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See these quality ICOM receivers at your local authorized ICOM dealer today.

*Specifications of the IC-R7000 guaranteed from 25,1000MHz and 1260,1000MHz. No coverage from 960-1025MHz.

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In 26 countries around the world, tens of thousands of amateurs know that Kantronics is the leader in bringing tomorrow's technology to their stations today. They also know they will always be among the first to incorporate just-introduced features and modes with Kantronics software and firmware updates.

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Version 2.85 KAMs have increased Packet Cluster™ compatibility, KA-NODE™ path preservation, KA-NODE recognition of the "NET" nodes and HF baud rates from 50 through 300! And there are three new mailbox commands: List Mine, Read Mine and Kill Mine.

and Tomorrow...

Will the Real Dual-Port Please Stand Up?

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Kantronics All-Mode™ (KAM) has Packet, WEFA, ARQ, FEC, RTTY and CW reception. But we have five models to suit your particular taste. Ask your dealer for the best choice today...and tomorrow.
**Affordable DX-ing!**

**TS-140S**
HF transceiver with general coverage receiver.
Compact, easy-to-use, full of operating enhancements, and feature packed. These words describe the new TS-140S HF transceiver. Setting the pace once again, Kenwood introduces new innovations in the world of “look-alike” transceivers!

- Covers all HF Amateur bands with 100 W output. General coverage receiver tunes from 50 kHz to 35 MHz. (Receivers specifications guaranteed from 500 kHz to 30 MHz) (Modifiable for HF MARS operation. (Permit required)
- All modes built-in. LSB, USB, CW, FM and AM.
- Superior receiver dynamic range Kenwood DynaMix™ high sensitivity direct mixing system ensures true 102 dB receiver dynamic range.

**New Feature!** Programmable band marker. Useful for staying within the limits of your ham license. For contesters, program in the suggested frequencies to prevent ORM to non-participants.

Famous Kenwood interference reducing circuits, IF shift, dual noise blankers, RIT, RF attenuator, selectable AGC, and FM squelch.

- M. CH/VFO CH sub-dial. 10 kHz step tuning for quick OSV at VFO mode, and UP/DOWN memory channel for easy operation.
- Selectable full (QSK) or semi break-in CW.
- 31 memory channels. Store frequency, mode and CW wide/narrow selection. Split frequencies may be stored in 10 channels for repeater operation.
- RF power output control.
- AMTOR/ PACKET compatible!
- Built-in VOX circuit.
- MC-43S UP/DOWN mic. included.

Optional Accessories:
- AT-130 compact antenna tuner
- AT-250 audio mobile antenna tuner
- 65/66/67 head phones
- IF-232C/IF-10C computer interface
- MA-5/VF-1 HF mobile antenna (5 bands)
- MB-430 mobile bracket
- MC-43S extra UP/DOWN hand mic
- MC-55 12V power cable
- MC-60A/MC-80/MC-85 desk mic
- PG-2S extra DC cable
- PS-430 power supply
- SP-41/SP-50B mobile speakers
- SP-430 external speaker
- DR-922A: 2 kW PEP linear amplifier for CW/SSB
- TU-8 CTCSS tone unit
- YG-435C-1 500 Hz Deluxe CW Filter
- New 500 Hz CW Filter

**TS-680S**
All-mode multi-bander
- FM 65-54 MHz 10 W output plus all HF Amateur bands (100 W output)
- E-dithered FM receiver frequency range 45 MHz to 60 MHz. Specified from 50 to 54 MHz
- Same functions of the TS-140S except optional VOX (VOX-4 required for VOX operation)
- Pre-amplifier for 6 and 10 meter band.
FEATURES

WIDEBAND FREQUENCY ANALYZER 9
Adelbert Kelley, AA4FB

The Weekender: A TRANSMIT CONTROL FOR MOBILE OPERATION 24
James M. Bryant, G4CLF

A 2-METER CONVERTER WITH Q MULTIPLIER 33
Norman J. Foot, WA9HUV

FAMOUS EQUIPMENT OF YESTERYEAR 43
John Nagle, K4KJ

Ham Radio Techniques: ANTENNA MATCHING SYSTEMS 54
Bill Orr, W6SAI

AN INEXPENSIVE VFO FOR THE YAESU FT-102 62
Robert H. Armstrong, VE3RF

The Weekender: COLLAPSIBLE QUAD FOR 10-METER HILLTOPPING 70
L.B. Cobik, W4RNL

Practically Speaking: TEST EQUIPMENT FOR DIGITAL ELECTRONICS 76
Joseph J. Carr, K4IPV

A LOW-NOISE DESIGN PRIMER 80
Bob Lombardi, WB4EHS

Elmer’s Notebook: SIMPLE INSTRUMENTS — RF OUTPUT MONITOR 91
Tom McMullen, W1SL

DEPARTMENTS

BACKSCATTER 4 FLEA MARKET 84
EDITOR’S NOTES 4 HAM MART 88
COMMENTS 6 DX FORECASTER 96
HAM NOTEBOOK 40 ADVERTISERS INDEX 98
PRODUCT REVIEW 42 READER SERVICE 98
NEW PRODUCTS 48, 53
A Juxtaposition of Technologies

It's fun to take a look back at the past from time to time to see how technology has changed. Last month we previewed Kenwood's new state-of-the-art HF transceiver, the TS-950S. The TS-950S offers the latest in digital signal processing (DSP) technology and ergonomically designed operator features.

This month John Nagel, K4KJ, takes us back to the early thirties with a retrospective piece on the Sky Buddy and several other Hallicrafters radios of that era. This remarkable juxtaposition of technologies serves to show us how much the science of communication has changed in the fifty or so years since the Sky Buddy was first manufactured. Communications technology has made great strides forward since then. We take these changes for granted, however, and have lost touch with exactly how much radio has changed.

Recently, a newly licensed Novice stopped by to see me. He was looking for some help in getting on the air. He already had a receiver and had just been given a Heathkit DX-35 transmitter. He was flummoxed by the transceiver; he had no idea how to peak a grid, tune and dip the final. He was also missing some crystals (Crystals? Who uses those archaic things?) and was having no luck finding any. Luckily, I had mine from twenty-plus years ago squirreled away and was able to get him set up for 15 and 80 meters.

As we sat watching the unit warm up, I was taken back to my Novice days and remembered fondly how much fun I had in that one year as WN1GG. After I showed him how to peak the grid and dip the final, he went home to finish setting up his station. I'll give him a call in a few days to see how he's doing. Frankly, I had forgotten how complex station set up could be. Like most of the rest of us, I've been spoiled by the features and convenience of today's transceivers. I'd also forgotten the limits of a crystal-controlled transmitter. Split frequency operation was normal back when I started in radio. Sometimes the station you were working was half the Novice band away. I had only three crystals for the 15-meter Novice band, so I spent many hours either scanning the band looking for someone close by or calling hopefully to someone 50 or 10 kHz (or more) away. Those were fun days.

WARC bands

I recently put up an antenna for 18 and 24 MHz. Gary Nichols, KD9SV, sent me a prototype of a trap dipole he's designed. (The antenna will be featured in an HR article early next spring.)

The antenna is very light and installs in almost any location. As I tuned across the 18 and 24 MHz bands, I was amazed at the quality of propagation. I'll be the first to admit that I made no rush to get on any of the WARC bands when they were first authorized. However, I'm beginning to think I made a mistake. I've found a number of my low band cronies there; they've been extolling the virtues of 18 and 24 MHz to me for months. Well, they were right. 18 and 24 MHz are two fun bands. There's plenty of DX to be worked from every corner of the earth. I hope you haven't waited as long as I have to get on. While activity is spotty now, these bands will sound like 15 or 20 meters as more hams find out how good 18 and 24 MHz can be! Imagine, wall-to-wall DX. See you there.

Craig Clark, NX1G

Editor's Notes

It's been just over a year since the "New" Ham Radio was introduced and your response has been tremendous. More and more Amateurs are reading Ham Radio Magazine.

When we began this new phase in Ham Radio's history, our intentions were to apply the high technical standards you expect from Ham Radio to the kinds of articles you're interested in right now. Recent reader surveys and evaluation cards indicated you had a desire for more short construction articles, practical projects, and weekenders, along with both brief and in-depth technical pieces that have long been a mainstay of the magazine. We've listened to your requests and have spent the last fourteen months working with our authors to bring you just what you've asked for.

This past year has been a good one — so let's keep the momentum going. I'd like to ask those of you who have played a part in shaping Ham Radio's new focus to continue sending us the articles your fellow readers have asked to see. I'd also like to urge those of you who haven't yet shared your pet projects with your peers to take this opportunity to become a Ham Radio author. We pay well and make every attempt to get your efforts into print as soon as possible. HR uses up a lot of material in a year's time, so we need your help to keep our pages both full and interesting. Let us help you share your ideas with an international audience!

Terry Northup, KA1STC
Kenwood brings you the greatest hand-held transceiver ever! More than just “big rig performance,” the new TH-215A for 2 m, TH-315A for 220 MHz, and TH-415A for 70 cm pack the most features and the best performance in a handy size. And our full line of accessories will let you go from hamshack to portable to mobile with the greatest of ease!

- Wide receiver frequency range. Receives from 141-163 MHz. Includes the weather channels! Transmit from 144-148 MHz. Modifiable to cover 141-151 MHz (MARS or CAP permit required).
- TH-315A covers 220-225 MHz, TH-415A covers 440-449.995 MHz.
- 5, 2.5, or 1.5 W output, depending on the power source. Supplied battery pack (PB-2) provides 2.5 W output. Optional NiCd packs for extended operation or higher RF output available.
- CTCSS encoder built-in. TSU-4 CTCSS decoder optional.
- 10 memory channels store any offset, in 100-kHz steps.
- Odd split, any frequency TX or RX, in memory channel “0.”
- Nine types of scanning! Including new “seek scan” and priority alert. Also memory channel lock out.
- Intelligently 2-way battery saver circuit extends battery life. Two battery-saver modes to choose, with power saver ratio selection.
- Easy memory recall. Simply press the channel number!
- 12 VDC input terminal for direct mobile or base station supply operation. When 12 volts applied, RF output is 5 W! (Cable supplied!)
- New Twist-Lok Positive-Connect’ locking battery case.
- Priority alert function.
- Monitor switch to defeat squelch. Used to check the frequency when CTCSS encode/decode is used or when squelch is on.

Optional Accessories:
- PB-1: 12 V, 800 mAH NiCd pack for 5 W output
- PB-2: 12 V, 500 mAH NiCd pack (5 W output)
- PB-3: 7.2 V, 800 mAH NiCd pack (5 W output)
- PB-4: 7.2 V, 1600 mAH NiCd pack (15 W output)
- BT-5 AA cell manganese/alkaline battery case
- BC-7 rapid charger for PB-1, 2, 3, or 4 - BC-8 compact battery charger
- SMC-30 speaker microphone
- SC-12, 13 soft cases
- RA-3, 5 telescoping antennas
- RA-8B StubbyDuk antenna
- TSU-4 CTCSS decode unit
- VB-250: 2m, 25 W amplifier (14 W input)
- LH-4, 5 leather cases
- MB-4 mobile bracket
- BH-5 swivel mount
- PG-2V extra DC cable
- PG-3D cigarette lighter cord with filter

KENWOOD U.S.A. CORPORATION
2201 E. Dominguez St., Long Beach, CA 90810
P.O. Box 22746, Long Beach, CA 90802-8746

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

There has been a lot of talk about how slowly ham radio is growing and the need for new Amateurs. The talk usually centers on code versus no code, or club activities to recruit new hams. Hams are also urged to get the message out by various PR efforts.

It seems to me that there is a tendency to allow groups or organizations to do the work (i.e., ARRL or clubs) without accepting the responsibility ourselves. At the same time, I hasten to say that such efforts from the ARRL and clubs do have merit — it is just that in the process individual hams do little or nothing.

What I propose is that each one of us recruit just one ham to the ranks of Amateur Radio. Let's see: 400,000 hams × 2 = !

Bruce Bennett, K2PDJ, Alexandria Bay, New York

CHALLENGING YOUTH

Dear HR

The letter by Paul Swearington, W9PJF, (July 89) also expressed my thoughts on why we don't have more people interested in Amateur Radio. I became interested when I saw an article in the old Pilot radio magazine. It was on a transmitter using a UV45 tube in a tuned plate tuned grid circuit for use on the ham bands. As a result, the bug bit me. I had to get my license and so I started learning the code. The challenge was learning the code and building a transmitter.

Many of us started on 80 CW, but the challenge was to get on tone. The 75-meter band was restricted to class A hams so 160 was the band we went to. It was a fairly easy step to add a modulator to the CW rig and change a few coils. Most of the rigs were crystal controlled and most were homebrew. Today the step from CW to tone is virtually impossible if you want to have the present state of art, unless you buy a transceiver. The only challenge here might be in raising the money, but after that what? Learning all the knobs and bells can keep them going for awhile, but are they really gaining any real technical knowledge. It is alright for the oldtimers to go this route but it is the younger generation that will be the designers of tomorrow. We need this group to keep this country ahead in electronics and what better learning ground than ham radio.

I would venture to say that most Novices want to get on tone after spending some time on CW. The Novice expansions for tone or no-code license do nothing to improve their technical qualifications if they have to go out and buy a commercially built rig.

I would like to see the 160 band opened up to the Novice and Technician. It would be a band that they could get on tone, albeit on AM. But at least it would be feasible for them to construct receivers and transmitters for this band without having an engineering degree. With the experience and the challenge of building their own equipment, many will go on to build better and more refined equipment. But they need a stepping stone to get there.

I have operated 160 for many years. Before World War II this band was heavily occupied and you could make a contact at almost any time of day or night. Today you may hear a few stations in the evening but they generally are on a net. There is plenty of room and plenty of challenges from homebrew transmitters and receivers to antennas. Or could it be that our younger generation doesn't like challenges?

Jim Pepper, W6QIF, Orinda, California

A young Amateur speaks out

Dear HR

I am a member of the West Branch Amateur Radio Club (Williamsport, Pennsylvania). Our club just recently had its first "discussion" on the "no-code" topic. It was the second meeting I had been to and, being 15 years old, I saw actions that did not please me. The words became heated, and from everything I heard, I gathered that "no-code" is supposed to bring more people into our hobby. Some of our club members mentioned that they knew some "brilliant" people who would be interested in radio, if not for the code. If they are so brilliant, why can't they do the 5 wpm that a 5 year old child can do? Instead of arguing about whether there should be a code free license, let's get off our "butts" and do some advertising! Get the local club to make some signs, announcements on fm radio, arrange a showing of the ARRL promo tape. Most of all, work on the school system. Our hobby is being dominated by adults. We need the kids! Forget about your opinions and like John Muhr, KT0F, said in the August issue, "Get out there and wave the Amateur Radio banner!"

Nate Meredith, KA3TZJ, Jersey Shore, Pennsylvania

(continued on page 90)
Kenwood... pacesetter in Amateur Radio

Warp Drive!

TS-790A Satellite Transceiver

The new Kenwood TS-790A VHF/UHF all-mode tri-band transceiver is designed for the VHF/UHF and satellite "power user." The new TS-790A is an all-mode 144/430/1200 MHz transceiver with many special enhancements such as automatic uplink/downlink tracking. Other features include dual receive, automatic mode selection, automatic repeater offset selection for FM repeater use, VFO or quick step channel tuning, direct keyboard frequency entry, 59 memory channels (10 channels for separate receive and transmit frequency storage), multiple scanning and multiple scan stop modes. The Automatic Lock Tuning (ALT) on 1200 MHz eliminates frequency drift. Power output is 45 watts on 144 MHz, 40 watts on 430 MHz, and 10 watts on 1200 MHz. (The 1200 MHz section is an optional module.)

- High stability VFO. The dual digital VFOs feature rock-stable TCXO (temperature compensated crystal oscillator) circuitry, with frequency stability of ±0.3 ppm.
- Operates on 13.8 VDC. Perfect for mountain-top DXpeditions!
- The mode switches confirm USB, LSB, CW, or FM selection with Morse Code.
- Dual Watch allows reception of two bands at the same time.
- Automatic mode and automatic repeater offset selection.
- Direct keyboard frequency entry.
- 59 multi-function memory channels. Store frequency, mode, tone information, offset, and quick step function. Ten memory channels for "odd split!"
- CTCSS encoder built-in. Optional TSU-5 enables sub-tone decode.
- Memory scroll function. This feature allows you to check memory contents without changing the VFO frequency.
- Multiple scanning functions. Memory channel lock-out is also provided.
- ALT—Automatic Lock Tuning—on 1200 MHz eliminates drift!
- 500 Hz CW filter built-in.
- Packet radio connector.
- Interference reduction controls: 10 dB RF attenuator on 2m, noise blanker, IF shift, selectable AGC, all mode squelch.
- Other useful controls: RF power output control, speech processor, dual muting, frequency lock switch, RIT.
- Voice synthesizer option.
- Computer control option.

Optional Accessories:
- PS-31 Power supply
- UT-10 1200 MHz module
- VS-2 Voice synthesizer unit
- TSU-5 Programmable CTCSS decoder
- MC-433 Hand mic
- PG-3S Extra DC cable

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MFJ Grandmaster Memory Keyer
More than user-friendly ... it's really easy-to-use

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Simple ... intuitive ... you instantly know which knob to turn, what button to press. It's unmistakable.
That's the MFJ Grandmaster concept -- more than user friendly ... it's really easy to use.

There's no keypad, no complex keystroke sequences to confuse you.

The new MFJ-486 Grandmaster Memory Keyer gives you the best of both worlds -- all the features you'll ever need and the easy-to-use MFJ Grandmaster concept.

Exclusive CW Word Processor™
MFJ's exclusive CW Word Processor™ lets you change a message in memory without having to rekey it all in.

Special function keys make it simple to move around within any message, insert, delete and change your message until it's just the way you want it.

With other memory keyers you have to erase an entire message and rekey it all in to make even the smallest change.

Combine messages into other messages
The MFJ-486 lets you combine frequently used messages into other messages.
You can store QTH, rig/antenna, QSL info and other comments in separate memories.
Then you can easily build a new message by keying in memory numbers wherever you want that info in your message.

MFJ's Custom-Speed™ Control
Customize your speed control to fit you!

By pressing the Speed Set button, you can set your slowest speed to start at 4, 5, 6 -- any speed up to 20 WPM -- and your fastest speed is 20 to 100 WPM.

Matching CW speed to a QSO is best done by ear as you adjust a speed knob.

With keypads you have to figure out the exact speed of your contact and then go through an awkward keystroke sequence.

That's why matching speed with a keypad is so demanding.

Without MFJ's Custom-Speed™, a wide range speed control is very hard to use because the slightest touch causes radical speed changes.

Built-in CW Course
The MFJ-486 gives you a well-organized three step CW course for upgrading and teaching.
The first step gives you random five character groups. After you learn the letters you can add punctuation.
The second step gives you random 1-8 character groups for real-world code practice.
The third step gives you an infinite number of random plain English QSOs in the same format as FCC ham license tests.

When you can copy these random QSOs, you're ready to pass your test and upgrade!

You also get Farnsworth option, answer-replay to check your copy, punctuation on/off and earphone jack for private practice.

Remote Control ... for memories and function keys
The MFJ-77 remote control lets you control your message memories and CW Word Processor™ function keys at your key paddle for only ... $19.95.

It's a lot more useful than a remote that gives you no editing functions and only lets you control a few memories.

MFJ Keyers are used year after year
Not so long ago there was a glut of keypad keyers. They were novel, and a lot of hams spent their money.

But because they were hard to use they ended up in drawers and closets. They were soon no longer made.

Most original MFJ keyers are still being used -- day after day and year after year.

Why? Because they're easy-to-use. And that's why more new MFJ keyers are being put on the-air today than ever.

More for your money
To make it really easy-to-use, it cost more to build the MFJ Grandmaster.

It just takes more hardware -- knobs to turn, buttons to press, LEDs to show you what's going on. Plus it takes more labor, more software, more everything.

It's a real bargain compared to cheaper-to-build but harder-to-use keypad keyers.

Plus More...
You get over 8000 characters in 10 soft-partitioned memories -- far more than you'll ever need.

You also get ... lithium battery backup, automatic serial numbering, automatic message repeat, beaconing, A or B type Iambic keying, manual or automatic word spacing, speaker, earphone jack, easy-to-use front panel controls for speed, volume, tone, weight and delay, tune control, powerful Z-80 microprocessor plus much more.

9x2½x½ inches. Use 12-15 VDC or 110 VAC with MFJ-1312. $12.95.

One Full Year No Matter What™ Guarantee
You get MFJ's full one year no matter what guarantee.

That means MFJ will repair or replace your MFJ-486 (at our option) no matter what happens to it for a full year.

Others give you a 90 day limited warranty.

What do you do after 90 days when it burns up. Or before 90 days when they say, "Sorry, your limited warranty doesn't cover that?"

Why take chances when MFJ gives you no matter what protection for one full year?

Don't struggle with keypads -- enjoy the easy-to-use MFJ Grandmaster

Don't struggle with a hard-to-use keypad and complicated keystroke sequences.

Choose the memory keyer that's really easy-to-use and has all the features you'll ever need -- the new MFJ-486 Grandmaster.

