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- MC-43S extra UP/DOWN hand mic
- MC-55 (6 pin) gooseneck mobile mic
- MC-60A/80A/85 disk mics.
- PG-25 extra DC cable
- PS-430 power supply
- SP-64/SP-50B mobile speakers
- SP-430 external speaker
- SW-100/200A/2000 SWR power meters
- TL-922A 2 kW PEP linear amplifier
- TU-8 CTSS tone unit
- YG-455C-1 500 Hz deluxe CW filter
- YG-455C-1 New 500 Hz CW filter

Complete service manuals are available for all Kenwood transceivers and most accessories. Specifications, features, and prices are subject to change without notice or obligation.
January 1988

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Hello Terry, Good Luck Dorothy

Meet Terry Northup, our latest addition to the Ham Radio magazine staff. She has handily started taking over the responsibilities once enjoyed by Dorothy Rosa and will be working with our authors to communicate the quality technical information that you expect from us. If one is allowed to judge by first impressions Terry brings to HR, besides her obviously finely-tuned editorial skills, a vitality and spirit that is synonomous with what we perceive is needed in Amateur Radio in general.

Dorothy, prior to leaving for her new job as Senior Editor of 80 MICRO (International Data Group's monthly magazine for users of Tandy's MS-DOS) shared with us her feelings about Terry and about her own 5 years on the staff at HR.

"Terry, a skilled journalist and former publicist for the American Trucking Association brings relevant experience and strong writing, editorial and 'people' skills to a position that's as personally rewarding as it is professionally demanding. She also brings a resilient sense of humor and what a former employer described as a 'fine sense of the ridiculous'. That's good because she'll need both qualities in considerable quantity.'"

If you consider that magazine, newspaper or any periodical production can be likened to a smooth running machine, a treadmill really, that relies on all the participants contributions to maintain demanding schedules then you get to appreciate everyone's efforts. Dorothy recognized this when she tried to sum up her 5 years at the magazine.

"It’s difficult to say goodbye to my colleagues at ham radio- not just to those whose names appear on the masthead, but to those whose names you never see: Beth McCormack, editorial department secretary; Teresa Leger, bookstore manager; and Phil Alix, chief of shipping, inventory and logistics. For ability, patience, and tireless goodwill, these folks are tops."

Dorothy, never really at a loss for words had one last message for the authors and columnists: "Goodbye, guys...73,88—and get those proofs back on time, darn it!"

The voice will be different and the methods as well but the message will still be the same ... Ham Radio magazine—how may we help? Get in touch with Terry and see what we’ve already discovered and I’m sure you’ll enjoy working with her.

Rich Rosen, K2RR
Editor-in-Chief
Kenwood brings you a wide range of 220 MHz gear designed for every need. Choose from two types of mobile and two types of HT. The TH-315A is a full-featured HT covering 220–225 MHz. Ten memory channels and 2.5 watts of power (5 W with PB-1 or 12 V DC.) Uses the same accessories as the TH-215A for 2 meters or TH-415A 440 MHz. For truly “pocket portability,” choose the TH-31BT, a thumb-wheel programmable, 1 watt unit. For mobile use, select the TM-321A or TM-3530A.

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MFJ-931 creates artificial RF ground with random wire
also, electrically places far away ground directly at your rig

- Creates artificial RF ground with random length wire
- Electrically places a far away ground directly at your rig
- RF ammeter makes tuning for maximum RF ground current easy
- Eliminates "RF bites", RF feedback, TVI/RFI and other problems due to inadequate RF ground
- Improves radiation pattern distorted by poor RF ground

Don’t we all sometimes have problems getting a good RF ground?

Unpleasant problems. Problems like RF "hot spots" that "bite" our lips or fingers when we transmit; like excessive RF coupling to AC lines that causes everything to quit working; like our neighbors screaming about TVI and RFI; like our computers computing jiberish; or like being unable to talk across town because of extreme ground losses or radiation pattern distortion.

"Hey, my rig is on the second floor. There’s no way I can get a good ground." you’re thinking, or "I already have an excellent ground but the long ground connection wire causes reactance and acts like a high impedance circuit, isolating my rig from true RF ground."

What to do
Use the new MFJ-931 to create an artificial RF ground! It resonates a random length of wire thrown along the floor and produces a tuned counterpoise. This artificial ground effectively places your rig near actual earth ground potential even if your rig is on the second floor or higher with no earth ground possible.

Also, the MFJ-931 electrically places a far away RF ground directly at your rig -- no matter how far away it is. The MFJ-931 reduces the electrical length of the ground connection wire to virtually zero by tuning out its reactance.

How it works
The MFJ-931 connects between the ground connection of your transmitter or antenna tuner and a random length of wire thrown along the floor. Two knobs are adjusted for maximum RF ground current using its built-in RF ammeter. This resonates the random wire, converts it into a tuned counterpoise and presents an effective low impedance near ground potential to your rig, thus creating an artificial RF ground.

To electrically place a far away ground directly at your radio equipment simply connect the MFJ-931 between your rig and the connecting ground wire and adjust its two knobs for maximum RF current using its RF ammeter. This tunes out the reactance of the connecting wire, reduces the electrical ground lead length to virtually zero and electrically places your far away ground directly at your rig.

Get an effective RF ground
Get an effective RF ground. Eliminate "RF bites", RF feedback TVI, RFI and many other annoying problems due to inadequate RF ground, and -- at the same time -- improve your radiation and radiation pattern for more DX.

The MFJ-931 covers 1.8 to 30 MHz and has a built-in RF ammeter for indicating RF ground current. It’s ruggedly built in an all aluminum cabinet with a brushed aluminum front panel and measures 7/8x3x7 inches. It comes with a one year unconditional guarantee.

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Dear HR:

The INUS system can provide an answer for the “possessed” described in K2RR’s editorial (October 1987), which I appreciated so much.

According to INUS, all actions and possessions are either Indispensable, Necessary, Useful, or Superfluous (INUS). The actions and possessions of DX-minded Hams can be categorized as follows:

Indispensable: an antenna (tubing or wire), a proper transmission line, a 12-VDC mobile rig and a battery (or whatever, as long as it’s able to receive and transmit), a key, a headset, a log, and a clock — plus a lot of determination and careful listening.

Necessary: a steerable antenna with more bands, a mike, an SWR meter, an antenna tuner matched to a linear amplifier for low-band DXing, a place in the house for the station, an operating manual, a book on propagation, a subscription to a DX bulletin — as well as patience, spare time, and a world atlas.

Useful: a keyer, a grid-dip meter or antenna bridge, a 2-meter HT. Maybe get a new gray or black box, see what’s inside and how it compares with my brave 15-year-old rig?

Superfluous: all things not classified above, including pieces and parts for homebrew projects never completed and other parts that were to be used for all those Someday I’ll build a...’s. Maybe awards can be put here! (Heresy perhaps, but really, it’s not the paper that makes the fine DXer, the good friend, the helpful Elmer...)

Because junkboxes tend to grow out of control, it’s best to go through them and keep only those items you really need. But selecting the useful goodies isn’t so easy; there are many reasons we keep things. In such as case, apply the “time test”: any item not used during the first year after purchase, should be assigned second-class status. If it hasn’t been used after a second year passes, it’s best to sell it, trade it, or give it away. Better yet, make a collection and offer the whole thing to a radio museum. When the SK hour rings, I’ll bring nothing along.

A station covering more than a normal sized desk — one layer high — is in danger of elephantitis. And the ham who chooses to get involved in more than one mode soon discovers that too much rig = too much money and too little time dedicated to each individual mode; results are poor.

People eat for hunger or appetite. If they eat for hunger only, they are able to maintain a good physical and mental form, and actively enjoy life. In the second case, the choice of diet is impulsive, not balanced. Fat accumulates, cholesterol levels go up, and sedentary diseases appear. (Being an M.D., I see that every day.) The same is true for ham stations...

Dr. Michel Christ, XE1MD
Mixcoac, Mexico 03900

short circuits

dc-dc converters

In W3CZ’s October, 1987 article, “Pulse Width Modulated dc-to-dc Converters,” the artwork shown in fig. 1 should be moved to fig. 3. The artwork shown in fig. 3 should be moved to fig. 1. The captions should remain as shown.

In fig. 5A, the IC block diagram is of the SG3524, not the UG1524 — in fact, the text states this. In addition, the LH1605K is not available from Digi-Key as stated; the LM3524 is.

Dean LeMon, KROV sure is! Dean got active in Amateur Radio when he was 16 years old and earned his Extra Class license in less than four years! “It’s a fascinating hobby and a great way to meet all kinds of new people from all over the world.”

Dean has cerebral palsy and got started in Amateur Radio with help from the Courage HANDI-HAM System. The HANDI-HAM System is an international organization of able-bodied and disabled hams who help people with physical disabilities expand their world through Amateur Radio. The System matches students with one to one helpers, provides instruction material and support, and loans radio equipment.

Isn’t it time you got radioACTIVE with the Courage HANDI-HAM System?

Call or write the Courage HANDI-HAM System WO2SW at Courage Center, 3915 Golden Valley Road, Golden Valley, Minnesota 55422, phone (612) 588-0811.
Visual and aural correlation enhances capture, protects ears

In my general search mode in our CW bands, I usually prefer to listen with a bandwidth of 500 Hz or more. This relatively wide bandwidth makes the mechanics of tuning easy, giving my “ear-brain” filter free rein. Only when the going gets rough in terms of noise or QRM do I switch in my very narrow, steep-skirted filter. In the past when I did this, I often lost and had to retune the very signal I was trying to isolate.

Fortunately, adding this small electronic device to your receiver can do wonders. By taking advantage of your brain’s ability to correlate visual and sonic inputs, it helps you make the transition from wide to narrow bandwidths quickly, easily, and with precision.

hearing and seeing CW

Our ear-brain filter capability enables us to focus our attention on a bandwidth as narrow as 50 to 100 Hz (it varies with the individual), anywhere within the normal audio range. For example, if you’re one of the lucky ones who can focus to a 50-Hz bandwidth, and your receiver has a 3-kHz noise bandwidth, you can generally hear a CW signal nearly 18 dB below the noise. This “focused” bandwidth is inferred from the power of a single tone that you’re able to perceive in relation to, and in the presence of, a known power contained in an audio bandwidth of white noise. (It doesn’t take into account the difference in antenna noise and copy error rates, however.)

In a practical sense, this means that even if no other signals are present and you increase the gain of your receiver to bring a very weak signal to a 70-dB sound pressure level, you’ll present your hearing mechanism with a sound pressure of nearly 90 dB from noise alone. If there are other signals within the 3-kHz bandwidth, the sound pressure total may exceed 90 dB.

Permanent hearing damage begins when sound pressures reach approximately 90 dB for extended periods, and the amount of exposure time necessary for damage to occur is said to decrease as the sound pressure level increases. These factors present a compelling argument for the use of a narrowband filter, even if you can copy that weak DX signal in the presence of noise and QRM and don’t think you need one.

Admittedly, switching to a narrow filter can be awkward — and the better the filter, the worse it gets, because although our ear-brain filter is good at detecting incremental frequency changes, it’s not nearly as adept at recalling or recognizing an absolute frequency. As a result, if you’re listening to a signal using a relatively wide bandwidth and you shift to the narrow, steep-skirted filter, chances are you’ll lose the signal and have to retune to find it. The odds are about 50 percent that you’ll not only tune in the wrong direction but also have to retune very slowly, consuming precious time and feeling your frustration mount.

To overcome this problem, you can put the brain’s ability to correlate sight with sound to work. Even though visual copy of CW is limited in speed, it can help compensate for the ear’s weakness in absolute frequency recognition. To provide this capability, all you have to do is add an LED, with associated circuitry, that’s driven by the output of a narrow filter. The block diagram in fig. 1 shows a typical arrangement.

Using the blocks shown, the narrow filter, LED driver, and power amplifier are constantly ON. Input to the power amplifier is selected either from your receiver’s output or from the filter. The inclusion of substantial voltage gain in the power amplifier ensures the ability to listen to a filtered weak signal at a moderate-to-low gain level from your receiver. This is desirable because the presence of strong signals outside the filter bandwidth, but inside your receiver’s bandwidth,

* 0 dB is the threshold level of human hearing. 70 dB is the approximate sound pressure level of a one-on one conversation.

By Don E. Hildreth, W6NRW, 936 Azalea Drive, Sunnyvale, California 94086
could saturate some receiver stage if the receiver’s gain is high.

**system details and function**

Figure 2 shows the circuit details of an eighth-order synchronous filter with a design bandwidth of approximately 40 Hz, a precision rectifier with a voltage gain of 10, a pulsewidth noise discriminator (PND), an LED driver transistor, and power amplifier.

In operation, a signal tuned to the filter’s center frequency is fed to the input of the precision rectifier. The output from the rectifier is conditioned by an emitter-driven buffer to drive an emitter-coupled pair of transistors that serve as a PND. With the circuit values shown, the LED will respond to signal input amplitude levels from a receiver down to a nominal 0.1 volts RMS. The PND acts to ignore any signal until it has existed for a minimum length of time as determined by the installed value of $R_s$. As shown, this circuit doesn’t recognize any signal voltage until it has existed for about 20 milliseconds. In addition, the circuit resets in less than one millisecond after an accepted signal stops. In this way, impulse noise, which usually lasts for less than 20 milliseconds, is rejected and 20 milliseconds is shaved from the leading edge of each coded “dit” and “dah.” This provides the LED system with significant impulse noise rejection as well as an increased OFF time between the coded elements.

Modification of the code elements in this way can compensate, to some degree, for the eye’s retentivity characteristic, which places the upper limit on visual code perception. Figure 3 shows a simplified representation of how this functions. A more detailed analysis of the PND was presented in a previous article.¹

**general filter requirements**

If you’re concerned only about protecting your hearing from high noise pressure levels, steep skirts aren’t required. A fourth-order bandpass filter designed for a nominal 50- to 100-Hz bandwidth, or a comparable 10- to 15-pole high-pass/low-pass combination adjusted to form a similar bandwidth, will do what is required. But if you wish simultaneous protection from high-level QRM that’s very close in frequency to a desired signal and protection from wideband noise as well, an eighth-order bandpass — preferably in Butterworth or Chebychev configuration — is a minimum requirement.

The filter included in this article is an easy-to-build eighth-order Gaussian class design. An eighth-order Butterworth cascade was described in a prior article.²

Though the ringing performance of these narrow, steep-skirted filters can be a problem, they will allow comfortable copy to at least 25 WPM or so, depending on the individual. To mitigate the ringing and enable the use of filters that are still narrower, you can add a carrier-activated limiter between the output filter and power amplifier.³ Clearly, as bandwidths narrow and as skirts fall more quickly, the visual tuning aid becomes more beneficial.

**operating with sight and sound**

To put this system into practice, turn your receiver’s AGC off. Select a signal in the wideband position. As you tune through the beat note frequencies, you’ll notice that the signal excites the LED only when it’s in the narrow filter’s bandwidth. Correlation between the LED and sonic outputs will be clearly recognized. As a corollary, if the wrong signal — that is, not the signal that you are focused on — is in the narrow filter’s passband, the lack of correlation will be clearly perceived.

There isn’t much question that copying code visually from a blinking LED is slower than copying by ear, but this system doesn’t require that you copy with your eyes — only that you sense correlation. What’s more, you don’t have to actually watch the LED; peripheral vision is all you need. Of course, you’ll probably look directly at the LED in the beginning, but you should be able to wean yourself from that habit reasonably quickly. Once you do this, you can put the LED anywhere it can be seen from the corner of your eye.
fig. 2. Sight and sound CW schematic diagram.
When copying high-speed code, it may appear that the LED isn’t keeping up to speed. This is an illusion. The problem isn’t with the LED, but with our eyes, which just can’t release light energy as fast as they can accept it. Under such circumstances, the OFF spaces tend to fill, making visual copy at high speeds extremely difficult. (This is what made 16 frame-per-second movies and TV possible.)

Besides the sonic benefit of the correlation function, there’s a tuning “feel” assist. As you tune a signal while switched to the wider bandwidth, sonic feedback relative to knob control isn’t lost. The end result is that the very critical knob control associated with very narrow filters is reduced. Once a signal is nicely in place, as indicated by the LED, you simply switch your audio to the narrow filter and you’re right where you want to be.

In addition to these relatively mechanical improvements, there may also be some psychological benefits from parallel sensory excitation.3

Regardless of motivation, adding sight to sound in the detection of CW is relatively easy and inexpensive — and with your eyes, ears, and brain working together.

references
3. Unpublished manuscript; send SASE to author for details.
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</tr>
<tr>
<td>CV-2240</td>
<td>3CX10,000U7</td>
<td>54-88</td>
<td>10 kW†</td>
</tr>
<tr>
<td>CV-2250</td>
<td>3CX10,000U7</td>
<td>170-227</td>
<td>10 kW†</td>
</tr>
<tr>
<td>CV-2400</td>
<td>8874</td>
<td>420-450</td>
<td>300/1250 W*</td>
</tr>
<tr>
<td>CV-2800</td>
<td>3CX400U7</td>
<td>850-970</td>
<td>225 W</td>
</tr>
<tr>
<td>CV-2810</td>
<td>3CX400U7</td>
<td>910-970</td>
<td>190 W</td>
</tr>
</tbody>
</table>

*Pulsed power
†Peak sync, or 2.5 kW combined in transistor service
a battery-backed master power system

Dependable dc power for normal and emergency operation

An ac power supply — whether it’s just a simple series-regulated supply or a more complicated switching power supply — may add as much as 20 percent to the price of a single piece of today’s solid-state equipment. A typical 20-amp power supply, for example, costs over $100. It also takes up space and generates heat. If it fails, your expensive equipment can suffer serious damage.

My station consists of four solid-state transceivers, a few solid-state linear amplifiers, a packet radio TNC, a memory keyer, and a 220-MHz transverter. All but the larger amplifiers, the packet CRT, and the rotor controls require 12 volts; if I were to purchase a power supply for each of the remaining items, the cost would exceed $400. Consequently, I’ve developed a power system that exceeds the ratings of any commercial supply, is totally backed up by a battery, and operates the station during total power failures for several hours. The system is safe, and its stability is very good.

The basic system, shown in fig. 1., involves four blocks: the battery system, the battery charging system, the monitoring system, and the 12-volt distribution system.

- The battery is a “maintenance free” car battery purchased from a discount store for $29.95. I use standard battery clamps with a compression fitting to connect the large cables to the terminals. The terminals are protected with chemical pads to reduce corrosion. Mounted on a wooden surface — not directly on the cement floor — the battery is positioned away from anything that might come in contact with, and thereby short out, the terminals.

- The battery charging system is a homebrewed regulated power supply that I built using surplus computer power supply parts. Capable of providing up to +16 volts or currents of up to 75 amps continuous, it weighs over 100 pounds but costs very little to build. Though it could easily supply the radios by itself, I decided not to run it directly into them. The output voltage is fed to the battery through a large series diode that provides isolation from the battery when the ac power fails — whether because of a blown fuse or a general power failure. Mounted on a large heat sink and wrapped in insulation tape, this diode is rated at 100 amps and 100 PIV. Also in series with the battery and battery charger are a 25-amp quick-blow fuse and a current-measuring shunt that allows monitoring of the charging currents to the battery.

- The battery monitoring circuitry measures three parameters of the electrical system: the battery’s terminal voltage (10 to 15 volts), the battery’s input charge current (0 to 20 amps), and the battery’s output current to the system (0 to 50 amps).

The battery terminal voltage monitor shown in fig. 2 is composed of circuitry that provides metering from +10 to +15 volts. This allows me to use a 500-μA movement meter, on which each major graduation is equal to 1 volt. A 500-μA meter has an ohms-per-volt rating of 2000. This means that the amp meter is converted to a voltmeter by placing a series resistance of 2000 ohms per volt of desired range. Any internal resistance of the meter must be considered as part of this total resistance.

In order to get the meter to read from 10 through 15 volts, I biased the negative side of the meter to +10 volts by placing a three-terminal adjustable voltage regulator in series with the supply voltage and placing the output directly on the minus side of the meter. I could have used a precision voltage reference such as a temperature-compensated zener diode or a voltage reference. I chose values for setting the regulator to 10 volts to minimize voltage drift with aging and temperature.

