utility baluns are low-loss, wideband, 1:1, "current-type" 50-ohm baluns with large, saturation-resistant ferrite cores. Controlled winding reactance gives a nearly flat VSWR curve from 160 to 10 meters. Power rating is 1500 watts for the B1-2K and 4 kW for the B1-4K. All connections are soldered and leads from the internal transmission line brought outside the case for direct connection to the antenna wire. Each balun is completely potted. They are designed for use in wire antenna systems. The price is $15.95 for the B1-2K and $19.95 for the B1-4K.



The RemoteBalun© mounts outside where it connects to a balanced transmission line. A short length of low-loss coaxial cable connects the balun to a Transmatch.

Power rating is 1.5 kW in low-duty cycle CW and SSB applications; the price is $27. Optional interconnect coaxial cables with connectors are available.

The C-series (Stick Balun©) line is for retrofit applications in existing wire antennas and beams. The C1-2K enhances antenna operation by improving transmission line isolation and balance. The Stick Balun is a low-loss design with high transmission line isolation. Winding reactance is 1100 ohms at 3.5 MHz. Power rating is 1.5 kW and the core saturation resistance is high. Phase delay is 2.6 degrees at 3.5 MHz. There are 75-ohm models available for use with the quarter-wave matching sections. The price for the C1-2K and C75-2K is $15.95. Higher power models are available.

For more information or a catalog, write the RADIO WORKS at Box 6159, Portsmouth, Virginia 23703.

Circle #302 on Reader Service Card.

Voltage surge protection

American Voltage Products surge protection devices provide the home and commercial user with equipment protection at optimum dollar value.

The VSS-1 is for use on any 120-Vac single or three-phase distribution panels and clamps at 160 Vac while providing 70,000 watts and three-leg protection. The unit comes with 18-inch leads and protects computers, VCRs, stereos, typewriters, FAX machines, TVs, telephone systems, process controllers, motors, microwave ovens, home video games, appliances, and more.

The VSS-7 coaxial power cube (standard 1.4"×1.2"×8") has male and female coax connectors. The unit is rated to clamp at 160 Vac with a 70,000-watts rating, 6,500 A maximum. The cube is designed for use with 75-ohm cable and is applied in data links in building coax networks or the antenna side of cable television.

For more information contact American Voltage Products, Inc., 18 Morse Drive, Essex Junction, Vermont 05452.

Circle #303 on Reader Service Card.

Full remote frequency control with FC-900 Interface

Advanced Computer Controls, Inc. announces the new FC-900 Interface, supported by several of its repeater controllers. The FC-900 Interface permits use of the ICOM IC-900 transceiver band units as remote base and link transceivers. The system approach is cost effective as only the band units are needed, not the ICOM fiber optic controller and interfaces. Hookup is simple.

Full remote frequency control is available through Touch-Tone commands. Amateur frequencies are supported on six bands from 29 to 1300 MHz.

Remote bases and links let you extend the range of the repeater, link it to other repeaters for emergency and public service use, and benefit from the site elevation on all bands.

The price of the FC-900 Interface is $225. An optional programmable CTCSS encoder is $25. For more information contact Advanced Computer Controls, Inc., 2356 Walsh Avenue, Santa Clara, California 95051.

Circle #304 on Reader Service Card.

Two new repeater modules

Hamtronics, Inc. has announced two new products for building VHF and UHF repeaters.

The COR-4 COR/CWID module is a new low-power unit which combines all the features of the CWID and COR-3 (including courtesy beep) in one 3"×7" module. This new unit uses CMOS logic and an EPROM for programming. Introductory price is $99 for the kit or $159 wired and tested.

The TD-3 Subaudible Tone Decoder/Encoder can be used with any subaudible tone on Hamtronics or most other receivers. It has repeater service features (like remote on/off capability when used with TD2 Touch-tone module). The price is $24 for the kit, $69 wired and tested.

For a catalog on the entire line of repeater modules send $1 to Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535.

ANALOG PANEL METERS

Take advantage of analog panel meter benefits

By Hugh Wells, W6WTU, 1411 18th Street, Manhattan Beach, California 90266

Even though most electronic devices are digital these days, analog meters are still popular. You can find them at garage sales, swap meets, surplus outlets, and in many Amateurs' junkboxes. There's a good, reasonably priced selection to choose from. Panel meters were designed as single-application indicators, but you can easily convert them to other uses with external circuitry.

Because some meters have unusual markings, many shoppers bypass valuable ones at swap meets in lieu of those that look more familiar. A meter's value lies in its sensitivity and its ability to adapt to a new use, regardless of its original scale markings. If you're careful, you can change scale markings on non-hermetically sealed meters and increase the instrument's versatility.

The more you understand about a specific instrument, the easier it is to use. My computer program* helps me develop external circuit values to meet new applications for my panel meters, using the techniques that follow.

Theory

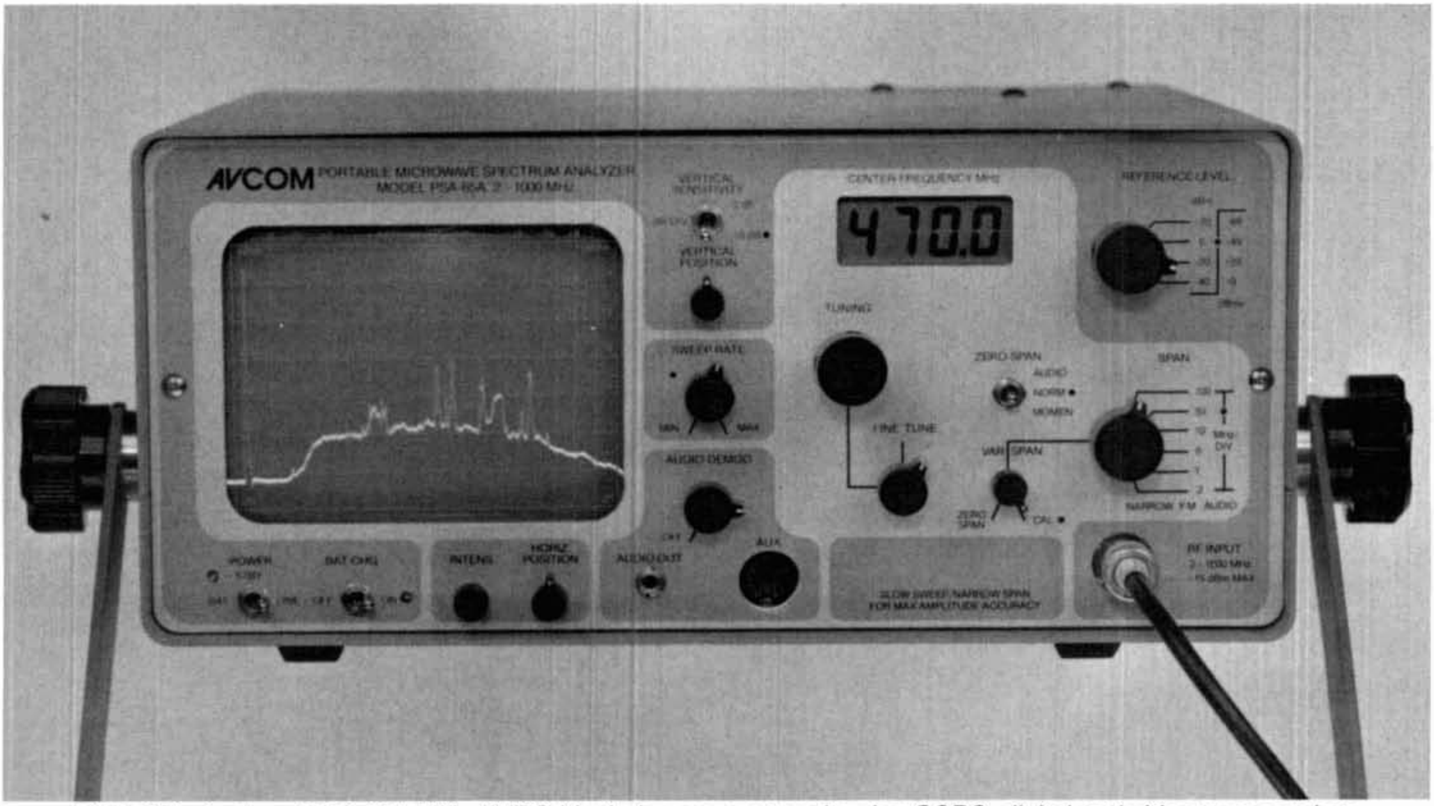
Meters are used to measure voltage, current, resistance, power, RPM, temperature, and other electrical and electro-mechanical functions. Each converts a function to an electrical signal, and then to a pointer position on the meter scale. There are many types of meters that provide indications of an electrical quantity. Analog panel meters are current operated (versus electrostatic). Current-operated meters work as a result of electromagnetic motor action, where the mechanical movement of a pointer is proportional to a magnetic force. The force develops between a permanent magnet and the magnetic field created around a coil of wire through which a current flows.

Two of today's popular meter movements use electromagnetic motor action: the plunger (moving iron) and the D'Arsonval type. The D'Arsonval uses a moving coil, and is preferred because of its indication sensitivity and repeatability. The plunger-type meter is more suitable for applications where the accuracy of an indication is unimportant.

The D'Arsonval meter uses a horseshoe magnet with its open ends close together, creating a magnetic gap. Soft iron pole pieces with semicircular ends are fitted to the ends of the magnet to narrow the gap, and create a uniform magnetic-field pattern that translates to a linear-scale indication. The semicircular ends face each other, forming a round gap area. Some meter manufacturers cut the pole pieces on a bias. This creates a nonlinear function which satisfies a particular application. The majority of pole pieces are cut straight to provide linear indications. A round piece of soft iron is mounted

*Send a large self-addressed stamped envelope to *Ham Radio* Magazine, Greenville, New Hampshire 03048. Ask for W6WTU computer program. Ed.

A New Spectrum Analyzer From AVCOM!!!



PSA-65A display of 270-770 MHz TVRO block downconverter showing SCPC, digital and video transponders.

The newest in the line of rugged **spectrum analyzers** from AVCOM offers amazing *performance* for only $2,675.

AVCOM'S new **PSA-65A** is the first low cost general purpose portable spectrum analyzer that's loaded with features. It's small, battery operated, has a wide frequency coverage and is accurate - a *must* for every technician's bench. Great for field use too.

The **PSA-65A** covers frequencies thru 1000 MHz in one sweep with a sensitivity greater than -90 dBm at narrow spans. The **PSA-65A** is ideally suited for 2-way radio, cellular, cable, LAN, surveillance, educational, production and R&D work. Options include frequency extenders to enable the **PSA-65A** to be used at SATCOM and higher frequencies, audio demod for monitoring, log periodic antennas, carrying case (AVSAC), and more.

Can't wait to find out more about this revolutionary new AVCOM Spectrum Analyzer? Then see us at the ***SPACE/STTI Las Vegas Show, March 21-23, THE INTERNATIONAL MOBILE COMMUNICATION EXPO in Las Vegas, March 29-31***, or ***Dayton HAMVENTION, April 28-30.*** Write, fax or call **AVCOM** for brochure and specifications sheet.

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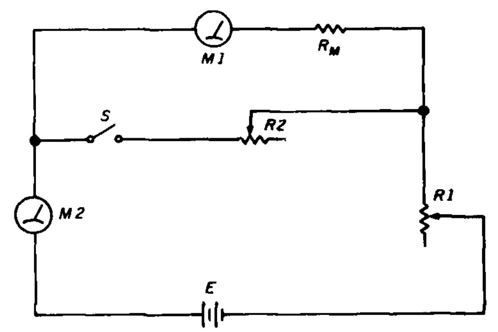
between the semicircular pole pieces, concentrating the field pattern within the gap.

A moving coil, made of many turns of small diameter wire wound into a rectangular shape, is mounted lengthwise around the center pole piece. Some coils are wound onto an aluminum frame/bobbin; others have no bobbin. In either case, the coil must be lightweight, with a shape that lets it move freely in the gap between magnet and center pole.

Pointed-wire pins called pivots are mounted (usually cemented) to the coil in the axis of rotation, along with spiral springs and an aluminum pointer. The pivots provide a low-friction bearing surface for the coil. In some meters the coil is mounted with a taut band instead of pivots. The taut band reduces the bearing-surface friction and improves indication accuracy and repeatability. A twist in the taut band creates the return spring function provided by the spiral springs used with pivots. The complete coil assembly is called a meter movement.

FIGURE 1



Technique for measuring internal resistance.

Internal resistance

Wound wire makes up the coil portion of the movement. The wire has a resistance depending on wire diameter and length. The completed coil has an internal resistance (R_m), which you need to consider during all external circuit calculations. There are some applications (like voltmeters) where R_m is small compared to the multiplier resistance and can be disregarded. Meter applications involving a shunt (an ammeter, for instance) require that R_m be considered in the external resistance calculation.

Generally the value of R_m is unknown, but you can determine it using an indirect measurement method. Attempting to measure R_m by direct means (as with an ohmmeter) could cause excessive current or voltage to be applied to the meter coil and damage it. An indirect measurement method is shown in **fig. 1**. This method involves adjusting R_1 for a full-scale deflection of M_1 with a voltage source (E). Resistor R_2 is then attached in parallel with M_1 and decreased in value until M_1 indicates exactly one-half the full-scale value.

TABLE 1

Typical internal-resistance values as a function of coil current.

I_m	R_m (ohms)
15-20 μA	4000
50 μA	1200
100 μA	850
200 μA	600
500 μA	150
1 mA	76
2 mA	60
5-10 mA	16

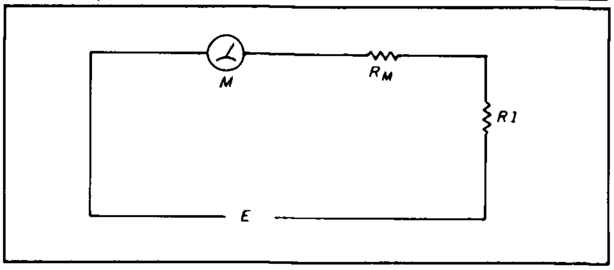
You may need to adjust R_1 slightly to maintain the same total current indicated by M_1 while at full scale. Meter M_2 is an indicator ensuring that total current remains constant as you adjust R_1 and R_2. In theory, the resistance of R_2 is exactly equal to R_m, and the combined current of R_2 and M_1 is equal to the original M_1 full-scale current. You can measure the resistance of R_2 with an ohmmeter for the value of R_m, after disconnecting it from M_1. The indirect method yields a reasonably accurate value of R_m, suitable for external circuit calculations.

Table 1 shows a listing of R_m values developed emperically from meters of different current ranges and manufacturers. You may use the table values to estimate R_m as a function of current. However, there's no specific value of R_m suitable for all meters of a specific current range. The actual R_m value varies by manufacturer, full-scale current value, strength of the magnet, gap spacing, and the number of turns and diameter of wire on the coil. Identifying an R_m value to within 20 percent of actual is usually sufficient for most Amateur applications, but a closer value may improve calibration accuracy. You can correct the meter calibration error introduced by an estimate of R_m when selecting your external resistors.

Accuracy

An instrument's measurement accuracy depends on many factors. These are functions of manufacturing tolerances and external circuitry. The typical accuracy of a D'Arsonval panel meter is 2 percent. That tolerance degrades to 3 to 5 percent with the addition of external multiplier resistors and rectifiers. Meter accuracy is normally determined at the full-scale value, and the resulting error is applied to all remaining scale indications. Some measurement applications require an accurate single-point indication. A 2-percent full-scale instrument with low-pivot friction and repeatable pointer positioning can yield a single-point calibration accuracy of 0.5

FIGURE 2



Single-range DC voltmeter.

percent or better. But, you should consider other points on the same scale as having an accuracy depending on the full-scale tolerance value — not equivalent to the single-point calibration accuracy.

Sensitivity

You can define meter sensitivity by either full-scale current or ohms-per-volt value. Meter sensitivity is most commonly defined in ohms-per-volt. It's determined by the amount of resistance that must be used in series with the meter to cause a full-scale deflection when 1 volt is applied. For instance, a 1-mA meter has a sensitivity of 1000 ohms per volt, and a 50-μA meter has 20,000 ohms per volt. Disregard the internal resistance (R_m) value when determining sensitivity.

Applications

Whether you can use a meter directly depends on its application and the external circuit in which it's placed. Few panel meters are used without external circuitry. Resistors are added externally for DC applications; resistors and rectifiers are added for AC use. You may use a bridge rectifier in a metering circuit to satisfy a nonpolarized DC application. The changes in scale factor result from the addition of the rectifier.

DC voltmeter

To use a panel meter as a voltmeter (see **fig. 2**), you'll need a series-connected resistor (R_1) to reduce the current to the desired amount. Determine the value of R_1 by:

$$R_1 = \frac{E}{I_m} - R_m \qquad (1)$$

where
R_1 = multiplier resistor value
R_m = internal resistance of M
I_m = full-scale meter current
E = desired full-scale voltage value

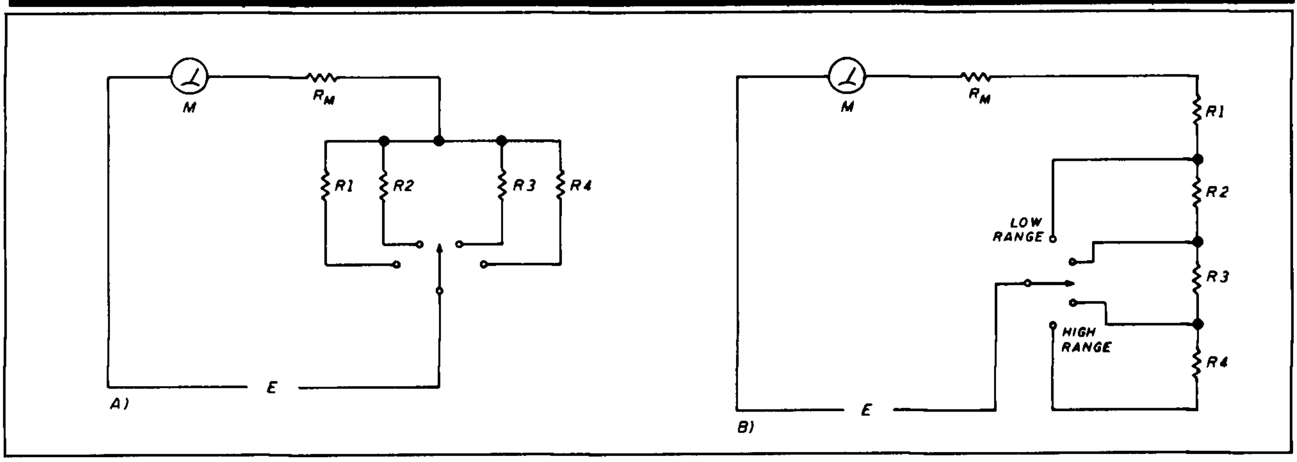
A single multiplier resistor satisfies the need to measure voltages less than the full-scale value. Switching additional resistors into the circuit for R_1 lets the meter function over different voltage ranges. I've shown two multiple-range circuit techniques. **Figure 3A** shows a switch used to select an independent value of R_1 for each desired range; **fig. 3B** shows stacked incremental resistor values. Determine the value of each resistor by using **eqn. 1** for **fig. 2**. Now you can determine the value of each resistor sequentially, after calculating R_1. (R_m is usually disregarded.) Define each additional range resistor by calculating the total resistance value, then subtracting from it the sum of the previously determined values (see **eqn. 2**).

$$R_X = \frac{E_{Range}}{I_m} - (R_m + R_1 \cdots R_4) \qquad (2)$$

where
R_x = total multiplier resistance value
E_{Range} = desired full-scale range voltage
I_m = full-scale meter current
R_m = internal resistance
$R_{1\text{-}4}$ = incremental-range resistance value

You can consider tradeoffs when selecting one rang-

FIGURE 3



Multiranging voltmeter. (A) Individual resistor multiplier. (B) Stacked resistor multiplier.

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Lodging: April 7
License Exams: March 26
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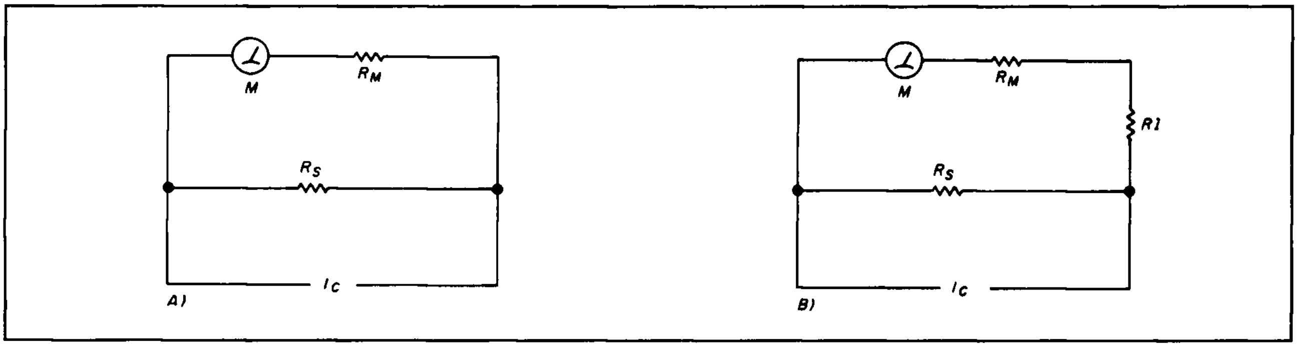
FIGURE 4



Ammeter circuits. (A) Shunt multiplier. (B) Series and shunt multiplier.

ing method over the other. Scale accuracy for the circuit in **fig. 3A** depends on each individual series resistor. For **fig. 3B**, the scale accuracy depends on the resistor tolerance of each lower range value in the stack. Perhaps the main advantage of **fig. 3B** over **fig. 3A** occurs when the meter is used to measure high voltage. If you use carbon resistors, you must consider — and not exceed — the voltage breakdown of each. Typical carbon resistors have a maximum safe voltage drop depending on their physical size. This may be translated to wattage: 1/4 watt = 100 volts, 1/2 watt = 300 volts, 1 watt = 500 volts.

Ammeter

An ammeter differs from a voltmeter in that it's connected in series with the external circuit, rather than in parallel. The ammeter is placed in series with a voltage source and its load circuit; this allows the meter to indicate the current drawn by the load. A shunt is placed in parallel with the meter coil, so only a portion of the external current flows through the coil. The amount that flows through the meter is a linear indication of the total current. The remaining current flows through a shunt resistor as shown in **fig. 4A**.

When you calculate the shunt value, you must know the full-scale current value, internal resistance, and the shunt current. Determine the shunt resistance by

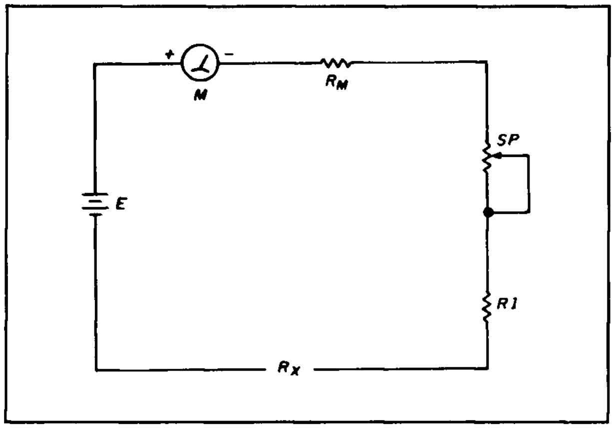
$$I_{Rs} = I_c - I_m$$

$$R_s = \frac{R_m \times I_m}{I_{Rs}} \qquad (3)$$

where
R_s = shunt resistance
R_m = internal resistance of M
I_m = full-scale meter current
I_{rs} = shunt current
I_c = external circuit current

As the circuit current to be measured becomes very large (as compared with the meter-coil current), the resistance of the shunt becomes very small — sometimes too small to be easily managed. Solve this problem by adding a resistor in series with the meter. This allows it to function as a voltmeter. It will then measure the voltage drop across the shunt, as shown in **fig. 4B**. Although the meter is measuring voltage, its scale is calibrated in current. Assume that a current of 10 A is flowing through an R_s value of 1 ohm. E = 10 volts by Ohm's Law, and you'd select a value of R_1 which would provide a full-scale indication of 10 volts (10 A) on the meter.

FIGURE 5



X1-series ohmmeter.

Multi-ranging an ammeter requires a current-scale switching method theoretically involved in selecting a value of the shunt resistor for each current range. However, it's better to perform the range switching in the low-current circuits where switch-contact resistance has the least effect on the resulting indication. With R_s as a single fixed resistor, you may select values of R_1 to provide a multi-range capability.

Ohmmeter

An ohmmeter indicates the resistance of an unknown circuit or circuit element. Because it is a resistance detector, the ohmmeter can also be used to check circuit continuity. Sometimes knowing if the circuit is continuous is more important than knowing its resistance value.

The ohmmeter is essentially a voltmeter with an internal, rather than external, voltage source (see the series type in **fig. 5**). The pot (SP) and resistor R_1 make up the multiplier resistor allowing the voltage source to drive the meter to full scale. A fine-current adjustment, made with the pot, lets you obtain a full-scale indication when R_x (**eqn. 2**) is equal to zero. The scale calibration on a series ohmmeter is the reverse of that on a voltmeter scale. The $R_x = 0$ point is at full scale, with discernible measurement values read more easily in the upper three-fourths of the scale. (The scale values are usually too compressed in the lower quarter of the scale and provide only an approximation.)

Placing an unknown resistor (R_x) in series with the ohmmeter circuit causes a decrease in total current. The new lower current value is then translated to a resistance value for R_x on the meter scale.

When selecting circuit-component values and calibrating the ohmmeter scale, make several assumptions for the sake of convenience. After you've determined the total multiplier-resistance value for the circuit, assume that the working portion of the pot value is 10 percent of the total. To allow for pot adjustments, select the pot's total resistance to be 15 percent of the total circuit resistance.

Develop scale values for an ohmmeter through an iterative process by decreasing the meter current in increments and calculating R_x at each increment. The equation for determining a value of R_x is

$$R_x = R_t \frac{I_1 - I_2}{I_2} \qquad \textbf{(4)}$$

where

R_x = unknown resistance value

R_t = total circuit resistance (when $R_x = 0$)

I_1 = full-scale circuit current

I_2 = circuit current value when $R_x > 0$

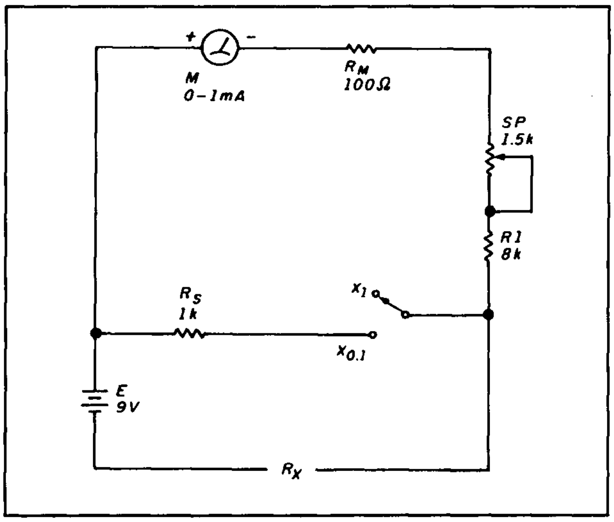
You can establish a multi-ranging capability for an ohmmeter by selecting the source voltage and full-scale meter current for the desired resistance range. Choosing a high-voltage source and a low meter current will provide a high-resistance measurement range. Likewise, increasing the circuit current through R_x will lower the measurable range. Many circuit designs have been developed for multi-ranging an ohmmeter. I'll discuss three examples.