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MFJ ... making quality affordable
WIDEBAND FREQUENCY ANALYZER

Analyzer checks for spurious oscillations and amplitudes, and assists in tuning

By Adelbert Kelley, AA4FB, 2307 S. Clark Avenue, Tampa, Florida 33629

As a result of interest generated by articles I'd read in QST and Ham Radio, I decided to build the wideband frequency analyzer shown in Figure 1. I needed a test instrument that would show spurs and relative signal amplitudes, and would help me with alignment when I experimented with VHF and UHF circuits. The idea of using the shop oscilloscope for a panoramic display of the signals from 20 to 400 MHz looked attractive. K2BLA's analyzer in QST had an ingenious circuit which gave the frequency on a digital display. He used the scaler output of a cable TV converter in a frequency counter that subtracted the oscillator offset, then counted and presented a three-digit readout of the frequency of any signal present at the center graticule in the oscilloscope display. He measured unknowns by tuning the analyzer until the signal crossed the center line.

You can use my analyzer to check circuits for spurious oscillations and amplitude, and assist in tuning. It needn't be tuned precisely to display a signal, doesn't require close coupling, and has a wider frequency range than a grid dip meter. My unit has the following specifications:

- Frequency coverage of 54 to 900 MHz in two bands with no gaps in coverage.
- A digital readout which displays the frequency of the center graticule of the oscilloscope to + or − 1 digit. It continues to give a useful reading even when the frequency sweep is reduced to zero and only the manual tuning knob is used.
- Two steps of selectivity, good sensitivity, and uniform frequency response. It will display all the FM, TV, Amateur VHF/UHF, and communications services in a metropolitan area when connected to a TV antenna or even a random wire.
- FM audio monitoring to identify unknown stations, and a simple design with parts count at a minimum consistent with good results.

Of course this isn't a spectrum analyzer. As a homebrewer, I don't have the resources to produce a true spectrum analyzer. The unit only approximates a logarithmic amplitude response, which is good enough for me. I use a decade attenuator to read relative dB amplitudes when I need more accuracy. The voltage versus frequency response of varactor diodes in cable and TV tuners is inherently nonlinear. This matters only if you want to read the frequency off the graticule of the scope. A better method is to rotate the fine tuning until the signal in question is at the center of the graticule, and read out the frequency on the digital display.

TV tuners have been evolving away from switched inductor and capacitor to solid-state varactor tuning. The varactor tuner uses the capacitance change across a silicon diode that takes place when a reverse DC voltage is varied. The capacitance increases as this control voltage is lowered. If a sawtooth waveform of sufficient amplitude and correct average DC is substituted for this DC control voltage, the tuner tunes its frequency range rapidly, and very little circuitry is needed to obtain a panoramic display. The combination of solid state and no moving parts means greater reliability, smaller assemblies, and easy interfacing. This, in turn, results in low cost and high performance.

**Tuner construction details**

The NEC cable tuner requires no modifications. It's well shielded and appears to have a good frequency response. The 53-channel display was almost flat when I checked out our local cable system on the completed analyzer.

I wanted higher frequency coverage than 400 or 450 MHz and had a UHF tuner left over from a previous project, so I decided to try it. However, UHF tuners don't have built-in scalers. I solved this problem by adding an RCA CA3179E chip to the tuner in a circuit that should also be easy to add to any make of solid-state tuner.

Most UHF TV tuners cover channels 14 through 88 only, but the Mitsumi covers more — 500 MHz, actually. It's worthwhile to try to find one. Look for a UES-A55F or UES-A56F. Radio Shack sold one (stock no. 277-220) in 1983, but I

* Available as a kit from Circuit Board Specialists, (303)542-4525
One line diagram frequency analyzer.
NOTE:
A COUNTER CONNECTED TO OUTPUT OF PRESCALER SHOULD READ ABOUT 1.838MHz FOR LOW END AND ABOUT 3.793MHz FOR HIGH END OF MITSUMI TUNER RANGE. THIS IS EQUAL TO A VCO FREQUENCY OF 470.5 TO 971MHz.

1-F COMPONENTS

INPUT  RF  MIX  VCO

TUNING LOOPS
VIEW OF TUNER WITH COVER REMOVED

UE5 - 45SF
(R. S. # 277-220)
MITSUMI TUNER

PRESCALER -256

Mitsumi tuner prescaler installation detail.
haven't seen any recently. If you can't locate a Mitsumi, use any available tuner and settle for its top frequency. Modifications covered in Reference 5 outline how to wind a simple transformer on a ferrite bead so you can use the tuner at 63-MHz output. There's also information on how to modify the input so it's unbalanced and shielded. This is easy to do. Many tuners are already fitted for unbalanced input. Use phono plugs and jacks and miniature coax for connections and signal routing. This Mitsumi tuner was designed for an IF output of 44 MHz, and operates well at 63 MHz — the same as the cable tuner.

Figure 2 gives details of the prescaler installation. I mounted it on a small pc board and coupled a short, single-turn pickup loop to the local oscillator in the tuner. Oscillator operation wasn't affected because very little energy is required to drive the CA3179. The CA3179E is readily available and inexpensive. If you're adding the scaler to another type of tuner, use the minimum coupling necessary. Make it mechanically secure, and keep the lead lengths short.

**Tuner checkout**

Attach a 7805 three-terminal regulator to the UHF tuner so it's powered when the tuner is on. Check the operation of the scaler after the scaler installation is complete and the resistors are mounted on the tuner as shown. Connect the tuner to a temporary test source of +12 volts. Then connect the output of the scaler to a frequency counter, and monitor it while you adjust the varactor tuning voltage over the range of 0 to +32 volts. Look for any dropout in count. If any loss occurs, make a minor adjustment to the

---

*Spectrum analyzer 10.7-MHz IF assembly.*

*Jameco Electronics (415) 592-8097 Stocks all the ICs and most of the small parts used in this project $20 minimum order.*
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- 10Hz digital frequency display
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- Three scan modes
- Noise blanker

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- Direct digital synthesizer (DDS)
- Dual VFOs
- Band memory registers
- Sensitive 105db dynamic range receiver
- Panel-selectable RF preamp and attenuator
- Built-in controller for optional AH-3 remote antenna tuner for HF operation.

The outstanding IC-726 puts all the exciting DX action of sunspot cycle 22 right at your fingertips, and it is confidently backed with ICOM's no-compromise one year warranty. See this amazing unit at your local ICOM dealer.
VCO/scaler coupling and recheck until the scaler operation is reliable over the entire varactor voltage range. The VCO frequency is the counter reading multiplied by 256; the signal frequency is the VCO frequency minus the first IF frequency, 63. You now know the exact tuning range of your tuner. I obtained counter readings of from 1.838 to 3.793 MHz, equal to a VCO frequency of 470.5 to 971 MHz. The high end signal frequency was 971 – 63, or 908 MHz; the low end limit was 470.5 – 63, or 407.5 for 63-MHz IF frequency.

The IF circuit

Figure 3 shows the schematic of the dual conversion IF strip. This is a crystal-controlled, double conversion receiver, which uses either a Motorola MC3356 or an RCA CA3089 FM detector. The AM output of the detector is the analyzer output to the oscilloscope; the FM output gives a speaker monitoring capability. I have built IF strips using both detectors and they work equally well. I would recommend the CA3089 because it’s easier to find and doesn’t require the TL082 op amp. I installed the narrow 15-kHz filter because I happened to have one in stock. It isn’t used often.
The superior engineering designs, quality and high performance that AEA built its reputation on are now available in its dynamic new line of antennas. Developed and manufactured by Mike Staal K6MYC, president of M² Enterprises and co-founder of KLM antennas, the product line includes an assortment of 2-meter, 6-meter and 440 MHz antennas and accessories for fixed or portable applications. AEA/M² antennas are already recognized for their superior performance by many moon-bouncers.

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For further information, see your local AEA authorized dealer, or call AEA at (206)775-7373.

### Table

<table>
<thead>
<tr>
<th>Model</th>
<th>6M-5</th>
<th>6M-2WL</th>
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<th>2M-18XXX</th>
<th>2M-6WHLD</th>
<th>2M-CP14</th>
<th>2M-CP22</th>
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<td>20</td>
<td>22</td>
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</tbody>
</table>

### Notes
- Gain - dBd, gain over a dipole. Boom - Length, feet and inches.
- Weight - Weight in pounds. Antenna weight/shipping weight.
- Windload - Windload area in square feet. F/B - Front-to-back ratio, dB.
- 6M - Six meters. 2M - Two meters. WL - Wavelength.
- HD - Heavy-duty. CP - Circularly polarized. EB - Eggbeater.

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THE TWIN BANDER

DR-570T

The ALINCO Model DR-570T is a dual band transceiver offering big value in a small package. The independent main band and sub-band operation permits full duplex operation. The front panel is easy to read and understand. The LCD display lets the operator know at a glance which functions are in operation. The built-in duplexer has a single antenna output for a dual band antenna. ALINCO has listened to the consumer and in response has created the versatile DR-570T which is truly user-friendly with minimal effort.

- ULTRA-COMPACT BODY
  5 7/8" (W) x 2" (H) x 8 1/2" (D)

- HIGH POWER
  45 watts on 2M and 35 watts on 70 cm.
  Approximately 5 watts low power.

- EXTENDED RECEIVER RANGE
  (130-169.995 MHz) on 2M, 144-147.995 MHz transmit.
  440-449.995 MHz on 70 cm.
  (transmit and receive)
  (Specifications guaranteed on amateur bands only. Modifiable for MARS/CAP permits required)

- SIMULTANEOUS
  Receiving on both bands at the same time
  Scanning; intermix scan modes on both bands at the same time

- INDEPENDENT
  The volume, squelch and control dial are independently adjustable on both bands.
  You can store the following information on both bands at the same time. Priority function, choice of 37 encoding/decoding sub-tone frequencies, call channel, scan function (program, memory channel, VFO or unique open channel scan), memory skip, bell function, + or - repeater shift.

FULL FEATURES

- FULL DUPLEX CROSS BAND OPERATION
  Transmit on one band while receiving on the other band -- telephone style.

- AUTOMATIC BAND EXCHANGE (A.B.X.)
  When in the ABX function is active, an incoming signal on the sub-band will activate an automatic exchange between the main band and the sub-band.

- PRIORITY
  The VFO frequency is monitored for 5 seconds and then shifts for one second to the selected priority channel (In both bands at the same time).

- DUAL SPLIT SHIFT OPERATION
  Operates odd offset operation

- BELL FUNCTION

- REPEATER REVERSE FUNCTION

- CALL CHANNEL FUNCTION

- BEEP FUNCTION

- 20 MEMORIES (10 FOR EACH BAND)
  Each memory channel can store frequency, repeater offset, encode/decode frequency.

- 4 SCANNING MODES
  Program scan, memory scan, band scan and unique open channel scan (opposite to normal busy scan). Scan stops on a busy (or open channel) channel and then resumes approximately 5 seconds after stopping even if the signal is still present.

REPEATER OPERATION
The DR-570T can be used as a cross band repeater.

EASY TO OPERATE FUNCTION

- LARGE AMBER MULTI-FUNCTION LCD DISPLAY
  Visible in all conditions, it indicates main and sub-band frequencies, frequency step, "on air", "call", CTCSS, "PRI", "REV", "-", "+", "T" (tone), tone frequency, "MUTE", "LOCK", "ABX", "J", "BUSY", "F", "S/RF meter", "REV"

- MHz FUNCTION FOR BOTH BANDS
  One MHz is increased or decreased per touch

- SELECTABLE DUAL AND SINGLE BAND OPERATIONS
  One touch selection with pressing of twin key

- SELECTABLE BAND MODE (MAIN/SUB)
  One touch selection with pressing of band key

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TORRANCE, CALIFORNIA 90501
Tel: (213) 618-8616 Fax: (213) 618-8758
The sweep circuit

Most of the sweep circuit already exists in any oscilloscope. The circuit is WA2PZO’s idea.* Find a point in the oscilloscope wiring where the horizontal deflection waveform has zero DC component. This would be the output of the complementary transistor pair that drives the H deflection plates. Usually there’s an unused Z axis jack that you can use to bring this signal out of the scope. Proceed with care when making this modification. High voltages are present in any oscilloscope. Measure the p-p voltage at this point; it will probably be well over 100 volts.

Figure 4 shows the analyzer’s sweep circuit. There should be about 35 volts p-p across the sweep width potentiometer. Change the value of R2 to obtain the correct voltage. A multicontact relay lets you switch the various voltages and change tuners with a single panel switch. The diode clamps in the sweep potentiometer circuit prevent the sweep voltage from exceeding the supply voltage on either band.

The sawtooth ramp from the oscilloscope is really a

* Science Workshop, Box 310, Bethpage, New York 11714. Carries the NEC cable tuner and some other parts.

**FIGURE 4**

Sweep circuit of the analyzer.

**FIGURE 5**

Multiple voltage power supply for the analyzer.
rapidly changing DC voltage. The LM311 switches its state at an adjustable point (set by R1) on this ramp, which sets the exact time during the sweep that the frequency display samples the scaler outputs.

The counter circuit

The timebase of 1.024 milliseconds in the counter is a little unusual. It's in binary instead of the usual BCD because the scalers divide by 256 instead of powers of 10. Consequently, all the rest of the timing values in the counter are binary.

Figure 6 shows the counter circuit. This is the basic circuit, with typical preload switch values for a 12-bit dip switch. I used this circuit while working on the 0 to 400-MHz tuner frequency display. The switches made it easy to adjust the counter to compensate for the unknown frequency offset.

The power supply

The analyzer required four voltages: +5, +12, +24, and +32. The easiest way to get these voltages is to use the circuit in Figure 5. I mounted all the power supply components, with the exception of the transformer, on a 2-3/4 x 5" single-sided pc board. Radio Shack stocks most of the parts.

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#278-205

Pkg. of 2/1.79

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#278-198

1.69

(3) M-385 UHF T Adapter.

#278-189

3.49

(4) Type PL-259 Dual-Female Adapter. 

#278-199

1.69

Switching Buys


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14.95

(1) SPST Automotive Relay. 

#278-746

1.89

(2) DPDT Knife Switch. 

#276-1403

2.19

(3) Shielded Adapter.

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(4) SPST Relay. 

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**SPECIFICATIONS**

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<thead>
<tr>
<th>Model</th>
<th>Freq. MHz</th>
<th>Power Input</th>
<th>Power Output</th>
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<th>Gain-dB</th>
<th>DC +Vdc</th>
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<th>RF Conn.</th>
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</table>

Models also available without GaAs FET preamp (delete G suffix on model #). All units cover full amateur band - specify 10 MHz bandwidth for 420-450 MHz amplifier. Continuous duty repeater amps also available.

Amplifier capabilities: 100-200 MHz, 225-400 MHz, 1-2 GHz, Military (2BV), Commercial, etc. also available - consult factory.

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Adding automatic preset switching for VHF and UHF to basic counter drawing.

of the local oscillator in the NEC. (I later found it to be 610 MHz.) I determined the correct switch settings for the UHF tuner, and then had to find a way to enter these binary values into the system when switching between tuners.

Data selectors U11, U12, and U13 do this by acting as a 12-pole two-position switch. The circuit in Figure 7 shows the data selectors hard wired so the correct binary switch presets are present at the IC inputs. One section of U10 selects the correct scaler. This is a flexible arrangement which can be used with another brand of cable converter and/or another UHF tuner. Just find the preload values with dip switches, then replace the switches with data selectors.

The counter circuit works as follows. A value equivalent to the oscillator’s offset in the tuner is preloaded into U1, U2, and U3 when one-shot U4 is toggled as the LM311 detects center line crossover of the sweep. U4 resets U6 and U7, and sets both sections of U9 — a dual RS flip-flop. At this point, U9 pin 2 is enabled and the count signal is at pin 13, but the gate doesn’t pass the signal because pin 1 is low and the NAND gate is inhibited. U6 starts counting clock pulses to establish a 1.024-ms timing interval. U1, U2, and U3 count down from the preset value until they

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reach zero, and output a borrow pulse at U3-15. The borrow is inverted and clears one section of U9, enabling U8-1. U8 starts to pass prescaler pulses, which are divided by 4 in U1. This continues until the 1.024-ms time interval has elapsed. At this point, U6-15 goes high, inverted in U8-3. The section of U9 that has been keeping U8-2 enabled suddenly goes low, and stops the counting in U7. When U9-1 is cleared, U9-6 generates a pulse transferring the new count to U7's latch and display circuitry. U7 displays this value until the next count is completed and transferred into the latches. U7 supplies current to the multiplexed seven-segment display in a standard circuit using transistors to switch digits.

Mechanical construction

The unit is housed in an inverted 15" x 9" x 3" aluminum chassis. The circuit boards are mounted on standoffs similar to those in the TVRO in the Gibson articles. The counter circuit was wire wrapped and the layout is shown in Figure 8. It's advisable to shield the counter assembly completely because of the digital noise. I built the IF detector circuit on a double-sided pc board because it provided an excellent way to eliminate feedback and reduce shielding problems. I now use wide masking tape as resist, and trim it with an X-acto® knife to make the pc trails. It's inexpensive and easy to work with.

There are two BNC jacks on the panel for the two signal inputs. I shielded these jacks with scrap pc board material. I used two more BNC jacks at the back of the chassis for sweep in and signal out.

The marker generator

You'll need a marker generator (shown in Figure 9) to verify that the counter is working correctly and to help in initial setup. Even though everything now works properly, I still use the marker generator when I start out to verify that
100-MHz marker.

**PARTS LIST**

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<tr>
<td>L2</td>
<td>T50 toroid 7T no. 22</td>
</tr>
<tr>
<td>L3</td>
<td>4T no. 22 over L2</td>
</tr>
<tr>
<td>R1</td>
<td>47 ohm 1/4&quot;-watt fold over no. 30 wire wound full</td>
</tr>
<tr>
<td>Y1</td>
<td>100-MHz crystal (Texas Crystals)</td>
</tr>
</tbody>
</table>

All other resistors 1/4 watt. 0.01 μF capacitors are miniature disc.

**REFERENCES**


all is well. I used a circuit which pulses the marker on and off to make it stand out.

The marker generates harmonics of 100 MHz up through 900 MHz. You may have to experiment a little to get the oscillator circuit that works best with your crystal. The one shown is the best of the several I tried. Build the marker last, and use your working analyzer. You'll wonder how you got along without it.
A TRANSMIT CONTROL FOR MOBILE OPERATION

By James M. Bryant, G4CLF, 16, Church Road, St. Marks, Cheltenham, GL51 7AN, U.K.

Recent editions of the Highway Code for Great Britain recommend that drivers do not use handheld microphones while at the wheel of a car. Many Amateur operators are now using boom microphones attached to a headband, the seatback, or the sunvisor. These microphones leave both hands free for driving.

The driver-radio operator still has the problem of switching his transceiver between receive and transmit. A common solution is VOX or voice operated transmission — a circuit which switches from receive to transmit whenever the operator speaks. While useful, this has several disadvantages in a motor vehicle:

- While a well-designed VOX circuit will reject noise from the receiver of the rig it is being used with, it will still respond to the loud external noises common in a motor vehicle.
- A VOX causes the transmitter to transmit anything the operator says — even if it is addressed to another person in the vehicle (or another driver!). This function makes VOX operation rather inconvenient.
- It may also respond to speech from a broadcast receiver; many operators listen to the car radio while monitoring Amateur frequencies.
- VOX circuitry needs careful adjustment if it is to respond properly, particularly over a wide range of ambient temperatures.

The circuit to be described is a substitute for VOX. It requires the driver to operate a push-button switch to start and finish a transmission; this only requires the use of his hand for about as long as any of the other vehicle controls. (A foot switch, like an old-fashioned headlamp dip switch, might also be used.) The circuit also has other useful features.

Operating features

The control consists of a single push-button switch. If it is pushed briefly the transceiver starts to transmit and continues to do so until either the button is pushed for a second time and released, or a preset time interval is exceeded. (This causes the transmitter to time out before a repeater does.) If the button is pushed and held down for more than a second, the transceiver will transmit only until the button is released. This combination is very useful. To make a short call (but longer than a second) the button is used like a conventional push-to-talk (PTT) switch; for longer transmissions it need only be touched once at the start and again at the...

![System diagram of control circuit.](image)
Waveforms of different modes of operation. (A) Using the timeout. (B) Push to talk/Push to stop. (C) PTT operation.

Circuit diagram.

end. If the transmission exceeds a preset time it is ended automatically. The last feature has three benefits:

- It prevents garrulous individuals (like the author) from talking interminably.
- When operating through a repeater with a time-out it prevents one from wasting breath talking and not being relayed.
- If the button is touched accidentally it limits the length of the unintended transmission. This last feature is quite useful as it is by no means uncommon to have repeaters blocked out for a considerable time by a mobile station who has accidently gone to transmit with a PTT locking device.

System description

A functional diagram of the control is shown in Figure 1. It consists of a flip-flop, two time delays (one of 1 second and one of whatever timeout delay is required), two gates, and a switch to operate the PTT line of the transceiver being used.