Since I wanted to read from 10 volts up to 15 volts, the total range is 5 volts. Assuming 2000 ohms per volt, this translates into a total series resistance of 10,000 ohms. To ensure accuracy, I selected a 20-turn

By Eric L. Smitt, K9ES, 10 Bowling Green Lane, Worcester, Massachusetts 01602
trim pot with a value of 10k and trimmed the resistance in series with the meter to make the meter agree with the reading of a digital voltmeter placed directly across the battery terminal. I routinely check measurement performance with my digital voltmeter, and find little, if any, voltage shift as time passes and temperatures change.

Current measuring of dc currents is done most easily with current shunts, or very small resistances, where series current produces a very small voltage drop, which is proportional to the amount of series current. I selected a criterion specifying that no shunt voltage drop would exceed 100 mV. To calculate the required resistances for the shunt, use Ohm's Law:

\[ R = 0.1V / \text{max amps} \]

5/1000 ohms for 20-amp shunt
2/1000 ohms for 50-amp shunt

These resistances are very small, but with more high-current supplies available, resistor manufacturers are producing wirewound resistors with very low values. I found several 0.01-ohm, 6-watt, 5-percent wirewound resistors at a hamfest. To produce a 20-amp shunt (fig. 2), I paralleled two of these resistors together, using braid from RG-8 coax. To produce the 50-amp shunt, I paralleled five of these resistors together. The monitoring meters are actually 500-\( \mu \)A

fig. 1. Master power system block diagram.
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meters, with series resistance to make them read from 0 to 100 mV.

The shunts must be mounted in the actual heavy wiring. The voltage pickup wiring can be a twisted pair going to the series resistance/meter units. The series resistance (including the meter resistance) for each meter is 200 ohms (remember 2000 ohms/volt). The actual series resistances were made using 20-turn, 100-ohm trim pots. Once the meter shunts and series elements were made, calibration was done with the DVM unit, connected to monitor large currents.

The power distribution circuitry is probably the most critical. All the best precautions taken to reduce voltage drop in shunts and maintain regulation of the system will be irrelevant if care isn’t taken to use sufficient wire size. Stranded wire is a must in this application; solid copper wire is too difficult to work with in these sizes. Because of the currents that would result from a short, the wire must also be insulated.

I discovered that marine supply stores sell battery wiring for power distribution in boats. But because anything purchased through a marine supply store is likely to be very expensive, I decided to parallel six No. 10 stranded wires for each leg. I also placed a 25-amp series fuse between the isolation diode and the battery charging supply, and a 50-amp fuse (from a surplus dynamotor unit) between the battery and the radios. These fuses are very important, and must be included.

All wires in the positive and negative bundles are first soldered together and then to a large terminal strip mounted in a plastic electrical box. The positive plastic box and the negative box are separated by a distance of 5 inches in the hope of eliminating the possibility of short circuits. The terminal strips, also found at a hamfest, were selected to handle 25 amps per screw connection.

While all connections to the radios are made using compression-type screw lugs, I soldered the wires to the lugs and placed insulation over all exposed wire. I used the original wiring supplied by the manufacturer for each radio; these have in-line fuses to prevent damage to the system in case the radio fails.

A few words of caution are necessary. Do not omit the two fuses mentioned earlier. The 25- or 30-amp fuse will protect the battery if the charging fails, which would result in an overvoltage. The battery, which acts like a large capacitor, will consume as much current as you can supply; if you were to place a high voltage (above 15 volts) across its terminals, it would continue to accept charge until it exploded! Placing a fuse in series protects the battery and the radios if the charging supply fails (as it would, for example, if it were struck by lightning) and short out the regulator, leaving nonregulated voltage on the radios. Don’t omit this fuse from your installation!

The 50-amp output fuse protects against a short circuit’s delivering enough current to melt the wiring. Remember that the battery has a "cold cranking output” rating of several hundred amperes, which can

---

**fig. 2. System monitoring schematics:** (A) supply current monitoring; (B) charge current monitoring; (C) battery voltage monitoring.
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melt wire and start a fire. The battery will overheat, and perhaps explode. Don’t omit this fuse, either.

Some of my friends are reluctant to use a lead acid battery in the ham shack because they worry about hydrogen gassing and the possibility of explosions resulting from gases mixing near an open flame. These problems are real! But you can avoid gassing by limiting the battery voltage to 13 volts (or less). Your transmitted output power will be slightly lower, but your radio will still work well, and the battery life will easily exceed several years.

Avoid charging the battery to a level at which you hear the sounds of gassing. This bubbling noise is the first indication that you’re producing excess hydrogen gas. Keep the voltage below the point of gassing or replace the battery if gassing occurs with a battery terminal voltage near 13 volts.

Remember, too, that car batteries contain sulfuric acid. Every time you work near the battery, wash your hands and launder clothing that might have touched any liquid near the battery. Keep a barrier between you and the battery in case it explodes. Don’t smoke or allow any open flame near the battery. Hydrogen gas will rise, but don’t let it accumulate by covering the battery in an airtight enclosure. And don’t place the battery on a cement surface; the calcium in the floor will cause the battery to die!

first aid

If acid contacts your skin, wash the affected area with a large volume of water immediately. Spread a mixture made of baking soda and water on the affected area and seek medical attention if the area is large or if the skin is burned. If acid gets into your eyes, rinse them thoroughly in the shower and get to a hospital immediately.

Should acid get on your clothing, remove all contaminated items and wash all exposed skin. Then soak the clothing in water mixed with baking soda. Sulfuric acid will destroy cotton clothing.

Remember that battery acid is very dangerous. Use all appropriate precautions whenever you work with batteries.

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24 January 1988
new uses for old tv tuners

Don’t throw them away — put them to work in a variety of handy applications

Like any other tuner, the TV tuner is the front end of a receiver — and it’s the front end, of course, that determines which frequencies a receiver will hear. Used ahead of a low-band receiver, the TV tuner becomes a VHF/UHF converter for that receiver.

Typical VHF TV tuners cover a frequency range of 54 to 216 MHz and UHF TV tuners cover 420 to 900 MHz. Think of the ham bands that are either covered by or adjacent to those ranges; some (220, 450, and 902 MHz, for example) are within the tuning range of stock tuners, and others (6 and 2 meters) are adjacent. Still other bands may be reached with some modification of the tuner.

It doesn’t take much to get the tuner operating as it was designed, and it’s always best to do this before beginning any modification. Getting the tuner working requires applying the appropriate voltages and feeding the i-f output to a receiver tuned to 47 MHz. A signal generator with a known signal or harmonic in the desired frequency band makes the retuning operation much easier. Once the unit is operating, check the frequency coverage to determine what you’ll have to do to move its coverage to the desired band.

TV tuners come in many sizes and shapes, but fall into three basic categories: detent, variable, and varactor. Detent tuners have a band switch and a fine tuning adjuster. Variable tuners use a tuning capacitor to cover the entire tuning range. Varactor tuners use varactor diodes as tuning capacitors for band coverage. A voltage is applied to the varactor diode to change its capacitance; the higher the voltage, the lower the capacitance, and vice versa.

intermediate frequency

When a TV tuner is used as a converter, its i-f output is fed into a receiver’s antenna input. The receiver then operates as the tuner’s i-f amplifier and detector. The i-f frequencies vary according to the date of manufacture and the type of application for which the tuner was designed. Black-and-white tube TV sets built from about 1947 through 1957 used an i-f of 21 to 27 MHz, while color sets have an i-f centered at about 47 MHz. Cable TV and VCR tuners have an i-f of 63 MHz (channel 3), with a bandwidth of approximately 6 MHz. If the tuner is solid-state, it will probably have an i-f of 47 MHz unless it’s from a VCR tuner.

Many suitable receivers are available for operation in the 47-MHz region. Receivers for 30- to 50-MHz communications and scanning are quite common and work well with TV tuners. Some Amateur receivers also cover 47 MHz.

When using an Amateur receiver with a narrow passband, it will be necessary to tune the receiver across the i-f frequency after the tuner has been set to a desired frequency. Note that frequencies tuned by the receiver will be reversed from the normal tuning scheme. Most TV tuners have the local oscillator frequency set above the incoming RF. This means that a direct frequency translation does not occur, and the incoming frequency decreases as the receiver’s dial frequency increases.

The tuning reversal is caused by the fact that the tuner’s oscillator frequency is fixed above (i.e., higher than) the RF input frequency. With the i-f being tuned to a higher frequency, the frequency difference between the RF and the i-f decreases.

applying power

Before applying power, it’s necessary to examine the tuner and identify all of the terminals. If possible, remove the cover(s) to expose the wiring; this will help in identifying the connections.

The antenna input terminal(s) will be obvious as either two pins or a phono connector. Some UHF varactor tuners use a single pin for an antenna input. When several other phono connectors appear in addition to the antenna input, one may be used as the i-f output and another may be used as the UHF tuner i-f input. The UHF tuner input provides a means of tying the UHF signal into the i-f through the channel selector switch. For ham converter purposes, the UHF input connector may be ignored.

There are five important terminals on most tuners for voltage application: $V_{cc}$, (sometimes marked B + ); AGC; AFC (found only on more recent models); band switch (discussed under “varactor tuners,” below);

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

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and i-f output. Tube TV tuners also have a tube heater terminal which is usually 6.3 volts, but it may be another voltage value if the tuner was designed for use in a series string heater circuit. For solid-state tuners, the voltage required for $V_{cc}$ is (+15) to 20 volts; for AGC, it's (+10) to 5 volts. The i-f output terminal is either a wire or a phono connector. If the output is a wire, it will protrude through the tuner wall and may be attached to a terminal strip mounted on the tuner’s case. For most tuners used as converters, this i-f wire may be connected directly to the center conductor of a coax feeding the antenna terminal of the receiver.

A few tuners require a voltage to be applied to the i-f wire to provide power to the transistor/tube mixer (see fig. 1). Determine the need to apply power before actually doing so to reduce the risk of circuit damage. Measure the resistance between the i-f wire and the transistor collector or tube plate. If the resistance value is below 50 ohms, power is probably required.

Attach an antenna to the tuner’s antenna terminals to obtain an input signal from any source. Even though most tuners have a 300-ohm balanced antenna input, grounding one terminal and feeding the other with 52-ohm coax seems to have little effect on signal sensitivity. A 5- to 10-foot wire attached to the ungrounded antenna terminal should be adequate.

Voltage applied to the AGC terminal (normally positive with respect to the case) will control the tuner’s sensitivity, and when varied with a potentiometer, will function as an RF gain control. A fixed voltage may be applied later on. With the tuner and receiver operating, tune to a known signal (TV or otherwise) and adjust the AGC voltage from (+10) to 10 volts for maximum received signal (measure and record the AGC voltage value for future reference).

### Tuning Aids

Make a set of tuning aids to assist in making coil adjustments during frequency modifications. Small metal rods (1/16 inch diameter x 1/4 inch long) attached to a plastic or wooden stick are useful tools for adjusting VHF and UHF coils. Brass, a diamagnetic material, will reduce the coil’s inductance when inserted. Inserting the metal can also increase the circuit capacitance, but the net result will be an increase in the resonant frequency. Inserting an aluminum rod of similar size will lower the resonant frequency slightly. Aluminum, being nonmagnetic, won’t affect the inductance value, but will increase the circuit capacitance, causing a lowering of the resonant frequency. An iron rod, being magnetic, will increase the inductance value and lower the resonant frequency; a powdered, rather than solid, iron rod would be preferable at VHF and lower RF frequencies. Brass and aluminum rods, however, have been found to be the most useful in working with VHF and UHF tuner modifications.

These tools are used to determine if any improvement is to be gained by coil adjustment before the adjustment is actually made. For example, if the signal strength of the incoming signal is improved as the...
brass rod (as opposed to aluminum) approaches the coil, then the inductance value should be reduced slightly. A signal improvement with either aluminum or iron indicates that an increase in inductance is required.

**detent tuners**

Detent tuners for the VHF bands use either a drum or switch mechanism for changing channels. On this type of tuner, a fine-tuning adjustment is provided by either of two means: by oscillator slug adjustment or by a dielectric tuning capacitor that changes the oscillator circuit capacitance.

Putting the detent tuner into one of the ham bands may require modification of the coils. You’ll need a signal generator of some kind to track the effects of retuning; it doesn’t take much adjustment for most tuners to move over into adjacent ham bands.

As an example, let’s assume that you want to modify a tuner for 6 meters. Select channel 2 (54 to 60 MHz) on the tuner. Adjust the fine tuning for the lowest frequency. Using a signal source, locate the tuner’s input frequency. If it’s already in the ham band, no modification is necessary. If it has to be lowered a bit, try increasing the tuner’s oscillator trimmer capacitance, squeezing the oscillator coil wires together, or adding an additional turn of wire to the coil.

The channel 2 oscillator coil will be the easiest to identify because it has the greatest number of turns of those on the oscillator wafer switch. Increasing the inductance — either by squeezing the coil or adding a turn of wire — will lower the frequency sufficiently.

Retuning of the tuner’s input circuits is usually necessary. However, the oscillator coil must be retuned and put on the desired frequency before the RF and mixer circuits are touched. It’s important to tune and measure only one circuit at a time during the modification.

**varactor tuners**

Of the three types of tuners, varactor tuners provide the most flexibility for Amateur use because the tuning range is generally continuous and may overlap the ham bands without modification. Cable-ready VCR tuners, for example, cover about 39 to 290 MHz. Frequency coverage of 6, 2, and 1-1/4 meters is available without tuner modification. UHF varactor TV tuners cover the top part of the 450-MHz band and will require modification to cover the 902-MHz band. A signal source is necessary when modifying tuners for these bands.

Modifying the tuning frequency of a varactor tuner requires a change in the inductance value of the oscillator. But because space is tight, capacitor changes are difficult to make. To move a VHF tuner up to 220 MHz, it’s necessary to decrease the inductance value of the oscillator coil, then the inductance value should be reduced slightly. A signal improvement with either aluminum or iron indicates that an increase in inductance is required.
Tuning is accomplished by providing a variable tuning voltage from 0 to 30 volts. The most satisfactory tuning resolution is obtained by using a ten-turn potentiometer to provide the vernier voltage adjustment (see fig. 2).

One of the greatest problems observed with the varactor tuner occurs when the oscillator frequency-modulates as a result of voltage fluctuation on the tuning voltage line and power supply bus. A fairly large capacitor (e.g., 1 to 10 µF) placed on the tuning voltage line will reduce this tendency. Shielding the line and regulating the power supply bus will help, too. Adding the large capacitor reduces the tuning slew rate. You'll overshoot the desired frequency if you turn the tuning knob too rapidly.

The 100-k resistor between the potentiometer and tuner is optional unless the circuit is to be used as a spectrum analyzer.

If the tuner has two or more bands, frequency selection is accomplished by diode switching within the tuner. Switch control is obtained by applying a voltage to the appropriate diode(s). For example, I tried the scheme shown in fig. 3A on a Sony two-band VHF TV tuner. When the high band was selected, a positive voltage was applied to both terminals; when the low band was chosen, voltage was applied to only one. The actual voltage required for switching didn't seem to be critical on the Sony tuner as long as it was kept between 8 and 14 volts. However, the greatest signal sensitivity occurred at +12 volts.

A Mitsubishi VCR tuner had three band switch terminals. Figure 3B shows the circuit developed for selecting its bands. The selection voltage had to be +15 volts for maximum signal sensitivity, and when not used, the terminals had to be pulled to ground (a soft pull-down was sufficient, but floating the terminal failed to work). This particular tuner had independent AFC and tuning voltage terminals. Apparently fixed voltages were established for band selection and rough channel tuning. An AFC voltage was then applied for fine tuning.

**variable tuners**

In some tuners, a variable capacitor provides the means of tuning through the channels. Variable UHF tuners have been around the longest and are generally the most readily available. Mechanically, they're difficult to tune by rotating the shaft when they're used with narrowband receivers following them. Once tuned, however, they seem to be quite stable. Unfortunately, very few of these tuners have RF stages, and their sensitivity suffers for weak-signal activity. A good outside antenna and/or RF pre-amp is suggested as a means of improving performance.

The circuit of the tuner is very basic, with one or more passively tuned circuits ahead of a diode mixer. Each one of the tuning sections is a coaxial cavity with a capacitor at the top of the coaxial line. A transistor oscillator provides the injection signal for mixing. Power supply voltage stability for the oscillator is critical, although the actual voltage value is not. Most will operate very well on a 9-volt transistor battery. Some tuners of this type also have varactor diodes in their oscillator circuits to accommodate AFC. Examine the lead(s) attached to the diode for polarization; occasionally, both ends of the diode are brought out of the case. The cathode end (the end with a stripe) will be attached to the positive source and the anode end will be attached to ground. A tuning voltage applied to
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- VSWR: 1.5:1
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- Beamwidth: 48°
- Feed Imp: 50 ohm
- Balun: 4:1 coax

**MECHANICAL:**

- Element Length: 13½" max.
- Boom Length: 64°
- Turn Radius: 64°
- Windload: 4 sq. ft.
- Weight: 1½ lbs.
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- Mount: Rear

**CJ440**

**ELECTRICAL:**

- Bandwidth: 420-470 MHz
- Gain: 11.2 dBi
- VSWR: 1.5:1
- F/B: 20 dB
- Beamwidth: 48°
- Feed Imp: 50 ohm
- Balun: 4:1 coax

**MECHANICAL:**

- Element Length: 13½" max.
- Boom Length: 64°
- Turn Radius: 64°
- Windload: 4 sq. ft.
- Weight: 1½ lbs.
- Mast: 1½" o.d.
- Mount: Rear

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Reader Service CHECK - OFF Page 114
the diode provides fine-tuning control around the frequency selected by the tuning capacitor (see the technique used in fig. 2).

The tuning range of the UHF variable tuner generally covers the top end of the 450-MHz band up to 890 MHz. Modification of the tuner would be necessary if you wanted to reach the 902-MHz band, but this would take the tuner out of the 450-MHz band. The oscillator, for most tuners, is on the high side of the RF input. Therefore, before making any modification, be sure to verify the placement of the oscillator above or below the RF input. Verification is accomplished at the lowest frequency. Adjust the tuner to the lowest frequency possible and locate the RF input frequency with a signal source. Once you find it, increase the signal source frequency up 94 MHz (two times the i-f, 47 MHz), which is the detected RF frequency plus 94 MHz. If the signal is heard — even though it may be weak — the oscillator is probably above the input. Return to the previous RF input frequency and decrease the signal source frequency by 94 MHz (detected RF minus 94 MHz). If the signal isn’t heard, then the oscillator is on the high side. Should the signal source be heard on both sides, shift the tuner to a new frequency and run the test again, since you’re hearing generator harmonics or spurs on one side.

Another technique used for identifying the tuner’s oscillator placement is varying the received i-f frequency. This technique works when a tunable receiver follows the tuner. Locate the RF input frequency with the signal source and adjust the frequency dial for peak signal into the receiver. Take note of the receiver’s dial frequency. Then increase the signal source frequency by a few kHz. Re-tune the receiver dial to receive the signal again and note the new frequency indication. If the frequency is lower, the tuner’s oscillator is above the incoming RF. If it’s higher, the oscillator is below the incoming RF. Repeat the technique a few times for verification.

Assuming that the oscillator is on the high side of the RF, two choices are available for 902 MHz tuner modification. The first choice requires moving the oscillator up about 30 MHz, with modifications to the RF and mixer circuits made later. The second choice requires leaving the oscillator where it is and modifying the RF and mixer circuits by moving them up 94 MHz, placing them above the oscillator. The first choice is probably easier, although the oscillator may stall or become sluggish at the higher frequency (the oscillator transistor is approaching 1000 MHz).

The modification may be as simple as reducing the fixed capacitance in the oscillator circuit. The fixed capacitors are wires or metal tabs attached by one end to the walls near the top end of the cavity. Bending them against the wall, away from the tuned line, reduces the capacitance and may be the only tweaking required. Check the new oscillator frequency before modifying the RF and mixer circuits. If the oscillator frequency is at the desired frequency, bend the mixer wire/tabs against the wall while monitoring for a peaked signal level transferred through the tuner. You can use a plastic or wooden stick to bend wires while the circuit is operating, but you’ll have to remove it from the circuit to assess the effects of the adjustment. Then move on to the RF circuit and repeat the peaking process.

