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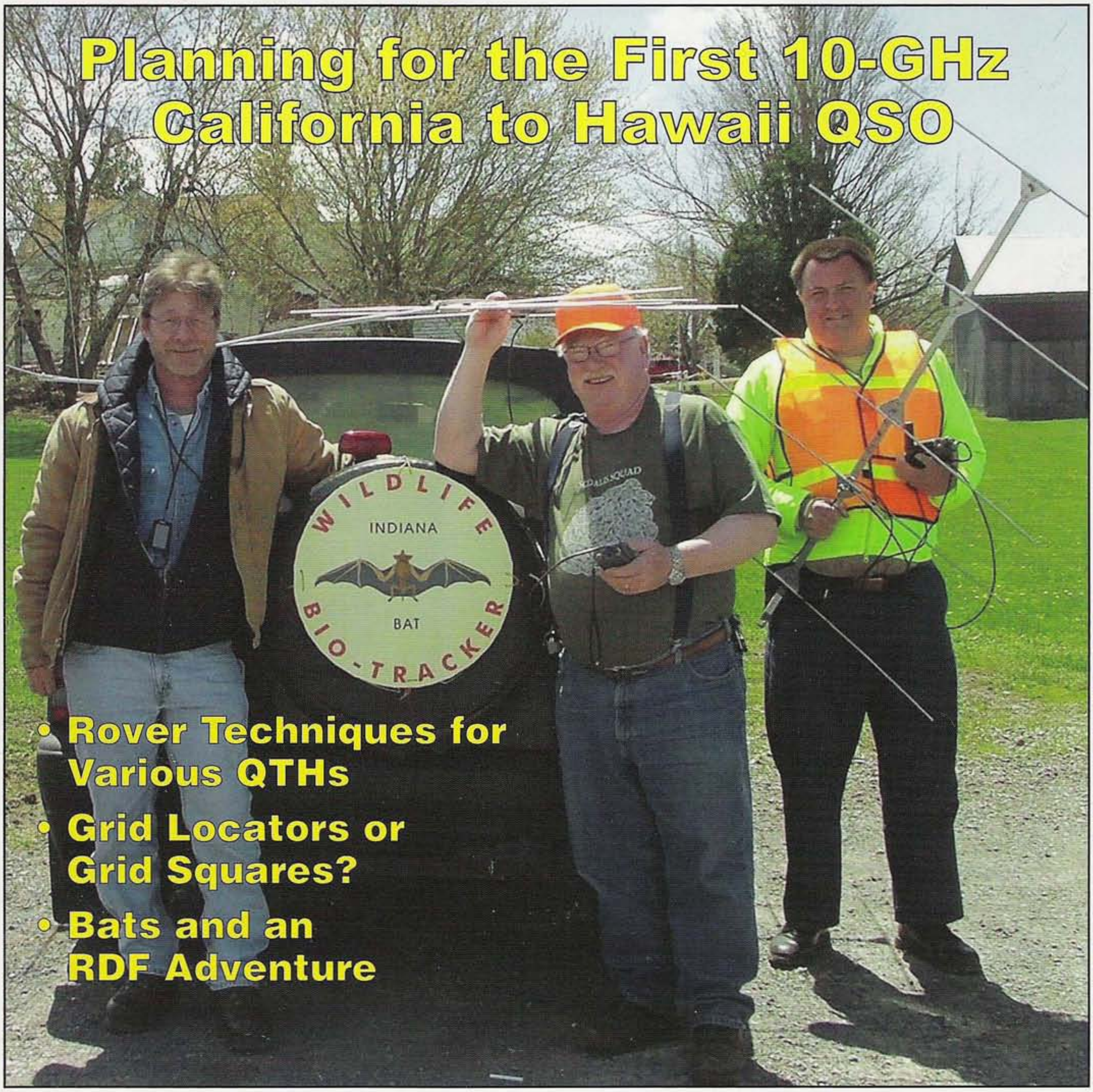

Planning for the First 10-GHz California to Hawaii QSO

- Rover Techniques for Various QTHs
- Grid Locators or Grid Squares?
- Bats and an RDF Adventure

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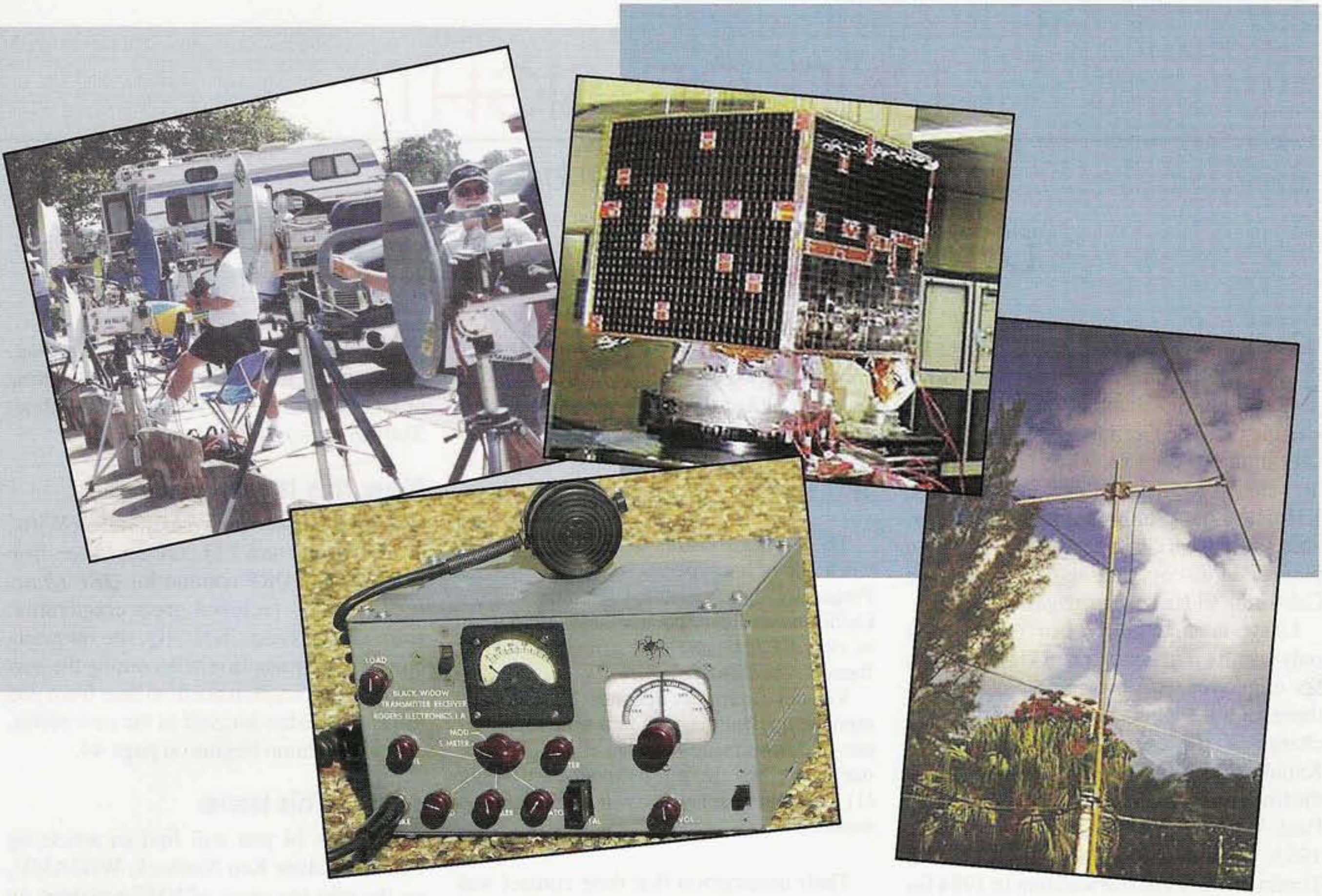
FEATURES



COLUMNS

DEPARTMENTS

On The Cover: How are a batmobile and hidden transmitter hunting related? When you strap transmitters on bats' wings, you have to have a chase vehicle and a team to man the vehicle. For more on this bat-fulling story, see the "Homing In" column by KØOV beginning on p. 32.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

One Thing Leads to Another

During the course of my editing duties I was reading the article "California to Hawaii Attempt on 10 GHz" by Features Editor Gordon West, WB6NOA (beginning on page 6), when I came across his reference to Ralph "Tommy" Thomas, KH6UK. As Gordo explains, Tommy, along with John Chambers, W6NLZ, was a pioneer in discovering and exploiting the California to Hawaii propagation duct.

I have been an admirer of Tommy, not only for his pioneer work in Hawaii when his employer, RCA, transferred him out there for a few years to be the engineer-in-charge of the company's transmitter at Kahuku, Oahu, but also for his having made the first 2-meter meteor-scatter contact with Paul Wilson, W4HHK, on October 22, 1953. I had wondered what happened to Tommy since I interviewed him in 1994 for my VHF column in *CQ* magazine. Knowing that he was in his 90s then, I rather doubted that he was still alive. Even so, I did the most logical thing, something many of us do when we check on fellow hams: I looked him up on QRZ.com. What I discovered led me on a detective trail that would lead all the way back to Hawaii.

Upon arriving at Tommy's information at QRZ.com, I was saddened to read in the biography section that Tommy was a Silent Key. I figured as much, after reading his date of birth as 22 December 1903. However, knowing that he had died only served to pique my curiosity. My first clue was the fact that someone had taken the trouble to write in his biography section "Ralph Thomas is a Silent Key." Who had made the updated entry? Was it a relative?

I sent an e-mail to Fred Lloyd, AA7BQ, the owner of the QRZ.com website, asking him for permission to find out who had updated Tommy's information and explaining that I wanted to do a piece on Tommy for a future column in *CQ*. In response, Fred graciously assisted me in getting in touch with that person.

As it turns out, the person is Mark Shultise, WA3ZLB, who happens to be Tommy's nephew. In our initial correspondence Mark sent me copies of three newspaper articles dating back to the 1950s and 1960s. One bit of trivia that fascinated me concerning the first California to Hawaii contact between Tommy and John was found in one of those articles.

In *The Sunday Home News,* New Brunswick, New Jersey, the Sunday, August 4, 1957 edition, I read the following:

> Thomas made history in Hawaii last month when one of his experiments with Very High Frequency signals resulted in contact with a California amateur operator 2,600 miles away at virtually the same time a massive meteor flared in the Hawaiian skies.
>
> Veteran electronics operators on the island report it marked the very first time such contact had been made between Hawaii and the mainland. They attribute it to one of two things: (1) Freak atmospheric conditions, or (2) A meteor shower.

Their assumption that their contact was a result of a meteor shower rather than via the previously unknown weather-created duct is not surprising in retrospect. It was only four years earlier that Tommy had made that first meteor-scatter contact with Paul on the same band. It would be a couple of years of frequent communications on 2 meters plus setting a still-standing DX record on 220 MHz on June 22, 1959 before John would deduce that the propagation was weather related.

Another seemingly trivial item in Mark's initial e-mail intrigued me. He began it by writing "Aloha Joe." Who else but someone living in Hawaii would greet someone with the word "aloha"?

It turns out that after an initial vacation trip to Hawaii in 2002, Mark decided to return there for good. He has become a Kona Coffee farmer and lives on the big island of Hawaii. His QTH is Captain Cook, which is a two-hour drive from Pahoa, the QTH of Paul Lieb, KH6HME, who as you will read in Gordo's piece is the Hawaiian-side contact for the potential 10-GHz QSO. What an incredibly small world we live in!

I have forwarded Paul's phone numbers to Mark and will leave it up to them to make contact with one another. Hopefully, the nephew of the pioneer of the California to Hawaii duct might possibly be a witness to another pioneer setting yet another record between California and Hawaii. Whatever happens, you will read about it in this magazine and in my column in *CQ*. Speaking of *CQ* magazine, I plan to have more about Tommy in my September column.

New This Issue

With this issue we welcome Bob Witte, KØNR, as the new FM column editor. Bob also writes a QRP column for *QRP Quarterly.* He has received great cooperation from Gary Pearce, KN4AQ, the outgoing editor, in his transition to becoming the new editor. Even so, Bob needs to hear from you as he establishes himself as the new editor. His first column begins on page 44.

Also in This Issue

On page 14 you will find an article by Features Editor Ken Neubeck, WB2AMU, on the past ten years of VHF activities on the lower VHF+ ham bands. In addition, on page 20 is part one of a two-part article on roving by Paul Goble, ND2X, and Wayne Gardener, N4FLM. Also, beginning on page 26, is an article on the misnaming of grid locators by Emil Pocock, W3EP. As usual, you will find the regular columns by your favorite columnists spread throughout the magazine.

Next Issue

In the next issue of *CQ VHF* we hope to establish yet another column related to our specialty of VHF communications, that being radio control. We have been in touch with Del Schier, K1UHF, who is considering writing a regular column on that subject. Del writes for *Fly RC* magazine. Watch for the next issue to see what develops.

And Finally . . .

Thanks to your support this magazine continues to grow, both in the number of regular writers and in readership. We really appreciate your support, which continues to inspire us to commit to more and more excellent coverage of this specialty within our wonderful hobby. If you have an idea or project that you would like to consider publishing, please contact us and we will discuss developing it with you.

Until the next issue... 73 de Joe, N6CL

The California to Hawaii Attempt on 10 GHz

This summer Chip Angle, N6CA, and Paul Lieb, KH6HME, will attempt to contact one another on 10 GHz via the well-known California to Hawaii propagation path. Here WB6NOA covers the history of the VHF and above records held to date via the circuit, as well as the difficulties Angle and Lieb are facing in their attempt to establish yet another microwave record.

By Gordon West,* WB6NOA

This summer hams from southern California and Hawaii hope to establish a world-record terrestrial tropospheric ducting contact on the 10-GHz X-band. Chip Angle, N6CA, has spent the last few years completing final assembly, final testing, and final alignment of all of his homebrew equipment in Hawaii and his portable equipment at the U.S. mainland side of the circuit. Chip indicates the equipment is more than ready at each end of the 2400-mile path, and favorable July tropospheric ducting weather will hopefully move in, settle in, and create the path.

A Well-Known Path

The southern California to Hawaii VHF/UHF tropo path has been recognized for over 50 years. The military, conducting Operation Tradewinds, regularly established a San Diego to Hawaii path on VHF frequencies during summer months. It was also during the 1950s that internationally known VHF/UHF DXer John Chambers, W6NLZ, began VHF operating schedules in Hawaii with Tommy Thompson, KH6UK.

Sure enough, on July 8, 1957 John and Tommy made contact on 2 meters, and on June 22, 1959 they again made contact on 220 MHz. Back in the 1950s, 432 MHz was characterized as too high in frequency because of the 2400-mile path loss, yet Chambers indeed worked up a 432-MHz system and *heard* Tommy's signal from Hawaii. However, as life moved on, Tommy moved back to New Jersey, returning to his old callsign W2UK, and was not able to complete the path. For quite a few years after the W6NLZ to KH6UK contacts no one in Hawaii had that special fascination with VHF/UHF tropo ducting and the microwaves above.

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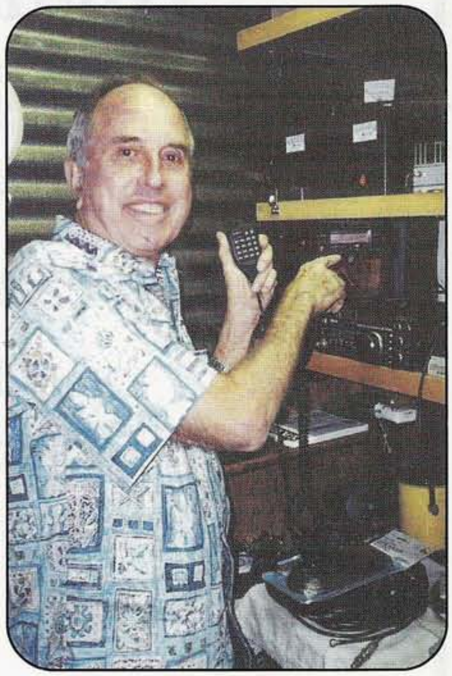
Then Along Came Paul, KH6MHE

Twenty years went by with no California to Hawaii activities except for a few summertime reports of California 2-meter repeaters, where 20-watt mobile stations claiming to be in Hawaii were saying "aloha" for several hours on end. Of course, no one believed that an AM signal on 2 meters would ever propagate over the 2400-mile path, so the Hawaiian mobiles were told to quit pulling our legs and move on to another repeater.

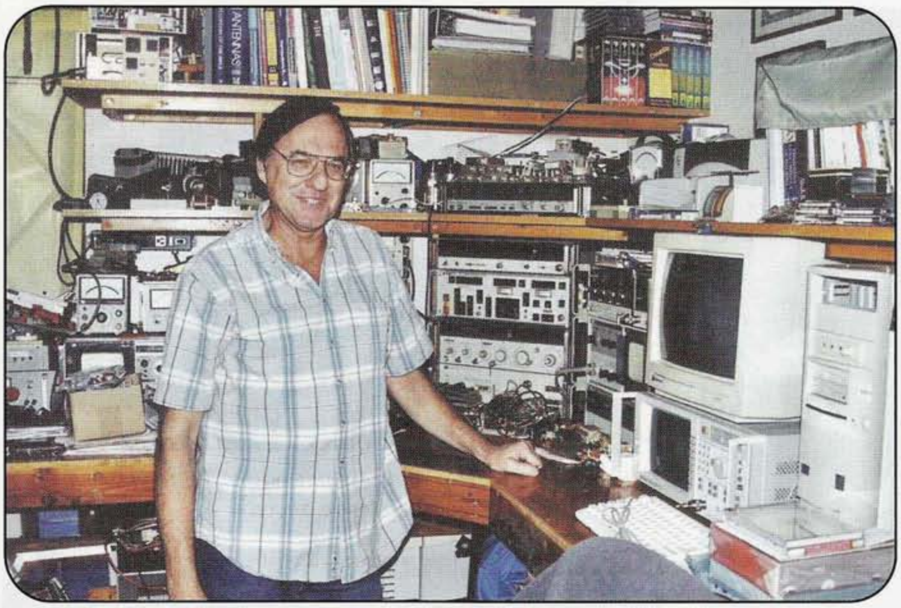
Paul Lieb, KH6HME, was a southern California transplant to the big island of Hawaii. Paul was fascinated with the tropo ducting possibilities between Hawaii and the mainland, so he and Bob, W6PJA, assembled a 432-MHz beacon inside a tin shack on the side of the Mauna Loa volcano, 8200 feet above sea level. The shack was not very warm, as it gets chilly at that altitude. However, it was full of television translators who didn't mind an affable ham taking up a few feet of bench space to squirt a signal over a nearly impossible 2400-mile path back to the mainland.

Once operating, Bob was the first to hear the new beacon. Next the 432-MHz signal was armchair copy for Louis Anciaux, then WB6NMT, now KG6UH and HL9UH, whose home was perched on San Diego's Point Loma, at nearly the exact same spot as some of the original military tradewind tropo experiments. It took Paul several hours to navigate the lava roads to get up to the beacon site. Once the beacon's signal dropped, the first 432-MHz contact was established on July 18, 1979, followed by the first CW 432-MHz contact made by Jay Mahoney, W6YDF.



Paul Lieb, KH6HME, gets set for 10 GHz this July and August.

In June 1981 Chip, N6CA, built and shipped to Paul the 1296-MHz beacon. Sure enough, a after a couple of years trying they made the first 1296-MHz contact. On a day when Chip heard the beacon, he jumped in his 1976 Chevy van and coordinated with Paul on 2 meters SSB for an easy CW two-way on 1296 MHz. Chip's transverter was running 1 watt via a TRW-52601 transistor driven



Chip Angle, N6CA, ready to establish the 10-GHz record for the first QSO from California to Hawaii.

by a Motorola transistor to a rat-race mixer with a milliwatt at 28 MHz for injection. The output fed a water-cooled (mobile!) 7289 driver tube that delivered 30 watts output. This drove a 180-degree ring hybrid homebrew setup that split the signal into two 15-watt levels. These two signals drove two individual 7289 amplifiers in parallel for a maximum power output of 500 watts. However, with a little experimentation on the air, it was quickly realized that weather conditions were far more important than brute power in completing the 2400-mile path.

In the 1990s Chip sent more equipment to Paul, and they become regulars in setting microwave records, conquering 902 MHz, 2.3 GHz, 3.3 GHz, and finally 5.6 GHz, all on CW without the aid of a computer pulling signals out of the mush. In the meantime, members of the San Bernardino Microwave Society were going hot and heavy on 10 GHz SSB, scoring valuable finds from the aerospace industry and the monthly swapmeet at TRW!

July 15, 1994 was the first major effort to establish a 10-GHz contact with Paul in Hawaii from the southern California mainland. Chip had developed a very nice 10-GHz system that Paul could get on the air to a fixed 10-GHz antenna aimed squarely at southern California. Jack, N6XQ, began X-band calls to Paul, followed by an evening attempt by Dave, WA6CGR, who was located near Los Angeles International Airport. Frank, WB6CWN, was on Sunset Ridge near Claremont overlooking the Los Angeles basin, and he too tried to hear the 10-GHz beacon and establish a two-way contact on X-band.

Robin, WA6CDR, also lit off his monster 10-GHz dish antenna. Even with major power levels from TWTs, the monster dish antenna still could not bridge the path, even though VHF and UHF beacon signals were so strong that I was able to talk from an FM handie-talkie to Paul over the 2400-mile path with full quieting! However, nothing on 10 GHz.

Studying the Path

Over the last ten years Chip and members of the San Bernardino Microwave Society have studied the path between Hawaii and southern California, collectively sharing ideas on how to improve the microwave systems at both ends of the circuit. Chip completely redid both stations for this year's 10-GHz California to Hawaii world-record QSO attempt.

"I am satisfied that my new 10-GHz system for KH6HME will establish our 10-GHz Hawaii to California contact," commented Chip, who was featured in the April 2005 issue of *QST* for all of his accomplishments on VHF, UHF, and microwaves.

"*CQ VHF* readers can ride right along with me on the bench and see the projects for the Hawaii efforts I have completed by linking to my website: <http://www.ham-radio.com/n6ca>. To see the construction pictures of the KH6HME 10-GHz station, go to <http://www.ham-radio.com/kh6hme> and click on the "Construction Pictures" link," added Angle.

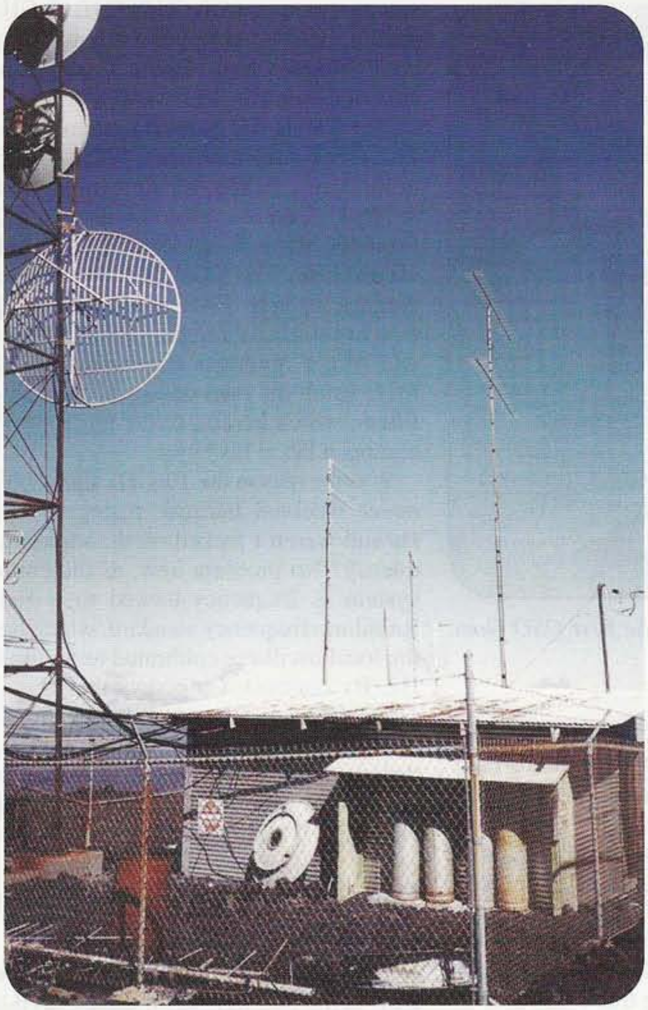
The KH6HME X-band system yields 10.3 watts at the feed horn, with a 1.6-dB noise figure. A WR-90 waveguide and a W2IMU feed are used for the 0.6 f/D Prodelin offset feed, 48-inch Ku band, 40-dBi dish. The 10 watts comes from a Hughes 1177H TWT amplifier. Chip converted LNBs for the pre-amplifiers and direct up/down conversion to 28 MHz using his own design of bandpass filters, which he constructs in his well-equipped lab at his home.

Was the reason the 10-GHz signal was never received because mainland and Hawaii weren't locked on the same frequency? No problem now, as the entire system is frequency-locked to a Ball Rubidium frequency standard, which has the local oscillator calibrated to within 1 Hz. By contrast, Chip says that it was probably not that the stations were on different frequencies, but rather inaccurate dish antennas were probably the greatest contributor to the lack of success on the previous 10-GHz attempts.

This Summer's 10-GHz Efforts

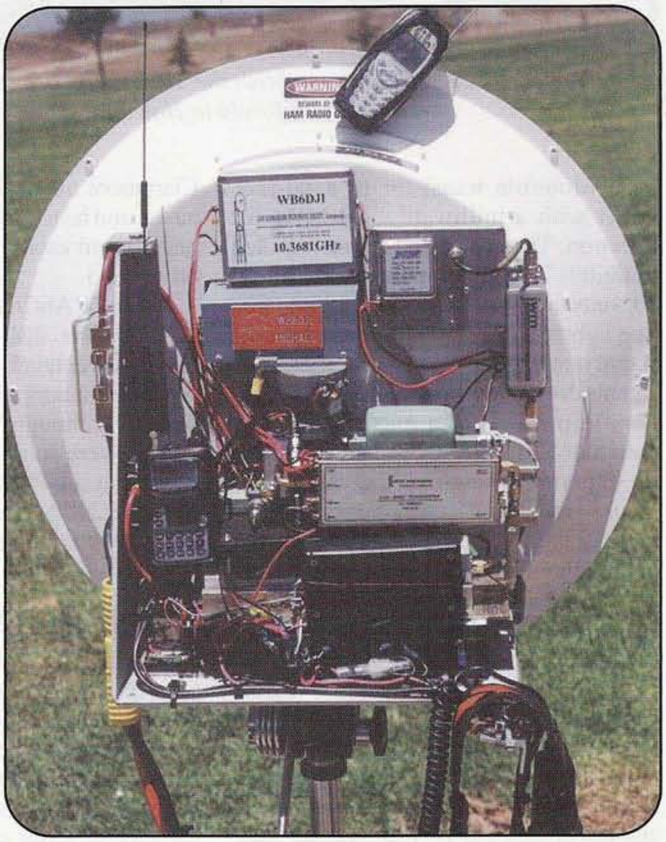
Paul says he is sure that equipment problems in the past have been solved, so this year he is definitely ready for the 10-GHz efforts. "Statistically, July is always our best month for tropospheric ducting, and I will have all of Chip's equipment in place and up and running for the 2400-mile effort," he added. Paul regularly spends three months in southern California during the holiday season and the rest of the time on the big island of Hawaii, where he works down by the water near Hilo. Upon hearing from the mainland that propagation is present, he instantly jumps in his vehicle and heads for the Mauna Loa volcano operating site, a modest 2-hour drive along a lava field road which saw a lava flow go through it just a few years ago.

"It is always exciting up on the hill. I tune into the FM broadcast band coming in from the states as I head up to the 8200-foot elevation. This gives me a good idea of how strong the duct is open to California. I also watch the cloud layer; when the blanket of clouds is just below the operating site, conditions usually will be great on all VHF and UHF bands, and hopefully soon the X-Band!" said Lieb, smiling as he poses for a quick photo



The Hawaii tin shack up 8200 feet, where Paul, KH6HME operates up to a week at a time trying for the 10-GHz record.

The 10-GHz tuneup and test put on by the San Bernardino Microwave Society.



Both SSB Electronics and Down East Microwave modules are popular with 10-GHz microwave operators.

beside the southern California Ed Tice house, where Ed and Paul often talked about the California to Hawaii tropo path. Coordination for the X-band attempt usually takes place on the 2-meter band or 70-cm band. If X-band propagation is favorable, 2 meters and 70 cm over the 2400-mile path will always be at a peak.

Chip added, "We have shipped Paul some hardline connectors and cables for a new 2-meter rebuild at the Mauna Loa end of the circuit. Paul will be running a pair of 7-element M^2 Yagis pointed at southern California from the Mauna Loa volcano site. The upgrade to his 2-meter operation was accomplished through donations from the Western States Weak Signal Society (http://www.wswss.org); Mike Stahl at M^2; and myself, plus a lot of tweaking before everything got shipped to Paul and Fred, W6YM, over in Hawaii."

Once a month about 40 X-band (and higher!) operators get together as part of the San Bernardino Microwave Society (http://www.ham-radio.com/sbms). "Our monthly SBMS meeting turnouts pack the house, because many of our members bring show-and-tell microwave gear," explained President Chris Shoaff, N9RIN. He indicated that the $15 per year membership and newsletter keep everyone's interest high and further all of the efforts going into this year's 10-GHz try between California and Hawaii. Each summer before the two 10-GHz ARRL contests SBMS members turn out on a rural city park test range for receiver, frequency, and power-output checks.

"Put up a 10-GHz horn at any hamfest gathering and it's like a magnet, attracting hams to see what happens at 10,000 MHz," commented Kent Britain, WA5VJB, who is a member of the North Texas Microwave Society (http://www.ntms.org) and *CQ VHF*'s "Antennas" columnist.

This same "show-it-off" technique was also a big draw at the recent Amateur Electronics Supply Superfest, with 10-GHz demos put on by the local Badgers contesters microwave team (Marc Holdwick, N8KWX, president, <n8kwx@arrl.net>). "We make it a point to show off 10 GHz to VHF and UHFers to get more operators onto X-band," explained Holdwick, an echo of what the Northeast Weak Signal Group (http://www. newsvhf.com) and Mt. Airy VHF Radio Club (http://www.ij-net/pack-rats) are also doing to promote X-band excitement. At their respective annual conferences, the Southeastern VHF society (http://www.svhf.org) and the Central States VHF Society (http://www.csvhfs.org) also make it a point to conduct public 10-GHz microwave demos to encourage more hams to jump into the action.

Has this article begun to pique your interest? You don't need to completely homebrew your 10-GHz station. Many companies have equipment that is literally plug-and-play! Among them are SSB Electronics USA (http://www.ssbusa.com); Prodelin (http://www.prodelin.com); and Down East Microwave (http://www.downeastmicrowave.com).

"We have complete 10-GHz TX/RX systems that may easily be configured with most VHF or 10-meter multi-mode rigs," commented Gerry Rodski, K3MKZ, of SSB Electronics USA. "These complete systems are not lightweight either," added Gerry, referring to power outputs at 10 GHz at the 2- and 3-watt levels! This could easily make possible a QSO with Hawaii if conditions are right this summer along the southern California coastlines.

There will be over 300 West Coast hams listening in on the 2-meter Hawaii beacon frequency (144.170) for an opening. As the tropospheric duct begins to build, there may be as many as 100 West Coast hams relaying reception reports to the ducting website maintained by Russ Sakai, KH6FOO, at: <http://hiloweb.com/kh6foo/bbs/subduct.html>. When the 432-MHz beacon from Hawaii starts pounding into the West Coast at above S-9, the word goes out to 10-GHz operators.

"By the end of July, or at the latest the middle of August, we should see success from all of our 10-GHz efforts," said Chip. By the time you read this article, the word may have spread on weekly ham news broadcasts that the 10-GHz record was set. Over 40 southern California X-band operators hope to follow up on Chip's initial record-breaking contact, furthering all of the efforts that Chip and SBMS members have put in on the 2400-mile over-water path.

"We are ready! Let's all hope for great Pacific tropo conditions this summer!" exclaimed Chip, ready to jump in his Suburban to head for the hill to complete the circuit. ■

The Classic "Black Widow" VHF AM Transceiver

The once popular Black Widow AM transceivers have all but disappeared from our memory—and from any sources of used equipment. Here N8RG describes how he found and restored a 2-meter version of this radio.

By Ray Grimes,* N8RG

It was in the mid-1950s when *CQ* magazine began to print advertisements for an exciting, new, affordable ham VHF AM transceiver strangely called the "Black Widow." These transceivers were primarily marketed by Arrow Sales, Inc. and their distributors.