The various modes of operation are shown by the waveforms in Figure 2. In every case the flip-flop changes state when push-button switch S1 is first operated and both time
delays start. The output of the switch and the Q output of the flip-flop go to an OR gate which drives the output switch.

If the switch is released at once, the short time delay is reset and the Q output of the flip-flop holds the output switch closed until the long time delay is complete. The flip-flop is then reset (Figure 2A).

If the switch is pressed again during the delay (Figure 2B) the flip-flop changes state again and the long time delay is reset when the first time delay is complete, but the output switch is held closed (as in Figure 2B) until S1 is released.

**Circuit Description**

The system is built around two CMOS devices, IC1 (a 4013 dual D-type flip-flop) and IC2 (a 4093 quad dual-input NAND Schmitt trigger), two VMOS transistors, two diodes, three resistors and four capacitors. The circuit diagram of the controller is shown in Figure 3.

The circuit works because of the use of the 4093. A normal CMOS gate circuit has a linear region where small changes in input produce small changes in output; in other words it acts as an amplifier. A Schmitt trigger, on the other hand, is a "snap-action" device. If the input is changed the output remains unmoving until a threshold is passed, when the output switches to its new value. However, if the input is then moved backwards it must move some distance back (called the "hysteresis") before the output snaps back to its original state. The characteristics of a normal CMOS gate and a Schmitt trigger gate are shown in Figure 4A and Figure 4B, respectively.

CMOS Schmitt triggers have very high input impedance so there will be a delay between the input changing state and the output if they are driven via a resistor/capacitor timing circuit (Figure 5A). If there is a diode in parallel with the resistor, the delay when the diode is conducting will be minimal but the delay when the diode does not conduct will be defined by the resistor as in Figure 5B. You can thus use CMOS Schmitt triggers to make time delay circuits which reset very quickly. Of course, NAND CMOS Schmitt triggers can be used as simple NAND gates.

The operation of the circuit in Figure 3 is quite simple. The input to gate 1 of the 4093 is held high by a 100-k resistor (R1) to the positive supply rail. The push-button S1 grounds the input to the gate, which causes its output to go high. Capacitor C1 (100 nF or 0.1µF) debounces the switch and also prevents RF from the transmitter from affecting it. If S1 is located a long way from the controller, a ferrite bead should be slipped over the wire near the gate to minimize RF pickup.

When the output of gate 1 goes high it drives the clock of flip-flop 1 (flip-flop 2 is not used and all its inputs should be grounded) and its outputs change state. This is because the Q output is fed back to the D input. The output of gate 1 turns on transistor Q1 and the Q output of the flip-flop turns on Q2. Either Q1 or Q2 will switch the PTT line of the transceiver.

As well as driving the flip-flop, the output of gate 1 is inverted by gate 2 and applied, via a time delay of about 1 second formed by R2 and C2, to one input of gate 3 which drives the reset input of the flip-flop. As long as both inputs to gate 3 are high its output will be low, but if either goes low its output will go high and the flip-flop will be reset. The other input of gate 3 is driven, via a time delay formed by R3 and C3, from gate 4 which inverts the signal at Q. R3 and C3 could be driven directly from Q without an inverter, but since gate 4 is otherwise unused it is better to buffer the relatively large C3. The two diodes, D1 and D2, ensure that when the outputs of gate 2 and gate 4 go high capacitors C2 and C3 will recharge quickly.

If, when S1 is first pressed, it is held down for longer than the first time delay (Figure 2C) the flip-flop is reset when the first time delay is complete, but the output switch is held closed (as in Figure 2B) until S1 is released.

**Figure 1**

Comparison of transfer characteristics. (A) Normal CMOS gate. (B) Schmitt input CMOS gate.

**Figure 5**

Delay circuits. (A) Schmitt trigger in delay configuration. (B) Delay configuration with fast reset. (Reacts slowly to a rising edge and quickly to a falling edge — or vice versa if the diode is reversed.)
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There are two subtleties of design in the time delays. One is that the timing resistors R2 and R3 are driven by the gates as shown in Figure 6A. The circuit would also work if they were grounded as in Figure 6B, but the standby current would be several µA instead of a few nA. The other subtlety is that the timing capacitors C2 and C3 are fully charged in their standby state. This is unimportant so far as C2 (a ceramic capacitor) is concerned, but being biased continuously will reduce the leakage current of C3 — a tantalum bead electrolytic.

The circuit will operate from any supply voltage between +5 and +15 volts but its timing is affected by major supply voltage changes. It has negligible current consumption in its standby state and does not require an ON/OFF switch. An alkaline 6-F22 (PP3) battery makes an ideal power source, which should last for several years. During timing periods its consumption may rise to about 50 µA and while S1 is pressed it will draw nearly 200 mA.

The output switch uses two VMOS transistors with their drains paralleled to give an OR function. They could be replaced by one VMOS device, two diodes and a resistor, as shown in Figure 7A, but this circuit increases the current consumption during switching by about 80 µA. If VMOS transistors are hard to obtain they may be replaced altogether by an NPN transistor (almost any small-signal type will do), two diodes, and two resistors (Figure 7B) but this will increase current consumption during switching to about 200 µA.

The output switch will only work with PTT lines that are grounded to operate. The VMOS device recommended, a VN10 from Siliconix, will work with positive voltages up to +50 volts and is capable of sinking 100 mA. If an NPN transistor is used the limit is about 80 percent of its Vceo rating. PTT line currents are generally less than a mA.

**Timing**

The threshold voltages of 4093 Schmitt triggers vary from device to device. It is not, therefore, possible to give values for R3 for particular delays. Some experimentation is necessary. Using the same 4093 and 47 µF tantalum bead capacitor that you are going to use in your finished equipment, build the circuit in Figure 8. Connect a p.s.u. or battery of the same voltage as the finished project and check that when the switch is closed the LED lights after a delay of a few minutes. Open the switch and leave the circuit powered for several hours for the leakage current in the capacitor to drop (leakage in electrolytic capacitors is always greatest just after they are powered up). Close the switch and time the delay until the LED lights.
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If this time delay is $T$ seconds then the value of timing resistor that you must use for a delay of $t$ seconds is $t/T$ megohms. When you have calculated this, replace the 1-meg resistor with the new value and check that it is correct. It is reasonable to find an error of up to 10 percent due to leakage in the capacitor and you may wish to adjust the calculated value to get a more accurate performance (increasing the resistor increases the time delay and vice versa). When you have finished these tests you can build the circuit using the components you have tested.

If you want several different delays you can switch several different values of $R_3$. It is important that the switch is placed at the end of the resistors connected to the output of gate 4 and on no account the end connected to the input of gate 3 (Figure 9).

**Construction and connection**

The circuit is very simple and may be built using almost any construction technique. A circuit board layout and placement diagram are shown in Figure 10; this is by no means necessary. The only important feature of the construction is that leakage currents at the positive terminal of $C_3$ must be avoided. The circuit and its battery are so small, and need attention so rarely, that they may be mounted almost anywhere. By adding a 75L03 regulator to prevent supply variations, you could mount them inside the rig itself. The power is taken from the unswitched side of the incoming +12 volts DC supply. The circuit timing in this case should be tested at +5 volts and not with a 9-volt battery (see Figure 11).

Much more important than the mounting of the circuit is the mounting of the push-button switch $S_1$. I have mounted mine on the transmission tunnel just behind the gear lever. The possibility of a foot-operated switch (to the left of the clutch) has already been mentioned, and many operators have switches on the gear lever itself. Other possibilities include steering column mounted switches (sometimes available from motor accessory shops) or a button on the steering wheel itself, although considerable problems arise from making connections which are not affected by rotation of the wheel.

**Conclusion**

I have been using this controller for over a year now and find it far more convenient than a VOX. It has proved very reliable in service and a major asset in preventing inadvertent repeater time-outs. 


A pc board is available for $1.75 plus shipping and handling from FAR CIRCUITS, 18N640 Field Court, Dundee, Illinois, 60118. 

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---

**FIGURE 9**

Variable delay option. If $R_3$ is switched it must be switched at the end away from the input to gate 3.

**FIGURE 10**

PC board. (A) Foil side. (B) Component placement diagram.

**COMPONENT LIST**

- **Capacitors**
  - $C_1, C_2, C_4$: 100 nF (0.1 F) 50 or 63 volt miniature ceramic
  - $C_3$: 47 nF 10-volt bead tantalum (observe polarity) (If the supply is more the +9 volts use a 16-volt capacitor.)

- **Diodes**
  - $D_1, D_2$: 1N914 or 1N4148 or any general purpose silicon diodes

- **Integrated circuits**
  - $I_1$: 4013 (or CD4013, MC14013, etc.)
  - $I_2$: 4093 (or CD4093, MC14093, etc.)

These are both 4000 series CMOS available from many manufacturers with slightly different letters.

- **Resistors**
  - $R_1$: 100 k
  - $R_2$: 10 meg
  - $R_3$: Several meg (see text)

All resistors are 1/4 or 1/8 watt 10 percent

- **Transistors**
  - $Q_1, Q_2$: VNI0KM or VNI0LM (Siliconix) VMOS transistors or any other small N-channel VMOS which can be switched with CMOS/TTL logic

---

**FIGURE 11**

Installing the controller in the rig.
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<table>
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<th>Gain (dB)</th>
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Inline (rf switched)

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Achieve high IMD rejection in dense signal environments

By Norman J. Foot, WA9HU!, 293 East Madison Avenue, Elmhurst, Illinois 60126

My original homebrew 2-meter converter, built in 1984, was designed primarily for reception of weak signals from the Oscar 7 and 10 (and later Oscar 13) Amateur satellites. I used a mast-mounted, low noise 20-dB gain preamplifier to minimize the overall noise figure.

While the loss of the coaxial cable leading into the station was only a few dB, I included an RF amplifier at the converter's input so that future installations could tolerate much higher cable loss without loss of overall sensitivity. Using this converter I made many exciting contacts around the world via Amateur satellites.

2-meter IMD

Lately I've become aware of what at first appeared to be 2-meter repeater signals in the Oscar 13 downlink frequency band. Further investigation showed these to be third-order IMD (intermodulation distortion) products generated inside my converter.

I don't remember encountering IMD interference from 2-meter repeaters until recently. There were probably fewer repeaters four or five years ago. Today, according to a recent repeater directory, there are over 40 repeaters in and around the greater Chicago area. Most of these are within 20 miles of my location.

Figure 1 shows typical 2-meter repeater activity in my region, as viewed on a spectrum analyzer. The repeater density in metropolitan areas like New York or Los Angeles is probably comparable to or greater than that shown in Figure 1.

My converter originally used a 3N201 RF amplifier in the front end, with three high-Q tuned circuits. The gain was quite high and, consequently, IMD was a real problem — despite what would normally be considered reasonably good front end selectivity.

Third-order IMDs are spurious signals generated by nonlinear devices. An offending spur is located at a frequency equal to the difference between the second harmonic of one signal and the fundamental of the other. Some of these spurs may fall in the satellite passband. For example, if two repeaters are on at the same time, and one transmits on 146.61 MHz while the other transmits at 146.27 MHz, the third-order interfering signal would appear at 145.93 MHz — inside the Oscar 13 downlink passband.

Preamp gain and linearity

A cursory inspection of the repeater frequencies in my area reveals that there are possibly a dozen frequency combinations that can produce IMDs that fall in the 145.825 to 145.975 MHz Oscar 13 downlink passband. These spurs are usually developed in the converter's first mixer. Generally, a preamplifier can handle high amplitude signals without producing significantly strong IMD, but its bandwidth and gain are large. Consequently, it amplifies unwanted (out-of-band) signals and passes them to the nonlinear mixer. My 2-meter preamplifier has 20-dB gain and is very linear, having a two-tone intercept point at about 12 dBm as shown in Figure 2. The possibility that it would cause IMD is remote; however, its bandwidth is very large. (See References 1, 2 and 6 for information regarding the theory of intermodulation distortion.)

Signal analysis

Assume that you have two repeater signals delivered by the downlink antenna, each at −50 dBm levels. They are amplified to −30 dBm by the preamplifier, and possibly to −20 dBm by the converter’s RF amplifier. The third-order IMD for this condition was measured on a spectrum analyzer to be 40 dB below either of these signals. This is equivalent to a −90 dBm signal at the antenna, much
Typical spectrum of activity. (Downlink antenna at 45 degree elevation.)

stronger than some Oscar 13 downlink signals.

Another factor influencing IMD is downlink antenna directivity. IMD is more noticeable if the satellite is near the horizon, when the downlink antenna may be pointing directly at a repeater.

Once a spurious signal has been generated, no amount of IF selectivity can reduce it. Corrective action boils down to providing the least amount of preamplifier and RF gain consistent with maintaining adequate overall noise figure and minimizing front end bandwidth. It's generally a good idea to retain high preamplifier gain, but minimize RF stage gain. Reducing RF bandwidth is by far the most effective means for reducing IMD signals.

Q multiplier

Recently, I experimented (and had considerable success) with a 2-meter Q multiplier circuit in an attempt to produce an exceptionally narrow RF passband width. By definition, a Q multiplier is a selective amplifier with controlled regeneration. This may sound scary at 145 MHz, but read on.

After having shown by bench tests that repeater or other out-of-band signals could be responsible for IMD interference when given the proper conditions, I decided to build an outboard Q multiplier to perform actual tests using a 2N5486 JFET as the active element.

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of my converter, adding an RF attenuator pad at its output to limit overall gain. After I added a potentiometer to control bandwidth, it was obvious that the Q multiplier had indeed reduced the levels of the offending spurious signals. Except under unusual circumstances, the IMD was for all practical purposes eliminated. My next step was to modify the converter to include the Q multiplier in place of the original RF stage.

The converter

Figure 3 shows the overall 145-MHz converter including the Q multiplier, crystal oscillator, mixer, and IF amplifier. The Q multiplier is a variable gain, variable bandwidth RF amplifier. It drives a double-balanced mixer (DBM) through a 9-dB pad. A local oscillator (LO) signal is fed to the DBM through a 3-dB pad from crystal oscillator Q2. The 28-MHz IF output signal is the difference between the 145-MHz signal frequency and the LO frequency. A double-tuned 28-MHz filter feeds the IF output to J2. The converter will provide 144 MHz at an IF of 28 MHz using a 116-MHz crystal. If the converter is dedicated to Oscar 10 and 13, use only a 117-MHz crystal is recommended; it will produce an IF of 28.825 to 28.975 MHz. Note that the decimal digits of 28 MHz then correspond to the 145-MHz decimal digits, enabling quick determination of the actual downlink fre-
Oscar 13 converter.

**Oscar 13 converter.**

*Oscar 13 converter.*

**Gain and bandwidth**

The Q multiplier bandwidth is controlled by potentiometer R11 located on the front panel of the receiver. Converter gain varies with the setting of this control and is highest when the bandwidth is narrowest. When the satellite is at apogee (maximum range), I adjust the control for minimum bandwidth (maximum gain). Signal levels are often very high when the satellite approaches perigee, so I increase the bandwidth. This, in turn, decreases signal levels at the mixer. Gain and bandwidth tend to compensate in terms of minimizing spurious signals.

Capacitor C15 is a special handmade capacitor which couples the two tuned circuits at the mixer output. It's made by soldering a short piece of no. 16 copper busbar to the high side of one coil and placing the other side against the high side of the other coil. A piece of Teflon™ sleeving prevents a short.

The mast-mounted low noise preamplifier that precedes the converter is powered by 15 volts DC, which is fed over the center conductor of the interconnecting coaxial cable for remote preamplifier operation. R1 is a 300-ohm 1-watt limiting resistor, used to avoid a catastrophic failure in the event the cable center conductor should short to ground.

Capacitors C3, C6, and C11 are piston trimmers with the six-turn coils soldered to them directly with short leads. C4 is a fractional pF coupling capacitance made by soldering a short piece of no. 16 copper busbar to the high side of one coil and placing the other side against the high side of the other coil. A piece of Teflon™ sleeving prevents a short.

### Gain and Bandwidth

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Converter gain and bandwidth.

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**REFERENCES**

**Bandwidth**

Figure 4 illustrates the RF bandwidth of the converter for various settings of the selectivity control, in terms of overall converter gain. The narrowest useful bandwidth is less than 200 kHz, corresponding to an overall converter gain of 9 dB. This setting provides maximum skirt steepness, which gives maximum protection from out-of-band signals. If the bandwidth control is advanced still further, the RF stage will oscillate. This is indicated by receiver quieting. Selecting the narrowest possible bandwidth requires knowledge of the control setting where oscillation starts. To facilitate smooth control, I use a ten-turn Bourns potentiometer. Note the dashed curve in Figure 4 which shows the bandwidth of the original converter for comparison.

**Q multiplier benefits**

It's clear from this set of curves that the Q multiplier is effective in terms of reducing and controlling front end bandwidth. Since I modified my converter to include the Q multiplier described here, I hear IMD developed in my converter from unwanted signals only on rare occasions and under unusual conditions. In addition, the bandwidth control is a handy means of setting gain to compensate for close-in and far-out satellite conditions.

My current interest is satellite communications, but the converter I've described may also be useful for 2-meter point-to-point communications, or whenever a dense RF environment may cause IMD interference. With the IMD problem now under control, I'm getting a lot more fun out of my satellite communications equipment.

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A complete slow scan television station for your IBM PC or compatible. Send and receive images in up to 10 shades of gray depending upon your graphics card and printer.

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196-23 Jamaica Ave., Hollis, NY 11423
Phone: (718) 468-2720 Mon. thru Thu.
A Low Cost Battery Pack For Your Kenwood TH-25AT Handheld

I have a TH-25AT that I use for extended periods of time. Consequently, I need batteries with longevity. I looked into different batteries and discovered Kenwood’s PB-7, an 1100 mAh. The capacity looked right, but the PB-7 was too large for my pocket. I continued my search and found the BT-6 covered Kenwood’s PB-7, an empty battery case for $15.95. I added the same capacity and is the same size each.* My homebrew battery pack has the same capacity and is the same size as the PB-6 battery supplied with the HT and cost me just $29.95.

I used the BT-6 and PB-6 batteries for about a week and found they worked well. However, I had to remove the six batteries from the BT-6 battery case every evening and charge them in my NiCd charger overnight for the next day’s use.

I needed an easy way to charge the batteries without removing them from the case, but the Kenwood-supplied BC-9 charger wouldn’t slide onto the BT-6 case. I compared the BT-6 case and the PB-6 battery pack and found that the rail on the case next to the + terminal was longer. Using an X-Acto™ knife, I trimmed 0.28 inches to match the rail on the BP-6 battery pack. After I made this modification the BC-9 charger slid on, and I was set for a 15-hour charge without removing the batteries.

Those with a BC-11 charger who’d like to leave the batteries installed in the BT-6 case while charging can try a different modification. Just add two 0.25-inch square copper pads to the back of the case to mate with the contacts in the BC-11 rapid charger.

Modifying the BT-6

Remove the batteries and lay both packs back side up on your worktable. Cut two 0.25-inch square copper pads, smooth the edges with a file, and lay them on the back of the BT-6 case matching the location of the pads on the PB-6 battery. Mark their location and remove the pads. Drill two small holes in the center of the marked area using a bit no larger than no. 22 wire. Next use a no. 10 drill bit to countersink the holes on the outside of the case. Do this by hand only.

Take some no. 22 stranded wire, strip the ends of two wires a small amount, fan out the strands butting them against the center of the copper pads, and solder. Don’t let the solder build up. The pads must fit flush to the back of the case. To check your work, pull the wire through the drilled holes to see if the solder area is too large. If it is, you may have to enlarge the countersink a small amount or reduce the solder area. When everything looks right, bond the pads to the case with a small amount of Krazy Glue™. Make sure the glue is dry before going on to the next step.

Route the wires inside the case to the terminals on the pads on top of the case. Make sure you are routing the wire from the positive pad to the positive terminal and the negative wire to the negative terminal.

Check with a continuity meter to see that the positive lead goes to the positive terminal and the negative lead goes to the negative terminal. After you’ve confirmed this, install the batteries as marked in the case. Now close the case, being careful not to pinch the wires. Using a voltmeter, make sure that the right pad is positive and the left pad is negative.

These modifications will let you charge your BT-6 battery pack in 15 hours with the BC-9 wall charger or 45 minutes using the BC-11 rapid charger.

I’ve had this battery and charging system for the last seven months. I find it works very well and meets my needs for a second battery with a compatible charging system for the new Kenwood TH-25AT handheld.

T. H. Jenson, KE6WF

Control by Tones

The use of control tones in Amateur Radio is increasing. Although there are many different tone schemes, there are three systems in common use for Amateur Radio. They are: tone burst, Dual Tone Multi-Frequency, and Continuous Tone Controlled Squelch System (CTCSS).

Tone burst

Tone burst is usually a single burst of 1750 Hz at the beginning of a transmission. It is used extensively in Europe to access repeaters. Although fitted to some VHF equipment, it is not used in New Zealand.

DTMF

Also known in the United States as Touch Tone®, it is the system used with the push button telephones. These phones have oscillators to generate a pair of tones for each number on the key pad. The standards and available integrated circuits were developed originally for the telephone service. Now the technique is being used widely in Amateur Radio gear. It is used to control intelligent repeater systems.