Example 1. You can make a very low range ohmmeter by modifying the circuit of **fig. 5**. The unknown is in parallel with the meter coil, instead of in series with it. If the meter R_m is 100 ohms, the measurable range of R_x is from zero to about 500 ohms with 100 ohms at midscale. Placing a shunt across the meter and raising circuit current further reduces the R_x range to perhaps 0 to 50 ohms with 25 ohms at midscale. Placing R_x in parallel with the meter coil causes the ohmmeter scale to indicate that R_x is equal to infinity at full scale, instead of the normal zero at full scale for a series type.

Example 2. By adding a high-voltage source and compensating R_1 value to the circuit shown in **fig. 5**, you can extend the measurable R_x range to several megohms.

Example 3. In **fig. 6** a typical series ohmmeter circuit has a shunt in parallel with the meter to raise the external circuit current. You can switch the shunt in and out to provide an X_1 and $X_{0.1}$ range capability. In this example, I've provided circuit values for analyzing the currents involved. With the shunt in place, the external current will have been raised over the meter current by a factor of 10. At $R_x = 0$, 10 mA will flow through the external circuit and 1 mA will flow through the meter, providing a current ratio of 10:1. The value of current difference between the meter and the external circuit will flow through the shunt (i.e., 9 mA). The resulting resistance-measuring range will be from 0 to 5000 ohms with 450 ohms at midscale. With the shunt removed, the measurable range will be 0 to 50,000 ohms with 4500 ohms at midscale.

FIGURE 6



Dual-range ohmmeter.

AC voltmeter

You can also use a DC panel meter to measure AC voltages by adding a rectifier to the metering circuit. Measurement values will be different from those with DC because of the rectifier, and because the meter movement will respond only to the average current. Assuming a sine waveform and a half-wave rectifier, the current flow through the meter coil will be about 63 percent of the peak value for one-half cycle. On the other half cycle, the current will be zero. The meter movement will average the two values, producing a pointer position

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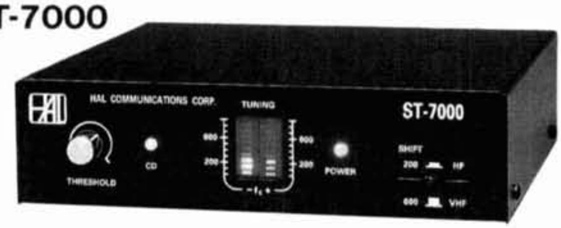

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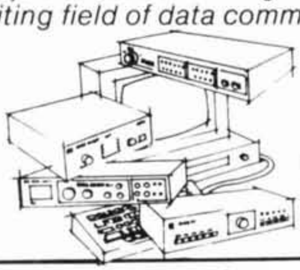

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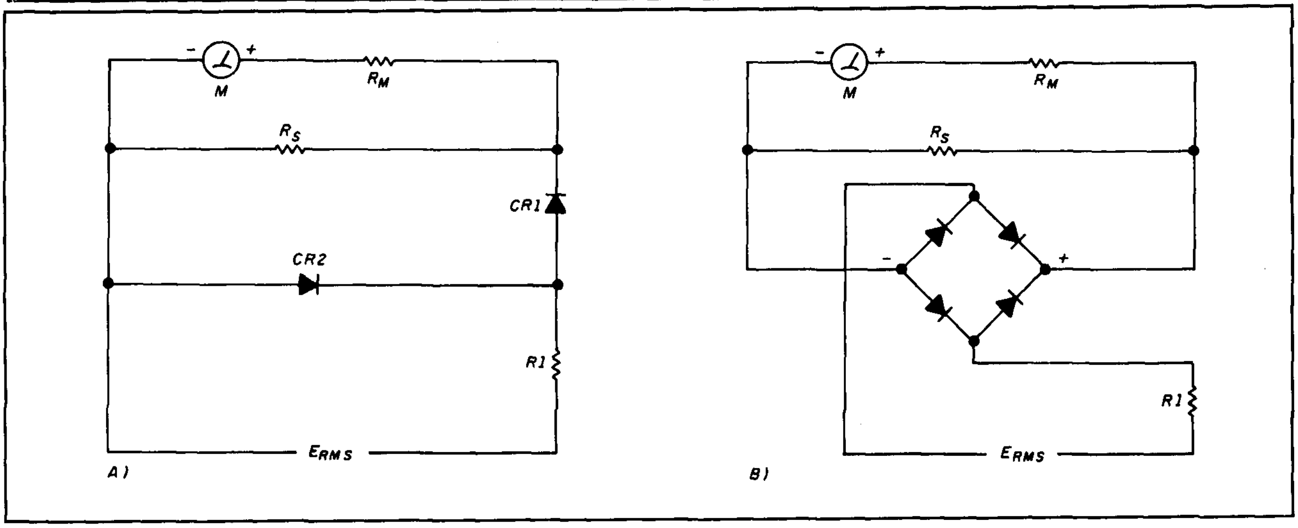
FIGURE 7



AC-voltmeter circuits. (A) Half wave. (B) Bridge.

equivalent to 45 percent of the root-mean-square (equivalent DC) input. The scale would be calibrated in rms.

When you use a bridge rectifier, both half cycles will cause coil current to flow, allowing the pointer position to move to the equivalent of 90 percent of the rms input. This is twice that of a half-wave rectifier. Again, the scale would be calibrated in rms.

Calculate the series multiplier resistance used with either rectifier using the following equations.
Half-wave rectifier:

$$R_1 = \frac{0.45 \times E_{rms}}{I_m} - R_m \qquad (5)$$

Bridge rectifier:

$$R_1 = \frac{0.9 \times E_{rms}}{I_m} - R_m \qquad (6)$$

where
R_1 = multiplier resistor value
E_{rms} = full-scale rms voltage value
I_m = full-scale meter current
R_m = internal resistance of M

The actual multiplier resistance value must be reduced by the series-forward resistance value of the rectifiers, or by an alternative method of subtracting the forward rectifier drop from E_{rms} for the calculation.

Figure 7 shows half-wave and bridge rectifier circuits commonly used with DC meters for making AC voltage measurements. You use two diodes in the half-wave application, with CR_1 allowing current to flow through the meter. Diode CR_2 conducts on the alternate half cycle, preventing th^ voltage across the meter rectifier from rising to the source voltage. A high-reverse diode voltage could cause a sufficient leakage current to flow, resulting in meter indication errors. The two diodes, each conducting on alternate half cycles, keep the reverse voltage drop across the other diode to a small value. This means the reverse breakdown voltage of the diodes can be much less than the voltage being measured. Typically, the diode peak reverse voltage (PRV) is in the range of 25 to 100 volts.

Diodes have a square law forward-conduction curve which, if allowed, would cause the meter's scale values to be nonlinear, particularly at low points on the meter scale. In an attempt to maintain measurement scale linearity, diode conduction currents are kept fairly high, placing the operating point on the vertical (nearly linear) portion of the diode's forward-conduction curve. Increase the diode current by shunting the meter, thereby lowering the sensitivity value. An AC voltmeter will have a sensitivity of 5 or 10 k per volt. However, if the basic meter sensitivity is less than 5 k, additional meter shunting is seldom necessary.

Computer program

The computer program mentioned earlier was written on an Atari in BASIC. I developed it around the circuits I've described to ease the implementation of panel meters for new applications. I've tried to keep the code general to accommodate the many BASIC dialects in use. A few dialects will require minor changes to the code for accommodation, and the following comments are provided to assist you in making those changes. For those dialects not able to handle LPRINT statements, you may use an OPEN statement followed by PRINT. Should you run into a situation where the dialect won't handle a variable containing two-letter alpha characters, try changing the

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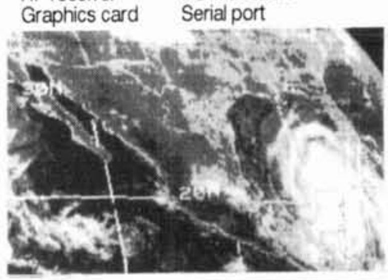

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second letter of the variable to a number. The same change must be made to all like variables within the program. Each line of code containing an equation has been given a REMark statement to clarify the function or action being taken. You may disregard the REM statements when entering the code into the computer, although they can be helpful if you need to debug the program.

I've placed all INPUT statements on the right end of the line. For some dialects, the INPUT may be moved to the left end of the line, eliminating the PRINT command.

For the AC-voltmeter calculation, the program provides the option of loading the diode rectifier for meters having a sensitivity greater than 5 k/volt. When loaded by the program, the meter shunt and multiplier values are given for a sensitivity of 5 k/volt. The program assumes that you'll use silicone diodes as rectifiers, and that their forward-conduction voltage drop is 0.7 volt. If you use copper oxide, germanium, or other rectifier types instead, the D value in lines 1390 and 1400 should be changed accordingly.

The program is a series of function/calculation blocks driven from a menu. The menu provides a GOTO command call for the function selected. Upon completing the function, the program returns to the menu for your next action. I've also included printout samples from each block. You can use these samples to determine proper program operation. With the exception of the ohmmeter scale calculations and resulting printer output, all calculations and printouts are to the screen. The ohmmeter portion of the program provides the scale marking (calibration) as it applies to the relative coil-current value. The tabulated output makes the scale-marking task much easier.

Internal resistance is an important factor in most calculations. It should not be ignored until you know its effect on the results of calculations. The computer program requests an R_m value for nearly every function. If the value is unknown, use either a value from **table 1** or enter 100 ohms.

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5. *Theory and Use of Electronic Test Equipment*, TM 11-664, Departments of the Army and Air Force, 1952, page 158.
6. Harry E. Thomas and Carole A. Clarke, *Handbook of Electronic Instruments and Measurement Techniques*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1967, Chapter 2.
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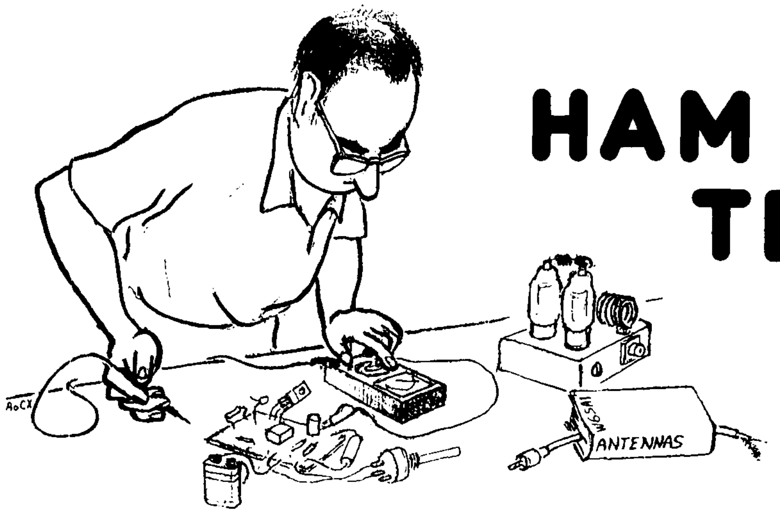
Article F **HAM RADIO**



HAM RADIO TECHNIQUES

Bill Orr, W6SAI

Antenna projects for spring

It's a little too early for serious antenna work in most parts of the country. But spring will soon be here and it's time to start thinking about all those great DX antennas you're going to erect! Here are some interesting antenna projects you readers have sent to me.

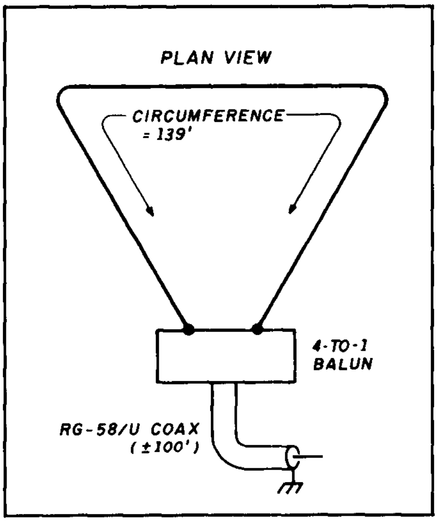
The AG9C horizontal loop antenna

I think the loop antenna has more interesting variations than any other! Bob Morrison, AG9C, has had excellent DX results with a full-wave horizontal delta loop that he uses on 40, 20, and 15 meters "as is," and with a tuner on 80, 30, and 10 meters (**fig. 1**). The only materials you need are about 139 feet of no. 14 copper-weld wire, a 4:1 balun, a few insulators, and a length of 50-ohm coax line.

Bob examined the antenna radiation pattern at 7, 10, 14, 21, and 28 MHz using the MININEC3 computer program with the Sommerfield-Norton option. He assumed a 20 foot height and poor ground (k = 5, and $\Gamma = 0.002$ siemens/meter). In general, Bob found that gain patterns are comparable to a dipole cut for each of these frequencies. One exception, he noted, is that the loop patterns are more omnidirectional than those of similar dipoles.

"The design is very forgiving," Bob comments. "Loop antenna patterns remain excellent when side lengths are unequal and/or the three corners have unequal heights."

FIGURE 1



Top view of the AG9C horizontal delta loop. Antenna works without tuner on 40, 20, and 15 meters. Tuner permits operation on 80, 30, and 10 meters.

Bob's observed SWR readings on the loop (taken through 100 feet of RG-58/U) are: 40 meters—1.55 at 7.0 MHz, 2.4 at 7.3 MHz; 20 meters—1.2 at 14.0 MHz, 1.7 at 14.35 MHz; 15 meters—1.38 at 21.0 MHz, 1.70 at 21.45 MHz; 10 meters—2.7 at 28.0 MHz, 3.7 at 28.5 MHz, 5.9 at 29.0 MHz, and 3.6 at 29.7 MHz.

You can move the minimum SWR point in the 10-meter band by changing the total length of the wire in the loop 6 inches at a time.

Bob says the loop can be used on 80 and 30 meters by adding an antenna tuner in the station. The input impedance of the loop on 80 meters is very high, as it is at a half-wave resonance. The mismatch at the balun causes high SWR and considerable power loss in the balun and coax line. Nevertheless, a tuner easily matches the feedline to the transmitter. Antenna radiated power is reduced, but adequate, over the CW portion of the 80-meter band.

The two-radial ground plane revisited

In my October column I mentioned that two radials seem sufficient for an elevated ground-plane antenna. Along this line, Gunter Hoch, DL6WU, wrote to me about a two-element "ground-plane Yagi" he observed atop a nearby United States Army depot. The antenna is shown in **fig. 2**. It consisted of a quarter-wave folded radiator and a reflector mounted over a pair of radials. He estimated from the size that it was cut for a frequency near the 2-meter band.

This is an interesting concept. With a couple of remote-controlled relays at the antenna it would be possible to switch quickly from a vertically polarized ground-plane Yagi to a two-element, horizontally polarized

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SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
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SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

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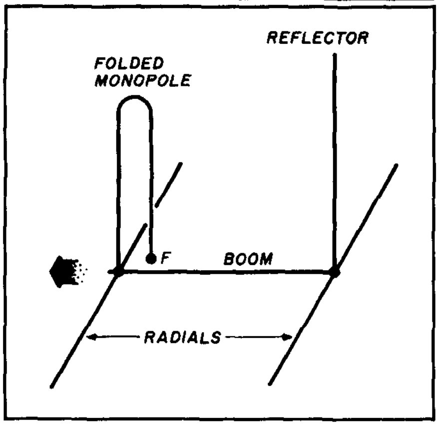
conventional Yagi. The horizontal elements are cut to serve as a driven element and a reflector — just the ticket for a single antenna to work mobile stations (vertically polarized) and over-the-horizon DX (often horizontally polarized). I'll leave the details up to you!

DL6WU has submitted VHF Yagi data for inclusion in the *ARRL VHF Manual*.

FIGURE 2



Quarter-wave folded radiator is fed at F. Vertical elements are mounted above quarter-wave horizontal radials. (Courtesy DL6WU)

What is the correct radial length?

I mentioned some comments by Collin Stiteler, KE6VZ, about the correct length for ground-plane radials in my March column. Collin has raised another interesting question: "Many how-to-do-it articles on ground planes suggest that you make the radials something like 5 percent longer than the radiator. Why is this? Other articles call for radials equal in length to the radiator. If there are sufficient radials, they approximate a horizontal disc conductor. Should the radius of this disc be equal to, or 5 percent greater than the length of the radiator?"

Collin thinks that resonant radials should actually be a little shorter than the length of the radiator, not longer (as is occasionally stated), since the radials approach a "fat" conductor, or disc. The physical length of a "fat" conductor is less than that of a "thin" one for a given frequency, and Collin suggests that this rule should also apply to resonant radials.

This is an intriguing thought. I've always cut my radials to the same length as that of the radiator. Once I built a 21-MHz ground plane with radials 5 percent longer than the radiator. I couldn't notice any difference in operation or SWR measurements, as compared with an earlier, conventional ground plane. This leads me to think that radial length is unimportant (within 5 percent), at least in the HF region. Any comments on this question?

"Torching the Cat" and other exploits

I received a letter from "Doc" Sayre, N7AVK, who most assuredly deserves membership in the Antenna Experimenter's Club. Doc writes, "Fashioning a sky wire is truly exciting. I have loaded rain gutters on 160 meters (torching the cat in the process), fir trees on 15 meters (the nail gets hot and you shouldn't drive it in very deep for best results!), an all-band well casing about 160 feet deep, and an unusual buried run of two 4-0 insulated aluminum wires about 1/4 mile long that works amazingly well on 80 and 160 meters." He concludes, "If you're not thinking and improvising, then you're just taking up space!"

Good show, Doc!

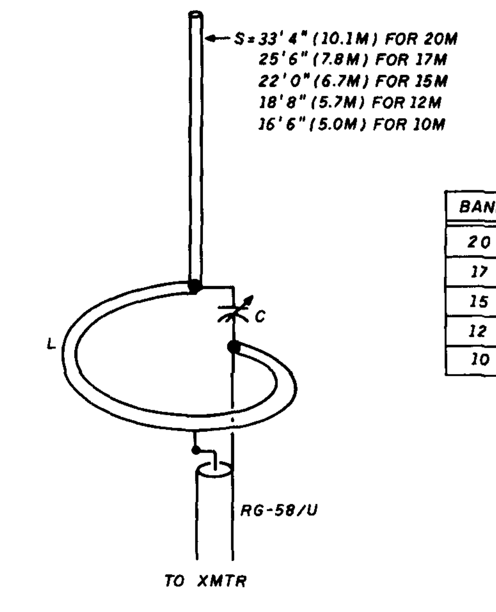
The gamma loop fed vertical antenna

In *The Radio Amateur Antenna Handbook*[1] I described an interesting DX antenna (shown in **fig. 3**). It consists of a half-wave vertical dipole fed at the bottom with a "ground independent" feed system.

The antenna shows about 1.8-dB gain over the classic ground-plane antenna and requires no radials. Feedline isolation is very good.

The feed system provides a match between the high-impedance end of the dipole and a low-impedance coax line. A parallel-tuned circuit will work. A low-loss design consists of a large, horizontally mounted single-turn coil in parallel with a high-voltage capacitor. The combination is resonant at the antenna's design frequency.

FIGURE 3



BAND	L (mH)	C (pF)
20	1.40	100
17	1.25	85
15	1.05	75
12	0.85	65
10	0.70	50

Vertical dipole fed with parallel tuned circuit at base. L-C circuit resonates at middle of band of choice. (Courtesy Radio Publications, Inc.)

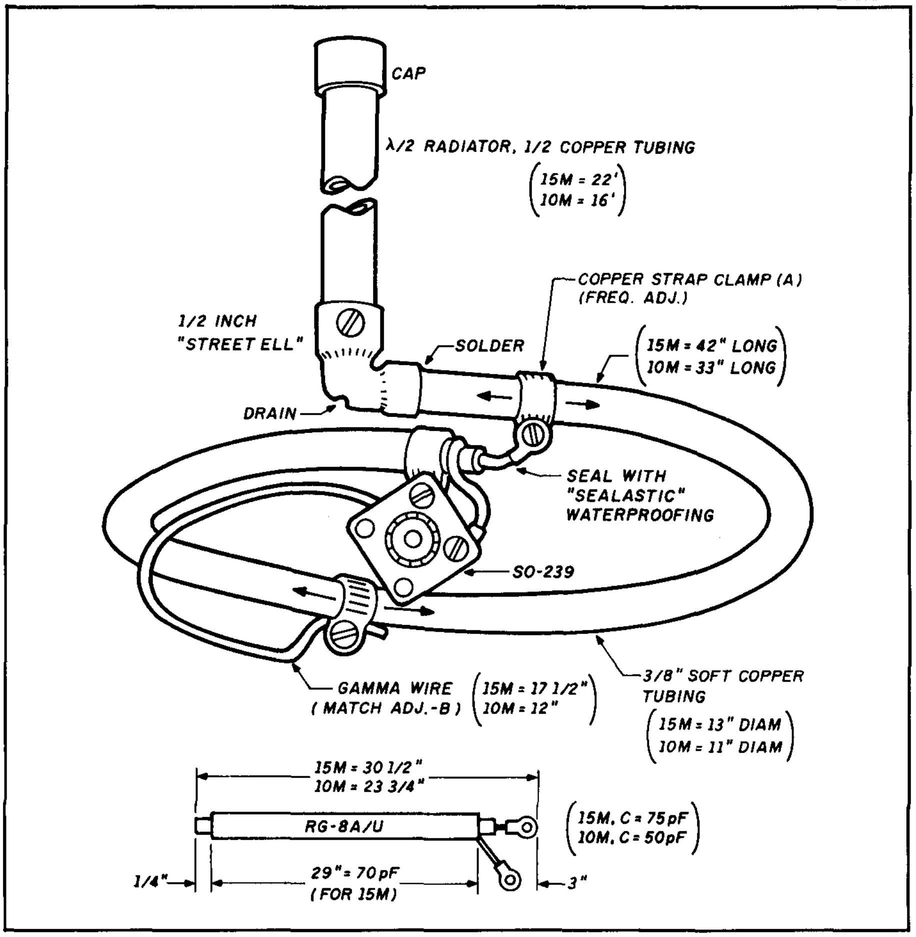
John O'Brien, W2YYI, has solved the mechanics of making a waterproof tuned circuit and a high-voltage capacitor of inexpensive materials (see **fig. 4**). He makes the antenna and resonating coil out of soft, 1/2-inch, thin-wall copper tubing available from hardware and home improvement stores. The assembly is put together with a soldering torch.

In my original design, I achieved an impedance match by tapping the coax line on the single-turn inductor at the appropriate point. John, on the other hand, uses a gamma match system. I think his method is the better of the two. The gamma capacitor is made of a section of RG-8A/U coax cut to length and inserted in the copper tubing. The shield of the coax is attached to the shell (ground) of the coax receptacle. The center conductor is soldered to the gamma wire, which is tapped by a tubing clamp on the coil near the base of the antenna. The gamma wire is a length of PVC insulated house wire, or bare copper wire.

The antenna is adjusted for lowest SWR on the feedline by moving the two clamps along the coil. Clamp A is adjusted for frequency and clamp B is adjusted for the best impedance match. John notes that bending the gamma wire closer to, or further away from, the loop also affects the SWR.

Finally, John says you can make a "cheap and dirty" equivalent by substituting wire for the antenna and the loop, and making the capacitor out of a piece of double-sided pc board!

FIGURE 4

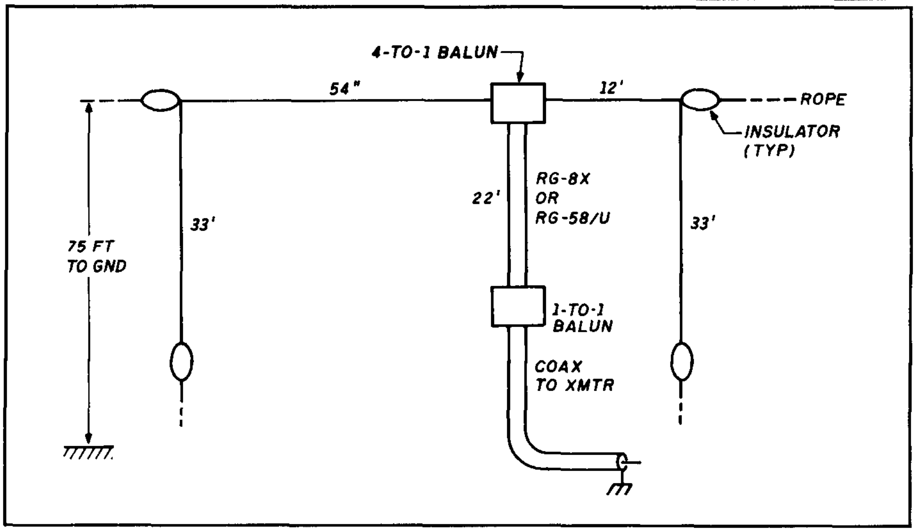


Gamma loop-fed vertical for 10 or 15 meter bands. Capacitor is made of RG-8A/U coax and is slid inside copper tubing — Vaseline® helps!

The W4TDI "Carolina Windom" array

In the May 1988 column I discussed the Carolina Windom antenna, which seems to be enjoying some popularity. In brief, it's a multiband antenna fed with a stub and balun, which operates on more than one ham band. Ray Hoffman, W4TDI, making a virtue out of necessity, erected a version of the Carolina Windom between two trees only about 75 feet apart (see **fig. 5**). It was impossible to erect a 132-foot

FIGURE 5



The W4TDI version of the "Caroline Windom" antenna. Configuration works as broadside array on 20 meters with cloverleaf pattern. (See my column, May, 1988 for more data on "Carolina Windom" antenna.) A "Carolina Windom" kit maybe obtained from the Radio Works, Box 6159, Portsmouth, Virginia 23703, phone: 804-484-0140.

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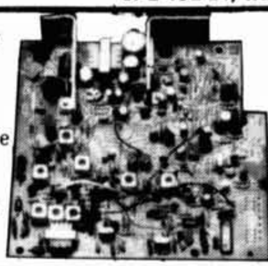

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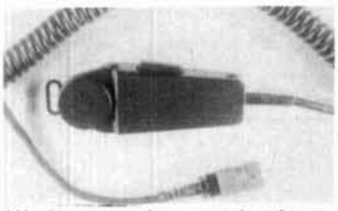

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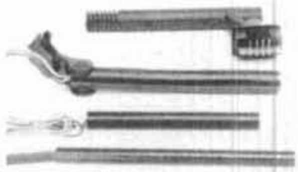

Shown above are 4 ferrite rods, figures A, B, C measure 4-11/16" x 13/32" long. Each has a coil and a tuneable slug inside the plastic case. The rod in figure D measures 7¼ x 11/32". Figure A has a ball swivel and terminates in 4 leads. Figure B utilizes a hinged swivel and terminates in 5 8" color coded leads. Figure C terminates in 5 8" color coded leads. Figure D terminates in 6 inches of 3 ohm lead antenna wire. All Unused. Shipping weight for any of the above is 8 oz.