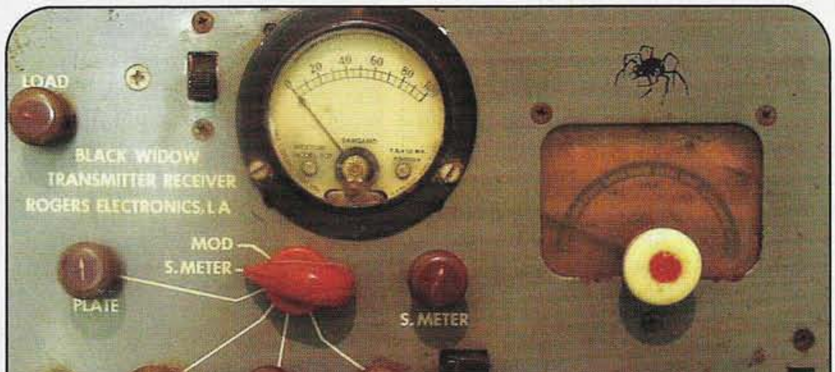
The January 1958 edition of *CQ* featured a "*CQ* Reports on" article by Don Stoner, W6TNS, on the Black Widow. The Black Widow AM transceiver was available for 10 meters (TXR11-CQ), 6 meters (TXR10-CQ), 2 meters (TXR9-CQ), and 220 MHz (TXR12CQ) per the Rogers Electronics catalog 27-611, with all being offered at $165 each. There were several options listed, such as an AC-only power supply (Cat. 13861 PS2-CQ) which sold for $27.50, a universal 6V/12V/115 VAC power supply with speaker for $36.50 (Cat. 47611PS3), surplus new 12V dynamotors for $6.95 each, and there was also mention of a future "Plug-In VFO" option that may never have materialized.

In the mid-1950s CQ *printed advertisements for the Rogers Electronics Black Widow VHF AM transceiver.*

The Black Widow measured only 9 inches wide, 5 inches high, and 6 inches deep and weighed only $7^1/2$ lbs. Those who grew up with the popular Gonset Communicators may never have operated one of these unusual Black Widow radios sets, or they would understand their appeal. I recall seeing Black Widow 2-meter transceivers used on local transmitter hunts, where the proud owners showed off their new radios to anyone who could spare a half hour to listen to a lecture about the virtues of this new radio set. I still can visualize the Black Widow's plain gray, square sheet-metal cabinet, the half-moon panel meter, and the bright-red knobs that looked somewhat like those of the Gonset "Gooney Bird."

The Black Widow was manufactured in West Los Angeles by Rogers Electronics, located near Jefferson Blvd. and Fairfax Blvd., on a side street that once accommodated small light-industrial buildings and modest homes. That area was redeveloped some years ago, and while the Rogers Electronics Carmona Ave. street address still exists, a run-down, four-unit apartment building adorned with a security fence and security grates on the windows now occupies that property.

The Black Widow transceivers were hand-wired and hand-assembled in a garage-shop manufacturing environment. The very basic Black Widow transceiver was designed to be competitive with the fully-accessorized Gonset Communicator II, which sold for $229.95 (in 1957 it was replaced by the improved Gonset Communicator III, which included push-to-talk). The Black Widow sold for $169.95 less speaker, microphone, antenna, and power supply. You could purchase a matching power supply, or build your own, providing 6 or 12 volts for the filaments, and 200 to 300 volts at around 200 ma. No mention of a mobile mounting



The author's Black Widow before restoration. (Photos by the author)

*3212 Tigertail Dr., Los Alamitos, CA 90720

bracket was found in any Black Widow literature, although the service manual states: "Four corner screws permit universal mounting."

A single 2-inch panel meter serves as a receiver relative signal-strength S-meter and a transmitter tuning meter for multiplier and final stages plus modulation indication, selected by a front-panel-mounted rotary switch (below the panel meter). As those were the days when most hams built and experimented with sometimes marginal mobile radio equipment, it was not unusual to have a bare-bones mobile transceiver without a squelch circuit, or a dynamotor power supply that was as loud as the receiver audio.

Rogers Electronics advertised that it had researched the best of current military communications technology of the day and had incorporated it into the Black Widow. The radio does indeed have some good features even though it was truly a low-cost product. The 2-meter Black Widow, for example, has a decent tunable, dual-conversion AM superheterodyne receiver, using a 6BZ7/6BQ7 cascade preamplifier circuit resulting in 0.5 microvolt sensitivity. Sharp receiver selectivity and good image rejection are attained through use of a dual-conversion receiver design with a high IF of 6 MHz and a 1500-kHz low IF. A 6T8 tube serves as detector, AGC, noise limiter, and first audio amplifier. A 5687 dual triode vacuum tube operates as the second audio amplifier and audio output stage, producing $^1/_2$ watt of audio into a 4-ohm speaker load. A 0B2 tube is the B+ regulator for the receiver local oscillator circuit. The transmitter multiplies the 8-MHz crystal output 18 times to 144 MHz. A single 2E26 tube produces 8 watts of RF output into a 50-ohm unbalanced antenna, with excellent 100% Class AB^2 plate modulation from a pair of 6AQ5s operating in push-pull. An open-frame DC relay is used for antenna and B+ switching functions. There is even a crystal spotter circuit to help find your own transmitter frequency on the variable receiver dial.

The Black Widow featured microphone-operated push-to-talk (unlike most of the more costly Gonset II Communicators). It even offered a carbon/crystal/dynamic microphone selector switch, although it required disconnecting the radio from the mobile mounting bracket and removing the top cover to gain access to the interior chassis-mounted rotary switch. Six- or 12-volt DC operation is fairly easy to implement, but it requires removal of the radio bottom plate and some internal terminal strip jumpering of the filament string. A 6-pin, recessed Cinch-Jones chassis-mount type male connector is provided on the rear panel for all external power and speaker connections.

The Black Widows had a few quirks, as some panel slide switches weren't labeled, but other controls were. The service manual makes note of the location and purpose of the unmarked Noise Limiter switch (lower right corner) and the Spot switch (left side of the panel meter). The transceiver, although designed for low cost, was a brilliant example of 1950s' RF engineering. The 220-, 144-, 50-, and 28-MHz transceivers had the same basic chassis, with certain components deleted for the lower bands. The 28-MHz transceiver had front-panel hole plugs where 144- or 220-MHz multiplier stage tuning controls would have been installed. The Black Widow made extensive use of dual-section miniature vacuum tubes to save space and cost. The cabinet provides some ventilation holes and louvers that may have proved to be inadequate for extended mobile or base use in warm environments.

These transceivers were definitely built with low cost in mind, reflected in their hand-made construction. Components such as panel switches, potentiometers, and the panel meter were mounted directly on the formed sheet-metal housing front panel. The radio was assembled around these components, sometimes hiding access to these parts completely. This produced real challenges in isolating troubles and replacing components, where other components had to be removed to gain access to almost inaccessible regions of the cabinet interior.

Black Widow transceivers are extremely hard to find these days. After looking for several years for one in any condition, I was fortunate to locate one on eBay. I thought I would be outbid by hundreds of interested buyers, but to my surprise I was the only bidder, capturing this rare find for around $35. I am beginning to believe that before this article is read by *CQ VHF* subscribers there may have been fewer than a dozen of us who even knew what a Black Widow transceiver was (and maybe a lot more who knew but didn't care).

The restoration of my Black Widow 2-meter transceiver was largely a matter of reconstructing damaged and missing parts by close examination of advertising photos and magazine article artists' conception drawings. The Black Widow transceiver I bought had the wrong panel meter installed and exhibited some cabinet rust and wear around the silk-screened control panel's white lettering. The top cover was completely missing. I was able to purchase a complete Rogers Electronics 2-meter Black Widow operator manual from Surplus Sales of Nebraska, including a schematic diagram, complete with engineering sign-offs by J. Rogers in September 1955. That, plus a few magazine advertisements and the Don Stoner article were enough information to get me started on this challenging restoration project.

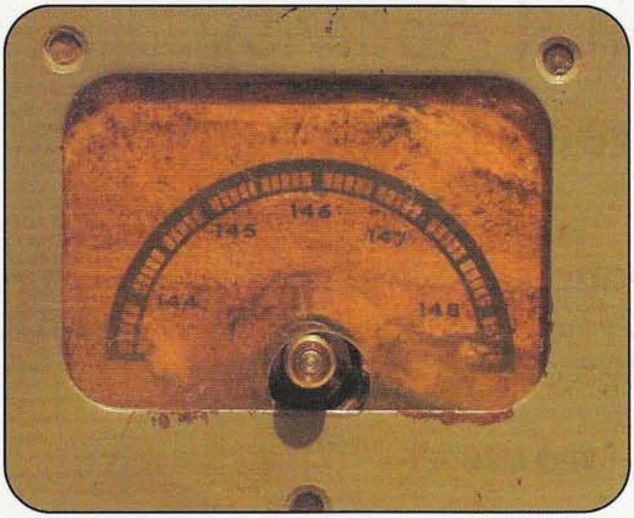
The Restoration

I decided to salvage and mechanically modify the 0–1 ma., 2-inch panel meter that came with this transceiver, removing the meter movement from its housing and grinding down the round mounting flange. I then made a new black plastic bezel to replicate the original one. As I maintain a good scrap box, some black plastic that looked similar to the original meter bezel was found. The new meter bezel was epoxied to the modified meter faceplate. A new meter shunt resistor was required to balance the meter readings for all metering positions. All transmitter metering functions read normally. The S-meter mode on the Black Widow normally reads backward (right to left action), in the same fashion as the Gonset G-66 mobile receiver. The S-meter circuit has plenty of sensitivity, so it is just a matter of getting used to the reverse meter operation. An S-meter Sensitivity control is provided (below the S-meter, to the right of the meter switch).

As with almost every old radio, the #47 dial lamps were found to be burned out. Closer inspection also identified a scorched 3500-ohm, 25-watt wirewound resistor that serves as a B+ current-limiting resistor. It soon became evident that the former owner of this transceiver had a problem with high voltage over-current that was blowing the internal B+ fuse and resorted to wrapping the open fuse with foil paper from a cigarette package. A new 1/4A fuse and a

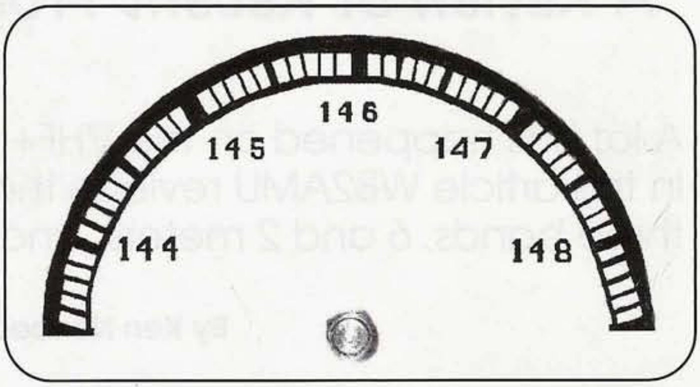
Top view of the now restored transceiver. Notice the new shunt resistor on the back of the panel meter.

Bottom view of the restored transceiver. One can easily see how printed-circuit boards have simplified internal packaging of today's radios.



← *The original, badly damaged dial face.*

The author's computer-generated replacement dial face. ↓



The restored Black Widow, which resides with the author's other vintage radio gear.

The back of the restored transceiver.

replacement 2E26 appear to have corrected any B+ over-current problems.

I then attempted to remove a badly damaged dial face to replace it with a computer-generated replacement that I would make. I was soon challenged by the economical design of the Black Widow, where some parts simply couldn't be removed without special tools or removal of numerous components. Such was the receiver planetary dial drive assembly. I eventually came to realize that I would have to somehow replace the receiver dial face with the complete dial drive assembly in place. I used the macro lens setting on my digital camera to photograph the badly deteriorated receiver dial face as mounted in the transceiver. I then imported the digital photograph into a photo editing program, spending several hours replacing missing black lettering (pixel by pixel) and digitally erasing countless background blemishes on the dial paper stock while restoring the bright-white dial background. The old dial face was carefully removed, and a new paper dial face was slit at the bottom to fit around the dial shaft and glued into place. The results are impressive, if I do say so myself.

A 12-volt power cable was made and the radio was powered up by slowly bringing up the A+ and B+ voltages to limit inrush current. The radio came to life without hesitation, and after realignment it performed almost completely to the manufacturer's specifications. A 2E26 was the only tube replacement made, bringing the Black Widow up to its rated 8 watts output power. A dynamic mobile microphone was used to check modulation. The open-frame relay was cleaned with contact cleaner, using a relay burnishing tool.

The physical restoration was much more of a challenge than the electronic repairs. The paint was closely matched using semi-gloss enamel spray paint obtained from a hobby store. Careful masking was done to preserve the lettering, and in particular, the Black Widow symbol. The gray paint was feathered by light sanding to blend into the original paint. Press-On Transfer lettering was installed to replace some of the worn panel white lettering and then carefully over-sprayed with a clear acrylic to protect it. The missing top cover became a larger project than expected. I soon discovered that having small louvers stamped into a piece of sheet metal would be expensive. I then began a search for scrap sheet metal with small louvers that could be cut to size. I eventually located a rack cabinet back panel with small louvers that would fit my requirements. The fabricated replacement top cover was cut to size and drilled. The new cabinet top was painted to match and installed.

This restored Black Widow is displayed among my personal ham radio museum pieces. Not only was this a fun restoration project, it was also a history lesson about an enterprising small amateur radio manufacturing business that has faded into obscurity, like so many others over the years. ■

VHF Weak-Signal Activity

A Review of Recent Progress for Three Bands

A lot has happened on the VHF+ bands over the past ten years. In this article WB2AMU reviews these happenings on the bottom three bands, 6 and 2 meters, and 125 cm.

By Ken Neubeck,* WB2AMU

Every once in a while it's a good exercise to take a reality or temperature check with regard to the ham radio hobby. One aspect that is worth exploring is the progress of activity on the VHF bands over the past decade.

VHF is defined as the frequency range from 30 MHz to 300 MHz. In North America this includes three amateur radio bands: 6 meters, 2 meters, and 125 cm (222 MHz). In parts of Europe and Africa there is also another VHF band allocation at 70 MHz (4 meters).

The three VHF bands used by hams in North America have interesting forms of propagation that make certain days special in comparison to the line-of-sight contacts that are made. In this article we will review the progress of weak-signal activity over the past decade for these three bands.

6 Meters

It is now the year 2005, and it can safely be said that 6 meters is no longer the forgotten band amidst all the allocated ham radio bands. A number of things have changed the fortunes of the "Magic Band" over the past decade, and it has become a very popular band during the summer months. Publicizing the many unique propagation conditions of the 6-meter band, ranging from sporadic-*E* to *F2*-layer activity, as well as the availability of more commercially made equipment have increased the band's popularity.

I remember how things were on the band back in 1990, when I first got on 6 meters with a Swan 250 transceiver that I picked up at a local flea market. I found that it was very hard to figure out the nuances of the band and when to listen for any activity. All too often back then 6 meters was quiet, and I wondered when contacts could be made. My first real wave of contacts was during the September VHF contest in 1990. All the contacts I made then were of the line-of-sight variety up to a distance of 200 miles away.

I had heard rumors from other operators that at times the band had skip activity, but available reference material such as the *ARRL Operating Manual* did not clearly spell out what the best times were to listen on 6 meters. Various VHF books discussed some of the propagation modes on the band, but the information presented was of the broad-strokes variety, without specifics.

It was not until June 1991, just hours before a VHF contest, that I worked my first sporadic-*E* contact on 6 meters from my location in Long Island into Florida. Gee, I thought, maybe long-range stuff on 6 meters can be worked after all! When the contest started, I worked a large number of stations and was amazed that a dead band could come to life! Over the balance of that summer I looked at anything I could find about the band (remember that this was before the Internet became really popular), but I could only find general information in the *Operating Manual* about what kind of conditions could be found on 6. Unfortunately, this information was too general for it to be of much use to a newcomer to the band, and much information had to be gained by the laborious process of word of mouth. Because the information was so broad, it made the band seem much more mysterious than it really is.

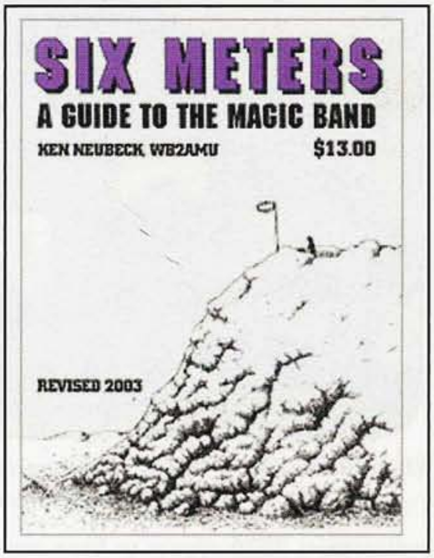


Figure 1. Here is the book that started getting the word out about 6 meters. It still remains the one and only book out there dedicated to 6 meters. First published by WorldRadio Books in 1994, a second edition came out in 1998, followed by a third edition in 2003. Each edition featured additional pages with the current scientific information about propagation along with up-to-date amateur radio observations on the 6-meter band.

It then became obvious that more articles and a dedicated book for the 6-meter band were needed. I had written an article on 6 meters for the December 1992 issue of *QST,* and from that article I was able to write additional articles for *WorldRadio*. In 1993 when that magazine sent out a request to its readers for ideas for books, I suggested that I write a book dedicated entirely to 6 meters. After a few

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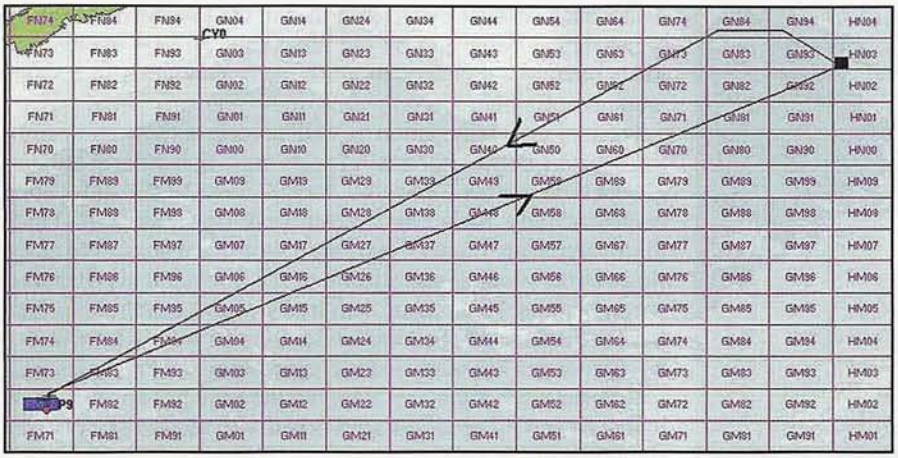


Figure 2. This map, constructed by George, GM4COK, and on his web page, shows George's 6-meter maritime mobile excursion during July 2003 on the cable repair ship Sir Eric Sharp. *He started from Bermuda and went through several rare all-water grids to grid HN03, where cable had to be repaired using an underwater robot that was controlled from the ship. Clint, W1LP, is another well-known maritime 6-meter operator who has navigated through many all-water grids over the years. All-water grids are a real treat for 6-meter operators because of the difficulty of finding operators passing through. (Map by George Szymanski, GM4COK)*

months the staff accepted my proposal and off I went!

I realized right at the conception of the project that I needed the input of 6-meter operators with significant operating experience and from other locations. Thus, with the help of veteran operators such as Tom Glaze, K4SUS, and Frank Moorhus, AA2DR, and the input of others, I was able to put together the first and only book dedicated to just 6 meters, with it debuting at the 1994 Dayton Hamvention® (see figure 1) . The book has since gone into two additional editions, in 1998 and in 2003, with added pages and updated information.

Even after the book came out in 1994, there was still a lack of equipment for the band. A few new radios were available, such as the single-band Yaesu FT-690, the Kenwood TS-60, and the triband Yaesu FT-650. However, this was still not producing the desired results. It was not until the wave of HF plus 6-meter transceivers such as the ICOM IC-706 and the Yaesu FT-100 that a real difference was seen in increased use of the band. Now at times HF operators would check out the 6-meter band with these new transceivers.

Hams who made the journey from HF to 6 meters quickly found that the summertime sporadic-*E* season on 6 was consistent between May and August year in and year out. Some of these openings can be quite intense. Of course, too, aurora backscatter makes an occasional appearance on 6 meters, even during reduced sunspot activity. This was the case in the June 2005 ARRL VHF contest, where a major aurora opening occurred on 6 meters in the U.S. and Canada during the last five hours of the contest, creating a pile-up of CW signals on the band.

No doubt the greatest amount of 6-meter excitement over the past decade came about during the fabulous *F2* openings that started in October 2001 and continued into February 2002. This period of *F2*-layer activity occurred months after the peak of sunspot Cycle 23 and caught many by surprise. In September 2001, the daily solar flux values stayed consistently above 200, and this continued over the next few months, resulting in daily 6-meter openings via *F2*. East Coast stations in the U.S. were working into Europe in the morning, and then in the afternoon the opening would shift between the East Coast and the West Coast. It was truly an exciting time for the 6-meter band!

Six meters easily lends itself to DX-peditions and rare-grid-square expeditions. Over the past decades operators such as Jon, NØJK; Jimmy, W6JKX; and Johan, ON4IQ, have activated a number of rare countries, as well as some rare grids. A most interesting grid-square expedition is the one GM4COK mounted in July 2003, when he operated 6 meters from a ship that worked on underwater cables (figure 2). With a 5-watt FT-817 radio, he activated over two dozen all-water grids, leaving from Bermuda and going into the mid-Atlantic.

There are a number of dedicated 6-meter radio clubs such as SMIRK, the Six Club, and the Southern California 6-meter Club. They keep the flame for 6 meters alive. There are a few dedicated 6-meter Internet sites as well. The best one in terms of active spotting is run by Tim Havens, W4TRH: <http://www.dxers.info>. I cannot emphasize how valuable this website has been, both in terms of the technical information, and the spotting information that is present on the chat page of this site. Many short sporadic-*E* openings, as well as developing aurora openings, have been spotted on this site.

Perhaps the only real issue with 6 meters these days is adherence to the recommended band plan. Strictly speaking, the DX window of from 50.100 to 50.125 should only be used for DX contacts and not for domestic QSOs. Also, the use of both calling frequencies—50.110 MHz for DX and 50.125 for domestic stations—should be used carefully by 6-meter operators. For example, when the band is quiet, a station that gets a response to a CQ on 50.125 might be within the guidelines of good sportsmanship in completing the

Jon Jones, NØJK, used this simple two-element Yagi with good success during one of his earliest trips to Bermuda. (Photo by NØJK)

A three-element, 2-meter Yagi is a small antenna that is easy to set up for portable operations. Here is the setup that WB2AMU employed in searching for 2-meter tropo activity near a 250-foot hill that also features a public park with a Vietnam War monument. (Photo by WB2AMU)

QSO on that frequency. However, if the band becomes more active, it is wise to move up the band and call CQ. During many great sporadic-*E* openings 50.125 MHz becomes a zoo of activity such that it is virtually impossible to complete a QSO. Obviously, it makes sense to spread out on the band.

Another situation is the use of 50.110 MHz. It is fine for a domestic station to call CQ DX a couple of times on the frequency and then stop if there is no answer. There are some stations that call long strings of CQ DX, effectively blocking the use of the frequency by anyone else, be it a DX or domestic station. Good judgment should always be used. Call once or twice, and if there is no answer, move off this frequency.

Six meters continues to grow and it is a major band for VHF contests as casual operators join in on the fun. The June 2005 VHF contest featured sporadic-*E* openings on the west coast of the U.S. while a major aurora event occurred on the east coast of the U.S. and Canada. While the band could be used more for local contacts, overall it is in good shape and will probably continue to grow steadily in activity.

2 Meters

Two meters is the staple of amateur radio, going back to the days when 2-meter FM became king in the late 1960s. Repeaters were the rage on 2 meters FM for a number of decades. Recently, though, cell phones have become more popular.

If you are concentrating on weak-signal or simplex work on 2 meters, you need to take advantage of the propagation modes that occur on the band. The three major modes of propagation enhancement found on the 2 meter band are tropospheric ducting, aurora backscatter, and sporadic-*E*.

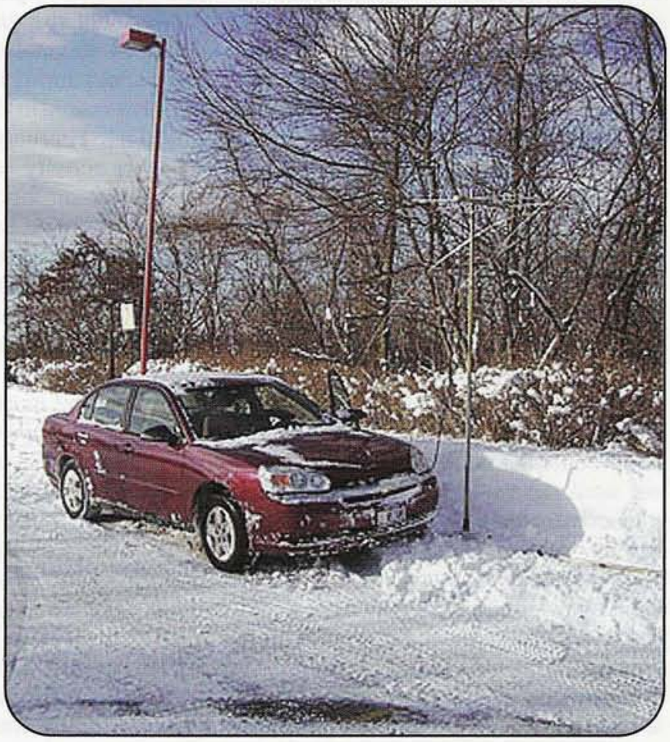
Tropospheric ducting is the bread-and-butter mode for the 2-meter band, with aurora backscatter and sporadic-*E* being present during exceptional conditions. In the case of aurora, geomagnetic activity has to be pretty high such that 6 meters is solid with activity. Sporadic-*E* is pretty much the same way and initially may be detected during solid conditions on 6 meters with signals shortening. However, sporadic-*E* on 2 meters is at best a once or twice occurrence during the summer in the U.S. However, as witnessed by the great July 7, 2004 opening, it gives operators a chance to work many new grids in a short amount of time!

I started my participation in VHF contest activity by operating 6 meters only. After several years of participation in the single operator, portable category, I added more VHF bands to my contest activity, including 2-meter weak-signal work. As I had discovered with 6 meters, there are a significant number of quiet times in the weak-signal portion of the 2-meter band. In some ways, 2-meter weak-signal activity has significant hurdles that have to be overcome as compared to 6-meter weak-signal activity. Six meters has many hams championing it when compared to 2-meter weak-signal activity, but the band has an advantage in that *Es* and *F2* openings are worked with modest effort at the right time of the year.

After hearing some of the enhanced tropo conditions on 2 meters during the contest, I also started to listen to the band on a regular basis during non-contest periods. In addition, I started to listen to 2 meters during major periods of geomagnetic activity to work stations via aurora activity.

Occasionally, a path opens from Long Island along the coast into North Carolina. Every so often it seems as if the same area comes in via a strong opening. One station I have worked from this area is Jim, AA3ID. Now while extended tropo paths can often occur in the summer and fall, I actually worked AA3ID during an unusual period of tropo extension in February 2005 at noontime at my work location using a three-element beam suspended from a tree. I also used it to search for tropo activity on 2 meters during the spring of 2005.

(Continued on page 70)



Two meters is ideal for portable operations during VHF contests, too! Here is the same setup used by WB2AMU right after a major blizzard during the January 2005 VHF contest. (Photo by WB2AMU)

The Margelli-Miller Behind-the-Scenes Story

By Gordon West, WB6NOA, and Joe Lynch, N6CL

It was a battle between modern technology (cell-phone text messaging) and old-fashioned CW to see which was faster in conveying a message. The object of the contest was to transmit the message over the air via the respective (cell phone and amateur radio) wireless spectrum. The two ham contestants were Chip Margelli, K7JA, and Ken Miller, K6CTW. The *Tonight Show* is shot before a live audience in near real time, so the challenge was to do the contest right the first time.

Chip reported that there were many technical challenges in pulling off their CW competition in one live take. In particular, the show is shot within a very tight block of time, with little or no time to spare for QRM problems on the ham bands from studio birdies, or vice versa. Chip commented, "Ken Miller, K6CTW, arrived before I did and RF swept the studio area using his portable spectrum analyzer."

"Yikes, our planned RF band was full of birdies. In fact, 160 meters through 2 meters was filled with signals that might have QRMed our efforts to send and receive a usable CW signal. The birdies were ultra low level confined inside the studio, but nonetheless, too many HF birdies to dodge!" he added. Even so, Chip anticipated this problem well ahead of time, so his rigs of choice were a pair of Yaesu FT-817s, battery operated, with UHF capabilities hopefully beyond birdie land! One of the radios belonged to Chip and the other was supplied by Dan Dankert, N6PEQ, a weak-signal VHF operator in the Orange County, California area.

As it turned out, Chip's choice of radio and frequency paid off. "We found quiet on 70 cm," commented Ken, K6CTW, who prepared for a "one take only" performance on the show. Being the good weak-signal VHF enthusiast that Chip is, he made sure that their radios were tuned to 432.200 MHz.

"To further minimize any chance of QRM, Chip and Ken found good signals over the 15-foot path with the FT-817 antenna menu selector to open antenna," noted Janet Margelli, KL7MF, adding that Chip and Ken set the FT-817s to low power with no antenna connections. Even so, they still had good copy over the 15-foot path, and the radios easily tolerated the open antenna circuit with no problems. In spite of this provision, the close proximity of the two radios made it possible for Ken to easily hear Chip's weak-signal CW transmission and thereby copy the message. Best of all, there was no chance of RF getting into sensitive circuits in the studio. It is important to note that the radios were props. While it appeared that Chip and Ken were in contact with each other, legally no QSO actually took place.

Commenting on the time constraint, Janet stated, "We had only the commercial break time to set up the two stations," adding that the setup took place right after Jay Leno's monologue. Janet handled the transmitting station's setup with Bencher paddles at Chip's location, and the receiving station, plus earphones, pen, and paper at Ken's location – all within the three-minute station break! "A quick double check of signal quality and strength took place within seconds of coming back on camera," added Janet, who was one cool cookie under pressure!

The message, a slight variant of GEICO Insurance Company's advertising slogan "I just saved a bunch of money on my car insurance," was secret until the sending started. The contest against the text messengers was an easy win, with Chip and Ken loafing along at around 28 wpm, with time to spare when they finished.

"The rigs worked perfectly, Morse Code wins again, and ham radio gets a great boost on national television," added Chip, who was so pleased with the under-pressure contest that he gave his CW sending fingers a cool blow down and the camera his classic smile, while Ken beamed after perfect copy of the CW sent script.

For ham radio exposure, the *Tonight Show* with Jay Leno did us well, thanks to professional hams who took the assignment just days before air time and undertook the technical setup just seconds before the stage came alive with CW at its best!

Transmitter Testing—Part 2

Reprinted from *DUBUS* magazine, in the second part of this two-part article SM5BSZ concludes his discussion of how to correctly measure transmitter quality.

By Leif Åsbrink,† SM5BSZ

In part one of this article we discussed our justification for transmitter testing, and the average power spectrum and peak power measurements. This time we cover ALC and SSB, measurements using notch filters, and comparisons among transceivers on SSB, as well as present an extended discussion on the results of our testing.

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ALC and SSB

ALC is just a DC-coupled AM modulator which will add the spectrum of the ALC signal to both sides of the carrier. But if the ALC signal has a fast-rise, slow-decay characteristic, the bandwidth of the added modulation becomes very large. It then is essential that the modulation amplitude is very low; other-

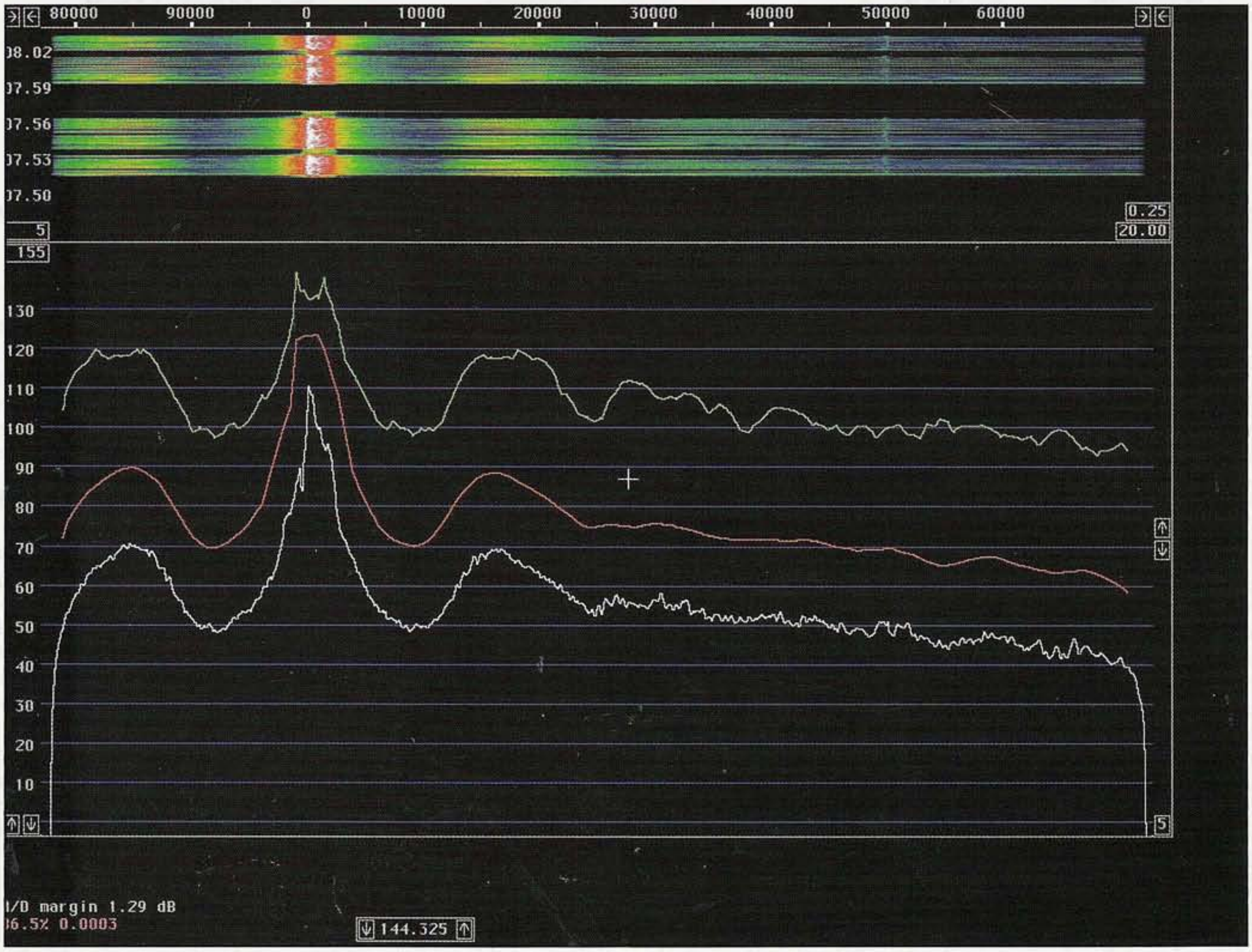

Figure 16. The spectrum of an FT817 in SSB mode on 144 MHz. The splatter is due to an instability of some kind. The signal is clean at voice high levels, like when saying "Aaaaa" into the microphone, and also at low levels. Somewhere in between the splatter is terrible as this image shows. This unit must be regarded as faulty. I do not know how often this kind of error is present in these rigs, but I have seen another one that did not have this error.