A bit of consideration is needed for fellow operators when using DTMF. It
R5 is the antenna designed for space age living, on small city lots, apartments, condominiums or for travel in motor homes. If you have limited space, or galaxies of space, R5 will give the most performance from your transceiver.

R5 electrical halfwave, only 16’ 4” tall design allows the antenna to be mounted virtually anywhere, without compromising performance. It easily handles 1800 watts of power with a solid state matching network giving full band coverage of 10-12-15-17-20 meters.

Easy set-up makes this antenna ideal for portable or fixed installations. It performs without a rotator, or tower. A simple support mast and 50 ohm cable is your connection to ham friends around the world.

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is important to use your callsign and to comply with the radio regulations. It also helps other stations if you outline your intentions. In Wellington I use the following procedure to ask the Belmont 710 repeater for a report on my signal:
1. I dial up the 710 repeater in the normal way.
2. I say, "This is ZL2SX seeking a signal report."
3. I keep transmitting and, using the key pad, I dial 7 1 0 #. Then, without releasing the mic button, I say, "This is ZL2SX testing."
4. Finally, I let the button go and listen for the report.

As repeater systems become more intelligent, the use of DTMF signaling will enable us to "command" the system to do all sorts of fancy and useful tricks. DTMF commands will be used extensively on the National Link to be installed soon.

**Dual Tone Multi-Frequency (DTMF) Standard**

**Frequencies:** 697, 770, 852, 941, 1209, 1336, 1477, and 1633 Hz.

- **Tolerance:** Nominal frequency ±1.5 percent.
- **Twist:** All tones to be within ±3 dB of each other before transmitter preemphasis.
- **Deviation:** The deviation of the 697-Hz tone will be 1.2 Hz.
- **Amplitude Range:** The decoder will operate with tones ±2 dB and −10 dB from nominal deviation.

The tones 697 to 941 are called the "low" tones and represent the rows of the keyboard from the top down. The "high" tones represent the keyboard columns from left (1209) to right. As an example, when you push the "B" key an 852-Hz tone and a 1336-Hz tone are sent together, ideally at the same level. Most Amateur Radio key pads have the 1633-Hz column tone needed for the full set of 16 digits (0-9, #, A,B,C,D). Most telephones have only 12 key pads, as A,B,C,D have no functions in telephone systems.

Note that the DTMF signals will pass through the link and most repeaters without serious distortion. However, in some applications, DTMF signals may be locally regenerated.

**CTCSS**

This is known by various trade names: Private Line, Channel Guard, Selecttone, and others. With this system, the receiver's squelch circuit disables the audio output until the specified subaudible tone is received. This means that your receiver will be quiet until it hears a call from a station using the system. There are 38 standard subaudible tones; encoders and decoders are available for most Amateur VHF and UHF sets. The Wellington VHF Group has been selling units for $35.

I use this system when I am expecting a call from my wife. Our rigs use the same CTCSS subtone, and transmit it whenever the rigs are keyed. If we want to monitor for a call from each other but would rather not be distracted by other repeater users, we engage the CTCSS decoder and the radio is quiet until it hears the correct subtone. It is a very effective system. There are restrictions on some of the tones, as not all repeaters are capable of retransmitting low frequencies.

**Continuous Tone Controlled Squelch System Standard**

- **Frequencies:** Only EIA Standard tones recommended.
- **Tolerance:** Encoder: nominal frequency ±0.1 percent. Decoder: ±1 percent.
- **Deviation:** 0.5 kHz.
- **Amplitude Range:** The decoder will operate with tones +2 dB and −10 dB from the nominal deviation.
- **Response Time:** For frequencies less than 100 Hz, 350 ms maximum. For frequencies above 100 Hz, 200 ms maximum.
- **Talk-off:** Greater than 20 dB, 300 Hz to 3.4 kHz.

CTCSS may be required for some linking applications. However, the digital voice circuits used in link are designed to notch (more than 10-dB attenuation) tone frequencies up to 100 Hz. It is recommended that tones between 67.0 Hz and 85.4 Hz be used where CTCSS is used for control at a link end. Where users wish to use CTCSS for selective calling, tones between 123.0 and 250.3 Hz are recommended.

An understanding of the various tone control systems has given me more enjoyment in this great hobby of ours. I hope it does the same for you.

David Andrews, ZL2SX

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**PRODUCT REVIEW**

**HF Add-on For ICOM IC-R7000 Receiver**

If you own an ICOM IC-R7000 or are thinking about getting one, consider this modification.

A.R.E. Communications Ltd. of London, England, manufactures a board that can be installed in the ICOM IC-R7000 to add HF band receive capability. The board also adds 99 HF memory channels.

The HF kit contains a pc board with components, sixteen wires of various colors and lengths, three sections of coaxial cable, mounting screws, wire wraps, and detailed instructions. The instructions are clear and contain numerous well-labeled photos and diagrams.

The pc board mounts firmly to a spot which ICOM provided for placement of one of their accessories. Placing your A.R.E. board here ensures that it will be mechanically secure and electrically sound. It's important to follow the instructions step by step. Even though you install just sixteen wires between the board and the receiver, those connections are made all over the interior of a radio stuffed with components.

I persuaded my friend Jay to modify his IC-R7000. Three and 1/2 hours later we had the modification in place and were ready to give the radio the "smoke" test.

Jay and I already knew the 7000 provided good reception on the VHF/UHF bands. After a quick check to be sure those bands were unaffected by the changes, we focused our test on the HF bands. The dimmer switch that used to control the brightness of the display now served as the toggle between VHF/UHF and HF receive capability. The instructions suggested that we use the first 30 memories on HF to store frequencies from 1 MHz to 30 MHz in one 1 MHz steps.

We made our unscientific HF evaluation by comparing the modified ICOM 7000 with a stock Collins KWM-380. Whenever we found an unscientific frequency on the Collins, we could pick it up on the ICOM with similar signal strengths. Jay now has an all-mode receiver that can literally go from DC to 2 GHz for a cost of just $149 — truly a good investment.


de NIGCF

Circle #301 on Reader Service Card.
Times have changed! Today when an Amateur wants to buy a new receiver, he begins by reading the specifications. Cost isn't a critical factor most of the time. But it wasn't always that way.

Note the prices as you browse through this issue of Ham Radio; numbers between $1000 and $2000 are common. Even the used equipment advertised in HR's "Flea Market" has comparable prices. The present generation takes these numbers in stride; however, we members of the older generation are amazed. Many of us remember a time when we had trouble finding $29.50 to buy a Sky Buddy. What changes there have been in 50 years!

In the first days of store-bought equipment — during the Depression in the early 1930s — you usually started by reading the price list. A fellow knew how much money he had in his wallet, and that was his limit.

The Hallicrafters Company built its reputation offering affordable receivers for the Depression trade. The receivers may not have been the highest performance type available, but they did provide a lot of signal for the money. Many Amateurs, who might not have had a chance to get on the air, had the opportunity with a Hallicrafter.

I'd like to tell you about three Hallicrafters receivers that were popular among Amateurs of the day because of their low cost and correspondingly good performance.

The Sky Buddy

Amateurs remember different pieces of equipment for different reasons. Some remember the performance, while others remember unusual operating features. Some equipment may be especially treasured because it was used in a first QSO, or because the operator could afford to buy it and (as a result) get on the air.

The Sky Buddy, which went for $29.50, is remembered fondly because it was a good "buddy" to many aspiring Amateurs — especially to those teenagers who bought it during the Depression. Not many Amateurs had the resources to pay $185 for an HRO, or even $100 for an NC-100, but some could afford $29.50.

I remember my own Sky Buddy well. I was a junior high school student in the St. Louis area in the late thirties, and worked in the school cafeteria an entire semester to earn enough to buy one. I had been using a two-tube regenerative receiver described in the 1939 edition of The ARRL Handbook and was able to copy W9BSP's code practice transmissions from Olathe, Kansas, but 160 meters was the only band I could receive. Carrying the Sky Buddy home from the old Walter Ashe radio store on Pine Street was one of the thrills of my adolescence. I connected a 10-foot antenna strung around my bedroom floor, and the first station I heard was a W6 on 20 meters. I don't think any station since then has sounded as loud and clear!

I was also able to receive shortwave broadcast stations, especially those from Europe. Tuning across the SWBC bands in early September 1939, I heard Adolph Hitler announcing the march of the German Army into Poland. Even without the translation, I could tell by the tone of his voice that his speech was not conciliatory! But I wasn't mature enough to realize the effect that broadcast would have on everyone's lives.

The Sky Buddy also played another important role in my Amateur Radio life. I had always been sorry I traded in my Sky Buddy. In fact, I have yet to meet anyone who owned one and let it go who isn't sorry he disposed of it. Well, about 15 years ago I was walking through a hamfest flea market and saw one exactly like the one I had owned, in mint condition. I couldn't resist; I bought it! It was the first acquisition in what has become a collection of over 100 pieces of Amateur Radio equipment from the 1930s. I'm rapidly running out of space to keep my wife. (Wife's note: "You think he jests?")

The original Sky Buddy, first advertised in the September
JAPAN RADIO
Contact us for full shortwave reviews.

The JRC TH-115A/TH-215A is the best shortwave receiver known for, with a full complement of advanced features. Noted reviewer Larry Magne says, "... This 525 is as close to the optimum shortwave listener's receiver as is in existence... unquestionably the best overall shortwave listener's receiver on the market today." Contact us for full details. $1179.95 (+$12 UPS)

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SCAN CATALOG
This brand new catalog offers the latest in scanners, wideband radios, antennas and accessories. Bearcat, Regency, Icom, Yaesu, etc. $1 Postpaid

Informative Catalogs

A Receiver for the Connoisseur

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NRD-525

The Japan Radio NRD-525 combines the high-performance JRC is known for, with a full complement of advanced features. Noted reviewer Larry Magne says, "... the 525 is as close to the optimum shortwave listener's receiver as is in existence... unquestionably the best overall shortwave listener's receiver on the market today." Contact us for full details. $1179.95 (+$12 UPS)

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was 550 to 18,400 kHz. A restyled version was announced in the May 1938 issue of QST, along with the first Sky Buddy. The receiver featured an airplane-type, two-speed tuning dial, then popular for both broadcast and Amateur receivers. It had seven glass tubes (including an RF preselector, magic eye tube, and rectifier), a 5-inch speaker, band switching, and a tone control. Its price was $49.50, which was moderate for the time. The Sky Chief was less than any competing superheterodyne receiver except, perhaps, the National Company's FB-7 — which didn't have an RF preselector or direct reading tuning dial, and used plug-in coils.

Hallicrafters' products were restyled early in 1938, and the Sky Chief was renamed the "Sky Champion." The tube count was increased to eight, five of which were metal. The magic eye tube was eliminated, and two more working tubes were added. The frequency range was extended to 44 Mc/s to add the 10-meter Amateur band and the 30 to 40 MHz emergency services sector, which was just beginning to be occupied. This version was known as the S-20 and is shown in Photo E.

The S-20 provided an optional external S-meter to replace the magic eye tube as a signal indicator. This cost-saving measure was one of the ways Hallicrafters managed to hold the price down, yet still provide features that helped keep amateurs starting out feel confident in their ability to use a receiver effectively.

In 1940, the Sky Buddy was redesigned again. A separate bandspread control was added and its frequency range was expanded to 40 MHz, which included the 10-meter band. This model, called the S-19R, is the one Amateurs generally think of as being "The" Sky Buddy.

The name "Sky Buddy" has an unusual origin. According to Bill Halligan, the founder of Hallicrafters, when the receiver was in the prototype state Hallicrafters was trying to find a snappy name for it. A youngster nicknamed Buddy used to hang out around the Halligan backyard and help Bill with his yard chores. This youngster was so friendly and helpful that Bill named the new receiver after him. Unfortunately, Halligan was not able to remember Buddy's real name. I would be happy to hear from anyone who knows — especially from Buddy himself.

Looking back, I see that the Sky Buddy isn't one of those receivers remembered as having great capabilities — because it didn't. You may think of it affectionately as the affordable model that gave you your start in Amateur Radio, and a lot of pleasant listening.

The Sky Champion

If you were fortunate enough to be able to spend a little more to begin with, or if you'd just been given a raise and could buy a better receiver, the next step up was the Hallicrafters' Sky Champion.

This family of receivers, while not the least expensive, could still be called low cost. The family included two receivers called "Sky Champion," and a third, which was actually the earliest, called "Sky Chief."

The Sky Chief was announced in the September 1936 issue of QST, along with the first Sky Buddy. The receiver featured an airplane-type, two-speed tuning dial, then popular for both broadcast and Amateur receivers. It had seven glass tubes (including an RF preselector, magic eye tube, and rectifier), a 5-inch speaker, band switching, and a tone control. Its price was $49.50, which was moderate for the time. The Sky Chief was less than any competing superheterodyne receiver except, perhaps, the National Company's FB-7 — which didn't have an RF preselector or direct reading tuning dial, and used plug-in coils.

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The S-20 provided an optional external S-meter to replace the magic eye tube as a signal indicator. This cost-saving measure was one of the ways Hallicrafters managed to hold the price down, yet still provide features that helped keep
them ahead of the competition. For an additional $6.95 you could buy an external S-meter with a separate meter cabinet styled to match the receiver. The S-meter plugged into a five-prong socket on the rear apron of the receiver, as shown on top of the receiver in Photo E.

The RF gain control had a switch which closed in the maximum clockwise position (maximum RF gain) and illuminated the S-meter scale. Try putting an AC voltmeter across pins 1 and 5 of the S-meter socket on the rear apron and operate the switch; you should measure 6.3 volts AC.

These optional S-meters are hard to find. I've only seen one and its style is different from those shown in Hallcrafters' advertisements of the time. I'd like to hear from any collectors who have S-meters with different styling.

The December 1939 issue of QST announced a new version of the Sky Champion just in time for Christmas. The circuitry was upgraded to include electrical bandspread, a second tuning knob was added, and both tuning dials were illuminated. The newly developed Dickert automatic noise limiter was also included, increasing the tube count to nine. This version was known as the S-20R (see Photo F). The price remained $49.50, and Amateurs got even more for their money.

The S-20R was a very serviceable receiver. Like many of the receivers of the 1930s, its popularity depended more on its price/performance ratio than on performance alone. The Sky Champion series isn't a good performer on SSB because it uses a diode detector and because its bandwidth is designed for AM phone.

In spite of its simplicity, those who owned and used one remember it fondly. Novices and SWLs lucky enough to find one in good working condition will discover it makes an excellent starting point into radio.

The Skyrider Defiant

As the 1930s came to an end, the Depression eased and many who were hard-pressed in the middle thirties found their economic position improved. A better receiver was within their budget. Or, it may have been that many who were working in the radio business found their skills in greater demand as war came in Europe. Amateur Radio training and experience made Amateurs more sophisticated.

Receivers in the middle price range were becoming more important to both manufacturers and Amateurs. These receivers had to have enough refinements above economy class to make customers willing to pay more. But if they had too many goodies, they took sales away from the high profit, top-of-the-line equipment.

Receiver design had advanced from an art to a science by the end of the 1930s, and designers were able to offer a wider range of capabilities. Manufacturers were constantly judging ideas for midpriced receivers, evaluating which useful features they could add to a receiver without significantly increasing its cost. Equipment like S-meters and crystal filters became common.

Hallicrafters had established its name because of its policy of giving a lot of signal for a buck. They enhanced this reputation by developing two medium priced receivers: the Skyrider Defiant, the SX-24, and the Super Defiant, the SX-25. The SX-24 was first advertised in the July 1939 QST; it was the lower priced of the two at $69.50, plus $12 for a matching speaker. It had nine tubes, including one stage of RF preselection and single-ended audio output (see Photo G).

In February 1940 Hallicrafters announced the SX-25
The Skyrider Defiant SX-24.

Super Defiant as a replacement for the very popular SX-17. The SX-25 cost $99.50, including a matching speaker. It had 12 tubes with two stages of RF preselection, an audio phase inverter, and push-pull audio output (see Photo H).

In the 1942 Hallicrafters' catalog these receivers were priced at $74.50 and $104.50, respectively. Besides an S-meter and crystal filter, which by the late thirties had become common in all but the lowest priced receivers, Hallicrafters added “frequency meter tuning.” When the main tuning dial was set to one of four red lines (one for each of the Amateur bands, 80 through 10 meters), the bandspread dial was calibrated accurately in frequency for that band. This was a new concept which Hallicrafters soon adopted in their other receivers.

The two receivers appear quite similar except for their name, Skyrider Defiant or Super Defiant, and their model number, SX-24 or SX-25, embossed on the metal main tuning dial cover. However, there are less obvious differences in the bandswitch and selectivity switches located just below the main tuning dial. On the SX-24, the selectivity positions and the band numbers are silk-screened on the cabinet as are the rest of the control labels. On the SX-25, the labels for these two controls are embossed on the skirted knobs themselves.

Internally, the most striking difference is the additional tuning condenser (capacitor today) gang required for the extra stage of RF preselection. The SX-25 uses two 2-gang capacitors rather than one 4-gang capacitor, possibly because 2-gang capacitors were originally used on another receiver (like a Sky Buddy). It may be that two 2-gang capacitors were simply cheaper than one 4-gang capacitor. Another obvious difference is the increased tube count of the SS-25.

The SX-24 became a casualty of World War II; Hallicrafters didn’t produce any of them after the war. The SX-25 was advertised in The ARRL Handbook in 1946, but not in 1947. Apparently, Hallicrafters needed a medium-priced receiver they could put into production quickly after the war, and chose the SX-25.

In retrospect, the Defiant family were medium priced receivers whose performance approached that of the high priced sets. They were widely used by Amateurs who could afford more than economy class, but not the luxury line. I believe they deserve more historical interest than they have received to date.

Summary

These low cost receivers have an important place in radio history because they were in a price range which put them within the budget of the majority of the Amateur community. This may be why they remain so popular among collectors and restorers.

Attention! All amateur photographers and artists...

Over the years many of you have read and responded to our calls for manuscripts. Now I have a new request for those of you whose talents lie in different directions. I’m looking for eye-catching artwork for Ham Radio covers. Do you have a picture of an interesting Amateur Radio event, a wild looking antenna, a ham shack with a difference? Do your talents run to drawing or cartooning? Why not let us take a look at your work and see if it has the makings of a good cover piece?

Here are the basics. For those submitting photos, we prefer large-format transparencies or slides taken with 120 film. Shots taken with 35 mm film are sometimes usable, but often are not sharp enough when blown up to cover size. For those submitting drawings, colorful ones are best. But a dramatic black and white picture could also have possibilities.

Don’t be shy. Send us what you’ve got. Hans Evers, PA0CX, a favorite Ham Radio artist, was discovered when he included a doodle at the bottom of a manuscript he sent us. Could you be next?

Terry Northup, KA1STC
New Dual Band HT

Kenwood offers the TH-75A Dual Band HT which features:
- Dual Watch function
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- Uses the same accessories as the TH-25AT (except soft cases)
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- CTCSS encode/decode built in
- Automatic Band Change (ABC)
- Automatic offset selection on 2 meters
- Tone alert system for quiet operation
- Automatic battery saver circuit extends battery life
- Supplied accessories:
  - Dual band rubber-flex antenna, PB-6 battery pack, wall charger, belt hook, wrist strap, water resistant dust caps.

Universal Timer Counter Module/Panel Meter

Optoelectronics Inc. has introduced a new ten-digit universal counter/timer module with direct frequency response from 0.1 Hz to over 150 MHz. There are up to nine digits of resolution per second. Functions include frequency, period, period average, time interval, time interval average, ratio, prescale, over range, and a 16-segment analog input bar graph.

Module size is 1.8” high x 3.55” long x 0.6” wide, suitable for OEM use in custom instrumentation or in a digital panel meter application. The ten-digit 0.25” character height LCD display has annunciators for function, gate time, range, measurement units, input A/B, low battery, prescale, and 16 bar graph segments.

Other features include an on-board 1 ppm 20 to 40 degree C 10-MHz timebase with calibration adjust trimmer, LCD contrast control pot, CMOS counter inputs (400 mV sensitivity typical), gate light LED, and an eight-bit A/D on board. Four control inputs are for momentary push buttons. The connector is a 14-pin dual 0.025” header. Power requirements are 5 volts DC, 50 mA. The module costs $225 in single quantities and $149 in hundreds.

For details contact Optoelectronics Inc., 5821 N.E. 14th Avenue, Fort Lauderdale, Florida 33334. Phone: (800)327-5912 or FAX (305)771-2052. In Florida call (305)771-2050.

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New Tower-mount Preamplifier

WI-COMM Electronics, Inc offers a new tower-mount preamplifier in a weatherproof aluminum housing which covers the band from 10 to 900 MHz.

"On-Glass"® Disguise Amateur Radio Antenna From A/S

The Antenna Specialists Company has introduced Model AP-143, an On-Glass disguise antenna for the 2-meter band. The new model uses the “pigtail” configuration of cellular antennas to hide the presence of professional radio equipment inside the vehicle.

The antenna’s on-glass design, with capacitively coupled transmission through glass, requires no ground plane and permits quick, no-holes installation. The 26-inch stainless steel whip is covered with a black DUR-A-COAT™ finish for long life. The antenna has a power rating of 100 watts continuous, 150 watts intermittent, and a VSWR of less than 1.5:1.