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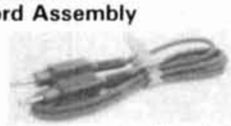
FIG. B; 1½" overall length. 1-3/8" of the shaft is threaded. 6-32 thread. 7/8" cloth covered foot. Sold in bag of four units.
Shpg. Wt. ¼ Lb. **SP-122A-51** **$1.00/bag**
FIG. C; ½" overall length. 19/32 of the shaft is threaded. 8-32 thread. 5/8 cloth covered foot. Sold in bags of 4 units.
Shpg. Wt. ¼ Lb. **SP-142C-51** **$1.00/bag**

EECO STRIP SWITCHES

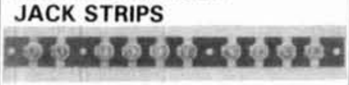
Unused EECO strip switches still in tubes. Hexidecimal. Output 0-15. Adjusting them is accomplished by your thumb or a screwdriver. Size 13/16" x 3/4" x 3/8".
Shpg. Wt. 4 oz. **SP-431-52** **$1.00**

DUAL 3.5mm Plug/Cord Assembly

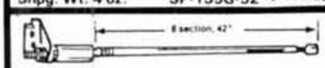


This is a very nice audio grade cable made by Sony. The braided shielded cord is just over 3 ft. long. Each end has a molded 3.5 mm plug on it with a strain relief. Color is gray.
Shpg. Wt. ¼ Lb **SP-102B-51** **$0.75**

RCA AUDIO/VIDEO JACK STRIPS



RCA jacks are the standard in home audio and video equipment. If you are building, modifying, or repairing any pieces of equipment these are very handy to have around. Our offering has 10 RCA jacks on a phenolic strip which can be easily cut, should you not need all 10 for one project. Condition; carefully removed from unused equipment.
Shpg. Wt. 4 oz. **SP-135G-52** **$1.00/10**



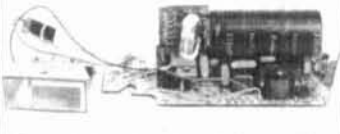
ANTENNA

New telescopic antennae made for Panasonic TV perfect for various uses such as Ham radios CB sets, walkie talkies, AM-FM radios, and of course for TV sets which the kids are always breaking. Antenna telescopes into a 6 inch length and extends up to 42 inches (which seems almost magical).
Shpg. Wt. 1 Lb. **SPL-33B-51** **$2.00**

HI-VOLT SUPPLY

Used, hi-voltage power supplies made by Varo. We do not know what they were originally used in. The high voltage nature of this device should "spark your imagination". The input 115VAC, 60 Hz, output is 13.5 KVDC at 0.31mA.
Shpg. Wt. 5 Lbs. **PS-37-51** **$12.00 each**

PHOTO FLASH BOARD



Pictured above is a photo flash assembly from a Sun Gun camera. We have been told these are a manufacturer overrun due to a model change. The flash is very compact and is complete less case and battery holder. The photo flash cap is rated at 400uf, 330 volts. Please be careful when experimenting with this device as it could give you a good whallop. The strobe tube measures 1.5" long. Run on 3-6 VDC. AA size batteries are ideal.
Shpg. Wt. 1 Lb. **SPL-96A-51** **$10.00**

PRECISION HELIPOT®

Unused Beckman Helipots model 7246. The value is 25 ohms at 0.25% linearity. Beckman manufactures high quality components and these are no exception. They have a beautiful feel. Body size; 1-7/16 x 7/8" Brass bushing with handware. Metal shaft has stops. Regular price of this device is over $38.00 each.
Shpg. Wt. 4 oz. **SPL-207A-51** **$7.50**

SOLID STATE RELAY

This Crydom relay runs on 3.5 to 8 VDC. SPST no contact. Rated at 240VAC @ 2 amps. N.O. List Price $15.00. Crydom part No. 53022A. Unused.
Sh. Wt. 8 oz. **SP-113B-51** **$2.50**

CONTROL SIGNAL RELAY

These unused 24VDC, 4PDT (2P make before break) general purpose relays have contacts rated for 2 amps. The relays have solder terminal lugs with a mounting stud. If desired, they can be plugged into a socket (not supplied). List price is over $14.50 each.
Shpg. Wt. ¼ Lbs **SP-214-51** **$1.75**

SOLDERLESS STACK-UP BANANA PLUGS

We have a bunch of these banana plugs in yellow and green. Loosening the grass set screw allows insertions of your test lead. The banana plugs can be stacked by inserting them through hole in plug as pictured. Similiar to Pomona part No. 1325. New, surplus. Please specify yellow or green.
Shpg. Wt. 2 oz. **SP-300B-51** **$0.40**

ELECTRO LUMINESCENT PANELS

There is a lot going on with electroluminescent technology and we have an inexpensive way for you to get into experimenting with it. We can offer to you EL panels and DC to AC inverters. The panels are all unused. The size is 4¼ x 2-1/8". When power is applied they glow an earie green. The use of the DC to AC module allows them to be used on 6 to 12VDC. The output of the modules is 80 VAC to 115VAC, 400 Hz. This allows them to run at peak brightness and efficency. They will run on 110V, 60 Hz. at reduced brightness but there are inherent dangers when using line voltages and caution should be used. Complete with hook-up diagram.
EL PANEL
Shpg. Wt. 4 oz. H-37 $3.50
Power Module
Shpg. Wt. 4 oz. H-69C $2.50

BARRIER STRIPS

Mfg. by Kulka Smith. Dual 18 point closed back. 20 amp. List $3.52 each. New.
Shpg. Wt. 1 Lb. **SP-128A** **$1.25**

VARIABLE RATE STROBE KIT

We provided you with all the parts necessary, including the PC board and schematic so you can make a nice strobe. When finished it will run on 4.5 to 6 VDC. The power can be either from batteries or a wall adapter of about 200 mA.
Shpg. Wt. 1 Lb. **SP-225-51** **$7.00**

ICE CUBE RELAY (115VAC)

These 115 VAC, 5 amp contact rating relays are so named because they are close to the size of an ice cube. We have different types as listed below. These normally sell for up to $12.00 each. Relays come with covers, not shown.
Fig. A 2P2T;
Shpg. Wt. 4 oz. **SP-328-51** **$1.25**
Fig. B, 4P2T;
Shpg. Wt. 4 oz. **SP-195B-51** **$1.75**
Fig. C, 2P2T; diode protected
Shpg. Wt. 4 oz. **SP-273A-51** **$1.50**

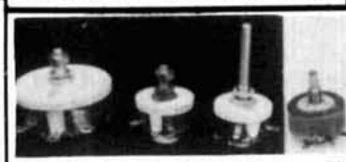
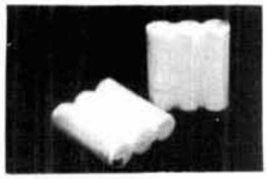


Figure A: Mfg. by Ohmite, 7.5 ohms, 75 Watts at 3.16 amps.
Shpg. Wt. 1 Lb **SPL-274B-52** **$2.50**
Figure B: Mfg. by , aprox. 25 Watts at 500 ohms, 0.22 amps.
Shpg. Wt. 1 Lb. **SPL-336B-52** **$2.00**

AA RECHARGEABLE BATTERY PACKS



A large manufacturer of portable telephones has just released to us a bunch of nickel cadmium battery packs. From what we can learn, if a phone comes back for any reason, the first thing the technician does is replace the battery regardless of the phone failure. This lot of batteries is a mized bag, but is priced accordingly. The packs contain 3 AA size cells with solder tabs on them. We will provide you with a sheet showing how to rejuvenate batteries of this type. The packs are rated at 3.75VDC at 500ma.
Sh. Wt. ½ lb. SP-120-51 $2.00

SPRAGUE DUAL 15 AMP FILTER

The diagram on this hefty line filter shows 2 RC networks for ultra cleaning of EMI. It has dual inputs and outputs for filtering both sides of line voltage. Each one is NEW and made by Sprague.
Shpg. Wt. 2 Lbs. **SPL-45C-51** **$5.00**

ELECTROSTATIC SHIELDING TAPE

Scotch No. 1245

We have 100 rolls of new Scotch* brand copper foil shielding tape. The tape has a conductive adhesive backing which will stick to almost any clean surface. It comes in 18 yard ½" wide rolls. This should be a fast sell-out. Compare our low price to the regular price of $17.00/roll.
Shpg. Wt. 1 Lb **SP-430-52** **$2.00**

MEMORY BATTERIES

Varta is the manufacturer of this partucular nickel cadmium battery. It consists of 3 quarter sized button cells stacked one on top of another. The cells are heat shrinked together. Steel legs w/PC leads are welded on. We can not find the Varta part No. (170DK) to get an exact spec on it, but our guess is 3.6V @ 225mA. The size is ¾ x 1". Unused, excellent condition.
Shpg. Wt. 4 oz. **SP-134A-51** **$2.50**

RHEOSTATS

We have four different rheostats. Figures A & B have bushings with mounting and locking nut and are screwdriver adjustable. Figure C has a 1.5" long shaft and can be adjusted by hand or screwdriver. Figure D has a ½" x 1/4" long shaft for knob mounting. List price is over $15.00 each.

Figure C: Mfg. by Ohmite, 25 Watts at 1,500 ohms, 0.13 amps.
Shpg. Wt. 1 Lb. **SPL-207B-52** **$2.00**
Figure D: Mfg. by Clarostat., 25W, at 6 ohms.
Shpg. Wt. 1 Lb. SP-436-52 $2.00

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piece of wire on his property and keep it reasonably out of sight. He made his antenna 66 feet long and then dropped the two ends down vertically. The horizontal portion of the antenna is 75 feet above ground. He uses a feedline a half wavelength long on 75 meters, and the antenna works well on all bands between 80 and 10 meters without an auxiliary tuner.

W4TDI's antenna was, by chance, broadside to Europe. He found that, while working well on 75 meters in all directions, it did a great job into New York on 40-meter skeds with W2TBZ. But the big surprise was on 20 meters! Ray found he was getting exceptional signal reports on that band; Europeans said he had an "outstanding" signal. During the Russian DX contest he worked 26 stations in a row on the first call, in competition with the "big guns."

Ray felt these results were not in keeping with a conventional "all-band" antenna and he could only assume the excellent reports were caused by the antenna's unusual configuration. He generalized that the currents in the two vertical sections were in phase on 20 meters, resulting in two half-wave verticals in phase — separated by a full wavelength. This provides a cloverleaf pattern with two lobes perpendicular to the plane of the antenna and two lobes in the antenna plane. Gain is modest, perhaps 3 dB. But, because of antenna height, the angle of radiation is quite low.

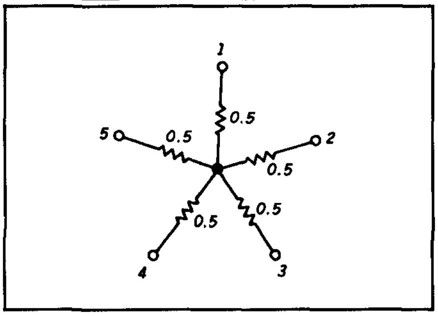
Feeling he had stumbled onto something unusual, Ray built a 160-meter version of the antenna. It worked well on 160 meters, and results were very good on 75 meters. His most impressive results were achieved on 40 meters, and the antenna even worked on 20 meters — but not as well as the smaller version.

Ray is very enthusiastic about this simple antenna and is anxious to hear from anyone who tries it.

The Dead Band Quiz

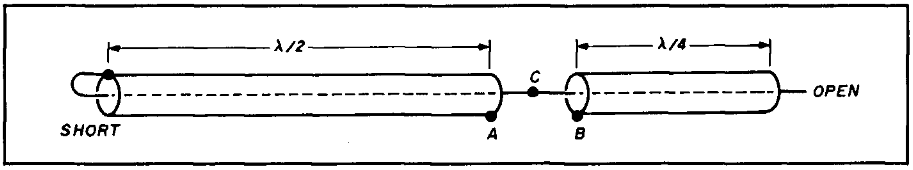
Answers are still trickling in for the locomotive/hornet quiz given in the October column. Judging from the number of replies (over 400 to date), you all appreciate a challenge.

FIGURE 6



Five 0.5-ohm resistors in star connection provide 1 ohm between any two terminals.

FIGURE 7



One length of coax an electrical half-wave length long is shorted at one end. A second piece a quarter-wavelength long is open-ended. The inner conductors are connected at C, but the outer shields are not. What is the impedance between the two outer shields (points A and B)?

The quiz on parsing the National Anthem was a dismal failure. Either you all got an "F" in English composition and were too bashful to enter, or weren't interested in this quiz! The sentence structure contains the subject "you", the verb "can see" and the object "what". Kudos to Tim Bratton, K5RA; Joe Vogt, W5JF; Jack Wells, KØYPE; John Peak, KE6HS; Eric Nichols, KL7AJ; Harry Johnson, NV7K. All of you go to the head of the class!

Last month's Dead Band Quiz

K4IHP's Black Box has five terminals. The resistance between any two terminals is 1 ohm. **Figure 6** shows the connections within the box. Okay?

W3DZH's jar filled with transistors required a little brainstorming. If you have the March column in front of you, consider this:

A direct attack on the problem gets far too complex. It's actually easier to solve another problem instead, and then go back to the original.

Consider the leftover transistors: one if dividing by 2, two if dividing by 3, three if dividing by 4, four if dividing by 5, five if by 6 and six if by 7.

The key to the solution is to ask yourself the question, "What if there had been one more transistor in the jar?"

Aha! If this is so, then the number of transistors would have been evenly divisible by 2, 3, 4, 5, 6, and 7. That number is the least common multiple of those intergers, 2 × 3 × 4 × 5 × 6 × 7, which is 420. But of course, that's not the way it was — the smallest number of transistors Our Hero had was one less than that, or 419 devices! Q.E.D.

Thanks to Joe Caffrey, W3DZH, for that brainbuster.

A new Dead Band Quiz

Consider two pieces of RG-8/U coax cable connected as shown in **fig. 7**. One length is an electrical half-wave long, the other is an electrical quarter-wave long. Note that the inner conductors are connected at the joint A-B, but the outer shields are not. What is the impedance between points A and B (the two outer shields)? Send your QSL card with your answer to me at Box 7508, Menlo Park, California 94025. I'll give the solution in a future column. Good luck, and see you on the low end.

References

1. William I. Orr, W6SAI, and Stuart D. Cowan, W2LX, *The Radio Amateur Antenna Handbook*, Radio Publications, Inc., Box 247, Lake Bluff, Illinois 60044. (Also available from *HAM RADIO* Bookstore for $11.95, plus $3.50 shipping and handling.)

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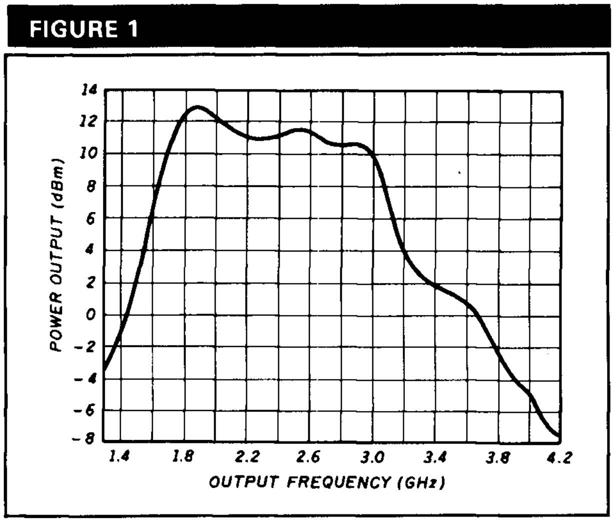
THE WEEKENDER



Doubler power output for P_{in} = 7 dBm.

UHF GaAsFET doubler

To obtain low noise and high performance from a VHF, UHF, or microwave downconverter you need to use a high-level, low-noise local oscillator (LO). It's common practice to connect the output of a crystal oscillator directly to the LO terminals of a 2-meter converter. If the operating frequency is 145 MHz and the IF is 28 MHz, the crystal would operate at 117 MHz. My Oscar 13 downconverter operates this way.

On the other hand, a 432-MHz converter needs 10 dBm of 404-MHz oscillator power developed from a 101-MHz crystal followed by two frequency doublers, like those described by W1JR.[1] A 1296-MHz converter needs a 1152-MHz LO if the first IF is 144 MHz. For this you can use a direct-frequency synthesizer like the one described in my UHF VCO article.[2,3] A 2304-MHz converter with a 144-MHz IF requires a 2160-MHz LO. You can obtain this by multiplying the output of a 1080-MHz phase-locked loop (PLL) by 2.

More often than not, it's difficult to obtain sufficient LO power at 2160 MHz and above without the aid of step-recovery diodes (SRDs) and cavity resonators. Avoid this kind of complexity by using a GaAsFET frequency multiplier like the one I've described here.

Description

The UHF doubler provides over 10 dBm of output power anyplace in the band from 1800 to 3000 MHz, when driven from a 7-dBm signal in the 900 to 1500-MHz range. It's intended primarily for use as the LO in a downconverter but it has many other uses.

The performance of MESFETs and MMICs as frequency doublers up to 24 GHz has been investigated.[4,5,6] Varactors or SRDs, normally needed for multiplication, aren't required. The FET simply operates as a nonlinear amplifier; harmonics generated when the gate is driven into conduction are amplified by the drain circuit. The DC current requirements for a FET doubler are only about 28 mA.

I used a 2 to 10 GHz Avantek AT-12570 small-signal GaAsFET for my doubler; other types will work as well. While I limited my experimental circuits to about 3000 MHz, the device should operate up to 10 GHz or higher, if required. You may wish to cascade two of these doublers to provide a 10-dBm LO signal for a 3.4 or 5.8-GHz converter.

Performance

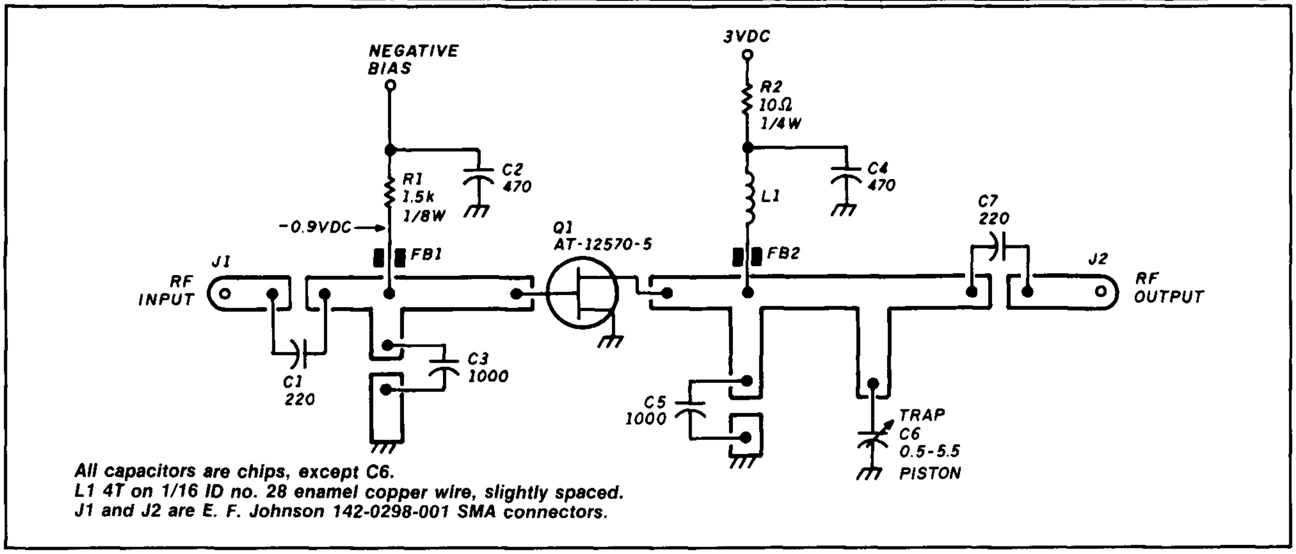
The input circuit of the UHF FET doubler operates at 1080 MHz, with the output circuit centered at 2160 MHz. However, performance is very broadband as shown in **fig. 1**.

Nominal I_{dss} is specified on the manufacturer's data sheet[7] as 80 mA. I operated the doubler with sufficient drive to achieve approximately 28 mA of average drain current. I_{dss} is highest at band center because the input circuit provides the best match to 50 ohms.

Feedthrough of the driving signal into the output is reduced only slightly by the filtering characteristic of the output microstrip circuit. Without additional filtering, the fundamental signal may be only 3 dB below the desired output level. I added a tunable trap circuit consisting of a 0.5 to 5.5-pF piston trimmer and a 1″ long, 1/8″ wide copper strap connected in series to ground, as illustrated in **fig. 2**. With the trap installed, fundamental output level was −40 dBm, while the third and fourth harmonics were 27 and 33 dB, respectively, below the desired signal. Since my requirement was for narrowband (fixed frequency) use, the trap was the obvious choice. For broadband operation, a bandpass or high-pass filter could be used instead.

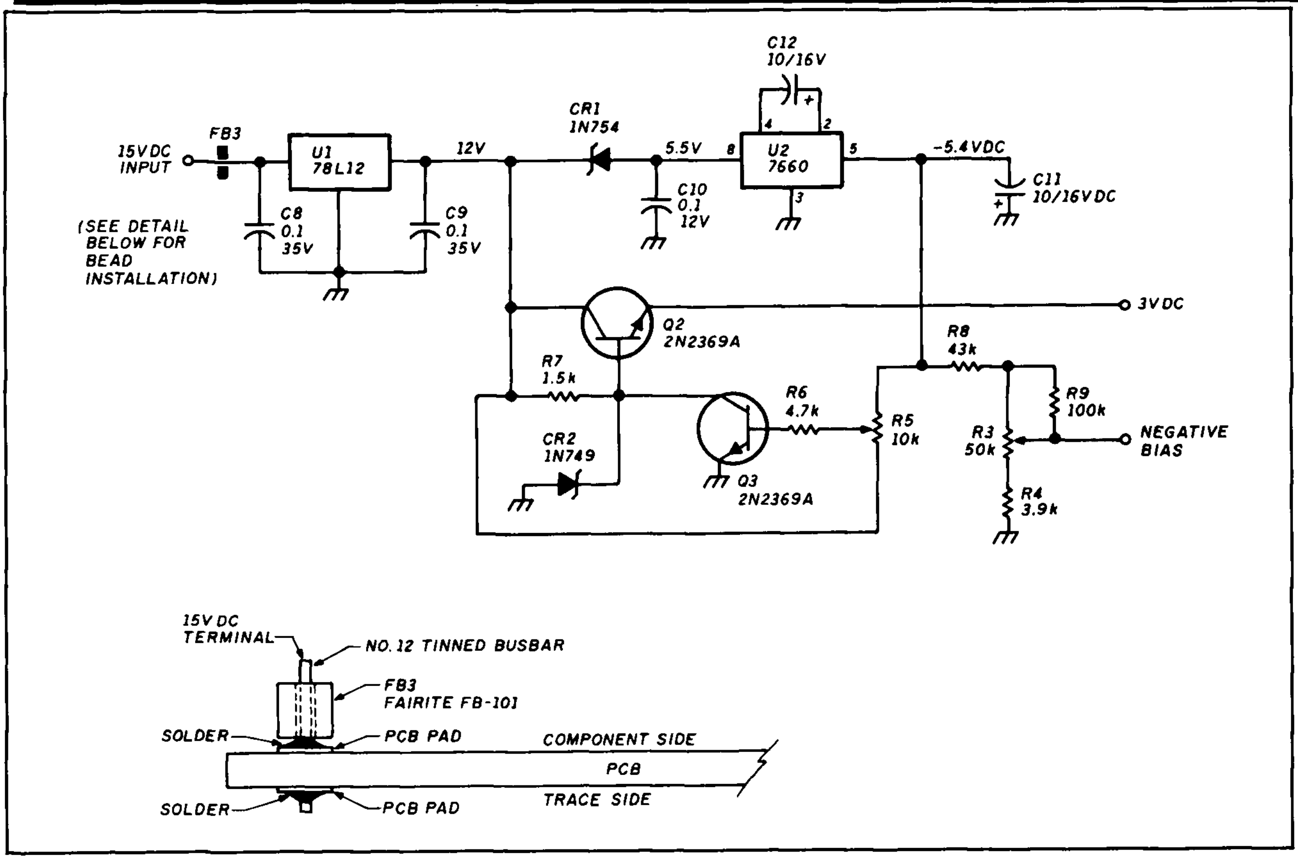
By Norman J. Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois 60126

FIGURE 2



Schematic diagram, GAsFET doubler.

FIGURE 3



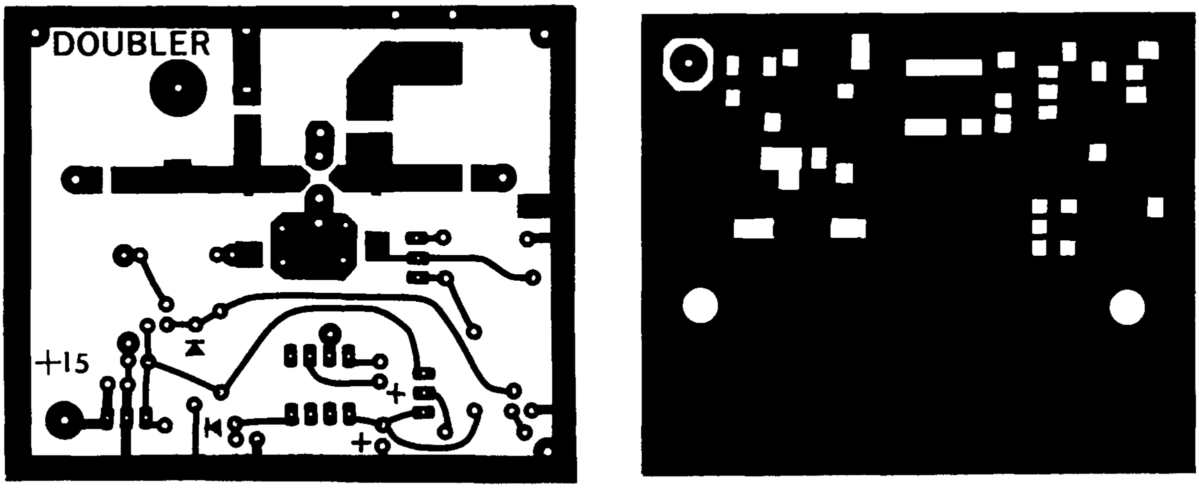
Schematic diagram, power supply/regulator.

Design

The FET doubler is etched on double copper-laminated epoxy fiber glass (G-10) pc board material. One side is used as a ground plane; the RF circuit traces are etched on the other side. Through grounds are made by passing no. 26 tinned copper busbar through ground holes and soldering on both sides.