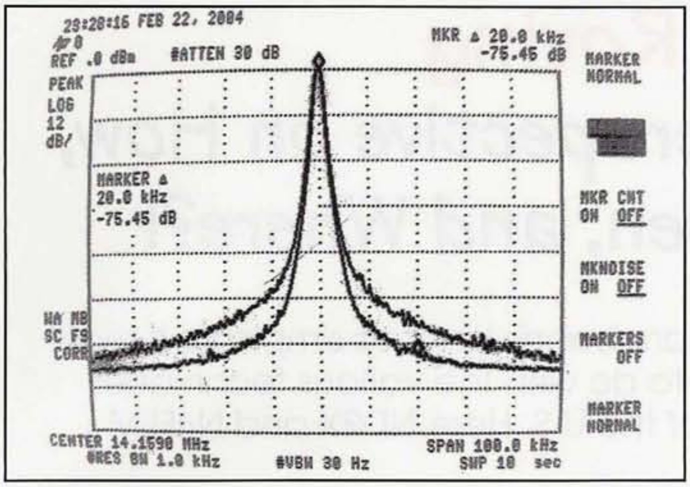

Figure 17. Performance of the HP8591A spectrum analyzer. The upper curve is peak hold and the lower curve is the average-power spectrum. At 20 kHz the average spectrum is 75.45 dB below the carrier, which translates into –101dBc/Hz. The peak-hold spectrum is at about –65 dB with respect to the carrier. Note that the vertical scale is 12 dB per division.

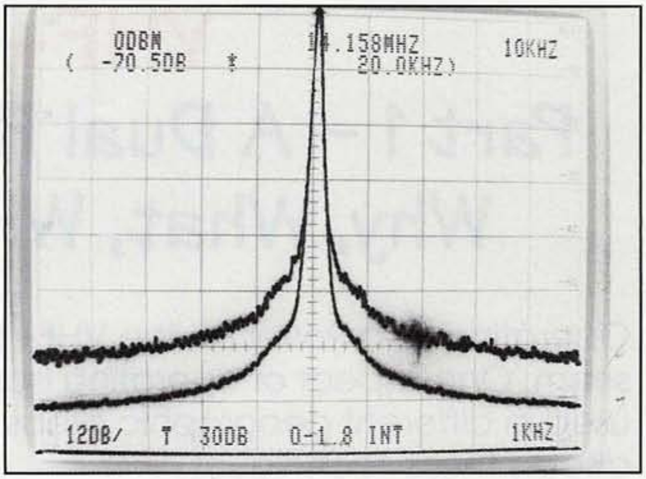

Figure 18. Performance of the TEK2753P spectrum analyzer. The upper curve is peak hold and the lower curve is the average-power spectrum. At 20 kHz the peak-hold spectrum is 70.5 dB below the carrier. The average-power spectrum is 12 dB lower, which translates into –111dBc/Hz. Note that the vertical scale is 12 dB per division.

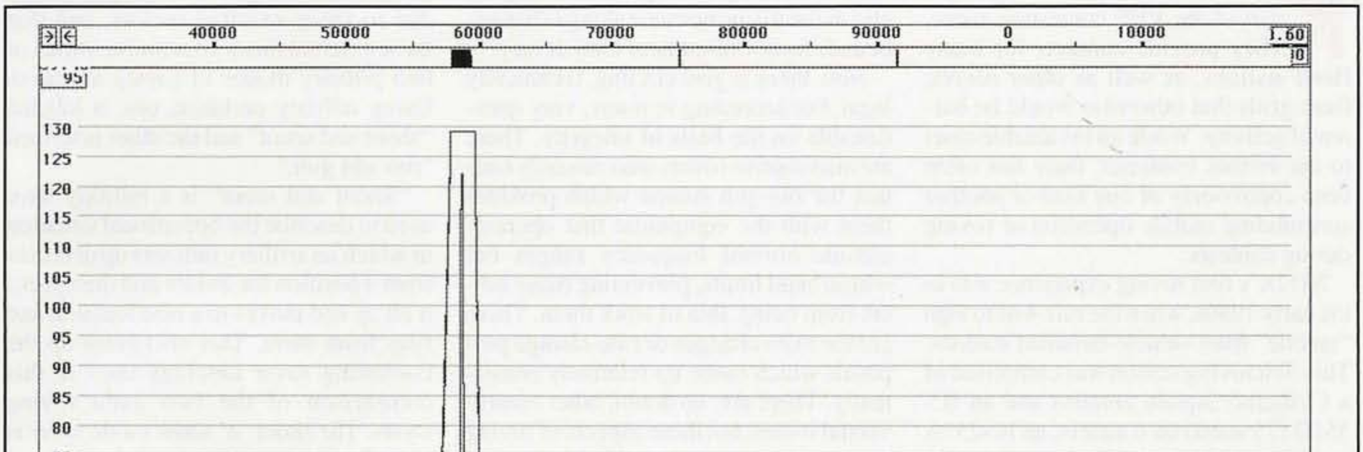

Figure 19. Performance of the WSE converters with Linrad in TX test mode. Counting from the top, the first curve is peak hold, the second is peak power averaged with the equivalent of a 1-second RC time constant, and the third and the fourth are average-power spectra. The first three spectra are at a bandwidth of 2.4 kHz. At 20 kHz the average spectrum is 109 dB below the carrier, which translates into –143 dBc/Hz. Because the system uses direct conversion, the spur at 91 kHz is the mirror image. The spur at 75 kHz is the DC offset and 1/f noise of the Delta44 surrounded by the low-frequency magnetic field from a fan picked up by the Delta44. The spurs at 43 and 107 kHz are due to second harmonics inside the Delta44.

(Continued on page 72)

VHF+ Roving

Part 1 – A Dual Perspective on How, Why, What, When, and Where?!

Operating as a Rover on the VHF+ ham bands is not as simple as it may seem. One aspect of operating has to do with the various techniques used in different geographic areas of the U.S. Here ND2X and N4FLM discuss these techniques.

By Paul S. Goble,* ND2X, and Wayne Gardener,† N4FLM

Rovers have become an important part of the VHF contesting scene. They provide contacts for many fixed stations, as well as other rovers, from grids that otherwise would be barren of activity. While an invaluable asset to the serious contester, there has often been controversy of one kind or another surrounding mobile operation or roving during contests.

ND2X's first roving experience was in the early 1980s, when the rule was to sign "mobile" from vehicle-mounted stations. This first roving station was comprised of a Cushcraft Squalo antenna and an IC-551D (75 watts) on 6 meters; an IC-251A and KLM 160-watt brick, through a splitter to two quarter-wavelength mag mounts, one on either *side* of the Suburban for horizontal polarization; and 25 watts of 440 FM to a two-section collinear vertical whip. This was the family vehicle, complete with family. The second harmonic, NEØM (see March 1984 *QST*, page 54), gave an additional contact to each station worked by ND2X/m.

There was great gnashing of teeth in some quarters over the fact that two contacts from two different callsigns originated from the same station, even though it was clearly in accordance with the "family station and equipment" aspect of the rules. The main concern of most of the complainants was probably generated because WBØDRL, with his superior antenna systems at the time, worked both calls in so many more grids than anyone else as the trip progressed along I-70 eastbound, from Colorado to New Jersey.

Now there is grid circling, technically legal, but according to many, very questionable on the basis of integrity. There are also captive rovers who can only contact the big-gun station which provides them with the equipment that operates outside normal frequency ranges but within band limits, preventing many others from being able to work them. There are the rules changes or rule-change proposals which come up relatively consistently. There are, no doubt, other controversial issues, but these aspects of roving are beyond the scope of this treatise and will not be discussed. The purpose here is simply to compare and contrast the two main roving modes used in the continental United States.

Discussion

Based on lengthy exchanges/threads in the blogosphere of various amateur radio e-mail reflectors, and discussion with folks at hamfests and ham radio society conferences, it is obvious that many hams do not understand roving. ND2X was once accused by an East Coast ham on one reflector of being the only one in the country to use the run 'n' gun mode. This often-demonstrated lack of understanding is, apparently, because many are unaware of the various parameters that impact roving, of development of the equipment suites and antenna configurations used, and of operating techniques applicable to any given route or portion thereof. It is apparently a mystery to many that roving routes and plans vary due to many external factors, and that these external factors determine which of two primary modes of roving are used. Using military parlance, one is labeled "shoot and scoot" and the other is termed "run and gun."

"Shoot and scoot" is a military term used to describe the operational situation in which an artillery unit sets up and fires from a position for awhile and then packs it all up and moves to a new location and fires from there. This also sums up the contesting rover ideology used in this comparison of the two main roving styles. The shoot 'n' scoot mode rover is a station moving amongst a series of advantageous terrain locations, stopping at each, raising one or more towers with directional high-gain antennas, and operating for a time before packing up and moving to the next point of terrain advantage, sort of like a series of mini Field Days. The emphasis in shoot 'n' scoot roving is to maximize the number of contacts achieved.

"Run and gun" is a term used by the military to describe firing one's weapon while moving, applicable to individual soldiers firing while running, and up echelon to weapon systems such as tanks firing while in motion. In like manner, the run 'n' gun mode rover is a station operating "mobile in motion" for all but an occasional few minutes here and there, *never* changing antenna configuration at any time during the contest from that used while in motion. The emphasis in run 'n' gun roving is to maximize the number of grids activated and therefore the number of unique grid combinations achieved.

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Note that the first mode involves radical changes in antenna systems and configuration between that used while in motion and that used while stopped on some terrain vantage point or other. The second mode never alters antenna configuration, from contest start to contest end. Neither type of roving is better or worse than the other; they are simply different. On any rove, as determined by one's chosen route and its geo-political characteristics, a rover might employ either one or a combination of both.

Roving Parameters

As stated, the geo-political characteristics of the route chosen for any given rove determine the roving mode to be employed. Every rove is impacted by a combination of terrain, vegetation, existing roads, infrastructure and traffic, population density and distribution, climate and weather, and area-specific propagation.

Terrain: In general, a roving route can be described in terms of mountains, hills, rolling terrain, or flat, open spaces. Clearly, any significant rove is going to involve a combination of these characteristics. It's easy to visualize the effect of mountains as one drives on almost any interstate in the eastern time zone (north of Florida), looking up hundreds of feet to the top of surrounding terrain while winding along a mountainside through some river valley or other. The same is evident if driving through the Rocky Mountain ranges or the Sierra Nevada mountains.

Continuing with an amazing grasp of the obvious (a little humor here), hills are like mountains except much smaller; rolling terrain is the situation where the road varies up and down in elevation, blocking antennas from the desired propagation path in the low spots; and flat, open spaces are where one has pretty much 360 degrees of being able to see the horizon off in the distance. Photo A is a picture of this last situation. It was taken in Texas, but this same situation is often encountered (and not limited to) the middle third of the continental U.S. and is affectionately known as "miles and miles of miles and miles."

Note that the term "mountaintop" used herein actually refers to any point of terrain advantage. This includes everything from actual mountaintops such as Pike's Peak or Mt. Washington, etc., to much less prominent locations such as bridges that exhibit a "height above average terrain" advantage; examples include the bridge over the Delaware River on Interstate 295 in southern New Jersey or the bridge over the Mississippi River on Interstate 10 in Louisiana. Even getting off at an interstate exit and operating from a shoulder of the associated overpass can provide enough advantage to make the difference between completing a contact and not!

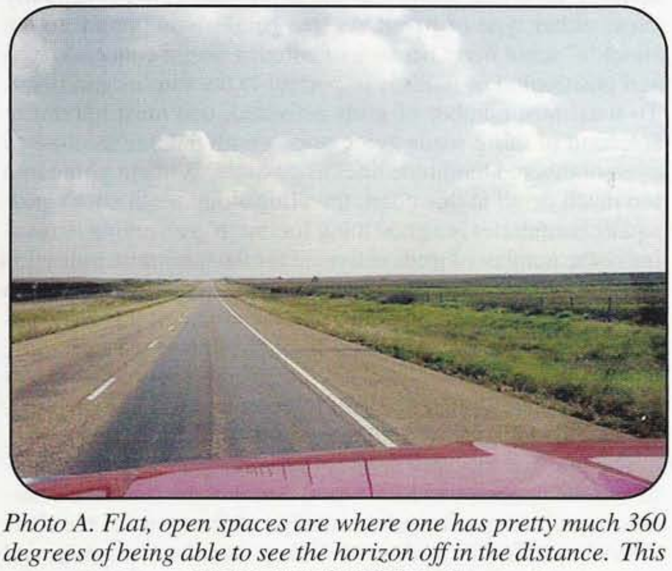

Photo A. Flat, open spaces are where one has pretty much 360 degrees of being able to see the horizon off in the distance. This photo was taken in Texas.

An interesting phenomenon, easily observable if operating while in motion, is presented by the physics of shadowing and diffraction. It is especially evident in rolling terrain. The easiest example to visualize is driving on a road which travels directly away from or directly toward a distant station. While in receive, notice that just after going over a hill that "blocks" said station, the signal virtually disappears. However, as progress is made down the hill, even though proceeding lower in elevation, signal strength slowly increases, peaking again at the top of the next hill. The worst propagation occurs just after disappearing behind any terrain that comes between a mobile station and a distant station. This is due to shadowing. The increase in signal strength as progress downward takes place, away from the initial shadowing point, is due to diffraction. If the mobile station is transmitting, the distant station will notice the same decrease/increase in receive signal strength as that observed by the mobile station.

Photo B. Within the continental U.S., trees are the hindrance most commonly encountered by roving stations, as evidenced by this photo, which was taken in Texas.

Vegetation: The vegetation of primarily concern to rovers is trees. There are other forms of vegetation—e.g., dense hedge rows, large bushes, and the like—but trees are the hindrance most commonly encountered by roving stations within the continental U.S (see photo B).

While roving on I-95 in Maryland, ND2X had no problem making contacts on 50 through 222 MHz, but he noticed a definite decrease in 432-MHz performance and found 1296 MHz to be virtually impossible. Mountaintop stations running respectable power and high-gain antennas could not be heard, nor could the 85-watt mobile signal. The trees densely packed along both sides of the road absorbed so much energy above 432 MHz that communication on those frequencies was virtually impossible.

I-95 in Maryland sports relatively flat (rolling at worst) terrain, but it is lined by these densely-packed trees, all at least 60 feet tall. If surrounded by trees, one must find a way to raise

Photo C. In most of the western portion of the central time zone, most of the trees are in little groups well off the road, planted around houses as wind-breaks.

one's antennas above the treetops to operate successfully at frequencies above 400 MHz. This illustrates why tree size is such a concern to shoot 'n' scoot rovers; they must know how tall their towers must be to clear trees at their selected operating locations. It also matters whether the trees are deciduous or coniferous and what time of year it is; trees with no leaves do not absorb nearly as much RF as their "clothed" cousins!

There are those portions of the continental U.S. that do not present a vegetation problem. The Maryland I-95 example is in direct contrast to most of the western portion of the central time zone, where most of the trees are in little groups well off the road, planted around houses as wind-breaks (photo C). Using the ND2X 23-cm SSB experience again, the best 1296 -MHz DX on the East Coast was from FN20 to the Pack Rats in FN21, while ND2X/M in EM23 worked K5VH in EM00 without difficulty. The difference was not so much terrain as it was vegetation or, more accurately in the latter case, the lack thereof!

Roads, Infrastructure, and Traffic: Roads and highways vary from those (as in New Jersey) which wind through the countryside following old Indian trails, to the arrow-straight

Photo D. Roads with tall mountains on both sides and thick roadside foliage 50 feet high or more are generally the rule rather than the exception. This does not present the most favorable operating conditions for a mobile-in-motion VHF station.

miles and miles of miles and miles of roads in the American Great Plains. In between, one finds those which follow the dictates of terrain, as with the interstates that traverse the Appalachians, Ozarks, Catskills, or any other mountain range, such as I-70 west of Denver in the Rocky Mountains. In eastern Tennessee, for example, if driving up I-75 north, one has a pretty good indication what the lay of the land does. It goes up and up and up then down and down and down. Unfortunately, the majority of interstates are routed primarily in and through valleys, as are many of the secondary roads. Roads with tall mountains on both sides and thick roadside foliage 50 feet high or more are the rule rather than the exception. This does not present the most favorable operating conditions for any mobile-in-motion VHF station, to say the least (photo D).

Photo E. This road, with no shoulder, sports a 70-mph speed limit and a great radio horizon!

One will also encounter man-made hindrances to propagation, like those hilltops where the roadbed has been cut out and travels through the resulting man-made gully for anywhere from several tens of feet to significant fractions of a mile. Anyone who has operated mobile through a metropolitan area has traveled roads sandwiched between concrete walls much taller than the height of the mobile antennas. There are also concerns about construction and the delays this could potentially cause either type of rover. As tree height is important to the shoot 'n' scoot rover because of antenna height concerns, type and positioning of roads is important to the run 'n' gun rover. To maximize number of grids activated, one must maximize selection of those roads going north-south that are as close to even-numbered longitude lines as possible. Without going into too much detail at this point, traveling along north-south grid-square boundaries is a good thing for run 'n' gun roving to maximize the number of grids activated for the minimum miles driven. Fortunately, many roads meeting this requirement exist in the Great Plains. The other nice characteristic of this last category of roads is that the speed limit is often at least 70 mph, which helps when one's goal is to cover as much ground as possible. The road shown in photo E, complete with no shoulder, sports a 70-mph speed limit and a great radio horizon!

The Indian trail roads, on the other hand, have low speed limits and are generally to be avoided. Many accesses to the desirable mountaintops do, unfortunately, exhibit many of the characteristics of Indian trails, even if they were built recently, and cannot be avoided if one is in shoot 'n' scoot mode (photo F).

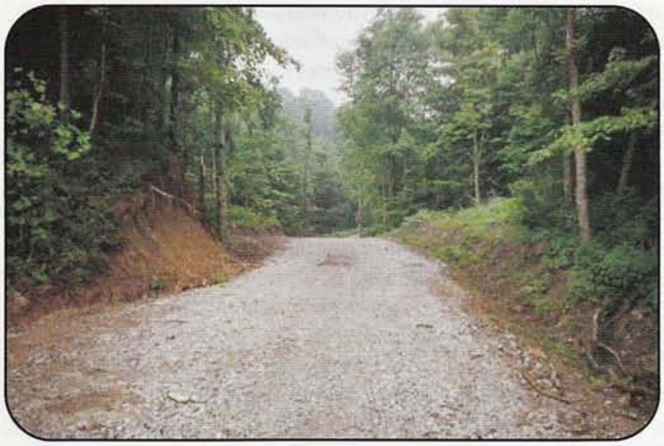

Photo F. Indian trail roads have low speed limits and generally are to be avoided.

Roads between shoot 'n' scoot locations can be vastly different or border on non-existent. At many shoot 'n' scoot locations the last few 100 feet or more of "road" are not much more than a trail. Often there is a steep incline that is either gravel or blacktop that's in bad need of repair. If it's gravel, the turns will exhibit "washboard" and there is no way to go over this type of road, except very slowly. A scary aspect of many blacktop roads is meeting that big truck hauling coal at breakneck speed down the side of the mountain! There are also those "switch back" turns, the ones where the back end of the vehicle passes the front end on the way through the turn. This has a tendency to make passengers motion sick—not a good thing for traveling up or down a mountain, and it's no help when trying to talk the XYL into going along!

From a pure infrastructure perspective, it is necessary to consider fuel consumption and refueling requirements. Nothing ruins the fun any faster than getting out the old magnifying glass and map and sitting in front of the vehicle's headlights at 0230 local in some Podunk town while (1) trying to find your way to someplace you heard was really good, and (2) trying to find a sign that indicates whether the gas station is going to open at all on Sunday, and if so, when. Always fill or top off the tank before heading out to or through remote areas.

There are also considerations of traffic density; we all have roadways we know to avoid at certain times because traffic is so heavy that delays are inevitable. I-35 from 30 miles north of Austin, Texas southward to San Antonio, between 1000 and 2200 local any Sunday is an excellent example, as is the Washington, D.C. beltway any rush hour. Generally speaking, since most long contests are on weekends, rush hour through metropolitan areas is not a concern. Some of the sprint contests might feel the impact, however, since 1900 local start times can still see the effects of rush hour in some areas. Also, extra care is needed if one is traveling an area where the bars close at 0200 local Sunday morning (Saturday night) and you're pushing to get to that next grid or mountaintop!

Population Density/Distribution: The population of the continental U.S. is approximately 291.5 million, distributed as shown in the accompanying map (figure 1). According to ARRL figures, of the roughly 660,000 licensed hams in the U.S., about one third are totally inactive, one third are really active, and another third get on the air sporadically (a little sporadic-*E* lingo there), perhaps for contests and such. Further,

Figure 1. The general distribution of population within the continental U.S. Note that there are just three clearly defined areas of high population density on the West Coast.

about one third of the last two thirds are in any way VHF active. This means, optimistically, that perhaps as many as 146,000 hams nationwide are going to be on the air for at least a portion of any given major VHF contest. This is less than one half of one percent of the general population. The map depicts the general distribution of population within the continental U.S. Note that there are just three clearly defined areas of high population density on the West Coast. Starting from about 97 degrees west longitude and moving eastward, population density picks up, and it can be seen that the eastern third of the nation sports the most major population centers. Further, the northeast quadrant is actually the dominant area for general population density. Note that each dot on the map represents 30,000 folks.

Based on the figures and estimates above, the VHF contesting dilemma, for both fixed and roving stations, can be shown. Assuming uniform VHF-active ham distribution throughout the general population (a *big* stretch), this means, optimistically, that there could be as many as 15 hams who might be on for a portion of a VHF contest anywhere one might find 30,000 population. In most cases, however, this is a *very* optimistic figure. While all these numbers are estimates, and some of the assumptions are questionable, it should be evident that there aren't very many folks on VHF except perhaps in major population centers. In Lubbock, Texas, for example, with a population of almost 200,000, there may be as many as eight hams on during any given VHF contest, and often most or all are operating at the W5LCC club station. In fact, on Sunday morning at 0630 local during the September 2000 ARRL VHF QSO Party, in the area of Omaha, Nebraska, with a population of over 725K, not counting all the suburbs outside the actual city limits, there was nobody on the air! All contacts from that area were from one or two grids away. This rather bleak picture is an excellent illustration of why many fixed stations find rovers such a valuable asset during contests!

Even if the most optimistic scenario of all the above assumptions and estimates were to be true, it is a fact that in nearly two thirds of continental U.S. one would run out of folks to contact well before one would run out of contest. An aspect of roving in these portions of the country is that as one runs out of stations to contact, one moves on to another area with more, new stations to log.

An additional aspect of population density is that there are significant areas of the continental U.S. in which almost everyone goes to bed by 2230–2300 local on Saturday night. For the run 'n' gun rover, this can cost up to eight hours of no contacts, severely limiting final grid count. ND2X arranged with VHF amateurs along the route to stay up during the wee hours of Saturday night to give contacts from approximately 2300 to 0600 local time Sunday morning, at which time they became too far away to hear. It turns out that the assumption that there would be activity in the Omaha area at that time of the morning was erroneous. If there is a next time, arrangements will be made for at least 2230 local time Saturday night to 0730 local time Sunday morning!

Climate and Weather: Heat, cold, precipitation, wind, and almost any other meteorological factor one can imagine impact roving and choice of roving routes. Many mountaintops are not accessible in the winter. Forget Pike's Peak most years from early October through late April, for example, because the snow prevents access to the top of the mountain. Mt. Washington can be a challenge because of wind from time to time, even without precipitation. Ice and snow are clearly potential show stoppers in the winter months for anywhere above the Mason-Dixon line (roughly 39°43' 22" N) or at higher elevations. Many times this limits travel to interstates and other major routes that are well and quickly cleared of snow or kept relatively clear of ice with chemicals. In the best situations, it can slow travel significantly.

If roving through the southernmost states from June through September inclusive, air conditioning is an absolute must, not only to keep the operator from dripping all over the equipment, but to keep the equipment within permissible operating temperature limits. This is especially the case during daylight hours with sun beating down on the vehicle, but if the temperature is 85 degrees or more at 2230 local time, as it often is in San Antonio and points south during the summer, it's important at night, too. Generally speaking, the best month for rovers covering a wide area is September, when it's generally not to hot nor too cold. It's more or less between the hottest of the summer and the coldest of the winter, and weather impact generally will be minimal. There are always exceptions—"your mileage may vary"!

Special "Area-Specific" Propagation: As the story goes, "There I was, on my way to Southeast VHF Conference at the end of April 2003, working into Florida from the mobile on three bands from 144 MHz to 432 MHz, traveling 72 mph on I-30 through EM23 in northeast Texas." It was the start of that year's spring tropo season which graces the southeast U.S. every year. Propagation across Lake Michigan, with the population centers surrounding the lake shores; the California-Hawaii VHF ducting which has been so well documented; and the fair possibility of aurora in the far northern states are all examples of area-specific propagation. Okay, so San Antonio had aurora once, in August of 1987, but it's not something that is at all likely. It's not that these modes don't occur anywhere except as mentioned; it's that some areas exhibit periodic tendencies to perform. The spring tropo in the southeast continental U.S. is pretty reliable, late April through early June, and it is always hoped that it will extend into June far enough to support the ARRL contest; sometimes it does. What fun!

(to be continued)

Back-Up Power Switching For Home and Repeater Applications

What happens when we lose power at our home QTH? Usually we are off the air. Here WB9YBM provides a simple solution to the problems faced by a loss of power.

By Klaus Spies,* WB9YBM

We have seen the benefits that uninterruptible power sources provide for our computers during glitches or outages from the power company. The same benefits can be of use to the amateur community to allow for emergency communications during power outages. In keeping with the make-it-ourselves attitude (and frugality, for some) of the Amateur Service, here's a way we ourselves can make a back-up power source.

In the early days, any switching done for high-voltage or high-current applications was done by relays or solenoids. In some applications this may still be the safest approach; with few modifications the following circuits can be adapted to use relays. Our main focus here will be diode switching, since diodes are much faster and therefore less likely than relays to cause transient glitches during the switching process. In the modern microprocessor-based equipment, which seems to be more sensitive to power purity than older equipment, clean power is certainly more of an issue, so our focus here will be on diode switching.

Parts numbers in the following circuits are intentionally not specified, as they are specific to the current requirements of each user's application. While it may be tempting to use, let's say, a diode capable of a maximum current of seven amperes because the fuse of our equipment is rated for that amount (or the equipment is rated for a maximum current draw of that amount), in-rush current during equipment turn-on must be considered as well—which is why typically even fast-blow fuses don't open until approximately twice their rated current is exceeded. On the other hand, if all you're building is a switch for back-up power to your hand-held transceiver, a diode the size of your lunch box is definitely overkill! On another cautionary note, if a diode is designed to be mounted to a heat sink, it is highly recommended that this feature be utilized. The diode might keep working inside your air-conditioned house with no problem. However, if you're operating mobile or portable in the middle of the hottest summer day in your area, you should not have to worry about equipment failure.

Figure 1 shows a basic diode switch circuit, using a battery as a back-up. The resistor, "R," is included to trickle charge the battery during normal operation. You will need to refer to the battery's data sheet to calculate the proper value. If you can find convenient meters at a hamfest, you can even include current and voltage meters to show the status of your battery, but these are optional.

For proper charging, there must be a positive voltage difference between the input and the battery voltage.

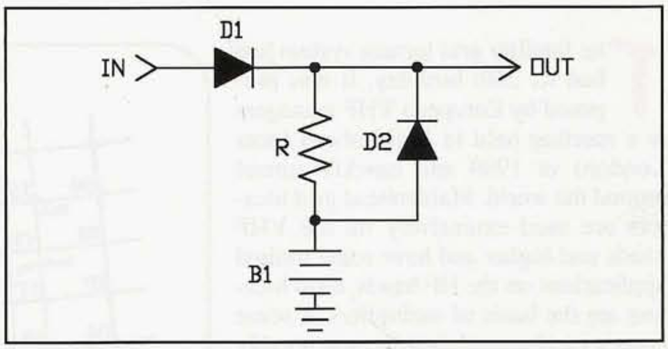

Figure 1. A basic diode switch circuit using a battery as a back-up.

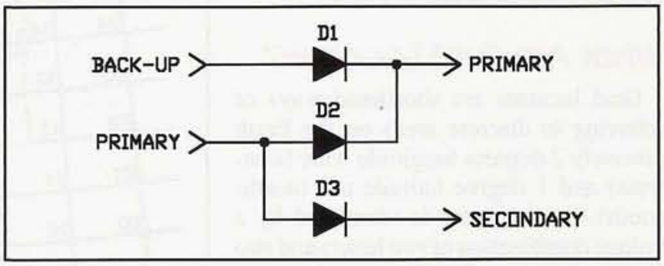

Figure 2. By adding a third diode, the longevity of the back-up power source can be extended without increasing the size of the back-up supply.

If extended operation is expected, or if power demands exceed the short-term capabilities or long-term capacity of the back-up power source, the longevity of the back-up power source can be extended without the necessity of increasing the size of the back-up supply to levels that might not be affordable or practical. This can be accomplished simply by adding a third diode, as shown in figure 2. Figure 2 is very similar to a concept that is already in use in many vehicles; this is how electrical equipment, such as car clocks, are wired. For clarity, the recharge resistor has been omitted here, but it can be added as shown in figure 1.

The primary output is used to power the primary equipment—transceivers in the hamshack, transmitters, receivers, and control circuitry in a repeater, etc.—while the secondary output powers the less important accessories, such as amplifiers, spare receivers, and other devices not vital to the basic operation of the station or repeater. When the primary power source cuts out, only the more vital primary devices will retain power. In an emergency involving a power outage, a QRP repeater is better than no repeater at all! ■

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Grid Locators Are Not Squares

An accident in history at the Central Staes VHF Society's conference in 1981 caused some confusion about the society's grid locator award. The award called for identifying one degree by one degree "squares," and the term squares stuck and carried forward into the Maidenhead Grid Locator Program. Here W3EP explains why a grid locator is not a grid square.

By Emil Pocock,* W3EP

The familiar grid locator system just had its 25th birthday. It was proposed by European VHF managers at a meeting held in Maidenhead (near London) in 1980 and quickly spread around the world. Maidenhead grid locators are used extensively on the VHF bands and higher and have some limited applications on the HF bands. Grid locators are the basis of multipliers in some contests and several awards, most notably the ARRL VHF-UHF Century Club (VUCC), which began in 1983.

What Are Grid Locators?

Grid locators are shorthand ways of referring to discrete areas on the Earth precisely 2 degrees longitude wide (east-west) and 1 degree latitude tall (north-south). Each locator is identified by a unique combination of two letters and two numbers. Each two-letter combination indicates a particular field that measures 10 degrees latitude by 20 degrees longitude and contains 100 locators. Individual grid locators within each field are numbered from 00 to 99, beginning in the southwestern corner. Figure 1 shows a typical field. As it takes 324 fields to cover the globe, corresponding to the letter combinations AA through RR, it is easy to calculate that the Earth in its entirety is covered by 32,400 unique grid locators.

A typical grid locator in the center of the United States is about 170 km (107 miles or so) wide and 111 km (69 miles) tall (see figure 2). This is a rather large piece of land to pinpoint the location of a specific station, so grids can be further divided into 576 sub-locators, each of which is 5.0 minutes of longitude wide and 2.5 minutes of latitude tall. Sub-locators are designated by two lower-case letters. The full six-place locator for Lebanon, Connecticut, for example, is FN31vp. Sub-locators are sufficient to place a station in the mid-section of the United States with an accuracy of about 4.3 km (3 miles more or less), as shown in figure 3.