For the second choice, retuning the RF input and mixer circuits will put them above the oscillator by 47 MHz. Raising the frequency of the cavity requires shortening the cavity or reducing the capacitance at the top. One modification technique requires the removal of capacitor plates to raise the cavity frequency by 94 MHz. If possible, avoid removing the variable capacitor plate; once removed, the plates cannot be reinstalled.

The output of the diode mixer may be connected directly to the coax center conductor going to the receiver. But you’ll have to determine if signal sensitivity improves when you shunt the coax with a 10- to 22-k resistor. The diode requires a dc current path for proper mixing action to take place. You can place a 10- to 22-k, 1/4- or 1/8-watt carbon resistor inside the mixer cavity near the i-f output. One end of the resistor is soldered to the i-f output connector wire from the diode. The other end of the resistor is soldered to the case ground. An alternate method is to place a coaxial “tee” in the i-f line going to the receiver. A resistor is shunted across the center lead and shield at one of the ports of the “tee.”

**tubed tuners**

Tubed tuners will be either detent or variable types and will require a power supply voltage, B+, of 80 to 150 volts, with 100 to 105 volts preferred. The proper heater voltage will also be necessary. Tubed tuners frequently require that the mixer plate voltage be supplied through the i-f output circuit. In the absence of an output transformer, a 1-mH RF choke connected between the i-f output lead and B+ will provide the power (see fig. 1). Signal output can then be coupled from the lead through a 1000-pF capacitor to the center conductor of the coax going to the receiver.

Fortunately, tubed TV tuners don’t require an AGC voltage for proper operation. But for maximum signal sensitivity, the AGC lead should be grounded, not left floating. The addition of a negative voltage variable from 0 to 10 volts will function as an RF gain control.

Because of their bulk, tubed tuners are fairly easy to modify. But because of their age, most tubed tuners cover 50 MHz, 146 MHz, and 220 MHz within the oscillator’s tuning range for the selected band.
In the past, the Amateur’s favorite was the Mallory Inductuner (circa 1949), which used three spiral-wound inductors covering 50 to 220 MHz in two bands. By disabling the band switch that caused the tuner to jump over the 88- to 175-MHz band segment, you could modify the tuner to cover 2 meters.

A detent favorite was the Standard Coil drum tuner (circa 1952). All of its coils were mounted in clips to form a drum; removing all except the one being worked on provided ample room for modification. Later model tuners used a 6BQ7/6BZ7 cascode RF stage that provided excellent weak-signal sensitivity.

power supply

The power supply requirements are generally the same for all solid-state tuners. However, since voltage fluctuations and hum cause the local oscillator to frequency-modulate, a well-regulated and filtered power supply is an absolute must. Any of the popular three-lead, fixed-voltage regulators are quite satisfactory for use with TV tuners. Variable voltage regulators such as the LM723 and LM317 allow users to select voltage values.

The typical solid-state tuner $V_{cc}$ voltage requirement is (+)15 to 20 volts (50 to 100 mA). Varactor tuners also require a 24- to 30-volt (5 to 10 mA) regulated source for tuning control, and possibly 12 to 15 volts (10 to 20 mA) for band switching. Some tuners, such as the UHF variable tuner, will operate satisfactorily on a 9-volt transistor battery. Battery life is determined by the amount of current drawn by the particular tuner.

Oscillator stability, the most important factor, depends on thermal heating and voltage variation. Regulation and low $V_{cc}$ line impedance are key factors in reducing the oscillator’s tendency to frequency-modulate. Taking advantage of the oscillator’s sensitivity to voltage variations, small adjustments in $V_{cc}$ may be used to provide a fine-tuning capability. A $V_{cc}$ tuning control can be implemented by placing a low-value potentiometer in the regulator voltage sense circuit of one of the variable voltage regulators. Small changes in potentiometer resistance will cause small changes in the $V_{cc}$ value, which will result in an oscillator frequency shift.

applications

Low-band communications receivers (30 to 50 MHz) appear to be inexpensive items at ham swap meets, perhaps because of diminished interest in low-frequency activity. In general, the low-band receivers were well designed and continue to perform adequately. Adding a TV tuner as a front end converter can provide such receivers with new life.

Variable or varactor tuners are preferred for use with fixed-frequency receivers because of their tuning capability. Detent tuners would work well also, but would be limited to single-channel monitoring.

When used with scanning receivers, TV tuners function as converters to extend the received frequency coverage. One of the advantages of using a scanning receiver lies in the fact that the TV tuner i-f may be scanned from about 43 to 48 MHz, allowing the selected input frequency of the tuner to be scanned over a 5-MHz segment. The tuner’s RF frequency is adjusted during the initial setup of a band and then left alone. Tuning occurs by scanning the i-f. Detent tuners work well in this application.

One of the better uses of wide-frequency range receivers is as a spectrum analyzer. Together in such an application, the varactor tuner, a 30- to 50-MHz communications receiver, and an oscilloscope functions as a spectrum analyzer. The receiver’s first limiter
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dc output (or last i-f, if sufficient scope gain is available) is connected to the vertical input of the scope, providing a voltage amplitude display as a function of signal strength. The limiter output of a tube-type receiver swings negative, causing the scope display to swing downward unless the scope input can be switched to negative. A negative swing, as opposed to a positive swing, on the scope is of little consequence unless one’s eye cannot adjust to the downward display of the signal.

To provide a frequency display on the horizontal axis, the varactor tuner must be swept over a range of frequencies with a sawtooth waveform. This may be accomplished in one of two ways: by obtaining the sawtooth sweep voltage from the scope or by generating a sawtooth voltage external to the scope. Older model Tektronix scopes had a sweep output terminal on the front panel that provided ready access to the internal sweep voltage. The voltage output from the scope terminal was quite high, however — usually up to 100 volts. Approximately 0 to 3 volts is all that’s required for adequate tuner sweeping. A resistor in series with a potentiometer will ratio the sweep voltage to the desired amount.

Should the user’s scope not provide a sawtooth output voltage, an external sweep generator (fig. 4) may be used. A sync pulse is provided by the circuit to trigger the scope so that the trace will sweep and track along with the tuning voltage to the tuner. Some horizontal nonlinearity will be observed in the analyzer display. However, the amount is tolerable. The effect is caused by the difference in sawtooth linearity characteristics between the scope sweep and the external generator. Obtaining the sweep from the scope masks most of the effects of sweep nonlinearity. The remaining nonlinearity in the display is caused by the non-uniform voltage-to-frequency conversion of the varactor diode.

The sawtooth voltage is used to drive the tuning voltage line (see fig. 2) of the tuner in sync with the scope sweep, resulting in a signal voltage versus frequency display on the scope. Controlling the tuner frequency and sweep width separately allows the tuner to “look” at single or multiple signals near the center of the tuner’s frequency setting.

The narrow passband of the typical 30- to 50-MHz receiver makes the tuning of the TV tuner critical but still satisfactory for analyzer work. However, a wider passband receiver makes the spectrum analyzer easier to handle. Readers who want to build a wider passband receiver are referred to K4IPV’s article, “Poor Man’s Spectrum Analyzer,” which appeared in the September 1986 issue of ham radio.

TV tuners are available from Science Workshop, P.O. Box 333, Bethpage, New York 11714. — Ed.

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**Suppose you’ve decided** to learn a new language — French, for example. You could choose to study with a teacher in a classroom or on your own, using cassette tapes or records. In either case, you’d notice that the instructor would begin by pronouncing each word normally at the appropriate speed, but would lengthen the pauses between the words or syllables to give students time to recognize individual sounds.

Let’s assume you’ve opted to learn French from records or tapes. What would happen if, instead of playing them at their proper speed, you played them at a slower speed? You’d probably have great difficulty recognizing any words at all.

Learning Morse Code is like learning a new language, and listening to code at five wpm is just like listening to language records or tapes played at the wrong speed.

At five wpm it’s easy to fall into the trap of counting dots and dashes. Most people can’t reach 13 wpm this way, so when they switch to learning to hear the rhythm patterns (i.e., *sounds* — Ed.) instead of individual dots and dashes, they’re essentially learning a new code.

Unfortunately, this experience is often accompanied by a discouraging loss of speed, just when they need encouragement to upgrade. Too many would-be Generals give up at the Technician level because of the difficulty of breaking the dot and dash counting habit to relearn code at 13 words per minute.

The fastest way to a General Class license is to start at 13 wpm, with generous pauses between characters for an overall speed of five words per minute. This way, you’ll learn code characters by recognizing rhythm patterns rather than by counting dots and dashes. Once you’ve learned to recognize the patterns, all you have to do is concentrate on reducing your reaction time. Just as on the language records, you’ll find the time between the characters helpful for recognizing them and writing them down.

To skeptics who insist that they can’t learn code, I like to introduce the letters V and B. I simply suggest that they think of the V as the Roman numeral V. I ask them to recall Beethoven’s Fifth Symphony, noting that the sound of the Morse V sounds just like the opening phrase: *di-di-di-dah*. For the Morse letter B (as in “Beethoven”), you just play it backwards: *dah-di-di-dit*. After a short demonstration, they can pick these letters out of small code groups, even though they may have to pause to figure out how many dots and dashes are used for each letter. This trick often provides the confidence they need to continue studying code.

**code practice from the computer**

When I started preparing for the Extra Class code test, I wasn’t sure whether I was really improving my copying or merely remembering the material on the recordings. I bought one of those code practice keyers that generates random code, with an adjustable delay between characters. But without a printout of answers against which I could check my work, I was still unsure of my progress. When I finally got around to looking at computers, I was surprised to find how difficult it is to find a code program that includes the continuously variable spacing my keyer provides. Most programs offer only the choice of standard spacing or standard spacing plus one full space. This is too big a jump; a better method would allow for gradual reduction of the length of the pauses between characters, with character speed remaining constant.

Hearing of my problem, a friend offered me the use of his Commodore 64 computer and challenged me to write a code program that provides the variable spacing I believe is essential for learning the code. *Morse Code Teaching Tools*, the result of that effort, allows you to set the character speed and overall word speed to any logical combination of speeds between five and 50 wpm. It also performs the following functions:

- **Random practice.** Choose letters, numbers, punc-

By Dennis L. Green, KB8CS, 20039 Murray Hill, Detroit, Michigan 48235
getting the timing right

The program timing is based on words of five characters and one space, for a total of 50 time elements. Dots and the time between dots and dashes are each one time element in length. Dashes and the time between characters are three elements long. A space character has the same timing as a silent “e” in a spoken word — that is, one element without the sound plus the usual three elements of time between characters. The word “PARIS” fits this description. When you set the word speed slower than the character speed, the three time elements between characters are lengthened. If you try a speed test, remember to put two spaces before the last word instead of the trailing space, since it’s rather difficult to hear when a “space” has ended.

After filling my trash can with a number of early versions of this program, I discovered why it’s so hard to generate accurate code on the Commodore 64 computer. A signal from the Complex Interface Adapter (CIA) chip’s timer causes the computer to stop whatever it’s doing sixty times per second to run a built-in machine language program that updates the clock registers and scans the keyboard and stores the value of any depressed key in memory. These interruptions in the execution of the program make the code inaccurate (and sloppy sounding) if a program loop is used to control the code timing. Using the clock registers in a loop to control the code timing won’t work any better because they’re updated too infrequently and the keyboard routine must finish before the BASIC program resumes execution and can respond to the change in the clock register.

To generate accurate code, it’s necessary to use the CIA chip’s timer interrupts to control the sound chip and give it priority over the keyboard and clock functions. The effect on the keyboard response shouldn’t be noticeable to the average typist, and the clock isn’t used by this program. The modified interrupt handler machine language is POKEd in from DATA written in BASIC to avoid the need for an assembler to enter the program listing. When you’re familiar with machine language, you may wish to use the data to create a binary file, which will load faster.

how to get a copy of the program

Because of its considerable length (7 pages, 315 lines of coding) the program listing cannot be reproduced here; a free printout is available from ham radio for a No. 10 SASE with two units of first-class postage. If you’d like to have a ready-to-use copy of the program on a disk, send a certified check or money order for $8.00 to Robert A. Evans, NBGFE, 23540 Manistee, Oak Park, Michigan 48237.
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RS-M SERIES

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VS-M AND VRM-M SERIES

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<td>RS-20S</td>
<td>16</td>
<td>20 5/8 x 10 x 5/8</td>
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</table>

*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off)
build a QSO “beeper”

End-of-transmission tone becoming more common

As an Amateur, you’re no doubt familiar with the courtesy tones heard over repeaters, indicating the end of each transmission. You may have also heard end-of-transmission tones in SSB communications during contesting or poor conditions. This article describes several different circuits for producing these tones, along with some discussion of how they operate. I like to refer to these circuits as “QSO beepers.”

operation timing

The Beeper (fig. 1) transmits one or more short tone bursts after you’re finished talking. This indicates to other stations that your station has finished transmitting and is now in the receive mode.

In many radios the PTT line from the microphone immediately unkeys the transmitter when you’re through talking. However, if this were allowed to happen with a QSO Beeper in place, these trailing courtesy tones would be cut off. Therefore, after you unkey, the Beeper keeps the PTT line keyed (active) for the short interval of burst tone activity (see fig. 1).

The interval \(\text{WAIT1}\) provides a delay-before-burst or “DBB” period. Without this short interval, the following beep tone (\(\text{BEEP1}\)) would “ride” the audio of the quick-fingered operator who unkeys instantaneously after talking. A duration of 0.1 seconds usually works well, but isn’t critical.

\(\text{BEEP1}\) is the desired tone burst, usually around 1 kHz and about 0.1 second or so in length. The pitch and duration are selected to provide a comfortable sound.

The other DBB intervals (\(\text{WAIT2}\), etc.) provide the same spacing effect as \(\text{WAIT1}\). The next desired tone bursts — designated \(\text{BEEP2}\), etc. — have characteristics similar to the first.

Simple circuits can be used to produce these DBB intervals and the tone bursts. A single-burst Beeper cascades the DBB and burst generators. A multiburst Beeper can be made by cascading several single-burst Beepers. When the burst tones are set to different pitches (\(\text{BEEP1}\), \(\text{BEEP2}\), etc.), a melody distinctive to each station can be produced.

Figure 2 illustrates the general circuit of the Beeper. The Beeper is connected between the microphone output plug and the microphone input jack to the radio. Audio from the microphone connects directly through the Beeper to the radio. The Beeper’s courtesy tones are injected into this line at the proper time.

A level transition detector senses when the PTT line from the microphone changes state as you unkey at the end of a transmission. This transition triggers the time interval generator to produce a pulse of fixed duration. This gating pulse in turn gates both the PTT electronic switch (controlling the radio) and the audio oscillator, producing the tone burst.

Since many PTT microphones operate by grounding a control line normally “pulled high,” the circuits described here “pull” the radio PTT line to ground during transmit (see fig. 1). This can be achieved with an open-collector NPN transistor placed in conduction at the proper time. For improved circuit operation, a very low-resistance VMOS (TMOS, etc.) FET could be used in place of the bipolar device.

An extra line from the radio (via the microphone

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SPECIFICATIONS

<table>
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<th>Model</th>
<th>Freq. MHz</th>
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<th>Output</th>
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<th>Gain-dB</th>
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<td>19 N</td>
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defining the gate's digital state. The output of the gate follows this input spike with a pulse of width directly proportional to the resistor and capacitor values. Values of $R_p = 470 \text{k}$ and $C_p = 0.22 \mu\text{F}$ provide a pulse of about 0.1 seconds, yielding an effective delay-before-burst interval. (Triggering on the negative-to-positive transition instead can be accomplished by connecting the resistor to ground instead of the positive supply line. Note that the output in this case is also the inverse of the previous case, providing a negative-going pulse.)

**audio oscillator**

Figure 4 shows one way of implementing the tone

cable, for example) or an internal battery can supply dc input power. The use of CMOS circuitry keeps the dc input power requirement low, allows wide supply-voltage operation (+3 to +18 dc), and provides high noise immunity. The high input impedance of the CMOS gates allows realizable component values to be used in generating the desired time constants. Low power consumption and small size make the Beeper perfect for QRP outings (such as Field Day), net operation, and contesting.

**time delay circuit**

Figure 3 illustrates one way of implementing the time interval (pulse) generator, which is also referred to as a monostable multivibrator or "one-shot." Upon a positive-to-negative edge transition capacitor $C_p$ produces a single spike at the input of the gate, charging through resistor $R_p$. This spike causes the gate input voltage to momentarily cross the threshold level burst circuit, also referred to as a gated astable oscillator. Upon application of the burst-control signal, the gate is enabled and the output changes state. Resistor $R_o$ feeds this output signal back to the gate input and capacitor $C_o$. As $C_o$ discharges, the gate input voltage crosses the threshold level defining the gate's state and the output follows this input change. This out-of-phase feedback mechanism causes $C_o$ to charge and discharge at a determinable rate, with the gate input voltage rising and falling accordingly. An output oscillation will be produced at a rate inversely proportional to the values of $R_o$ and $C_o$. Notice that the tone burst has the same duration as the input burst-control signal because the gate is active only during this time.

Values of $R_o = 10 \text{k}$ and $C_o = 0.1 \mu\text{F}$ provide a frequency of about 1 kHz, producing a pleasing beep tone. A low-pass filter composed of $R_f$ and $C_f$ remove the high-frequency components of the gate's square

January 1988  41
The circuit shown in fig. 5 illustrates a Beep that produces a single beep. The first section, U1A, makes the necessary waveform inversion of the PTT negative-to-positive transition to that of positive-to-negative required by the “one-shots” (as in fig. 1 and fig. 3). R1 provides the necessary voltage pull-up for the microphone PTT switch that connects to ground when keyed.

Two “one-shots” have been cascaded to provide the necessary time delays. The first interval at U1B (by C1 and R3) is the DBB interval described previ-ously. The second interval of U1C (by C2 and R4) sets the length of the beep tone. The resistor and capacitor values shown provide about 0.1 seconds of delay through each one-shot stage.

The output of U1C controls or gates the audio oscillator of U1D (set by C3 and R7), yielding the output tone burst. Low-pass filtering is provided by R8 and C4. Potentiometer R9 allows the amplitude of the tone burst to be set. Capacitor C5 simply blocks dc between U1D and the audio line; many active microphones receive dc power from the radio via this line, which must not be interfered with by the dc present at the potentiometer output.

Transmitter keying (PTT) is provided by the open-collector NPN transistor, which is turned on during both one-shot intervals by “wired OR-ing” through diodes CR2 and CR3. U1A is also ORed via CR1 to key the radio PTT line while the operator is keying the microphone. Without CR1 the radio PTT line would be active only during the DBB and tone burst periods via CR2 and CR3 (fig. 1). As previously mentioned, a very low-resistance FET could be used at Q1 in place of the bipolar device for improved performance. The collector current and open circuit voltage present on the radio PTT line must be considered when selecting Q1. Most solid-state rigs with PTT keying via the microphone operate this control line with relatively low voltage and current that are easily handled by the 2N2222 or its equivalent.
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DPDT switch S1 allows the Beeper to be switched in or out of the circuit as desired. Note that in the “bypass” mode, dc power to the Beeper doesn’t have to be applied for the radio to be keyed by the microphone; thus, normal radio operation is restored. The base-to-ground resistor at Q1 ensures that Q1 won’t conduct while the Beeper is in the bypass mode.

**a dual-tone QSO beeper**

The circuit shown in fig. 6 describes a Beeper that produces either a single tone or two tones in sequence. Here the single-tone Beeper described above is cascaded for sequential operation. For simplicity, a single panel switch is used to select either the bypass mode, or the one- or two-beep mode. However, two trade-offs must be made in the bypass mode when using only the single switch: first, dc power to the Beeper is always connected, which will probably not pose a power consumption problem; and second, input to the Beeper is always connected (even though it will be...
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functionally inhibited). More on this second tradeoff follows.