I calculated the RF circuits with the aid of a computer program I developed for the 1296-MHz preamplifier published in *Ham Radio* Magazine.[8] I obtained

FIGURE 4



UHF GAsFET doubler artwork.

the scattering parameters from the manufacturer's data sheet. Despite the fact that the doubler isn't a "small-signal" device, it needed very little trimming to optimize its performance.

One of the doubler's important features is its stability. Because input and output circuits are an octave apart in frequency, there's little (if any) likelihood that feedback will cause instability. As a precaution against out-of-band feedback, I equipped both the gate and drain DC return circuits with ferrite beads.

The doubler schematic is shown in **fig. 2**. **Figure 3** shows the power supply. Artwork for the board is shown in **figs. 4** and **5**. Negative gate voltage is supplied from a common 12-Vdc source with an IC7660 voltage inverter. This is identical to the circuit I used in my 1296-MHz low-noise preamplifier article.[8] The circuit protects against FET damage should the negative supply fail.

Tune up

Before installing the FET, connect a 150-ohm resistor temporarily between drain and ground. Apply 15 volts to the DC input terminal and adjust trimpot R5 for 3.0 Vdc across the resistor. Remove the resistor and install the FET, taking the usual precautions against static charge.

Next, apply 15 Vdc between the DC input terminal and ground. Then, with the input RF drive power shut off, adjust gate-bias pot R3 until the drain just begins to draw current. This isn't a critical adjustment, because when RF power is applied the drain current will increase to a value depending on the level of drive power. I suggest that you set the drive power to a level that produces a FET drain current of about 30 mA. Although higher drive levels will produce higher drain current and more power output, don't exceed $I_{dss}/2$.

PARTS LIST

Capacitors		
C1,C7	*220-pF chip*	
C2,C4	*470-pF chip*	
C3,C5	*1000-pF chip*	
C6	*Erie 0.5-5.5 pF*	*glass piston trimmer*
C8,C9	*0.1 35-volt tantalum*	
C10	*0.1 12-volt monolythic*	
C11,C12	*10/16-volt electrolytic*	
Potentiometers		
R3	*50 k*	*ten-turn trimpot*
R5	*10 k*	*ten-turn trimpot*
Resistors		
R1	*1.5 k 1/8 watt 5 percent*	
R2	*10 ohms 1/4 watt*	
R4	*3.9 k 1/4 watt 5 percent*	
R6	*4.7 k 1/4 watt 5 percent*	
R7	*1.5 k 1/4 watt 5 percent*	
R8	*43 k 1/4 watt 5 percent*	
R9	*100 k 1/4 watt 5 percent*	
Solid-state Devices		
U1	*78L12 regulator*	
U2	*ILC7660 inverter*	
CR1	*1N754*	
CR2	*1N740*	
Q1	*Avantek AT12570-5 GaAsFET*	
Q2,Q3	*2N2369A*	
Miscellaneous		
J1,J2	*EFJ 142-0298-001*	*SMA connector*
FB1,FB2,FB3	*FB-101*	*ferrite bead*
	pc board	
	eight-pin IC socket	

Note that the FET doubler includes a 10-ohm resistor in series with the drain circuit and 3-Vdc supply. Assess drain current by measuring the voltage across this resistor. The total current drain will be about 40 mA. You can control the output power by adjusting input drive level.

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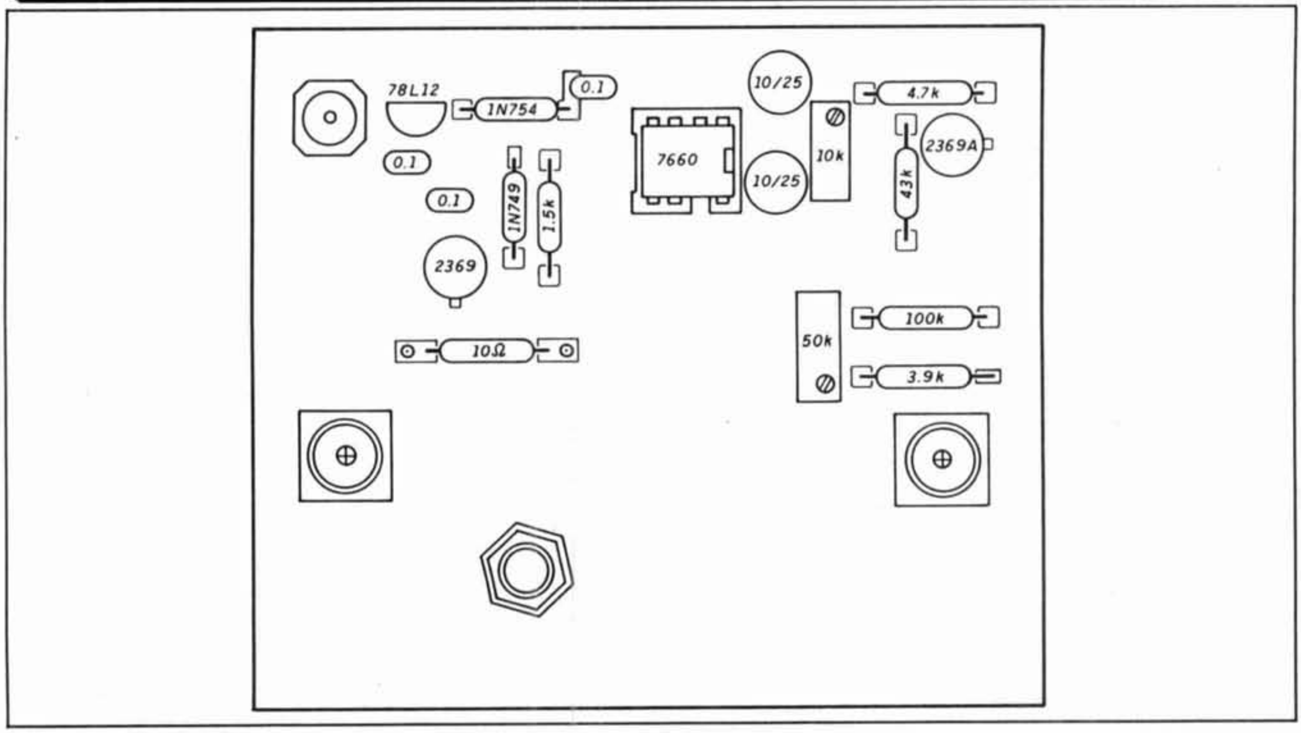
FIGURE 5



Component layout on groundplane artwork.

Conclusions

This simple but effective UHF GaAsFET doubler exhibits power gain. It provides over 10-mW output over nearly an octave band. As I suggested earlier, it may be possible to design the circuit for operation up to and beyond X-band* by using the same technique.[4] In my application, the doubler operates as the LO driving a balanced mixer in my 2304-MHz converter. If you have questions regarding this or similar applications, send a no. 10 SASE to the author.

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*5200 – 11,000 MHz. – *Ed.*

THE HAM NOTEBOOK

Ferrite beads as antenna and tower guy isolators

One of the nagging questions about antenna systems is the possibility of pattern degradation resulting from current flow on guys, feedlines, and even the antenna support tower.

It's standard practice to cut the guy into pieces about a quarter wavelength long at the highest operating frequency and place strain insulators between the pieces. This cuts the coupling to a low value, effectively preventing appreciable current on the guy and stopping guy radiation. While the solution works, no one seems happy with it — largely because of fears of reduced strength, and the work it involves. Many try using a balun in the hope that it will solve any feedline problem, but tower radiation is almost always accepted "as is."

I found an easy solution to all of these problems. Simply use ferrite isolators, usually as beads. This technique was first described as a balun by Walt Maxwell, W2DU.[1] It's easily extended to any problem involving unwanted current flow.

It isn't necessary to have a perfectly isolated insulator. For example, suppose a guy section is a half wave long at the operating frequency. It would have a resistance at the current node of about 70 ohms. Placing enough beads on the guy at the high current point to increase the impedance to 700 ohms would cut the current to 1/10, and the power radiated by the guy to 1/100 of its original value. Even cutting the current to 1/3 of its original value would be helpful.

The exact number of beads you'll need depends on the operating frequency, and the size and type of the beads. (See the W2DU article, and the latest *ARRL Antenna Handbook* for design curves and data.) Anywhere from three to ten beads would be a good start, assuming you're using a material that has a fairly high μ at the operating frequency. Ten to 25 beads would be the most that are really beneficial.

It isn't necessary to cut guys (or coax feeders) loose to slide beads over the end on systems already in use. Split beads and shapes are available, and do nearly as well. (See the manufacturer's literature for information.)

Another possible solution is to use ferrite beads, instead of insulators, on the antenna itself. Suppose you want to use the top guy of the tower as a sloper. Put a number of beads at the top end of the guy close to the tower. Place more beads a half (or quarter) wave down the guy, and feed as for a normal sloper. (If you are using high power, you may find it necessary to use very low loss material for the first few beads. This will avoid heat problems.) Building slopers and delta loops in this way is a snap, even for towers which are already up.

Towers themselves are more of a problem, because of their size and parallel paths through the structure. For low frequencies, liberated TV yokes and sweep transformer cores are good — and readily available. They're usually so cheap (free) that you can be generous with placement. For best results, the ferrite should enclose each tower member, but it helps to just lay the ferrite close to the member.

You can calculate ferrite position by using the quarter-wave rule, or you can measure the guy/coax/tower resonance with a grid dip meter. The easy way is to make up a few special coils for the dipper. Each should be triangular in shape and about 20 inches on a side for low frequencies, or 6 inches per side for the higher bands. Solid Teflon™ insulated wire is ideal, but standard house wire works well. Use your frequency meter rather than trying to make a calibration curve.

To get close coupling, place the side of the triangle away from the dipper body close to the conductor. Tune for dips as usual. After you find the resonances, put some ferrite into the place that looks best, and check again. The dip may have disappeared, or shown a marked decrease. (If you can decrease the dip to at least 1/10 of its original value, you should be in good shape.) Sometimes moving the ferrite helps; at other times more ferrite is necessary. The goal is to have no appreciable dips at or close to operating frequencies. It's also a good idea to check harmonic frequencies, and to eliminate any such resonances if found.

After you've placed the beads, use weatherproof tape or silicone rubber to hold the ferrite in place and protect it from weather.

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1. Walter Maxwell, W2DU, "Some Aspects of the Balun Problem," *QST*, March 1983, page 38.

R. P. Haviland, W4MB

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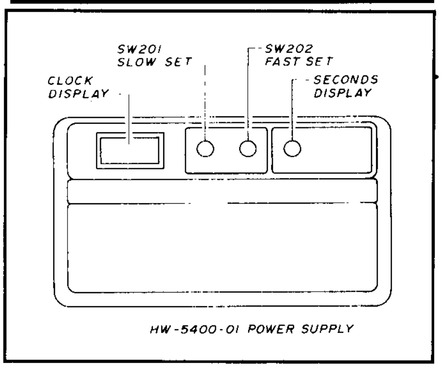
Improving clock setting for the HW-5400

I finally decided that there must be a better way to set the clock on my Heath HW-5400-01 power supply. My method of setting the time with a long pin or toothpick had to go! I also wanted to be able to set the clock to WWV to the nearest second. Here's my solution.

You'll need three small momentary SPST push-button switches. A set of Radio Shack no. 275-1574 or equivalent is fine. First, disassemble the power supply's front panel. Next, drill out the two holes on the front panel, grill, and escutcheon (they're labeled SW201 and SW202), and one extra hole an inch to the right of SW202 for the "seconds" display switch. See **fig. 1** for placement. (Remember to remove the metal switch springs from the display circuit board.) Mount the switches through the panel and grill,

FIGURE 1



Placement of holes for adding SPST switches to the HW-5400-01 power supply.

placing the escutcheon on last to cover the mounting nuts. Bend the tabs of the new SW201 and SW202 switches so they clear the circuit board. Connect one side of all three switches together and then to the 14-volt source by inserting the wire through the slot of SW202 on the circuit board. Solder the wire to the silver foil.

Solder the other tab of SW201 to the "hot" leg of R202 and the second tab of SW202 to the "hot" leg of R203. Now solder the other tab of the third switch (seconds display) to the circuit board pad of pin 34 of U201.

Pressing the seconds switch displays the "ones" minute digit and both seconds digits. Simultaneously pressing "seconds" and "fast set" lets you reset the seconds to zero without a minute carryover. To ensure an accurate setting to WWV, simply set the clock a minute ahead, press seconds, fast set, and hold the setting until WWV catches up — then release. Viola! Precise clock settings to the nearest second.

Dexter King, AB4DP

A tricky RFI solution

When the XYL said I was interfering with the broadcast receiver, I was stunned. After all, I thought I had solved just about every problem caused by my transmitter — even operating full power on all bands.

"Are you sure?" I said.

"Well, it has been more than 50 years since you tried to teach me the code, but I can still follow the key clicks well enough to make out W2YW. And, that new renewal you got from Gettysburg says you are W2YW — so, yes, I am sure."

The receiver was an eight-band Federal Model 8B1000 and it was picking up key clicks on a few spots in the broadcast band. One of them was at 1390 kHz — the QRG of one of her favorite stations to sleep by, because it's an all-talk station. The interference occurred when I operated on 15 meters, and with all the activity now on 15, I simply had to find a solution.

First, I wound some no. 24 dual zip-cord on a 1/2″ ferrite rod 5″ long, slipped it under the battery pack compartment, and wired it into the AC line. This was no help. I was on the right track but headed in the wrong direction.

Next, I tried a Kenwood R2000, using a piece of bell wire thrown out the window for an antenna. No sign of any key clicks, but the wife turned that solution down saying it had "just too many buttons." Now what?

With the Federal receiver switched to battery and the line cord pulled, it still picked up the key clicks.

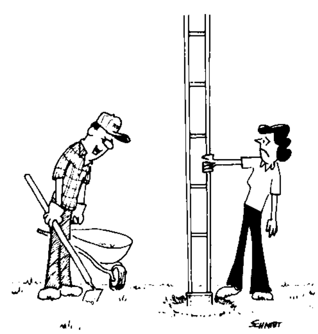
The solution was simple, but took a little doing to find. An extension cord was plugged into the other half of the wall duplex outlet where the offending receiver was connected. This fed two desk lamps and an electric clock. Pulling the extension cord killed the click. Evidently the two lamps, extension cord, and clock made up an antenna that was picking up the 15-meter signal and creating a more intense RF field around the receiver. The loop stick in the receiver picked this up.

I didn't have any more ferrite material, so I dug through my junk and found an RF high-voltage transformer from an old, old TV set. I cut off all the windings with a hacksaw and wound another extension cord around three sides of the ferrite form. I plugged the makeshift choke into the wall outlet, plugged the line cord feeding the lamps and clock into the output end of the choke, and all my clicks were solved. As I said earlier, I was on the right track with the line filter. The trouble was, I was in the wrong place!

Article I **John Labaj, W2YW**

FEBRUARY WINNERS

Congratulations to Teddy Coggin, WD4CWV, our February sweeps winner and John Pivnichny, N2DCH, author of February's most popular WEEKENDER — "High-Impedance Rotary Step Attenuator." Both will receive a copy of *The Radio Handbook* by Bill Orr, W6SAI. To enter for April's drawing, send in the evaluation card bound into this issue, or submit a WEEKENDER project. You could be our next winner! *Ed.*



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A REMOTE DRIVER/ CONTROLLER
FOR A TWO-ANTENNA SYSTEM

By **William L. Schreiber, NH6N**, 73-4327 Imo Street, Kailua-Kona, Hawaii, 96740

Set azimuth and elevation from the comfort of your shack

This article describes a simple light-duty, dual-rotator assembly that allows you to set the azimuth and elevation of two lightweight, low wind load antennas by remote control. It's ideally suited for satellite operation, with uplink and downlink antennas each requiring different orientation.

A variety of rotators — including one that combines azimuth and elevation in a single housing — are readily available. Because I wanted an azimuthal rotator with a silent control box, I chose a Winegard TV rotator that cost about $40. For elevation, I decided to use the approach that had been so successful in my solar panel sun tracker.[1] That plan involved using a 12-volt DC Mazda windshield wiper motor (about $3 at the junkyard) and a 2-foot length of threaded 1/2-inch steel rod. A 3-inch flexible coupling was used to compensate for mechanical misalignment. I tried using a 3-inch piece of auto heater hose and two hose clamps initially, but the combination of sun and mechanical stress caused this arrangement to fail after about six months.

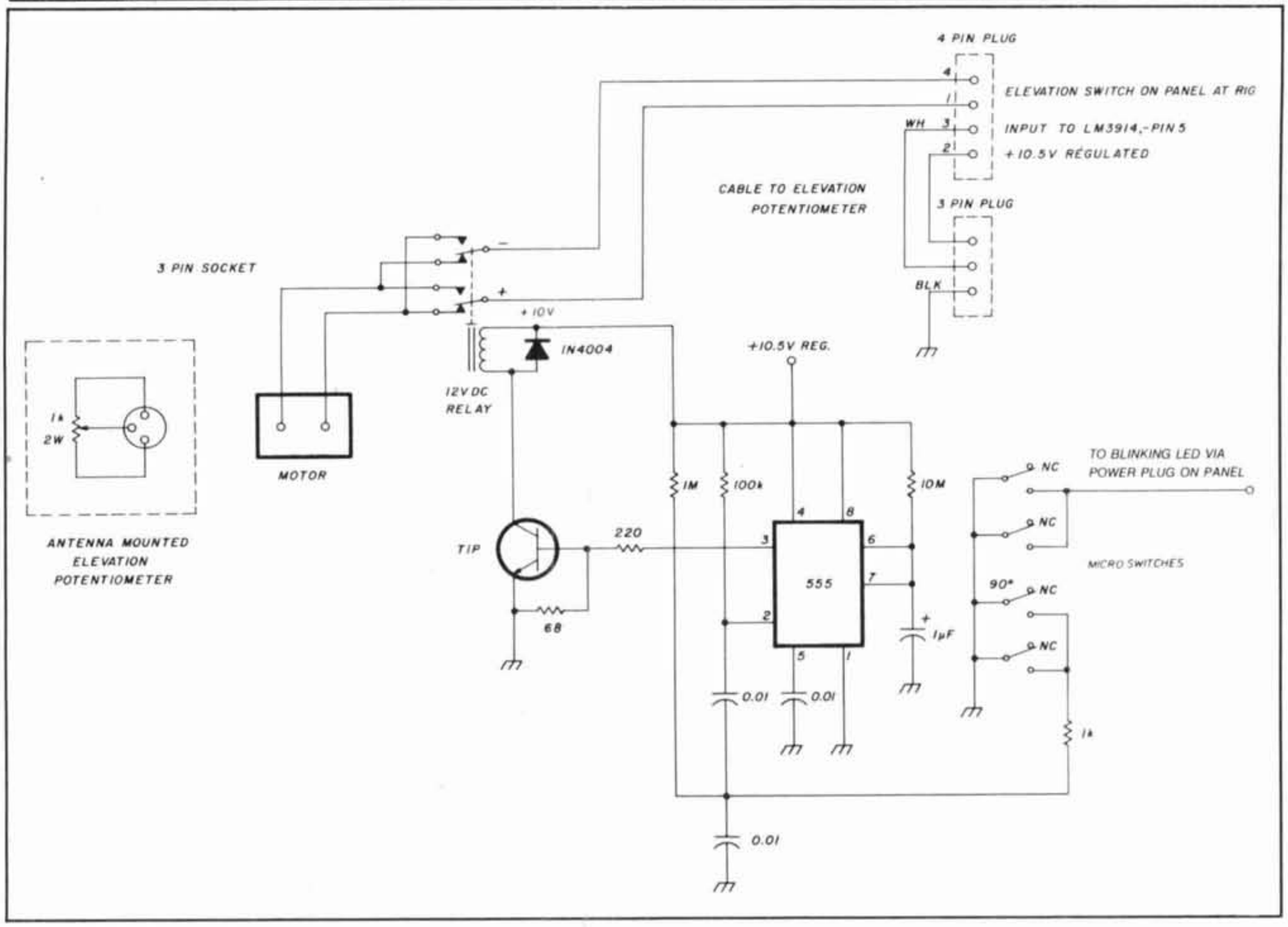
The elevation assembly consists of two 6 × 8-inch pieces of 1/4-inch aluminum plate connected by a 1-inch piano hinge. A 5-foot long × 2-inch diameter fiber glass rod (manufactured by KLM) is used as the boom and an antenna is mounted at each end. The boom is rotatable through 90 degrees with a lead screw mechanism like the one in the solar panel setup.[1] The other plate (which becomes the base) has a floor flange bolted to it; a 2 foot length of 1-inch water pipe is screwed into the flange. The pipe is then attached to the Winegard rotator which is bolted to the mast.

The windshield wiper motor is bolted to another 6 × 8-inch piece of 1/4-inch thick aluminum plate which is attached to the opposite side of the base plate by another 1-inch piano hinge. (See **photo B**). This assembly permits the motor to move up and down as it turns the lead screw and offers further compensation for mechanical misalignment (see photos).

PHOTO A

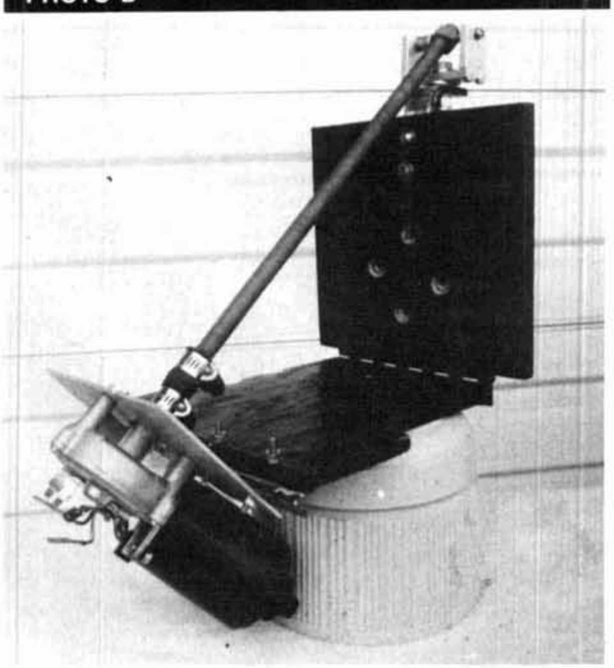
Left front view of elevation drive at maximum elevation showing fiberglass rod support for antenna. Also shown is electronics box with limited switch control circuit.

FIGURE 1



Antenna mounted part of elevation control. VHF/UHF antenna.

PHOTO B

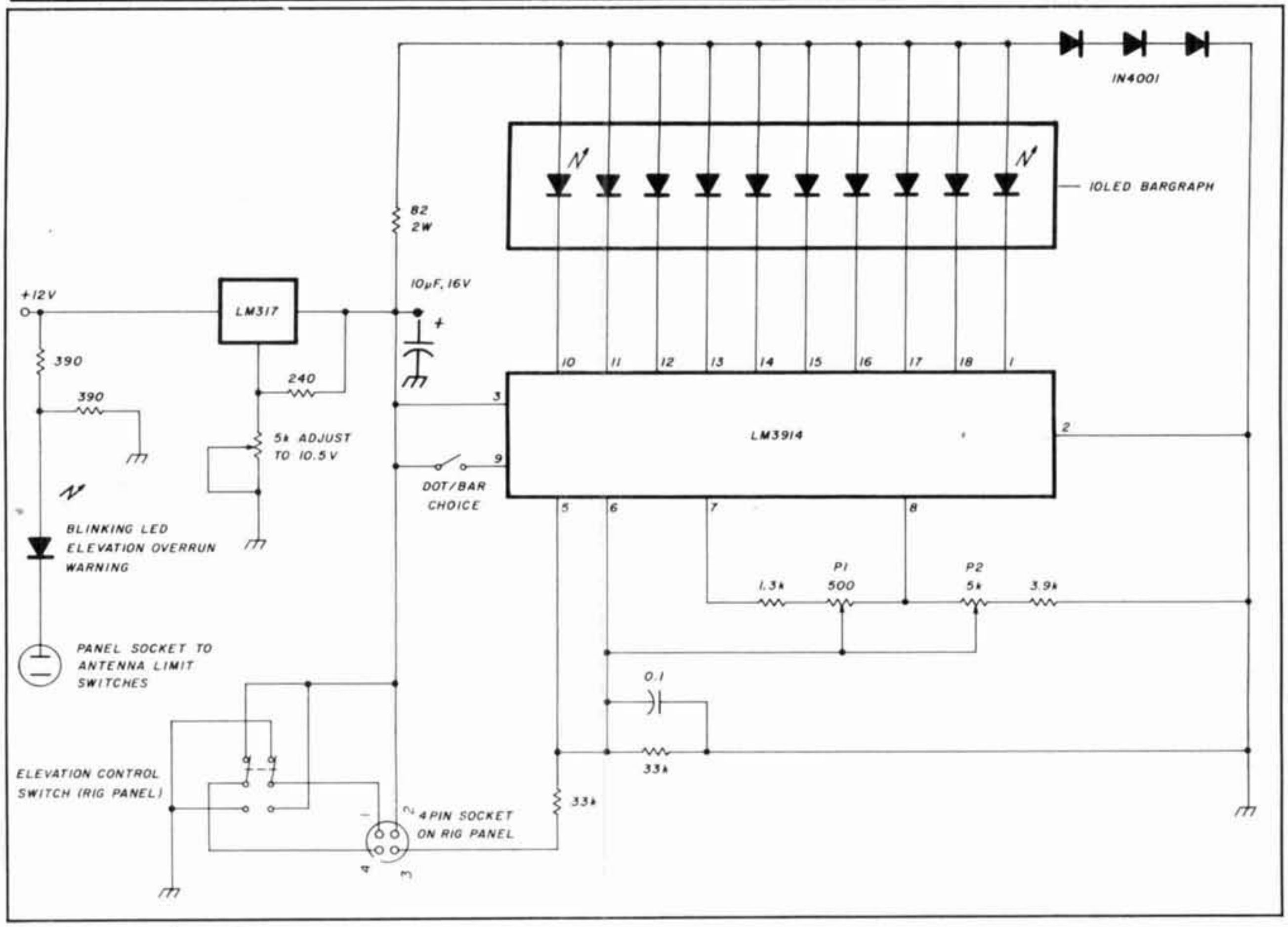


Side view of elevation drive with windshield-wiper motor attached.

It takes about 3 minutes for the antennas to go from 0 to 90 degrees elevation. There's a potential problem here, however, with the antennas not visible from the station: they could be inadvertently driven below 0 degrees or above 90 degrees, and this could destroy the system. To prevent this, and to make the system as foolproof as possible, I installed two Microswitch limit switches at each extreme of elevation travel. One causes an LED (RS-276-036) to blink in the shack just before the whole system hits bottom or top; the other activates an antenna-mounted timer and relay that automatically reverses the motor for 30 seconds.