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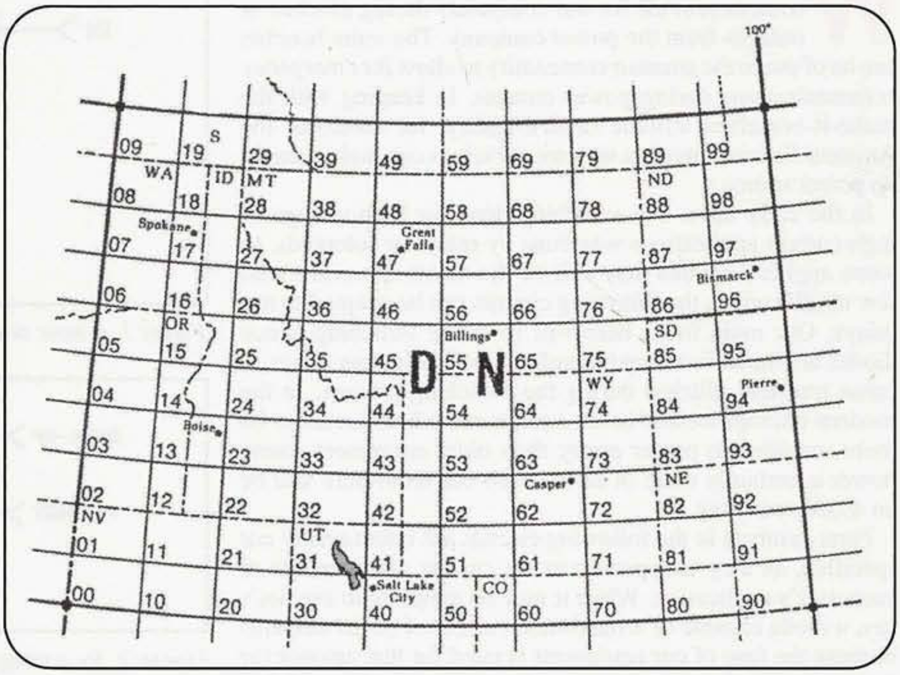

Figure 1. The grid locator field DN includes all of Idaho, Montana, Wyoming, and parts of adjacent states and provinces.

Sizes and Shapes

Now here is the tricky part. Although every grid locator is precisely 2 degrees wide by 1 degree tall, grids have different sizes and shapes, depending on where they are on the Earth. Most astonishingly, not a single grid locator anywhere in the world is a square, although a few (360 to be precise) come close. To be perfectly accurate, not a single grid locator is a rectangle either, although most locators more closely resemble trapezoids than any other shape. The confusion arises from viewing grids on flat Mercator-projection maps, which show latitudes and longitudes as parallel lines and thus all grid locators as equal-size rectangles (see figure 4).

In actuality, the north-south lines of longitude, which form the sides of all grid locators, are curved and converge at both poles. This prevents grid locators from being true rectangles, which are four-sided figures with interior 90-degree angles and parallel sides of the same length. Grid locators (well, most grid locators, as you shall soon see) do have four sides, but only the top and bottom are

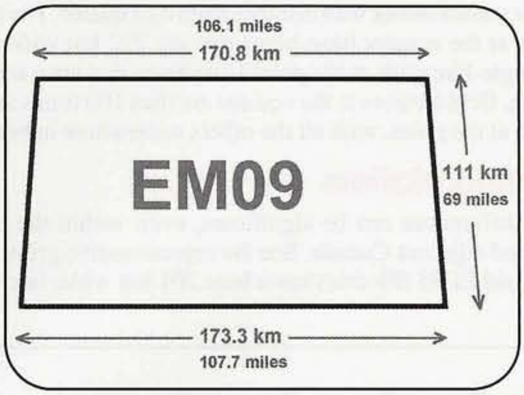

Figure 2. EM09 (Kansas), a typical grid in the center part of the United States, is roughly 107 miles east-west and 69 miles north-south. The top and bottom (along lines of latitude) are parallel, but of different lengths. The sides (along alternate lines of longitude) are actually curved.

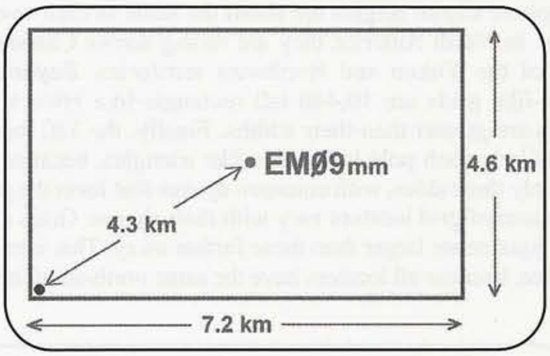

Figure 3. Six-place locator EM09mm (in the middle of the grid) is roughly 4.5 miles wide by 3 miles tall. The actual location of a station within this subgrid could be as great as 4.3 km from the center. Therefore, the distance error between two stations in the mid-section of the country using six-place grid locators could be as much as 8.6 km (5.6 miles).

parallel. The sides bend toward the north, making the tops of grid locators shorter than their bases. Take a close look at figure 2 again. Since the top of one grid locator is the base of the one immediately above it, grid locators are also different shapes and sizes. (This is all true only in the Northern Hemisphere; everything is reversed south of the equator.) Sinuosoidal map projections, like the one in figure 5, show this more accurately.

There are 180 distinctly shaped grid locators and 180 of each variety. They can be divided into four basic different types, as shown in figure 6. Squat rectangle-like locators, which are wider than they are tall, are the most common and account for 21,240 of the 32,400 total. They can be found between the equator and 59 degrees north and south latitude, which includes the heavily populated tropical and temperate zones of the world. Next comes a single row of 180 square-like locators in each

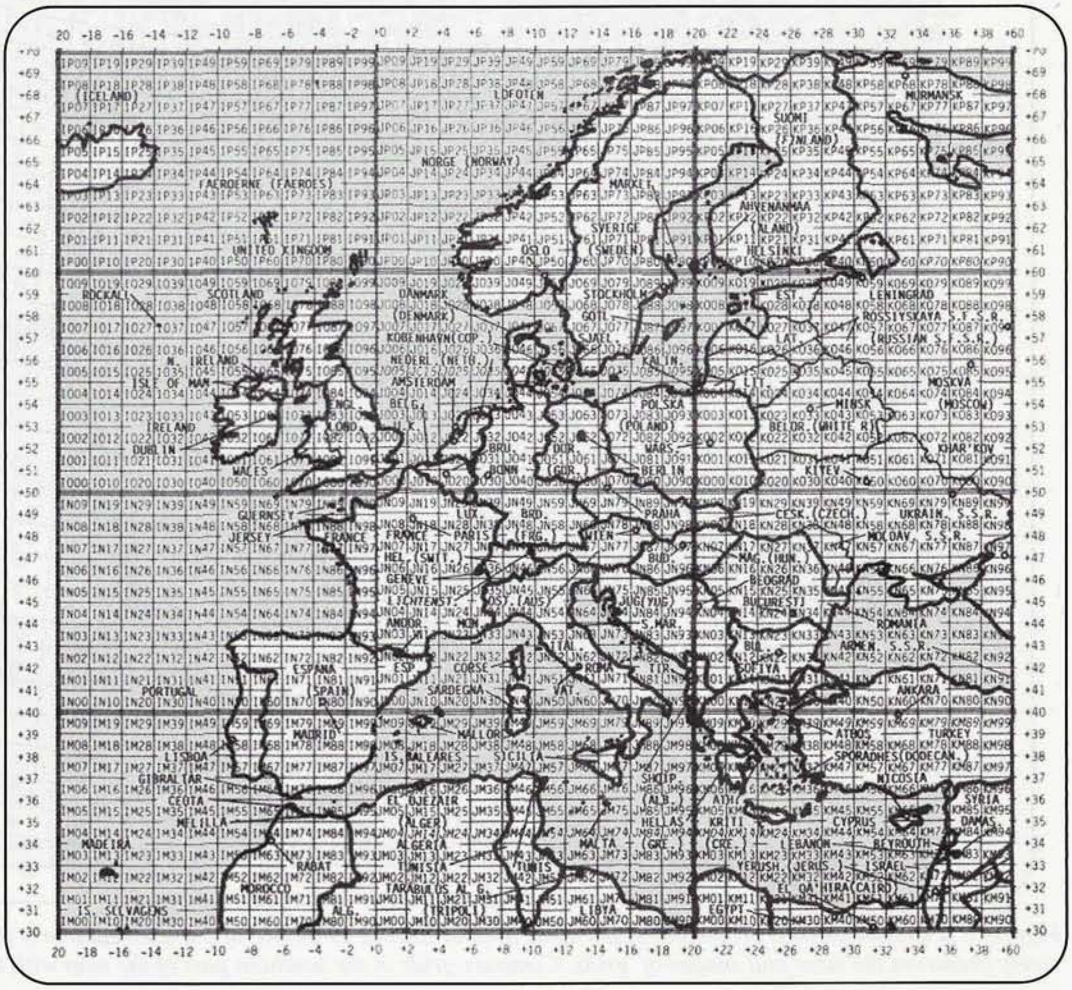

Figure 4. A flat Mercator map projection of Europe, showing 12 fields, gives the impression that all grids are rectangles of the same size. This is a convenient way to show grids, but this kind of map distorts actual sizes and shapes.

hemisphere whose heights are about the same as their average widths. In North America they are strung across Canada just south of the Yukon and Northwest territories. Beyond the square-like grids are 10,440 tall rectangle-like grids whose heights are greater than their widths. Finally, the 180 locators that encircle each pole look more like triangles, because they have only three sides, with common apexes that form the poles.

The area of grid locators vary with their shapes. Grids closer to the equator are larger than those farther away. This is easy to visualize, because all locators have the same north-south height, but their widths shrink with distance from the equator. The largest locators at the equator have bases that are 222 km wide, while the triangle-like grids at the poles have bases that are a mere 3.9 km wide. Grid locators at the equator are thus 100 times as large as those at the poles, with all the others somewhere in between.

Location Matters

Size differences can be significant, even within the United States and adjacent Canada. See the representative grids in figure 7. Grid EL95 (Florida) has a base 201 km wide, in contrast

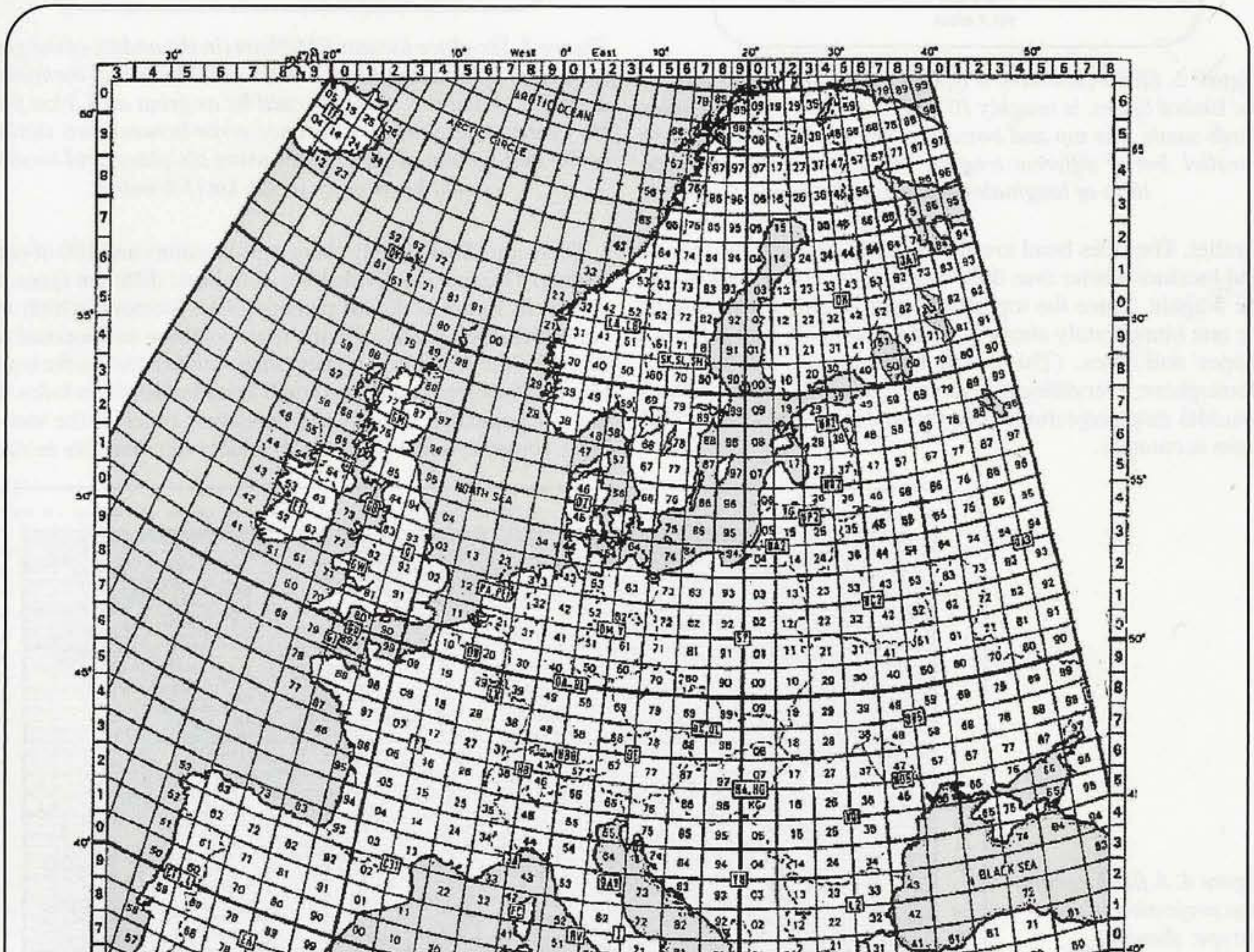

Figure 5. A sinusoidal map projection of the same area of Europe (with two of the most southerly fields truncated) more accurately preserves the sizes and shapes of grids. Compare grids in the southern part of the map with those in the north.

Type	Description	Number of grids
	Northern Hemisphere	
	Triangle-like at the North Pole	**180**
	Rectangle-like, taller than wide 60—89° (29 unique sizes)	**5,220**
	Square-like 59—60°	**180**
	Rectangle-like, wider than tall 0—59° (59 unique sizes)	**10,620**
Equator		
	Rectangle-like, wider than tall 0—59° (59 unique sizes)	**10,620**
	Square-like 59—60°	**180**
	Rectangle-like, taller than wide 60—89° (29 unique sizes)	**5,220**
	Triangle-like at the South Pole	**180**
	Southern Hemisphere	
	Total	**32,400**

Figure 6. The 180 distinct sizes and shapes of grid locators (90 in each hemisphere) can be categorized into four basic types.

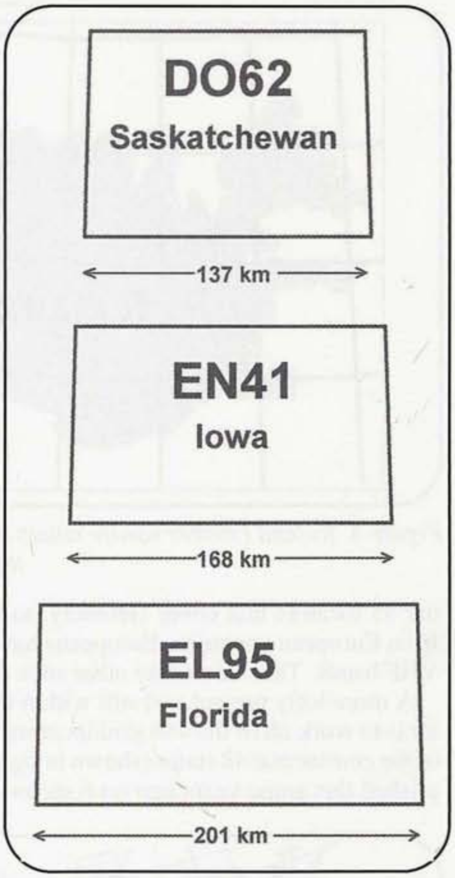

Figure 7. Representative grid locators in the U.S. and Canada are different shapes and sizes. All grids are 111 km (69 miles) north to south, but may have different widths.

to DO62 (Saskatchewan), which is just 137 km wide at its base and has a much smaller area. EM09 (Kansas) lies about midway between these two. Differences in grid sizes are more dramatic for places separated by larger north-south distances. Take a look at figure 8. Tropical Honduras overlaps 11 grid locators, but sub-arctic Iceland, which covers about the same land area, includes parts of 22 locators.

It follows that the distances between grid locators are also shorter where grid locators are smaller. This can make a significant difference on the microwave bands and has implications for other activities. For example, there are more grid locators within single-hop sporadic-*E* range (about 2,200 km) in Europe than in the United States, because European locators are smaller on average.

Work All Grid Locators

Collecting grid locators, whether as multipliers in a contest or as a lifetime achievement, has become an obsession among many VHF operators. VUCC endorsement levels are nearly without end, in contrast to awards based on states, DXCC entities, or even U.S. counties. During the more than 20 years since the VUCC program has been in existence, a few stations have confirmed 1000 grid locators on 6 meters, the most for any VHF band. That is an exceptional achievement, but it is still a long way from working all 32,400 locators. That is undoubtedly impossible within a single lifetime. The number of locators is just too large and there are other practical difficulties.

The number of workable grids can be pared down to something more manageable. Just 13,164 grid locators of the 32,400 total contain land, even if just an island. Further excluding Arctic and Antarctic locators, on the assumption that most are uninhabited or have only few permanent residents, leaves about 9750 locators. Of those remaining, probably no more than 5000 have significant population and any radio amateurs. Of course, maritime mobile stations and expeditions to uninhabited places can make it possible to contact stations in otherwise impossible grids, but this exercise at least puts the problem into a more reasonable perspective. Still, 5000 locators may be too lofty an ambition even for a lifetime of on-the-air activity.

There are more practical goals that are both challenging and attainable. It is possible to work all 100 grids in some heavily populated fields. A few operators have already tallied all the grids in the EM and EN fields on 6 meters and probably on 2 meters as well. The same might be accomplished for field JN in Europe and perhaps other fields. Making contact with stations in all the grids within the various U.S. states and many individual countries is also attainable. Just 17 grids will do the trick for a mid-size state such as Missouri, for example, while 50 grids are required for Texas. Many 6-meter operators, including a few in the U.S. and Canada, have worked all of the 22 locators that touch some part of England and

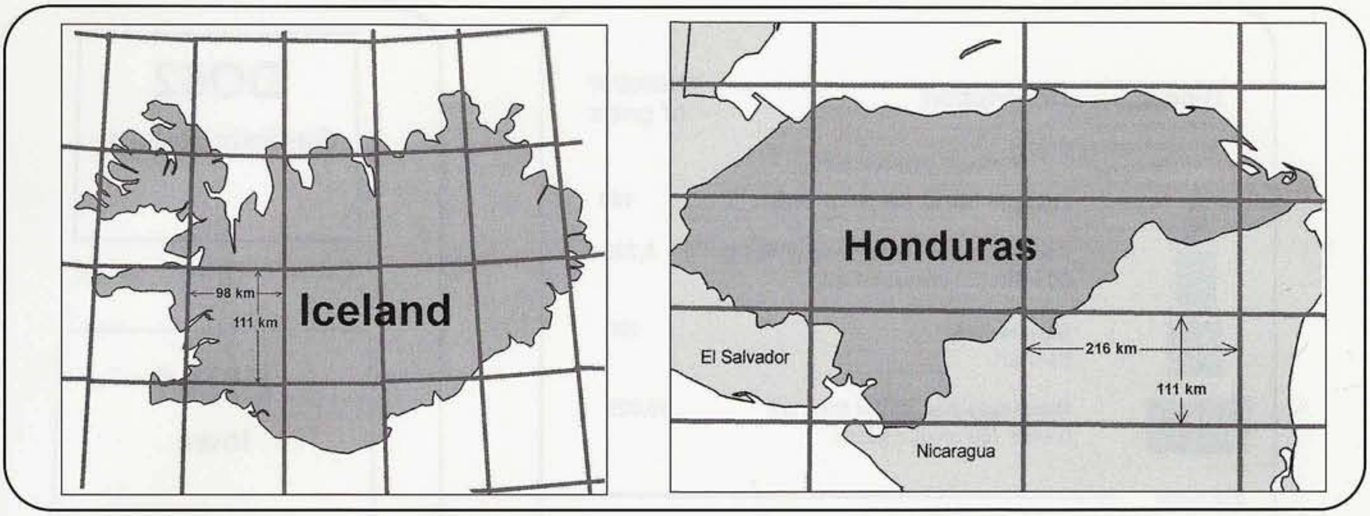

Figure 8. Iceland (39,699 square miles) includes twice as many grid locators as Honduras (43,433 square miles), even though the two countries are about the same size.

the 35 locators that cover Germany, to take some examples from European countries. Europeans have done so on several VHF bands. There are many other such possibilities.

A more lofty project and still within the realm of possibility is to work all of the 488 grid locators that touch some part of the continental 48 states (shown in figure 9). W5FF accomplished this some years ago on 6 meters from New Mexico, but he is the only one so far. Several of these locators contain only small bits of U.S. territory, counting off-shore islands. DM02 makes the list because San Clemente Island, adjacent to the southern California coast, is in that locator. FN25 includes a tiny portion of Moses Island in the St. Lawrence River, which puts it just within the United States. A small bit of DL89 intrudes into Big Bend National Park, but that piece

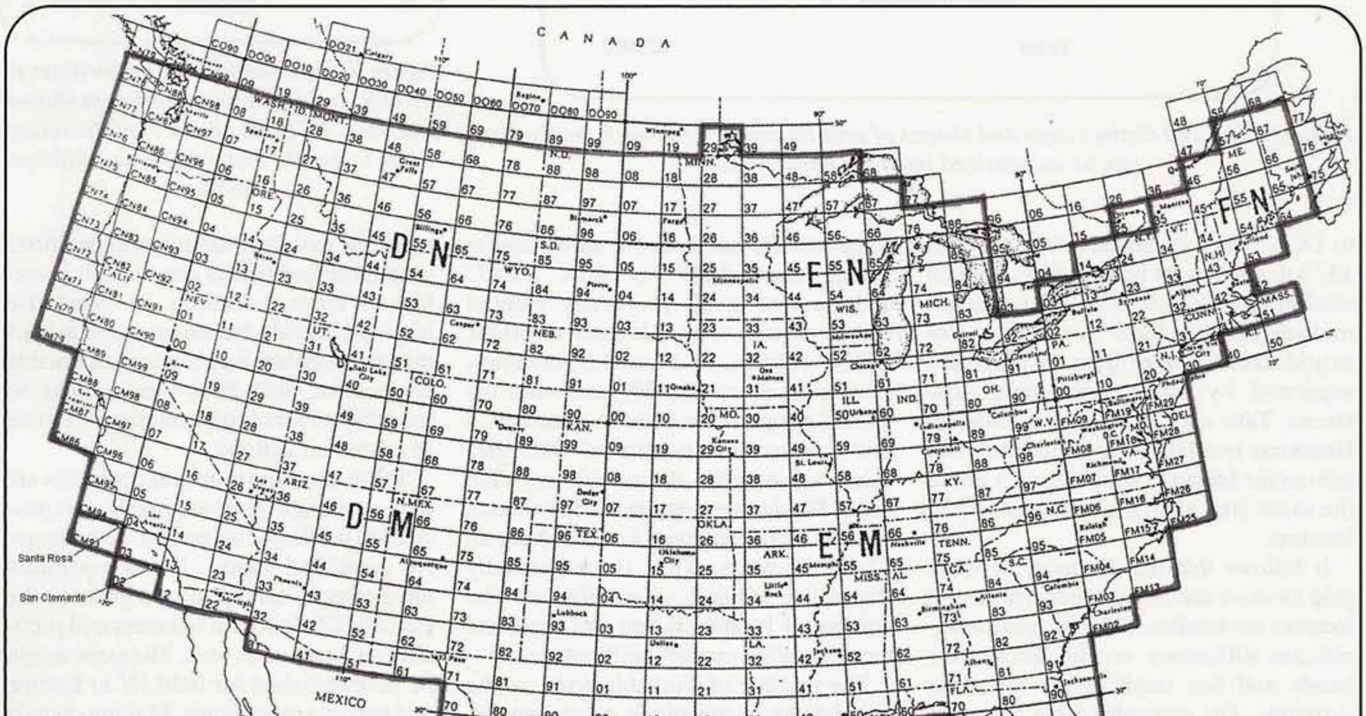

Figure 9. The 488 grid locators of the continental 48 United States. Grids CM93, DN02, EL94, and FN25 are not accessible by land from the rest of the country.

of U.S. territory does not have road access. There are other such curiosities along the borders and coasts of the U.S. You will have to decide for yourself whether to count a locator that touches the United States if the station worked is actually maritime mobile or located in Canada or Mexico.

Working the grid locators in all 50 states boosts the challenge significantly. Hawaii adds 20 locators, but half of them encompass outlying islands with small populations, if any inhabitants at all. About 236 grid locators include some part of Alaska, including the Aleutian Islands, but most do not have resident radio amateurs. This raises the total number of locators for all 50 states to at least 744 (there is some uncertainty about the exact number in Alaska). The total number of grid locators in Canada also exceeds 700, and the majority of Canadian grids are sparsely settled as well.

If you want to accumulate grids in a big hurry, go with a friend and some hand-helds to the North Pole. While your companion makes contacts with you as he or she walks in a circle from grid to grid around the pole, you can tally locators at an astonishing rate and earn several VUCC awards in an hour or so. Figure 10 shows all 180 grids at the North Pole. It will be quite clear from that vantage point that grid locators assuredly are not squares.

My thanks to Curt Roseman, K9AKS (EN41sl), for his help in this project and to those who first heard this article as a presentation at the Central States VHF Conference in Des Moines, Iowa (July 1999), the Mid-Atlantic VHF Conference in Philadelphia, Pennsylvania (October 2001), and the Eastern VHF/ UHF Society Conference in Enfield, Connecticut (October 2002). ■

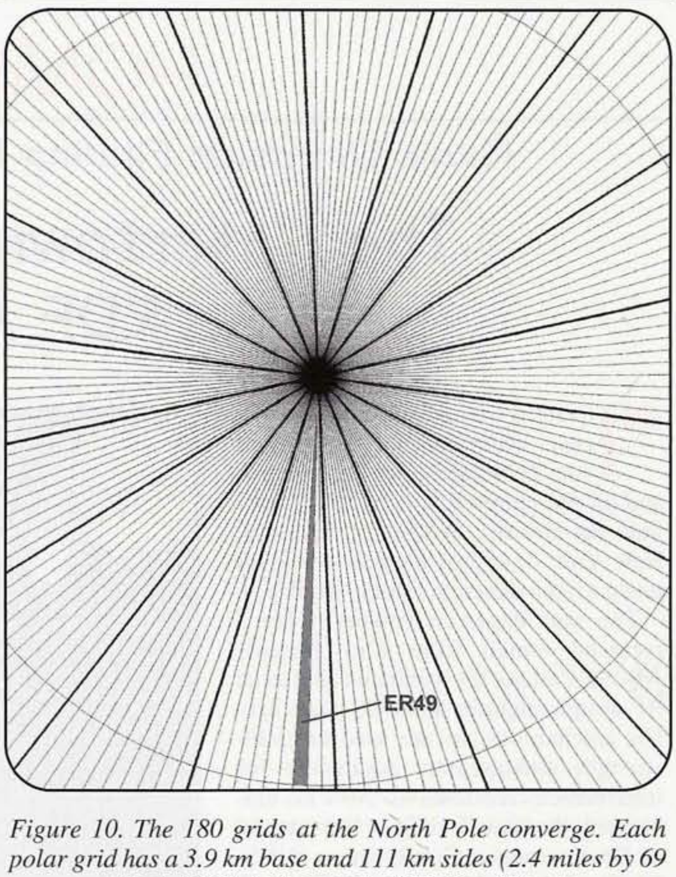

Figure 10. The 180 grids at the North Pole converge. Each polar grid has a 3.9 km base and 111 km sides (2.4 miles by 69 miles). ER49 is due north of Moline, Illinois.

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

The Watertown Sodalis Squad
An RDF Adventure

"It really was the ultimate experience, better than the Grand Canyon, Yellowstone, whale watching, and all the places I've been to!" That's how Pat Browns, WN8Z, of Syracuse, New York described his four weeks of intense radio direction finding (RDF).

The saga began in January, when I received e-mail from Carl Herzog, AB2SI. Carl got his first ham ticket as an RF design engineer about 20 years ago. His antenna designs are used on field-strength measurement equipment for interference certifications. Now his employer is the New York State Department of Environmental Conservation (NYSDEC). "I was doing some wildlife work in my spare time and taking independent study courses," he says. "It was a lot of fun, so I made the switch and now it's like being on vacation every day."

The Watertown Sodalis Squad. Left to right are Bill Kitchen; Pat Browns, WN8Z; Kevin Shannon, WA2ISC; and Dave Aitcheson, KB3EFS. (All photos by WN8Z)

Carl's agency was preparing for two radio-tracking projects to take place from mid-April to mid-May. He and others would attach VHF transmitters to Indiana Bats (*myotis sodalis*), an endangered species,[1] as they left the caves in which they had been hibernating. The goal was to find their summer habitat out on the landscape. Both projects would be happening simultaneously and he needed volunteers to help with radio tracking. One site would be near Watertown, at the eastern end of Lake Ontario. The other would be near Kingston, between the Hudson River and the Catskills.

Previous research suggested that the bats might fly anywhere within 300 miles, but probably less than 50 miles. "Sodalis do not limit themselves to wilderness," Carl wrote. "They are often found in farm country or even suburban areas. The 300-mile radius includes southern Ontario and Quebec; bats know nothing about national borders."

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In my previous experiences with migratory bird studies, it was good to have a large number of participating hams scattered over a very wide area. Just being able to hear and log the tags was sufficient to help the researchers. However, these bats were not flying cross-continent and exact locations would be important. What Carl needed was a team of intrepid trackers who were willing to scour the countryside. I posted Carl's request on my website and hyped it on Amateur Radio Newsline and other ham news outlets. I was disappointed when I didn't get many replies, but I discovered later that Carl had gotten all the help he needed, both from stay-at-home hams and those who would go out in the wild.

"We ended up with a total of five new field workers," AB2SI told me. "Three of them were on the project full time. They heard about it through your site and called my office to volunteer. When I found out that all of them knew radio propagation and had done a significant amount of RDF, I thought it would be a good match. We had some extra funding and we were able to hire them for the study."

Since Carl's office in Albany is a considerable distance from Watertown, it was difficult for the regular staff to work at the site for long periods. Having volunteers doing the ground work was a big plus. "It was as easy as you could imagine from my point of view," he says. "These people needed hardly any training."

WN8Z was among the first to respond to AB2SI's request. After working in two-way radio and paging since the late 1970s, Pat retired in 1998 to travel the USA in a motorhome. On his last 30-month trip, he had followed the postings about tracking owls and other critters on my website and on the Biotrackers mailing list.[2]

"I never got into any organized ham radio RDF contests, but this has to be the ultimate foxhunt," Pat told me. "The first week was chaotic and we newbies had no idea what was going to happen when

Learning Bat Behavior with RDF

Out of 45 bat species in the USA, about one third are either threatened or endangered. There are millions of bats in New York State, but the number of Indiana Bats is only between 30,000 and 35,000. *Myotis sodalis* is the only federally-listed endangered bat in the state. The worldwide population for this species has declined drastically since the 1960s, dropping from about 800,000 down to about 300,000.

According to AB2SI, "Most other mammal species have been researched to a very significant extent, but bat biology is so difficult to study that there are basic questions we don't yet know the answers to. It's only been in recent years that we've been able to get transmitters small enough to put on them so we can use radio tracking as a tool."

In other parts of the country bats spend time underground year-round. In New York the cave bats only spend the winter there. At present there are only nine caves and mines in the entire state where Indiana Bats do that. Research indicates that this is because the bats are limited in the temperature range that they can tolerate during hibernation; most caves are too hot or too cold.

Sodalis must be relatively undisturbed throughout the winter. If cave explorers were to wake them, even for a short time, they would use up their stored food resources and perhaps not last through the winter. This is not an issue in New York, because the sites are gated or on private property with no access for the public. That may explain why the New York population loss is not as great as it is elsewhere.

Another hypothesis is that bats are losing habitat that they need in the summertime to survive. The Sodalis crew helps researchers study that summer habitat, including the kinds of trees and the area around the trees. "It seems that they can actually be near a fair amount of development," AB2SI reports. "Many of the big dead or dying trees in which we find bats are right on the edge of people's back yards in the suburbs. They also like the living shag-bark hickory, because its bark has a peeling characteristic even on a healthy tree. They like to climb up under the bark."

An Indiana Bat. (Photo courtesy of Carl, AB2SI)

those bats were released. However, the internet is great, and with the studying I did, the posts on your web page, and the talks with Carl, we went packed and ready to go. We had tents, sleeping bags, and even an air mattress in the back of my Geo. We had no clue where we were going to end up."

Others in the Watertown Sodalis Squad, as they called themselves, were Kevin Shannon, WA2ISC, Dave Aitcheson, KB3EFS, and Bill Kitchen. Pat had high praise for them all. "Although Bill has no amateur radio experience, he has tracked moose for the Conservation Department and really has a knack for this," he says.

Snatch, Attach, and Dispatch

The Watertown bats were expected to emerge from hibernation in large numbers around April 15. The team would be ready to net about 30 females, glue on half-ounce radio transmitters, and then try to follow them to the trees where they would form maternal colonies and bear their young. Fortunately, the weather was good and everyone was in shirtsleeves.

"We hams didn't have a clue what we were getting into," relates Pat. "When Carl called and invited us to the tagging operation, his game plan was for us to program the wildlife receivers, make sure their scan worked, and verify that each one heard the tag signals. But we got right in there, helping hold the bats and attach the transmitters. It was obvious that we weren't just there to track, we were getting closely involved."