For details contact The Antenna Specialists Company, 30500 Bruce Industrial Parkway, Cleveland, Ohio 44139-3996. Phone: (216) 349-8400.

Circle #305 on Reader Service Card.

See your nearest Kenwood authorized Amateur Radio dealer for more details or write: Kenwood USA Corporation, PO Box 22745, 2201 E. Dominguez Street, Long Beach, California, 90801-5745. Suggested retail price: $549.95.

(continued on page 53)
Have you been trawling the bountiful main for a new product? We have just netted it—the TP-38 microprocessor controlled community repeater panel which provides the complete interface between the repeater receiver and transmitter. Scuttle individual tone cards. all 38 EIA standard CTCSS tones are included as well as time and hit accumulators, programmable timers, tone translation, and AC power supply at one low price of $595.00. The TP-38 is packed like a can of sardines with features, as a matter of fact the only additional option is a DTMF module for $59.95. This module allows complete offsite remote control of all TP-38 functions, including adding new customers or deleting poor paying ones, over the repeater receiver channel.

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(continued from page 48)

MHz. The preamplifier gain is 25 dB, noise figure is 3.1 dB typical, 1 dB gain compression is at -10 dBm minimum, VSWR input is 2:1, and powering is +12 to 15 volts. Power is supplied via the output connector by a wideband DC block (bias tee). Standard connectors are type N female. Lightning static protection at the input and reverse polarity protection on the DC supply line are included. Wideband DC block is also available, along with the RX-RX switch (SPDT) and the amplifier bypass switch module (insertion loss 0.15 dB maximum, isolation 50 to 70 dB at 900 MHz, set time 5 ms. through power 10 watt maximum, powering +12 to +15 volts, and VSWR is 1.3:1 typical). The SPDT switch can be used to combine two antennas at the preamp input, the bypass switch module can be used to insert a pad/filter into the signal path.

For additional information contact WI-COMM Electronics, Inc., Box 5174, Massena, New York 13662. Phone: (315) 769-8334.

Circle #307 on Reader Service Card.

Midland LMR Announces Data-Capable Syn-Tech™ Mobile Models

Midland LMR’s new data-capable Midland Syn-Tech two-way FM mobile radios incorporate direct FM modulation (factory installed only) and are identified by the addition of a letter “D” suffix to the model number. They are the 110 watt 40-54 MHz models 70-052CD and 70-056CD (dual-mount and trunk mount), the 40 watt 148-174 MHz models 70-340BD and 70-440BD, the 30 watt 450-470 MHz models 70-530BD and 70-630BD, and the 15 watt 800 MHz models 70-915D and 70-970D.

For more information contact Midland LMR, Marketing Department, 1690 N. Topping, Kansas City, Missouri 64120 or call 1-800/MI-LAND (1-800-643-5263), extension 1690.

Circle #304 on Reader Service Card.

Hamtronics New Computer-Controlled REP-200 Repeater

Hamtronics new REP-200 Repeater has all the features of their earlier units plus a microprocessor-controlled COR, CWID, autopatch, and DTMF decoder/encoder with over 45 functions — including built in testing features. It is available for 10, 6, and 2 meters, 220, 440, and 902 MHz, and for the high and UHF commercial bands.

The COR, CWID, DTMF controller, and autopatch are all on one board, along with new signal and power distribution circuitry. Four pc boards have been combined into one module, with IC sockets for easy service. Surface mount capacitors are used in many places to reduce size and enhance performance.

Rugged welded RF partitions are an integral part of the compact new chassis, with Pern nuts to seal the covers for optimum shielding. The rack panel is only 3-1/2 inches high.

All interconnections are done through the controller board to eliminate cable harnesses. External cables for power, telephone, monitor speaker, and auxiliary receiver are made with push-on terminals which plug directly into the controller board. There are more front panel indicators, color-coded LEDs indicate status of all major functions.

On the 2 meter and adjacent commercial band, a new 25-watt RF output option is available. In the unlikely event that isn’t enough power for your application, you can add our accessory 100-watt PA. On UHF, choose from 10 watts with basic repeater or up to 65 watts with add-on PAs. On 900 MHz, choose 10-watt basic repeater or 40 watts with add-on PA.

For more information contact Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535. Phone: (716) 392-9430, FAX (716) 392-9420.

VHF/UHF Dual Band FM Transceiver from ICOM

ICOM introduces a new FM dual band mobile transceiver. The IC-2400A has independent frequency readouts and volume and squelch controls for complete dual band operation. Features include:

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For details contact ICOM America, Inc., 2380 116th Avenue N.E., PO Box C-90029, Bellevue, Washington 98009-9029.

Circle #303 on Reader Service Card.

Handy New Tool from Nemal

Nemal Electronics International has introduced a new ratchet crimping tool. It offers full cycle ratchet operation with machined dies and features a pin ratchet and wire locator. Part number CT2320 accommodates wire sizes from 20 to 30 gauge.

For additional information contact Nemal Electronics International Inc., 12240 NE 14th Avenue, North Miami, Florida 33161. Phone: (305) 899-0900 or FAX (305) 895-8178.
By Bill Orr, W6SAI

ANTENNA MATCHING SYSTEMS

Last month I discussed some unusual circuits capable of matching a coax line to a Yagi antenna. This column deals with an adaptation of the L-network, commonly called the "Beta" or "Hairpin" match. It's a simple and easily constructed matching device that any home builder can use with his beam antenna.

Generally speaking, the feedpoint impedance of a Yagi (regardless of the number of elements) falls between 15 and 25 ohms. The problem is to reach a reasonable match between these impedances and a 50-ohm coax line.

The picture is complicated by the fact that when matching is achieved at the design frequency of the antenna, it deteriorates when the antenna is operated off frequency. The L-network, however, is "user friendly" (low Q) and provides a good match across the HF Amateur bands, in spite of the impedance gyrations of the driven element. Some matching schemes will not do that.

When the line impedance is greater than the feedpoint impedance of the antenna (as is the general case), the L-network takes the forms shown in Figure 1. Only two components are required — an inductor and a capacitor. It's possible to eliminate the series-connected component by making the driven element take its place. This is accomplished by detuning it slightly to introduce a value of series reactance equal to that of the missing network component. If the driven element is longer than the resonant length, its feedpoint reactance will be inductive (positive). If it's shorter than resonance, the reactance will be capacitive (negative). In this case, the shortened element will not be used.

Because the feedpoint of the Yagi is balanced with respect to ground it's necessary to use a balun with the matching network, as shown in Figure 2.

Using the reactance match

In most cases, the driven element of the Yagi is shortened to exhibit a series capacitive reactance. A shunt inductor provides the positive reactance of the proper value. The shunt inductor can be a coil, or it may be a "hairpin" of wire (see Figure 3A and 3B). Most commercial beams using this matching scheme prefer the hairpin over the balanced driven element is matched to coax by shortening it and using a parallel inductor at the feedpoint. A balun is used to match the antenna to unbalanced coax.
The shunt inductor may be either a coil or "hairpin."

**Figure 4**

Shunt reactance values required for various values of feedpoint resistance. Typical baluns are listed in the chart.

---

inductor because the inductance (length) of the hairpin can be adjusted easily. The two approaches are equally effective.

The homebrewer, on the other hand, may find the coil inductor easier to build than the hairpin. I prefer the coil because it's cheap, easy to wind, and can be adjusted at the center of the element — which is within easy reach from the top of the tower. (I don't like the idea of hanging out over open space to adjust the shorting bar on a hairpin match.)

In any event, the only adjustments you need to make in either system are to the length of the driven element and the inductance of the coil, or hairpin.

**A practical matching circuit**

The L-network parameters are summarized in Figure 4. The X-axis of the graph represents the feedpoint impedance of the Yagi driven element, and the Y-axis the value of shunt reactance necessary to achieve a match to a 50-ohm line.

For example, assume a Yagi has a feedpoint value of 20 ohms. The corresponding value of shunt reactance, as shown by the dashed lines, is 40 ohms. The actual inductance of the coil is determined by the formula. The driven element must be shortened, or "equalized," to provide the capacitive portion of the network.

**Equalizing the driven element**

To make this matching system work, the driven element must be slightly detuned (equalized) to provide the necessary reactance at the feedpoint. What does this mean in practice?
By definition, when an antenna is detuned from one frequency it becomes resonant at another. For example, assume the driven element of a Yagi is resonant at 14.2 MHz, has a feedpoint resistance of 20 ohms, and you want to match it to a 50-ohm coax line. A frequency run of the antenna will resemble the SWR curve of Figure 5. At the resonant frequency, the minimum SWR value is 50/20, or 2.5:1. The SWR gradually increases as the antenna is operated off frequency (Figure 5, curve A).

A Beta match is used at the feedpoint to reduce the SWR. The correct value of inductance is determined from the table and an appropriate coil is placed across the feedpoint. An SWR plot of the antenna is run across the 20-meter band and compared with the plot run without the coil. The driven element and inductor combination are now resonant at 13.8 MHz instead of 14.2 MHz and minimum SWR is about 1.5:1 (Figure 5, curve B). Adding the matching inductor has lowered the indicated resonant frequency of the driven element by 400 kHz. Resonance is now outside the 20-meter band! The final step is to shorten the driven element to restore resonance at 14.2 MHz. Once you’ve done this, the minimum SWR at the resonant frequency will be very close to unity (Figure 5, curve C). Squeezing or expanding the coil turns a bit will drop the SWR curve "in the slot."

This procedure determines the correct length of the driven element indirectly, providing the required value of negative reactance at 14.2 MHz in order to make the matching system work as it should.

Is equalization necessary?

Equalization is necessary, especially with regard to solid-state transmitters that don’t like to load into a transmission line having a high value of SWR. The amount of equalization required for the matching system to work depends upon the ratio of antenna feedpoint resistance to the coax line impedance. The greater the ratio, the more equalization (less coil inductance) required.

The problem is to determine the degree of shortening required to equalize the driven element. Very little information exists about the reactance change per unit of length for a Yagi driven element of a certain diameter. The reactance change is a function of frequency, element diameter, and taper. It generally amounts to a foot or more at 14 MHz, and correspondingly lesser amounts for the higher frequency bands. I challenge the readers of this column to come up with a computer program that relates reactance change of a half-wave element to the aforementioned parameters!

The adjustable Beta match

This relative of the hairpin match combines an adjustable impedance transformer with a balun. It’s usable with antenna feedpoint impedances between 10 and 40 ohms. Basic operation follows that which is outlined for the hairpin match. The device is the parallel reactance portion of the L-network (Figure 6). The series react-
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Inductive and capacitive values for antenna equalization when 50-ohm coax line is used.

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**Designing the Beta match**

Assume the coax is 50 ohms and the Yagi feedpoint resistance at resonance is 20 ohms. In Figure 7, the value of Xc is -24.5 ohms and the value of XL is 41.5 ohms Figure 8 shows that the ratio of XL to balun impedance is 41.5/325=0.127, as read on the Y-axis. The balun length, as read on the X-axis, is about 7.5 electrical degrees. To get the answer directly in feet, use Figure 9 for the 20-meter band. In this example, the balun length is about 1.4 feet, or 17 inches, for a ratio of 0.127 (read on the Y-axis).

The series reactance value (Xc) of -24.5 ohms is achieved by shortening the driven element. It would be nice if this value could be computed, rather than determined by the heuristic (cut-and-try) technique. As I mentioned before, it's about a foot for 20 meters.

**Elevated radials work! Good news for 160-meter DXers!**

In my April and October 1988 columns I reported on the work of Doty, Adler, and others in computing and testing the practicality of using a few above-ground radials in place of buried radials, or a ground screen for low frequency vertical antennas. The May 24, 1989 issue of *Radio World* reports that in November 1988 a full-scale AM antenna system was tested in Newburgh, New York under the direction of Clarence M. Beverage of Communication Technologies, Inc. The test frequency was 1580 kHz. The facility consisted of a 120-foot guyed tower with the base insulator 15 feet above ground. An elevated ground system consisting of six quarter-wave radials was used. The tests were conducted under a special field test authorization provided by the FCC.
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Field measurements run on the antenna showed that the radiated field was equal to that obtained from a 105-foot tower and a traditional ground system of 120 quarter-wave buried radial wires. The observed data confirmed theoretical data as computed through the use of a mathematical modeling technique called the "Method of Moments."

This is good news for low frequency operators partial to vertical antennas! The elevated radial system is thought to provide superior performance when compared with the buried ground system because it allows the collection of electromagnetic energy in the form of displacement currents, rather than inductance currents in the earth. In addition, the elevated ground system is less susceptible to changes in ground conditions caused by variation in moisture content in the earth.

It was determined that a frequency of 1200 kHz would require radial elevation of 20 feet and that 680-kHz operation would require elevation of 35 feet. Accordingly, a 160-meter operation would require elevation of somewhat less than 15 feet. I hope the FCC will authorize the use of above-ground radials in the broadcast service, quickly. Meanwhile, what are you waiting for?

REFERENCES
1. Radio World, a controlled circulation publication of Industrial Marketing Advisory Services, Inc., 587 Columbus Pike, Suite 310, Falls Church, Virginia 22041.

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AN INEXPENSIVE VFO
FOR THE YAESU FT-102

The basis of this circuit
is a solid-state
Franklin oscillator

By Robert H. Armstrong, VE3RF, 55 Birchview Road, Nepean, Ontario, Canada K2G 3G3

How would you like an external VFO for your Yaesu FT-102 that doesn't require any modifications or cost a small fortune? Mine uses the transceiver's digital readout, works on either or both transmit and receive, and drifts so little you'll need a frequency standard to measure it. Interested? Read on.

How it all started

In 1982 I bought a Yaesu FT-102 as a Christmas present (for myself). I got the AM/FM board and some crystal filters for CW and SSB, but I couldn't go the extra $500 or more for an external VFO. Not only was there not a "plain vanilla" VFO available, but the $500 one had memories, scanning functions, and a veritable calliope of bells and whistles. Besides, I couldn't see any real need for split frequency at that time.

Everything went beautifully until the 10-meter band started to open up this past year. I suddenly discovered that the 10-meter FM band required 100-kHz splits, and I didn't have that capability. I remembered an ad for the FV-102DM external VFO, which stated that the correct operating frequency was always displayed on the FT-102 digital readout. If I could do that I wouldn't need a fancy dial on the external VFO.

Fortunately, I had purchased a technical supplement for the FT-102 when they were available, although at the time I thought the price (about $25) was atrocious. Since then I've installed all the relevant mods, repaired the receiver preamp switch, and replaced a defective meter.

Digging into my supplements, I discovered the connections for the external VFO plug, and learned that I could indeed use the internal digital readout to display the frequency of an external VFO. This plug is an eight-pin DIN plug, type B (P1 in the schematic). There are two types of eight-pin DIN plugs. Naturally, according to Murphy's Law, I got the wrong one first. The correct plug is the nonsymmetrical one. (See Figure 1). Notice also that the pin numbering is not what one would consider normal — not me anyhow.

Developing the ideal VFO

Armed with all this technical information on how to connect the external VFO plug, I started looking for a suitable circuit. My ideal was preferably without coil taps, and certainly without parallel capacitors — too big to be air spaced, which could ruin the tuned circuit Q. I wasn't having much luck, until I came across the circuit for the Franklin oscillator in the RSGB Handbook. This is reproduced in Figure 2A. The Franklin oscillator has no large capacitors paralleling the tuned circuit, and no taps on the coil. Only a pair of small coupling capacitors connects the coil to the oscillator circuit. It's an astable oscillator (multivibrator to us old-timers). The tuned circuit is in parallel with one of the crossed feedback lines, where it offers a high impedance across the line at the resonant frequency, and a low impedance at all other frequencies.

This looked interesting so I built an FET circuit on a proto-board, scaling the drain resistors to work with an 8-volt supply. The circuit is shown in Figure 2B. Note the similarity to the original tube circuit. I had to increase the coupling capacitors to 10 pF to ensure reliable oscillation at that voltage. This oscillator delivered 1.3 volts p-p at about 1000-ohms impedance. This was too high for the FT-102, which requires 200 mV p-p at 50 ohms. I followed it with a Darlington emitter follower to lower the impedance and a lowpass filter simi-
Eight-pin DIN plug showing pin numbering. Type B is the correct plug.

**TABLE 1**

Function of the pins of the FT-102 rear panel connector marked EXT VFO and RCVR — A.

This connector is an eight-pin DIN type B female connector. It is called J7 on the schematic diagram of the complete FT-102 transceiver, and is in the upper left corner of the diagram. Attached to pin 1 of J7 is an unlabeled DPDT switch. It operates when a connector is inserted into J7. It removes the 8-volt DC bias from the internal VFO signal, turning off the diode-switching circuit which normally accepts the internal VFO signal. If you plug a blank DIN connector into J7, the digital display blanks out. The 8-volt input to the internal VFO is connected to pin 1 of J7 when a connector is inserted.

**J7 pin functions**

1. Internal VFO enable input. Eight volts must be applied to pin 1 to enable the internal VFO when a plug is inserted.
2. Twelve volts output from the transceiver. The maximum available current is 300 mA.
3. Output, 500 kHz. Adds 500 kHz to digital display when required. An example is the 28S to 29-MHz band (not used).
4. TX 12 volts. Twelve volts is supplied to this pin by the transceiver in the transmit mode.
5. CW 8 volts. Eight volts is supplied to this pin by the transceiver in CW mode (not used).
7. Chassis ground.
8. Sample of VFO input selected (not used).

Table 1). The VFO measured current is 55 mA, well within the available 300-mA maximum. A 7808 voltage regulator reduces the 12 volts supplied to the 8 volts desired. This is a bit of "overkill," the 7808 will handle better than 1 A, so it doesn't need a heat sink. You can replace the 7808 with an LM317 adjustable regulator. The LM317 may be easier to find, and requires only two external resistors to program it. This circuit is shown at the bottom of the schematic in Figure 3.

The FT-102 has another 12-volt output available on transmit only. This powers an SPDT relay which switches the 8-volt supply to provide both a receive-only and a transmit-only voltage. These switch the VFO diode circuits in the FT-102 and are selected with the front panel EXTERNAL/INTERNAL toggle switches. I could have done this with CMOS logic, but I had the relay on hand. The complete circuit of the VFO is shown in Figure 3.

**Mechanical construction**

- **Tuned circuits.** Now that I'd designed the VFO, I had to build it. I measured a military surplus coil on a 1-3/8 inch...
Schematic diagram for the FT-102 external VFO.

ceramic form; it had 6.8 μH inductance. I used an FM-tuning capacitor that had been in the junkbox for a couple of years. It had three sections which, when connected in parallel, produced 30-pF capacitance change. This enabled a frequency shift that exceeds the required 5.0 to 5.5-MHz VFO frequency range slightly. A 150-pF air-spaced, screwdriver-adjusted trimmer capacitor completes the tuned circuit.

- **Circuit board assembly.** Keeping as much room as possible around the coil, I mounted the tuning and trimmer capacitors in one end of the cabinet and assembled the electronic parts on top of them. I don’t usually build pc boards for my projects as they are one-of-a-kind things. I used a universal circuit board and assembled this circuit at the right side of the cabinet. You don’t need to take any special precautions. Just be sure to make the assembly as mechanically stable as possible.

- **Reduction gear and tuning capacitor.** One aluminum bracket holds the 3:1 reduction gear for the dial; another ties from this to the back of the case as a support for the tuning capacitor. I bent both brackets to fit the cabinet by hand and assembled them with nuts, bolts, and lockwashers. My leads are as short and direct as possible. All ground leads in the oscillator circuit are connected to a common ground at the frame of the tuning capacitor. I used an insulated coupling between the tuning capacitor and the dial to avoid hand capacitance effects. The coil is raised to the center of the clear space with spacers, in keeping with the idea of having everything clear of the coil by a distance at least that of the coil diameter. This is necessary to obtain a high-Q tuned circuit.

- **Dial readout.** If you look at Photo A, you’ll notice that the dial reads backwards. This is because the VFO frequency is subtracted from other frequencies in the FT-102. If you have a double shaft tuning capacitor, arrange it to have maximum capacitance at the clockwise end of the dial. This will make it read forward. The dial consists of a paper scale behind a plastic plate. The

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**FIGURE 3**

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- **C3, C11** 22-pF tantalum, 10 volts
- **C4, C5** 10-pF silver mica
- **C6** 100-pF mica preferred, ceramic otherwise
- **C7** 62-pF mica or ceramic (see text)
- **C8** 150-pF mica or ceramic (see text)
- **C9, C10, C16** 1-pF tantalum, 10 volts, Radio Shack 272-1434
- **C12** 330-pF mica or ceramic
- **C13, C15** 470-pF mica or ceramic
- **C14** 100-pF mica or ceramic

Inductors

- **L1** 6.8 µH, 16 turns of no. 16 tinned copper wire on 1-3/8 inch diameter ceramic form, coil length 1-7/8 inches
- **L2, L3** 1.8 µH, 13 turns of no. 24 enameled wire on FT 50-61 core

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- **R1, R4** 1000
- **R2, R3** 1 meg
- **R5** 150 k
- **R6** 560 k
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- **R9** 6800
- **R10** 240, R10 and R11 required only if LM317 voltage regulator is used
- **R11** 470

Miscellaneous

- **Q1, Q2** MF1-102 or ZN3819 N-channel JFET, Radio Shack 276-2035
- **Q3** MPSA30 Darlington transistor, Radio Shack 276-1631 is an assortment of six Darlington
- **U1** 7808 voltage regulator, substitute LM317 (see Figure 4). LM317 is Radio Shack 276-1778
- **RY1** SPDT contacts, 12-volt coil, Radio Shack 275-241 or 275-213 (DPDT)
- **S1, S2** SPDT toggle switches, Radio Shack 275-625
- **P1** Eight-contact DIN plug (type B), Armaco-type DD-8281 (should be available from Yaesu as a replacement part for the FT-102DM synthesized VFO, Yaesu USA, 17210 Edwards Road, Cerritos, California 90701.