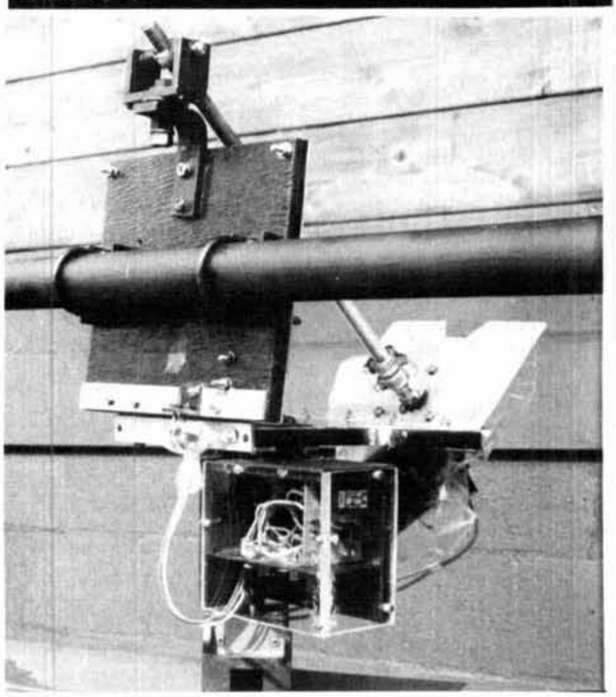
A circuit built for this purpose is shown in **fig. 1**. A manually-triggered monostable that uses an LM555 is employed. When the first limit switch is activated, a ground is placed on a blinking LED in the station, signaling the operator to reverse the motor control switch promptly. If the operator doesn't respond quickly enough, a second switch is activated, powering up the timer and causing the relay to change state and reverse the motor. This continues for about 30 seconds, which should be plenty of time for the operator to recognize the error. The 555 times out, the relay releases, and regular motor control can now occur.

FIGURE 2



Elevation control + indicator.

PHOTO C



Right front view of elevation drive at maximum elevation showing fiberglass rod support for antenna. Also shown is electronics box with limit-switch control circuit.

The whole assembly is bolted to the lower antenna mounting plate and encased in a 3 x 5 x 2-inch weather-tight plastic box.

elevation angle indicator

This design provides a simple, reliable elevation angle indicator. Instead of choosing an old-fashioned analog meter, I opted for a bank of LEDs.

A nice circuit for this indicator (**fig. 2**) is one originally intended for use as a voltmeter and described in the *National Linear Data Book.*[2] The driver IC is available from Radio Shack (No. 276-1707) or other vendors. The LEDs, also from Radio Shack (276-081), come in a nice ten-element block. Controls P1 and P2 adjust the point at which the bottom and top LEDs activate. It's necessary to set these alternately as the antenna is elevated and depressed, so that the array starts at 0 degrees rather than 90 degrees, and also so that the whole array is lit at maximum elevation and unlit at minimum. This takes a bit of juggling back and forth, as well as setting the antenna pot so that it covers a full 90 degrees before it hits the stops. Doing this isn't as complex as it sounds, but does require two people: the operator in the station and a helper at the antenna.

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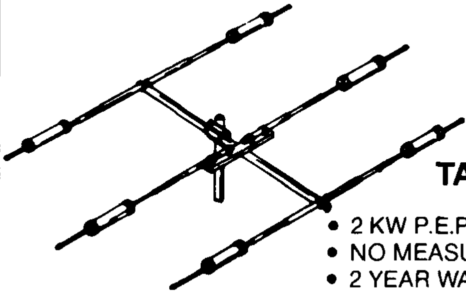

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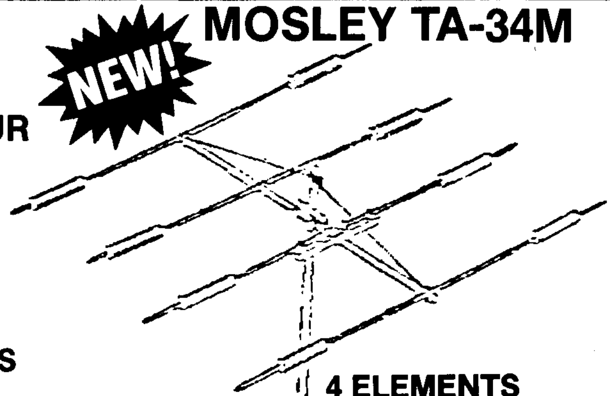

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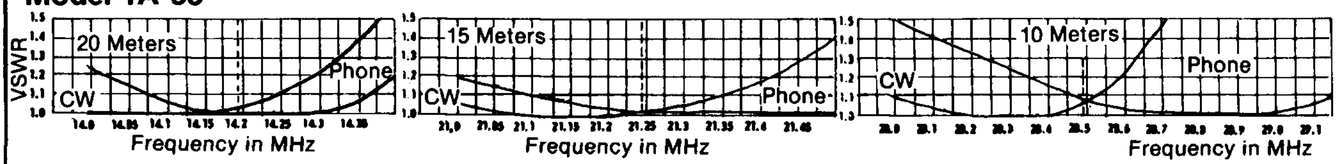

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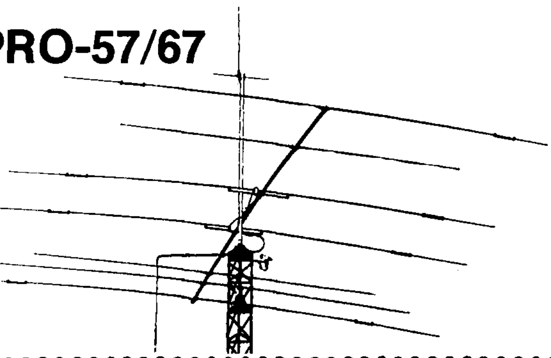

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105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
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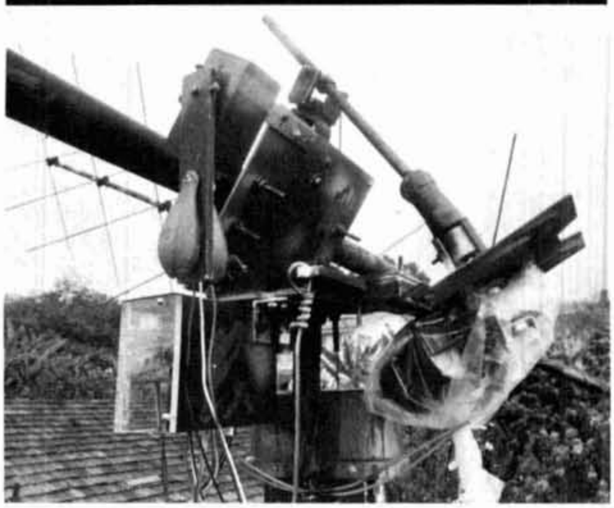
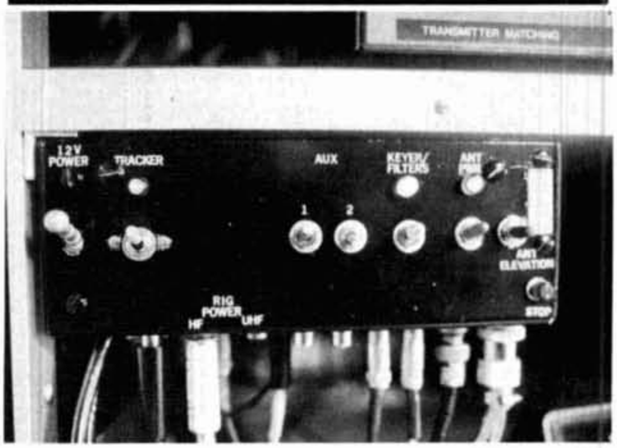


Left rear side view of antenna drive system. Elevation pot arm with lead weights is visible at top.

PHOTO E



DC control panel, column of LEDs and "Stop" LED used for elevation indication on right side.

All that's needed to actuate the circuit is a variable source of DC representing elevation angle. A clever way to do this appeared in the Amateur press several years ago.[3] A good-quality linear potentiometer is mounted in a waterproof box on the elevation part of the antenna. The potentiometer shaft has a 1/2-pound lead fishing weight attached; this keeps the shaft vertical no matter what elevation angle occurs. Feed the pot with 12 volts DC on one end, ground the other, and pick off the elevation-dependent voltage from the center tap. This goes to pin 5 of the LM 3914 driver IC, where it's conditioned and trimmed to light the LEDs progressively.

I opted for ten LEDs to indicate 9 degrees each, which might be too coarse for a purist. It's a simple matter, however, to cascade as many LEDs as desired; a circuit for this purpose is included in reference 2. While the antennas have a rather narrow beamwidth, in fact, it's still much wider in practice than the 9 degrees represented by a single LED.

My station operates almost entirely from a 12-volt storage battery kept charged by a photovoltaic (PV) panel. There's no reason why you can't get by with regular 120-volt service.

References

1. William L. Schreiber, "Complete Solar Power for Your Ham Station," *ham radio*, December, 1984, page 14.

2. *Linear Data Book*, National Semiconductor Corporation, 1982, pages 9-163.

3. George Chaney, W5JTL, "An Inexpensive Elevation Indicator," *ham radio*, June, 1985, page 67.

Article J **HAM RADIO**

THE CONVOLUTED LOOP

Here's a small, very efficient, low-band radiator

By **Ted Hart, W5QJR**, P.O. Box 334, Melbourne, Florida 32902

A small loop antenna can provide excellent performance for both transmitting and receiving.[1] The convoluted loop in **fig. 1** is a single conductor configured to produce two orthogonal loops. This results in an antenna with high performance, small size, and an almost ideal radiation pattern for operation at the low end of the HF spectrum. The antenna is designed for mounting at ground level over a small counterpoise; its height is less than 0.04 wavelength.

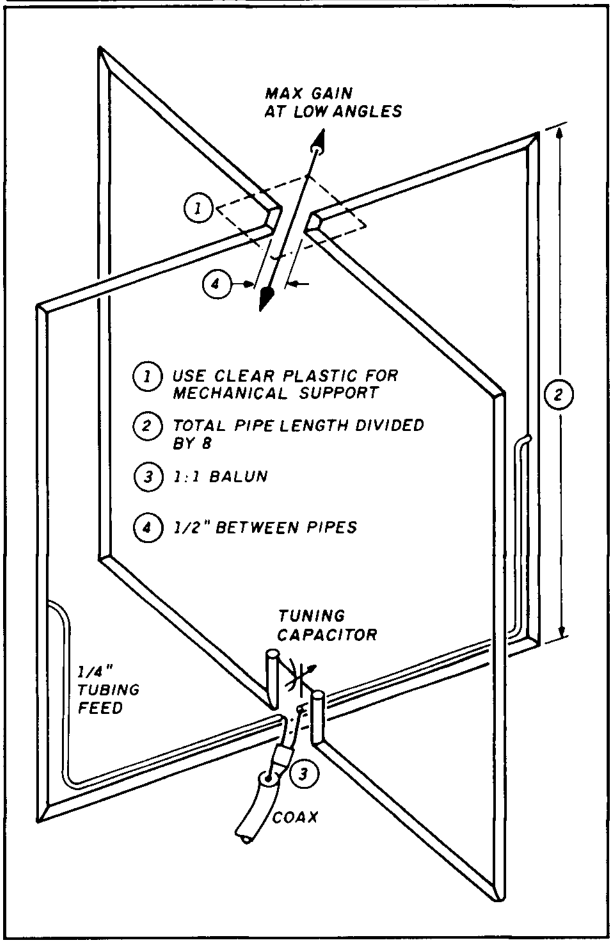
Theory

Table 1 lists the equations developed to define the convoluted loop. The computer program at the end of this article is based on these equations.

The efficiency of any antenna is defined as the ratio of the radiated power to input power. This is conveniently expressed as the radiation resistance divided by the sum of the radiation resistance plus loss resistance. Because small antennas are characterized by low radiation resistance, efficiency is a major concern. On the other hand, large antennas have a high radiation resistance compared with the loss in the antenna conductor.

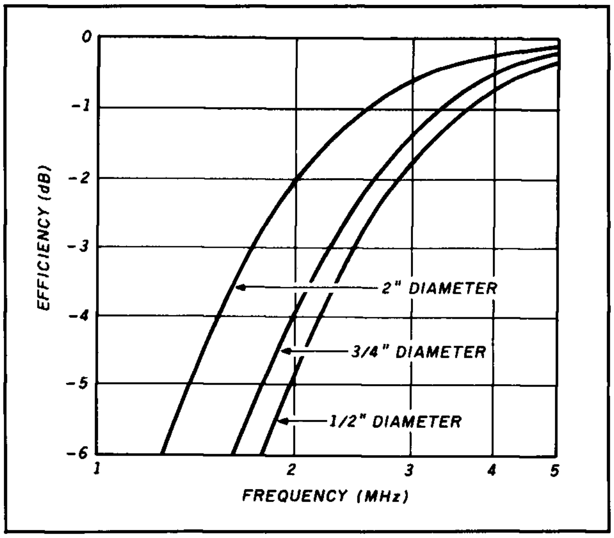
The radiation resistance for a small loop antenna is dependent on the area enclosed by the conductor and the operating frequency.[2,3,4] The antenna will become self-resonant if the conductor length is greater than 1/3 wavelength due to distributed capacity. This sets the maximum length of the conductor. The equations

FIGURE 1



Physical layout of the "convoluted loop."

FIGURE 2



Effect of conductor diameter on efficiency — total conductor length is 80 feet.

TABLE 1

Equations for a Convoluted Loop Antenna.

Efficiency of an antenna	$\epsilon = R_R/(R_R+R_L)$
Radiation resistance—ohms	$R_R = 3.38 \times 10^{-8}(F^2A)^2$
Total area—square feet	$A = 4(S/8)^2$
Loss resistance—ohms	$R_L = 9.96 \times 10^{-4}\sqrt{F}(S/D)$
Q	$Q = X_L/(2(R_R+R_L))$
Bandwidth—MHz	$BW = F/Q$
Inductance—henries	$L = 1.13(5.6624 \times 10^{-7} \times S^{0.6984})$
Inductive reactance—ohms	$X = 2\pi FL$
Distributed capacity—pF	$CS = 1.1374 \times 10^{-11} + 4.684 \times 10^{-13} \times S$
Tuning capacitor—pF	$CT = 1/(2\pi F)^2L) - CS$
Voltage across tuning capacitor	$VC = \sqrt{PQX}$
Plate spacing for CT—inches	$SC = VC/75000$
F—operating frequency—MHz	
D—conductor diameter—inches	
S—conductor length—feet	

reflect the fact that a single conductor forms two loops for this antenna. When a reflecting screen is placed under the loop, the effective area of the loop doubles because of the image concept. In the equation for area, the multiplier of 4 covers both the dual loops and their reflected images. For a square loop design, each side of one loop is the total conductor length divided by 8. The maximum area is achieved for a given conductor length when the conductor is circular. The area is reduced to 87 percent for an octagon and to 78 percent for a square, when compared with a circle. For mechanical simplicity, a square loop with a reflecting screen is used for the example in this article.

The small loop area results in low values of radiation resistance. The primary component of loss resistance results from the loss in the conductor; a small component is due to ground loss, which will be discussed later. Therefore, a low-loss conductor is required. To minimize loss, use copper pipe. The equation for loss resistance includes skin effect loss for copper pipe, which varies as a function of frequency.

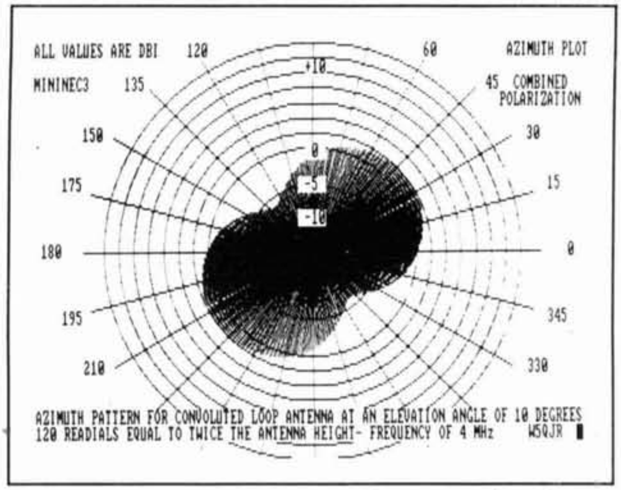
Although efficiency is a major design parameter for any antenna, the Q of the antenna must be considered for small high-efficiency ones. Large diameter conductors allow the Q to be sufficiently high to affect the instantaneous bandwidth in such a way that it may be too narrow for the type of modulation desired. High Q is also an indication of very high voltages across the tuning capacitor. Small conductors, which have higher loss resistance, will produce lower Q and lower efficiency. For this reason it's necessary to make tradeoffs in the design of the convoluted loop for a particular application. For most applications in the HF frequency range, 3/4-inch copper pipe (9/10 inch outside diameter) is a reasonable compromise. **Figure 2** presents efficiency versus frequency for various size conductors, indicating only small improvements for larger, more expensive, copper pipe.

The equations for inductance and distributed capacity are based on data derived from convoluted loops of varied sizes at various frequencies — primarily between 1.8 and 10 MHz. The tests were performed on the latest version of MININEC3.[5] They have been derived for 3/4-inch copper pipe and square loops only. Once the inductance and distributed capacity have been calculated, the convoluted loop is considered a simple resonant circuit. This lets you calculate the inductive reactance and the tuning capacitor value. Multiply the equation for inductance by a value of 1.13 to cover the effect of the matching network. The matching network is an autotransformer type of match, having both series and mutual inductance.

You can calculate the Q of the antenna once you know the inductance and resistance. Divide the standard equation for Q by 2 to include the effect of the transmitter/receiver loading; it's the system Q that is important, not the Q of the antenna as a stand-alone component. The calculated bandwidth of the antenna is the ± 3 dB bandwidth, assuming a perfect match (VSWR = 1.0:1) at resonance. At the 3-dB frequencies the calculated VSWR is 5.1:1 and the resistance and reactance values are equal, resulting in a 45-degree phase shift of the equivalent resonant circuit.

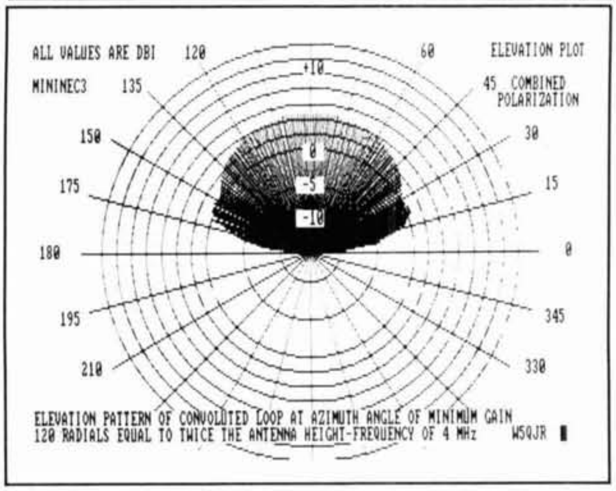
The voltage across the tuning capacitor is a function of the transmitter power and the antenna impedance. Despite the fact that the voltage can be very high, it's not excessive for available tuning capacitors. Although vacuum variables are preferred, the spacing for an air variable is calculated based on 75,000 volts per inch spacing.

FIGURE 3



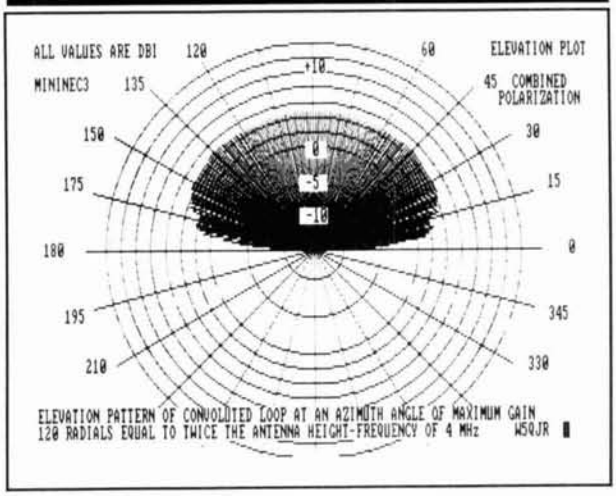
Azimuth pattern for the convoluted loop at an elevation angle of 10 degrees. Pattern was made at 4 MHz with 120 radials equal to twice the antenna height.

FIGURE 4



Elevation pattern of convoluted loop at the azimuth angle of minimum gain. Pattern was made at 4 MHz with 120 radials equal to twice the antenna height.

FIGURE 5



Elevation pattern of convoluted loop at an azimuth angle of maximum gain. Pattern was made at 4 MHz with 120 radials equal to twice the antenna height.

Antenna evaluation

I've drawn some conclusions based on experimental results of the convoluted loop, and from data calculated by MININEC3.

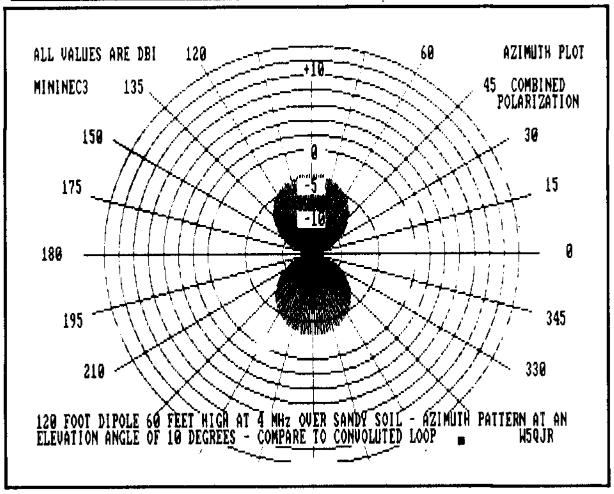
The antenna is easy to build. Simply cut sections of copper pipe and join them with copper elbows. Pieces of clear plastic in the center at the top and bottom provide good insulation and mechanical rigidity. The length of the longer pieces of pipe are equal to the total conductor length divided by 8. Cut the shorter pieces to length at the top to allow 1/2 inch between the 90-degree bends, which are made of two 45-degree elbows joined with a short section of pipe. Remove a short section of pipe at the bottom for installation of the tuning capacitor.

You must solder or braze each joint in the antenna to minimize joint resistance. Use a low-loss tuning capacitor (a vacuum-variable, for example). If you connect the loop ends to the two stators of an air variable split stator or butterfly capacitor, placing them in series with RF currents flowing through the rotor, there is no loss due to wiper contacts. But you *must* weld or braze all pieces of the capacitor. The typical variable capacitor has plates installed and held in place by mechanical pressure only; this results in high resistance at each mechanical joint. The high loss will make the loop inoperable. You can correct this deficiency by removing all aluminum plates and replacing them with copper or double-sided pc board material. Then you can use straps to bond the plates together and provide connection to the loop conductor.

Although you may tune the antenna over a wide frequency range, it must be tuned to the operating frequency because of its narrow instantaneous bandwidth. Do this by using a stepper motor to rotate the shaft of the variable capacitor. The unit I prefer has a 7.5-degree step angle and includes a small 300:1 gear head reducer. This motor is manufactured by Hurst Manufacturing in Princeton, Indiana. The part number is 3004-001. They also produce an integrated circuit (part no. 22001) that makes an ideal driver, with the simple addition of a few components and a power supply. Reduce the gear ratio for a vacuum variable, because numerous shaft revolutions are required to vary the value of capacity from minimum to maximum.

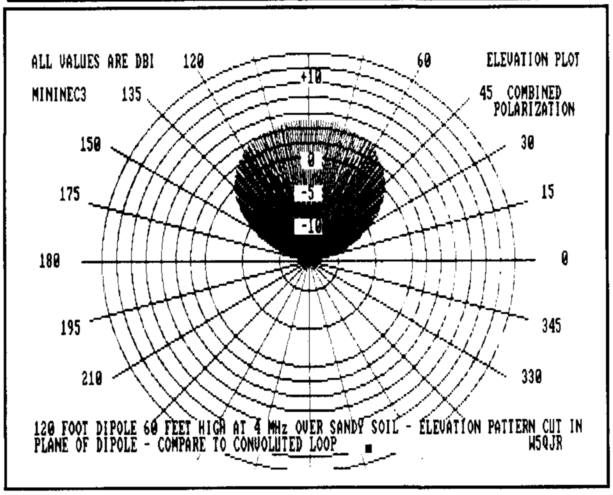
You must feed the convoluted loop as a balanced antenna. A 1:1 balun transformer is required for 50-ohm coax feed. Make the feeders from 1/4-inch copper tubing wrapped with black plastic electrical tape for insulation. Each feeder is the length of one of the

FIGURE 6



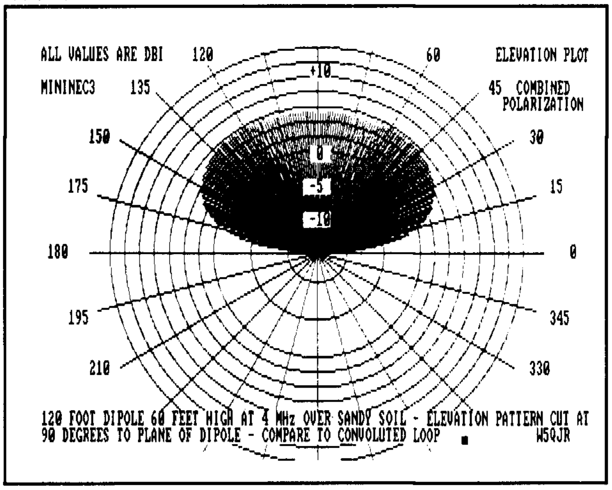
A 120-foot dipole at 60 feet for 4 MHz. Azimuth pattern at an elevation angle of 10 degrees over sandy soil.

FIGURE 7



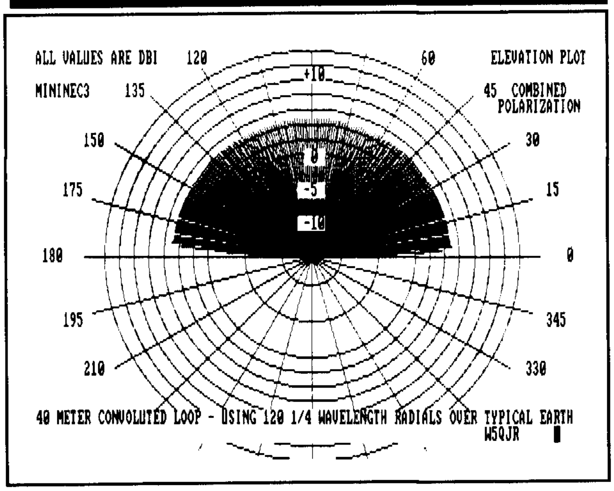
A 120-foot dipole at 60 feet for 4 MHz. Elevation pattern cut in plane of dipole over sandy soil.

FIGURE 8



A 120-foot dipole at 60 feet for 4 MHz. Elevation pattern cut at 90 degrees to plane of dipole over sandy soil.

FIGURE 9



A 40-meter convoluted loop using 120 quarter-wavelength radials over typical earth.