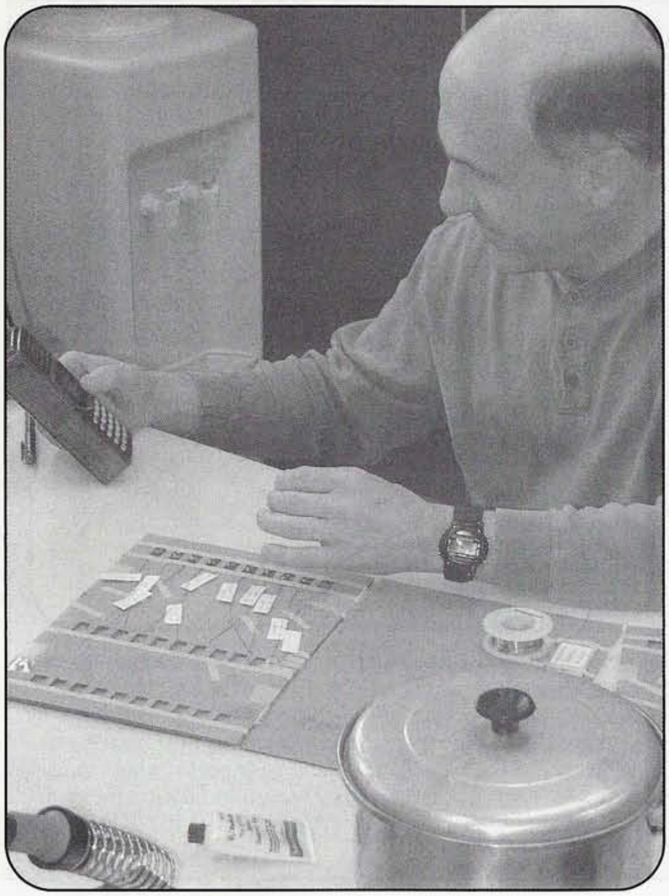
For maximum signal-to-noise performance, professional wildlife tracking receivers such as the R-1000 by Communications Specialists of Orange, California[3] are narrowband (about 2 kHz bandwidth). The Watertown study transmitters were specified to be on six different frequencies between 150.0 and 150.8 MHz for most efficient scanning. Due to minor variations in the individual tags, it was important to verify that the bandpass of the six programmed frequencies in each receiver would encompass all of the actual tag frequencies.

"It was quite an experience under time pressure," AB2SI explains, "because we had the bats in our hands at the moment. You can't check the exact frequency until you've actually glued the transmitter to the bat, because the body capacitance of the animal shifts the tag frequency on the order of a kilohertz. That's enough to contribute to the issue of whether you can copy it or not.

"Our frequency range is a compromise," Carl continues. "We could use 216 MHz, where antennas would be smaller, but increased multipath and foliage attenuation would make tracking more difficult. Frequency drift would be greater, too. My agency has a lot of equipment at 150 MHz for studying other endangered animals. We track anything big enough to carry a transmitter, but we haven't figured out how to tag butterflies yet."

Carl's crew glued the tiny transmitters with 6-inch thin-wire antennas directly to the fur of the captured bats. With luck, all of them would stay on through the study period and then fall off after the batteries were exhausted to minimize adverse effects of their weight. All bats were released at dusk. AB2SI did initial tracking from the air as they took off at 15 to 20 mph. The majority went south and the rest went north.

NYSDEC does aerial RDF with small fixed-wing aircraft. A Yagi antenna is mounted on each wing, aimed to the side. A switch inside the cabin chooses each antenna separately or both combined. When flying a grid search, Carl alternates



Carl Herzog, AB2SI, checks programming on a receiver. The bat transmitters are attached to cardboard.

between antennas to determine incoming direction of any bat signal he hears. "The airborne Yagis are usually 2-element," he explains. "We tried some 4-element models this year, but there wasn't any performance improvement and the pilots hated it because extra wind resistance slowed down the plane."

AB2SI says that on release night, a special search pattern is used: "We fly in circles around the site about three miles away and we listen only to the outside ring. When the bats fly under the plane and continue in the direction they're going, we pick them up. We plot our position on a laptop running mapping software with GPS, giving us the bearing of the animals' departure from site. As it turns out, they fly pretty much in a straight line to wherever they're going to go.

"On the following days, in daylight, we fly a grid search pattern to find them. It's fairly easy if we know the direction they took and they don't fly too far. We fly parallel lines spaced as far apart as we feel we dare, which in this case is about two or three miles. Under good conditions, our RDF range is three to four miles. These bats usually roost in trees during the day, so at 10 to 30 feet up they put out a good signal.

"Once we pick up a tag, we switch between left and right antennas. When it's stronger on one side, we tell the pilot to fly in that direction until the signal is equal strength on each side. Then we follow it along as far as we can until there is a sudden drop in signal strength. That usually means we are right over the top.

"For each fix from the air, we send the ground crew in because we want to locate and mark the exact tree. We are studying the characteristics of individual trees and their surroundings. Indiana Bats tend to pick large ones that are dead or dying and where the bark is peeling off. They like to crawl up underneath the bark. A substantial tree might have 50 bats in it, all arriving from the same winter site."

Plans were to have the plane up as much as possible for several days to help the ground trackers. Unfortunately, the weather did not cooperate. Rain severely limited the flying time. After a few days, Carl left the Watertown project in the hands of the ground crew as he and the other professionals headed 225 miles away to Kingston to tag 18 Indiana Bats for the second study.

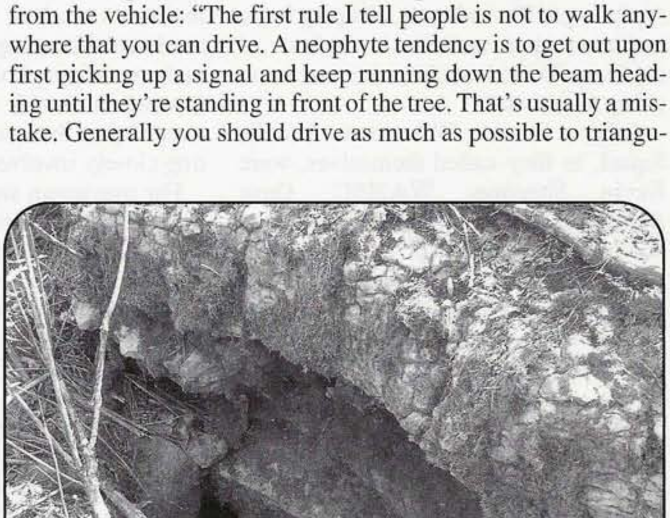
Pat, The Bat Man

WN8Z says that his Geo Tracker almost looks like one of the bats. Three-element horizontally-polarized beams emerge from both the left and right front windows, held by homebrew brackets to aim them broadside to the vehicle. A ComSpec R-1000 connects to the left beam, his Yaesu FT-817 to the right beam, and an ATS wildlife receiver to a vertical antenna on the roof. All three receivers scan the six frequencies, pausing four seconds on each to make sure no pulses are missed.

According to WN8Z, "It was a bit hectic at first juggling three receivers, but it's proven extremely effective. In one pass down a road, I cover the left and right sides with the horizontal beams. The 5/8-wavelength omni hopefully catches the signals that tend to vertical. On the passenger seat I have my laptop fired up with Delorme Topo 5 and GPS, tracking my position. If I get a hit on a tag, I stop, park, and use the R-1000 and beam to shoot a bearing.

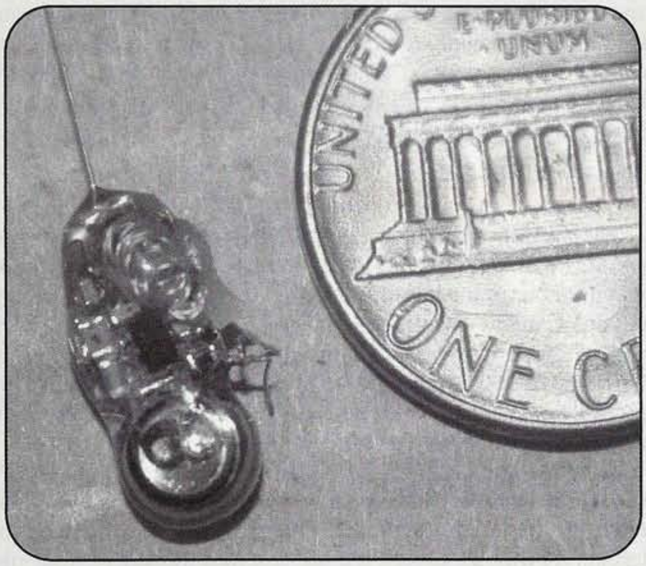
"I plot the beam heading on the laptop and move on to another spot to shoot a beam heading, then again draw the line on the laptop display. I do this from several locations if I have to. It's worked well. One bat was three miles away when I picked it up. The intersecting lines on the laptop brought me straight to the correct corner of the wooded area that I found it snoozing in."

AB2SI agrees that as much RDF as possible should be done from the vehicle: "The first rule I tell people is not to walk anywhere that you can drive. A neophyte tendency is to get out upon first picking up a signal and keep running down the beam heading until they're standing in front of the tree. That's usually a mistake. Generally you should drive as much as possible to triangu-



The Watertown area bats spent the winter in this cave on the bank of the Black River.

Dit ... Dit ... Dit

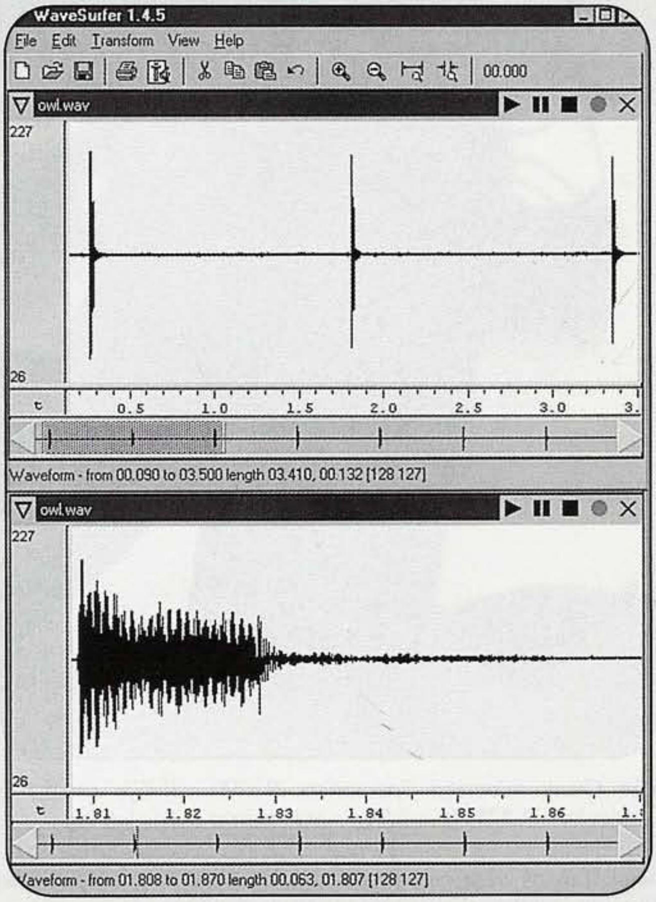


A radio tag for a bat next to a U.S. penny for size reference. (Photo courtesy of Carl, AB2SI)

Researchers have it relatively easy when studying large mammals and even some large birds such as the Sandhill Crane. They can place Argos satellite transmitters on them and see their positions on the Internet from their offices (for more on Argos satellite tracking, go to: <http://www.argosinc.com/system_overview.htm>). However, it takes at least a half watt to get the signal to a satellite. At 20 to 30 grams, Argos transmitters are too big and too heavy to place on sparrow-size birds and bats.

Government guidelines tell researchers to use radio tags that are only 3 to 5 percent of an animal's weight. AB2SI explains that his are as minimal as you might imagine, with a one-stage unshielded crystal oscillator powered by a hearing-aid-size cell. To maximize battery life, output is a 20-millisecond pulse about once every second or two. The pulse envelope is not rectangular, but quite ragged. There is a distinctive "chirp."

Weak short-pulsed signals are not well suited to spread-spectrum or Doppler RDF technology, so AB2SI's team has to track bat transmitters the old-fashioned way, using gain antennas and sensitive narrowband receivers with product detectors, just like amateur radio VHF weak-signal operations.



Audio waveforms of a wildlife radio tag as detected by a narrowband receiver with BFO. (By Joe Moell, KØOV)

Do the tags harm the bats? "We do our best to take really good care," Carl says. "We have a vet on site when we're handling them. We feed them and give fluid injections to help them get over the trauma. With that, they seem to act in a totally normal way. They successfully integrate into the colonies and fly at normal speeds without any trouble."

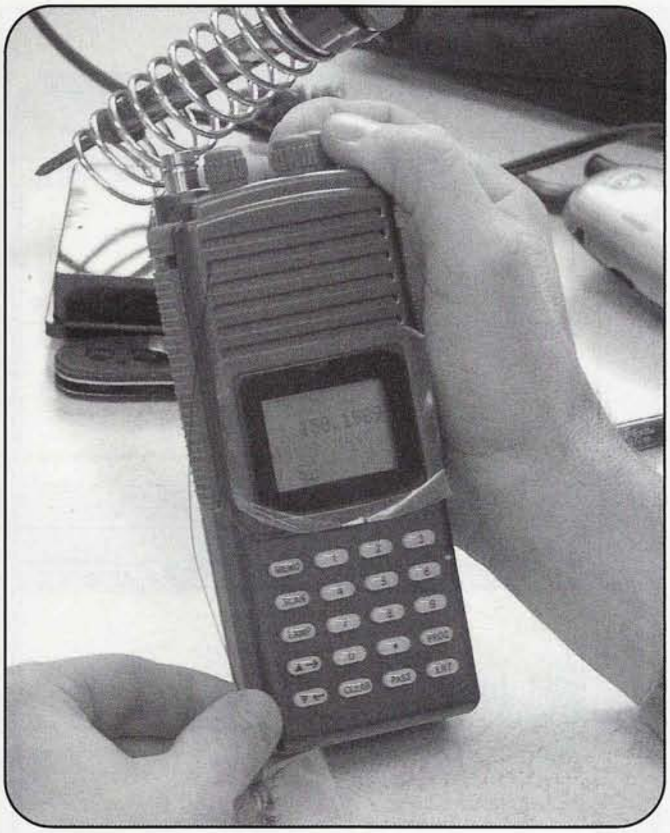
late and get a good idea where the bat is, circling all around it if necessary. Many an hour has been wasted walking, only to find the transmitter 100 yards from the road."

This was particularly good advice in some of the Watertown area terrain. "Those little girl bats really like the swamps," says Pat. "Multipath there is unlike anything I have ever experienced. The signal reflections can and will fool you. Slogging through muck and water thigh deep was a daily task, as we had to pinpoint these bats right to the trees they were napping in. This was the ultimate in low-power foxhunting; I don't think the USA Championships could be more difficult."

The territory was divided up among the team members. Pat sometimes worked all by himself. At other times he teamed with WA2ISC, whose primary mobile receiver was a Yaesu FT-100. "Kevin and I are both familiar with weak-signal VHF and have worked well together in our strategy of snagging signals," WN8Z says. "He is a long-time ham who retired from a career in telecommunications.

"We found that many of the bats were following Interstate 81 south of Watertown. There's not a lot of population in that area but it's a well-traveled corridor, so the cell-phone providers have towers on both sides every couple of miles. They are at the high spots, so Kevin and I started hopping them. We would go to each tower and beam down the corridor to see if any of the bats were in the area. In the first couple of days when the tag batteries were fresh, we were picking them up three to four miles away from those sites. When I found the actual tree, I checked the distance and it averaged 2500 to 3000 feet from the highway through swamps and woods.

"In the morning we would start tracking bats into the trees, record the exact coordinates, get in the car and find another signal to track. At night we did exit surveys. Each tracker would pick a marked tree towards dusk, get under that tree, and start watching to see if any bats exited to feed. If only one or two came out, they were probably still looking for a home and not going to stick around. On the other



The Communication Specialists R1000 wildlife tracking receiver. AB2SI is holding a transmitter in his left hand.

hand, if many came out, it indicated that a maternity colony was forming and they were going to stay in that area.

"When I am out of the car I always carry GPS. I set a 'car' waypoint when I leave my vehicle before heading into the unknown, and I wear it on a lanyard around my neck so that it tracks as I go. I also make sure to have a backup compass for the times when dense overhead cover blocks the GPS signals or when the batteries go dead. GPS is not an option for bio-tracking; it's an absolutely necessary tool."

It sounds like an old joke, but people actually do own swampland. According to AB2SI, "Almost all the time in this part of the country, the target ends up falling on private property. We don't have any authority to just traipse in there and find the bats, so we don't trespass unless we first make a lot of effort to find the owner. For the most part, we haven't run into much trouble locating them, but there are some absentee landowners in this part of the country, people living downstate in Long Island or New York City. Fortunately, our hams were locals and one of them seemed to know almost everybody in the county! He turned out to be quite an asset."

Another problem was false-alarm signals from local oscillators of scanners, not just those of the researchers but in homes and vehicles of nearby residents. AB2SI states that most false pulses were on 150.725 MHz, perhaps related to a local public-service agency being widely monitored.[4]

This year's study results were very pleasing to NYSDEC. Trackers located 26 of the 32 bats from Watertown and 16 of the 18 at Kingston. All were within 40 miles of the release site. None of the bats appeared to have ventured into adjacent states or Canada, but of course the team can't be sure about the few that it didn't find.

"The research is going to prove extremely valuable in our efforts to ensure the continued existence of this endangered species," Carl announced proudly afterwards. "Amateurs contributed significantly to this project. Frankly, we couldn't have done it without you. You can expect that others in the wildlife biology community will be looking to draw on your collective knowledge and experience in the future."

Great PR Opportunity

The sudden appearance of antenna-equipped vehicles and people running through backyards and wading through swamps waving aluminum raised a lot of curiosity, especially in tiny Adams Center, where many of the bats ended up. "This is an area where people still pull over to make sure everything is okay when they see cars parked alongside the road," says Pat. "This presented many chances to explain the basics with just the right emphasis on the 'why' of ham radio involvement.

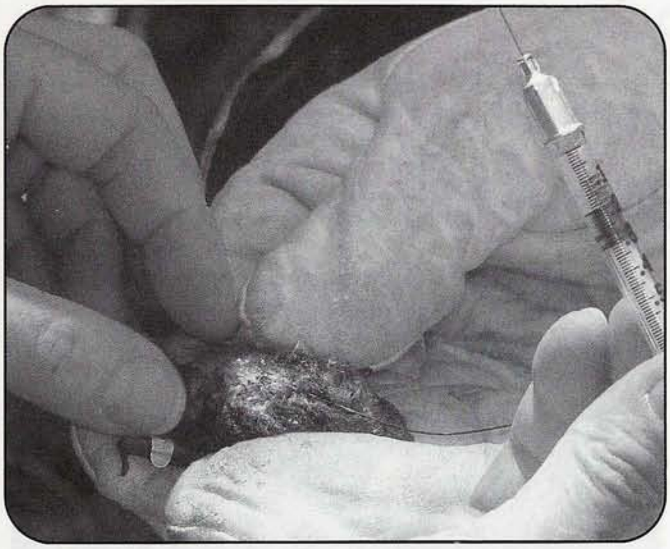
"About a week into it I had a sign made up to cover my spare tire. You wouldn't believe how many people came up and talked to us to us after that. I think I had the youngest bio-tracker. A mother sought me out and told me her 11-year-old son wants to be a biologist. Could she bring him down to meet me and ask questions? Sure!

"I gave him an R-1000 and a 3-element handheld and showed him how to use it. Before we even moved he was saying, 'Are we going that way?' I said, 'You're the tracker, let's go.' Through the muck we went, four tenths of a mile in. I had no idea where we were going, but that little guy actually did a track and took us down to the tree.

"There was another group of kids that couldn't wait to get out of class every day to see if my car was parked down at the restaurant that we used as an office. They wanted to tell me what they had learned about bats since I last saw them. I'm planning a slide presentation to go into the schools and explain why we were there and what we do in amateur radio and biology."

I admit that I'm a bit envious of the experiences that these folks had in the swamps of New York State. Their experience

WN8Z's Geo outfitted for bat tracking. When cruising for signals, Pat has Yagis aimed left and right with a scanning receiver on each one, plus a third receiver on a vertical whip.



This Indiana Bat has just been fitted with a VHF transmitter and given a fluid injection.

was challenging, educational, rewarding, and fun. According to AB2SI, "They thought they should be paying us to do it!"

WN8Z agrees: "It was the ultimate in transmitter hunting. When Carl posted and I responded, I had no idea what to expect, nor any knowledge of bats. I had never owned a pair of hip waders in my life, but sure was glad I took Carl at his word when he told me to bring them. I am honored and proud to have been a part of this critical research team. We've all got our hands up for next year's study."

Pat also had high praise for New York area hams and scanner fans who monitored the six frequencies from their homes. "Your time and efforts were not in vain," he says. "Every day I talked with hams who devoted time listening from as far as 70 miles away and to others who were right in the Watertown vicinity. Every minute that each of you contributed to this project was worth 60 or more to us in the field. Negative data is valid data. By letting us know where you heard no signals, we could concentrate our time in other areas. Thanks to each and every one of you!"

Next year NYSDEC plans to tag and track Indiana Bats in the Syracuse area. Researchers studying other flying and crawling animals, including Burrowing Owls in southwestern states, are considering using ham help in the coming months. If this appeals to you, visit <www.homingin.com> for the latest news and information.

Please keep sending those stories and photos of RDF activities in your area to me for use in future "Homing In" columns.

73, Joe, KØOV

Notes

1. <http://www.fws.gov/endangered/i/a/saa08.html>
2. Biotrackers is an Internet mail reflector for persons interested in volunteer wildlife monitoring and tracking. To join, send an e-mail to <biotrackers-subscribe@yahoogroups.com> with no subject or text. To prevent spam, only list members may post and all new subscriptions must be approved by the moderator.
3. <http://www.com-spec.com/r1000/r1000.htm>
4. For details of the unique characteristics of these tags and how to distinguish false alarms, read the article "Was That Really a Wildlife Tag?" at <www.homingin.com>.

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

VHF+ on a Shoestring

Welcome back to the new "Beginner's Guide" column for the second installment! During the intervening months I hope you have taken a serious look at your plans for VHF+, have assembled a list of realistic goals for your proposed station (or possibly a station upgrade), and have at least done some research on the type of gear, accessories, and antennas you need to obtain to make it all happen. Should you be really industrious, quite possibly you've already procured some or all of the gear and are in the midst of making things come to pass. If so, good for you!

VHF+ Weak-Signal Station on a Budget

This column's subject matter resulted from my musings over "the goode olde days" during my tour of duty in England as G5CSU. I arrived in the UK in early 1979 and left in mid 1984. Undoubtedly, this was the best, most productive time of my Air Force career and equally productive in my pursuits in the amateur radio hobby.

The "blokes" have an entirely different way of doing things than we "Colonials." They design and build; we buy. The average British radio amateur has a very small station that features a mixture of homebrew and commercial gear. Due to the outrageous Value Added Tax (VAT), which tacks an extra 15% (at least that is what it was when I was there over 25 years ago) on top of each purchase, British hams tend to be frugal and build a lot more than their stateside counterparts. This is not a bad thing.

My family and I lived off base during my entire tour of duty in the UK. We were intertwined in the local culture, and that included all aspects of ham radio. I soon became a member of the G-QRP-Club and started building many small accessory projects from the pages of the club's quarterly newsletter, "SPRAT" (Small Powered Radio Amateur Transmissions). This led me to try more ambitious homebrew projects, resulting in my becoming a well-rounded radio amateur and dedicated homebrewer.

When we stateside hams think of 2 meters, we immediately think in terms of 2-meter FM and repeaters. Using the 2-meter FM repeaters in the UK was "different," to say the least. With only a handful of repeater pairs, the Brits had managed to make good use of their repeaters. However, the majority of 2-meter FM operation took place on simplex frequencies. Since the antennas were relatively small in comparison to HF antennas, and the British license structure was such that there were many more VHF license holders than HF license holders, it seemed only natural that there was a lot of VHF+ experimentation, in addition to FM activity, going on in the UK.

Early on in my tour I procured an ICOM 2-meter IC-202 (later I obtained an IC-202S, the last model of this line that featured both USB and LSB) along with an IC-402 for 70 cm. These little "Bookcase Radios" were produced from about 1979 to 1985. They featured SSB and CW operation and 3 watts PEP RF output—admittedly not a lot of RF, but when coupled to a good antenna system, more than enough to work all sorts of DX throughout Europe when conditions were favorable.

The Icom IC-202 is probably the cutest VHF rig ever built, and even by today's standards, still a capable exciter for use with a "brick" amp or, used barefoot for some QRP hill-topping outings. With 3W PEP output on 144 MHz, and a reasonable receiver (made better by some mods available on the Internet) the IC-202 is an inexpensive way for a neophyte VHF+ operator to break into the high bands.

My first station was just off base at RAF Lakenheath (Suffolk, East Anglia) and consisted of the IC-202 and IC-402 exciters feeding an 11-element Cushcraft 2-meter Yagi and a "no-name" brand 19-element Yagi for 70 cm. These two Yagis were stacked about 5 feet apart on a 30+ foot mast attached to the side of our house. Turning this affair was an old CDE 44 rotor that I bought from another ham who was leaving the UK shortly after I arrived. Both antennas were fed with RG-8U foam dielectric coaxial cable. The feedlines were each less than 25 feet in length, so even though RG-8 is not the preferred cable for UHF, coaxial cable losses were minimized due to their short runs.

At a "radio rally" (hamfest to you "Colonials") I obtained a Maidenhead grid map of the UK and Europe. One day the 2-meter FM simplex frequency came alive with chatter about a "lift" that was "on" (whatever *that* meant). I was soon to learn that a "lift condition" was what we in the states called a tropo-ducting event or possibly a sporadic-E propagation enhance-

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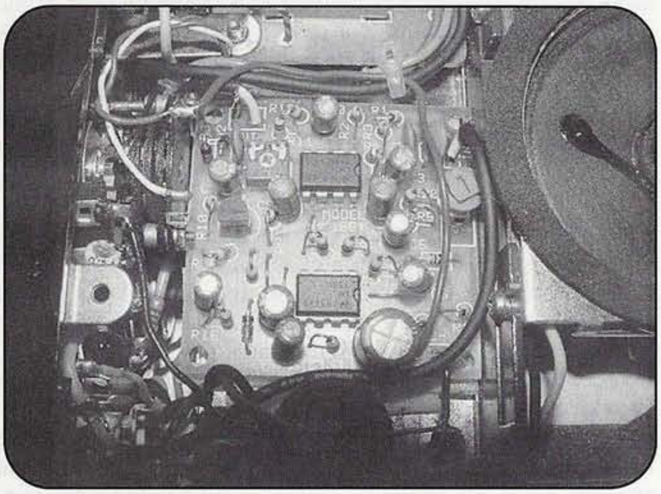


This photo shows a close up of the Ten-Tec speech processor that is wired into the audio chain right at the back of the mic plug. The speech proc, when properly adjusted, is a great way to maximize the miniscule 3W PEP output and make this rig sound a lot bigger than it really is. The speech processor mod should be considered if this radio is to be used barefoot or as a portable station for roving or hill-topping.

ment. At any rate, as I turned my small array east toward Europe, signals on 2 meters began to rise, followed by an increase in signals on 70 cm. Both bands were hopping, and I was soon engrossed in swapping signal reports and collecting grid squares from all over Europe, as my minuscule 3 watts of RF seemed to work miracles for over an hour.

In all my 17 years as a ham radio operator (at that time) I had never experienced anything remotely as hectic, frantic, and utterly fascinating as that first lift condition I experienced at my RAF Lakenheath QTH. Wow! When the bands opened up I quickly found that 3 watts (PEP) RF output was definitely up to the task of bagging some seriously rare grid squares. My QRP instincts were whetted, but most of all the lure of VHF+ had taken hold . . . and I was never the same again.

Back to VHF+ on a Shoestring . . .

Reminiscing about these days of yore in jolly olde England got me to thinking about how easy it would be to assemble a VHF+ weak-signal station that performed admirably under favorable propagation conditions with a paltry cash outlay. If then, why not now? That was the seed that started to germinate and resulted in my pitching this idea to Joe Lynch, N6CL, editor of *CQ VHF*.

Initially I had a Yaesu FT-857 on hand that I had intended to use as the prime mover for the frugal VHF+ station. Through a series of seemingly unrelated events, I ended up selling that radio and had nothing to use for my prime mover except my little Yaesu FT-817 QRP rig. That got me thinking about how difficult it would be to acquire the IC-X02 rigs again and assemble the same basic VHF+ weak-signal station I had originally used in England over 25 years ago.

Yea, Though I Walk Thru the Valley of e-Bay

Let me just say that e-Bay is a very evil place! It causes normal people, normally sane people, to do weird things such as spend lots and lots of money in pursuit of "stuff" that they *really* don't need. Having said all that, let me state categorically that without e-Bay I doubt that I would have assembled the entire range of IC-X02 rigs in such short time.

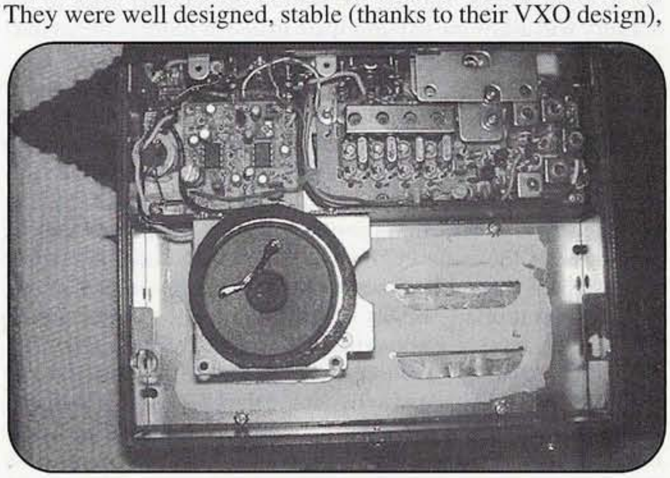
Starting with a plea on the QRP-L reflector, I soon had the IC-202 of Dave Benson, K1SWL, for a grand total of $75. Not bad! This was followed by an IC-215 for 2 meters FM from Keith Hibbert, WB2VUO, from the depths of the Great Bergen Swamp in upstate New York. Cost: trade for an old MFJ antenna tuner. Not bad! Another e-Bay deal netted the IC-502 for 6 meters direct from Japan. Cost: $130 sans s/h. Not great, but not all that bad either. The IC-402 came from a ham in Washington State for $125 less s/h. Again, not a stellar deal, but not a bad one either. So for a total cash outlay of $330, I assembled an entire trio of exciters for my VHF+ station within six weeks! In addition, I came up with a 15-channel, crystal-controlled 2-meter FM rig that matched the rest of the station. Who says you can't get good deals in this day and age?

With the exception of the IC-202, all of these rigs were in great physical and electrical shape. The IC-202 took some work to bring the case around and get rid of some grit and grime, but in the end the entire quartet of Bookcase Radios look brand new, and they are quite impressive all lined up on my operating bench! Now if I could just find all the matching 10-watt linear amplifiers and power supplies.

Why the IC-X02 Rigs?

With all the current crop of solid-state, microprocessor-driven DDS rigs on the market, why did I decide to use these 25-year-old ICOM rigs? Several reasons, actually. First, the availability and price of these rigs would allow a VHF+ neophyte the option of purchasing *just one* of the rigs (I'd start with 6 meters, personally) and give VHF+ operation a try without spending gobs of money and investing hours of time on assembling a state-of-the-art multi-band station. After all, if you spend a bundle just to find out that you really don't like listening to all that static for hours on end waiting for a band opening, then a small expenditure of funds is certainly more easily assimilated than one totaling many hundreds or thousands of dollars.

Second, the IC-X02 rigs were good performers, in their day. They were well designed, stable (thanks to their VXO design),



This is a wide shot of the battery box (note the flattened partitions) and the placement of the speech processor where the speaker used to live, and the subsequent repositioned speaker. The only major drawback to this method of mounting the processor is that the speaker no longer sits directly below the holes in the side panel, which tends to mute the receiver audio a bit. Headphones or an external speaker solves this problem. There is plenty of room for added mods in the modified battery box.

and could be powered from an internal battery pack made up of nine alkaline "C" cells. By today's standards, of course, they leave a lot to be desired, especially in the dial-readout accuracy area. However, a cheap counter will easily spot your rig's frequency within a couple of hundred Hertz, so that really is a non-issue.

Third, these rigs beg to be modified, upgraded, and enhanced by swapping out the older MOSFET active devices (3SK40s) in the receiver with GASFET devices (BF-981s) and adding things such as preamps, speech processors, "brick" RF linear amplifiers, etc. By being willing to undertake some basic mods, and with a little homebrew effort, we are going to learn some things about VHF+ operation. After all, if it were ultra-simple to assemble a good weak-signal station for the VHF/UHF bands, then it wouldn't be any fun, now would it? By modifying and upgrading these simple little rigs, it is possible to not only learn something new regarding this aspect of our hobby, but have some fun, improve our ham radio skills, and acquire some pride in accomplishment all at the same time.

My Goals

In keeping with the previous column's emphasis, here are the goals for my personal VHF+ weak-signal station:

1. Assemble a triband VHF+ station using IC-X02 radios as exciters.

(a) Timeframe: on/before mid-February 2005.