As in the single Beeper, U1A provides the necessary signal inversion of the PTT line, with R1 providing the pull-up function. Notice here that when switch S1 is in the bypass mode, the input via R2 is still connected to the radio. If the radio uses a relatively high voltage for the PTT “pull-up,” the IC can be damaged if this voltage exceeds the IC supply voltage. Optional diode CR6 limits the input voltage at U1A from exceeding the supply voltage, with resistor R2 providing current limiting. Alternatively, a zener diode of appropriate value could be used between the input of U1A and ground. In rigs where the PTT pull-up voltage is the same or less than the Beeper supply voltage, no problem should exist, so CR6 can be omitted. U1B sets the first DBB period (by C1 and R3) and U1C provides the necessary gating (by C2 and R4) for the first tone burst oscillator U1D. U2B sets the second DBB period (C3 and R5) and U2C (with C4 and R6) gates the second tone burst oscillator U2D. Gate U2A multiplexes the tone burst signals from U1D and U2D and buffers them for output to the low-pass filter of R11 and C7 and level setting potentiometer R12. The radio PTT line must remain active throughout the intervals (WAIT1 + BEEP1 + WAIT2 + BEEP2 + ...). This is achieved by OR-ing the control gating lines together. As with the single Beeper, PTT operation is provided by the open-collector NPN transistor, which is held active during all one-shot intervals by “wired-ORing” through diodes CR1 through CR5. Again, CR1 is required to key the radio while the microphone PTT line is activated by the operator (see fig. 1).

The DPDT-center-off switch allows selection of single or dual beeps, or of bypassing the unit. In the dual-beep mode, all the “one-shots” are cascaded. Notice that in the single-beep mode, U2B is inhibited by tying the input to the supply line. This allows only the first DBB period and the first tone burst to be transmitted. The radio PTT line is immediately unkeyed after this first tone burst.

Two switches could be implemented to disconnect dc input power and the Beeper input while in the bypass mode. Switch section S1B of fig. 6 could still be used, while a DPDT switch identical to S1 (A and B) in the single Beeper of fig. 5 could be added. This would alleviate the problems of the single DPDT-center-off switch previously discussed. A DIP header with 1/8-watt resistors that plugs into an IC socket can be used for the interval- and pitch-setting resistors of R3, 4, 5, 6, 9, and 10. This allows flexibility for changing values later, but doesn’t take up as much room as potentiometers.

a multi-tone QSO beeper

It’s also possible to make a Beeper capable of
Dual-tone Beeper parts list:

<table>
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<th>Component</th>
<th>Value</th>
<th>Note</th>
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<td>0.7μF, 50 volts</td>
<td>nonpolarized (RS 272-1069)</td>
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<td>C10</td>
<td>100μF, 35 volts</td>
<td>electrolytic (or tantalum) (RS 272-1028)</td>
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<td>CR1,2,3,4,5, and CR6 (if used)</td>
<td>1N914</td>
<td>general signal diode (RS 276-1620)</td>
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<td>Q1</td>
<td>2N2222A</td>
<td>general purpose NPN (RS 276-1617)</td>
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<td>R3,4,5,6</td>
<td>470 k</td>
<td>1/4 watt (RS 271-1354)</td>
</tr>
<tr>
<td>R9,10</td>
<td>10-30 k</td>
<td>1/4 watt (set for tone pitch) (RS 271-13xx)</td>
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<td>R12</td>
<td>100 k</td>
<td>potentiometer (RS 271-338)</td>
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<tr>
<td>S1</td>
<td>DPDT center-off toggle or slide</td>
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</tr>
<tr>
<td>sockets</td>
<td>14-pin DIP</td>
<td></td>
</tr>
<tr>
<td>U1,2</td>
<td>CD4093B</td>
<td>CMOS quad NAND Schmitt (74C132) (RS 276-1999)</td>
</tr>
<tr>
<td>perfboard with solder pads, 0.1-inch centers</td>
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producing many tones in sequence. The one-shot intervals could conceivably be cascaded indefinitely, producing many DBB and burst intervals. However, component count would increase accordingly.

A less complex circuit — operating on a slightly different principle than that previously described — could be produced. The end-of-transmission on the microphone PTT line could still be detected as a state transition. However, instead of using discrete time interval “one-shots,” a clock (gated astable circuit) and a serial shift-register could be used to create alternate intervals for DBB and burst gating. The various audio burst lines would be diplexed into a multi-input NAND gate, as in the dual Beeper. The shift-register outputs could be ORed to control the (NPN) PTT switch. The last register output desired should be fed back to disable the clock and reset (i.e., clear) the register.

Similarly a (gated astable) clock could drive a multi-bit binary (or BCD) counter chip (e.g., a 74C161). The counter’s binary output could be decoded into many single lines by a demultiplexer chip (e.g., 74C154) to create the DBB and burst gating intervals. Again the astable burst outputs would be diplexed by a multi-input NAND gate.

Note that in both these methods the length of each interval cannot be different because each clock pulse has identical width. Also keep in mind that each additional beep tone increases the length of the transmission; the operator on the receiving end may not need to hear an entire melody to know that you’ve finished transmitting (some repeaters sport three courtesy tones, but these tones are wisely kept very brief).

**alignment**

Tune-up of the QSO Beeper’s interval, tone pitch, and tone amplitude can be done with an oscilloscope; a two-channel scope works nicely. By monitoring the audio and PTT lines at the radio microphone port, the signals can be verified against those of fig. 1. Beeper amplitude is best set by relative comparison with the microphone audio level. (The microphone level may be reduced if the potentiometer is set at too low an impedance.)

Checking the tone(s) can be done without continuously keying and unkeying the transmitter. While keying the radio with the microphone PTT switch, monitor the Beeper audio line to the radio. Flip the mode switch between the dual-beep (center) position and the bypass position. The Beeper will inject its tone(s) onto the audio line every time this is done, alleviating the need to switch from transmit to receive and back again just to produce the tone(s).

The true and final check should, of course, be on the air. Comments from a receiving station should be helpful. An auxiliary receiver also is very convenient for monitoring the QSO Beeper.

If you choose to modify the Beeper, avoid connecting the radio PTT line (and the PTT switch) directly to the input of the Beeper; a feedback loop would be set up when the radio PTT line is keyed (pulled low), preventing the negative-to-positive transition via the microphone PTT line.

I’m looking forward to hearing your Beeper during our next contest QSO.
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6th ARRL Computer Networking Conference held in Redondo Beach, California, August 29, 1987. 29 papers (approximately 150 pages) will appear in the proceedings booklet. Copies will be available at the conference or from ARRL after September 1.

MICROWAVE UPDATE 1987 held in Estes Park, Colorado, September 10-13, 1987. 15 papers (approximately 100 pages) appear in the proceedings booklet. Copies will be available at the conference or from ARRL after September 14.

Proceedings booklets are $10.00 each plus $2.50 per order for postage and handling ($3.50 for UPS.)
NEW BOOMER DISTANCE RECORDS

220 Mhz on June 14, 1987 Bill Duval, K5UGM of Irving, Texas using the 220B Boomer made the first ever 220 MHz sporadic E contact with W5HUQ/4 in Florida.

2 meters on June 14, 1987 Jim Frye, NW70 using the 4218XL Boomer contacted Jim Poore, KD4WF using a 215WB Boomer to set a new 144 MHz overland distance record of 1960 Statute miles.

2 meters on August 3, 1987 Gordon West WB6NOA, using a ½ watt handheld into a pair of 4218XL Boomers contacted KH6HME in Hawaii a distance record of more than 2400 statute miles.

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radio addiction: case history of an enthusiast

I recently bought a house in Tucson. When I first confronted the real estate agent, I advised her of its necessary attributes: four bedrooms, two baths, a large lot, underground utilities, and no antenna restrictions. I chose northwest Tucson over the more scenic southern foothills, where the Catalina Mountains blocked the great circle route to my favorite radio target: Europe. Northwest Tucson has a nice clear horizon in that direction.

That night, after signing away my life savings, I thought about the purchase. "My God," I thought to myself, "how much simpler life would be without this radio addiction!"

As the agent showed me the house, I imagined where the main tower would be placed, the orientation of the zepps, and how I could actually place a full-sized 160-meter dipole on the lot. Thoughts about how the rugs really didn't match my furniture, the amount of work required for redecorating, and the like, were secondary. It was obvious that a serious metamorphosis had transpired: I had finally asked—and answered—the question, "Why is Amateur Radio so important?"

The answers lie deep inside all of us. But this time I dared to quantify them, to analyze my own addiction's history—and then, in a moment of impudence, actually write everything down! Prejudice, bias, love, hate; all surfaced. But it really began long ago and far away . . .

It was 1957 in South Chicago. I think it was my mother's hi-fi set that did it. The power amp didn't have a cabinet, so the transformers and tubes were naked to youth's curiosity. And what tubes they were! A 5U4 rectifier and those noble push-pull 6L6s. I was only six, but somehow I knew that the tubes were the components of consequence. Turn the switch on, and they made a crinkling sound as the red filaments lit up. As the rectifiers kicked in and the filter capacitors inhaled their charges, jumping blue lights danced around the glass envelopes. Music would then emerge from the speaker cabinet.

It was as if this curious assemblage were alive, waking up to perform its miraculous functions. If those had been the last tubes I'd ever seen, I'm sure I'd swear they were over a foot tall. First conclusion: It's OK to like tubes.

For six-year-olds, particularly those who grow up to be engineers, curiosity eventually leads to more direct involvement. (If observation is interesting, manipulation must be bliss!) I remember grabbing one of the 6L6s—I think it was the right-hand one—and yelling out as the heat singed my inquisitiveness. The next thing I remember was my mother telling me, with great urgency and unusual directness, never to play with tubes, hi-fi's, or electricity again. "Wow," I decided, "this stuff must be better than I thought!"

My parents loved music. I inherited that affection, but with some twists: when I hear "The Blue Danube," for example, I don't conjure up images of a placid river scene reminiscent of the Hapsburg dynasty; I envision a pair of 6L6s!

I had to be content with just watching those tubes until we added another piece of equipment to the hi-fi: a radio tuner. By this time—age eight or nine, perhaps—I was actually operating the hi-fi, but under strict instructions not to "play" with it. I began DXing the a-m broadcast band. My mother asked me why I preferred to listen to fading noisy signals rather than clear, clean local stations. That was a good question. In retrospect, I've reached a second conclusion: It's OK to listen to noise.

A few years later I began reading radio books written for young people. The Chicago Heights Public Library had three. Then I read about Amateur Radio and found that these guys didn't just listen, they transmitted—even farther than WLS!

One night as I was listening to Petula Clark sing "Downtown" on the old 6L6s, I heard "CQ CQ CQ 40 THIS IS W8MAE PORTABLE 9 OVER." A few days later I found out that it was a guy down the street who had just moved in. I rang his doorbell and told him I could hear him on my hi-fi.

"Well then," he said, "I'll stop transmitting."

"No!" I said, "I've read about Amateur Radio and I'm very interested in it!"

He invited me down into his basement. I'll never forget that station: an SX-25, Viking II, with matching matchbox and a myriad of accessories, all on an old

By Robert J. Zavrel Jr., W7SX, P.O. Box 23447, Tucson, Arizona 85734

January 1988
beat-up wooden desk. A partially rusted Ohio license plate — W8MAE — hung on the wall. QSL cards were strewn about, and there were tubes everywhere — on the desk (these were the important ones) and in boxes on the floor. There was even a “dead” one hanging from a noose strung from a nail in the wall.

Marty was the first guy to tell me he liked tubes. “So do I,” I said. He turned up the volume on the SX-25. 40 meters was filled with a-m signals. We heard a CQ, and he responded. A switch was thrown, the receiver went mute, a red light came on, and we were on the air. The room lights that were on dimmed, and those that were off came on. This, of course, was precisely the type of electrical chaos that appealed to southside juveniles!

Marty was bald. He was dressed in his work clothes: soiled green coveralls. A steelworker, he’d been transferred from Cleveland to Chicago Heights. This coarse-looking character, this man of blast furnaces and hot rolls, threw that switch — and with all the eloquence and reverence of a Shakespearean master, clutched the D-104 microphone and made the QSO. Meters moved, lights dimmed, and high-modulating iron vibrated to this rich, deep Midwestern voice, a voice heard across the continent. I was spellbound with the magic of radio.

With an Elmer only three doors down, I got my Novice license (WN9RAT) within a year. Soon I was putting up antennas and trying to work DX.

Back then, Novices could run 75 watts input. The transmitter had to be crystal controlled. Crystals cost $3 each, a goodly sum for 14-year-olds in 1965; spending all I had on radios, I was always broke.

My friends, who thought I was weird, were the first to ask the recurring question, “What do you talk about on the air, anyway?”

“Signal report, name, location,” I replied, “and then anything that I think of.”

“Sounds boring,” they said.

Remarks like these always left me feeling disappointed, as if I’d somehow failed to convey my enthusiasm effectively. Examining this disappointment years later, I thought about other hobbies. What good is a pilot’s license, for example, if no passengers or cargo are transported? The pilot flies from Point A to Point A. How silly! Obviously, if you have to ask the question, you’ve missed the point. Just as pleasure flying is flying for the sake of flying, Amateur Radio operation is operating a radio for the pleasure of operating a radio. It doesn’t have to be more, it doesn’t have to be practical, because it’s the practice of an art. My third conclusion, then, is that it’s not what you say, but how you say it — and Amateur Radio is a very subtle way of saying who and what you are.

Then there was Tri-Town, our local radio club — a whole room full of guys who liked tubes. (Some of the guys even liked transistors, but they were just too weird for me.) Most of the guys liked 2 meters and were talking about repeaters. Their single-channel 2-meter rigs were big . . . bigger, even, than my NC-300. The rigs had plenty of tubes inside them, and the tubes had something to do with “limiting,” though I didn’t know what that meant. My dismay peaked when I heard how much DX could be worked with these rigs; it seemed like an awful lot of tubes for just talking across town. I remember thinking that “limiting” meant “limited DX.” Looking back on that experience, I came to my fourth conclusion: It’s OK not to get excited about fm.

Ted, K9YOE, was a member of the club. A DXer, he lived at home while attending college. He had an NC-300, a Ranger, and a three-element tri-band quad atop his parents’ roof. Ted was — and is — the finest operator in my recollection. His ears had the precision of a 10,000-point, real-time Fast Fourier Transform processor. With his 60-watt output, he managed nearly 300 countries confirmed, all on CW and a-m.

QST includes transmitter power class in their listings of ARRL DX Contest results. In 1967 or 1968, the top three in Illinois were “Class C” kilowatts; Ted placed fourth with a “Class A” 60 watts, followed by any number of high-power entrants. Ted was “cool” — even my sister, who thought all my friends were nerds, asked who he was after he came over to visit. My fifth conclusion? You can be a ham and still be “cool.”

Another member of Tri-Town was Oak, a friend of Ted’s. Now W9RX, Oak had a massive station in his basement built into a large homemade cabinet. In his back yard, there was situated a 120-foot tower with a TH6DXX on top and a prop pitch motor at the base. A full-sized 40-meter dipole was attached to the boom of the TH6DXX, and a sloping dipole for 80 rounded off this five-band monster. Oak taught me an important lesson: It’s OK to be extravagant with hardware.

Most addicts end up pushing the stuff they need, eking out a living and subsidizing their habits in the process. Amateurs are no exception — in fact, they’re licensed by the authorities, with special spectral places set aside for their habitual indulgences.

My case is typical. Mom warned me about the habit, and then Marty, a casual user, turned me on. My need for DX led to harder stuff; I wanted higher and higher antennas. I went to work in radio broadcasting. Finally, I graduated to the Big Leagues with a degree in Physics. Now, through my work, I’m an international dealer.

Sometimes the question arises, “Do you want to kick the habit? Go straight? Drink beer with the guys at the local bar every night and watch football on TV?” My seventh conclusion: No way!
commercial television
part 2: hardware

Our ham's-eye tour continues — with a close-up look at the technology

In part 1 of this article I described the evolution of and standards for TV signals. In this installment, I'll describe how these signals are actually generated.

If you were to walk into a typical TV control room (and I'd suggest that you do), you'd find a dark inner sanctum glowing with the light of TV monitors and green oscilloscopes. You'd also be greeted with several — possibly several dozen — equipment racks loaded with apparently unidentifiable equipment, which is in fact, likely to consist of sync-related devices.

Although the actual sync generator is really rather small, every piece of video equipment must be timed with, or "locked into" it. If the sync generator is the heart of a TV station, the sync distribution system is the arteries and capillaries. Each branch of the arterial system is called a DA, or distribution amplifier. Figure 1 shows a typical sync DA system. As you can see, this scheme allows any number of sources to be driven. In preparing fig. 1, I stopped drawing at 16 video sources; I could have easily gone to 64 sources with just one more generation of DAs.

These video sources can be just about anything including cameras, VCRs, electronic digital effects, film chains, or test signal generators. Regardless of what they are, station sync must be fed to all of them. Obviously, the sync generator is critical to the system; if it dies, you go off the air. If you go off the air, you lose money. If you lose money, you lose. And if you lose, you wish you had a spare sync generator. Consequently, most stations have a spare sync generator ready to go on line at a moment's notice.

If you didn't read part 1 of this article, this part may make little sense. If you did read part 1, you already know all about the sync signal and why it's so important in TV. You may recall that I omitted satellite receivers from the list of possible video sources at the conclusion of part 1; this is because it's difficult to plug your DA into a satellite and lock it up to your TV station. So what do we do if we want to use a satellite image in our TV station without recording it? We lock our sync generator to the satellite instead. This technique is known as "gen-lock" in TV circles. A station that's gen-locked to a satellite will exhibit extreme stability and frequency accuracy. All satellite uplinks are already gen-locked to atomic clocks, so if you're in turn locked onto the satellite, you'll have atomic accuracy, too. We can gen-lock a station to satellite sync even if we don't want to use the video programming from that satellite; in this case, we're really using the "bird" as a cosmic timer.

how it works

So, how does a sync generator work? Actually, the generator is nothing more than a digital clock with a few steps added. All begin with a 3.58-MHz crystal oscillator. This oscillator is useful in certain studio equipment needing a subcarrier (SC) input. Although the example shown in fig. 2 is now usually built on a single IC, it's important to understand its function.

The 3.579545 signal, being a wave, isn't of a suitable shape for the subsequent digital dividers. So it first goes through a comparator, which is a device used to convert sine waves to square waves. (Back in the old days we would have used a Schmitt trig-

By Eric Nichols, KL7AJ, Box 0, North Pole, Alaska 99705
fig. 1. Typical synch distribution amplifier system.

The electronic equivalent of a toggle switch, to do the job. Now that we have nice square waves, we can use them to drive our digital dividers and multipliers. (As an extra credit project for you digital folks, try to figure out how to divide by 455 using JK flip-flops. That should keep you going for a while!)

A careful look at fig. 2 will reveal that all the important frequency relationships necessary for TV are right there. And you can see that the relationships allow for quite a simple circuit, logically speaking. Remember, this was all developed before microprocessors or even transistors were available! Certain experimental HDTV systems rely on the ability to shift these numerical relationships at will, which is an easy job with microchips. But we'll skip that discussion because this article deals with NTSC (see part 1, December 1987, page 57).

**Transmission line review**

Before I can discuss sync distribution further, I need to talk about transmission line theory. (This may be painful for some of you, but this subject is essential). A transmission line is a device for carrying signals from a generator to a load. These signals can be video, audio, sync pulses, or subcarriers. In NTSC television, the transmission lines for video and sync pulses are coaxial cables with a characteristic impedance of 75 ohms. The characteristic impedance of a coaxial transmission line is a function of the ratio of the inside and outside conductor diameters. Figure 3 shows the cross section of a high-impedance line and a low-impedance line. Notice that even though the outside diameters of each are the same, the impedances are different.