The cable to the P1 plug requires one shielded and three unshielded leads. I made it about 2 feet long.

The cabinet I used is a Hammond type 1426KB. It measures 4" high by 5" wide by 5" deep. You can order this cabinet from: Hammond Manufacturing Company, 394 Edinburgh Road, Guelph, Ontario, Canada N1H 1E5, or 1690 Walden Avenue, Buffalo, New York 14225

**Parts substitution**

If you're like me, you'll want to change a few things. Very few of the parts are critical. Perhaps the most important are the two 10-pF capacitors that couple the frequency-determining tuned circuit into the oscillator. These should be the best capacitors you can get. I used silver mica, but ceramic disc capacitors would probably do. The tuning capacitor and trimmer are both air-spaced capacitors: nothing less should be used for these. I used tantalum bypass capacitors because they are good high frequency caps. The 1 µF capacitors at the regulator should be mounted as close to the regulator as practical because the regulator contains a high gain amplifier that will oscillate if not well bypassed.

I wound L2 and L3 on ferrite cores salvaged from a Jerrold CATV amplifier. Realizing that these wouldn't be reproducible, I got an FT50-61 core and wound another on it. It required 13 turns of no. 24 enameled wire for 1.8 µH. The universal pc board I used is similar to Radio Shack's 276-158.
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**Testing and calibration**

The two capacitors at the oscillator output (C7 and C8) form a voltage divider to reduce the oscillator output. Make C8 larger if you have too much output, or smaller if there's too little output. Measure the output at pin 6 of the DIN plug, loaded with a 50-ohm resistor, or plugged into the FT-102. It should be approximately 200-mV p-p.

Calibration is simplicity itself. Warm up the FT-102 on the 40-meter band with the external VFO attached for at least five minutes. Switch the RX switch on the VFO to the external position and set the tuning capacitor to maximum capacitance. Adjust the trimmer until the FT-102 digital readout reads slightly lower than 7000 kHz. Tune the VFO to the other end of its dial. The frequency should read slightly more than 7500 kHz. A reading lower than this would indicate that there's not enough variation of capacitance in the tuning capacitor; a much higher frequency would mean there's too much variation. Mine tunes from 6955 to 7525 kHz. You could also use a digital frequency counter to read the frequency.

Remember that it's backwards, so a VFO frequency of 5500 kHz corresponds to 7000 kHz, and 5000 kHz corresponds to 7500 kHz. If your counter requires more than the 200 mV at the output, there's more than 1 volt available at the drain of Q2 — although the counter may change the oscillator frequency by a few hertz.

When you've finished your work, but before you button up the cabinet, glue a schematic diagram inside the lid of the case. In five years time, you'll have forgotten all the circuit details and will need the diagram for servicing.
Ten meter activity is at a peak and the availability of small rigs like the HTX-100, the President, and the Ranger make wilderness portable operation more interesting than ever. Of course the weak link in the system is almost always the antenna. Mobile antennas are inefficient. Beams are too large for easy transport, even when they're broken down. Dipoles have to be hung. This usually means mounting them low to the ground, unless someone is willing to climb a tree.

The collapsible one-element quad described here provides most of the features hilltoppers want in an antenna:

- The quad loop shows high efficiency and, as a bonus, relative immunity from the effects of surrounding objects.
- Even at a 10-foot elevation, the quad shows a good bidirectional pattern.
- The antenna width is less than 9 feet and ideal for erecting in tight spaces (like between two cars).
- The antenna goes from storage to use (and back again) in less than 10 minutes — including rig tune-up.
- The quad collapses without disassembly into a package about 8" x 6" x 5-1/2" for easy transport.
- Except for a female coax connector (50-239) and a scrap of plastic, all parts for the antenna are available from the hardware store.

Electrically, there's nothing new in the collapsible quad. It's cut to the textbook formula that defines the quad's length in feet as 1005 divided by the frequency in megahertz. With a target frequency of 28.5 MHz, the overall loop is about 35-1/4' long or about 8'9" on a side. A quad loop at least a half wavelength above ground has a feedpoint impedance of about 120 ohms, a factor I'll discuss later.

Building the collapsible quad

The traditional way to build a quad is to use an X support with a single piece of wire around the perimeter. The hilltopper uses a different mechanical scheme. As Figure 1 shows, the antenna uses a PVC center support, aluminum L-stock horizontal elements, and wire vertical elements. The PVC pipe mounts over standard TV masts.

The PVC center support consists of two 5' pieces of rigid PVC plumbing pipe. The top piece is 1" diameter, the bottom piece is 1-1/4" diameter. This gives you an outside diameter of 1-5/16" for the top piece and an inside diameter of 1-3/8" for the bottom piece. They nest easily and loosely. Mount an acrylic plate cut to the dimensions shown in Figure 2 on each PVC section. A pair of no. 10 bolts and nuts per plate provide more than enough strength to hold the plates securely. I cut my plates from 3/16" scrap taken from a protector designed to go under an office chair. Use care when cutting the 1" x 3/4" wings to prevent stress cracks. Drill a small (1/16" to 3/16") hole at the inside corner and then cut to the corner. If you use a sabre saw, work slowly to prevent the hot plastic chips from binding the cut closed.

Drill the plate-to-PVC holes about 1-1/2" from the top and bottom of the plate. Drill holes for no. 10 hardware which will form the pivot points for collapsing the antenna elements in line with the wings. One-inch hose clamps slip over the L stock elements and onto the plastic wings to lock the horizontal elements in place. Squeeze the clamps to partially shape them to the odd element configuration.

Because each horizontal element is 4' 4-1/2" long, use 4 pieces of 3/4" x 3/4" x 1/16" thick aluminum L stock. I used 8' sections (Ease, Inc. no. 2207) and have enough left over for a 6-meter quad loop. Mount each element to the plate with no. 10 hardware, leaving a 1/8" gap between them. Make a bridge piece for the top section from no. 18 wire, ring connectors, and no. 6 hardware. Note the orientation of the L stock. The flat side of the L should face toward the center of the antenna, not outward. This provides good strength in the direction of tension from the side wires.

At the center of the bottom element, use a chassis punch
to cut a 5/8" diameter hole in one of the pieces for a modified SO-239. Be sure to leave enough room between the SO-239 threads and the L stock wall for the screw-on sleeve of the male connector. Cut off two opposing mounting hole corners from the female coax connector and file the cut edges smooth. Using the two remaining mounting holes, mount the connector to one side of the bottom horizontal element. On the prototype the connector is outside the no. 10 pivot hardware. If you widen the pivot points on the bottom section plate, there may be room to mount it close to the center gap between the two element pieces. Drill the other L stock section at the gap for no. 6 hardware. Make a no. 18 wire bridge and put a ring connector on one end. Solder the other end to the coax center pin.

Cut two pieces of wire (no. 18 insulated stranded wire works well), each 8'9" long. Solder ring connectors to each end. Drill the vertical side of the L stock at each corner for no. 6 hardware. Be sure the hose clamps are attached to the four pieces of L stock. Slide the top PVC section inside the bottom section, then connect the vertical wires to each side.

To complete the basic antenna, drill a hole through the two PVC sections at the center. Lay the antenna on a flat surface like a driveway or a basement floor. Extend the horizontal elements and lock them by tightening the hose clamps over the wings and securing the pivot hardware.
Top and bottom acrylic plate detail.

A simple method for drilling PVC pipe.
Extend the PVC sections until there's light tension on the L stock as the wire side elements reach their limit. Mark the inner pipe at this point. Make a vertical alignment mark on both pieces so the final product will be a flat plane.

Drill a hole through both pipes to fit a bolt or other pin. I use an old L-shaped Allen wrench a bit over 1/8" in diameter. Using a drill press will assure that you'll have well-centered holes. For free-hand holes, drill through one side of each PVC pipe only, preferably at the alignment mark. Using the larger pipe, wrap a piece of masking tape around the pipe at a slight angle so that the left edge of one end meets the right edge of the other, as shown in Figure 3, Step 1. Make a mark across the two edges. Remove the tape and spread it on a plate. Measure the exact center between the two marks, as shown in Step 2. Now follow Step 3 and replace the tape, aligning the center mark with the first hole you drilled. The drill line is where the other marks meet on the other side of the pipe. Measure the distance from the pipe end of the first hole and mark an equal distance on the reverse side. The cross hairs mark the point to drill. Use a very short bolt to hold the first inner and outer holes together and drill through the second outer hole to complete the passage for the pin.

Opening and closing the completed antenna

Place the completed antenna on the floor to practice opening and closing. To open the antenna for use, bring each L stock element to the horizontal. Slide the hose clamps over the plastic plate wings and tighten. Tighten the no. 10 pivot hardware. Make sure the no. 6 hardware is secure at the wire ends and bridge connections. Extend the nested PVC pipe section until the center holes are aligned and plug in the pin. All that remains is to connect the coax and put the antenna on a mast.

Reverse the process to collapse the antenna for transport and storage. Assume that you have removed the coax and dismounted the antenna from its mast. Loosen the hose clamps and slide them off the wings. Loosen the no. 10 pivot hardware and swing the horizontal elements to align with the PVC pipe. Remove the pin through the pipes and nest the sections together as far as they will go (to the plate bottoms). Use the side wires, tie wraps, or other binders to wrap each end of the collapsed assembly. The antenna is now ready for transport.

Mounting the antenna

Mounting the antenna to a mast requires a bit of thought and preparation. There are undoubtedly many schemes that will work. For hilltopping, I use two 5' sections of TV mast to elevate the bottom of the antenna 10 feet off the ground. I keep the swaged end of the masts down and have installed a crutch tip to the end that touches the ground to keep dirt out of the mast. I can use up to two more sections with simple rope guying.

The mast-to-antenna support section shown in Figure 4 serves two purposes. The slotted upper section of 1" PVC fits over the bolts that hold the plate to the bottom section of antenna PVC. The 9" slot holds well for hilltop operations, but wouldn't be suitable for taller masts subject to higher winds.

The 3' length of 1-1/4" PVC slips over the top of the TV mast. It's long enough to provide a secure mount and to allow redirection of the antenna by the "armstrong" method. Because the antenna shows a bidirectional pattern, even when close to the ground, it's important to be able to turn the antenna 90 degrees. You can add a rubber grip or handle to the bottom end of the PVC for easier turning.

Guying is simple with just 10 feet of mast. I loop three 15 foot 1/8" ropes over the top of the bottom plate. This anchors the antenna to the mast in light breezes. If the antenna is mounted between cars, I make loops to hold bungee cords hooked to fender wells or door handles. On open ground I tie the guy ropes to metal tent pegs. My YL, N4TZP, and I can assemble and erect the entire system in 10 minutes as nothing weighs more than about 5 pounds. Higher installations require more elaborate systems using guy rings and secure fastenings.

My simple mounting and guying system has survived 15 mile-per-hour breezes without difficulty. Anything above that level would kill my urge to operate on a hilltop, anyway.

Tuning the antenna

A quad can't resist the offset of its normal feedpoint impedance close to the ground. At heights above a half
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wavelength, the quad norm of 100 to 120 ohms permits the use of a simple matching section with 50-ohm output transmitters. A 5'7" length of RG-59 will perform the transformation. At lower heights, however, the section becomes useless.

Because the coax (RG-58) is only about 20 feet long its losses with a low power rig are small, even with SWRs above 3:1. This is why I use the simple homebrew T-circuit matching unit shown in Figure 5. The capacitors are 50-pF MAPC types with shafts. The coil is 12 turns of 1" diameter, 16 turns-per-inch miniductor type stock. A 12-position switch taps the coil at each turn. The tuner is in a 4" x 6" aluminum case salvaged from another project, but a smaller case would work. I keep an old SWR meter attached to the tuner with a double male connector. Tune-up is a quick process because my HTX-100 has a 5-watt output position, and there's a high safety margin if the initial settings are way off base. I have the quad settings marked on the case.

Changes of location require only the smallest tweaking of the capacitors to eliminate reverse voltage readings. The proof of the system is the usual mobile whip, and more free-standing then the usual dipole. The collapsible quad loop inexpensively fills a gap in the range of antennas available for portable 10-meter operators. 

**FIGURE 5**

Simple T-match circuit for the collapsible quad.
Joseph J. Carr, K4IPV

TEST EQUIPMENT FOR DIGITAL ELECTRONICS

In the past the Amateur operator with a technical bent dealt exclusively with what today is known as "analog electronics," i.e., RF, audio, and control circuits. But the digital revolution has touched Amateur Radio too, bringing us computerized and digitized ham gear. The modern HF transceiver is microprocessor controlled, as are many other bits of Amateur equipment. In this month's "Practically Speaking" I'll look at digital test equipment and highlight an affordable logic analyzer.

Once you get above the complexity level of a few chips, digital systems become quite a bit harder to "wring out" on the bench. It's difficult to service or analyze digital computer hardware because it's hard to get a good look at circuit operation as it sequences through its routine. Many things happen simultaneously — too many things to view on a simple oscilloscope (even a four-channel model). Sometimes you must view a large number of sequential operations and find a problem. It might also be necessary to examine a data stream to determine what's actually going on. The logic analyzer provides the solution to these problems. This instrument examines multiple logic lines simultaneously and reports on their status. Until recently, logic analyzers have been expensive instruments and somewhat beyond the reach of most people. The Heath Company now offers equipment that may help. Although the company is recognized by most Amateurs for its kit-built ham gear and low cost test equipment, Heath also makes a considerable line of digital instruments and the Heath/Zenith line of personal computers.

The Heathkit IC-1001 shown in Photo A is a kit-form digital logic analyzer with a surprising number of capabilities. It can examine and report digital logic activity on up to 16 digital input lines simultaneously. This capacity is sufficient for most 8 and 16-bit microcomputer applications. The IC-1001 is an inexpensive box that interfaces with any Heath/Zenith terminal or any IBM PC compatible. You need special software (included) to use an IBM PC as the terminal (DOS 2.0 or higher required). The interface to the terminal or the computer is via an RS-232 (DB-9 connector style) asynchronous serial communications port.

The IC-1001 has 2K of RAM and can store up to 2046 16-bit binary words. If you use a terminal unit, you can display 24 words at a time. If you use an IBM PC, the monitor will display up to the entire 2046 memory simultaneously. Displays include: address relative to trigger word, state, timing, hexadecimal or octal equivalent, and ASCII equivalent. All the standard baud rates used in personal computer applications (as well as most other digital applications) can be accommodated: 300, 600, 1200, 2400, 4800, 9600, and 19200 BAUD.

Under program control, you can specify the target trigger word that the IC-1001 is to recognize. The logic polarity (positive logic is normal, but you sometimes find negative logic) is selectable. There are also two modes — non-delay and delay. In the non-delay mode the analyzer will display data that occurred both before and after the trigger word (selected by the operator). In delay mode, you select the number of "qualifying clocks" that must occur following the trigger word before the IC-1001 starts storing the received data. Up to 50,000 clock cycles can be programmed into the delay mode.

Construction

The IC-1001 Logic Analyzer is a kit. An experienced kit builder can put it together in one day or two evenings. The layout (shown in Photo B) is very clean and easy to work with. The kit is built on a single pc board mounted in a 1.75 x 9.25 x 8.5 inch lowboy cabinet. An external transformer plug supplies power to the IC-1001 from the 115-volt AC power lines. The unit weighs just 2.9 pounds.

Because the IC-1001 is a newer Heathkit, the small parts (resistors, diodes, etc.) are attached to a paper "machine gun" belt in the sequence called for by the instructions. (Heath used to jumble everything together in brown paper bags for you to sort out.)

Internal view of the IC-1001 showing the printed circuit board layout. Note the clean design.
connections to the environment.

Rear panel of the IC-1001 contains all of the connections to the environment.

 PODs are used for connecting the IC-1001 to the circuit under test.

Although my hands are mildly arthritic and a bit plump, I found nothing hard about building the IC-1001. It's rare that I find no fault with the assembly of a kit, but I'm at a loss to find something negative to say about the IC-1001.

Using the IC-1001

The IC-1001 logic analyzer has a clean-cut front panel (see Photo A) with just an ON/OFF switch. The rear panel shown in Photo C contains all of the interconnections between the IC-1001 and its environment. The AC power connector on the left side is connected to the transformer wall plug that supplies power to the unit (the DC power supply is internal). The RS-232 serial port connector is the small DB-9 type that has become popular in recent years. (The 9-line "sort of" RS-232 has taken the place of the older 25-line RS-232 system.) A pair of trigger outputs is also provided. These BNC connectors output a signal, but one signal occurs at the trigger word while the other occurs after the specified delay.

There are three digital input ports on the read panel of the IC-1001. One is a clock input and the others are for the data word. The "high" byte accommodates the upper 8 bits of a 16-bit line, while the "low" byte accommodates the lower 8. These inputs link to the external circuitry being tested through a set of builder-assembled POD devices (see Photo D). These data line cables have a "hook plunger" clip on the ends to hook into the circuit being tested.

The Heathkit IC-1001 is a useful easy-to-build piece of digital test equipment. I've used mine for about six months and I'm a satisfied customer. For more information about the IC-1001 Logic Analyzer (-priced at $279.95) contact The Heath Company, Benton Harbor, Michigan, 49022.

Other instruments

As is true in most areas of electronics practice, the oscilloscope (see Photo E) is the most useful instrument for many digital troubleshooting jobs. The oscilloscope will display one or more time-varying signals. You read amplitude along the vertical axis and time along the horizontal.

For digital work, select a model with a high frequency vertical bandwidth (20 MHz or better) and more than one channel. The most common form of scope may be the dualbeam (which really means two channel). For a bit more money you can get up to four channels. For lower frequency work, it's possible to convert a dual channel scope into a four-channel model using an external switching circuit.

Low capacitance probes are a must. In fact, they are a must for most types of testing or measurement. These probes do not capacitively load the circuit under test. This means they produce a better rendition of the waveform in the circuit. The standard 1:1 and 10:1 switchable probes offered by most oscilloscope manufacturers are low cap types.

Oscilloscope probes are not just used for measurement. At a major university medical center on the East Coast, patients in the Intensive Care Unit (ICU) were monitored by a computer located in another building. Because this was in the early seventies and microcomputers and small minicomputers weren't yet invented, a relatively large computer was needed for the task. (ICUs today often run on IBM PCs.) The analog data was converted to a digitized format in the hospital ICU and transmitted across the street by a crude early form of modem.

At the computer room in the basement of the nearby building, the modem tones were demodulated to digital signals for input to the computer. Unfortunately, they were highly erratic and error warnings were common. The technician would try to find the problem, but it cleared up when he connected the low cap probe to the modem output. Thinking it was the cable plus the 'scope input capacitance, he tried shunting an equivalent value disk ceramic across the same point, but to no avail. Only the 'scope probe worked. That oscilloscope probe remained inside that computer rack for another 18 months when the experimental program was finished.

If you go to any well-equipped parts distributor or look in the catalogs of companies that sell test equipment, you'll find a series of logic probes for sale. These devices are handheld instruments that look a bit like fat oscilloscope probes, but don't connect to other instruments. There seem to be two or more distinct types. One probe, for instance, supplies either a logic level transition or a pulse when the button is pressed. These pulses (or levels) can be used to stimulate a digital circuit. A logic level can be generated by a circuit like the one in Figure 1A, while a brief pulse can be generated by the one in Figure 1B.

The other kind of logic probe is a pulse catcher. This device remains dormant until it receives a pulse. It then latches in one of its two stable states and produces an LED output indication. You can build a pulse catcher (of sorts) from a reset-set (R-S) flip-flop as shown in Figure 1C.

The circuits in Figures 1A, 1B and
can’t really replace a logic probe for convenience, but they do make dandy little construction projects. If you want to construct an experimental digital breadboard, you can build in these circuits to make your work a little easier. These breadboards use a kind of IC strip socket with a lot of holes arranged in parallel rows and columns, laid out in the 0.3-inch x 0.1-inch standard DIP pattern. Number twenty-two hookup wire is pressed into the holes in the socket to make interconnections. These strip sockets are available from most parts distributors. Use as many IC strip sockets as you need to mount the chips. Provide +5 volts DC at 1 A, ±12 volts DC at 0.5-A DC power supplies, and a few pulse generators and catchers, and you’ll be in business.