2. Research the Internet and locate mods/upgrades for IC-X02 radios and perform mods as needed.

(a) Timeframe: on/before mid-March 2005.

3. Construct two 2-meter Yagis using a July 1999 *QST* article, "A Five-Element, 2 Meter Yagi for $20" by Ron Hege, K3PF.

(a) Timeframe: on/before April 2005.

4. Erect "V/UHF Short Stack" for 2 meters and 70 cm.

(a) Timeframe: third week in April 2005.

These four short term goals, if accomplished on schedule, will allow me to have an operational triband (6 meter, 2 meter, and 70 cm) weak-signal station operational before my foot surgery. This operation will keep me away from work for about six to eight weeks. Having the station operational prior to the surgery will allow me to participate in one or more contests during my recuperation period, all with minimal cost outlay.

Okay, so how have I done so far? Well, the IC-202 receiver has been upgraded with the replacement of the 3SK40 device in the first mixer with a GASFET BF-981 which, according to the published modification, will decrease the overall noise figure (NF) of the radio by at least 2 or more dB. In order to get the "new" Q2 to function properly, you must mount it on the underside of the main PC board (remove the battery tray and access is easy!) and then short out R6 (check your schematic diagram) to properly rebias the BF981 device. In addition to the BF-981 mod, I also added a Ten-Tec T-Kit model 1551 speech processor (at a whopping $14.00 + s/h) to the transmit audio chain, and I have also bypassed the LC tuned filter in the receiver front end of the IC-202 for an additional NF decrease of about 2 dB. This LC filter is shared by the transmitter (it is the PI output filter that keeps the transmitter output clean) with the receiver input signal. While the filter is definitely needed on transmit, it is not necessarily required for receiving, and bypassing this filter definitely makes an improvement in the overall receiver NF.

Thus, for a minimal amount of work and a relatively small cash outlay, I have made approximately a 4-dB or better improvement in receiver noise figure (no small task), while substantially increasing the average DC output power of the QRP transmitter using the T-T speech processor. Coupling this modified exciter to a 35- to 70-watt 2-meter "brick" amplifier will yield a nice little 2-meter weak-signal station that can hold its own when coupled to a good set of antennas. Life is good!

The mods on the IC-202 are at <http:// www.qsl.net/pe1hwo/icom/ic202/mods/>, <http://www.hamdirectory. info/ICOM_VHF.html>, <http://users3. ev1.net/~g4fre/Ic202rx.htm>. The Ten-Tec website (www.tentec.com) will provide access to its secure site to purchase one of the T-Kit model 1551 speech processors. Once built, the processor is placed inside the IC-202 where the internal speaker normally sits, and is wired directly between the mic input and the main PC board where the mic plugs into the board using subminiature coaxial cable.

Take a close look at the photographs showing the placement of the speech processor and the repositioning of the internal speaker. Since this particular radio will not be used with internal batteries, the battery compartment of the IC-202 radio makes a great place to put mods such as preamps, speech processors, etc. With a little ingenuity, there is no doubt that someone could come up with a small 10–15 watt linear RF amp that could be added to the internal battery box of one of these little ICOM rigs, boosting the power output while maintaining everything internal to the radio!

Additional info on the BF981 device used in the mods on the IC-202 (replacement of Q2) can be found at: <http:// www.geocities.com/toddemslie/bf981_preamp.html>.

Notice that on my particular IC-202 I have flattened the internal baffles that separated the battery stacks inside the battery box to form a solid metal platform on which to affix some more modifications and circuit boards. One particular mod I am going to perform is to solid-state the T-R switching for CW. These rigs (all of them) have a front-panel switch that selects the CW mode, and that switch *must* be thrown *before* you can key the transmitter. Full break-in (QSK) it's not! My goal is to homebrew a solid-state switch that will work on key closure. Along this same line of thinking, I will be adding a Pic keyer chip from K1EL that has my callsign along with several embedded messages burned into the chip's memory. All I have to do is plug in the paddle set or a straight key and start sending CW. No switch throwing needed!

A final thought for this installment—frequency accuracy. Unfortunately, these cute little VHF+ rigs were manufactured just before digital readout became a standard feature on most radios. There are several modifications on the Internet that detail how to add a digital readout (more appropriately called a "digital dial") to these rigs (check <http://www.vhfman.freeuk.com/radio/ic202.html>). Due to the fact that these radios and their associated mods (many of them originating in Europe; I guess the IC-X02 series never became all that popular in the U.S.) are 15 to 20 years old, I am sure that there are much more refined methods of adding digital readout to these rigs. I will be researching this aspect and will report on what I find at a later date. Realistically, there should be a one or two chip circuits circulating out there on the web that when coupled to the IC-X02 local oscillator could easily be programmed to read the exact operating frequency to within several Hertz.

That's all for this installment. Please feel free to e-mail me (k7sz@arrl.net) with your questions and comments and any ideas you might have regarding this column. If you have done your homework, don't hesitate to send me pictures (with captions) of your station and I will do my best to get them into this column. 73, Rich, K7SZ

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: The **ARRL UHF and Above Contest** is August 6–7. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 20–21.

September: The **ARRL September VHF QSO Party** is September 10–12. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 17–18. The **144 MHz Fall Sprint** is September 19, 7 PM to 11 PM local time. The **ARRL 2304 MHz and Above EME Contest** is September 24–25. The **222 MHz Fall Sprint** is September 27, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 5, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 15, 6 AM to 1 PM local time. Note, you are to operate no more than five hours, in one-hour blocks during this contest time slot. The **50 MHz Fall Sprint** is 2300 UTC October 22 to 0300 UTC October 23. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 22–23.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 13–13.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or go to: <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs.org>.

Current Conventions and Conferences

September: The 2004 **TAPR/ARRL Digital Communications Conference** will be held September 23–25, 2005, in Santa Ana, California, at the Embassy Suites Hotel, Orange County Airport North. For more information, see: <http://www.tapr.org/dcc/>.

The **Mid-Atlantic States VHF Conference** is to be held Saturday, September 24, at the Courtyard Marriott, 3327 Street Rd., Bensalem, PA 19020; phone: 215- 639-9100. For further information, contact the conference chairperson: Jim Antonacci, WA3EHD, 215-659-4359; e-mail: <jantonacci@worldnet.att.net>, or Rick Rosen, K1DS, 610-270-8884; e-mail: <rick1ds@hotmail.com>. The web site for further info and maps is: <http://members.ij.net/packrats/latest.htm>.

The **Pacific Northwest VHF+ Conference** will be held September 30-October 1, at the Shilo Inn and Oceanfront Resort in Seaside, Oregon. For more information, see their URL: http://www.pnwvhfs.org.

October: The 2004 **AMSAT-NA Space Symposium and Annual Meeting** is to be held October 7–9, in Lafayette, Louisiana, at the Holiday Inn Central, located in downtown Lafayette, at the intersection of I-10 and I-49. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/>.

The annual **Microwave Update** conference dates are October 27–31, and it will be held at the Sheraton Cerritos Hotel, Towne Center, 12725 Center Court Drive, Cerritos, California 90703. For more information, please see the North Texas Microwave Society's URL: <http://www.ntms.org>.

Quarterly Calendar

Aug. 4	Moon Apogee
Aug. 5	New Moon
Aug. 12	*Perseids* Meteor Shower Peak
Aug. 13	First Quarter Moon
Aug. 19	Full Moon
Aug. 19	Moon Perigee
Aug. 26	Last Quarter Moon
Sept. 1	Moon Apogee
Sept. 3	New Moon
Sept. 11	First Quarter Moon
Sept. 16	Moon Perigee
Sept. 18	Full Moon
Sept. 22	Fall Equinox
Sept. 25	Last Quarter Moon
Sept. 28	Moon Apogee
Oct. 3	New Moon
Oct. 10	First Quarter Moon
Oct. 14	Moon Perigee
Oct. 17	Full Moon
Oct. 21	*Orionids* Meteor Shower Peak
Oct. 25	Last Quarter Moon
Oct. 26	Moon Apogee
Nov. 2	New Moon
Nov. 9	First Quarter Moon
Nov. 9	Moon Perigee
Nov. 16	Full Moon
Nov. 17	*Leonids* Meteor Shower Peak
Nov. 23	Last Quarter Moon
Nov. 23	Moon Apogee

—EME conditions courtesy W5LUU.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. To date this year the following organizations or conference organizers have announced calls for papers:

The **Mid-Atlantic States VHF Conference**: Please submit your paper as soon as possible to: Paul Drexler, W2PED, 28 West Squan Rd., Clarksburg, NJ 08510, or via e-mail to: <pdrexler@hotmail. com>. The listed deadline is July 31, but you may have a day or so after that date if you notify Paul of your forthcoming submission.

TAPR/ARRL Digital Communications Conference: Technical papers are solicited for presentation at the 24th Annual ARRL and TAPR Digital Communications Conference to be held September 23–25 in Santa Ana, California, and for publication in the conference *Proceedings.* Submission of papers is due by August 9 to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111; or via the Internet to: <maty@ arrl.org>.

Microwave UpDate: The deadline for inclusion in the *Proceedings* is September 5. If you are interested in writing and/or presenting a paper for the 2005 Conference, contact: Chip Angle, N6CA, P.O. Box 35, Lomita, CA 90717-0035; or via e-mail: <n6ca@ham-radio.com>. For more information about Microwave UpDate 2005 go to: <http://www.microwaveupdate.org>.

Meteor Showers

August: The *Perseids* meteor shower is predicted to be August 12. For more information on this shower, please see the "VHF+ Propagation" column on page 60.

October: The *Draconids* is predicted to peak somewhere around 1600 UTC on October 8. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* shower is predicted to peak around 1430 UTC on November 17.

For more information on the above meteor-shower predictions visit the International Meteor Organization's URL: <http://www.imo.net>.

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

A New Voice on FM

If you have been receiving *CQ VHF,* you will notice that there is a new author for the FM column in this issue. You may recall that in the Spring 2005 issue Gary Pearce, KN4AQ, announced that he was no longer going to write this column. I quickly volunteered to take over the responsibility. I want to thank Gary for writing a great column over the past three years. I've always found it interesting, and I will strive to maintain that quality and continue to improve upon it.

At first glance, writing the FM column might look easier than writing some of the deeper technical articles. This is true in terms of pure technical challenge. A challenge with this column, though, is dealing with the diversity of how hams use VHF FM. It really is the "utility mode," the band/mode that hams use on a regular basis to get things done. Some use it for chatting around town on simplex, while others make contacts on the local repeater system. Some radio amateurs are interested in building complex repeater systems; others just use them. VHF FM is also a very popular mode for working the OSCAR satellites. This can make writing about FM difficult, since the audience is somewhat fragmented. In many ways, VHF FM is taken for granted. too, since it is always there waiting to be used.

Frequency Modulation

FM is an interesting mode and VHF FM is arguably the most popular type of ham radio operation today. Let's take a look at some of the characteristics of FM.

Edwin H. Armstrong first described the practical use of *frequency modulation* in "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation" published in May 1936 by the Institute of Radio Engineers (IRE). The article is located online at <http://michael.industrynumbers.com/fm.pdf>. The first practical two-way FM radio telephone mobile system in the world was designed by Daniel E. Noble and implemented in 1940 for the Connecticut State Police. Clearly, FM radio has been around for a while!

FM certainly has gained acceptance in a variety of radio applications, including FM broadcast, television audio, two-way mobile radio, and VHF/UHF amateur radio. Like most technologies, FM has its advantage and disadvantages (see Table I). Let's compare FM (5-kHz deviation, as employed on the VHF+ ham bands) to the other popular phone mode, single sideband (SSB).

FM receivers tend to ignore amplitude variations in the signal, so many sources of electrical noise largely are suppressed. I was reminded of this during the recent ARRL June VHF contest when a thunderstorm approached from a distance. Every time there was a lightning crash, my 2-meter SSB transceiver put out a burst of noise in response, while the 2-meter FM transceiver remained silent. Armstrong emphasized this characteristic of FM for broadcast use as a distinct advantage over AM radio technology. (For a brief history of the development of FM, read Armstrong's article "Evolution of Frequency Modulation" (go to <http: www. mcmlv.org/Archive/Radio/FM_Armstrong.pdf).

Photo A. The Motorola HT-220 VHF handheld transceiver was a breakthrough product that many hams adapted to the amateur bands. →

Armstrong also promoted the high-fidelity nature of FM audio, a clear advantage in the broadcast arena but less so for two-way radio. Still, it is nice to have good, clean audio that is easy to understand and sounds like the original speaker.

Modern applications of FM in two-way radios include a squelch circuit that mutes the receiver until a signal is received. This makes for easy monitoring without having to listen to background noise. While there are SSB radios with squelch, the squelch operation is not nearly as decisive and accurate in determining when a signal is present.

Another key advantage of FM is the tolerance of error in the carrier frequency. In normal VHF ham radio use there is often a mismatch of over 1 kHz between the transmit frequency and the receive frequency. This kind of frequency error usually goes unnoticed on FM. Try this on SSB and you'll find that the received signal sounds like a very annoying Donald Duck. This

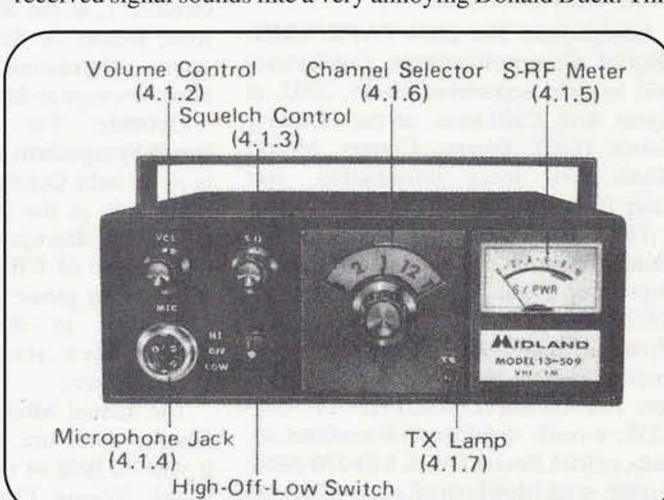


Photo B. The Midland 13-509 VHF radio is the 220-MHz version of the 2-meter transceiver mentioned in the article. The radios are the same except for frequency band. (From the original Midland manual)

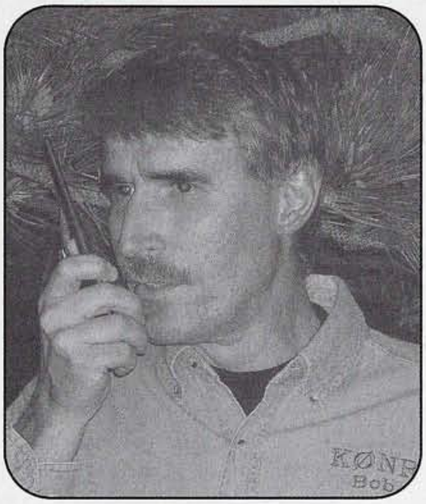
*e-mail: <bob@k0nr.com>

About The Author

Since the beginning of my amateur radio activity I've been interested in the VHF and higher bands. I think it started when I discovered that the 2-meter band had such a variety of operating modes (FM simplex, repeaters, SSB, CW, satellite, etc.). Later on I learned to appreciate 6 meters, appropriately known as The Magic Band, due to the frequent sporadic-*E* openings that really spice up things.

I enjoy building and using FM repeater systems, mostly on 2 meters and 70 cm. Over the years I've served on a number of technical crews for various repeater groups. Currently I operate the KØNR/R repeater in Monument, Colorado on 447.725 MHz with a frequency-agile 2-meter remote base and autopatch. The repeater has a weather radio connected to it that automatically activates a warning message on the repeater output when the National Weather Service broadcasts a warning. Although the repeater gets used every day, its real role in this world is to provide a place to experiment with repeater ideas.

While most of my operating is above 50 MHz, I have spent plenty of time on the HF bands. I've made enough contacts to qualify for WAS, WAC, and DXCC. At times I have done quite a bit of CW operating, and I passed the 20-wpm code test to get my Extra Class license many years ago.



CQ VHF *FM columnist Bob Witte, KØNR.*

Still, home base for me is always VHF and higher. My present passion is operating QRP on VHF and I write a column for *QRP Quarterly* on that topic. I usually am active during the major VHF contests, often operating from some mountaintop or other high-altitude location. If you want to know more about ham radio interests, please visit my website: <http://www.rwitte.com>.

Photo C. The Yaesu FT-208R was an early synthesized 2-meter handheld transceiver. (Photo courtesy of the <www.rigpix.com> website)

advantage of FM comes into play when any kind of tone signaling is used, such as DTMF, paging tones, and CTCSS. Try using tone signaling on SSB and you'll find precise tuning of the carrier frequency is required.

If FM is so great, then why isn't it used everywhere? For starters, FM has very poor weak-signal performance. That is, when the signal level starts to decrease with FM, it hits a point where the received signal rapidly becomes very noisy and difficult to copy. This is called the *threshold effect,* since the received signal hits a threshold below which the signal is difficult to recover. On the other hand, SSB signals gradually get noisier as the signal level decreases and can be copied at much lower levels than FM.

The other big disadvantage of FM is that it uses a wider bandwidth than the equivalent SSB signal to transmit the same basic voice information. On the VHF ham bands, FM is about 16 kHz wide compared with SSB which is roughly 3 kHz wide. Thus, FM takes up about five times the frequency space as SSB.

FM also has the characteristic of being "full on" any time the transmitter is keyed. When you press the Push-to-Talk button, the transmitter puts out full RF power regardless of whether or not you are speaking into the microphone. This is referred to as having a duty cycle of 100%. Compare this with SSB, where the RF output power tends to follow your voice modulation as you speak. This means that for the same voice signal being transmitted, an SSB transceiver will tend to use less power. This is another way FM is less efficient than other modulation techniques.

My FM VHF Story

Let me tell you a little bit about my journey through the world of FM VHF. If you have had some of these experiences, perhaps it will jog your memory. If not, perhaps it will provide some insight on how FM VHF evolved.

I first became aware of the world of FM VHF when I was an electrical engineering student at Purdue University in 1976. I did not have my amateur radio license at the time, but I had just discovered that the radio club on campus was offering license classes. I quickly joined the class and was on my way to getting my Novice license, later to be followed by my Technician license. There was a ham in one of my EE classes who was carrying around the coolest radio of the day—the Motorola HT-220 (photo A). This thing was the size of a small brick (7.6 × 2.8 × 1.5 inches), so it was large by today's standards. Back then it was the most compact handheld transceiver that you were likely to find on the VHF bands. A search on the web revealed that there are still quite a few HT-220 enthusiasts out there. Check out the HT-220 home page (http://www.batnet.com/mfwright/mfwright/HT220.html), which is dedicated to information on that Motorola radio. Even though I lusted after such a compact and totally cool handheld, the going price for that radio was way out of my price range.

My first VHF transceiver (and my first ham transceiver) was a Midland 2M FM mobile rig, Model 13-500 (photo B). Of course it was crystal controlled, since almost all of the FM VHF gear was crystal controlled back then. Like most radios at the time, it required two crystals per channel, one for transmit and one for receive. It came standard with a pair of crystals for 146.52-MHz simplex. If I remember correctly, it also came with a

Photo D. An assortment of modern portable VHF/UHF amateur radio transceivers.

pair for 146.34-MHz TX/146.94-MHz RX, the so-called "three-four/nine-four" pair. This was the most popular repeater pair at the time. The rig also had a 146.94-MHz transmit crystal, so one of the channels was set up to run simplex on 146.94 MHz. To use the repeater at Purdue, the rig had a 146.16-MHz TX/146.76-MHz RX crystal pair. It was also set up for running simplex on 146.76 MHz. With crystals going for at least $5 each ($10 per pair), it was easy to add $100 or so to the cost of the 12-channel transceiver.

Of course, this was the problem with crystal-controlled radios. You spent a bunch of money filling out the channels and then you still might not have the right frequency pair. Imagine driving across country, hoping you had the right crystals for the available repeaters. The radio I should have purchased was the ICOM IC-22S, which was one of the first cost-effective synthesized 2-meter transceivers. It had a diode-matrix that did the programming of the synthesizer, so you could set up the 22 channels to your favorite frequency pairs (never having to buy a crystal). If you changed your mind or your home location, you could reprogram the channels by moving the position of the programming diodes.

Speaking of synthesizers, I remember one of my fellow college students had an HT-220 with an add-on synthesizer that could tune any frequency without the need for crystals. Unfortunately, the synthesizer made the transceiver about 50% bigger and reduced the battery life to about five minutes (okay, maybe it lasted longer than five minutes, but it really consumed the

Frequency Modulation

Advantages	Disadvantages
High noise immunity	Poor weak-signal performance
High-quality audio	Relatively wide bandwidth
Clean squelch operation	100% duty cycle, independent of modulation
Tolerance of errors in carrier frequency	

Table I. Advantages and disadvantages of FM versus SSB for amateur radio use.

batteries quickly). I remember that the talk around the radio club was that synthesizers were just no good for handheld radios. Of course, it wasn't but a few years later that the major ham equipment manufacturers proved that notion wrong by introducing synthesized handhelds (with reasonable battery life) such as the ICOM IC-2AT, the Kenwood TR-2400, and the Yaesu FT-208R (photo C).

All modern VHF/UHF ham transceivers are synthesized, covering their respective frequency bands right out of the box. What an improvement over the old crystal rigs in terms of frequency agility! Think about organizing a local ARES exercise with crystal-controlled rigs; you had better make sure everyone has the right crystals plugged into their radios. There will be no last-minute arbitrary frequency changes. It puts a special emphasis on the concept of having a standard calling frequency. Everyone had crystals for 146.52 MHz, as it was the least common denominator.

Modern VHF FM rigs continue to amaze me (photo D). I suppose I should be used to it by now, but being able to buy a fully-synthesized 50-watt 2-meter transceiver for under $200 still amazes me. These rigs come with all the bells and whistles . . . maybe *too many* bells and whistles.

The Column . . . Going Forward

I've always been a fan of *CQ VHF* magazine, so I jumped at the chance to do this column. My request to you is for you to send me your ideas on VHF FM and provide feedback on the column. I think it works best if the column is interactive. In fact, I'd be willing to hand the keyboard over to you for an issue if you have a particular topic worth writing about, so send me your ideas!

There are a number of things concerning VHF FM that I am likely to address in this column. For starters, it seems that while VHF FM is still a very popular mode, on-the-air activity is declining. I often scan every repeater frequency in my area and the frequencies are generally quiet. This is noticeably different from a decade ago. Hams in other parts of the country report a similar pattern. I've spent less time monitoring the simplex frequencies, but they also seem underutilized.

Another current topic is the use of digital technology on the VHF bands—or more correctly, the distinct *lack* of use of digital technology. Sure we have AX.25 packet radio, including APRS (Automatic Position Reporting System), but what about using the latest digital modulation techniques for our next generation "utility mode"? Mobile phones largely have switched to digital technology, and the remaining analog cell sites are being phased out. APCO (the Association of Public-Safety Communications Officials) has established a digital radio standard known as APCO 25, or Project 25, for use with public-safety mobile radios. For more information on APCO or Project 25, please see: <http://apcointl.org/frequency/project25>.

Is there something different about ham radio communications that drives us to stay with good old analog FM, or are we just a bunch of Luddites? ICOM recently introduced transceivers that are based on the D-STAR standard. For more information on D-STAR, go to ICOM's website: <http://www.icomamerica.com/amateur/dstar>. Is this the future of digital communications for VHF and up? I'd like to hear from anyone using D-STAR or APCO 25 on the ham bands.

In future columns I am sure I'll cover some technical topics such as repeater systems, FM modulation and deviation, mobile antennas, HT antennas, tone signaling, etc. Some operating-oriented topics also come to mind, such as using FM VHF during Field Day, using FM during VHF contests, and general mountaintop portable operating.

For the most part, FM VHF is a local phenomenon. Issues and activities occurring in New York City may not be the same as those in the middle of Nevada. This is a place where I need your help in rounding out the column with information on what is happening in your corner of the ether.

That's all for this issue. Please let me know what you are doing in the world of FM VHF/UHF. Be sure to let me know your thoughts on any of the topics mentioned above. Reader feedback is always encouraged!

73, Bob, KØNR

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

2-Meter Multimode Radios Used in Microwave IF Transverters

Microwave transverters and even the VHF transceivers that are used with them as low-frequency IF radios all have one thing in common that we take for granted—the exceptional frequency stability that we have come to enjoy in equipment available in today's electronic market.

It was not long ago when all VHF equipment was crystal controlled, be it military surplus or equipment such as the Gonset communications equipment, which was AM-only operation and had vacuum-tube construction. Today, crystal-controlled operation is still in use with some of the available radios, but most multimode radios now use some form of phase-locking oscillator in the microwave transverters to a synthesized IF radio that is frequency agile and supports multimode operation.

Adapting these radios for IF-frequency service to be used with converters from microwave frequencies can be trying in some cases and easy in others. I thought I would take the time to answer questions that have popped up concerning what IF radio system I would recommend for converter operation.

Well, for me that's easy, in that anything that is economical (a bargain) and functions is just great. Taking the other extreme, a system can be homebrewed using key component parts widely available today. This would allow the hearty to construct their own receiver or even a transceiver for use as an IF converter in our microwave systems. It is one way, hard as it may be. I would like to spend the time operating on a hilltop rather than designing an IF system. That leaves one choice available for me, and it's the used surplus market.

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Putting Together the System

In any case, constructing a microwave transceiver is based on the components and systems we can locate to bring the design to fruition with economy and functionality. All transverters consist of a local oscillator, RF preamp, and transmitter power amp, along with coaxial relay switching for conversion from a high microwave frequency to a low-frequency IF system. This design, at least for the transverters I have built, is based on the IF system I plan to use for the transverter. In almost all cases this is an all-mode transceiver for 2 meters. However, a 70-cm all-mode transceiver can be used just as well.

For most amateurs, the IF system is whatever can be found inexpensively in the used surplus market or at local swapmeets. Juggle what you have for an LO (local oscillator) and what is needed for an IF system to convert the high frequency to your IF system. Two meters allows for simple filters to get rid of the other mixer products in converting from a microwave frequency to your IF radio. For example, it gets harder to use a 28-MHz IF radio for conversion; it will work, but the filters required must be quite sharp in bandpass to eliminate 28-MHz harmonics. With a 2-meter IF, the products are now 144 MHz apart and easier to filter out.

For start-up 2-meter equipment, there are many transceivers that could be used. This includes the ICOM 820H, or other great rigs that cover both 2 meters and 70 cm. Although they can be used, it would be overkill in using such an expensive radio for IF use. I prefer to work out of the junk box and not push my credit-card limits.

These rigs will work well, but as it is with all things, there are other points to consider. One of the modifications required to an expensive, high-power output radio the consideration of how to reduce the output power (10 to 50 watts) to a level capable of driving a mixer in transmit, reduced in power to something less than +20 dBm (100 mw). In this case I prefer not to modify such a radio, but rather leave it in its original

One of the Kenwood TS-700A 2-meter transceivers that I use for 1296 MHz and 10368 MHz (10 GHz) operation in my home shack. It's an old, but good radio for shack use. It is easy to modify for low RF power output, has dial frequency control for totally manual operation, and is good in any lighting conditions. It also has an internal AC power supply for ease of operation in the shack. Cost is about $50 used and working.

condition so as not to cause it harm or ruin its value.

For the IF radios that I use I achieved this low-power level of operation through an easy modification to the IF radio. It is simply soldering the low-power switch to provide low-power output all the time, disallowing high-power operation. My ICOM IC260 is wired this way. This modification, used with a home-built switching circuit that incorporates a 5- to 10-dB attenuator constructed out of 1/4-watt resistors, brings the IF radio system down to a power output level of something in the 100-mw range. This power level will not destroy any microwave converter or mixer circuit should the relay switching fail and you transmit with this power level into the receive mixer preamp of the microwave converter. The modification using 1/4-watt resistors is economical compared to using a high-power attenuator of 30 to 40 dB for the 1- to 10-watt power output levels.

Power levels above +20 dBm can and will blow a microwave mixer. Sure you purchase a replacement mixer at a premium price, but why go to the trouble of working with 10 watts or more in some transceivers just to attenuate the high power that has to be reduced for converter use? Using a low-power, modified 2-meter transceiver for use with your microwave converters, especially a transceiver obtained from the used surplus market, can be a very good choice when compared to an expensive rig that would better serve as a liaison radio.

The Radios

Let's take a look at some of the radios I have used for converter use and the simple mods, liabilities, and attributes of each.

The following 2-meter multimode radios are not the only possible ones, but they happen to be the ones I have stumbled upon at swapmeets and such over the years. These are all radios that I have in my shack at present. I did not want to modify my ICOM 820H in any way, and thus preferred to obtain a transceiver from the used market and convert it for my carry-around, knock-about IF system for microwave converters. A benefit is lower cost for used older equipment.

Using an expensive radio such as the IC-820H can be justified for base station for transverter IF use, but I still prefer to use the radio for liaison operation from the home QTH. For 2-meter IF strips at my QTH I use the Kenwood TS-700A. I have three that I use as these strips—one for 1296 MHz, one for 10,368 MHz, and one as a backup spare. This is an old radio but a good one and is very inexpensive. The highest price I ever paid for one is $65, which is not a bad deal, as they are easy to modify. A problem with the TS-700A, though, is the dial VFO mechanism seems to use a roller coil that develops rough spots and thus poor connection of the roller inductor track operated by the main tuning dial. This is not a big problem, however, and can be fixed by rolling the dial over these spots with a back and forth motion to clean the track on the main tuning dial. One of these days I will tear apart the TS-700A to fix this problem once and for all.

There are a lot of options on the used surplus market. Older multimode 2-meter rigs that do not have CTCSS tones for modern repeater operation are available and can be a good to look for. Rigs I have found include the ICOM IC-245

The SANTEK LS-202 multimode 2-meter HT. This one still works well even after being dropped, which cracked the battery compartment. Repairs included a new external volume control, and a 5-pF cap to replace the unobtainable final RF transistor, providing low RF power output for converter use. The masking tape shown here is needed to hold the battery compartment on the HT body. The plastic clips to hold the radio together had broken off long ago. A common problem with this radio is the audio pot going open and it having to be replaced with an external pot.

The ICOM IC-260 multimode radio. This one still serves as my backup radio, it being the easiest radio with which to operate 2 meters SSB. Its only drawback is the red LED dial, which needs to be shaded from direct sunlight to be able to read the display. When contemplating outdoors operation, I usually tape cardboard over the top of the unit, shielding most of the sunlight from the dial.

with SSB adapter and the Kenwood TS-700A, as mentioned. As the ICOM rig is smaller, it is the better choice. The Kenwood rig is more of a base-station radio. However, the Kenwood can be converted to 100 mw output power with the addition of a pad made from three each 1/4-watt resistors with a 4-minute modification. This pad can be removed and installed easily such that the radio can be returned to its original condition.The pad is installed on the inside bottom cover on the drive coax to 10-watt module input in series with the coax to termination point on the 10-watt module. What is required is a 10- to 15-dB pad. With the pad, maximum power is just under 100 mw power out. It has worked well for years in my home shack.

Another 2-meter, all-mode transceiver is the Yaesu FT-480R. It has a high/low-power switch that can be locked on low power by soldering a jumper. Then all you need to get rid of is 1 watt of power or less to reach the mixer driving power of something less than 100 mw. A consideration here is that the Yaesu FT-480 has a dial that uses a green display which is good for sunlight, while the ICOM IC-245 used a red LED that is very difficult to see in sunlight. (Note that the FT-780R, which looks exactly like the FT-480, is for 450 MHz. Be careful when you look at these radios to be sure you get what you want—the 2-meter version or the 70-cm version.)

The Kenwood TS-700 has a mechanical dial that is easy to see in any lighting conditions, and conversion to low power is quite easy. Just insert a 10- to 15-dB 1/4 -watt resistor "T" pad in the drive cable to the final amp compartment in series with the drive coax cable and amp box feed-through with the shunt resistor tied to ground.

Another consideration in a 2-meter, all-mode radio, but one which is harder to locate, is the Santek LS-202 handheld. This is an SSB/FM handie-talkie. I use this radio for lots of things. While it uses a manual frequency control, backed up by a plus/minus frequency adjust knob that is helpful, frequency accuracy is not apparent on this HT. However, for test work and general operation it a great find. I found mine in a repair shop in Colorado, with parts hanging out of the unit (a basket case). I was told the receiver worked, but due to the unusual grounded case to collector configuration on the power output transistor, the shop owner could not find a replacement final transistor. I told him that it was great anyway, and I purchased it for a song. I then replaced the final transistor with a 5-pF capacitor and the HT now puts out 60 mw, if I talk really loud.

Another radio that should be considered is the ICOM IC-260. Again, it is available because there are no CTCSS tones for repeater operation. It has a red LED for dial calibration, which is a negative point, but that is not insurmountable. It is easy to convert to low power, 100 mw or less, and is just as easy to return to its original condition. The best thing is that it is not very expensive on the surplus market—possibly $100 fully working. Low-power conversion consists of setting the switch to low power by removing the bottom cover plate and soldering the jumper on the switch, making it permanently on low power even if the switch is set to high power. The drive filter circuit can easily be tweaked to obtain 60 to 100 mw. It is a very simple modification.