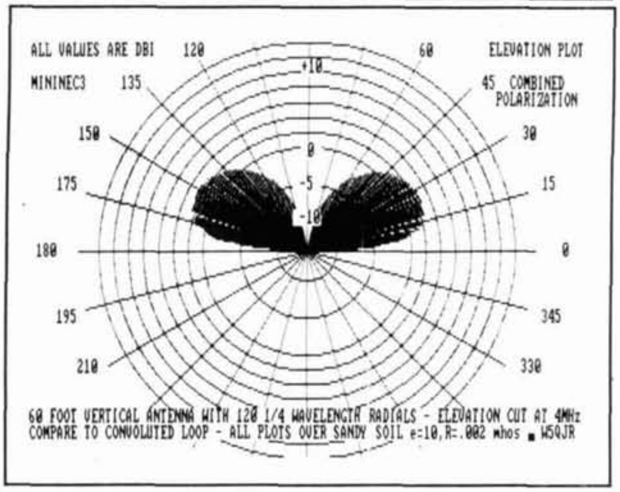
long sides of the loop, formed to the inside of the loop antenna orthogonal to the loop that includes the tuning capacitor. The spacing between the feeder and loop conductor and the length of the feeders determine the feedpoint impedance. Once you've soldered the ends of the feeders, bending the feeders to vary the spacing will let you achieve a very low VSWR. This is only one of many ways to feed this antenna; I find it the most convenient.[6]

The loop develops a very high magnetic field. If the loop is placed close to ferrous metal, like reinforcing material in concrete, some rain gutters, or antenna towers, RF energy will be coupled into the ferrous material. This reflects a change of impedance into the loop, increasing its loss resistance and decreasing its efficiency.[7]

Because of its magnetic properties, the convoluted loop isn't sensitive to electrostatic fields (the major cause of reception of man-made noise). You'll notice a significant improvement in signal-to-noise reception in noisy areas. In theory, the value is 26 dB. As a result of the high Q, the antenna serves as a preselect filter prior to the receiver. This improves reception in the presence of impulse noise, especially from lightning during thunderstorm activity.

Earlier I suggested that the antenna should be used in conjunction with a counterpoise. **Figures 3, 4,** and **5** present radiation patterns derived from MININEC3 for a 10-foot tall convoluted loop operating at 4 MHz with a counterpoise made of 120 radials — each having a length equal to twice the height of the antenna. Because you're dealing with the reflected energy only (not conducted energy), the radials don't need to be connected to the loop. All patterns presented in this article are over a ground with a dielectric constant of 10 and a conductivity of 0.002 siemens, representing

FIGURE 10



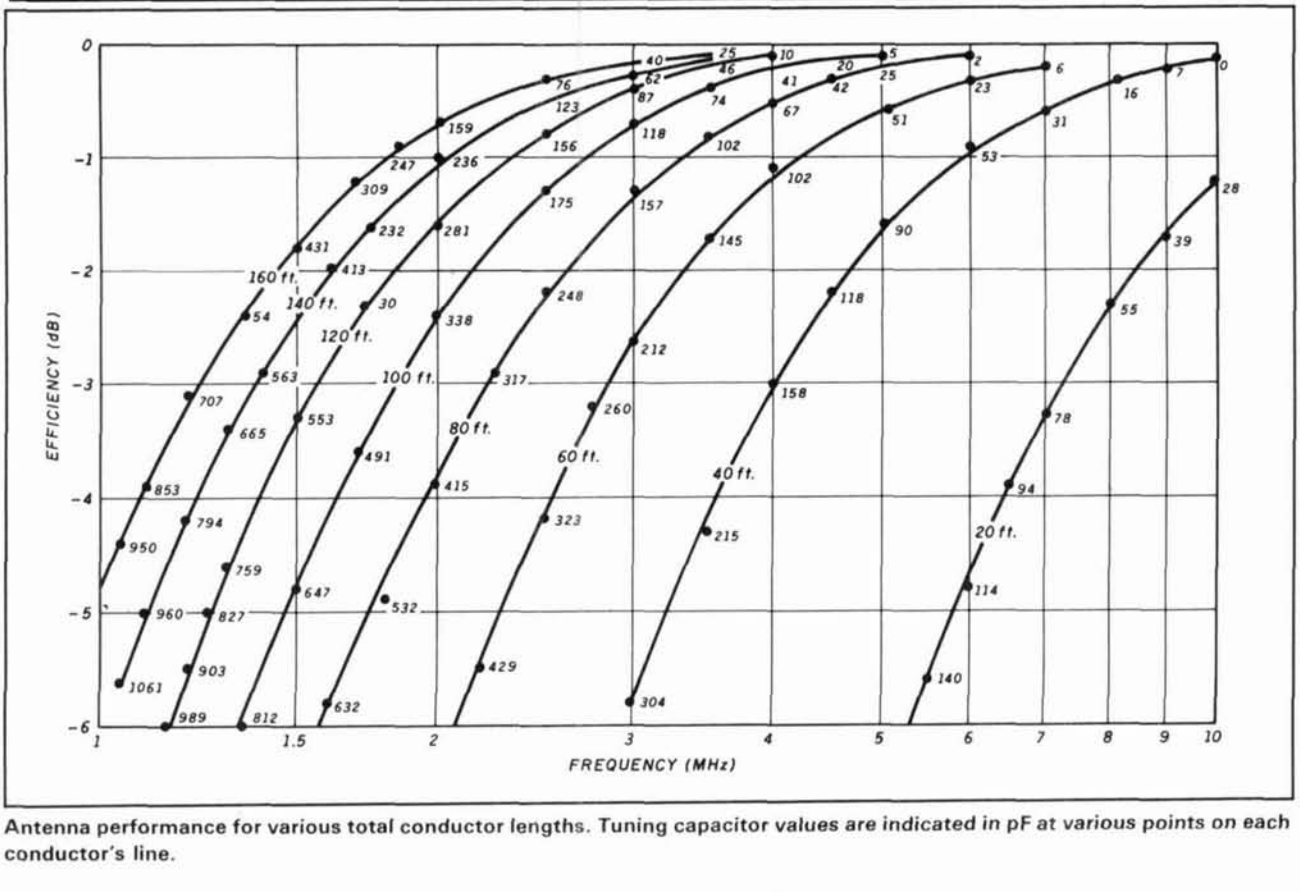
60 foot vertical antenna with 120 quarter-wavelength radials. *Elevation cut at 4 MHz.*

FIGURE 11

```
          PARAMETERS OF A CONVOLUTED LOOP ANTENNA

INPUT VALUES AS REQUESTED FROM THE FOLLOWING PROMPTS:

SPECIFY OPERATING FREQUENCY IN MHZ --? 4
SPECIFY TOTAL LENGTH OF PIPE IN FEET --? 80
SPECIFY TRANSMITTER PEAK OUTPUT POWER IN WATTS --? 1000

RESULTS

FOR A 80 FOOT PIPE, .9 INCH DIAMETER AT 4 MHZ ---
RADIATION RESISTANCE OF THE ANTENNA = 1.344 OHMS
THE LOSS RESISTANCE OF THE ANTENNA = .177 OHMS
EFFICIENCY = 88 PERCENT, WHICH IS (RELATIVE TO 100%) = -.5 dB
THE Q OF THE ANTENNA = 109
THE BANDWIDTH OF THE ANTENNA = 36.697 KHZ
THE VALUE OF THE TUNING CAPACITOR = 67 pfd
FOR 1000 WATTS, TUNING CAP VOLTAGE = 6115 VOLTS
THE CAPACITOR PLATE SPACING MUST BE .08 INCHS
THE HEIGHT (AND WIDTH) OF THIS LOOP IS 10 FEET
- - - - - - - - - - - - - - - - - - - - - - - - - -

WANT TO TRY A DIFFERENT FREQUENCY ? (Y/N)

1LIST  2RUN 3LOAD"  4SAVE"  5CONT6,"LPT1 7TRON8TROFF9KEY   0SCREEN
```

Example of the prompts encountered when running the program for determining the parameters of a convoluted loop.

FIGURE 12

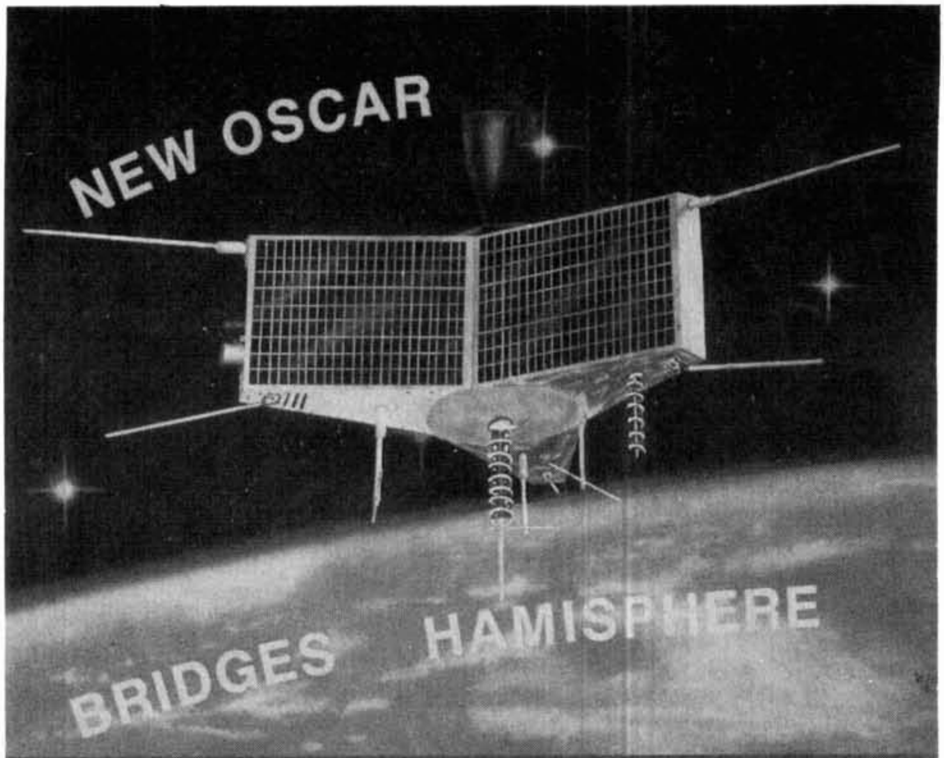


Antenna performance for various total conductor lengths. Tuning capacitor values are indicated in pF at various points on each conductor's line.

sandy soil in Florida. The patterns are based on antennas with perfect conductors. Actual patterns can be determined by reducing the pattern gain by the efficiency calculated for a particular size antenna. **Figures 6**, **7**, and **8** are presented for comparison based on a dipole over the same ground. **Figure 9** is a convoluted loop at 7 MHz over 120 1/4-wavelength radials, and **fig. 10** is a 1/4-wavelength vertical with 120 1/4-wavelength radials, given for comparison.

It's important to note (see **fig. 9**) that hemispherical coverage is achieved, allowing the antenna to be used for both local and long range communications. As a result of its magnetic properties, a loop antenna produces significant radiated energy at low elevation