An oscillator that can be used as a clock or clock replacement in digital circuits is another useful piece of test equipment. If you want to make a digital oscillator, use a 555 IC timer connected in the astable mode (and connected to a +5 volt DC power supply). Or, if you have a square wave generator, you can make it into a suitable clock by providing a TTL output. On my Heath HG-18 (an oldie) I provided the output by using a CMOS 4050 chip (operated from +5 volts DC) as a TTL output buffer (Figure 2). The input of one stage of the 4050 is connected in parallel with the square wave output. The output level control must be set to something over 3 volts peak for the circuit to work properly. I added a separate BNC jack on the front panel for the TTL output so I wouldn’t ruin the regular bipolar ±10 volt square wave output. Now let’s shift gears a little bit.

Why can’t I ham it up in the hospital?

A reader collared me at the swapfest operated by the ham club at Goddard Space Flight Center in Greenbelt, Maryland. He had been hospitalized for surgery in the same hospital where I was once employed as a bioelectronics and biomedical engineer. He was perplexed and annoyed that the hospital authorities wouldn’t let him keep his 2-meter, 5-watt handheld transceiver. He wanted to know why they were so narrow minded. Because I helped formulate some of the hospital rules involving radios about a decade ago, I was able to give a little insight. Modern hospitals are complex.

FIGURE 1A

TTL level generator uses a 7404 TTL hex inverter (five sections of the 7404 are available for other uses). If an inverter is not available, then one can be made by shorting together the two inputs of a 7404 NAND gate.

FIGURE 1B

A 74121 TTL one-shot chip outputs both Q and NOT-Q 100-nS pulses when the pushbutton is pressed.
Pulse catcher is an R-S flip-flop with an output indicator. Initially press S1 to reset the circuit. Thereafter, when a pulse is received it will turn on the LED.

A CMOS 4050 is used to convert bipolar squarewaves to TTL-compatible squarewaves.

places with a large array of electronic instruments for monitoring and treating patients. Some of these instruments are EMI sensitive. While a TVI complaint in your neighborhood isn't an earth-shattering event, a nonworking patient monitor in the coronary care unit or telemetry unit can cost someone his life.

Very early one morning in the mid-seventies I was trying to troubleshoot a problem. An electrocardiograph (ECG) VHF telemetry signal was riding in on the wrong channel, obscuring the signal of the patient to whom it was assigned. I traced the problem to EMI from the local oscillator of an FM broadcast receiver. The FM radio whip was only a foot or so from the 17-inch telemetry whip hanging from the ceiling, where it was connected to a 60-dB wideband VHF preamplifier. The problem was an old-fashioned intermod situation.

We banned FM radios at the nurses' station that night. While we could have gotten away (technically, that is) with banning the single offending station on the FM dial, it seemed more reasonable to just ban the radios altogether. During that same era, incidently, the airlines banned FM radios on flights. It seemed that the FM LO could also interfere with avionics gear.

While I sympathize with the sick ham (when I was "in" for a gall bladder operation in 1986 I had to live by my own rule), it seems that the rule is here to stay in most hospitals.

That's all for this month. I can be reached at POB 1099, Falls Church, Virginia 22041 and would like to have your comments and suggestions for this column.
A LOW-NOISE DESIGN PRIMER

Some ideas on improving receiver noise

By Bob Lombard, WB4EHS, 1874 Palmer Drive, Melbourne, Florida 32935

Noise. Throughout the history of Amateur Radio, noise has been one of our biggest problems. Few topics have had quite so much written about them in the Amateur literature or in professional circles. Because of this coverage, newcomers to the field may feel overwhelmed by the references available. In what follows, I've attempted to cover the subject in enough depth to allow you to complete some designs and feel comfortable with the subject. There are a couple of types of noise that are the most frequent contributors to receiver noise problems; I'll start by treating them separately.

Thermal noise and the universe

The discovery that any component above absolute zero in temperature generates thermal noise proportional to its temperature is attributed to Ludwig Boltzmann, one of the great physicists of the nineteenth century. Boltzmann's relationship shows that the noise voltage generated depends on the temperature of the component, its resistance, and the bandwidth in Hz that you measure in, or:

\[ E = \left( \frac{ktB}{R} \right)^{1/2} \]  

where \( t \) is temperature in degrees Kelvin, \( B \) is bandwidth in Hz, \( R \) is resistance, and \( k \) is Boltzmann's constant (1.381 \times 10^{-23} \text{ Joules/K degree}).

In terms of power:

\[ P = \frac{E^2}{R} = ktB \]  

A 50-ohm resistor measured at 20 degrees C in a 1-Hz bandwidth delivers a power level of 3.98 \times 10^{-21} \text{ watt}. It's customary in receiver work to refer to power levels with respect to 1 mW, and this power is -174 dBm. Of course no receiver could better that mark, but the 1-Hz bandwidth is almost never used in real life. Because power increases directly with bandwidth, the level goes up 10 dB for every times 10 increase in bandwidth. In a 2-kHz bandwidth, for example, the power level goes up by 33 dB, to -141 dBm. This is close to the case for a typical SSB signal.

This level is roughly 7.9 \times 10^{-21} \text{ watt}, or 0.020 \text{ \mu V} in 50 ohms. A typical "good" HF receiver will claim 0.50 \text{ \mu V} sensitivity, but although this may seem poor when compared with the thermal noise value, it's actually better than you need. The noise that we often refer to as QRN is the reason.

There are many sources of QRN: the sun, certain astronomical sources, the din of distant thunderstorms, and a myriad of urban and suburban noise sources. The noise level at the receiver input from these sources determines the receiver's useful sensitivity. Table 1 shows typical numbers used in the design of HF radio links.

The numbers in this table are normalized for bandwidth; just add this number to the thermal noise floor described earlier to reach the usable sensitivity. For example, at 30 MHz in a typical suburban location you would add 38 dB to the SSB noise floor of -141 dBm to get -103 dBm. This translates into 1.58 \mu V in 50 ohms. Suddenly that 0.5 \mu V sensitivity seems generous. Furthermore, the noise at lower frequencies is even higher and storms create even more noise.

Noise from the receiver and noise figure (NF)

All electronic amplifiers currently available produce some noise along with their amplification. This noise takes several forms including shot, popcorn, and schottky noise. The exact nature of each type of noise is related to the physics of the devices used and is not really important here. For now it's enough to know that such noise exists and is unavoidable — at least to some degree.

Most hams have heard the term noise figure before, especially those who operate VHF/UHF in the weak signal modes. The definition of noise figure used by Friis in 1944:

<table>
<thead>
<tr>
<th>Location</th>
<th>Frequency MHz</th>
<th>Quiet Rural</th>
<th>Quiet Suburban</th>
<th>Noisy Suburban</th>
<th>Noisy Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>40</td>
<td>42</td>
<td>48</td>
<td>62</td>
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is perhaps the simplest and the best. According to Fris, the noise figure of a network is the signal to noise ratio of the input divided by the signal to noise ratio of the output, expressed as a decibel ratio, or:

$$NF = 10 \log \frac{S/N \text{ in}}{S/N \text{ out}}$$

This means the noise figure is the decrease or degradation of the signal to noise ratio as the signal goes through the network. Notice that this implies at least a two port network with one output and one input.

Because noise figure is a property of two port networks, it isn't the right term to use for the characterization of oscillators or terminations. Terminations have their noise level set entirely by Boltzmann's $kT$. Oscillators will produce noise along with the desired signal, but this is best expressed as a carrier to noise ratio.

Mixers, on the other hand, are three port networks and do have a noise figure. The noise present on the local oscillator also comes into play here: LO noise adds directly to the noise already present on the desired signal, degrading the S/N ratio even more. The common double balanced mixer is a passive network, and so has its insertion loss as its noise figure.

LO C/N (carrier to noise) ratio is more of a concern today than it was before the advent of the PLL synthesizer. Synthesizers can be quite poor from the standpoint of noise sidebands — a problem that was almost unheard of in the era of crystal oscillators. I'm sure many of you have noticed that when the ham down the block gets a shiny new rig, the noise floor of the universe jumps up every time he transmits.

Finally, note that noise figure is independent of gain or modulation.

Cascades of amplifiers, each contributing gain and noise, result in a change of noise figure from that of the front end noise figure. The method of calculating cascade noise figure is simple, but it requires a little manipulation. The noise figure must be converted to its ratio by taking the antilog of $F$. Given this:

$$F_{\text{system}} = F_1 + \frac{(F_2 - 1)}{G_1} + \frac{(F_3 - 1)}{G_1G_2} + \ldots + \frac{(F_n - 1)}{(G_1G_2\ldots G_{n-1})}$$

where the subscripts 1, 2, ..., n, denote the stage number proceeding from the front end, stage 1, back. It should be obvious that if the front end is high in gain and low in noise figure, it essentially sets the system noise figure. Furthermore, regardless of gain, you can never be better than the front end.

**Measuring NF**

While measurement of noise figure is done commercially with specialized (read that expensive) test equipment, it's possible to measure it with methods accessible to the Amateur.

The most straightforward method is the two power or 3-dB method. You need a noise source with a known excess noise ratio to perform this test. Probably the biggest problem is knowing your excess noise ratio — the amount of noise that the source puts out over an equivalent resistor at the same temperature. Reverse biased zener diodes are frequently used to generate noise; they can provide 30-dB of excess noise ratio. Surplus vacuum tube noise sources are available from time to time and are usually characterized, or can be. In this method, shown in Figure 1, only three steps are required:

- Set a convenient power level reference at the power meter with the noise source "out" or "cold." The power meter can be measuring actual detected RF power on a microwattmeter or audio power at the receiver speaker terminals.
- Insert the 3-dB pad and turn on the source.
- Vary the attenuation until the reference obtained. At this point, the attenuated excess noise ratio of the source is the noise figure of the receiver. The noise figure is the excess noise ratio (ENR) minus the attenuator setting in dB.

Ideally, the calibrated attenuator would be a continuously variable type, but a step attenuator will do if you can find one with small enough steps. Lacking that, precut lengths of cable will make calibrated attenuators that are easy to coil up and keep around. You'll need different lengths for each band of interest, lots of connectors, and cable that you can trust to meet some attenuation versus frequency curves. If you don't have this type of cable, you'll need a way of measuring the attenuation directly (e.g., your microwattmeter).

**Minimum Discernible Signal (MDS) and Noise Figure (NF)**

Noise figure is an excellent figure of merit for receivers. Unfortunately, it doesn't tell the complete story. The minimum discernible signal (MDS) is another important number. MDS, just as its name implies, is the weakest signal that the receiver can detect at some level of readability. The low NF alone doesn't do much good if the receiver can't hear below a millivolt. You'll recognize this as another way of stating sensitivity, although the results are usually stated as dBm in 50 ohms. A poor MDS means that there is insufficient gain in the receiver, usually at the IF; because the front end will amplify anything that hits it.

**Designing for Low NF**

The selection of the front end device is the best place to start in a low noise design. It should come as no surprise that FETs are generally capable of better noise performance than bipolaros. GaAsFETs, silicon MOSFETs, and JFETs are good choices for hams in the VHF and above spectrum, as they are readily available and reasonably priced. The newer HEMTs (High Electron Mobility Transistors) are really HEMFETs and may be the "new wave" in microwave design.
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LISTING OF BASIC PROGRAMS FOR SOLVING CASCADE NOISE FIGURES.

I'm not aware of these devices being available to hams. Bipolars have made recent progress in this area, and are often a reasonable choice.

Once you've chosen the front end, use Equation 4 to optimize the rest of the receiver chain. I've included a simple BASIC program (Figure 2), based on Equation 4, to calculate the system gain and NF of a cascade of gains and losses. (The program is in GWBASIC for the IBM PC and clones, but you should be able to translate it to other machines with no trouble.) It's often helpful to add more gain at a more modest NF before the first mixer, especially if it's a double balanced one. Remember that passive circuits like pads or filters have conversion loss, so their through loss is used as their NF and negative gain in the equation.

The data sheets for the device you've chosen frequently provide some bias information and input impedance for minimum NF. These data have a habit of either being at the wrong frequency, or just plain incomplete. Many times a designer chooses a device simply because its data sheet is more complete than others and leaves less room for guesswork.

Biasing the device for the desired collector or drain current is relatively straightforward, but should not be ignored. The bias must be stable for all variations expected in operating conditions, like the temperature extremes of a mast mounted preamp.

Matching to the device is done via manual methods, Smith Chart, or computer (or both). It's best to leave some adjustability in the design of the matching network to allow for part-to-part variations, and to use the highest Q (lowest loss) components that you can get.

An example of a simple circuit design is included in Appendix A to show these ideas in a more concrete form.

Designing for low noise is easier than correcting for it later. Consider the ideas and references presented here before trying your next receiver design.

REFERENCES:
2. H.T. Friis. "Noise Figure of Radio Receivers," Proceedings of the IRE, July 1944, pages 419-422

*Various Amateur and commercial software packages are available to perform this function.
Appendix A
Design Example

Design a low noise amplifier to operate at 432 MHz with an NF of 1.5 dB or less.

The data sheets for the Avantek AT41472 show that the device is capable of a typical NF of 1.3 dB when biased for a collector current of 10 mA. This will yield a stage gain of 14 dB (typical). Since the S parameters are supplied at 400 and 500 MHz, I’ll interpolate a set of S parameters for 432 MHz linearly. (Knowing that the actual device will likely vary from these, I’ll build in some adjustment.)

When Vce = 8 volts and Ic = 10 mA:

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**Step 1:** Bias the device:
Assumptions are Vce = 8 volts, Ic = 10 mA, Ve = 2.5 volts, hfe_{dc} = 30, Vcc = 12 volts.

\[
Re = \frac{Vc}{Ie} = \frac{2.5}{0.01} = 250 \text{ ohms (249 standard)} \tag{1}
\]

\[
Vc = 2.5 + 8.0 = 10.5 \text{ volts} \tag{2}
\]

\[
Rc = \frac{(12-10.5)}{0.00} = 150 \text{ ohms} \tag{3}
\]

\[
R_{bb} = \frac{3.2 \text{ volts}}{3.3 \text{ mA}} = 960 \text{ ohms (976 standard)} \tag{4}
\]

\[
R_{bt} = \frac{(12-3.2 \text{ volts})}{(3.33+0.33)} = 2404 \text{ ohms (2430 standard)} \tag{5}
\]

**FIGURE 3**

DC biasing of the device.

The complete DC bias is shown in **Figure 3**.

**Step 2:** Match the impedance of the input and output
Although the data sheet for this transistor doesn’t show an optimum source impedance for lowest NF, the data shows that the NF in a 50-ohm system is very close to the optimum NF. Consequently, I’ll design for matching a 50-ohm source and load. **Figure 4** is the Smith chart used to find the matching networks.

**FIGURE 4**

Smith Chart plot of the complex matching impedance.

**FIGURE 5**

Complete circuit with matching networks.

470-pF caps are used as RF coupling/DC blocks and the emitter bypass. The cap at the emitter should be a chip cap, and should be mounted as close as possible to where the emitter leaves the case. The coils, though small, are buildable using small diameter air-wound inductors and minimal leads.

Although I didn’t build this circuit, I did verify that it passes computer simulations. My purpose here is not to present a working LNA design, but to demonstrate the design process. According to a professional CAD program, the amplifier has a gain of 13.26 dB at 432 MHz. I couldn’t analyze the noise figure due to limitations in the manufacturer’s data, but the resultant gain and input impedance agree closely with the data sheet’s prediction for gain at minimum NF. The procedure is essentially the same if the source impedance for optimum noise figure isn’t 50 ohms, with the exception that you match to the different value.
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CONNECTICUT: November 12. SCARCA Indoor Ham Radio and Computer Flea Market. North Haven Park and Recreation Center, 7 Lisle Haven. North Haven. Sellers admitted at 7 AM. Buyers 9 AM to 3 PM. Tables $12/advance: $15/door. General admission $3 per person. Talk in on 146.01 FM. Reservations for tables must be received with check by November 2, 1989 and no reservations by phone. For information or reservations: SASE to: SCARCA Flea Market, PO Box 81, North Haven, CT 06473 or call between 7 PM and 10 PM at (203) 265-6476.

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OHIO: November 26. 4th annual Swapfest sponsored by the North Coast ARC, North Olmsted Community Cabin, 12134 Lorain Road, North Olmsted, OH 44070. Admission: $3/advance: $5 at door. Please inform Walt Fitch, N8HCD.

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November 10-12: Veteran’s Day Special Event Station sponsored by the Armed Force Amateur Radio Net, 0001Z Nov 10 to 0000Z Nov 12 to honor all Veterans who are now Silent Keys. Work any of 304 members to receive a certificate. Sugg Freq: Phone—3,920, 7,280, 21,375, 14,290, 28,470. Novice 28-400, CW—7,060, 7,125. Send #10 SASE to W6BDR, 16 Berkeley Circle, Newington, CT 06111.

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FREE 1989-90 Florida two meter repeater directories are currently being distributed by the Hernando County Amateur Radio Assoc. of Brooksville, FL. Ask for one at any official Florida Welcome Center or SASE to Repeater Directory, Hernando County ARA, PO Box 1721, Brooksville, FL 34609.

LICENSE EXAMS: Middlesex Amateur Radio Society (MARS) has scheduled the following exams: October 10 and December 12. United Methodist Church, 381 Main Street, Portland, CT 6:45 to 9 PM. November 18—Portland Public Library, 20 Freesmore Avenue, Portland, CT 1 to 5 PM. To pre-register call Ed Kerr, KN6Y (203) 342-3400. Walk-ins allowed. The Middlesex MARS Net meets every Tuesday evening at 7 PM at the United Methodist Church. All are welcome.

LAUREL ARRL monthly (except December) amateur exam sessions for all-license classes. No fee is charged. Pre-registration is required. Call (201) 725-1212. Maryland Radio Center, 8576 Laurel Dale Drive, Laurel, MD 20707.


AMATEUR RADIO CLASSES: For those people interested in obtaining a license, a list of those interested in becoming licensed operators is provided by the Northern California Radio Club. The club has scheduled the following classes: November 29, 7 PM, MIT Room 1-150, 77 Mass Avenue, Cambridge, MA. Reservations requested 2 days in advance. Contact Don Hoffmann at (617) 496-2088. Exam fee $4.50. Bring a copy of your current license (if any), two forms of identification, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

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<tr>
<th>MODEL</th>
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<table>
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<td>WLA26M</td>
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<td>21</td>
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Congratulations on your editorial in the September 1989 issue of Ham Radio. You have presented a balanced, concise viewpoint which is also well written.

While I was not especially keen on your magazine, you are making a believer out of me! Recent issues have been very informative, and I now look forward each month to receiving my copy.

Keep up the good work.

Marvin J. Fein,
Newport Beach, California

QSL cards available

Dear HR

The American Amateur Radio Club of Korea has in hand 55 pounds of QSL cards, some as much as 10 years old. These were recently released to KARL by the Postal Department. If you were (or know someone who was) a United States Forces Korea "HL9" during the past 10 years, a SASE to American Amateur Radio Club of Korea, PO Box 153, APO San Francisco, California 96206, will get your cards. Don't forget to include your HL9 callsign and the dates it was valid.

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SIMPLE INSTRUMENTS — RF OUTPUT MONITOR

The RF output monitor can be used as a piece of test equipment for relative measurements, or as a station accessory that will constantly monitor the output of your transmitter. Construction is easy; it's basically a modified section of coaxial cable and an RF detector circuit. Similar circuits have been described in various publications before, but it's such a useful device that it's worth another look.

How it works

Before I get into the details of the device, let's take a look at the theory that makes it work. Everyone's familiar with the transformer shown in Figure 1. As with most transformers, it has a primary and a secondary winding. Current flowing through the primary induces current into the secondary, which can be applied to a load or measured with a meter. In many circuits, like household power lines and audio output circuits, the transformer is a part of the load, and whatever is hooked to the secondary winding is also part of that load. In Figure 1 I've placed a load in series with the transformer primary. The transformer then responds to the amount of current that flows through the load by inducing more or less current into the secondary windings. If the load current changes, the voltage measured at the secondary will follow. By calibrating the meter carefully, you can determine the amount of power flowing through the load.

Notice that there's no iron core shown in the transformer in Figure 1. This should be a tip-off that the transformer is working somewhere in the radio frequency range, rather than at audio or power frequencies. From here it's an easy step to a device that will monitor the power being dissipated in an RF load (like an antenna). Figure 2 shows a similar RF transformer complete with primary and secondary "windings," although they don't necessarily look like windings. If we remember that even a straight piece of wire will produce a magnetic field when current flows through it (did you ever perform the good old experiment with a piece of bell wire, a lantern battery, and a compass?), then it makes sense that any current flowing in the center conductor of the coaxial cable will induce a current in the "secondary" wire that's very close by inside the metal shield braid (see Figure 3). That is really the essence of this simple test device. It's an RF transformer that produces a secondary current flow in response to the amount of current flowing in the primary circuit, which includes the load. This can be an antenna or dummy load, depending on which is hooked to the end of the coax. Now, let's build one.

Construction

As long as you're working at frequencies in the 3.5 to 50-MHz range, there's nothing really critical about the construction. Just follow good construction practices. For frequencies of 25 to 50 MHz, a piece of RG-8/U (or similar) cable approximately 4 to 6 inches long will suffice. You'll need a couple of connectors (your choice) to fit on the ends of the cable, as well as a diode and some other parts. If you can find them, I suggest using connectors that have a "funnel" type hood that connects to the shield braid — it makes a very neat job.