So, what does this all have to do with video transmission? Well, if video travelled through coax cable infinitely fast, there would be no significance. But electrical signals travel through cables at a finite speed, typically around 66 percent of the speed of light in free space. Because of this, we have the possibility of the signal being reflected from the receiving end of the line, if corrective measures are not taken to prevent
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fig. 2. Sync generator block diagram.

fig. 3. Low and high impedance transmission lines.
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IC-2AT Features. The IC-2AT is ICOM's most popular handheld on the market. The IC-2AT features a DTMF pad, 1.5 watts output, and thumbwheel frequency selection. The IC-2A is also available and has the same features as the IC-2AT except DTMF.

Accessories. A variety of slide-on battery packs are available for the IC-02AT and IC-2AT, including the new long-life 800mah IC-BP8 which can be used with both handhelds.

Other accessories include the HS-10 boom headset, HS-10SB PTT switchbox, HS-10SA VOX unit (for IC-02AT), and an assortment of battery pack chargers.

The IC-02AT and IC-2AT come standard with an IC-BP3 NiCd battery pack (IC-02ATHP comes with IC-BP7 battery pack), flexible antenna, AC wall charger, belt clip, wrist strap, and ear plug. See the IC-02AT and IC-2AT 2-meter handhelds at your local ICOM dealer.
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**KENWOOD**

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this. We prevent reflections by terminating the transmission line with a resistor equal to the characteristic impedance of the line. In video, we terminate the end of every coax cable with a precision 75-ohm resistor.

We could reverse the definition and say that the characteristic impedance of a transmission line is that which experiences no reflections when terminated with a known resistance. In other words, we can send a signal down a piece of transmission line which is unknown and change the value of terminating resistor until no reflections are experienced. Under these conditions we can then measure the value of our terminator, and then know that the characteristic impedance of our line is the same value. Fortunately we don't have to do all this in real TV, because we use only cables known to have a 75-ohm impedance, but we can still terminate a cable improperly by either using too many terminations or terminating the cable somewhere other than the end (non-terminal termination!)

What does an improperly terminated signal do? Depending on the nature of the original signal, reflections can manifest themselves in different ways. If the signal is continuous, such as an RF carrier, the signal reflected from the unterminated end recombines with the power going the “right” direction to form standing waves. These standing waves are voltage lumps and valleys which repeat at periodic intervals from the end of the cable. Also the input impedance will no longer be equal to the characteristic impedance of the line at every point on the line. Instead, we’ll have a high SWR. If the generator is an RF transmitter, retuning of the “finals” may be necessary to deliver full power into the line. Also, under certain conditions, a high SWR may cause undue stress on marginal coax cable.

Video and sync signals, by their very nature, are not continuous, and therefore reflections do different things to these signals. Since pulses from sync generators are of very short duration, it’s unlikely that a forward-going pulse and reflected sync pulse would ever overlap each other. So “standing waves,” as most radio people know them, aren’t the real problem. Instead, a sync pulse reflected from the end will be re-reflected from the sync generator and will reappear at the load end in a more or less random time, depending on the length for the cable. This causes “ghosting” or double-syncing. Unfortunately, these ghosts can’t be removed by reorienting the receiving antenna or twiddling the fine tuning knob on the receiver; instead these ghosts will be built into the transmitted signal!

The point of this is to say that it’s a good idea to terminate the cables in a TV plant properly. But proper termination of the cables hasn’t solved all our problems. You’d think that at 66 percent of the speed of light you wouldn’t have to worry about the time it takes for a video signal to get from point A to point B in a studio. Unfortunately, nothing could be further from the truth. One of the big headaches in TV engi-
neering is trying to insure that all the video sources arrive at the switcher (more on switchers later) at the same time.

Small mis-timings usually result in tiny color phase (hue) shifts between sources. This can usually be corrected electronically at the receiving end. Longer mis-timings result in a visible left-right shift of the picture. The only way to correct this is to make sure that all the video cables are the same length. This, of course, means that every cable is as long as the longest cable, regardless of whether you need that much stretch or not. That is why the first thing most people ask when they see a control room is, "Why do you have all that extra cable lying around?" I'd love to cut all the cables to just the right length and neatly bundle them somewhere, but I've never seen a TV control room where it worked out that way. TV is one place where you first make it work, and then you try to make it pretty. When you finally do find a place to put all the cable, someone wants to add a new video source, and then you go through it all over again.

video sources

Now that we've temporarily exhausted the subject of coax cables, let's talk about video sources. The first and most basic video source is, of course, the camera. I could trace the history of camera tube development, but I'll stick with the most common type of "eyeball," the vidicon. (There are several varieties of vidicons known as saticons, plumbicons, and Ledicons, but these are only chemically different; the actual wiring is about the same.)

A vidicon is essentially a backwards TV picture tube. Instead of using an electron beam to control the emission of light, we use a property known as photoconductivity to control an electric current. The main difference is that the screen of a vidicon is very small and perfectly flat. The screen of the vidicon is coated with a photoconductive layer of antimony sulfide. If we were to focus a visual image on the surface, we would, of course, have light and dark areas. The light areas are highly conductive, while the dark areas are resistive. As in any other tube, an electron beam emitted from a hot filament is focused to a very thin beam with magnetic yokes (coils). This electron beam is scanned across the glass disk by magnetic yokes much as it is in a TV receiver. The vertical deflection yoke does the same thing at a 60-Hz field rate. When a beam hits a light spot, it flows out of the signal electrode with ease. When it hits a darker spot, less electron current flows out the signal electrode. This signal fluctuates in accordance with the scan and illumination of the vidicon surface. Obviously, the narrower the electron beam, the better the resolution of the vidicon. Keep in mind that a full-size raster must be concentrated on a vidicon with a 0.66 inch face diameter.

The output of a vidicon is extremely weak and is not linear (i.e., in direct proportion) to the light falling upon it. The weak signal is accommodated by using a low noise field effect transistor. (This used to be done with low-noise triode tubes such as those in the famous Nuvistor series.) This preamplified signal then goes into a gamma corrector. Gamma is the mathematical name for the non-linear voltage characteristics of a vidicon. A gamma corrector is just an amplifier that has an amplification characteristic that is equal but opposite to that of the vidicon. What we get out of our gamma-corrected preamplifier is a video signal of a voltage directly proportional to the light level. Without gamma correction, we have contrast that looks washed at medium gray levels — not very pleasant to watch.
the sync adder

Now all we have to do is take our video signal and add it to our station sync. The device that does this is called a sync adder; its product is called composite video, or video + sync. Most cameras have internal sync adders.

Now we can take our composite video signal and feed it to a monitor by means of a properly terminated 75-ohm coaxial cable transmission line. Voila! A picture appears.

it's all done with mirrors

If we want a color picture, we just have to do the above three times; once for red, once for blue, and once for green. Figure 5 shows a color separator for a three-gun color camera. As you can see, it’s all done with mirrors. There’s actually no difference in the actual vidicons; the only difference is in the color light that’s fed to them. A vidicon doesn’t know anything about the color of light hitting it. It simply knows how much is there. You can’t tell blue video from red video from green video, either.

A dichroic is a mirror that transmits one color light and reflects another. I don’t know how it’s done, but expensive as they are, I’m not surprised that they do it so well!

The dichroic/mirror system separates all visible light into one of three vidicons. Now, what about colors that are neither red, green, nor blue? Are there any colors that never get transmitted at all? Yes! This is where all that psycho-visual testing (see part 1) came in: to determine which color frequencies we could do without. As it turns out, by combining the primary colors (red, green, and blue) colors, not enough gets left out to be easily noticeable. This is fortunate because we have only three colors to work with when we play the whole thing back. Fortunately, with only three colors, we can fake just about any color necessary. White is a combination of all three colors — but not in equal parts; 30 percent red, 59 percent green, and 11 percent blue gives you white. Now do you see why TV is such fun?

As I said in part 1, when no color information is present on a video signal, we have no 3.58-MHz subcarrier. Our video signal contains only luminence or brightness information. This occurs when the output from all three vidicons is in the 30:59:11 ratio. We achieve this by means of quadrature modulation or "IQ" modulation. "IQ" stands for "in phase and quadrature." (Quadrature simply means 90 degrees out of phase.) Although some knowledge of trigonometry is helpful in understanding quadrature modulation, it’s not essential. Basically, it consists of adding two carriers at 90 degrees and allowing them to add or subtract from each other by shifting their relative phases. Figure 6 shows this action. The top drawing shows the normal 90-degree phase between and I and Q. The middle shows the Q shifted to the left so that the two signals are in phase (0 degrees shift) and add. The bottom shows the shift to the right of Q and how the signals cancel out, leaving no amplitude on the resultant. In every case, though, the individual I and Q amplitudes are the same.
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**balanced modulators**

The actual phase shifting is accomplished with balanced modulators, the inner workings of which are beyond the scope of this article. Also in real life, the I and Q are both shifted, but in opposite directions. Now the only trick is to arrange things so that the condition of fig. 6C prevails when no color is present. In other words, we have to put the information from three cameras onto only two axes. This process consists of what's known as matrixing, and a matrix is nothing more than a bunch of precision resistors. The sum of I and Q modulator outputs will be 0 (no carrier) when the output from each of the matrices is equal and opposite in polarity. Keeping in mind that magical 30:59:11 ratio, we find that with the given resistor values, this will occur when the output from each gun is equal. (I'm not going to do all the addition here, so take my word for it!) All that's left is for us to do a couple of 180°'s and our signals will cancel rather than add. (Notice the 180°-degree phase shifters in the I and Q matrix.) The point here is that we have combined three guns into two modulators. Now if anything changes to upset the balance of our guns, such as when the input includes color, our balanced modu-
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lators will be unbalanced, allowing some 3.58-MHz carrier to leak out. This carrier will be compared in phase to the color burst in our receiver (see part 1) and decoded to give the right color.

the switcher

Now that we've generated a color signal with our camera, we need to run it to the switcher, the brains of the TV station. A TV switcher is just a switchboard that selects video sources. However, it must do so without introducing any visible glitches. It does this by switching during the vertical interval, that period of time between the frames when nothing is showing. How does the switcher know to do this? That's right; it's fed sync from the DA system.

When you push a button to select another camera or, for example, a VCR, the switcher waits a 30th of a second or so until it sees a vertical sync pulse and then throws the switch. In actuality, the switches in the video path are saturated FETs, which make almost ideal video gates.

Switchers can do other things besides selecting sources. They can do fades, wipes, and synthetic coloring. Switchers that do this are called SEGs, or special effects generators. A vertical wipe is easy; all the switcher does is wait a precise amount of time after the vertical interval to switch from one source to the next. This timing is selected by a joystick or fade/wipe bar. As the bar is moved down, it merely increases the delay time between the vertical interval and switch-over time. For those of you familiar with test equipment, this is identical in function to the "delayed sweep" mode on an oscilloscope.

After we do our switching, we need to run our signal to our transmitter. If our transmitter is on a distant hill, we send our video to a studio transmitter link (STL), which is no more than an fm microwave transmitter operating at 2, 7, or 13 GHz. STLs are extremely wideband; this allows us to get video from point A to point B with no measurable distortion.

Before we feed our STL or transmitter, we usually run our video through a processing amplifier or "proc amp." This device cleans up any garbage our sync pulses have accumulated in their course through the switcher. Also, unless you're using 2-inch quadruplex videotape equipment, the sync level is going to be off the chart. But that’s going to be off the chart. For some reason, 3/4-inch and 1/2-inch helical VCRs can't reproduce a decent sync pulse. The proc amp also allows us to adjust color burst amplitude and phase, and to set overall video modulation and setup level. It's sort of a final inspection before the signal hits the airwaves.

The first thing our video sees when it reaches a transmitter is a receiver equalizer or "predistorter" that compensates for delay time errors all TV receivers experience because of the intercarrier sound system mentioned in part 1. Rather than require that receivers fix their own problems, the FCC makes the broadcaster compensate for poor receiver design by introducing the opposite problem at the transmitter; hence the name "predistorter." Without receiver equalization, a color receiver has a comic effect; this is caused by the color information taking longer to get through the receiver circuitry than the luminance information. So the receiver equalizer introduces an equal but opposite frequency vs. time delay before it even gets to the transmitter. The receiver equalizer uses circuits known as all-pass filters to do this.

After we’ve butchered our perfectly good video with our receiver equalizer, we run it into an optional differential gain corrector. This is similar to a gamma corrector except in that it compensates for nonlinear responses in the power amplifier of the visual transmitter. Usually this circuit is bypassed when the tubes are new. As they get "soft," we can start adding gain correction. When the gain corrector can no longer do the job, we change the tubes. (Not a pleasant task at a minimum of $5000 for a moderate-power VHF transmitter. The price rises to $35,000 for a typical UHF transmitter.)

From here, it goes into an endless variety of modulators. The trend these days is to use a low-level modulator so we can use the same exciter to run any power level of transmitter. Our output power is then determined by how many stages of linear amplifiers (afterburners) we want to use. Our Harris BT5L transmitter uses a diode ring modulator, similar to the type used in many Amateur SSB transmitters. This system is very linear and broadbanded — i.e., high fidelity. Next we eliminate the lower sideband with a novel type of filter called a SAW (surface acoustic wave) filter, which is actually an electromechanical device that uses the properties of shock waves rippling across a piezoelectric crystal to achieve very precise frequency filtering. It requires no adjustments or tuning.

All this is done at about 37 MHz. From here, it's converted to the channel of operation. Almost all TV transmitters are hybrid — i.e., they use both tubes and solid-state devices. Vacuum tubes still offer clear advantages at high power levels.

Next we take our high power output signal and run it through a diplexer. Doing this allows us to use the same antenna for both transmitters. Both the diplexer and antenna are designed for optimum bandwidth. The system must exhibit less than 1.05:1 SWR over a 6-MHz wide channel. The shape of the batwing antenna is the key to this bandwidth. By using two batwings positioned at right angles and fed 90 degrees out of phase electrically, we can achieve a nearly circular radiation pattern (see fig. 9).

Figure 10 gives a crude explanation of how a bat-
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wing shape ensures broad bandwidth. The short dipole is resonant and works well at the top end of the channel. The long dipole is resonant at the bottom of the channel. By making a batwing sheet, we actually have an infinite number of dipoles of different length.

Any frequency signal falling within the 6-MHz limit will find a dipole of the correct length. This scheme has no effect on the directional characteristics of the system. Batwing antennas are all horizontally polarized. Circularly polarized TV antennas follow configurations other than the batwing, but that's a different subject altogether.

One major refinement of the batwing that makes this description a little too simple is that these things are firmly bolted to a solid steel pole. A few tricks are necessary to make the pole look like it isn't there, electrically speaking. Because the use of insulators is prohibited mechanically, the problem becomes even more amusing; actually, it isn't as difficult as it may seem, though it does require some understanding of advanced transmission line theory. We use the principal of shorted stubs, sometimes facetiously called "conductive insulators."

Speaking of transmission lines, these antennas are fed with 50-ohm transmission line, which is standard practice for RF power applications. Unlike flexible coax, 50-ohm TV transmission line measures 1/12 inches in diameter, contains solid copper pipes for both inside and outside conductors, and is very expensive...but then again, so is most of the materials and equipment that are used in TV.

Though I've now described a TV station from videocon to antenna, I've obviously left many questions unanswered. But by now you should at least know what those questions are. As I mentioned at the beginning of part 1, NTSC isn't the perfect system, but it works.

If you think you could do the job better, you're probably right — and there's probably a TV station somewhere that could use your ideas.

---

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Ode to older oscilloscopes

Old tube-type oscilloscopes are often available at flea markets at very little cost. Until the 1940s and 50s or so, oscilloscopes produced for most technical work were “recurrent sweep” models. This meant that the spot of light on the tube face swept continuously across the tube face, whether there was a signal to monitor or not.

Shortly thereafter the design of general purpose scopes underwent several dramatic changes. Older scope designs were inadequate for the tasks demanded of them by technicians and engineers. As newer designs evolved, the recurrent sweep type was replaced by the “triggered” sweep, in which the spot of light on the tube face swept across only when there was a signal present. By allowing the signal to control the sweep, a much more stable visual display was obtained. Better response at higher frequencies was another welcome improvement.

The newer scopes were easier to use, and would do things that the older models would not: for example, they would provide more accurate traces of higher frequency signals than the older ones. The sometimes jumping, jittery trace of the older recurrent-sweep scope was now replaced with the rock-solid, easily controllable, triggered trace.

The newer scopes were such a pleasure to operate that, by comparison, the ones they had replaced came to be viewed as relatively worthless relics.

Although the really worn-out older scopes are probably better left on the scrap heap, many of them are still in fair shape, and remain good performers for some uses. Note that I say “some uses.” I don’t mean to suggest that the older models are at all comparable to today’s scopes in performance; they are not. On the other hand, the older scopes can perform several tasks that are of considerable interest to many hams and radio buffs, and do them quite well. Let’s take a look at some of these applications.

**rf applications**

One useful application is the viewing of signals tapped from your receiver’s i-f section. Some receivers and transceivers have an output jack for this function. When used in this application, your scope trace will show you such things as the modulation characteristics of received signals in phone work, or the keying characteristics of CW signals (see fig. 1A and 1B).

Once I was given an older scope when I bought some other items at a flea market. Sometimes these old scopes work without repair; others may need minor repair. Luckily I found that all mine needed was the replacement of two tubes. *If you tinker with the innards of an oscilloscope, remember that there are very high voltages in most of these units.* Reduce the chances of sending an electrical current through your heart by following the slogan, “One hand in the circuit, one in a pocket.” My “free” scope now sits alongside my operating table (see fig. 2). Using it to view signals from my transceiver’s i-f, I find it’s a pleasure to be able to check the received signals by just glancing at the CRT. Such an accessory provides an education in judging signal characteristics.

Other rf applications for some of these scopes stem from the fact that, on various models, there was a means of connecting the test leads from rf signal sources directly to the deflection plates of the CRT itself! To locate the connections to these plates, look for a small porthole on the side of the case, near the neck of the CRT. The direct connections were neces-

By W. Clem Small, KR6A, R.R. 1, Box 181, Salisbury, Vermont 05769
necessary for rf work because the amplifiers used in these scopes had a much lower frequency response than those used in modern scopes. So by going directly to the CRT tube elements and bypassing the amplifiers, the amplifier-response problems were solved! By this direct-connection method, the older scopes could be used to view rf signals in the hf region and beyond.

Most radio handbooks include examples of other applications appropriate for these older scopes.

**tuning indicators**

RTTY, AMTOR, and other popular modes of communication perform only when the received signals are properly tuned in. Many of the interfaces in use for these modes of communication have outputs that can be connected directly to the inputs of the older scopes. The ease of tuning in a reluctant RTTY or AMTOR signal with a scope indicator can be appreciated only by one who has experienced it (see fig. 3). The new LED tuning indicators do work to a degree, but when it comes to tuning in a difficult signal, they don't hold a candle to an oscilloscope of any vintage. The older scopes are superb for this application. (I have a small, old Heathkit scope that's great for this job. That scope is located above, and to the right of the transceiver — see fig. 2.)

---

**fig. 1.** Scope traces: (A) sideband signal; (B) CW signal.

**fig. 2.** Two recurrent-sweep scopes are used; larger to monitor receiver i-f, smaller as RTTY tuning indicator.

**fig. 3.** Common ellipse pattern seen when turning the mark and space of an RTTY signal.
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audio too!

We mustn’t forget that the old scopes did a pretty fair job in audio work. Looking for distortion, clipping, and the like is a simple matter with a scope. Figure 4 gives an idea of how easy it is to see distortion present in audio signals.

Next time you come across one of yesterday’s oscilloscopes, think of all the fun — and even education — that you can get by applying one or more of the ideas covered above. With the price range of contemporary scopes in the hundreds and even thousands of dollars, using yesterday’s scopes today isn’t such a bad idea after all.
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drift and shift

Few circuit problems are less welcome than frequency drift — a gradual change of frequency, usually as a function of temperature — and shift, an abrupt change of frequency. Although the causes of these two related phenomena are different, they’re often confused with each other.

There’s also a difference between problems with new projects and drift in old equipment that once worked well. In a newly constructed project, or in new equipment from less reputable sources, the problem may well be an inherent error in the design. Some of these errors are easily corrected, while others are not. In equipment that once worked well, however, it’s more likely a matter of a failed component.

frequency shift problems

Resonant circuits in modern electronic equipment might be LC tuned by a combination of inductance and capacitance, or tuned by a piezoelectric resonator element ("crystal"). In either case, the cause of a sudden unwanted shift of operating frequency is usually related to some form of mechanical trauma somewhere in the circuit. In other words, some component has either broken down or suffered an intermittent connection.