Reader Service CHECK—OFF Page 118



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```
10 CLS PRINT "THIS PROGRAM DEVELOPED BY W5QJR FOR USE ON AN IBM PC"
20 LOCATE 10,10
30 PRINT "PARAMETERS OF A CONVOLUTED LOOP ANTENNA" PRINT
40 PRINT "INPUT VALUES AS REQUESTED FROM THE FOLLOWING PROMPTS" PRINT
50 INPUT "SPECIFY OPERATING FREQUENCY IN MHz" F
60 INPUT "SPECIFY TOTAL LENGTH OF PIPE IN FEET" S
70 INPUT "SPECIFY TRANSMITTER PEAK OUTPUT POWER IN WATTS" P
80 D = .9 'THIS IS THE OD FOR 3/4 INCH COPPER PIPE
90 A = 4*(S/8)^2 'THIS IS THE AREA OF 2 SQUARES MULTIPLIED BY THEIR IMAGES
100 RR = 3.38E-08*(F^2*A)^2 'RADIATION RESISTANCE
110 RR = FIX(RR*10000)/10000 'METHOD USED TO REDUCE TO 2 DECIMAL PLACES
120 RL = .000996*F^.5*S/D 'LOSS RESISTANCE
130 RL = FIX (RL*10000)/10000
140 E = RR/(RR + RL) 'EFFICIENCY, DECIMAL
150 E = FIX (E*100)
160 DB = 10*LOG(E/100)/LOG(10) 'EFFICIENCY IN dB
170 DB = FIX (DB*10)/10
180 L = (5.8624E-07*S^.6884)*1.13 'SELF INDUCTANCE OF LOOP
190 XL = 2*3.1416*F*1000000*L 'INDUCTIVE REACTANCE
200 Q = XL/(2*(RR + RL)) 'Q OF THE ANTENNA
210 Z = FIX (Q)
220 BW = F*1000000/Q 'BANDWIDTH OF THE ANTENNA IN MHz
230 BW = FIX (BW/1000) 'BANDWIDTH IN kHz
240 CS = 1.1374E-11 + 4.6841E-13*S 'DISTRIBUTED CAPACITY OF THE ANTENNA
250 CT = 1/((2*3.1416*F*1000000)^2*L)-CS 'REQUIRED TUNING C-CS
260 CT = FIX(CT*1E + 12)
280 VC = (P*XL*Q)^.5 'VOLTAGE ACROSS THE TUNING CAPACITOR
290 VC = FIX(VC)
300 SC = VC/75000 'PLATE SPACING OF TUNING CAPACITOR IN INCHES
310 SC = FIX(SC*100)/100
320 PRINT PRINT "RESULTS" PRINT
330 PRINT "FOR A" S "FOOT PIPE" D "INCH DIAMETER AT" F "MHz"
340 PRINT "RADIATION RESISTANCE OF THE ANTENNA =" RR "OHMS"
350 PRINT "THE LOSS RESISTANCE OF THE ANTENNA =" RL "OHMS"
360 PRINT "EFFICIENCY =" E "PERCENT, WHICH IS (RELATIVE TO 100%) =" DB "dB"
370 PRINT "THE Q OF THE ANTENNA =" Q
380 PRINT "THE BANDWIDTH OF THE ANTENNA =" BW "KHz"
390 PRINT "THE VALUE OF THE TUNING CAPACITOR =" CT "pfd"
400 PRINT "FOR" P "WATTS, TUNING CAP VOLTAGE =" VC "VOLTS"
410 PRINT "THE CAPACITOR PLATE SPACING MUST BE =" SC "INCHS"
420 H = S/8
430 PRINT "THE HEIGHT (AND WIDTH) OF THIS LOOP IS" H "FEET"
440 PRINT PRINT
450 PRINT "WANT TO TRY A DIFFERENT FREQUENCY? (Y/N)"
460 X$ = INPUT$(1)
470 IF X$ = "Y" THEN 480 ELSE 500
480 INPUT "SPECIFY THE NEW FREQUENCY IN MHz =" F
490 GOTO 90
500 PRINT PRINT "WANT TO CHANGE THE CONDUCTOR LENGTH ? (Y/N)"
510 X$ = INPUT$(1)
520 IF X$ = "Y" THEN 530 ELSE 560
530 INPUT "SPECIFY THE NEW PIPE LENGTH IN FEET =" S
540 GOTO 90
560 END
```

angles. This also confirms that there is very little ground loss for this antenna.

On-the-air tests, in comparison with other antennas, have confirmed the performance of the convoluted loop and verified the performance indicated by the patterns derived from MININEC3. Measurements on the antenna also confirm the accuracy of the equations. A sample run of the computer program is shown in **fig. 11**, to assist those who want to develop a convoluted loop antenna for a particular application. **Figure 12** presents a set of data run from the program.

The convoluted loop is a result of efforts to design a high-performance antenna requiring very little space. I hope others will modify this design (perhaps by putting a "twist" to the conductor) and achieve an antenna design that's truly nondirectional.

References

1. R.T. Hart, "Small High Efficiency Loop Antenna," *QST*, June 1986.
2. D.E. Barrick, "Miniloop Antenna Operation and Equivalent Circuit," *IEEE Transactions on Antennas and Propagation*, vol. AP-34, no. 1, January 1986.
3. R.W.P. King, "The Loop Antenna for Transmission and Reception," *Antenna Theory, Part 1*, McGraw-Hill, 1969, Chapter 11.
4. J.H. Dunlavy, "Wide Range Tunable Transmitting Antenna," U.S. Patent 3 588 905, June 28, 1971.
5. D.V. Campbell, "Personal Computer Applications of MININEC," *IEEE Antennas Propagation*, Society Newsletter, vol. 26, 1984, pages 5-9.
6. R.T. Hart, *Small High Efficiency Antennas Alias the Loop*, Eagle Press, 1985. (Available from W5QJR Antenna Products.)
7. Schelkunoff and Fries, *Antenna Theory and Practice*, Wiley, 1952.

Article K **HAM RADIO**

ATTENTION: WOMEN WHO SOUGHT EMPLOYMENT WITH THE VOICE OF AMERICA (VOA), THE UNITED STATES INFORMATION AGENCY (USIA), OR THE UNITED STATES INTERNATIONAL COMMUNICATION AGENCY (USICA) BETWEEN OCTOBER 8, 1974 AND NOVEMBER 16, 1984.

YOU MAY BE A VICTIM OF SEX DISCRIMINATION ENTITLED TO A MONETARY AWARD AND A POSITION WITH THE AGENCY.

UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

CAROLEE BRADY HARTMAN, et al., Plaintiffs, v. CHARLES Z. WICK, Defendant	Civil Action No. 77-2019 Judge Charles R. Richey

PUBLIC NOTICE

On November 16, 1984, the United States District Court for the District of Columbia found in this class action lawsuit that the United States Information Agency (USIA or the Agency), including the Voice of America (VOA), is liable for sex discrimination against female applicants for the following positions at the Agency. The USIA was also formerly known as the United States International Communication Agency (USICA). On January 19, 1988, the Court issued its opinion ordering relief in a variety of forms to potential class members. Accordingly, this case is now in the remedial phase.

JOBS COVERED

Specifically, the Court has found that the Agency has discriminated against women in hiring in the following jobs:

- Electronic Technician (Occupational Series 856)
- Foreign Language Broadcaster (Occupational Series 1048)
- International Radio Broadcaster (Other) (Occupational Series 1001)
- International Radio Broadcaster (English) (Occupational Series 1001)
- Production Specialist (Occupational Series 1071)
- Writer/Editor (Occupational Series 1082)
- Foreign Information Specialist/Foreign Affairs Specialist/Foreign Service Information Officer/Foreign Service Officer (Occupational Series 1085 and 130)
- Radio Broadcast Technician (Occupational Series 3940)

WHO IS INCLUDED

All women who sought employment with the Agency in any of the jobs listed above between October 8, 1974 and November 16, 1984 and were not hired may be eligible for relief. Also included are those women who were discouraged from applying for these positions during that time period. Even those women subsequently hired by the Agency in some capacity may be entitled to participate in the remedial phase of this case.

Women who sought employment with the Agency as Foreign Service Officers or Foreign Service Information Officers may be eligible for different kinds of relief depending upon the date of application and whether they sought employment at the entry level or mid-level. Women who sought employment with the Agency as **entry** level Foreign Service Officers or Foreign Service Information Officers in the years 1974-1977 must use the procedure outlined below. Women who sought employment with the Agency as **mid-level** Foreign Service Officers or Foreign Service Information Officers in the years 1974-1984 must also use the procedure outlined below. However, women who sought employment with the Agency as **entry** level Foreign Service Officers or Foreign Service Information Officers in the years 1978-1984 cannot use the procedure outlined below, since the Court has ordered an alternative form of relief for them and selected women in this group will be notified individually as to their rights.

RELIEF AVAILABLE AND HOW TO OBTAIN IT

Relief available to class members may include a monetary award and/or priority consideration for a current position with the Agency. *If you think you may be entitled to relief, you* **must** obtain a claim form, complete it fully, and return it to counsel for the plaintiff class, Bruce A. Fredrickson, Esq., Webster & Fredrickson, 1819 H Street, N.W., Suite 300, Washington, D.C. 20006 (202/659-8515), postmarked no later than July 15, 1989.

You may obtain a claim form in person and/or in writing from several sources: counsel for the plaintiff class, whose address is listed above; *in person from* USIA, Front Lobby, 301-4th Street, S.W., Washington, D.C. (8:15am-5:00pm), Office of Personnel Management (OPM), Federal Job Information Center (First Floor, Room 1425), 1900 E Street, N.W., Washington, D.C. (8:30am-2:30pm), or from area OPM offices throughout the country; in writing, VOA-Hartman, P.O. Box 400, Washington, D.C. 20044. *You should carefully consider all questions on the claim form,* **sign** it, and return it to counsel for the plaintiffs. **Do not, under any circumstances,** return the claim form to the Judge, the Court or the Clerk of the Court. The Judge, the Court and the Clerk of the Court **will not accept** the claim forms and **will not forward** claim forms to plaintiffs' counsel.

PROCESSING OF CLAIMS

The process for handling claims has not been finally decided. Thus far, the Court has ordered that responding class members demonstrate their potential entitlement to relief at an individual hearing to be scheduled at a later date. However, the Court has reserved the right to reconsider this procedure in the event the number of claims filed makes this approach unmanageable.

Should individual hearings be used, you will be fully informed as to the date and time of your hearing. Moreover, you will be entitled to legal representation by counsel for the plaintiff class or his designee at no cost to you. Legal counsel will discuss your claim with you prior to your hearing, help you prepare your case and represent you at your hearing. You may, of course, retain your own attorney to represent you, if you so desire.

At the individual hearing, you will be asked to demonstrate your potential entitlement to relief by showing that you applied for one or more of the covered positions during the period October 8, 1974 and November 16, 1984 and that you were rejected, or that you were discouraged from applying. Evidence may be required in the form of testimony, documents, or both. Once you have demonstrated these facts, USIA is required to prove, by clear and convincing evidence, that you were not hired (for **each** position for which you applied) for a legitimate, non-discriminatory reason, such as failure to possess requisite qualifications. Should USIA make such a showing, you would then be entitled to demonstrate that the Agency's reason is merely a cover for sex discrimination or unworthy of belief.

Following the hearing, the Presiding Official will decide whether you are entitled to relief and, if so, what relief is appropriate. You may be entitled to wages and benefits you would have earned if you had been hired (back pay) from the date of your rejection until the date relief is approved. Under the law, back pay is offset by earnings you may have had during the period. In addition, you may be found to be entitled to front pay (that is, compensation into the future until an appropriate position is afforded you). Similarly, you may be found to be entitled to priority consideration for employment with the Agency. If hired, you may further be entitled to retroactive seniority with the associated benefits and the value of any promotions you would likely have had if you had not suffered discrimination.

REQUIRED STEPS TO FILE YOUR CLAIM

To participate in the remedial phase, **you must fully complete the claim form** and return it, POSTMARKED NO LATER THAN July 15, 1989, to counsel for the plaintiff class. Your failure to do so will result in your losing all rights you may have in this lawsuit. If you have questions about your rights or procedures available to you, you may contact counsel for the plaintiff class:

Bruce A. Fredrickson
Webster & Fredrickson
1819 H Street, N.W., Suite 300
Washington, D.C. 20006
(202/659-8515)

October 4, 1988	*/s/ Judge Charles R. Richey*
Date	United States District Court Judge Charles R. Richey

ELMER's NOTEBOOK

Tom McMullen, W1SL

Voltage-variable capacitors

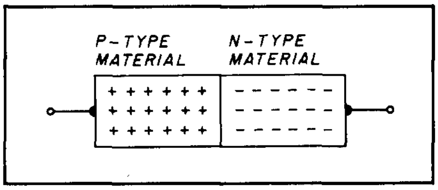
I'm planning a column for the near future about oscillators and what makes them work. For now I'd like to talk about one of the components used in many oscillators — a diode that acts like a variable capacitor. I thought a review of how this diode works would be useful. You may think that because it doesn't look like a capacitor, it can't act like one. But some variable capacitors can have an appearance completely different from those of earlier days and still pass the test.

For high-power use (in the power-amplifier stages of a transmitter or in an antenna-matching network, for example) the mechanically variable capacitor with its tolerance of high voltages is still the only way to go. For receiver RF amplifier stages or frequency-synthesized variable-frequency oscillators (VFOs), a little speck of plastic and metal will perform the same function as a mechanically variable capacitor — in far less space. They have other advantages as well.

How do they do that?

To understand how the process works, a physics lesson is in order. In earlier discussions of semiconductor devices like bipolar and field-effect transistors, I spoke of how they are made up of two types of material: P-type (with a scarcity of electrons) and N-type (with a surplus of electrons). These two kinds of materials can be put together to form a diode, as shown in **fig. 1**. Conductive leads

FIGURE 1



P-type semiconductor material and N-type semiconductor material are placed together to form a diode. The material can be either germanium or silicon.

are attached to each end to allow current flow from external sources and devices. The barrier or junction between the two materials is very thin, and a small voltage (0.6 volts for silicone devices) overcomes its resistance and permits current flow. Germanium devices require less voltage (typically 0.2 volts) to allow conduction.

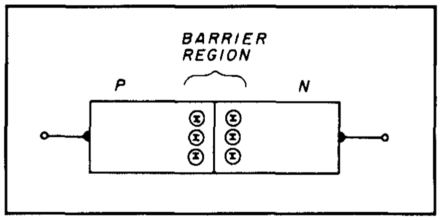
It's necessary to apply forward bias to the diode to obtain conduction when you want to rectify some AC, isolate a DC source, or whatever. But things start to get interesting when you apply reverse bias to the diode.

To go back to the basic physics of the device for a moment, it's the junction (or barrier) region that's important. When the two types of semiconductor material are attached to each other, a small number of electrons from the N-side cross the barrier and fill some of the vacancies on the P-side. These vacancies are often called "holes," but they're not really holes — they're atoms that have one less electron compared with the other atoms around them. These are the "impurity" atoms that were mixed in with the basic silicon or germanium when the alloy was formed.

Over on the N-side of the barrier, some impurity atoms have an extra electron compared with those surrounding it — hence the "surplus" of electrons. When enough surplus electrons from the N-side "cross over the fence" to fill the vacancies on the P-side, the semiconductor material close to the fence on both sides has neither surplus tenants nor vacancies. (This kind of material is called type "I," for intrinsic, which is another way of saying it reverted to its original number of electrons before the impurities were mixed in.)

Take a look at **fig. 2** and see what you have now. There are two types of

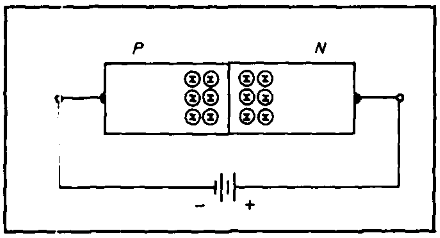
FIGURE 2



Some electrons migrate from the N-material over to the P side, creating a barrier region with neither surplus electrons nor vacancies for them. In this state, the barrier region is an effective insulator.

semiconductor material, with an insulator layer in between. It's beginning to look like a basic capacitor — two conductors separated by an insulator or dielectric. Now, let's see if acts like one.

FIGURE 3



When a voltage is applied to the diode, more electrons are available to fill more vacancies, causing the barrier region to grow. This effectively changes the amount of insulation (dielectric) between the two conductors.

Add some voltage and...

When an external source of electrons is connected to the junction (from a battery or power supply, for instance) the resulting pressure (also known as voltage) lets more electrons cross the barrier and fill some vacancies, as shown in **fig. 3.** To put it another way, the crowd along the fence is getting bigger. This is the same as putting a bigger insulator (dielectric) between the two plates of the capacitor. If this were an air-dielectric capacitor, you'd get the same effect by moving the plates farther apart. So now you have a varible-dielectric capacitor. Is this thing beginning to act like a capacitor? Sounds like it!

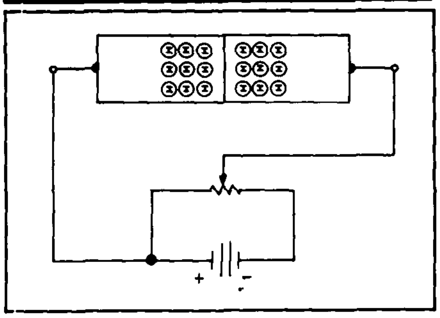
Can we control it?

Because this capacitor changes its dielectric in response to applied voltage, and since a change in dielectric equates to a change in capacitance, it is a variable capacitor. From here it should be easy to control the capacitance, as shown in **fig. 4.**

To demonstrate the principle, connect a potentiometer across a power supply (a 9-volt battery in this case). You'll need a means of detecting the capacitance change in order to get proof that it works. My ancient capacitance meter doesn't do well with values below 50 pF, so I came up with the scheme in **fig. 5.** L1 and CR1 comprise a tuned circuit that you check with a grid-dip meter. (My meter uses a vacuum tube, so it's still a "grid" dipper. A transistor or FET dipper will work equally well). L1 is ten turns of no. 22 enameled wire close wound on a 1/4-inch form, and CR1 is the diode being tested. R1 is a variable resistor that controls the voltage applied to the diode, and R2 is a current-limiting device — in case something should short. C1 is a large-value bypass capacitor, which completes the RF path in the tuned circuit and isolates the meter from the circuit.

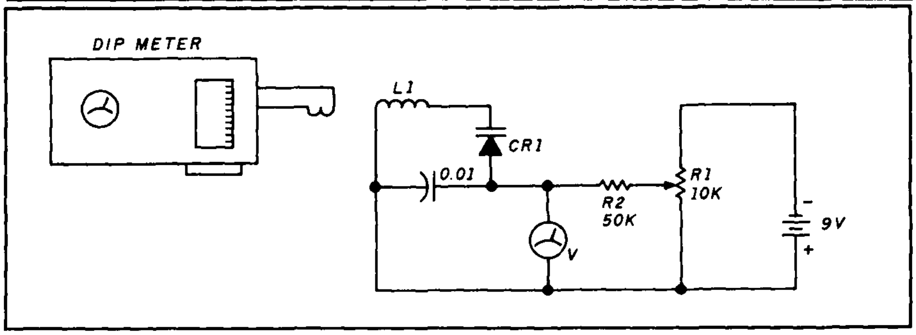
I placed the dip meter as far away as I could from the tuned circuit while still getting an indication on its meter. This prevents overloading the circuit with RF, which could cause CR1 to act like a regular diode instead of a variable-capacitance diode. Then I measured the voltage applied to the diode and checked the frequency. I changed the voltage and took another frequency reading. **Figure 6** is a graph of my results. The first diode I tested was a prototype designed for use in AM broadcast band circuits, marked

FIGURE 4



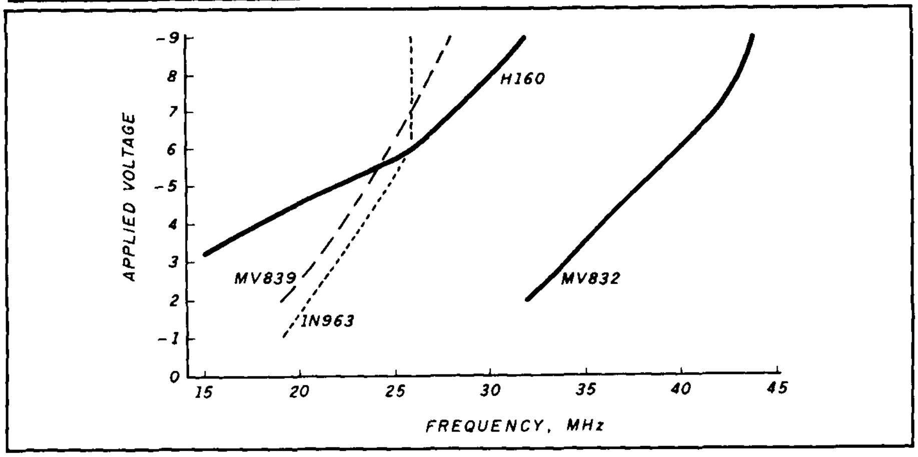
A variable voltage applied to the diode will cause the barrier region, and thus the capacitance, to change in response to the voltage.

FIGURE 5



If you don't have a capacitance meter capable of reading values down to 10 pF or less, you can test the principle with this setup. Components are explained in the text.

FIGURE 6



A plot of voltage versus frequency shows the results. A plot for a diode (1N963) not designed for use as a VVC (voltage-variable capacitor) is also shown. Its limited range is shown by the "knee" at −6 volts.

H160. I also tried two other types *designed for voltage-variable* capacitance use, the MV832 and MV839.

According to theory, almost any diode will act like a variable-capacitance diode to some degree, so I grabbed a 1N963 from my junkbox and wired it into the circuit to see what would happen. The results are also shown in **fig. 6**.

It became quite evident during this test that it's important to use a diode designed for the job. The 1N963 has a lower Q than the other diodes. I knew this because the "dips" at resonance were very shallow and broad in frequency. The MV832 also showed the same behavior, but not as severely as the 1N963. The MV832 has a smaller capacitance change than the others, as shown by its position on the graph. It should work well in the VHF region. The other diodes produced dips at resonance that were quite sharp, as expected of high-Q devices.

It appears that theory has triumphed again. You have a variable capacitor that can be controlled by a potentiometer and voltage source. This opens up a lot of possibilities, and eliminates those fussy shaft couplers that were always so hard to align with the dial drive on the front panel of your VFO. All the normal precautions about shielding, temperature compensation, anti-vibration protection, and the like still apply, however. A VFO circuit must be mechanically stable, no matter what type of capacitor you use. All diodes change characteristics with temperature; these will too, to some extent. It's not critical in many circuits, but this trait will be noticeable in a VFO.

And that's what makes a voltage-variable capacitor (sometimes known as a varicap) work. When my notebook item about oscillators appears in a later issue, you'll understand what that funny-looking diode is doing in the middle of things.

Article L **HAM RADIO**

NEW products

New for remote antenna switching

ComTek announces the new RCB-5 Remote Control Box — a five-position coaxial switch for remote antenna switching from one feedline.

The RCB-5's inside console control box selects from one to five antennas at once; the weatherproof outside switchbox contains five high-powered DPDT relays with gold-plated contacts. The RCB-5 can be used as a standard five-position remote control coaxial switchbox or to control stacked arrays. Optional wideband Toroidal Impedence Transformers (TIT-2 or TIT-3) for 50 to 100 ohms or 50 to 150 ohms are available for stacking two or three Yagis, respectively. All relays have 5 kW-rated gold-plated contacts. VSWR is below 1.05:1 up to 144 MHz. The outside switchbox uses 18-gauge steel with a zincate coating, a gold-chromate rustproof finish, and is dip-painted black. The inside console control box has a scratchproof Lexan™ front panel template. LEDs have diffusion covers. The switching knob has positive action with 15-degree detent positions.

The RCB-5 comes with 250 QSL cards, and is priced at $139.95 plus $12 shipping and handling. (Add 10 percent outside the U.S.) TIT-2 or TIT-3 comes in a weatherproof box with SO-239 IN and OUT for $19.95.

For further information contact ComTek, PO Box 202, Hopkinton, Massachusetts 01748.

Circle #305 on Reader Service Card.

Compact Amplified Speaker

Naval Electronics, Inc. has introduced the HTS-1 Amplified Speaker with features for use with handheld radios. The HTS-1 is compact, with a 3.5-inch speaker and 10-dB internal amplifier.

The HTS-1 is powered from internal batteries, or any external voltage from 6 to 15 Vdc through a DC jack. It has a built-in NiCd battery charger and an automatic shut-off that kills power to the amplifier when there's no audio input (receiver squelched). When switched off manually, the amplifier is bypassed and the input jack has a direct connection to the speaker.

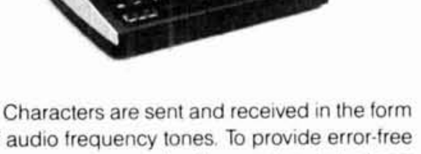
The HTS-1 has a tilted base for desk mounting. A special mobile harness is available for mounting the unit on the inside of a car door. A 5-foot cable with mini-plugs and a stereo-to-mono converter is included. A free stereo cable is available if you order two units for use with a personal stereo system. The cost is $29.95.

For further information contact Naval Electronics, Inc., 5417 Jetview Circle, Tampa, Florida 33634.

Circle #306 on Reader Service Card.

Printers communicate by packet radio

QWINT DATA, Inc. has announced a new packet radio modem option. It's packaged as an internal module with the QWINT terminal. The RDM1200 lets you send and receive written messages over radio links.



Characters are sent and received in the form of audio frequency tones. To provide error-free messages over radio, the modem includes a high-speed 7.37-MHz microprocessor, with these features:

- Synchronous HDLC protocol
- Automatic error detection and correction
- Multi-user networks
- Repeater capability
- Compatibility with HF, VHF, and UHF

The QWINT terminal may be interfaced with most voice radio transceivers. A jack and cable are provided. The radio modem connects to the microphone and speaker jacks of the voice radio. It also provides a digital output for controlling PTT circuitry, for switching into transmit mode under control of the packet radio protocol.

For more information contact QWINT DATA, Inc., 3455 Commercial Avenue, Northbrook, Illinois 60062.

Circle #307 on Reader Service Card.

ACB-4 phased array switchbox

ComTek introduces the ACB-4 phased array switchbox with controller. It allows gain and directivity from a vertical array by dividing power and phase among 2 or 4-element arrays. You supply the antennas and cables.

The ACB-4 has two boxes. The outside switchbox, installed near the antenna array, contains the 90-degree quadrature hybrid, 180-degree phase reversal transformer (both in toroidal form), and relay switching matrix. Four feedlines are attached to the antenna elements for a "4-Square" array; two are used for a 2-element array. Three-conductor control cable and feedline run back to the shack. Gain for the 4-square is about 5.8 dB with F/B typically 15 to 25 dB, depending on angle of arrival. Metal cabinets are 18-gauge steel, with anti-rust zincate and gold cromate finish, dip painted black. Relays use 5-k gold-plated contacts. The inside console control box has a scratchproof Lexan™ front panel template. The beam direction knob has positive click positions and no end stop, for continuous turning in any direction. The ACB-4 comes with complete instructions for installing ground-mounted verticals, ground-plane type verticals, or half-wave verticals with the unit. The price is $295, plus $12 shipping and handling. (Add 10 percent outside the U.S.). Contact ComTek, PO Box 202, Hopkinton, Massachusetts 01748.

Circle #309 on Reader Service Card.

GP21X Ginpole Kit

IIX Equipment, Ltd. offers the new GP21X Ginpole Kit for stamped open leg-type towers. Clamps adjust to fit the tapering tower sections and can be spaced any distance apart. A standard IIX pulley is furnished; the pipe is customer supplied. The price of the kit is $199.50. Immediate shipping is available.

For more information contact IIX Equipment, Ltd., PO Box 9, Oak Lawn, Illinois.

Circle #308 on Reader Service Card.

DX FORECASTER

Garth Stonehocker, KØRYW

Spring thunderstorm noise

Received noise sometimes spoils the best DX openings. There are many types of noise. The Russian woodpecker or the ham rig down the street are two examples of radio emitters, which can cause interference. Atmospheric, or thunderstorm, noise is more common. Like the DX signal, these noises are often propagated by the ionosphere. Other noise may come from a local factory or a badly maintained power line. Of all of these, strong local atmospheric noise is perhaps the most disagreeable at this time of year. Here's how it happens.

Spring storms occur in the Northern Hemisphere in March and April. Fronts of warm and cold air generate the first major thunderstorms of the year, with fast-moving cold fronts producing particularly potent thunderstorms. As a storm front approaches your area, you'll begin to hear a significant increase in the noise level. You'll start to notice this increase at a one-hop distance (about 600 to 1200 miles) when the storm front is west of your location. You can reduce the received noise a few dB by using a directional antenna like a rotating Yagi or a phased vertical array. Determine the noise direction and work DX in the opposite orientation, or do your best to null it out using a directional tradeoff between signal and noise strengths. Antennas with a low take-off angle (TOA) at the operating frequency are best because this noise normally arrives at angles greater than 30 degrees.

As the front gets closer, the noise level usually decreases until it's within a groundwave's distance (about 50 miles). Now you'll hear loud individual discharges. A horizontally polarized antenna is the best radiator to use to lower the noise as much as possible. As the storm approaches, its sounds become part of the "local noise." As it moves away its noise decreases, then increases again as the front reaches the one-hop distance point a day or so later. The directional low TOA antenna is helpful once again.

Cold fronts usually travel about 40 miles per hour, so it could take 15 to 30 hours to reach one-hop distance — averaging almost a day's frontal travel time before coming to (westerly) and after leaving (easterly) your station. If you watch the TV weather news daily, you can track the storm and note how its noise affects your operations. As the storm comes into the one-day-before position, there's a corresponding increase in noise. When it passes over your ham shack the next day, it will cause intense static crashes. As you watch the storm approach the day-after position, you'll notice some lingering noise before all's quiet again. It should remain quiet until the next storm comes your way. When looking for rare DX, you can save time by tracking storms. This will help you pinpoint when and where the most favorable listening conditions are likely to occur.

Last-minute forecast

The first and last weeks of the month should be times of high solar flux, resulting in higher MUF than the rest of the month. There's also a probability of solar flares, if the rise or fall of flux is over ten units per day — an April trait. The high MUFs will enhance DX conditions to the southern countries. The openings may be transequatorial DX openings toward late evenings (2200 local time), and during geomagnetic-ionospheric disturbances expected near the 5th through the 8th, the 16th, and the 26th. The lower night or daytime short-skip bands should be best the second and third weeks during times of lower solar flux, with its lower signal absorption. MUFs will come down nearer these bands and produce strong signals. During the disturbed days (and particularly nights), signals may be weak and variable (QSB) but from interesting DX countries. This is also an April trait.

The perigee of the moon's orbit (for moonbounce DX) is on the 5th, with the moon showing full phase on the 21st. There will be a short meteor shower (the Lyrid) on April 20th to the 22nd, with a rate of five per hour — hardly much help for meteor scatter DX. But a bigger shower (the Aquarid) starts before the end of April, peaks on May 5th, and ends in mid-May. Its rate should be 10 to 30 per hour.

Band-by-band summary

Ten, 12, 15, and 17 meters, the day-only DX bands, will be open midday to early evening almost every day to southern areas of the world. The openings on the higher of these bands will be shorter (if they occur at all), closer to local noon, and will provide a possibility of transequatorial openings.

APRIL

WESTERN USA

GMT	PDT	N (SIA AR EAST)	NE (JROPE)	E (. AFRICA)	SE (. AMERICA)	S (NTARCTICA)	SW (EW ZEALAND)	W (CEANIA USTRALIA)	NW (APAN)
0000	5:00	12	30	15	10	10	10	10	10
0100	6:00	12	30	15	10	10	10	10	10
0200	7:00	12	30	20	12*	12	10	10	10
0300	8:00	15	30	20	12	12	10	10	12
0400	9:00	15	20	20	12	15	10	10	15
0500	10:00	20	20	20*	15*	20	10	10	15
0600	11:00	20	20	15	15	20	10	10	20
0700	12:00	20	20	15	15	20	12	12	20
0800	1:00	20	30	15	20	20	12	12	20
0900	2:00	30	30	20	20	20	15	15	20
1000	3:00	30	30	20	20	20	15	15	20
1100	4:00	30	20	15	20	30	15	15	20
1200	5:00	20	15	12	20	30	20	15	30
1300	6:00	20	12	10	15	30	20	20	30
1400	7:00	20	12	10	12	30	20	20	20
1500	8:00	20	10	10	12	30	20	20	20
1600	9:00	20	10	10	10	20	20	20	20
1700	10:00	20	12	10	10	15	15	20	30
1800	11:00	30	12	10	10	12	12	20	20
1900	12:00	30	15	10	10	12*	12	15	15
2000	1:00	30	15	10	10	10	10	12	15
2100	2:00	20	15	12	10	10	10	10	12
2200	3:00	20	20	12	10	10	10	10	12
2300	4:00	15	20	15	10	10	10	10	10

MID USA

MDT	N (SIA AR EAST)	NE (UROPE)	E (. AFRICA)	SE (. AMERICA)	S (NTARCTICA)	SW (EW ZEALAND)	W (CEANIA USTRALIA)	NW (APAN)	CDT
6:00	15	20	15	10	10	10	10	10	7:00
7:00	15*	20	15	10	12	10	10	12	8:00
8:00	12	30	20	12	12	10	10	15	9:00
9:00	15	30	20	12	15	10	10	15	10:00
10:00	20	30	20	12	20	10	12	15	11:00
11:00	20	20	20	15	20	12	12	20	12:00
12:00	20	20	15	15	20	12	15	20	1:00
1:00	20	20	15	15	20	12	15	20	2:00
2:00	30	30	20	20	20	15	15	20	3:00
3:00	30	30	20	20	20	15	15	20	4:00
4:00	30	30	15	20	20	15	15	30	5:00
5:00	15	20	12	20	30	20	20	30	6:00
6:00	15	20	10	15	30	20	20	30	7:00
7:00	15	15	10	12	30	20	15	20	8:00
8:00	20	15	10	12	30	20	15	20	9:00
9:00	20	12	10	12*	30	20	20	20	10:00
10:00	20	12	10	10	15	15	20	30	11:00
11:00	20	12	10	10	15	12	20	30	12:00
12:00	20	12	10	10	12	12	20	30	1:00
1:00	30	15	10	10	10	12	12	15	2:00
2:00	30	15	12	10	10	10	10	15	3:00
3:00	30	20	12	10	10	10	10	12	4:00
4:00	20	20	15	10	10	10	10	12	5:00
5:00	20	20	15	10	10	10	10	10	6:00

EASTERN USA

EDT	N (SIA AR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (CARIBBEAN S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
8:00	15	20	15	10	12	10	10	12
9:00	20	20	15	10	12	10	10	15