I paid $50 for the IC-245 because it had a intermittent frequency synthesizer, which was traced to bad solder connections through the copper rivets soldered to the top and bottom of the board (before the plated through holes). Soldering a "Z" wire through the rivet and then soldering to the top and bottom trace made for a good electrical connection and the radio has worked great ever since. It was a big job to lift the synthesizer out of the chassis to get to the bottom of the board and all the rivets on the board, but the rig was inexpensive.

The big-brother version of the IC-245 is the IC-211, which is a base-station version of the 245. It has the same synthesizer rivet problem. Again, it is repairable, but it does take time to put the "Z" wires through the rivets, allowing good solder connections through the rivet and the top and bottom of the PC board.

Of course there is the king of the multimode transceivers, and that is the Yaesu FT-817, an all-mode, all-frequency, all-band, "triple A" radio in all respects. The only problem is that for a scrounger and swapmeet junkie it will be quite a while before this rig will be available at swapmeet prices. However, it features low-power operation and is small in size. It also has a lot of menu options for configuring the many features on the radio, which can be overwhelming. Even with a cheat sheet it can become somewhat difficult, as compared to older 2-meter multimode transceivers, which are essentially two- or three-function radios that even your grandson could operate time after time.

As you can see, there are all kinds of considerations when choosing a multimode radio, and I hope I have not confused you. In summary, the following points apply when you are considering buying a radio:

1. If it works and it's inexpensive, buy it. You won't be disappointed.

2. Be aware of the different dial displays—LCD, red LED, or green high-voltage displays. Consider what the effect will be when you are operating portable in sunlight on a hilltop.

3. If you have the time and the schematic is available, check out the power-cutting options on the radio you are considering.

4. If you can plug in the radio and give it a bench test, all the better.

What is my best IF system? Well, the FT-817 does rank up there for lots of reasons. However, when I get confused by the menu cheat sheets that I pack in the carrying case, I revert back to the IC-260 with a small cardboard shroud to shield the red display LED from sunlight.

Test Equipment

When it comes to test equipment to set the power to 100 mw, you could use a microwave power meter with a 30-dB attenuator. In my case, and again taking advantage of inexpensive surplus equipment, I found a Bird Wattmeter Model 6250 circa 1956. It reads power from 0 to 250 mw over the frequency range 30 to 500 MHz. I do, however, have a tendency to go overboard, and in this case it's the microwave power meters in my shack. I can calibrate the simple Bird power meter using my pair of HP 436 digital power meters and power heads for exacting work. But then what is a junkbox junkie doing with 436 power meters? I could use the power meter I recently found at our local swapmeet. It's an A-85-A antenna dummy load that uses three 47-type pilot lamps. Calibration is a little rough, though. You have to be a judge of power output as compared to lamp brightness. But then again, it only cost a buck!

73, Chuck, WB6IGP

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Satellite News, VO-52 (HamSat), AO-51 Mode V/S, SSETI, and AMSAT Space Symposium

Since the last column in the Spring 2005 issue of *CQ VHF,* HamSat has been launched and named VuSat OSCAR-52, or VO-52; this year's Dayton Hamvention® has come and gone with its goodies and demos; a launch date for SSETI has been announced; and details are now available for the AMSAT Annual Meeting and Space Symposium to be held in Lafayette, Lousiana in October. We'll start off with details of VO-52.

VuSat OSCAR-52, or VO-52 (HamSat)

Launch: VO-52 (photo A)was launched on May 5, 2005 and was released for use within 24 hours after launch. Since that time, it has been checked out in most of its modes and mode combinations and has been given a clean bill of health. Several "firsts" are associated with this launch: (1) it is the first Indian amateur radio satellite; (2) it was launched as the first payload on a new Indian PSLV-C6 launch vehicle; and (3) it was the first launch from a new Indian launch site. The AMSAT India people are to be congratulated for successfully accomplishing these feats on the first attempt.

Capabilities: The 43-kg satellite contains two mode B transponders. Only one is in use at a time. The transponders are linear, inverting, analog transponders suitable for SSB and CW. Frequencies are:

Downlink Passband:	145.870–145.930 MHz	USB/CW
Uplink Passband:	435.280–435.220 MHz	LSB/CW
Beacon1:	145.936 MHz	Unmodulated Carrier
Beacon2:	145.860 MHz	CW Telemetry

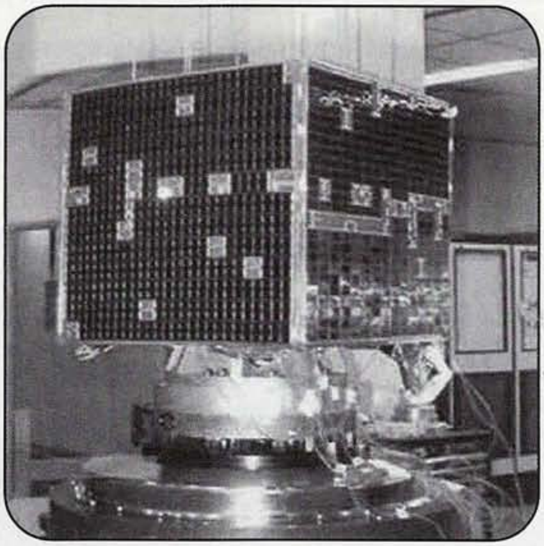

Photo A. VO-52 in the lab before launch.

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e-mail: <w5iu@swbell.net>

Thus far I have not heard the CW telemetry. Evidently, it is turned on by the command station when in the area of the command station. The satellite uses a lithium-ion battery and gallium-arsenide-based solar panels. Transmitter output is listed as 1 watt. VO-52 has been placed in a low-Earth, polar sun-synchronous orbit (SSO) at an altitude of 632 × 621 km with an inclination of 97.8 degrees with respect to the equator.

Operation: The downlink sounds excellent, and many stations are reporting success with QRP power levels on the uplink. Portable operation has been successful with a simple receiver (Kenwood TH-F6A), a simple transmitter (Yaesu FT-817), and an Arrow Antenna. Operation from a typical mode B satellite base station is excellent. This should be a real winner. We owe AMSAT India a real vote of thanks for providing this excellent satellite for the amateur radio operators of the world.

AO-51 Mode V/S

Since the last column, considerable interest has been generated in mode V/S operation through AO-51. This combination was first tried about a year ago during early checkout. The beauty of this mode is operation with a VHF low-power uplink with minimal attention to Doppler and utilization of the relatively high-power S-Band transmitter (2.5 watts) on AO-51. Of course, Doppler is a real consideration on the downlink, but with FM operation and 5-kHz steps it is manageable. Reception of the downlink is easily accomplished with very simple antennas and down converters left over from AO-40. As a matter of fact, antennas larger than the ones described below are very difficult to keep pointed at a rapidly moving, low-altitude satellite. A typical IF for the down converter is a 2-meter FM HT.

Over the past year several periods of mode V/S operation have been provided. The most recent period started on June 17, 2005 and ended with Field Day 2005. Mode V/S was also scheduled during the Dayton Hamvention® this year, and KO4MA made several mode V/S demonstrations. Drew used a small corner reflector and a K5GNA down converter (both items available from K5GNA). Photo B shows this combination. I have successfully used the same down converter with a WØLMB dual-band patch feed (photo C). Just about every combination you can think of has been used by someone—e.g., small helicals, small dishes, small Yagis, etc. They all seem to work and

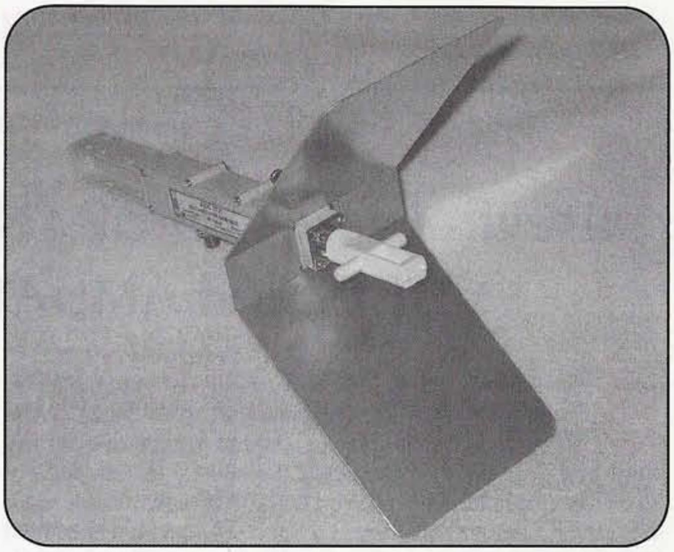

Photo B. K5GNA down converter with corner reflector.

provide good results. Field Day 2005 will be the real mode V/S test and should set the scene for another popular mode.

SSETI Express

The Student Space Exploration and Technology Initiative, or SSETI, project has produced the first pan-European student satellite with the cooperation of students from 12 European countries. SSETI is jointly sponsored by the European Space Research and Technology Centre (ESTEC), European Space Agency (ESA), European universities, and AMSAT-UK. Quoting Sam Jewell, G4DDK, from his talk at the 2005 Dayton Hamvention® AMSAT Forum, "The SSETI Express mission is an educational mission that will deploy CUBESAT pico-satellites, take pictures of Earth, act as a test-bed and technology demonstration, *and function as a radio transponder for the rest of its mission duration.*"

Three CUBESATs will be launched from the SSETI Express "Mother Satellite": XI-V from Japan, University of Tokyo; UWE-1 from Germany, University of Wurzburg; and Ncube-2 from Norway. Each of these CUBESATs contains its own communications package.

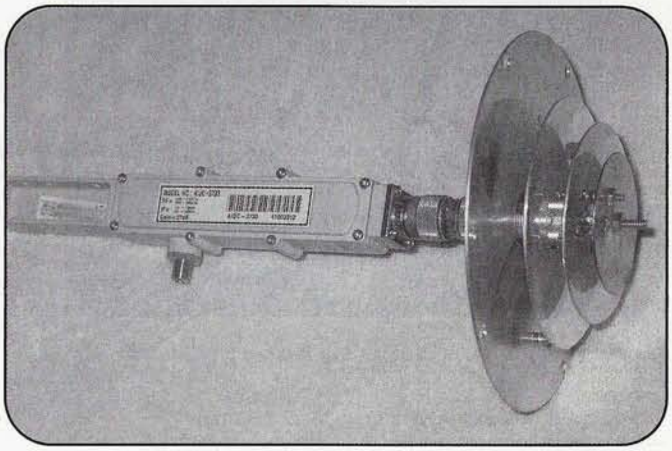

Photo C. K5GNA down converter with WØLMB dual-band patch feed.

Photo D. ARISS ground crew in Dallas at Hockaday School. Left to right: Keith Pugh, W5IU; Harold Reasoner, K5SXK; Tommy Davis, W5TCD; Bob Landrum, W5FKN; and Bob Dickey, K5HGH.

Two communications packages are part of SSETI Express: (1) a 437-MHz transceiver built by Holgar Eckart, DF2FQ, and (2) the S-Band package built by the AMSAT-UK team. These packages will relay 9k6- and 38k4-bits/sec data from the satellite to a ground station network of amateur radio operators and command stations. At the completion of the planned mission, the two packages will be configured as a mode U/S transponder for amateur radio use for the remainder of its life. This transponder will perform functions similar to the AO-51 mode V/S described earlier in this column.

As this column is being written, the finishing touches are being placed on SSETI Express in the Netherlands in preparation for shipment to Russia for launch on August 25, 2005. A backup launch date of August 26 has also been planned. A successful SSETI Express satellite will be a valuable addition to our flock of amateur radio "Birds."

AMSAT Space Symposium and Annual Meeting

The AMSAT Space Symposium and Annual Meeting will be held October 7–9, 2005 in Lafayette, Lousiana. The board of directors meeting will be held on October 6–7 at the same location. This year's meeting promises to be as informative as ever, with special attention paid to the progress being made on Project Eagle. Special consideration also should be given to attending this meeting due to the unique hospitality and food offered by the residents of Cajun Country, south Louisiana. If you have never experienced south Louisiana, this is your chance. In addition to the usual meetings and functions there is the Friday Night Shrimp Boil and the Sunday Morning Swamp Tour. I'm not sure where the satellites are in the swamp, but we will look for them! Everything is on the AMSAT web page, <http://www.amsat.org>, to make it easy to register for the symposium online. Sign up today and come on down to Cajun Country for the best Space Symposium yet.

Summary

We now have one new satellite, with another one on the way before the end of the summer. New ways of utilizing AO-51 continue to be discovered and explored. Equipping your station for the mode S downlink for AO-51 will put you in good shape for SSETI Express.

Please plan to attend the 2005 AMSAT Space Symposium in Lafayette and find out about all of the new and planned activity on amateur radio satellites while experiencing the unique hospitality and food in south Louisiana.

Nothing has been said so far in this column about the Amateur Radio in the International Space Station (ARISS), but this program continues. A record number of school contacts were made by the Expedition 10 crew, and the Expedition 11 crew may challenge that record.

Meanwhile, I recently participated in an ARISS contact for the Hockaday School Summer Program in Dallas, Texas and thoroughly enjoyed it, along with the other members of the ARISS ground crew from Fort Worth and Denton, Texas (photo D). See you here again next quarter!

73, Keith, W5IU

VHF+ PUBLIC SERVICE

Amateur Radio Support for Hospitals—A 25-Year Legacy

The First Steps in Supporting Hospital Communications

When a busy hospital loses its telephone service for any reason, it's a disaster for the staff and the patients. Admitting orders; requests for supplies, medicine, and blood; as well as calls to the Code Blue team depend on the telephone and paging systems.

In the Spring 2005 issue of *CQ VHF* I wrote about how hams stepped in 25 years ago when phones failed in a Fullerton, California hospital, eventually leading to the formation of an organization dedicated to backing up communications critical to patient care. All of us in the Hospital Disaster Support Communications System (HDSCS) firmly believe that hams everywhere must do more to meet the communications needs of their local medical facilities. This month I'll delve into the priorities and issues facing leaders of amateur radio emergency groups that take on this mission.

HDSCS Emergency Activations

68 Single-hospital telephone outages, due to
- **Switchboard/computer failures**
- **Severed cables (backhoes, etc.)**
- **Power failures and construction accidents**

7 Earthquakes
5 HazMat incidents
3 Wildfires
3 Floods
1 Mass-casualty incident
1 Area-wide phone outage

HDSCS has activated 88 times in response to communications failures affecting medical facilities. Of these, over three-fourths were single-hospital phone outages where the flow of important medical information was interrupted. If you think your ham group should only be planning to serve in widespread disasters such as hurricanes and earthquakes, please think again.

The Priorities

After the 1979 phone failure at St. Jude Hospital and subsequent ARES participation in a disaster drill there, six more hospitals in the county asked for ham radio support. What should the first priority be in providing that support?

A. Install an amateur radio station in each hospital.
B. Hold a class to get the hospital employees licensed.
C. Set up alerting plans for hospitals to get local ham help rapidly.

The correct answer is "C." Although it may seem counterintuitive, an installed ham station within a hospital is generally of limited use when phones fail and so should have a very low priority. Well-prepared hams with their own "go kits" are far more important. The only exception is hospital rooftop antennas; they can be quite helpful but should not be depended upon. This concept is so important that equipment preparedness for hospital support will be the topic of a future column.

Ham radio licensed employees in hospitals are not a complete solution, or even an adequate one. On average, we have needed a total of eleven hams for first response and relief in our single-hospital phone failure callouts, and sometimes lots more. Having a few hospital employees with tickets is far from enough, and when they're not at the facility in the wee hours, how will the hospital get help from ham radio operators?

Hospital employees all have important jobs already, and when they are doing them they won't be able to pay proper attention to the ham radio network. How much better it is to have a group of outside volunteer hams at the ready, as we do, to go into the hospital and be dedicated to performing communication tasks while the hospital folks go about their important patient care duties. Hospital hams may be helpful in non-emergency situations for liaison and education, if they happen to be interested. However, they should not be the primary amateur radio resource for their hospitals.

St. Jude Hospital had an installed HF station in the Rehabilitation Unit and one licensed employee (me) with portable 2-meter equipment in a desk drawer at the time of the 1979 phone outage. However, the stark reality was that the amateur radio response was sub-par back then, because there was no activation plan to bring in a sufficient number of communicators to assist the hospital. Although it was better than nothing, it was clear to me that there had to be a more reliable way for hospitals to get help from hams.

If, instead of a switchboard failure, an earthquake had occurred and severely damaged the hospital, a sufficient number of hams would not have thought to respond automatically. Even if they had, the hospital would not have known what to do with them. The use of amateur radio is not intuitive to non-ham hospital staff. It must be learned before the need occurs.

For the first Orange County hospital drill that included amateur radio, seven ARES members arrived at St. Jude Hospital prior to the start. All were set up in various units when the scenario began. Much was learned that day. The hospital staff members were certainly pleased with our communications capabil-

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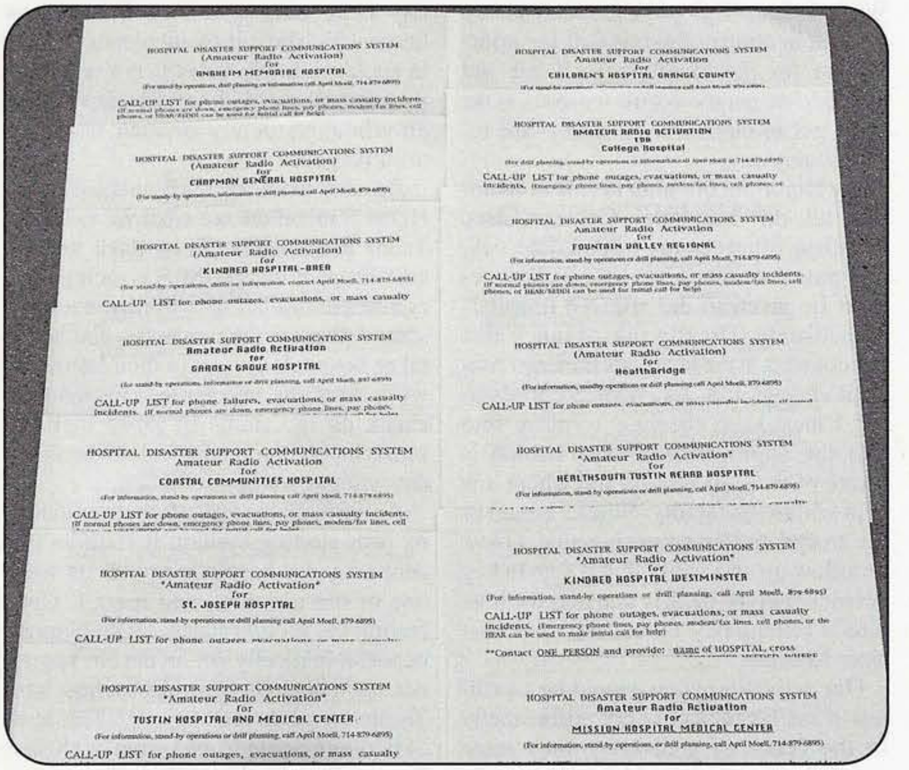

On display are Call-up Lists for 14 of the 33 hospitals currently served by HDSCS. Each hospital's list is tailored for its location and updated regularly. It includes both voice numbers and a unique pager code.

ities, but the drill did not teach them how to activate this group of communicators. The hams had not yet come to grips with how they would be notified if the real thing happened.

We realized this in our debriefing, and our first follow-up goal was to develop an activation plan for any localized hospital phone failure or mass-casualty incident. We knew that we couldn't wait, because the next emergency might happen at any time. With seven hospitals wanting amateur radio support and one of them asking "how will someone know we have problems in a major area wide disaster?" it was clear that we had our work cut out for us. A plaintive call on a repeater could never be a reliable callout procedure, certainly not one that could be written up in the hospital's formal disaster plan.

Direct Call-up Saves Vital Minutes

There are four crucial components to a successful activation procedure:

1. Direct access to hams
2. Redundancy
3. Regular review and update
4. Tests and drills

On a daily basis, hospital communications are time-critical and life-critical, so direct access from hospitals to the amateur radio emergency group is vital. Any "middlemen" waste precious time. I am aware of emergency groups in other parts of the country that are sponsored by local fire or law-enforcement agencies. The procedure that these groups tend to use, if they support the local hospitals at all, is to tell them to contact the fire or law-enforcement agency. In turn, these public-safety officials are supposed to initiate a callout of the hams.

This two-step process creates inevitable and unacceptable delays, even if the public-safety agency is prompt in responding to the hospital's request. A single-hospital phone outage is unlikely to become an officially declared disaster, even though it can be disastrous for individual patients in critical condition in that hospital. How will government agencies prioritize the phone failure, compared to a major fire or car chase that may be ongoing at the same time? In a mass-casualty situation, police and fire agencies may not be aware of any resulting hospital phone overload, and a ham response to the hospitals will not be near the top of their action lists.

Operating within the ARRL ARES (Amateur Radio Emergency Service) structure has made it a one-step process for hospitals to contact HDSCS directly. We know that this saves valuable time. In one phone failure, first HDSCS responders had been on site providing communications for 30 minutes, with more on the way, when the Orange County Communications Center called to alert me about the same outage. I was glad to have the backup of the Communications Center's call, but the hospital's ability to directly alert us had saved priceless time.

An alerting plan is not adequate without redundancy in both the hams to be called and the methods to call them. No person is available every hour of every day, yet I have had hospital personnel from outside my area tell me, "The leader of the Podunk ham club gave me his card and said if I ever had a communications problem to just call him." Do you really think that's a plan? What if the ham's phone line is busy or the hospital gets his phone machine? Worse yet, what if the hospital calls two years later and finds out that the ham contact is deceased? (I've heard that this actually happened in another state!)

Every hospital supported by HDSCS is given its own Call-up List of three persons for daytime/weekdays and three for evening/weekends. Depending on availability, the same hams might be on both day and evening lists. In every case, the persons on the Call-up List are normally available by phone at that time of day and are well versed on the activation procedures of HDSCS. They are not necessarily first responders themselves.

After a member on the Call-up List receives an emergency call from a hospital and obtains information on the emergency, it is up to him or her to immediately initiate an appropriate activation of the system. Hospital staff cannot take the time to make additional calls for us after the first successful one. Upon being called, the member first contacts one or more of the coordinators.[1] He or she then responds to the hospital, calls other members to do so, or establishes net control, as directed by the coordinator.

Names on the Call-up Lists are a mix of coordinators and experienced members. All are knowledgeable about the information that must be obtained from the calling hospital, and they are very familiar with how the amateur radio team functions. Because Orange County is a large area, the Call-up Lists reflect the geographic distribution of the members. Wherever possible, persons on each hospital's list are within a few minutes' drive of the facility.

You are probably wondering how HDSCS is contacted by a hospital if its phones are out. Depending on the nature of the outage, there are several effective ways. When switchboard equipment fails and underground lines are intact, HDSCS frequently is contacted from pay phones. Many hospitals have a few emergency phones that are separate from the main system, and/or a special emergency system that takes over the trunks when the normal switchboard goes down. Although such systems have only a very limited number of lines, they are adequate to activate the amateur radio team. Fax and modem lines separate from the main phone system are another possibility.

When underground cables are severed, affecting all lines to and from the hospital, cell phones have been used by hospital staff to call for help. An example was the 16-hour activation at Tustin Hospital last year.[2] In another instance, the employee was only able to get out the name of the hospital before his cell phone's batteries failed. However, that was enough to get our response going. Orange County has a hospital radio/data system called HEAR/ReddiNet, and any hospital can use it to contact another hospital, which could in turn alert the hams using its Call-up List. The same relay alert can be done via the hospital's paramedic base radio, if one is present.

Pagers are also an important part of the HDSCS activation system. Even though each hospital has at least three member voice numbers to contact, day or night, it is possible that all might be busy or not answered by a person. This was the case when West Anaheim Medical Center lost phones on the morning of Field Day 2004, when most members were away from home.[3] In a major mass-casualty incident or potential evacuation situation, hospital staff may be unable to take the time to call numbers until an answer is received, and then give details to a member. For both of these circumstances, our hospitals have a pager number to call, which brings a full response from HDSCS.

For pager response, each hospital is assigned a unique three-digit number that the caller inputs instead of a return phone number. The three-digit number immediately identifies the facility in trouble, without the page recipient having to recognize the phone number or call it back. When a three-digit page is received, we attempt to contact the hospital for information on the emergency. If we get through, we get the details we need. If we can't get through, we go into a full response anyway.

An important ongoing task is to maintain all the hospitals' Call-up Lists. Members often change work, home, cell, and pager numbers, and these changes must be given to the affected hospitals immediately. The flip side of this is that our contacts at the hospitals undergo constant change, too. As HDSCS coordinator, I must keep checking to make sure that the appropriate contact person is aware of the Call-up List and where it is kept within the facility. When I e-mail or fax an updated list to any hospital, I have to follow up and verify that it gets to key personnel in the facility and into the hospital's Emergency Procedures and Disaster Manual.

Our activation plans would be worthless if the hospitals did not utilize them. In the chaos of a disaster, they must remember to call us and know how to do so. The standardized Hospital Emergency Incident Command System (HEICS), used by all Orange County hospitals for mass-casualty incidents and other situations where an emergency is declared, calls for the Hospital Communications Officer to initiate an activation of amateur radio communications support. However, a one-hospital switchboard or trunk-line failure rarely results in a formal HEICS activation.

To ensure that hospitals practice calling hams, we include our activation in the mass-casualty drills which include every hospital over the course of a year. Rather than have hams in place within the hospital at the start of the drill, they are pre-staged nearby. Each hospital must go through its call-up procedure before the hams enter and join the net. Besides ensuring that the hospitals are familiar with the location of their Call-up Lists and the need to use them, our members have the valuable experience of coming into the hospital and setting up as the simulated emergency is in full swing.

Core Teams Provide Automatic Response

A tornado, earthquake, hurricane, or other major disaster may disrupt all telephone communications over a wide area, making it impossible for hospitals to call hams for help. Hams cannot assume that city and county agencies will somehow know which hospitals are in need of help in such cases. No news is not necessarily good news, and hospitals must not be afterthoughts in any amateur radio disaster response.

Besides being on Call-up Lists, most HDSCS members are what we call Core Team Responders. They have made a commitment that HDSCS is their primary amateur radio responsibility in a widespread disaster. They identify the hospital or hospitals closest to their home and work locations, and agree to respond and check on the status of those facilities immediately upon learning of the disaster, without waiting for a call.

An earthquake, tornado, or hurricane is its own alerting system. It shouldn't be necessary for hospitals to call us when one of these occurs, and it isn't. Upon feeling the ground shake, HDSCS members automatically get on the air, begin a net, and check on their closest hospitals. Similarly, when HDSCS members learn of flooding or wildfires within or close to Orange County, the group activates a net and checks on the hospitals most likely to be affected.

In our 25 years, rapid automatic response has proved vital in several emergencies. After the twin Landers (magnitude 7.3) and Big Bear (magnitude 6.4) earthquakes that occurred during Field Day 1992, HDSCS members immediately left their homes and Field Day sites to check on 34 hospitals in the county. We determined the status of most of them in less than 90 minutes and all of them within three hours. Member Gary Holoubek, WB6GCT, arrived at Buena Park Doctors Hospital to find it completely dark because the emergency generator had started and then failed. All of the facility's phones were down, too. Besides providing emergency communications, we obtained a priority response from Southern California Edison.[4]

Immediate Core Team response was important during the Laguna firestorm of 1993. One hospital asked for support and told of difficulty getting through to other hospitals in that part of the county. We responded to that one and also to three others that were eventually affected, saving valuable time. Moments after the 2002 Placentia Train collision took place, we were aware of the disaster and the location. We didn't wait for hospitals to call or page us, so when some of our hospitals called after getting their own Emergency Command Posts set up, our

HDSCS communicators were already heading into these hospitals or parking their vehicles, ready to go in.[5]

Rounding Up the Hams

An up-to-date roster of trained and prepared responders is the most important tool for activation of members in a call-up response. Just jumping on a repeater and trying to get anyone you can, as I had to do in 1979, might ultimately bring some help. However, it carries the risk of attracting some who are neither prepared nor suitable for communications in a hospital environment. Hams on the HDSCS roster have agreed to be hospital responders, to keep prepared, and to participate in regular training and drills. Even if your community does not have a specialized hospital response group such as ours, I recommend that there be a special list of hams identified for response to hospitals.

HDSCS members are encouraged to monitor our repeaters. A call there will usually yield some members who can respond immediately. Typically, though, more are needed and we turn to the roster. Besides a complete printout of members with home, work, cell, and pager phone numbers for each, our Coordinators have special First Wave lists that identify the eight members who should be called first for each hospital, in daytime or evening. Because the hams on these lists are the ones likely to be closest and most available to the facility in need, our response time is greatly improved.

As with the hospital Call-up Lists, our rosters and First Wave lists undergo constant revision. HDSCS members take our mission seriously and promptly advise coordinators of any changes in phone numbers and work schedules. Roster updates are disseminated to all members via e-mail as they come in.

In a Core Team response after an area-wide disaster, HDSCS members come up on our designated frequencies and advise net control as to which hospitals they are responding, based on their proximity at the time. If net control determines that some hospitals are being "left out" while others are "overcovered," responders are immediately reassigned as needed. The primary goal in the initial response is to ensure that all of our served hospitals are provided with a link to the outside world until their normal communications can be re-established.

If amateur radio operators wish to be viewed as serious about support to any agency, then they must be prepared at home and in their vehicles. An emergency communicator should not have to go home to grab gear out of the shack before responding to an assignment. HDSCS members perform equipment and personal preparedness such that they can make a Call-up or Core Team response immediately from their place of employment or from home.

Our family obligations come before our amateur radio responsibilities, of course. Hospitals have the same issues when calling in their own employees for emergency service. Therefore, we have found that they understand our occasional need to bring children or other family members with us on Core Team responses. Of course, having more than one HDSCS member in a family is a definite plus!

If a hospital in your area had a phone failure right now, what would staff members do? Would they know how to call for amateur radio help? Would they even think about amateur radio as a source of communications, both from unit to unit within the facility and from the hospital to their physicians and suppliers?

Amateur radio operators want our hobby to be known as a national resource and we like to wear T-shirts that say "Amateur Radio, When All Else Fails." However, we are no resource at all if important local agencies such as hospitals don't know that we can help and don't know how they can access our services. We aren't a viable resource if we don't plan ahead for how we will activate rapidly and serve these agencies.

With regular contact and activation procedures in place, amateur radio will be of service to hospitals long before all else fails. That's important, because when it comes to patients' lives and well-being, if hams wait until all else fails, they have waited too long.

Notes

1. At present, there are seven coordinators of HDSCS, including April Moell, WA6OPS, and six assistants. Total membership is approximately 75.

2. Details of this activation are at <http://members.aol.com/emcom4hosp/tustin04.html>.

3. Details of this activation are at <http://www.arrl.org/news/features/2004/06/30/1/?nc=1>.

4. Details of this activation are at <http://members.aol.com/emcom4hosp/history.html>.

5. Details of this activation are at <http://members.aol.com/emcom4hosp/metro2.html>

By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Bouncing VHF Signals Off "Shooting Stars"

Several times each year VHF enthusiasts are presented with the exotic operating opportunity created by shooting stars. The intense ionization caused by a meteor's demise as it burns its way into our atmosphere can be enough to reflect or refract VHF radio signals, making possible radio communication between two stations beyond line-of-sight, if only for a very short moment.

Reflecting VHF radio signals off meteor trails during one of the year's annual meteor showers is an activity that has been enjoyed for decades. Now new methods and techniques are being developed and explored using modern computing power. The newest tools even allow radio contact during periods outside the major meteor showers.

It is typical during major meteor showers for hundreds of two-way contacts (QSOs) to be made. I've even had the joy of making a few quick contacts between my meager station (a vertical mobile antenna tuned for 6 meters, with 100 watts on SSB) and stations up to two states away. This was accomplished during the *Leonids* meteor shower a few years ago. With the newest software tools, and with good equipment and a good antenna, along with prearranged schedules, many amateur radio weak-signal communicators make quite a few contacts all year long.

Most schedules in North America between VHF meteor-scatter DXers are for SSB QSOs. When using SSB, a 15-second sequence is standard, where the westernmost station calls first, and the rest of the minute is spent listening for the reply from the called station. Most often a QSO is completed on a long burn lasting several seconds. However, because most meteors only last from close to one-quarter second to a couple of seconds, there's usually not nearly enough time to get much information through on SSB.

This is overcome by using high-speed CW. If you tried to keep a 2-meter meteor scatter schedule with a station some 1000 miles away, you might hear five to ten short "pings" (a burst of radio propagation caused by the rapidly formed and short-lived meteor-trail ionization) lasting anywhere from a tenth of a second up to two seconds in length. A ping under a half of a second would be absolutely useless on sideband. Enter high-speed CW. With HSCW you could realize a speed of 2000 letters per minute (2000 lpm). In that same half-of-a-second ping 16 letters could be propagated to the receiving station. That is enough for a complete exchange and signal report! High-speed CW is more commonly called high-speed meteor scatter, or HSMS.

To ensure that only one station is transmitting at a time during a schedule, HSMS stations in North America transmit on alternate minutes. Typically, the westernmost station transmits on the even-numbered minutes while the easternmost station transmits on the odd-numbered minutes. During a minute, a meteor may fly between the two stations and briefly reflect a VHF radio signal. The QSO is completed when both stations have heard each other's callsign, a signal report (or some other piece of information), and the final "Roger." On 2 meters schedules usually last a half hour to one hour. I'll dig deeper into this mode later on in the column.