Figure 1 shows a partial circuit of an oscillator. The resonance of this circuit is determined by the combination of $C_1$, $C_2$, $C_3$, and $L_1$. If any of these components fails, changes value, or becomes disconnected, then the resonant frequency of the circuit will shift. If coil $L_1$ fails, the circuit will probably cease oscillating, so the fault will be obvious. But what if one of the capacitors fails? In that case, the circuit may well continue oscillating, but at a different frequency than before.

The trimmer capacitor was selected for our example in fig. 1 because those components seem especially at fault. After many years of experience, I can attest that trimmers seem to have a high casualty rate. Perhaps the worst offenders are the half-turn type that use silver deposited on a pair of ceramic surfaces. The mica compression types also fail, but at a lower rate than the other types. The failure mechanism seems to be looseness in the adjustment screw. Tap the capacitor gently with an insulated probe, and note whether or not the shift occurs.

Don’t make the mistake of assuming that the other forms are fault-free — far from it. Every form of fixed capacitor has at least a small failure rate, with failure usually attributable to disconnected leads inside the body of the capacitor.

Also, don’t overlook the possibility that the problem is due to the solder connections on the capacitor, especially where the capacitor is mounted on a printed circuit board that flexes easily. Although some bad joints slip past the eye of the factory Quality Assurance (QA) inspector — and subsequently last for years before failing — others die an early death because of trauma or flexure of the board. In addition to solder joint breaks, it’s also possible that the printed wiring track is cracked. In both cases, a little solder and a hot iron will solve the problem.

One of my colleagues is a ham who has a receiver-transmitter pair that was once the top of the line in Amateur circles. He noticed that the formerly very good receiver dial calibration was now about 25 kHz off. On inspecting the local oscillator VFO circuit, he found that the LO VFO contained a number of small fixed capacitors in addition to the frequency-setting trimmer and the main tuning variable capacitor. He made a few quick calculations of resonance to see which, if any, would result in about 25-kHz shift if it were open. He quickly identified a 27-pF unit that was part of the tem-

When you find a disk ceramic capacitor with a specified temperature coefficient, please don’t make the mistake of thinking that a low-temperature coefficient type is a better replacement. And don’t use another disk with a different temperature coefficient!

On older receivers, be sure to examine the main tuning capacitor for problems. I once had a terrible problem with a piece of equipment that exhibited both shift and drift in magnificent proportions. Although employed in a communications shop at the time, I didn’t get around to fixing the receiver for several months (the cobbler’s kids go-without-shoes syndrome). When I looked into the problem, it turned out to be dirty grease under the rotor grounding spring on the main tuning capacitor. That capacitor rotor is normally grounded to the chassis through its own frame. But because the rotor must move, a brass or steel grounding leaf spring or “spider clip” is usually placed around the rotor at the front bearing. The spring or clip grounds the rotor to the frame. But in that case, dirty grease had built up under the spring. Rather than causing operation to cease, however, the grease caused massive frequency shifts, drift when it wasn’t shifting, and a sad tendency towards microphonics.

Another problem in older receivers is poor grounding. I’ve seen frequency shift problems in many car radios, in two-way radios, and in other rf equipment caused by poor grounding or cracked ground tracks on the printed circuit board. In one infamous fm model, the fm front end was ground-
ed at only two points on the printed circuit. If that wasn’t bad enough, the ground ran around the edge of the card, and was stressed at one point... where cracks tended to develop. Although the circuit wouldn’t cease oscillating, the extra several inches of ground line on a flexing board caused operating frequency shifts. I suspect that the cause of the frequency shift was the added inductance of the printed circuit ground path.

At VHF frequencies the effect of distributed inductance and/or capacitance is more profound than at low frequencies. Again, judicious use of a soldering iron not only repaired the break but also added strength to the weak point.

**frequency drift problems**

Unfortunately, most electronic components exhibit some temperature sensitivity. This sensitivity is usually measured in terms of a temperature coefficient which specifies a certain shift of value in parts per million (PPM) per degree Celsius of temperature change. The temperature coefficient (or, casually, “tempco”) can be either positive or negative. A positive temperature coefficient (PTC) indicates that the component value will increase as temperature rises and decrease as temperature falls. A negative temperature coefficient (NTC) indicates that the value will decrease as temperature rises and increase as temperature falls.

Most inductors used in oscillator circuits have a PTC problem. The value of inductance (in microhenrys) is determined by the coil dimensions and the number of turns of wire. While the turns count remains constant, the diameter, length, and size of the wire used in the inductor are temperature-related.

The temperature coefficient of inductors can be minimized by design. If the inductor uses Litz wire (or some other low-tempco wire) and a low-tempco coil form, then the temperature coefficient is reduced tremendously. Old-fashioned cardboard forms are terrible sources of drift. According to

---

**fig. 2.** (A) LC-tuned VFO showing resonant tank circuit: (B) Piezoelectric crystal oscillator.
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January 1988
standard wisdom, the best forms are ceramic, but that's not true any longer. Fiberglass and other synthetic materials now provide better tempco characteristics.

Capacitors are also sources of temperature coefficient problems. Ceramic capacitors are available in either PTC, NTC or no-TC versions. Markings of "Nxxx" and "Pxxx" indicate the direction and value of the temperature coefficient. For example, an "N750" is an NTC device with a tempco of 750 PPM. The capacitor marked "NPO" has a low tempco, but it isn't precisely zero — as some people find out to their chagrin when they try to substitute really low-tempco caps with NPO ceramic units. In general, silver mica and polystyrene capacitors are the lowest-tempco units available.

So why not make all capacitors with low or nearly zero tempcos? Because they're sometimes used in temperature compensation circuits. Figure 2 shows two forms of oscillator, one LC tuned and the other crystal tuned. Both of these oscillators seem to have "extra" capacitors in the circuit (for example, C2 in fig. 2A and C1 and C2 in fig. 2B). In these cases, the extra capacitors are used for temperature compensation. They typically have small values compared with other circuit capacitors, but have precalculated temperature coefficients that will cause the capacitance to change a predictable amount with changes in temperature. Both circuits, even the crystal oscillator, will change frequency with changes in circuit capacitance, so the tempco of the compensation capacitors forces the frequency to change in a predictable manner. The idea is to counter the positive temperature coefficient of the inductor with an equal and opposite direction temperature coefficient of the capacitors.

Unfortunately, even some manufacturers don't understand drift. Several years ago, in my column for Worldradio, I passed along a request for information sent in by an Amateur working in the jungles of central America. He had a low-cost transceiver that had made a brief splash on the Amateur market. His problem was that it drifted badly, and, in fact, had always drifted, even when it was new. My request was answered by an engineer at Stoner Communications who passed along the information that the rig had been designed by a consulting design engineer whose reputation is spotless. His name is well known to technically oriented Amateurs, but in this case I suspect he would prefer to remain anonymous.

The designer reported that the original prototypes and first production units had a drift spec of 100 Hz in the first 15 minutes, and 50 Hz per hour thereafter . . . not terrific, but good enough for an inexpensive rig. The early rigs actually met the specification. So what happened?

According to the designer, the original design used Litz wire in the VFO inductor and a special low-tempco fiberglass form. The VFO also used DM-25 silver mica capacitors, except for a couple of ceramics used for temperature compensation. The inexperienced manufacturer, however, had employed a "kid technician" to redesign the rig to make it cheaper to produce. He replaced the Litz wire with enameled wire, the coil form with an off-the-shelf ceramic type, and the DM-25 SM capacitors with NPO disk ceramics. The result was a disaster.

Figure 3A shows the block diagram of an fm receiver. The local oscillator (fig. 3B) is kept on-channel by a dc control voltage from the automatic frequency control (AFC) output of the fm detector stage. The actual mechanism of frequency control is the variable capacitance (varactor) diode in the oscillator circuit (CR1 in fig. 3B). This type of diode is used in both LC-tuned circuits, as it's used in broadcast receivers as well as in crystal-controlled units used in communications equipment. If the varactor becomes defective, it will cause a frequency

![Diagram](image-url)
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shift; on the other hand, if the diode is intermittent, the circuit will jump on and off the channel as the diode opens and closes the circuit. Over the years, I’ve seen, however, quite a number of sets in which a newly developed (as opposed to inherent) drift problem was caused by a defective diode. For some reason, the diode capacitance was a function of temperature. I once measured — more casually than scientifically — about five diodes that showed this effect, and found that all had excessive leakage resistance in the reverse-bias direction.

Don’t overlook the dc power supply as a potential source of drift problems! Oscillators typically require fixed, well-regulated dc operating potentials for best stability. That dictum applies equally well to both LC-tuned and crystal oscillators. If the dc voltage, or bias voltages, change, you can expect the oscillator frequency to shift.

The problem with dc voltage is especially acute in mobile equipment, whether designed for communications or broadcasting. In the early 1960s I worked in a car radio shop that dealt with Blaupunkt receivers, the German-made radios found in Porsches, for example. One customer came in with an odd problem: his radio changed frequency with changes of engine speed. That set, which used vacuum tubes, had a germanium diode across the resonant circuit to limit oscillation amplitude. A gas-regulator tube that was supposed to keep the potentials applied to the circuit was defective. Because the power supplied to the radio varies markedly with engine speed, the now-unregulated power supply voltage applied to the oscillator also varied. Although I frequently chuckled at customers’ diagnoses, I never again doubted this customer’s description of the symptom: “... it changes stations when I pull away from a light!”

Modern mobile electronic equipment is probably more subject to this type of fault than some of the older equipment. In communications equipment and fm broadcast receivers, the oscillator voltage is typically regulated. In fig. 4A we see the zener diode regulator generally used in many car radio circuits; in fig. 4B, we see the threeterminal IC voltage regulator that keeps the oscillator voltage to +10 volts in a certain mobile transmitter master oscillator. If any of these components fail, shift or drift will result.

The nominal “12-volt” vehicle power supply is actually quite variable. With the engine off, my own car measured 11.8 VDC on one meter, and 12.05 VDC on my DMM. When the engine is started, however, the voltage varies from 12.3 VDC at an idle to 14.5 VDC as the engine speed is increased. To an oscillator inside electronic equipment, that range might be intolerable.

Crystal oscillators aren’t immune to drift problems, even when they previously worked well. In addition to the problems with dc power supplies mentioned above, it’s also possible for the crystal to become defective. Over the years, I’ve seen several sets in which a terrible drift problem resulted from defective crystal elements. Replacing the crystal solved the problem.

**problems peculiar to older equipment**

Certain older Amateur equipment exhibits a problem in frequency shift that’s due to the use of ferrite cores in the VFO and i-f coils. Ferrite cores age with time and heat, and as a result have a different permeability than when the equipment was first calibrated. I’ve seen that problem even on the legendary Collins Permeability Tuned Oscillator (PTO) used in their Amateur and commercial communications equipment. In some cases, a simple realignment will suffice to bring the coil back to the correct resonant frequency. In
other cases, replacement of the coil, or at least the ferrite core, is required.

Several years ago I had the opportunity to help a Novice on the air with a 20-year-old Heath DX-60B he bought for a song at the Gaithersburg Ham-fest. He complained that keying was erratic: sometimes it keyed, other times it didn’t. It rapidly became apparent by looking at the grid and plate meter readings that the oscillator wasn’t running all the time. It turned out that the DX-60B crystal oscillator circuit uses a tuned plate circuit. The ferrite core of the coil had dried out over the years and mistuned the oscillator. Readjusting the coil made the oscillator run properly.

heat problems

Because the source of many drift problems is the temperature coefficient of capacitors and inductors, it seems obvious that temperature needs to be controlled in radio equipment. In the past, several otherwise well-regarded pieces of equipment suffered drift because of the tremendous heat buildup inside the cabinet. In some cases, ventilation and a blower might help; in other cases, using a little insulation in and around the offending oscillator is also helpful. In certain crystal oscillator circuits we can make progress by designing in a crystal oven to keep the crystal temperature constant.

equipment modification

Amateurs have a long tradition of modifying commercial equipment. Although many mods are ill advised, some are certainly worthwhile and well engineered. The process is a lot less dangerous, incidentally, if you make good notes so that the rig can be restored to original condition if the mod doesn’t work out as expected. For most equipment, the first place to start is to make sure that the power supply voltage to the oscillator is stable. Check to confirm that the printed circuit board, its mounting, and individual components, are solidly anchored. Finally, make sure the circuit isn’t overheating.

If those methods fail to solve the problem, then and only then dive into the circuit to attempt temperature compensation. We’ll look into the subject in a future column. If you have any insight on procedures or techniques, please communicate them to me so that they can be shared with others.

conclusion

In many cases, the sources of frequency shift and drift problems may be difficult to detect. Understanding the causes and potential solutions of these problems goes a long way toward finding and correcting the fault.

I’d be happy to receive your comments, questions, and suggestions for future columns. My 1987 (and earlier) Callbook address is incorrect, so please contact me at P.O. Box 1099, Falls Church, Virginia 22041.

—David E. Fisher

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Asked to name a problem that universally impairs the pleasure of operating most mobile stations, regardless of mode or band, most hams will say, "a serious lack of adequate receiver audio." This isn't surprising, considering the micro-sized speakers that are now standard in new radios.

Miniaturization isn't a problem in the average Amateur home station, where the sound produced by a 2-inch speaker is more than adequate, but it does present a problem when a radio is mounted under the dashboard of a car. Typically, the speaker ends up directing its puny audio towards the floor, away from the driver, and into heavy carpeting — with dismal results.

This weekender shows how to overcome that problem. My external speaker, combined with an integral amplifier, provides enough audio for any situation. Used with a radio equipped with an external speaker or earphone jack, it will produce several watts of loud, crisp audio. A few milliwatts of audio will drive it to full output.

You can also add this amplified speaker to any of the popular hand-held VHF transceivers. By doing so, you'll improve your audio and dramatically extend the life of your hand-held's battery. You may also find that other small portable radios, scanners, televisions, cassette recorders and similar items can also make good use of this project.

the circuit

The amplifier circuit is built around the LM383 IC, which I chose because it's stocked by Radio Shack and is carried by RCA SK replacement-device dealers. Actually, almost any audio IC intended for 12-volt operation and capable of delivering 4 or 5 watts of audio will work, providing the necessary circuit changes are made. Figure 1 shows the schematic for the LM383 amplifier.

An input attenuator composed of resistors R1 and R2 reduces the audio level and prevents overdriving the amplifier. The 22-ohm resistor provides a low-impedance termination for the receiver audio stage. These three resistors weren't included on the pc board layout, but instead were mounted on a phenolic tie-strip to allow quick empirical substitutions to be made.

Negative feedback is used in this amplifier to improve its linearity and bandwidth and to set the closed-loop gain. The 2.7-ohm resistor sets the feedback level. (This value was optimum for this application. Values from 1 to 4.7 ohms may better suit other applications requiring more or less gain.) Capacitors C2 and C3, which help prevent rf detection, are mounted on the foil side of the board using short leads. Shielded audio cable, or even RG-174, should be used for audio connections between the speaker and radio.

how much audio is enough?

This amplifier will drive speakers between 2 and 16 ohms impedance. However, the load impedance sets the maximum audio power. Assuming a 13.8-volt supply, a 4-ohm speaker will allow about 5 watts of audio, while with a 2-ohm speaker the amplifier will deliver nearly 8 watts. Four watts of audio into an efficient speaker system is one heck of a lot of noise; a 4-ohm speaker will do well here.

putting it together

The amplifier is built on a small section of copper-clad PC material. Although this amplifier is intended for audio, a-f ICs will often perform well into the rf frequencies, so good hf practices — a wide, low-impedance ground plane, adequate bypassing, and short leads — must be followed if instability is to be avoided.

Stability is further enhanced by the use of inverse feedback and by the presence of the 0.22-μF capacitor swamping the amplifier output.

To reduce failures caused by mechanical vibration, larger parts, such as electrolytics, may be fastened to the board with a strip of silicone adhesive. The tab of the IC must be heatsunk; either the metal speaker enclosure or a piece of aluminum should be used. Use thermal compound between the LM383 tab and the heatsink.

selecting parts

Don't worry if the exact capacitor values aren't available; considerable leeway is permissible here. But choose the enclosure and speaker carefully. This isn't the place to cut corners. Select a rugged speaker with
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installation
Once the amplifier is built and test-
ed (and, I hope, working) it's time to
install it in the vehicle. Mount the
speaker in a clear, unobstructed spot
from which the audio can be directed
at the driver. Power may be taken from
the fuse block; look for a point labeled
"accessory" or "ignition." Usually a
female or male spade connector is
needed to make the power connec-
tion. Most automotive stores carry an
assortment of these crimp-on connec-
tors. Be sure to fuse the power lead
near the power take-off point. Some
cars may not have points available to
take the power off the fuse block. For
these rare instances it's possible to
purchase special "piggy-back" con-
nectors that allow additional connec-
tions to be made to existing fuses. If
alternator whine or other automotive
electrical noise is objectionable, try
taking power from a different point.
Going directly to the battery often
works well, but then a power switch
will be needed on the speaker. A brute-
force filter, consisting of a choke and
filter capacitor, is available from Radio
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I hope this speaker will increase your
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**Locator field list**

**Do you like challenges?** If the widespread acceptance of the DXCC, WAZ, and sundry other operating awards proudly displayed by Amateurs throughout the world is any indication, I'm sure you do.

Folke Roswall, SMSAGM, has taken it upon himself to compile, on a per-band basis, the total number of fields worked by individuals. This list appears in ham radio four times a year (see page 75 of the July issue for the first list published in these pages).

"But," you ask, "What's a field?" Glad you asked. According to the Maidenhead Locator system, the world is divided into 324 fields, or areas, each 20 degrees wide in longitude and 10 degrees wide in latitude. Though most encompass land masses, quite a few do not; this means no countries, no islands, no reefs—just water. So even if you've worked every country in the world and your name is at the top of the honor roll, you still probably haven't worked all the fields. For example, I'm very active on 80 meters, yet I've been able to snap only 148 out of 324 fields. I can think of a number of other 80-meter operators who are even more active than I am.

Have I tickled your competitive spirit? Think of the ultimate challenge: work all fields on all 19 bands on one specific mode. Some quick calculating shows that to be...uh...6156 contacts. That'll keep you off the streets (but probably get you into trouble with your family, your employer, etc.). Seriously, it's all for fun, and you'll learn a little more geography in the process.

All the necessary details are included on the accompanying chart. Folke would be very glad to hear from you. Please send your tabulations directly to him (his address at the bottom of the chart)—not to ham radio.

See you on 80!

---

**LOCATOR FIELD LIST**

**1987-09-30. COMPILED BY SMSAGM (JOIN DKK). WHO WILL BE THE FIRST RADIO AMATEUR TO WORK ALL 324 FIELDS ON THE SAME BAND?**

<table>
<thead>
<tr>
<th>AJ</th>
<th>BJ</th>
<th>CJ</th>
<th>DI</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>BJ</strong></td>
<td><strong>CJ</strong></td>
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<tr>
<td><strong>1.8 MHz</strong></td>
<td><strong>1 WJJR FN</strong></td>
<td><strong>25 WSMJ TC</strong></td>
<td><strong>35 WSMO LG</strong></td>
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<td><strong>30 WSMO YJ</strong></td>
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<td><strong>1 NWJY XJ</strong></td>
<td><strong>24 WSMO JN</strong></td>
<td><strong>34 WSMO JN</strong></td>
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</tbody>
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**Rich Rosen, K2RR**

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January 1988

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This list shows the number of fields worked according to the Maidenhead Locator system. A field is a block of 20° (longitude) × 10° (latitude). Rules: 1. All fields must have been worked via passive reflectors. 2. All stations involved must be on the earth's surface. 3. QSL cards are not required if you are sure that the other station considers the QSO complete. 4. All QSO's must have been worked from points within 3000 km of the reflected signal's origin. 5. There is no processing time for contacts to be eligible. A world map showing the 324 fields can be found in "The Radio Amateur's World (Locatlas) Atlas," that normally should be available at your national amateur radio society.