The idea is to assemble the section of coaxial cable with a fitting on each
When the single-wire primary "winding" is the center conductor of coaxial cable, the secondary can be a single wire placed inside the braid to intercept the magnetic field surrounding the primary.

end and to place a small insulated wire inside the shield braid, bringing the ends out to a diode rectifier and a metering circuit (see Figure 4). You can connect the fitting on one end of the cable, including the braid. Leave the other end bare for the moment. Remove all the vinyl covering from the cable and "bunch up" the braid so the weave is open enough to feed the piece of insulated wire in under the braid through a couple of small holes in the weave. Keep the wire far enough from the ends of the braid that the final soldering operation won't melt the insulation. When the wire is in place, stretch the braid out again to cover the center conductor and dielectric insulation, and install the fitting on the other end.

If you can't find the hoods, "tease" the braid into a couple of pigtails and solder them to lugs that fasten to the flanges with screws and nuts. It's a good idea to cover the braid with a layer or two of plastic electrical tape to hold everything in place.

You can ground one end of the small wire to the coaxial fitting or to a chassis if you're building this assembly into a enclosure of some kind. Connect the other end of the wire to the anode end of a diode — use a small stand-off insulator to hold things in place. The cathode end of the diode can go directly to a microammeter for low power uses, or through a resistor to monitor higher power levels. You can experiment to find values that work with whatever transmitter power output you need. Several resistors and a switch, as used in the meter described in last month's column, will make the unit more versatile.

If you'd like something a bit more high tech than a common meter, you might try one of those integrated circuits that drive a bunch of LEDs in a "light-bar" arrangement. You'll find them at many electronic supply stores and in catalogs — including Radio Shack and Jameco. Just follow the instructions that come with the IC and LED assembly, and you'll have a power monitor that shows relative power output whenever you key your transmitter. The LEDs will even follow your voice when you use SSB.

Simple instrument, simple tasks

One thing to remember about this device is that it's not a true power output monitor. It shows relative output only. You could, if you're a dedicated experimenter and really fussy, use an accurate wattmeter and a good dummy load and work up a calibration chart for the meter. The catch is that it would be good for only that frequency and into a dummy load. When you change bands the meter reading will change, and any mismatch at the antenna will also change the reading to some degree.

This device is not intended to accurately indicate reflected power (or SWR). It will show some indication if you turn it around and take the end connected to the transmitter and connect it to the antenna feed line instead.

FIGURE 4

Construction of the monitor section. The pick-up wire (secondary winding) is threaded under the shield braid through small holes at each end. A layer of electrician's tape or heat-shrink tubing over the completed assembly will hold everything in place. The resistor value can be from 100 to 47 k or more, as required for the power level you use. The capacitor bypasses RF to keep it out of the meter circuit; a 0.005 µF disk ceramic rated at 50 volts or more will do.
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but this reading may or may not mean anything. The reason is that the capacitance between the pick-up wire and the center conductor will always couple some RF energy into the secondary wire. True VSWR indicators are constructed to minimize or eliminate pickup because of this capacitance. The device will, however, be a very useful indicator of how things are working at either end of the feedline. If something drastic happens to either the antenna or the transmitter, you'll see a change in indication — and that's what this gadget was designed to show.

**Other frequencies**

I've had reasonably good results with this type of device at 144 MHz by using a 4-inch length of coax between fittings, and type "N" connectors rather than the usual SO-239/PL-259 types. At frequencies higher than this, the pick-up wire becomes a significant portion of a wavelength, and the extra wire in that short length of coax puts an "impedance bump" in the line. Amateur publications have described similar devices that use strip conductors made from PCB board material. These work well at VHF and UHF. You can obtain improved readings at the lower ranges (3.5, 7, 10, and 14 MHz) by using a coax length of 6 to 8 inches between connectors.

If you want to build the RF transformer section into a metal box along with a meter or the LED indicators, it won't hurt to bend the coaxial section into a "U" shape so the connectors are accessible on either the front or back of the enclosure.

I've seen this type of device built with the secondary wire placed in a small groove cut into the coax cable dielectric. This increases the sensitivity slightly, but the tradeoff is that the secondary wire disturbs the impedance of the cable to a larger degree than does the simpler type of construction. If you're working at very low power ranges, it may be worth a try.
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<th>ICS* (Amps)</th>
<th>Size (IN) H x W x D</th>
<th>Shipping Wt. (lbs.)</th>
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<td>5¼ x 19 x 12½</td>
<td>50</td>
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- Separate Volt and Amp Meters
- Switchable volt and Amp meter
  - RS-12M: 9, 12
- Separate volt and Amp meters
  - RS-20M: 16, 20
  - RS-35M: 25, 35
  - RS-50M: 37, 50

### RS-M SERIES

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<td>22</td>
<td>10</td>
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<td>10</td>
<td>4 x 7½ x 10½</td>
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<tr>
<td>RS-12S</td>
<td>9</td>
<td>12</td>
<td>4½ x 8 x 9</td>
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<tr>
<td>RS-20S</td>
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<td>5 x 9 x 10½</td>
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- Built in speaker

*ICS—Intermittent Communication Service (50% Duty Cycle 5 min. on 5 min. off)
WINTER DX SEASON

November through February is the winter DX season for most of us. Signal strengths are roughly 15-dB stronger on paths to Europe from the United States due to lower absorption of signal energy by ions in the D region. In this season the Northern Hemisphere D and E regions receive less energy (thus less ionization) because the sun is in the Southern Hemisphere. On any propagation path, absorption increases with the number of signal transits of the D region and varies inversely with frequency. In working DX to use the higher frequency bands to obtain more distance per hop, which results in fewer transits and less signal loss. But don't make a habit of counting on this; signals traveling a high-latitude path may be poor for several days at a time. This is known as the winter anomaly.

Along with lower signal attenuation, QRN decreases as fewer local thunderstorms pass through your QTH during the winter months. The sun's southerly location also affects the distant land mass thunderstorm generators. As the large thunderstorms near the equator move farther south, their noise decreases by about 6 to 8 dB. This is particularly noticeable on the 160, 80, and 40-meter bands.

How do these two winter DX season signal propagation parameters affect your receiver input? The weakest receiver input that can be amplified and detected is a function of the input signal to noise ratio, S/N. For receivers used in the HF bands the ratio limitation is usually the atmospheric noise received at the antenna input. The preceding paragraph indicates that there's a decrease of noise in this season. Thus your receiver input S/N denominator, N, should decrease by about 6 to 8 dB. As was mentioned earlier, the signal attenuation from less absorption should increase the signal by about 15 dB during the winter months. Your receiver input S/N numerator, S, should see this. Therefore, a total increase of 20 to 23 dB is available for digging out the weaker DX - making this time of the year better than any other. Do you have an unfulfilled WAC goal, or a friend you'd like to talk to in a third world country where they use low power transmitters? Now is the season; go for it!

Last-minute forecast

Expect DX conditions on the higher frequency bands to be best the first, second, and last weeks of November. Solar flux with accompanying MUFs should be high at these times. Look for good transequatorial openings in late evenings too. These openings may be enhanced around the 7th, 17th, and 27th because of the possibility of disturbances then. November is often quiet geomagnetically, but anything can happen at sunspot maximum. The lower bands, mainly nighttime, are expected to perform best during the third and fourth weeks - including Thanksgiving weekend. It's time to sit by the fireside, away from the cold dark night, and DX a little.

The Taurids meteor showers will occur from October 26th to November 22nd, with a maximum count of ten per hour from the 3rd through the 10th of November. Lunar perigee is on the 12th and a full moon falls on the 13th.

Band-by-band summary

Ten and 12 meters, the highest day-only DX bands, are nearest the MUF for Southern Hemisphere paths. They will be open most days during the 8 to 12 hour period after local noon for the solar flux available this November. These bands open on paths toward the east and close toward the west. The paths are up to 4000 km (2400 miles) in single-hop length and, on occasion, double that during evening transequatorial openings.

Fifteen and 17 meters, day-only DX bands open most of each day, have lower signal strengths and greater multipath variability than 10 and 12 meters. This variability will be best when the MUF is resting just above these bands until it drops below (a transition period that occurs after sunrise and just before sunset). Transequatorial openings will occur with distances similar to 10 and 12 meters.

Twenty, 30, and 40 meters are both daytime and nighttime DX bands. Twenty is the maximum usable band for DX in northerly directions during the day. It provides nighttime paths for the day-only bands, in combination with 30 meters. Forty meters becomes the main over-the-pole DX daytime band, with some hours covered by 30 meters. This path and east-west paths may be affected by 1 to 20 dB of anomalous absorption during a few days of the month.

Eighty and 160 meters, the night-only DX bands, exhibit short skip propagation during daylight hours, then lengthen at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the north-south near midnight, and ending up in the Pacific areas for a few hours before dawn. Remember the DX window of 3790 to 3800.
<table>
<thead>
<tr>
<th>OCEMBER</th>
<th>1989</th>
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<tbody>
<tr>
<td></td>
<td>JAN</td>
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<td>ASIA</td>
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</tr>
</tbody>
</table>

**Hamm Radio/November 1989** 97
ADVERTISER’S INDEX AND READER SERVICE NUMBERS

Listed below are the page and reader service number for each advertiser in this issue. For more information on their products, select the appropriate reader service number, make a check mark in the space provided, and mail this form to Ham Radio Reader Service, P.O. Box 2558, Woburn, MA 01881.

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Address: [Blank]
City: [Blank] State: [Blank] Zip: [Blank]

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Please use before Dec. 31, 1989.

We'd like to see your company listed here too. Contact Martin Durham at 603-878-1441 to work out an advertising program tailored to suit your needs.

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**READER SERVICE #**

Page #

**PAGE #**

127 - Ace Communications, Monitor Div 93
114 - Buckmaster Publishing 89
120 - Ace Systems 74
131 - Advanced Computer Controls 61
160 - Advanced Receiver Research 32
179 - AEA 15
123 - Aerospace 69
178 - Alinec Electronics Inc 16
165 - Aluma Tower Co 30
135 - AMC Sales, Inc. 60
148 - Crystal Associates 86
110 - AMSAT 90
146 - The Antenna Specialists Co 52
109 - Antennas West 52, 60, 93
159 - Antique Radio Classified 32
172 - ARE Communications 21
105 - Astron Corp 95
126 - Berkley & Williamson 98
125 - Berkley & Williamson 98
126 - Berkley & Williamson 98
126 - Berkley & Williamson 98
167 - C&J Sales 28
156 - Coxial Dynamics Inc 36
130 - Communication Concepts Inc 61
148 - Communications Specialists 49
122 - Creative Control Products 69
157 - Cundiff Associates 71
151 - Cushman Corporation 41
164 - Cymbal-Quasar Book 30
149 - Digital Digest 86
174 - Doppler Systems 20
140 - Doug Hall Electronics 55
143 - Down East Microwave 52
171 - Engineering Consulting 75
145 - Franklin-Belle Publishers 52
145 - The Grapevine Group Inc 90
137 - G.T.I. Electronics 41
147 - Ham Radio Outlet 50, 51
139 - Hamtronics 57
139 - Hamtronics, PA 39
139 - Health Company 35
183 - ICOM America, Inc. CII
180 - ICOM America, Inc. 13
124 - International Radio and Computers Inc 52
144 - Jari Crystals 98
163 - Jon's Electronics 90
121 - K&O Communications, The Ham Center 69

**PRODUCT REVIEW/NEW PRODUCT **

302 - The Antenna Specialists Co 48
302 - Hamtronics, NY 53
303 - ICOM America, Inc. 53
303 - Kenwood USA Corporation 48
306 - MFJ Enterprises 53
304 - Midland MPR 53
305 - Niglow Electronics 53
305 - OPTElectronics 48

**B & W PRESENTS A WINNING COMBINATION **

**MODEL PT2500A LINEAR AMPLIFIER**

The Barker & Williamson PT2500A Linear Amplifier is a completely self-contained tabletop unit designed for continuous SSB, CW, RTTY, AM or ATV operation, intended for coverage of all amateur bands between 1.8 MHz and 21 MHz. Two type 3502 glass envelope triodes provide reliability and rapid turn-on time.

**FEATURES INCLUDE:**
- Full 1500 watt output
- PI-network input for maximum drive
- Pressurized plenum cooling system
- DC antenna relay for ham-free operation
- Illuminated SWR and power meters
- Verifier tuning for accurate settings
- P-L output for greater harmonic attenuation

Ruggedly constructed for proven design, this amplifier reflects the manufacturer's critical attention to detail such as the silver-plated tank coil for maximum efficiency. Cathode neck fuse and internal/external cooling are among the protective and safety devices employed. Input and output impedances are 50 ohms.

Dimensions: 17" wide x 19" deep x 8.5" high
Weight: 80 lbs. (shipped in 3 cartons to meet FOB factory price)

Price: $2175.00 FOB factory. Price includes one year limited warranty.
Call or write factory for complete specifications.

**MODEL VS1500A ANTENNA COUPLER**

The Barker & Williamson VS1500A antenna coupler is designed to match virtually any receiver/transmitter or transceiver in the 10 MHz to 18 MHz range with up to 1500 watts RF power to almost any antenna, including dipoles, inverted vee, verticals, mobile whip, beam, random wire and others, fed by coax cable, balanced lines or a single wire. A 1.4 balun is built in for connection to balanced lines.

**FEATURES INCLUDE:**
- Series parallel capacitor connection for greater harmonic attenuation
- In-circuit wattmeter for continuous monitoring
- Verifier tuning for easy adjustment.

Front panel switching allows rapid selection of antennas, or to an external dummy load, or permits bypassing the tuner.

Dimension (Approx.): 11" wide x 13" deep x 6" high
Weight: 63 lbs.
Price: $499.00 FOB Factory. Fully warranted for one year.
Missouri Radio Center

Kenwood

- TS-940 "DX-CELLENCE"
  - All Band, All Mode Transceiver
  - Direct Keyboard Entry
  - Engineered for the DX-Minded and Contesting Ham
  - Its Got It All!

- TS-140S AFFORDABLE DX-ing!
  - HF Transceiver With
  General Coverage Receiver
  - All HF Amateur Bands
  - 100 W Output
  - Compact, Lots of Features

Kantronics

- TM-231A
  - 2 METER FM MOBILE
  - 50 Watts Output
  - 20 Multi-Function Memories
  - Selectable CTCSS Tone Built-in
  - Operate 4 Mobile Rigs with Optional IF 20 Interface and RC-20 Controller

Kenwood

- KT-Series Mono-Band Radios
  - 10-15-20-30-40-80 MODELS
  - SAVE BIG $$
  - Best Price and Complete Selection
  - Call Today!

Alinco

- TH-25AT
  --pocket-sized
  - AND POWERFUL
  - Frequency Coverage: 144-160 MHz (Rx), 144-148 MHz (Tx)
  - Front Panel DTMF Pad
  - 5 Watts Output
  - 14 Memories
  - TH-45AT Available for 440 MHz
  - $449.00 Delivered

- ALD-24T
  - 2m/70cm
  - Dual Band Mobile

MFJ

- SALE
  - LARGEST STOCK OF ALL
  - YOUR MFJ FAVORITE
  - ACCESSORIES
  - CALL TODAY FOR
  - BEST PRICE

- IC-32AT
  - SUPER DUALBAND
  - FM HANDHELD
  - 5 Watts on Both Bands
  - Receive 138-174 MHz
  - 440-450 MHz
  - Stores Standard and Odd Offsets

- IC-765 NEW HF TRANSCEIVER
  - Built-in Automatic Antenna
  - Tuner and Power Supply
  - 99 Memories • 100 W Output
  - 160-10M/General Coverage
  - Receiver
  - Band Stacking Registers

- FT-767GX
  - HF/ VHF/ UHF
  - BASE STATION
  - Add Optional 6m, 2m & 70cm Modules
  - Dual VFO's
  - Full CW Break-in
  - Lots More Features

- IC-725 NEW ULTRA COMPACT
  - HF TRANSCEIVER
  - USB/LSB/CW, AM Receive
  - Optional Module for AM
  - Transmit and FM TX/RX
  - 160-10M Operation • 100 W Output
  - Receive 30 kHz to 33 MHz
  - 26 Memories with Band Stacking Registers

- IC-4GAT
  - 440-450 MHz
  - 6 Watts

- FT-736R VHF/UHF
  - BASE STATION
  - SSB, CW, FM on 2 Meters
  - and 70 cm
  - Optional 50 MHz, 220 MHz or
  - 1.2 GHz
  - 25 Watts Output on 2 Meters,
  - 220 and 70 cm
  - 10 Watts Output on 6 Meters
  - and 1.2 GHz • 100 Memories

- TS-140S
  - HF Transceiver With
  - General Coverage Receiver
  - All HF Amateur Bands
  - 100 W Output
  - Compact, Lots of Features

- IC-4GAT
  - 440-450 MHz
  - 6 Watts

- IC-2GAT
  - 2 Meter & 440 Handhelds

- IC-2GAT
  - RX 138-174 MHz
  - TX 140-150 MHz
  - 7 Watts

- IC-4GAT
  - 440-450 MHz
  - 6 Watts

- TH-25AT
  - POCKET-SIZED
  - AND POWERFUL
  - Frequency Coverage: 141-163 MHz
  - (Rx), 144-148 MHz
  - (Tx)
  - Front Panel DTMF Pad
  - 5 Watts Output
  - 14 Memories
  - TH-45AT Available
  - for 440 MHz

- ALD-24T
  - 2m/70cm
  - Dual Band Mobile
  - $449.00 Delivered

- 25W, 21 Memories, Dual VFO’s
  - At an Unbeatable Price!

- 25W, 21 Memories, Dual VFO’s
  - At an Unbeatable Price!

- CLOSEOUT SPECIAL
  - Receive 30 kHz to 33 MHz
  - ONLY $169.
  - DELIVERED

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  - At an Unbeatable Price!

- CLOSEOUT SPECIAL
  - Receive 30 kHz to 33 MHz
  - ONLY $169.
  - DELIVERED
You Have Counted on Us for 15 Years

You have counted on OPTOELECTRONICS and more and more of you are counting on Hand Held Frequency Counters to be the best quality, to be affordable and reliable. We have been there for you with Frequency Counters that are compact and ultra sensitive.

All counters have 8 digit red .28” LED displays. Aluminum cabinet is 3.9” H x 3.5” x 1”. Internal Ni-Cad batteries provide 2-5 hour portable operation with continuous operation from AC line charger/power supply supplied. Model CCB uses a 9 volt alkaline battery. One year parts and labor guarantee. A full line of probes, antennas, and accessories is available. Orders to U.S. and Canada add 5% to total ($2 min, $10 max). Florida residents, add 6% sales tax. COD fee $3. Foreign orders add 15%. MasterCard and VISA accepted.

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OPTOELECTRONICS INC.
5821 N.E. 14th Avenue • Fort Lauderdale, Florida 33334
1-800-327-5912 FL (305) 771-2050 FAX (305) 771-2052
The new TS-950SD is the first Amateur Radio transceiver to utilize Digital Signal Processing (DSP), a high voltage final amplifier, dual fluorescent tube digital display and digital meter with a peak-hold function.

- Digital Signal Processor: DSP is the state-of-the-art technique that maximizes your transmitted RF energy.
- Your signal stands out because it is much more pure than your competition!
- You can even tailor your transmitted CW or voice signal waveshape!
- Dual Frequency Receive Function: The TS-950SD can receive two frequencies simultaneously. The sub-receiver has independent controls for frequency step size, noise blanker, and AF gain and its own digital display!
- New! Digital AF Filter: Synchronized with SSB IF slope tuning, the digital AF filter provides sharp characteristics for optimum filter response.
- New high voltage final amplifier: 50V power transistors are used in the 150W final section, resulting in minimum distortion and higher efficiency. Full-power key-down time exceeds one hour.
- New! Built-in microprocessor controlled automatic antenna tuner: The new antenna tuner is faster and you can store the settings in memory! (Manual override is also possible.)

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- Multi-Drive Band Pass Filter (BPF) circuitry: Fifteen band pass filters are available in the front end to enhance performance.
- High performance IF filters built-in: Select various filter combinations from the front panel. For CW: 250 and 500 Hz, 2.4 kHz for SSB, and 6 kHz for AM. Filter selections can be stored in memory!
- Kenwood interference reduction circuits: SSB Slope Tuning, CW/VBT (Variable Bandwidth Tuning), CW AF tune, IF notch filter, dual- mode noise blanker with level control, 4-step RF attenuator (10, 20, or 30 dB), switchable AGC circuit, and all-mode squelch.
- Built-in TCXO for highest stability.
- Built-in electronic keyer circuit.
- 100 memory channels. Store independent transmit and receive frequencies, mode, filter data, auto-tuner data and CTCSS frequency.
- Digital bar meter.

Additional Features:
- Built-in interface for computer control
- Programmable tone encoder
- Optional VS-2 voice synthesizer
- Built-in heavy duty AC power supply and speaker
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- Multiple scanning functions
- MC-43S hand microphone supplied

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