10:00	20	30	20	12	15	10	10	15
11:00	20	30	20	12	15	10	10	20
12:00	20	30	20	15	20	12	12	20
1:00	30	30	20	15	20	12	12	20
2:00	30	30	20	15	20	15	15	20
3:00	30	30	20	20	20	15	15	30
4:00	20	20	20	20	20	15	15	30
5:00	20	20	15	20	30	15	15	30
6:00	15	15	12	20	30	20	20	20
7:00	15	15	10	15	30	20	20	20
8:00	15*	15	10	12	30	20*	15	20
9:00	15	15	10	12	30	20	15	20
10:00	15	12	10	12	30	20	20	20
11:00	20	12	10	10	15	20	20	20
12:00	20	15	10	10	15	20	20	30
1:00	20	15	10	10	12	15	20	30
2:00	20	15	10	10	12	12	20	20
3:00	30	15	10	10	10	12	12	15
4:00	30	20	10	10	10	10	10	12
5:00	30	20	10	10	10	10	10	12
6:00	20	20	12	10	10	10	10	10
7:00	20	20	12	10	10	10	10	10

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IBM-PC SOFTWARE FOR PK-232. New CompRtty II/PK is the complete communications program for the PK-232/HK-232. Uses host mode of PK-232 for complete control. Text entry via built-in screen editor! Adjustable split screen display, including optional Triple Split ™ in Packet mode. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages, mailbox facility. Ideal for MARS and traffic handling. Requires 256k PC compatible. $65. Non-PK-232 version still available. Send call letters (including MARS) with order. David A. Rice, KC2HO, 144 N. Putt Corners Rd, New Paltz, NY 12561.

COMMODORE/AMIGA CHIPS (eg. 6510-$12.55, 6526-$13.50, 6567-$19.95, 6581-$14.85, 82S100-$15.75, 901 ROM Series-$12.50), PARTS, DIAGNOSTICS, HARD TO FIND ITEMS. Authorized service center. Fast REPAIRS, low cost (eg. C64-$49.95 plus UPS). Heavy duty power supplies for the C64-$27.95 plus UPS. Kasara Microsystems (Division of QEP), Route 9W/Kay Fries Drive, Stony Point, NY 10980, 1-800-248-2983 (outside NY) or 914-942-2252.

THE NATIONAL HAM SHOPPER. A bi-monthly buy, sell, trade publication (starting in April). Ads are quickly answered and published for fast results. $12/per year. $22/per 2-year subscription rate. Send: PO Box 10738, Elmwood, CT 06110.

R-290A Receiver Parts: Info SASE. CPRC-26 military Manpack Radio, 6 meter FM, with antenna, crystal, handset: $22.50, $42.50/pair. CPRC-26 Radio-only: $9.50. Add $4.50/piece shipping, $9 maximum. Baytronics, Box 591, Sandusky, OH 44870.

VHF MOBILE REPEATER, control ham station with HT, w/manual $75. Precision E-200-C RF signal generator 90kc-240mc $50. Heath ET-3100 semiconductor course with lab trainer $80. Other ham test equipment. K6KZT, 2255 Alexander, Los Osos, CA 93402. (805) 528-3181.

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DIGITAL AUTOMATIC DISPLAYS. Any Radio. Be specific. GRAND SYSTEMS, POB 2171, Blaine WA 98230.

FOR SALE: Amateur Radio collection. Receivers, transmitters, tubes, magazines, books. Misc. SASE for list. K4UJZ, 608 West Thompson Lane, Murfreesboro, TN 37129. (615) 893-5344.

SELL ITT Mackay digitally synthesized communications receiver model 3031A. Coverage 0.015-30 MHz, frequency selection within 5 Hz. Operated for less than 200 hours. Price $2800 or highest bid plus shipment. Weighs 19 lbs. Contact John Ekwall, Box 6014, S-60006. Norrkoping, Sweden.

ENGINEER WANTED. With Ham experience to develop Ham products. Exciting proposition for the right person. Box 498, Greenville, NH 03048.

MANY THANKS and Happy New Year to those who have helped me in acquiring old bugs. Still looking. WB4EDB, Smiley White, PO Box 5150, Fredericksburg, VA 22403. (703) 373-0996 Collect.

RECEIVER LAFAYETTE HE-10, general coverage extra clean $85. Swan FM-2X 2 meter mobile $90. Regency HR-2A 2 meter $85. K6KZT, 2255 Alexander, Los Osos, CA 93402. (805) 528-3181.

ANYONE INTERESTED in starting a firefighters net on HF send ideas or contact KA4TLC, Ricky Martin, Rt 1, Box 199-J, Hope Mills, NC 28348.

WANTED: We need Tektronix plug in, type 1L10, 1L20, 1L30, spectrum analysis for oscilloscope Tektronix type 547 and photocopy technical manual plug in 1S2 Tek. Angel Alvarez, EA1NN, San Anton 18-8-A 26002 Logrono, Spain.

UHF PARTS. GaAs Fets, mmics, chip caps, feedthrus, teflon pcb, high Q trimmers. Moonbounce quality preamps. Electronic sequencer boards. Send SASE for complete list or call (313) 753-4581 evenings. MICROWAVE COMPONENTS, PO Box 1697, Taylor, MI 48180.

COMMODORE-128 PROGRAM available to track the Amateur Satellites. Uses Keperlian data supplied by NASA free. Tracks up to 8 satellites simultaneously. Program also supports printing schedules and predictions for satellites. Use it to track MIR and talk to the Cosmonauts. SATRAK128, $26.50 includes shipping. Other information on this or other programs for the C128, requires a business size SASE. Reid Bristor, WA4UPD, PO Box 0773, Melbourne, Florida 32936-0773.

WANT: 32S3 xmtr, 250TL and 304TL tubes. KF6WM, 45300 Royal, King City, CA 93930.

DXERS—CUSTOMIZED PRINTOUT of antenna headings calculated for your location. List includes over 650 worldwide locations. Send Lat/Long coordinates, name, callsign, check for $12.95 U.S. Brian Henderson, VE6ZS, 23 Deermoss Pl SE, Calgary, Alberta, Canada T2J 6P5. (403) 278-2084.

WANTED: Operation/service manuals for Galaxy V transceiver. Joe Williams, KJ6OF, 38665 11th Street E., #2, Palmdale, CA 93550. (805) 947-1641 eves.

HANDICAPPED NOVICE needs HF equipment donated—anything please. KA3OUE, (412) 531-7443 anytime.

OFFICIAL MILITARY-TYPE ID TAGS. ("Dog Tags")!! Customized with your Call Letters, etc. 5 seventeen space lines. 20" nickel plated chain included. $4.29 postpaid. JPW ENTERPRISES, PO Box 353, Logan, Utah 84321

MAGAZINES WANTED: "Microwave Systems News" (MSN), "RF Design", "PCIM (Power Conversion & Intelligent Motion)" and "QEX" (1980-present). Call collect 519-742-4594 (Ontario) after 6 PM Eastern time.

IMRA International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

BACK ISSUES OF HAM RADIO. Have most issues from 1969 to 1974. Mint condition. $3.00 for single issues. WN0G, 319-377-3563.

HAM TRADER YELLOW SHEETS. In our 27th year. Buy, swap, sell ham radio gear. Published twice a month. Ads quickly circulate—no long wait for results. Send No. 10 SASE for sample copy. $13 for one year (24 issues). PO Box 2057, Glen Ellyn, IL 60138-2057 or PO Box 15142, Dept HR, Seattle, WA 98115.

VHF-UHF-SHF. Large SASE. West Coast VHFer, POB 685, Holbrook, AZ 86025.

CHASSIS & CABINET KITS. SASE. K3IWK, 5120 Harmony Grove Rd, Dover, PA 17315.

ANALOG AND RF CONSULTING for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

RTTY JOURNAL—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

RUBBER STAMPS: 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

ELECTRON TUBES: Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

"HAMLOG" COMPUTER PROGRAM. Full features, 17 modules. Auto-logs, 7-band WAS/DXCC. Apple $19.95. IBM, CP/M, KAYPRO, Tandy, C128 $24.95. HR-KA1AWH, POB 2015, Peabody, MA 01960.

WANTED: ARC-5 and SCR-274 equipment, parts and accessories, any condition. Ken, WB9OZR, 362 Echo Valley, Kinnelon, NJ 07405. (201) 492-9319.

WANTED: Ham equipment and other property. The Radio Club of Junior High School 22 NYC, Inc. is a nonprofit organization, granted 501(C) (3) status by the IRS, incorporated with the goal of using the theme of Ham Radio to further and enhance the education of young people. Your property donation or financial support would be greatly appreciated and acknowledged with a receipt for your tax deductible contribution. In Dayton, meet the crew from 22 and relax at our flea market tables, check in on 144.30 simplex. Please write us at: PO Box 1052, New York, NY 10002. Or call our round the clock hotline: (516) 674-4072. Thank you!

HALLICRAFTERS S-40 receiver (1946), fair condition, with service manual, $40 plus shipping. Include SASE. Nate Williams, W9GXR, 6915 Prairie Drive, Middleton, WI 53562.

HAM PROGRAMS and other "shareware" for IBM/compatibles. Large SASE for catalog. JK&S, POB 50521, Indianapolis, IN 46250-05221.

CUSTOM MADE EMBROIDERED PATCHES. Any size, shape, colors. Five patch minimum. Free sample, prices and ordering information. HEIN SPECIALTIES, Inc., Dept 301, 4202 N. Drake, Chicago, IL 60618.

WANTED: Drake Linear Amp Model MN4439- 1000W (2000 PEP), 1.8-30 MHz. Call Bruno Molino, VE2FLB, 26 Rue Des Anciens, Gatineau, Quebec J8T 3T2. (819) 561-3689.

RECONDITIONED TEST EQUIPMENT $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

SCHOLARSHIP. The Dayton Amateur Radio Association is now accepting applications for its 1989 Scholarship Program. The program is open to any licensed Amateur graduating from high school in 1989. For information and application forms write Scholarship Committee, 317 Ernst Avenue, Dayton, OH 45405.

COMING EVENTS

Activities — "Places to go . . ."

SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS: PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

Twenty, 30, and 40 meters are both day and night bands. Twenty meters is the maximum usable band for DX in the northern directions these days during the daytime. It then teams up with 30 meters to extend this coverage into the evenings. Forty meters becomes the main over-the-pole DX daytime band, with some hours covered by 30 meters.

Eighty and 160 meters, the night-only DX bands, will exhibit short-skip propagation during daylight hours, then lengthen for DX at dusk. These bands follow the darkness path, opening to the east just before your sunset, swinging more to the north-south near midnight, and ending up in the Pacific areas during the hour or so before dawn.

Article M **HAM RADIO**

MICHIGAN: April 1. S.T.A.R.S. Amateur Radio Association's annual Swap & Shop, Grandville High school, Grandville, 8 AM to 2 PM. Tickets $3/advance; $3.50/door. Tables—1st free, second $3.00. All indoors. Plenty of parking. Talk in on 145.270 K8XL/R. For information S.T.A.R.S., 1714 Havana SW, Wyoming, MI 49509. (616) 243-17509.

MARYLAND: April 1-2. The Baltimore Amateur Radio Club (BARC) will present the 1989 Greater Baltimore Hamboree and Computerfest, Maryland State Fairgrounds Exhibition Complex at Timonium. Gates open 8 AM. Admission $5 for both days. Children under 12 free. Large indoor dealer area. Indoor/outdoor flea market. For more information or reservations contact GBH&C, PO Box 95, Timonium, MD 21093-0095. Call (301) HAM-FEST 24 hr.

OHIO: April 2. The 11th annual Lake County Hamfest, Madison High School, Burns and Middle Ridge Roads, Madison. 8 AM to 3 PM. All indoor flea market, exhibits, programs, prizes, VE exams. Admission $4/door; $3/advance. 6' tables $5, 8' tables $6.50. Talk in on 147.21/81, 222.90/224.5. Contact Roxanne, 7803 Skylineview Drive, Mentor, OH 44060. Please SASE. (216) 953-9784.

COLORADO: April 2. The Longmont ARC is sponsoring a combined Hamfest and Computer Swap, Boulder County Fairgrounds, Longmont. 8 AM to 3 PM. For information Bob Dornan, WA2EKU, 1106 Fordham St, Longmont, CO 80501. (303) 651-3613 or Ken Parker, W0ONF, 1221 Aspen St, Longmont, CO 80501. (303) 772-4719.

ONTARIO: April 8. The 8th annual Durham Region Amateur Radio and Computer Flea Market. 9 to 2. Pickering High School, Church Street North, Pickering Village, Ajax. Sponsored by the South Pickering and North Shore ARC's. Admission $4. Vendors tables $7 plus admission by March 15. $10 plus admission thereafter. Talk in on 147.975 and 147.720. Reservations payable to South Pickering ARC, PO Box 53, Pickering, Ontario L1V 2R2. For information Ron Brown, VE3WZ (416) 839-3711. Mike Sherba, VE3DKW (416) 723-7674. Steve Bezuk, VE3MCZ (416) 831-0312.

MASSACHUSETTS: April 16. Tailgate electronics, computer and Amateur Radio Flea Market, Albany and Main Street, Cambridge. 9 AM to 4 PM. Sponsored by the MIT Radio Society and the MIT Electronics Research Society. Admission $1.50. Free off street parking for 1000 buyers. Sellers $6/space; $5/advance. Includes 1 admission. Setup 7 AM. For reservations before April 1 (617) 253 3776. W1GSL, PO Box 82 MIT Br, Cambridge, MA 02139. Talk in on 146.52 and 449.725/444.725—pl 2A—W1XM/R.

OKLAHOMA: April 15. The Lawton-Fort Sill ARC will hold their 41st annual Hamfest, County Fairgrounds, 8 AM to 5 PM No pre-registration necessary except for table space. Talk in on 147.39/99. For information Claude R. Matchette, 3411 NW Atlanta Avenue, Lawton, OK 73505. (405) 357-5870.

WEST VIRGINIA: April 15. The 5th annual Charleston Area Hamfest and Computer Show sponsored by the Tri-Counties Ham Club and the Kanawha ARC. 9 AM to 4 PM, Charleston Civic Center, Charleston, WV. Admission $5. Tables $6 each. A/C power $12. Walk-in VE exams. For dealer/flea market information write PO Box 1694, Charleston, WV 25326 or phone Bill Hutner, K8BS (304) 744-2650 or Lovell Webb (304) 342-7247. For other information write PO Box 9076, So. Charleston, WV 25309 or phone Doug Sweeney (304) 766-6655.

MINNESOTA: April 15. The Lake Region Amateur Radio Club's 2nd annual Hamfest, Otter Tail County Fairgrounds—Hockey Arena—Hy 59 South, Fergus Falls. 8 AM to 2 PM. VE testing, packet, Army MARS, satellite meetings. Demos, dealers, flea market, concession and more. Registration $4/door; $3/advance. 6' Tables $4. For information call (218) 826-6274 or write Keith McKay, N0FKF, Rt 1, Box 46, Battle Lake, MN 56515.

NEW JERSEY: April 15. "Flemington Hamfest 89", sponsored by the Cherryville Repeater Association, 8 AM in the Hunterdon Central High School Field House. Admission: $4 advance, $5 door. Children under 12 and XYLs free. Refreshments available from 6:30 AM. Advance tickets: Dave Hickson, KD2RC, 125 South Main St, Lambertville, NJ 08530. Tables: Marty Grozinski, NS2K, 6 Kirkbridge Rd, Flemington, NJ 08822. Information: (201) 788-4080 before 11 PM EST. VE testing begins at 10 AM, send FCC form 610, photocopy of current license, and a check for $4.75 (payable ARRL/VEC) to: Cherryville Repeater Association, VE Test Team, Box 308, Quakertown, NJ 08868. Talk in: 146.52, 147.975/375, 145.615/015, 222.52/224.12 and 449.85/444.85 MHz.

CONNECTICUT: April 16. The 6th annual Southington Amateur Radio Association's Flea Market, Southington National Guard Armory, 590 Woodruff Street, Southington. Admission $2. Children under 12 admitted free. 6' table space $8/advance; $10/door. For information on table space write SARA, PO Box 873, Southington, CT 06489. All classes of Amateur Radio exams. For pre-registration send info to Vinny Calandra, 44 Matthews Street, Southington, CT 06489. Talk in on 146.28/88, 222.68/224.28.

PENNSYLVANIA: April 16. AARG Hamfest and Computer Show, sponsored by the Appalachian Amateur Repeater Group, Lebanon Fairgrounds, Lebanon. Starts 8 AM. Admission $3.00. Indoor tables w/elec $5; w/o $3. Tailgating $2/space. Handi accessible. For information AARG, Homer Luckenbill, WA3YMU, 105 Walnut Street, Pine Grove, PA 17963. (717) 345-3780.

GEORGIA: April 22-23. Georgialina Hamfest, sponsored by the Amateur Radio Club of Augusta, Hippodrome, US 1 North, Augusta. Admission $3/advance; $4/gate. Covered arena. Tables $10, advance only. Acres of tailgating space. For information N4JA, POB 5943, Augusta, GA 30906.

OHIO: April 23. The North Coast Amateur Radio Club's third annual Swapfest, North Olmsted Community Cabin, 28114 Lorain Road, North Olmsted. 10 AM to 2 PM. Donation $2. Refreshments available. Nearby hotels and campgrounds. Talk in on 145.29R and 224.84R. For information Dan Sarama, KB8A, 15531 Rademaker Blvd, Brookpark, OH 44142. (216) 267-5083. Pauline Wells, KA8FOE, 5755 Burns Road, North Olmsted, OH 44070. (216) 779-8999.

DAYTON HAMVENTION: April 28, 29, 30.

OHIO: April 29. The 20th annual B*A*S*H will be held on Friday night of the Hamvention at the Conference Center (Madison Room) of the HARA Arena and Conference Center, same location as the Hamvention, starting at 7 PM. No admission charge. Free continuous entertainment. Hot dinner, sandwichs, snacks and beverages are available. Two exciting top awards and many others. Stay right at HARA when the Hamvention closes on Friday evening and meet your friends and join us for an evening of fun and entertainment. Sponsored by the Miami Valley FM Association, PO Box 263, Dayton, Ohio 45401.

NEW MEXICO: April 29 and 30. The Mesilla Valley Radio Club of Las Cruces will hold its 25th annual ham get together, the ZIA HAMFEST and BEANFEED at the Dona Ana Fairgrounds from 9 AM to 4 PM both days. Includes: great food, Ham Forums, VE exam, RV parking, exhibits, flea mart and more. Admission $5 and indoor tables $6. Contact: Joe Herring, WI5E, PO Box 234, Organ, NM 88052. Tel: (505) 382-5629.

MASSACHUSETTS: April 30. The Wellesley Amateur Radio Society's tailgate flea market, Wellesley Senior High School parking lot, 50 State Street, Wellesley. 9 AM to 2 PM. Admission $2. Handi accessible. Refreshments available. Talk in on 147.03 Wellesley Repeater. For more information David Kent, N2AWG, (508) 875-2126.

WISCONSIN: May 6. The Ozaukee Radio Club will sponsor its 11th annual Swapfest, Circle B Recreation Center, Highway 60, Cedarburg, 8 AM to 1 PM. Admission $2/advance; $3/door. 4' tables $2 each, advance only. Sellers setup 7 AM. For tickets, tables, maps, information send business SASE to ORC Swapfest, N5415 Crystal Springs Court, Fredonia, WI 53021. Talk in on 146.55 and 146.37/.97 repeater.

NEW YORK: May 6. The Putnam Emergency Amateur and Radio League will have their PEARLfest at the John F. Kennedy Elementary School, Foggintown Road, Brewster. 9 AM to 4 PM rain or shine. Admission $3. Indoor tables $8. Tailgating $5. Ham gear, VE exams, and more. Join us for a fun-filled day. Talk in on 145.135 KG1O/R. For registration contact Terri Cullum, N2GWF, 40 Mile Hill Road, Highland, NY 12528 or Jim Morgan, KA2FIQ, 39 Overlook Road, Ossining, NY 10562.

ARIZONA: May 5-7. The Cochise Amateur Radio Association's annual Hamfest, Club training facility, Sierra Vista. Free tailgating. Exams available. Handi facilities. Talk in on 146.52 or 146.76. For information N7INK (602) 378-3155 after 6 PM or write CARA, PO Box 1855, Sierra Vista, AZ 85636.

SOUTH CAROLINA: May 6 and 7. 50th annual Greenville Hamfest sponsored by the Blue Ridge Amateur Radio Society, American Legion Fairgrounds, Greenville. Saturday 8-5; Sunday 8-3. Admission $4/advance; $5/gate. Walk-in license exams, large exhibit area, indoor/outdoor electronic and computer flea market, free parking, camping, prizes. For advanced tickets or information SASE to Blue Ridge ARS, POB 6751, Greenville, SC 29606.

WISCONSIN: May 13. Lakeshore Hamfest sponsored by Mancarad Radio Club, Manitowoc County Expo Center, Hwy 42-151 and I-43 on County Hwy R. Starts 8 AM. Vendors setup 7 AM. Tickets $2/advance; $3/door. Swap tables $3. Exams, refreshments, prizes. Talk in on 146.61 and 147.03. Camping available. Contact: Mancarad Radio Club, PO Box 204, Manitowoc, WI 54220.

WEST VIRGINIA: May 21. The 11th annual TSRAC Wheeling Hamfest/Computer Fair, Wheeling Park. 8 AM to 3 PM. WV's largest Hamfest. Dealers welcome. Free flea market, admission only. Free admission for women. Free admission for children 14 and under. Admission $3/advance; $4/door. To reserve space contact Sandi Williams, WC8P, 9 East High Street, Flushing, OH 43977 (614) 968-3652. For tickets TSRAC, Box 240, RD 1, Adena, OH 43901 (614) 5546-3930.

CALIFORNIA: May 21. HAMSWAP, sponsored by the North Hills Radio Club, Folsom Community Clubhouse, Folsom. 8 AM to 3 PM. FREE admission. Auction, tailgating, free parking, park, kids rides. Tables $6/each. No advance sales. Talk in on 145.19 and 224.78. Contact NHRC, PO Box 41635, Sacramento, CA 95841 or call Bob, WA6ULL (916) 983-2776.

NEW HAMPSHIRE: June 3. The Hosstraders Flea Market is back at the Deerfield Fairgrounds. Admission $5 per person. Friday night camping nominal; no admission before 4 PM Friday. Profits benefit Shriners' Hospitals, last year's gift over $20K. Wheelchair accessible. Questions or map SASE to WA1IVB, RFD Box 57, West Baldwin, ME 04091.

OPERATING EVENTS

"Things to do . . ."

April 14-28. The Thames Valley College will be operating a special event station GB2TVC to celebrate its becoming an independent college. We will operate on all HF bands and 2m in RTTY, AMTOR, SSB and CW modes. A special QSL card will be forwarded to all contact.

April 15-16: The Old Pueblo Radio Club will operate W7GV, the oldest continuously active callsign in Arizona, from 1500Z to 2400Z to commemorate 60 years of worldwide Amateur Radio operation on the 10 meter band. CW, phone FM, and packet gateways. For a QSL send your QSL and SASE to W7GV, Box 42601, Tucson, AZ 85733.

April 22: The North Carolina Chapter of the Triple States RAC will be operating special event station N4KVF 1400Z to 220Z at the site of Reed's Gold Mine, in commemoration of the 12th anniversary of this state historic site, where gold was first discovered in the U.S. For certificate send #10 SASE to Walter Bastow, 484 High Rock Road, Gold Hill, NC 28071.

April 27-30. The Nebraska City Amateur Radio Club will operate special event station K0TIK from Arbor Lodge in Nebraska City, the home of J. Sterling Morton the founder of Arbor Day. 1400Z to 0000Z on upper portion of General phone bands, 80-15m and upper portion of 10m Novice phone band. For a certificate suitable for framing send 8x11 SASE and QSL to Barbara Nihart, President, Nebraska City ARC, 7731 Holdrege St, Lincoln, NE 68505.

April 29: W7UQ Centennial Reunion-on-the Air sponsored by the University of Idaho ARC. 14.230, 1900-2130 UTC; 28.400, 2130-2200 UTC, 7.230, 2200-0100 UTC. Help us celebrate the Clubs 60th year and the 100th anniversary of the University. Contact via callbook address.

The DeVry Amateur Radio Society has been a national VEC since February 23, 1984. We have over 40 testing groups nationwide and are continuing to grow. We offer a program based upon integrity and creativity. The forms our VE's are required to fill out are simple and to the point. We also reimburse all our testing groups for out-of-pocket expenses. If you would like to start a DeVry VE team in your area just call 1-800-327-2444, ext 2221 or 1-312-929-8500 or write DeVry VEC, 3300 N. Campbell Avenue, Chicago, IL 60618.

NORTH COAST ARC 1989 LICENSE EXAMS. 12:30 PM, Saturdays February 11, April 15, June 10, August 12, October 14, December 9. N. Olmsted Community Cabin, S of Lorain on W. Park. Novice thru Extra. Walkins allowed. Talk in on 145.29 repeater. For information Dan Sarama, KB8A, 15591 Rademaker Blvd, Brookpark, Ohio 44142. 267-5083 or Pauline Wells, KA8FOE, Rick Wells, K8SCI, 777-9460/779-8999.

AMATEUR RADIO CLASSES: For those people interested in obtaining a Novice (basic level) Ham license or upgrading to Tech/General, the Chelsea Civil Defense, in cooperation with QRA Radio Club, will sponsor Amateur Radio Communications classes evenings at Chelsea High School starting MARCH 7, 1989. For more information write Frank Masucci, K1BPN, 136 Grove Street, Chelsea, MA 02150. Please enclose your telephone number.

THE MIT UHF REPEATER ASSOCIATION and the MIT Radio Society offer monthly HAM EXAMS. All classes Novice to Extra. Wednesday, APRIL 19, 7 PM, MIT Room 1-150, 77 Mass Avenue, Cambridge, MA. *Reservations requested 2 days in advance.* Contact Ron Hoffmann at (617) 484-2098. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

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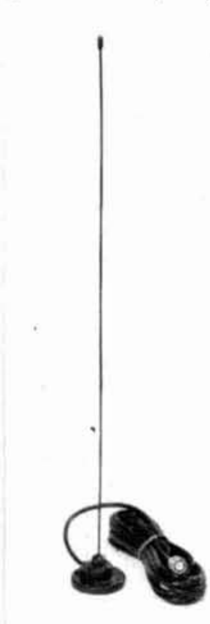
M-F 9-5:30 Sat 9-3

Antennas and mounts from Valor Enterprises

The model PAQM "communications extender" mobile, 2-meter VHF antenna provides mini quarter-wave reception. It installs easily with a 2-inch magnetic mount, 12 feet of cable, and a BNC connector (supplied). The unit can also be modified for 220 and 450 MHz.

Model PA270, two-plus-two, is a dual-band antenna for 146 and 450 MHz. It includes silver-plated spring-loaded contacts and will work on scanner radio UHF/VHF bands.

The Model PUC 450 UHF collinear gain antenna features silver-plated spring loaded contacts and 100-watt rated Motorola base. This unit has a 450 to 470-MHz frequency range.



For additional information contact Valor Enterprises, Inc., 185 West Hamilton Street, West Milton, Ohio 45383.

Circle #311 on Reader Service Card.

New switch for lightning protection

MFJ Enterprises, Inc. presents its new MFJ-1704 four-position antenna switch with lightning protection for $59.95.

This 50-ohm switch handles 2.5 kW PEP, 1 kW CW with low SWR. Isolation is rated from better than 60 dB at 30 MHz to better than 50 dB isolation at 500 MHz. Insertion loss is negligible.

The lightning protection device inside has cavity construction and metal strip leads that prevent chafing and shorting problems. Unused positions are automatically grounded, or the center ground position can be selected.

Contact MFJ Enterprises, Inc., PO Box 494, Mississippi State, MS 39762 or order toll free at 800-647-1800.

Circle #312 on Reader Service Card.

New TS-430 tuning upgrader

International Radio and Computers, Inc. announces the TS-430 Tuning Upgrader.

Stock TS-430s have just two manually selected tuning speeds: 19 kHz per tuning knob revolution and 100 kHz per revolution when the step button is depressed. The tuning upgrader adds a slower fine-tuning speed of 2.5 kHz per revolution. The upgrader requires three above-board solder connections and two plug-in connections.

The tuning upgrader also operates when the step button is depressed. In this mode, it automatically selects between 25-kHz per revolution and 100-kHz per revolution; the switchover point occurs at approximately 0.8 turns per second.

The unit uses low-drain CMOS circuitry, comes wired and tested, and has a 6-month warranty. The price is $34.50 plus $5 shipping and handling in the U.S., $15 elsewhere. Use Reference no. 215.

The TS-430 is available from International Radio and Computers, Inc., 751 South Macedo Boulevard, Port St. Lucie, Florida 34983.

Circle #313 on Reader Service Card.

Tower standoff brackets

IIX Equipment, Ltd. offers tower standoff brackets. These brackets let you mount two or three large antennas 40 inches off the tower face. Attachment clamps are adjustable to fit up to 4-inch tower legs; the brackets are drilled to fit 25G, 45G, and 55G towers. Bracket arms can be spaced any distance apart to accomodate the antennas. Brackets are hot-dipped galvanized and the necessary hardware is supplied. The brackets are available in two and three antenna models. The SO-12 Standoff Bracket (for two antennas) is $115.50 and the SO-13 Standoff Bracket (for three antennas) is $144.50. The brackets are shipped by U.P.S.

For more information contact IIX Equipment, Ltd., PO Box 9, Oak Lawn, Illinois 60454.

Circle #314 on Reader Service Card.

PCSP-1 power cord surge supressor

American Voltage Products, Inc. has introduced the PCSP-1 power cord, offering built-in surge protection for standard computers and electronic equipment. Unlike plug-in surge protectors, the PCSP-1 is less likely to be destroyed by furniture movement or unauthorized removal.

The PCSP-1 has 210,000 watts of protection. All three legs are protected and the unit glows while in operation. The PCSP-1 sells for under $20.

For more information contact American Voltage Products, Inc., 18 Morse Drive, Essex Junction, Vermont 05452.

Circle #315 on Reader Service Card.

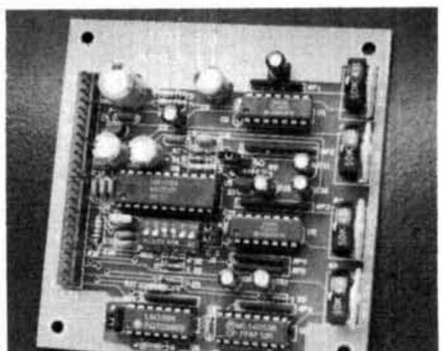
UAI-20 repeater audio interface

Creative Control Products has added the UAI-20 Universal Audio Interface board to its line. It is a repeater and link audio mixer featuring CTCSS decode, DTMF mute, and link monitor-mix control.

Audio inputs consist of repeater, link, control receiver, CW/tone, CTCSS tone, and an auxiliary input for other audio sources. Audio outputs include: repeater, link, and a DTMF output for the DTMF decoder on your controller.

Control inputs consist of repeater Carrier Operated Switch (COS), CTCSS mode, DTMF mute, and an auxiliary output from your controller for the link mute function. The CTCSS decoder output switches to the selected output level upon receiving the correct CTCSS tone.

The UAI-20 has an audio filter, which removes the sub-audible tone from the repeater receiver audio path. Automatic muting of the repeater receiver is provided when the selected CTCSS tone hasn't been decoded. CTCSS tones are selected by configuring the 6-position DIP switch to the appropriate CTCSS frequency.



An assembled, tested UAI-20 with manual is available at an introductory price of $89 plus shipping.

For more information, contact Creative Control Products, 3185 Bunting Avenue, Grand Junction, Colorado, 81504.

Circle #316 on Reader Service Card.

ADVERTISER'S INDEX AND READER SERVICE NUMBERS

Listed below are the page and reader service number for each advertiser in this issue. For more information on their products, select the appropriate reader service number make a check mark in the space provided. Mail this form to *ham radio* Reader Service, I.C.A., P.O. Box 2558, Woburn, MA 01801.

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*Please contact this advertiser directly. Please use before May 31, 1989.

KENWOOD

...pacesetter in Amateur Radio

All New!

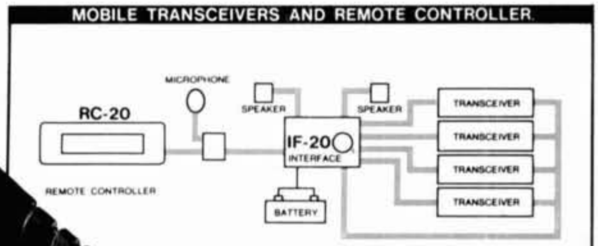
Stacked in Your Favor!

TM-231A/431A/531A

FM Mobile Transceiver

Looking for a compact transceiver for your mobile VHF and UHF operations? KENWOOD has a compact rig for each of the most popular VHF/UHF bands.

- **20 multi-function memory channels.** 20 memory channels allow storage of frequency, repeater offset, CTCSS frequency, frequency step, Tone On/Off status, CTCSS and REV.
- **High performance—high power! 50W (TM-231A), 35W (TM-431A) with a 3 position power switch (high, medium, low).**
- **Optional full-function remote controller (RC-20).** A full-function remote controller using the Kenwood bus line, model RC-20, may be easily connected to the TM-231A/431A/531A and can be mounted in any convenient location. Using the IF-20 interface the RC-20 may be connected to four mobile transceivers. (TM-231A/431A/531A or the TM-701A)
- **Multi-function microphone supplied.** Controls are provided on the microphone for CALL (call channel), VFO, MR (memory recall or change the memory channel) and a programmable key. The programmable key can be used to control one of the following functions on the radio: MHz, T. ALT, TONE, REV, DRS, LOW or MONITOR.
- **Easy-to-operate illuminated keys.** A functionally designed control panel with backlit keys increases the convenience and ease of operation during night-time use.
- **Auto repeater offset on 144 and 220 MHz.**
- **Built-in digital VFO.**
  - a) **Selection of the frequency step (5, 10, 15, 20, 12.5, 25kHz)** *TM-531A: 10, 20, 12.5 25kHz
  - b) **Programmable VFO** The user friendly programmable VFO allows the operator to select and program variable tuning ranges in 1 MHz band increments.
- **Programmable call channel function.** The call channel key allows instant recall of your most commonly used frequency data.
- **Selectable CTCSS tone built-in.**
- **Tone alert system—for true "quiet monitoring"!** When activated this function will cause a distinct beeper tone to be emitted from the transceiver for approximately 10 seconds to signal the presence of an incoming signal.
- **Easy-to-operate multi-mode scanning.** Band scan, Program band scan, Memory scan plus programmable memory channel lock-out, with time operated or carrier operated stop.
- **Priority alert.**
- **DRS (Digital recording system).** The optional DRU-1 can store received and transmitted messages for up to 32 seconds, allowing the operator to quickly check or return any call using the tone alert system.
- **Automatic lock tuning function (TM-531A).**
- **Repeater reverse switch.**



Optional Accessories

- **RC-20** Full-function remote controller
- **RC-10** Multi-function remote controller
- **IF-20** Interface unit handset
- **DRU-1** Digital recording unit
- **MC-44** Multi-function hand mic.
- **MC-44DM** Multi-function hand mic. with auto-patch
- **MC-48B** 16-key DTMF hand mic.
- **MC-55** 8-pin mobile mic.
- **MC-60A/80/85** Desk-top mics.
- **MA-700** Dual band (2m/70cm) mobile antenna (mount not supplied)
- **SP-41** Compact mobile speaker
- **SP-50B** Mobile speaker
- **PS-430** Power supply
- **PS-50** Heavy-duty power supply
- **MB-201** Mobile mount
- **PG-2N** Power cable
- **PG-3B** DC line noise filter
- **PG-4H** Interface connecting cable
- **PG-4J** Extension cable kit
- **TSU-6** CTCSS unit

KENWOOD

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COMMUNICATIONS & TEST EQUIPMENT GROUP
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Long Beach, CA 90801-5745
KENWOOD ELECTRONICS CANADA INC
P.O. BOX 1075, 959 Gana Court
Mississauga, Ontario, Canada L4T 4C2

Specifications and prices subject to change without notice or obligation.
Complete service manuals are available for all Kenwood transceivers and most accessories