Compiled quarterly since 1982, the list shows the situation on March 31, June 30, September 30 and December 31 at 2400 UT. Please send your info as soon as possible after each date to SMSAGM, Folke Roswall, Vasterkarslingan 50, S-194 25 Asunden, Sweden, Tel: 08-704-2786.
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the year was 1923 . . .
It all happened about 65 years ago. There were only a few thousand Radio Amateurs in the world. Many of them dreamed that they would someday converse across oceans. But though Americans had indeed heard a few European ham signals and hundreds of United States signals had been heard in Europe, it seemed that a two-way transatlantic QSO was virtually impossible.

However, on the night of November 27, 1923, the impossible happened. Leon Deloy, 8AB, of Nice, France worked Fred Schnell, 1MO, and John Reinartz, 1XAM. Four thousand miles of distance had been conquered in just a few hours. As 8AB said to 1MO, “This is a fine day.”

I had known John Reinartz for some years. He never tired of telling the thrilling story of that first contact. Deloy, 8AB, worked many American stations after the record-setting QSO, but it wasn’t until December 8 of that year that contact was established between u1MO (Kenneth Warner) and g2KF (J. Partridge), and the radio barrier between America and England was broken.

When I asked John why the first QSO was between USA and France rather than the United States and England — especially since 8MO was located on the Mediterranean coast of France, a good 700 miles further from the east coast of the United States than the British hams, who were centered around London — John had no answer, but explained that 8AB was always consistently louder than the British signals. I asked myself whether it was a matter of power, a better antenna, or a better location at 8AB. I thought I’d never know.

a visit to 8AB
The whole story passed from my mind until 1976, when I was living in Monaco and operating 3AOAF. Conditions from Monaco to the United States were spotty. Good openings were possible in the afternoon around 1600 UTC, but propagation was via the long path. That was a beautiful shot — downhill a short distance, then across the Mediterranean to the United States. Signals from California and other west-coast stations were strong and consistent. But working the United States from Monaco, the short path was a different story. Directly behind the principality, the French Alps towered thousands of feet in the air. The short path to the United States was a tough one, and only the stations on the easternmost coast of the United States could be worked. It was very difficult to work into the Midwest.

Observing this problem first-hand, I began to wonder how Leon Deloy had managed to work the Americans with such a robust signal. After all, Nice was only a few miles from Monte Carlo. How had 8AB conquered the French Alps with his primitive radio equipment?

I knew Leon was retired and living in Monaco. After much hesitation, I looked up his number and called him on the telephone. John Reinartz, who had met him years before, had told me that Leon spoke excellent English. So when he answered the phone, I wasn’t surprised to find that I had no difficulty explaining who I was and asking if he would consent to a short visit and an interview. Delighted, he invited me over for tea. Since he lived just a few blocks away, I walked to his home, where he greeted me at the door. As we sat sipping tea in his library, lined with books and decorations he had received from the French government for his work in communications, he told me the story of his record-breaking transatlantic radio work.

Hard work, good equipment, good operating technique, and a good antenna were the answer. The year before the great achievement, Leon had visited several prominent stations in the United States, observing their equipment, listening to band conditions carefully, and noting operating habits. He purchased some of the latest radio equipment to take home with him and spoke at length to Reinartz, examining his station carefully. Returning to his home in Nice, he put into practice what he had learned. When his station was assembled, he cabled the ARRL and told them he would transmit on the exceptionally short wavelength of 100 meters during the evening hours, starting on November 25th. The first night he was on the air, he was heard by Amateurs in the United States! Being appraised by cable that his signals were “crossing the pond,” he set up a schedule the next night with Schnell and Reinartz, who had just gotten special permission to use the 100-meter wavelength.

8AB’s signal was heard again. The
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THE AMATEUR RADIO VERTICAL HANDBOOK by Cpl. Paul H. Lee, USN (Ret.), NLP
Based upon the author's 5 years of work with a number of different vertical antennas design and construction information along with a number of practical construction ideas. Included are designs for simple 1/4 and 3/8 wave antennas as well as broadband and dual element directional antennas. Paul Lee is an engineer and avid ham and is Amateur Radio's resident expert on the vertical antenna. 1984. 2nd edition.
CO-VH: Softbound $9.95

THE RADIO AMATEUR ANTENNA HANDBOOK by Bill Orr, W6S1 and Stu Cowan, W2LX
Contains lots of well illustrated construction projects for vertical, long wire, and HF/VHF beam antennas. There is an honest judgment of the trade-offs and figures information on the best and worst antenna locations and heights, a long look at the quad vs. the yagi antenna, information on baluns and how to use them, and new information on the popular Storper and Delta Loop antennas. The text is based on proven data plus practical, on-the-air experience. 190 pages. 1978 1st edition.
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HF ANTENNAS — THE EASY WAY by John Haeberle, W8SIR
This tutorial is an excellent source book on antenna theory and applications. Examples of areas covered are: fundamentals, antenna and feedline terminology, baluns, ground systems, lightning protection, The Basic Antenna, the dipole, the zepp, G5RV, Windom, Special Antennas, the slope, the Beverage, folded unipole beams, W8LX, Yagi, two element quad, and the 160 meter band story. John's writing is easy to understand conversational style and is full of examples and handy tips and hints. There are no drawings or illustrations but John's prose paints pictures for clear and complete understanding of the information being presented. 1984 1st edition.
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AR-AM: Softbound $8.00

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January 1988
have grazed the edge of the Alps, then had a clean shot up the Var valley.

Although 8AB was no longer active, he still had a keen interest in Amateur Radio. With his permission, I took a photograph of him (Photo A), and one of an oil painting of him as a young man in his dapper French military uniform Photo B.

What a grand gentleman! Although he expressed hopes of coming to America again, his health prevented such a journey. He later told me that he had bought a shortwave receiver Photo A. "Mr. DX." Leon Deb. FaAB, at and listened to the ham bands on occasion, marveling at the ease of voice contacts with sideband signals.

When I heard of his passing, it was as if an era had ended. The Americans at the other end of the great contact town of Nice had a 25-cycle power source and the signal from France had a distinctive gargle on it as Leon applied high-voltage ac directly to his transmitter tube. This time, Schnell and Reinartz were ready. In no time at all, the Atlantic barrier was breached!

I had known the story before I met Leon Deloy, but to hear it from him personally was thrilling. I asked him exactly where he had lived in Nice. What was his QTH like? And what about the French Alps that effectively blocked the path? We discussed these things at length, and the day after the conversation I drove the few miles to Nice to the house from which Leon had made his record-breaking QSOs. The address was 54 Boulevard du Mont-Boron. The street was on the ocean side of the Lower Corniche, one of the main boulevards that ran from Monte Carlo to Nice. The home was a large, pleasant house in the French style. It had a small back yard, but the hills rose sharply behind the location, seemingly blocking it from a direct radio path to the United States.

After surveying the location, I drove to the top of the hills behind Nice and looked down on Boulevard du Mont-Boron. Yes, it was possible. The French Alps dropped in height as they approached the valley of the Var river. The coastline curved around and the mountains were to the north of 8AB, but the shot to the northwest — towards North America, that is — was reasonably clear. 8AB’s signals must

We will not see the likes of him again.

To Amateurs who talk across the Atlantic daily, the adventure of 8AB and the American Amateurs may seem like no big deal. But to the Amateurs of yesterday, all of whom operated in the region of 150 to 200 meters, his DX work on 100 meters opened the shortwave spectrum. Shorter was better, and Amateur activity began a downward trek towards the 100- to 80-meter region.

Amateur regulations were vague at the time. The Radio Laws of 1912 were still in effect, and while Amateurs could operate between 200 and 150 meters, they weren’t allowed above 200 meters. The waves below 150 — obviously useless — were not strictly regulated. Finally, in July, 1924, after much prodding by the ARRL, the Department of Commerce authorized the issuance of new licenses for Radio Amateurs permitting the use of wavelengths in the vicinity of the present bands, up to 20 meters. A maverick assignment at 5 meters was tossed into the pot, too. Amateurs applying for new licenses could operate in the new short wave bands. The downward march in wavelength began.

10-meter RFI and all that

First, the good news. The sunspot cycle is climbing rapidly and 10 meters is coming back to life. Many newer Amateurs have never experienced this band when it’s fully alive. Plenty of DX can be worked with low power, and there’s lots of room for pleasant contacts and rag-chewing.

And now the bad news. The second harmonic of a 10-meter transmitter falls right into TV channel 2, the third harmonic falls into TV channel 6, and the fourth harmonic falls into the channels assigned to air-to-ground communications.

Most Amateurs have no problem with the fourth harmonic, but the second and third harmonics (of even a 100-watt transceiver) can cause problems with nearby television receivers.

In addition, a 10-meter transmitter can overload the input circuits of a nearby TV set, even though the trans-
mister may be “clean,” as far as harmonic emission goes.

Television interference presents a delicate public relations problem because viewers always assume TVI is the hams’ fault and blame them accordingly. In short, TVI isn’t a big problem if you don’t have it, but it’s hell if you do!

Fortunately, many of the TVI problems associated with 10-meter operation can be solved. Your own TV receiver can serve as a guinea pig. If you have no interference problems with it, you might be in good shape with your neighbors. Alas, the ability of TV receivers to reject strong nearby signals varies from manufacturer to model. Your set may be interference-free, but the one next door may not.

**where to start**

The first step in resolving TVI problems is to place a high-pass filter in the lead-in of the TV set, right at the receiver terminals. Available for either 300-ohm ribbon line or 75-ohm coax, these filters will reject your signals and pass those of the television stations. Unless you’re running with a linear, a high-pass filter will knock your fundamental signal down sufficiently to protect the TV receiver.

Your next step is to place a low-pass filter in the coax lead to your antenna. For best results, the filter should be mounted directly on the back of your transmitter and securely grounded to the transmitter ground point. This will substantially reduce any harmonic energy.

You’ll find out that when you don’t permit the transmitter harmonics to run up your coax to the antenna, they’ll seek another avenue of escape. This will be via the interconnecting control leads, the microphone cable, and the power leads of your transmitter.

The next thing to do is wrap the power lead of your transmitter around a ferrite core or rod. Use a high-permeability ferrite*; it will be lossy at 28 MHz and higher frequencies, and any rf current flowing in the lead will be converted into heat in the core material. This simple fix will prevent rf powers from flowing into your electrical system.

You can wrap control leads around a smaller ferrite. Either a core or rod

*  A suitable ferrite rod around which you can wrap a line cord is the AMIDON R-33-050-750. With a permeability of 800 (33 material), it measures 7.5 inches long. A longer rod of similar material is the R-33-075-1200, which is 0.75 inches in diameter and 12 inches long — just right for the linear amplifier.

If a ferrite toroid is desired, the AMIDON FT 240-72, 2.4 inches (O.D.) and 1.4 inches (I.D.) is satisfactory. RG-8A/U or RG-59/U cable can be wrapped loosely around this core, as can 300-ohm ribbon line.

A split core to place over a coax line is the AMIDON 2X-43-151, which is suitable for RG 8A/U coax. Place the two halves of the ferrite over the line and tape them together.

In case of computer interference, AMIDON supplies split bars that fit over flat cables. The 2X-43-95 is for 2-inch wide cable and the 2X-43-051 is for 2.5-inch cable.

These devices are available from AMIDON, 12033 Otsego Street, North Hollywood, California 91607.
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<th>UHF</th>
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<tr>
<td>6M,2M, 220</td>
<td>$986</td>
<td>$636</td>
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will do the job. You may even have to place a ferrite in the microphone lead as close to the mic jack as you can get.

But what if you’ve done all this and still get TVI on channel 2 when you operate 10 meters?

the final cleanup

As I said, a nearby TV receiver will help you determine the interference relationship between your transmitter and your neighbor’s TV set. For my checks, I used the family TV set, which is about 30 feet away from my equipment. The TV antenna is about 40 feet away, and just below it is my 10-meter antenna. Two CB hand-helds provide communication between the transmitter operator and the TV checker. Using these techniques, and running 100 watts, I was completely clean on all channels. But when I turned on my kW linear amplifier, I knocked out channel 2 and cross-hatched channel 6.

All the cures applied to the exciter were then applied to the amplifier: a ferrite choke was placed in the power line, ferrite chokes were installed in the interconnecting leads, and a low-pass filter was added to the coax to the antenna. That made two low-pass filters — one after the exciter and one after the linear amplifier. Channel 6 was now clean, with only mild problems on channel 2.

The last step was placing a ferrite line choke on the TV receiver. The line cord was wrapped around a ferrite toroid, where the power cord left the back of the cabinet. Attention was then directed to the lead-in, which happened to be 300-ohm ribbon.

It’s possible for the TV lead-in to act as an antenna for hf signals or harmonics. These pass down the lead-in, with the two lead-in wires acting in phase as a common-pickup antenna. The unwanted signal just flows around the high-pass filter with little attenuation. To prevent this, I loosely wrapped the ribbon line through a 2-inch (O.D.) ferrite toroid. I passed three turns through the core and held them in place with a plastic wire-wrap, then placed this little filter just before the high-pass filter as shown in the illustration (fig. 1).

All in all, the ferrite filters seem to do a much better job in TVI suppression than do bypass capacitors. They’re also much easier to install. (More on interference reduction in a forthcoming column.)

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solar cycle update

Enough time has passed to take the guesswork out of determining the sunspot number (SSN) minimum. Since the official value, is, by definition, a 12-month running average, it takes a year’s worth of values to define the SSN centered on a date six months ago. The upward SSN trend also takes time to determine: from six months to a year, to be precise. The minimum for Cycle 21 could have occurred in September 1986 at a relatively high value of 12.3, although official international numbers are still being evaluated and things may change a little. This would make Cycle 21’s duration equal to 10.25 years, which is closer to the short end of the solar cycle range of 9.0 to 13.6 years.

Scientists at the Space Environment Center (SEC) at Boulder have been reviewing predictions made by several methods to see what Cycle 22’s maximum value, and the date of its occurrence, might be. A summary of their findings indicates 145 as the maximum value — a little lower than Cycle 21’s maximum. However, the values for Cycle 22 range from 118 to 185. Most of the scientists agree, however, that whatever the maximum might be, it will probably occur in 1990 (i.e., during the period from December 1989 to 1991). These predictions will be refined as the cycle starts its sharp ascent over the next six months.

The solar flux measured at Ottawa, Canada, on 2800 MHz (10.7 cm) indicates a slightly different Cycle 21 minimum than that obtained from sunspot records. The minimum solar flux, a measured quantity, occurred during the period from June 24 to June 30, 1986. This raw data was corrected to one A.U. (Astronomical Unit, or the distance between the sun and the Earth at equinox) in order to extrapolate solar flux values measured at the earth’s surface to those which occurred at the sun. The corrected minimum (at the sun) occurred in September 1986. However, the ionosphere “recognizes” only the measured values (at the earth’s surface), of course. Consequently, the period of the solar flux cycle was from June 1975* to June 1986, for a total length of 11.05 years. The lowest value of daily flux was 66 — a high minimum, indeed. This reinforces the prediction of a lower SSN maximum for Cycle 22. If this is accurate, expect a Cycle 22 SSN between 110 and 125 (160-180 flux), spread over the 1990 to 1992 time-frame. In any case, a rapid rise in flux should be noticed this winter. The geomagnetic field will become stable, and recurrent-type geomagnetic disturbances will subside until the 27-day flux peaks reach a value of approximately 150, after which time flares will become more potent and cause more intense geomagnetic disturbances of shorter duration.

We can look forward to more frequent 10- and 12-meter openings by the end of 1988. A steady increase in solar flux is occurring already. This increase is about 3 SSNs, or 2 flux units, per month, which is equivalent to a 0.13 MHz (or 13 percent) increase per month. This will soon increase to 5 SSNs or 3.8 flux units, which is about 0.17 MHz (15 percent) per month for noontime mid-latitude MUFs. Of course the normal 27-day flux variation period of the sun’s rotation is superimposed upon this steady increase. Flaring regions of sunspots will augment longer term solar flux values. On a daily basis, if there’s only a 2 to 3 flux unit change per day, the MUF will change by one-half percent per flux unit, with no delay. If, however, there is a change of 10 to 20 flux units in a day, the MUF will change by one-half percent per flux unit, with no delay. If, however, there is a change of 10 to 20 flux units in a day, the MUF will change by 30 percent of the flux unit (change), with a 2- to 3-day lag. Consequently, it’s possible to utilize the solar flux data transmitted by WWV, or available from the computer billboard at SEC, to determine 10- and 12-meter band conditions next year.

last-minute forecast

The higher frequency bands should be very good the first five days of the month and after the 21st. Look for good transequatorial openings to the southern countries. Openings may be enhanced during geomagnetic disturbances around January 8, 18, and 28. The lower bands are expected to be their best this winter around the 5th...
The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next higher band for possible openings.*

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through the 8th. However, during disturbances, expect lower MUFs and signal strengths and QSB on the auroral paths—i.e., long east-west and northern routes. Approximately one week later, after the beginning of these disturbances, look out for the winter absorption anomaly to occur, especially from the 18th on (listen for a STRATWARN from WWV).

Lunar perigee will occur on the 8th, with a full moon on the 20th. An intense but short-duration meteor shower, the Quadrantids, will occur between January 2 and 4, and last a few hours.

**band-by-band summary**

Ten, twelve, fifteen, and twenty meters will be open from morning till early evening almost every day and to most areas of the world. The openings on the higher of these bands will be shorter and will occur closer to local noon. Transequatorial propagation on these bands will more likely occur toward evening during conditions of high solar flux and disturbed geomagnetic field conditions.

Thirty and forty meters will be useful almost 24 hours a day. Daytime conditions will resemble those on 20 meters. Skip distances and signal strengths may decrease during midday on days that coincide with these higher solar flux values. Nighttime DX will be good except after days of high MUF conditions and during geomagnetic disturbances. Look for DX from unusual places on east, north, and west paths during this time. The usable distance is expected to be somewhat less than on 20 in the daytime and greater than on 80 at night.

Eighty and one-sixty meters will exhibit short-skip propagation during daylight hours and lengthen for DX at dusk. These bands follow the darkness regions opening to the east just before your sunset, swinging more to the south around midnight, and ending up in the Pacific areas an hour or so before dawn. The 160-meter band opens later and ends earlier than 80.
power measurements

The subject for this month’s notebook — power measurements — popped into mind while I was writing last month’s column. Rather than append a lengthy footnote to that dissertation (on 1200 MHz equipment — see December 1987, page 1131), I decided that the topic deserved more thorough treatment.

The trigger word was “PEP,” or peak-envelope power. Because power measurements have always been one of the elements of electronics that require some study, I’ll use this month’s column to explain what they’re all about.

dc measurements

There’s not a lot that’s exciting about dc power measurements, or about measuring equipment, for that matter. But it helps to know something about them so you’ll have some basis for what’s to follow.

You can learn all you need to know about dc with the aid of a voltmeter, an ammeter, and a couple of simple formulas. It’s all very straightforward: voltage times current equals power (E x I = P). If you don’t have an ammeter, you can measure the voltage drop across a resistor and obtain the power by using the formula P = E²/R. If you use an oscilloscope to look at a dc waveform, you’ll see a straight line across the screen, at a level that’s displaced from the zero-voltage line of the trace (see fig. 1A). By carefully calibrating the oscilloscope screen, you can read the voltage with precision. With dc, what you see is what you get — the peak voltage and average voltage are the same.

ac measurements

When you turn your efforts to measuring ac voltages, things get more complex. The meter you used for dc is no longer useful. If you connect the probes from a dc voltmeter across a source of ac, you might see no pointer movement at all, or perhaps just a blur as the pointer tries to keep up with the rapidly changing waveform. The common way to obtain an ac-reading voltmeter is to insert a rectifier diode in series with one lead (or sometimes a bridge rectifier, which will provide a higher resultant dc reading on the meter). This type of meter provides a reading that generally represents the average voltage of the ac waveform, shown in fig. 1B, although some read RMS and are marked accordingly on their scales.

An oscilloscope will show you the true value of the ac waveform, including the negative-going and positive-going peaks. With a calibrated oscilloscope, you can measure the peak voltage accurately.

The average voltage (of a rectified sine wave) bears a direct relationship to the peak voltage by the formula \( V_{av} = 0.637 \times V_{peak} \). Knowing this relationship, you can turn the formula around to use the average reading (from a voltmeter with a rectifier) as a means of finding the peak voltage: \( V_{peak} = 1.571 \times V_{av} \).

Though this relationship of average to peak holds true for any undistorted sinusoidal waveform, a distorted waveform doesn’t follow the same rules.

* Note that this value isn’t the same as the RMS voltage, which is obtained by \( V_{rms} = 0.707 \times V_{peak} \), and \( V_{peak} = 1.414 \times V_{rms} \).
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January 1988
**rf meters**

Meters that measure RF are basically the same as those used to measure lower-frequency ac; a dc meter with diode(s) will provide a reading that represents some percentage of the waveform that's applied to it. The percentage for RF won't be the same as for lower-frequency ac such as 60 Hz, however. Variables such as the efficiency of the diode, the amount of resistance and capacitance in the meter/diode circuit, and the frequency of the RF being measured will all affect the reading.

You can check RF output power by measuring the voltage across a known resistor. The "known resistor" can be your 50- or 75-ohm transmission line (fig. 2). The formula is P = E²/R, where R is the impedance of the transmission line. If the diode/meter combination is accurately calibrated, the results of such measurements are reliable.

Another common method of checking RF output power is to use a coupling loop inserted in the field of a transmission line. The loop samples the current flowing in the line, and can be thought of as a transformer working at radio frequencies. The RF energy picked up by the loop is passed through a diode and applied to a meter (fig. 3). The Bird (or similar) type of in-line wattmeter uses this technique.

For either of these methods, the meter and pickup circuitry must be calibrated and used in a properly terminated transmission line.

**PEP**

After that review of measurement techniques and instruments, let's look at some applications, such as measuring PEP. We all know that PEP stands for peak envelope power. But what's an *envelope*?

To follow this, look at fig. 4. If you have access to an oscilloscope and a signal generator with built-in modulation, you can see a waveform like this by connecting the output of the generator to the input of the 'scope, and then turning on the modulation. By experimenting a bit with the scan rate of
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the 'scope trace and with the level settings of the generator, you can produce a picture that appears very much like that which is shown in fig. 4C.

The modulation shown in fig. 4A and the RF carrier displayed in fig. 4B combine to produce the modulated carrier shown in fig. 4C. You’ll note that the larger waveform (the modulation) has what appears to be a mirror image of itself, with some parts that almost touch at the center of the vertical screen trace. If you increase the modulation level enough, these parts that touch will become flattened. This is overmodulation; if it’s done on the air, it will cause splatter that will interfere with other stations.

Inside the larger waveform are sweep traces that are of a much higher frequency. This is the RF carrier. It follows the modulation to its highest peaks and decreases to practically nothing on the negative-going parts of the waveform. The larger waveform with the RF carrier inside it is called the modulation envelope. That’s where the “envelope” part of PEP comes from, and the peak power is measured (or calculated) by using the voltage measured from the reference (zero) line to the tip of the modulation peak.

Here’s another bit of theory applicable to a-m transmitters: because every positive-going modulation peak is matched by a negative-going one, the average power input is always the same. Because of that, the plate current to the final amplifier doesn’t vary. (If it does, there’s something wrong — perhaps low RF drive, incorrect bias, a power supply that has a poor output filter, a weak p-a tube, etc.) This is true for both voice-modulation and sine-wave modulation because voice waveforms have positive- and negative-going peaks too. Your antenna (or feedline) current will, however, increase with modulation peaks because the output contains sidebands that add their power to the carrier.

the SSB problem

Single-sideband voice transmission doesn’t provide a steady RF-carrier output or a steady p-a power input that can be easily measured by common meters. A p-a plate-current meter will attempt to follow the modulation peaks when you speak, but because of the slow response time of the meter pointer, it will never quite catch up.* When you apply a steady tone (a test signal), the meter will show a steady value that’s useful for tune-up purposes, but voice modulation will produce a meter reading that’s only a fraction of that value. The ratio is very unpredictable; each person’s voice has

* This lag in response time in meter movements is called inertia, and is created by the mass of the pointer and any parts, such as the moving coil (armature), attached to it. The reluctance of the coil moving in a magnetic field also affects the inertia of the meter. External circuitry, such as a very low resistance across the meter terminals can also slow the response time of the meter, but this is called damping.
different peak-to-valley characteristics and different frequency content, and not all meters respond the same way. The meter reading for voice could be as low as 25 to 30 percent of that for steady-carrier conditions, for equivalent peak power.

Figure 5A shows a typical SSB output waveform with a steady one-tone test signal, and fig. 5B shows the output for a two-tone test signal. Figure 5C shows a voice-modulated SSB signal.

An oscilloscope can be used to monitor a voice-modulated SSB signal, and the peak voltage reading noted and used to compute the power at that instant. Oscilloscopes haven't found great favor among the Amateur community, however. Many of them are larger than the other components of the station, and most have an appearance more appropriate to a laboratory setting than an operating position.

Some manufacturers such as Heath, Kenwood, and Icom have produced “station monitors” designed to fit neatly into an equipment lineup. These dressed-up oscilloscopes will show the audio peaks and valleys, and if calibrated for the transmission line and frequency of operation, will provide a reliable means of checking peak power output.

There are RF-output meters that provide peak readings. Some are manufactured by the major suppliers of Amateur transceivers, and provide a choice of either RMS or peak reading. I've seen Bird wattmeters advertised as "peak reading," and there may be others I'm not aware of.

For you builders, there's a digital PEP wattmeter described in Chapter 34 of the ARRL's 1987 Radio Amateur's Handbook. It uses peak-detectors to sample the voltage on a transmission line, and a holding circuit to hold the value long enough for the digital readout to provide an indication.

The thing to remember about any meter that samples either the current or voltage in a transmission line is that they're accurate only if the feedline is properly matched. If you use 50-ohm coaxial cable, but your antenna appears as 30 ohms, the SWR will quite thoroughly mess things up so that the readings you get are meaningless. (This brings up the subject of SWR and VSWR, which I'll cover in next month's column).

**which measurement?**

So what does the FCC want you to measure? There's a "grandfather clause" in the regulations that permits General-class and higher licensees to use p-a plate input power as a measurement until 1990 — with a limit of 1000 watts.

Otherwise, all Amateur power levels are stated as PEP output, with a maximum for General-class and higher of 1500 watts.* (Note: when a higher-class licensee is operating in the Novice segment of any band, the higher-class licensee must observe the same power limits as the Novice).

Novices are allowed 200 watts PEP output on their segments of the 80, 40, 15, and 10-meter bands. On 220 MHz, the limit is 25 watts PEP output. On 1270 MHz, it's 5 watts.

You already have a yardstick that ignores the usually poor efficiency of the transmitter. With tube-type transmitters, efficiency depends upon correct drive, age of the tube, how hot the filament (or cathode) is, the Q of the output circuit, and how well the circuit is adjusted, among other things. All of these variables combine to make the actual output a rather uncertain figure.

With solid-state transmitters, efficiency is often poor to begin with, and it changes with applied voltage as well as circuit adjustment, matching to the load, and even operating temperature. So, although it's not as easy to obtain as p-a input, PEP output is a more universally "fair" measurement.

In case your transceiver has an internal RF power metering circuit (and many solid-state units do have such circuits), it can be used for a-m, CW, or FM after being properly calibrated by checking against a decent-quality output wattmeter and dummy load. For SSB, this type of meter won't provide an accurate indication of PEP output unless the manufacturer has specifically designed it to do so.

* Except on the 30-meter band, where the limit is 200 watts PEP output.
KPC-4 packet TNC

The Kantronics KPC-4 Packet TNC features dual 1200 baud ports allowing simultaneous connections and conversations through each port. This TNC is excellent for VHF to HF gateway operations, packet bulletin board connections and conversations through each port. The command structure is basically the same as for the KPC-2 TNC using the mailbox firmware, except for several new commands for controlling the dual-port feature and gateway functions. The manual is nearly 90 pages long with in-depth coverage of the packet commands and parameters used by the KPC-4.

Nine LED front panel indicators continuously monitor TNC operations. The MAIL LED lights when a station is connected to the PBBS, or plinks continuously to indicate when mail addressed to you is present. Two LEDs indicate transmitter ptt keying for each port, two others indicate when either port is receiving data. The RPT LED indicates when gateway or digipeater functions are actively in use. Unacknowledged packets cause the STA LED to illuminate. The remaining LED is the power indicator.

The KPC-4 will easily interface with most popular computers. All that is needed is a simple modem program to allow communications between the TNC and computer. The computer port uses true RS-232 levels for interfacing, or alternatively the levels may be converted to TTL by simply moving a jumper — permitting use with the popular Commodore 64 computers. For those few modern programs that use it, the KPC-4 supports TRS/CTS handshaking. The AFSK levels to the radio transmitter may be set at 10-mV or 50-mV via an internal jumper; or, alternatively, by changing internal resistors audio levels up to 1 volt are possible.

Prewired cable assemblies are supplied for both radio ports and for the computer port — no connector is supplied for the computer end of the cable. The manual provides detailed information and examples for interfacing the KPC-4 with your computer and radio.

Since the KPC-4 is capable of operating as a fully automatic independent gateway you can provide access for your local VHF/UHF area network to a mailbox or gateway system. Two principle commands control gateway operations — MYGate and Gateway. MYGate is used to program the gateway identification; this call must be different than that used for MYCall or MYAlias. This is easily done by changing the ssid extender, for example if K1ZJH were used for MYCall, K1ZJH-1 would serve for MYGate. The Gateway command is used to turn the gateway off or on from the computer keyboard. When this command is on, packets addressed through the KPC-4 digipeater from either port will be automatically transmitted through the other port and visa-verse. Obvious uses would include cross-connecting area LANS operating on different frequencies and/or bands, multiple band and/or frequency operation for a packet PBBS, or for providing secure non-Amateur “worm-hole” communication paths between distant LANS.

As with the other Kantronics products I’ve owned and used the KPC-4 uses high-grade components and is solidly built. For more information contact Kantronics, Inc., 1202 East 23rd Street, Lawrence, Kansas 66046, by K1ZJH Circle #308 on Reader Service Card.

Communications Receivers Principles and Design

The art of designing communication receivers incorporating the various analog and new digital techniques is frequently a well guarded trade secret. The new book, Communications Receivers Principles & Design (McGraw-Hill Book Company, ISBN 0-07-053570-1) by Ulrich L. Rohde (DJ2LR/KA2WEU) and T. T. Nelson Bucher makes this information available to the interested community. The original manuscript was developed from courses given at the University of Gainesville, Florida and George Washington University in Washington by Dr. Rohde, where he was appointed adjunct professor of electrical and computer sciences. Both authors have a successful career in the field. Dr. Rohde, while at RCA, had directed the Military communication business area which had major government contracts in this field, and Dr. Bucher was responsible for many of the modern signal processing technologies and hardware designs and implementation at RCA. The reader, therefore, can expect a wealth of useful information to be found within the book as a result of the authors considerable background.

The book, divided into 10 chapters, considers the following subjects:
1. Basic Radio Considerations
2. Radio Receiver Characteristics
3. Receiver System Planning
4. Antennas and Antenna Coupling
5. Amplifiers and Gain Control
6. Mixers
7. Frequency Control and Local Oscillators
8. Demodulation and Demodulators
9. Other Receiver Circuits
10. Receiver Design Trends

The authors have provided a nice mix of theoretical and practical information. Many useful detailed circuits are shown and systems analyses and trade-off studies are included. The intense use of special modulation methods by the Services to provide reliable communication even under poor propagation has prompted the authors to provide a good theoretical introduction into this field as well as detailed practical performance examples.

"Communications Receivers Principles and Design" will, with its cogent mix of theory and practical information appeal to radio amateurs, students in the field of radio communications and engineering managers who need a comprehensive overview of all the techniques.

Available from Ham Radio Bookstore for $69.95 postpaid.

K2RR
new accessories from ICOM

Instant satellite communications are now possible with ICOM's CT-16 Satellite Interface Unit when used with an ICOM CI-V System Transceiver. The CT-16 features an uplink switch to control the downlink and uplink transceivers, and a switch to select either normal or reverse tracking. The CT-16 may also be used in coordination with the UX-14 CI-V/CI-5 converter. The suggested list price is $97.50.

The UX-14 Converter enables you to adapt a CI-V system to a CI-V system. This allows the transceiver to be computer controlled, or for satellite operations using the CT-16 Satellite Interface Unit. The following radios are equipped with a CI-V port and can be converted for CI-V use with the UX-14: IC-R71A, IC-271A, IC-271H, IC471A, IC-751, IC-751A and IC-1271A. The converter is priced at $72.50.

Radio operations can now be externally controlled by a RS-232C I/O port equipped personal computer by using ICOM's CT-17 Communication Interface V (CI-V) Level Converter. Up to four ICOM CI-V radios can be used for controlling frequency, mode and memory information. Suggested List Price is $97.50.

To complement the growing activity on 220MHz, ICOM now has a 220MHz repeater available, the RP-2210. With frequency coverage from 216-236 MHz, selectable CTCSS/Carrier squeal operating system, and 25 watts RF output power, DTMF control and continuous duty cycle. The RP-2210 is a great way to get out of the mainstream activity. The Suggested List Price of the repeater is $1495.00.

Now ICOM offers the HM-46 and HM-46L Handheld Speaker Mic. The mini-sized speaker mic, HM-46 is big on audio for top panel connections on the IC-2AT, IC-02AT, IC-3AT, IC-03AT, IC-4AT and IC-04AT and the HM46L right angle connection speaker mic for the Micro series. Both the HM-46 and HM-46L have a swivel clip on the back to easily clip on your lapel or collar. The Suggested List Price of each mic is $29.99.

Circle #307 on Reader Service Card.

dual-band amplifier

A dual-band amplifier? Yes.

The HL-725D is a dual-band power amplifier for the 444 and 440 MHz bands, with low noise GaAs FET RX pre-amps. The HL-725D utilizes a large heat sink and the circuits of THL's stable, reliable HL-62V and HL-60U models. Because IN/OUT connectors are installed for both amplifiers, various combinations of dual TX and RX amplifiers can be used. Priced at $329.95, the HL-725D's are available from Encomm dealers. For details, contact Encomm, Inc., 1506 Capital Avenue, Plano, Texas 75074.

Circle #304 on Reader Service Card.

700 series towers

Microflect's new 12-page catalog describes the light-duty 700 Series tower, designed for cellular, UHF, VHF, and small microwave antenna applications. The standard three-legged tower configuration is available in 10-foot increments up to 160 feet.

The 700 Series easily adapts to Microflect's 800 Series towers to provide greater heights when required. The accessories section in the catalog includes pipe mounts, beacon light mounts, and grounding kits for the 700 Series. A price list is also included.

Complimentary copies will be sent on request. Contact Microflect Company, Inc., P.O. Box 12985, Salem, Oregon 97309-0985.

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firm grip

Fix-O-Fix is a vacuum suction pad that holds virtually any object firmly in any position — horizontally, vertically, sloping, or upside down — on almost any flat surface. Attachment is easy; to disengage the vacuum, simply turn the pad to the left.

Fix-O-Fix is available for just $5.00 plus $1.00 shipping and handling directly from LWC Enterprises, 38 West Center, Logan, Utah 84321.

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new rotor control option

Engineering Consulting has announced several new features for the Super Com Shack 64 remote base and repeater controller.

The advanced beam rotator control option (model HM-1) allows your system to control the Ham "M," Ham 4 or similar (i.e., CDR) rotators, complete with voice-announced bearings. The rotor option works in conjunction with the CS-8 relay card and the new HM-1 voltage-to-frequency converter, which plugs into the cassette port. The HM-1 samples a voltage from the rotor control box meter, which provides beam headings accurate to 1 degree. The control box switches (left, right, and brake on/off) are controlled via an interface cable that connects to the CS-8 relays No. 1, 2, and 3. An easy-to-install interconnect cable is used to parallel the control switches of the rotor control box, thereby allowing both manual and remote control of the rotor.

The HM-1 option ($49.95) operates in conjunction with the model CS-8 relay control board and CS64S Version 3.0 software. Program enhancements include provisions to allow using the remaining five open collector outputs on the CS-8 to activate external relays or controlling the CS-8 for programming the dip switch of a CTCSS (sub-tone) Encoder or Decoder. While in the directed page mode or from a mobile, it's possible to access up to 32 tones to individuals or groups. Whenever a station is being voicemerged, the selected tone is sent to enable the receiver audio to open the receiver squeal. Additional Version 3.0 software enhancements include the ability to quick dial (two digits) all 300 stored telephone numbers. Version 3.0 allows users to assign 32 CTCSSs (subtones) to groups or individuals, for automatic paging.

Version 3.0 is available to all Super Comshack 64 users who purchased the Model CS64S system since May 1, 1987 as part of Engineering Consulting's free upgrade policy.

For information, contact Engineering Consulting, 583 Candlewood Street, Brea, California 92621.

new HAMRAD publication

HAMRAD Press now publishes a directory of DX station operating information — The W17GS DX Locator, a monthly compilation of data relating to the operating times and frequencies of DX stations heard and worked during the current month contained in major DX newsletters, magazines, club bulletins, logs, and other sources.

Over 2500 reports of DX station activity are separately listed by time, frequency and call, providing a rapid reference of potential DX con-
contacts available during any time of day, and on any band from 160 to 10 meters. Bar and pie chart graphics also characterize DX station operating habits by band and time period, to highlight optimum operating conditions.

The W1TOS DX Locator is intended to supplement — not replace — the many fine DX newsletters currently available. Subscriptions are available from HAMRAD Press, P.O. Box 2458, Springfield, Virginia 22152. A one-year subscription (via first class mail) is $35; foreign airmail rates are available upon request.

**LCFIL filter design program**

LCFIL, a stand-alone CAD program for IBM-compatible and Apple Macintosh computers, provides design solutions for lowpass, highpass, and bandpass filters having up to 21 poles. You can specify input impedance, inductor Q, and other parameters. Arbitrary component values may be entered into a general-purpose building block, which allows analysis of many other L-C filter topologies.

LCFIL computes filter magnitude, phase, and delay characteristics and provides normalized and actual component values. Both linear and logarithmic frequency steps are selectable. Optional modules provide for CGA, EGA, and Hercules-compatible graphical representation and drive 30 different popular pen plotters. An optional signal processing module works with LCFIL to provide transient analysis capability. Inputs are free format with liberal error trapping.

The retail price of this program is $95. For details, contact BV Engineering, 2200 Business Way, Suite 207, Riverside, California 92501. Circle 1302 on Reader Service Card.

**World time clock**

The Azimuth Communications Corporation has announced a new World Time Clock, Model WT-80A, that features digital readouts with both local time and world time in 24-hour Zulu notation.

Outside the shack, a press-on light and snooze alarm allow its use as a travel alarm clock. Two AAA penlight batteries are required.

As a special introductory offer, Azimuth is offering these world time clocks — a $29.95 value — at $19.95 plus $1.95 for postage and handling (California residents add state sales tax.) To order, or for more information, contact Azimuth Clock, 11845 West Olympic Boulevard, Suite 1100, Los Angeles, California 90064. Circle 1301 on Reader Service Card.

**New tool kit**

Jensen Tools has introduced a new tool kit for advanced students of electronics and skilled hobbyists. Also appropriate for small service shops and skilled home repair, the Deluxe Tech School Kit (No. 238002) includes screwdrivers, nutdrivers, a wire stripper/cutter, pliers, scissors, wrenches, a hemostat, a mirror, a holding tweezers, soldering equipment and more. A total of 28 quality tools are furnished in a 13-7/8 x 6-7/8 x 7 plastic tool box with lift-out tray, positive latch, and carrying handle. The kit is priced at $79.00.

For more information and free catalog, contact Jensen Tools, Inc., 7815 South 46th Street, Phoenix, Arizona 85044. Circle 1309 on Reader Service Card.
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