Meteor Scatter Mode

Meteors are particles (debris from a passing comet) ranging in size from a speck of dust to a small pebble, and some move slowly while some move fast. When you view a meteor you typically see a streak that persists for a little while after the meteor vanishes. This "streak" is called the "train" and is basically a trail of glowing plasma left in the wake of the meteor. Meteors enter Earth's atmosphere traveling at speeds sometimes well over 158,000 miles per hour. The trains can last from several seconds to several minutes.

Meteor-scatter propagation is a mode where radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E* layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports a 60-second refraction on 6 meters might only support a 1-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

A great introduction by Shelby Ennis, W8WN, on working meteor scatter is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. OZ1RH wrote "Working DX on a Dead 50MHz Band Using Meteor Scatter," which is a great working guide <http://www.uksmg.org/deadband.htm>. W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

Perseids Meteor Shower

One of the most reliable yearly meteor showers is the *Perseids*. This shower, like other meteor showers, is named after the constellation from which it first appeared to have come. The shower's constellation is Perseus, which is located near Cassiopeia. *Perseids* favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

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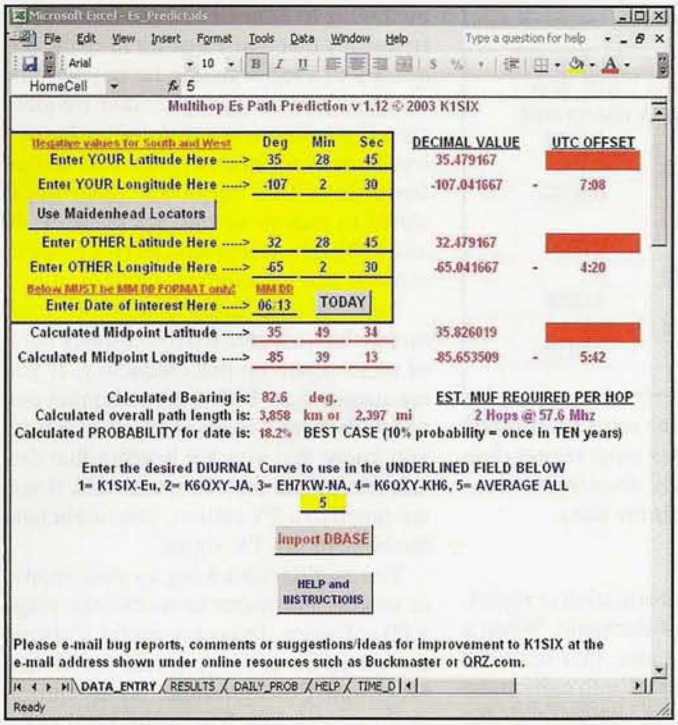
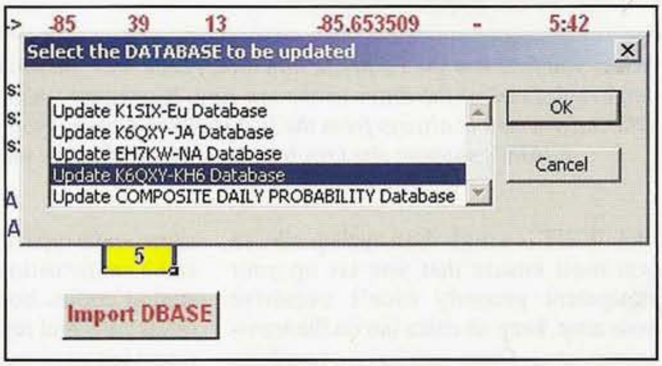


Bob Mobile, K1SIX's multi-hop sporadic-E prediction tool. With this spreadsheet application you might be able to increase your success rate by discovering possible windows of opportunity for establishing a QSO between you and a selected grid square.

Illustration of importing the most recent data into the database tables. Once you download the updates, place them into the default location for documents (typically in your Documents folder). Then select the Import button, which results in this dialog. Select each option, one at a time, to import that database.



Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three years later Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseids* meteors. The comet, known now as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

This year the shower will be active from July 17 through August 24. The peak is expected to be around August 12, between 1700 UTC and 1930 UTC. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contacts.

There was a prediction that last year's *Perseids* meteor shower would produce a "meteor storm," with hundreds of meteors per hour. This prediction did not pan out. However, some researchers are still suggesting, based on careful analysis and modeling, that this year or next might see a return of the primary peak with a high rate per hour.

The *Perseids* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter this could prove to be an exciting event.

The best time to work the *Perseids* VHF/UHF meteor scatter in North America is during the hours before dawn, as early as midnight, but more likely peaking after 2:00 AM until about 5:00 AM local time.

The characteristic *Perseids* burn is bright white or yellow and typically lasts less than a half second. The brighter meteors usually leave a persistent train or "smoke trail" that lasts a second or two after the meteor has vanished. This is not really smoke at all, but rather ionized gas created by the meteor passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Setting Up a *Perseids* VHF Schedule

If you have a reasonably powered computer with a sound card you could try your hand at using a digital mode for meteor scatter during the *Perseids* shower. Visit <http:// www.vhfdx.de/wsjt/> to obtain your copy of the WSJT computer program. WSJT stands for "Weak Signal communication, by K1JT." This program was created by Joe Taylor, a 1993 Nobel Laureate in Physics for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation. The program currently supports four principal modes, two of which primarily are useful for weak-signal communications via the short pings from meteor trails. These two modes are FSK441 and JT6M. JT6M is especially optimized for working meteor scatter on 6 meters, while FSK441 works well up into the higher VHF bands.

With either of these modes, the QSO exchange is much like other digital modes, where the communication is tex-

	C	D	E	F	G
	LAST UPDATED ------->	21-Aug-04	21-Aug-04	25-Aug-04	21-Aug-04
	FILENAME.dat ------->	SIX_Diur	JA_Diur	EA7_Diur	KH6_Diur
:L	DIURNAL DATA x DAILY PROB	K1SIX-Eu	K6QXY-JA	EH7KW-NA	K6QXY-KH6
	0.0000				0.0000
	0.0000	0.0005	0.0000	0.0000	
	0.0010				0.0058
	0.0001	0.0000	0.0000	0.0012	
	0.0000				0.0000
	0.0008	0.0097	0.0000	0.0043	
	0.0010				0.0058
	0.0013	0.0166	0.0000	0.0074	
	0.0019				0.0116

When you first run the Es *prediction tool, check that you have the most recent data imported. Look at the dates in the top row. If you don't have the most recent data (the most recent is always from the last summer season), you may download it from K1SIX's support site (see text for URL) and easily import the data.*

tual. WSJT is a high-duty cycle mode, so you must ensure that you set up your equipment properly (don't overdrive your amp, keep an extra fan on the transceiver, etc.). Once you have everything set up for operation, announce yourself on one of the scheduling sites on the Internet. Three of these are <http://www.pingjockey.net/cgi-bin/pingtalk>, <http://www.meteorscatter.net/>, and <http://dxworld.com/vhfsked.html>.

Most meteor schedules will run for 30 minutes, but they can be shorter or longer. You and the other operator must agree beforehand so that you are coordinated. Remember to follow the standard format, where the westernmost station transmits the call for the first 30 seconds while the other station listens. Then the other station transmits for the next 30 seconds. Each minute is broken in two parts, 30 seconds each part. The station in the most western end of the path will transmit during the first 30-second period. The most eastern station takes the second period to transmit. This requires that both of you are set to the same time, exact to the second.

When it is your turn during the minute, you would transmit something such as "KD7QKT NW7US KD7QKT NW7US KD7QKT NW7US." The idea is to keep things short and sweet. At least halfway into your 30-second period you might break your transmission for a pause, to see if there is a meteor burst that your schedule partner wants to take advantage of. A pause like this, of a second or two, gives the other station a chance to transmit data, if possible. Of course, you might pause a few times during each period.

What do you exchange? As with any mode of operation, you exchange callsigns, some type of information or report, and a confirmation of the same. When a station copies both calls, that operator sends calls and report. If both calls and a report are received, that station sends the report and a "Roger." When both get a pair of "Rogers" (this might take several exchanges) the QSO is officially complete. However, the other station will not know this. Therefore, it is customary to then send "73" to let the other station know that it's complete, even though the "73" is not required for a complete QSO. Mobile, portable, and DXpedition stations normally never send 73 unless they're shutting down, but instead return to calling CQ immediately after the exchange of Rogers. Full details are published at <http://www.qsl.net/w8wn/hscw/papers/hscw-sop.html>.

Can You Listen In?

It is possible for you to listen for meteor-scatter bursts. Some even hook up special software to graph the meteor-shower radio activity. You may also "tune in" via the Internet. Three sites that provide an opportunity to listen in are the Roswell, New Mexico forward-scatter radar at <http://science.nasa.gov/audio/meteor/meteorburst.m3u>, the Huntsville, Alabama forward-scatter radar at <http://science.nasa.gov/audio/meteor/forward-scat.m3u>, and the Naval Space Surveillance Radar in Roswell at <http://science.nasa.gov/audio/meteor/navspasur.m3u>. The best time to monitor is just before local dawn at these locations on August 13.

However, let's look at how you might listen in with your own radio. One method is to tune an FM radio to a clear frequency that is also known to be the frequency of a radio station far beyond line of sight. You can also use other frequencies, if you know of a transmitter located hundreds of miles away, licensed on that frequency. The frequency range most suited to meteor scatter lies between 40 and 110 MHz. It is most effective to select stations that are north or south of you.

You can then listen and record each meteor burst, identified by the quick burst of radio signal on that frequency. If you are tuned to an FM station channel and suddenly hear a burst of voice or music, you know that you are hearing that distant station via meteor scatter. Or, if you are tuned to a TV station, you might hear the buzz of the TV signal.

You might try hooking up your receiver to your computer to record the pings with software. Two very useful software tools used for this purpose are the Meteor DOS and Colorgramme. Visit <http://radio.meteor.free.fr/us/main.html> for details and download information. These are free specialized software programs used to detect and record radio signal echoes produced by meteor-shower pings.

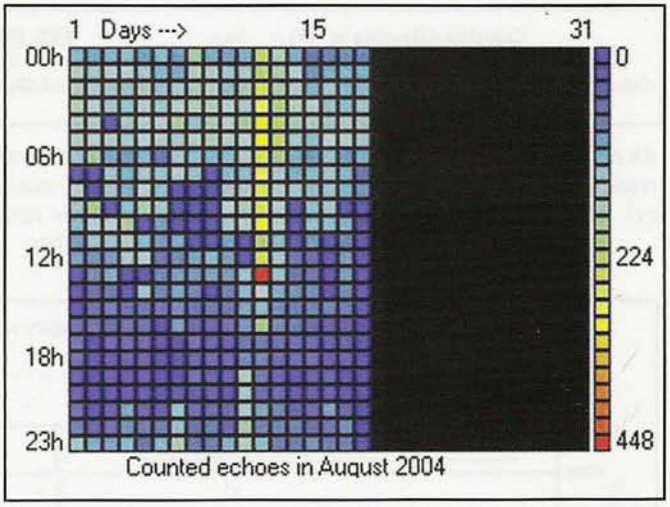
Finally, check out the Audio Gallery of Radiometeor Events at <http://www.amsmeteors.org/audio/index.html>. This site offers actual recordings of radio energy created by the meteors as they burn up.

Other Meteor Showers of Summer

Look for the *Draconids,* a primarily periodic shower which produced spectacular, brief meteor storms twice in the last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of a ZHR (zenith hourly rate) reaching 700. This was due to the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. The next return of the comet is in mid 2005. This year's peak is expected to occur on October 8 at 1600 UTC. The shower should be active from October 6 through October 10. The *Draconid* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year.

Another expected shower is the *Orionids,* active from October 2 through November 11, peaking on October 21

The main setup section of the main screen (first tab). This is where you enter your location, the distant station's coordinates, and other information needed to run the prediction. You can use grid squares or enter the latitude and longitude manually.



Using the Meteor DOS and Colorgramme programs you can produce a graph of your meteor-scatter reception with results like this example. This example is from the Perseids *meteor shower in 2004. Note the one hour when the echo rate reached 448 per hour!*

at 2000 UTC. The hourly rate could reach about 60 meteors per hour.

For more information, take a look at <http://www.imo.net/calendar/cal05.html>. Also check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and up-coming showers.

Sporadic-*E* Update

The season up until press time has been somewhat slow in North America. However, some very nice openings have been reported. Activity on 6 meters early in the season generated quite some excitement. Reports have been made of openings between New Mexico and stations as far away as 1800 miles that lasted from before 7 AM local time to nearly midnight. Other long openings on the East Coast and over other paths have been reported.

How have your sporadic-*E* experiences been this year? How does this year compare with previous seasons? Send me a note with your observations. I'll compile a summary for the next issue.

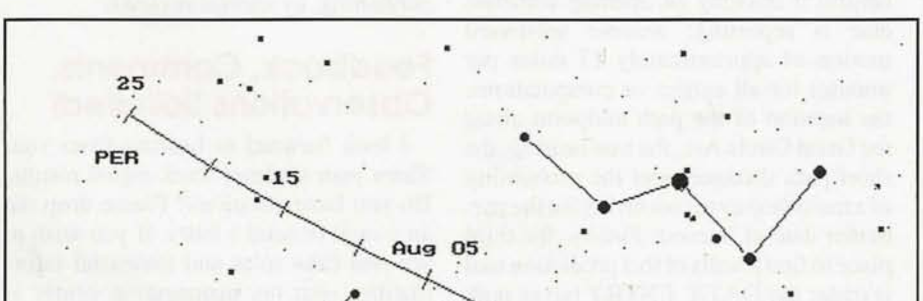
Check Out the Sporadic-*E* Prediction Tool

I've taken a look at Bob Mobile, K1SIX's Multi-hop Es Prediction Application <http://k1six.com/EsPredictApp.htm>. This tool has some interesting potential. This spreadsheet application is useful for mid-northern latitude paths where both ends are above five degrees north latitude. Using tables of data compiled from previous seasons, you can make a probability prediction of an opening between your station, and a grid square out beyond a single-hop. The prediction specifically is for the probability for multi-hop sporadic-*E* propagation of 50 MHz during the Northern Hemisphere peak *Es* season (May through August).

K1SIX writes, "*Es* may not be quite as 'sporadic' as once thought. In fact, it appears that there are certain repeatable characteristics and cyclical qualities to this mode of propagation that, once understood, may lead to a much higher probability of successful communications links across very large distances (up to and possibly beyond 10,000 km at 50 MHz!) in the VHF range. Who knows? With the proper 'tools,' some of these events may become quite predictable." Bob created this spreadsheet application as an attempt at compiling QSO data into tables that can be used to calculate the probability and best times for mid-northern latitude 50-MHz multi-hop *Es* paths between the two points entered by the user.

Bob's application includes five tables (databases) that must be updated each year. His website contains the latest tables, and the tool has a simple import utility. All of these five tables are updated at some point after the end of each summer *Es* season.

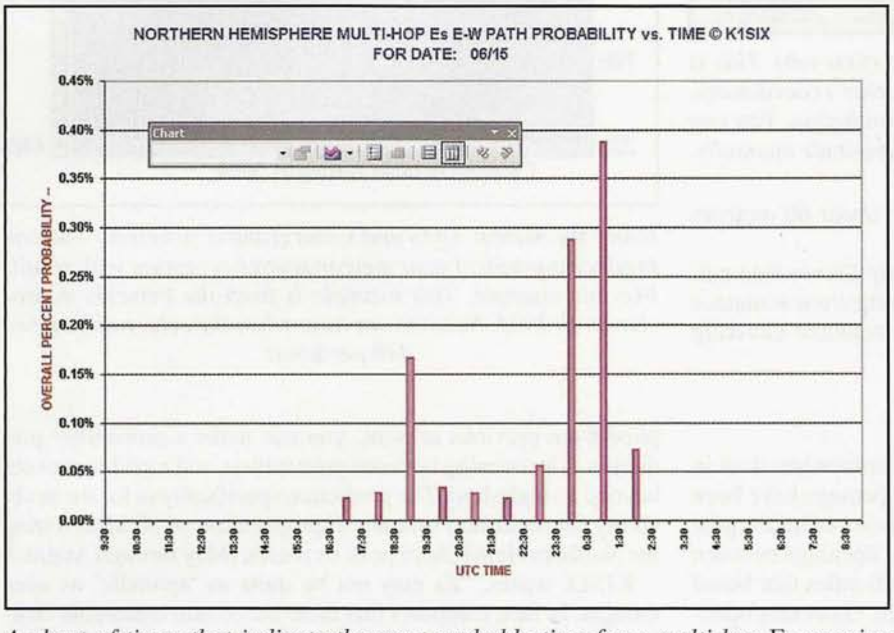
To use the application, you open the spreadsheet and enter in critical items of data under the DATA_ENTRY tab. This is considered the main screen for the tool. The first step is to enter your location either by providing your latitude and longitude using negative degrees for south latitudes and west longitudes (for instance, I am in Washington State, so my longitude is –122), or by pressing the "Use Maidenhead Locators" button to use grids for entry (in my case, CN87MQ). When using



The Perseids *meteor shower radient sky chart. (Source: IMO)*

Calculated Bearing is: 132.4 deg.		**EST. MUF REQUIRED PER HOP**
Calculated overall path length is: 5,154 km or 3,203 mi		3 Hops @ 64.0 Mhz
Calculated PROBABILITY for date is: 26.8%	**BEST CASE (10% probability = once in TEN years)**	

An example of the results from a prediction. Note that in this example the QSO would require three E-layer *hops (*Es *hops) at 64 MHz (MUF, maximum usable frequency). The probability is bleak, but as shown in the other results example, you are looking for "windows" of possibility.*



A chart of times that indicate the most probable time for a multi-hop Es *opening between the two grid squares you've entered for prediction. In this example run, the most probable time on June 15 would be at 0100 UTC.*

grids with two- or four-character input, the program will force the entry to the center of either the field or the locator. Input error checking is included.

Next you need to enter the date of your prediction. If you don't provide the date, the calculations will fail. Enter the date in MM/DD format. Finally, a diurnal database option between 1 and 5 must be entered into the data entry zone just above the Import DBASE button. An entry of 5 will average all of the diurnal database table data to give a composite model.

You can change any of these parameters to see how the results change. Depending upon location entered, you may see a better fit using a particular model. However, some of these diurnal models may not be statistically significant until a larger sample is gathered. This is one of the reasons a DBASE Update and Import Utility was designed.

The results of the computation show up in three places. The first is under the RESULTS tab. This is probably the most interesting. The chart displays the overall probability for the path at 30-minute increments of UTC time on the X axis versus percent probability on the Y axis. The second result location is under the DATA_ENTRY tab and is colored as red data, which includes the equivalent decimal degrees for all entries or computations, UTC offset time presented unrounded to minute resolution (may be helpful if tracking an opening someone else is reporting; assume westward motion of approximately 17 miles per minute) for all entries or computations, the location of the path midpoint along the Great Circle Arc, the true bearing, the short-path distance, and the probability of a multi-hop event occurring for the particular date of interest. Finally, the third place to find results of this prediction tool is under the DATA_ENTRY tab as pink data items which include the estimated number of *E*-layer hops required for the path of interest and the estimated MUF for each of the hops, assuming an operating frequency of 50.1 MHz. No attempt is made to account for cloud-to-cloud or ionospheric tilting. This information may be useful in determining the probability of a multi-hop path for a given range.

Although the probability values are small (and likely accurate), this is all about picking the best times and dates for a particular 50-MHz path of interest. Therefore, changing the dates and experimenting to achieve the "best numbers" will likely pay off.

The Solar Cycle Pulse

The observed sunspot numbers from March through June 2005 are 24.8, 24.4, 42.6, and 39.6. The smoothed sunspot counts for September through December 2004 are 37.6, 35.9, 35.4, and 35.3, continuing on the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from March through June 2005 are 90.0, 85.9, 99.5, and 93.7. The smoothed 10.7-cm radio flux numbers for September through December 2004 are 103.7, 102.1, 101.5, and 101.3.

The smoothed monthly sunspot numbers forecast for August through October 2005 are 19.4, 17.9, and 16.5. Note how these predictions are somewhat higher than the predicted values I gave for May through July 2005, in the last issue of this magazine. The current cycle does seem to have a more gradual decline slope than predicted, so the adjustments are tending to be higher each iteration. The smoothed monthly 10.7 cm is predicted to be 80.6, 78.8, and 77.4 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A* index (*Ap*) numbers from September through December 2004 are 13.6, 13.5, 14.1, and 14.8. The monthly readings from March through June 2005 are 12, 12, 20, and 13.

(Note that some of these reported indices are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Feedback, Comments, Observations Solicited!

I look forward to hearing from you. Share your summer weak-signal results. Do you have questions? Please drop me an e-mail or send a letter. If you wish to see real-time solar and terrestrial information, visit my propagation center at <http://propagation.hfradio.org>. If you have a WAP/WML phone or handheld device, browse at <http://wap.hfradio.org>. Happy weak-signal hunting!

73, Tomas, NW7US/AAA0WA

CQ's 6 Meter and Satellite WAZ Awards

(As of July 31, 2005)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IK0PEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Antenna Measurements and Ranges

This time we will cover some of the different ways of making antenna measurements, along with the advantages and pitfalls of each.

For 30 years now the Central States VHF Society has been holding an antenna contest during its annual conference. I have been doing the microwave portion of this contest for nearly 20 years. During a typical event we measure 100 to 125 antennas on all ham bands between 50 MHz and 47 GHz, and I hope to add 76 GHz for it this July!

Photo A. The 50-MHz antenna range at the 2003 Central States VHF Society Conference, which was held in Tulsa, Oklahoma.

CS VHFS 2003

RF Power—Hewlett Packard power meter and a test antenna. This is possibly one of the simplest ways to measure antenna gain. For the microwave bands the source needs to be running at least 100 milliwatts with a high-gain antenna. The receive end uses a standard RF power meter. The older HP 431s and 432s can be used. The newer 435s and 436s are nice, though, when they are available. Power meters by Marconi, Boolton, and others may also be used.

First connect the power meter to your reference antenna, hold up the antenna, and measure the power. Next connect the test antenna and take the reading. If the test antenna collects 3.2 dB more RF power, then the test antenna has 3.2 dB more gain than the reference antenna. You quickly realize the most important part of this setup is the reference antenna, as you know the gain of it.

Advantages

1. Direct readout of gain in dB
2. Simple

Disadvantages

1. Poor sensitivity; a lot of power is needed.
2. No frequency selectivity. The antenna may be picking up TV stations, etc., and giving a bad reading.

Photo B. The Hewlett Packard 435A power meter. Using a power meter and a test antenna is possibly one of the simplest ways to measure antenna gain.

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e-mail: <wa5vjb@cq-vhf.com>

Photo C. The HP 415E is a tightly tuned 1000-Hz audio meter.

1000 Hz—HP 415R SWR meter with diode detector and external speaker. For many years, the 1000-Hz method was the most commonly used antenna measuring technique. Perhaps you have noticed that many of the RF signal generators have a 1000-Hz AM modulation switch. The signal generator is connected to a source antenna and set to the desired frequency; modulation is set to 1000 Hz AM. At the receive end, both for reference and later, the test antenna is connected to a 1000-Hz AM indicator. Just a simple diode detector is connected to the test antenna. The 1000-Hz indicator and the level of the 1000-Hz audio are measured with a meter not unlike the VU meters we had on tape recorders. You don't have to use a signal generator. Marc, WBØTEM, has even been known to use a Kenwood TS-700 2-meter rig in the AM position as his source for the Central States VHF Society's 2-meter antenna range.

A diode detector typically has a poor SWR, so a 6-dB—or better yet, a 10-dB— attenuator is added to the input of the diode detector. The resistive losses mean a lower signal-to-noise ratio. Therefore, sometimes we may use a 6-dB attenuator when we really should use a 10- or 20-dB pad, but then we need the extra signal. The pad also provided a DC return path for the detector diode.

On the higher bands it is often difficult to find coaxial diode detectors. Fortunately, the HP 415s are quite happy with waveguide detectors. I have also used WR-90 to WR-10 style waveguide mixers as my 1000-Hz detectors.

The diode detector recovers the 1000 Hz AM right at the antenna. In a way, this is just a glorified AM crystal radio with an accurate measurement off the audio level. The HP 415, or one of the many similar units made by Marconi or Narada, contains a tight 1000-Hz filter, so other detected signals are filtered out with a simple audio filter.

Advantages

1. 20–30 dB more sensitive than a simple power meter.
2. Much fewer QRM problems.
3. Direct readout in relative dBs.

Disadvantages

1. Can still pick up TV video buzz and sometimes radar signals.

HP415E Notes. The HP 415E is a tightly tuned 1000-Hz audio meter. If you pick up a used one, first spray all the contacts in the range switch with contact cleaner.

The 415E uses a 700-ma 28-VDC NiCad battery pack. This is overkill, since the 415E pulls less than 10 ma. In the normal range it will work down to 8 VDC. In the expanded dB ranges it needs 16–18 VDC. I just mount a pair of 9-volt dollar-store batteries in mine and then it runs all day! On special occasions I'll put in three alkaline 9-volt batteries, as they seem to last a year or so with my typical operation.

On the back of the 415E is a BNC "Recorder" jack. This was used to drive an external stripchart recorder. The 1000-Hz signal is also on that jack in the same expanded range as the meter. Therefore, signals really jump out at you. Just make a BNC-to-audio adapter for some amplified computer speakers and you can listen to the signal. It's great for peaking the antenna without having to look at the meter. You also can instantly hear any video buzz or other interference on your 1000-Hz test signal.

Yes, it's called an SWR meter, but it was used with a slotted line to measure SWR. It is really just an AC volt meter tuned to 1000 Hz and calibrated in dB on the top and bottom scales. On the expanded scale you can resolve down to a 1/20th of a dB.

Network Analyzer. The "big boys" usually use a network analyzer to make these measurements. It's fancy equipment but very difficult to use in an open field, so it's not really suited to ham-type applications.

Advantages

1. Works over a broad range of frequencies.
2. Direct readout in dBs using the markers, and can output plots.

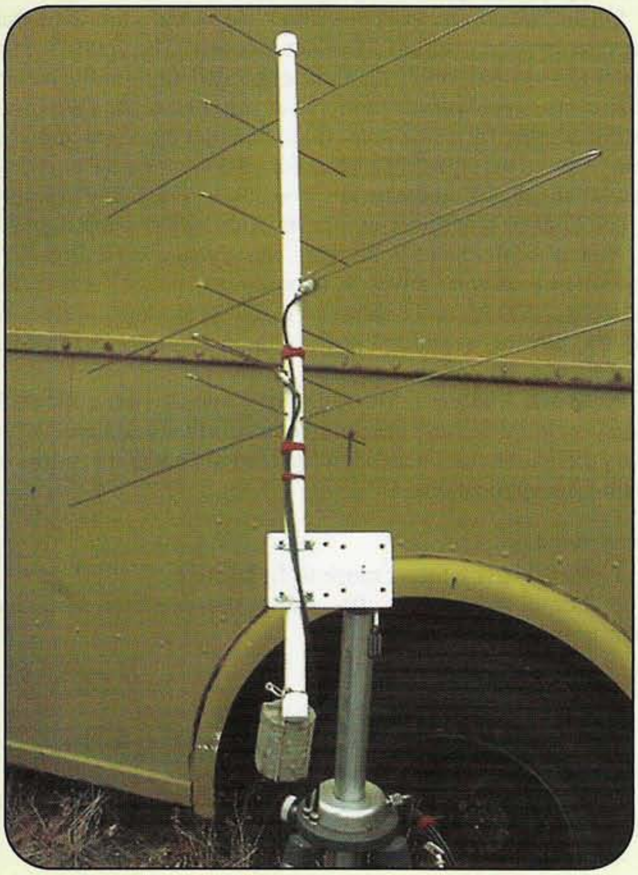
Disadvantages

1. Not a common piece of ham test equipment.
2. Works great in an EMI (electromagnetic interference) chamber, but is difficult to use outdoors.
3. Hard to see the display and peak an antenna when it is in direct sunlight.
4. Can easily be overloaded by local strong signals.

Photo D. Horn antennas are simple, hard to damage, and broadband, and their gain can be calculated with good accuracy. Thus, they make good reference antennas.

Letters, We Get Letters

Doug Wilson, WAØVSL, sent along this photo of his new AMSAT antenna. Doug combined the *CQ VHF* magazine articles about the three-element 145-MHz "cheap Yagi" and the six-element 435-MHz version to build this portable antenna. Thus far he has worked AO-27 and SO-50 with this antenna and a HT.



The new AMSAT antenna of Doug, WAØVSL.

5. Usually doesn't come with 250-foot cables so you can use them on VHF ranges.

Test Volume

You should find a test volume where the signal is constant to less than 1 dB of variation. Test-volume flatness is probably the greatest source of measurement error. If the signal varies by 2 dB over a 4-foot change in elevation or side to side and you are measuring a 4-foot dish, then one edge of the dish is seeing 2 dB more signal than the other edge. While the test equipment might be accurate to 0.1 dB, the measurement is off far more than that. However, with a little tweaking in the test-range geometry we can usually find an area with good signal-level flatness.

Test-volume flatness can be a real problem when comparing one Yagi to an array consisting of four Yagis. The signal is rarely flat on that large an area.

Test Distance

While the above holds true for Yagi arrays as well, it is much easier to visualize with a dish antenna. A dish antenna is focused

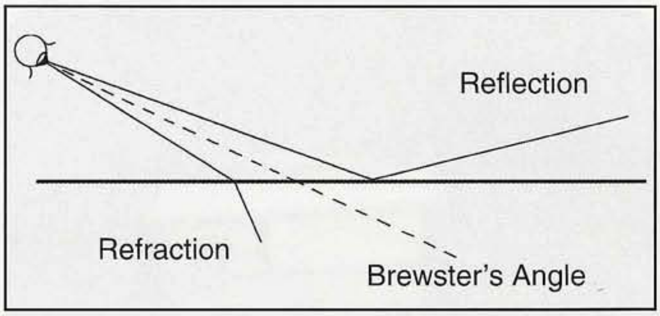


Figure 1. Brewster's Angle.

much like a telescope or a camera. If you test it on a short range, the antenna is out of focus. If you tweak the focus on a short range, the antenna is now "near sighted." I once played on 10 GHz with a 12-foot dish on a 300-foot range. Oh, did I have the signal peaked! Looking for sidelobes, I moved the source around a bit. That's when I learned the beam was over a foot wide at 300 feet. The dish was focused—to a point. It had fantastic gain, but when pointed at the moon the pattern was then too broad. Luckily, not too many hams bring really big antennas to our CS VHF Society antenna contests, but we really have to back up when someone does.

There is a formula for far field:

$R = 2\,(D^2)/\text{Wavelength}$

where:

R = range

D = largest dimension of the aperture

In this case, a 1-meter dish on the 3-cm band (3 footer on 10 GHz for the rest of us) comes out to 67 meters, or about 200 feet. However, that formula is very pessimistic, and we find we can use about half that distance on our ranges with little error.

Reference Antennas

I like to use a horn antenna as my reference antenna whenever practical. They are simple, hard to damage, and broadband, and their gain can be calculated with good accuracy.

For some time now it has been a tradition to measure microwave radar antennas in dBi. The use of dBi simplifies many microwave antenna calculations for beamwidth and gain, so most 902 MHz and up measurements are in dBi.

For the CS VHFS range WBØTEM uses a family of reference Yagis for 50, 144, 222, and 432 MHz. Their gain is taken from a composite of over 25 years of measurements and hours of comparisons to a dipole. On my VHF/UHF range I use a reference log periodic that covers 140 to 1400 MHz.

Going back to the test-volume problems, ideally you like the gain of the reference antenna to be kind of close to the gain of the antenna being tested. Similar "capture areas" help measurement consistency and cut down on linearity problems in test equipment. Using antennas with 10 or 20 dB of difference can introduce errors when the dB range of the equipment is switched.

Brewster's Angle

Brewster's Angle is something we see all the time, but rarely think about it. Imagine you're standing along the shore of a clear mountain lake. The air is perfectly still and there's not a

Photo E. the author's favorite setup is a wide-band antenna and a wide-band signal generator.

ripple on the water. Across the lake you see the trees perfectly mirrored, reflecting off the water. You look down and see the minnows swimming around. *Wait!* Is the water a perfect mirror, or is the water transparent?

About 20 feet out you see a gray area where the water changes from transparent to reflecting. That angle is Brewster's Angle. You can also see this mirror effect on a sheet of plate glass at a shallow angle, and even on a highly polished piece of furniture.

We can use this effect on an antenna range. After all, you wouldn't make a parabolic dish out of asphalt or dirt. Dirt just doesn't reflect well. Yet we use ground bounce to get an extra 3 dB of gain out of many antennas. It's all a matter of angles. At shallow angles the ground looks like a mirror. At steep angles the ground looks like, well, just dirt. As the radio waves get shorter, it gets easier to take advance of Brewster's Angle. We can use a shallow take-off angle and set up a ground-bounce range, or we can elevate the antennas and let the dirt absorb most of the reflections.

Signal to Noise plus Noise

I like to have a 20-dB signal-to-noise ratio on the test ranges. There are several errors when you get close to the noise floor. As an example, if the reference antenna has a 1-dB signal over the noise and the test antenna is 2 dB, the extra gain in the test antenna is 3 dB, not 1 dB. Measurement errors such as this are a problem when the signals are barely above the noise. However, 20 dB extra signal can be a challenge on 24 GHz, 47 GHz, etc., so we often have to use plus 10 dB or so. That's another reason why we don't always like to make the range as long as the far-field equation recommends, but we can still keep the total errors to a few tenths of a dB.

My Favorite Setup

A wide-band antenna with a wide-band signal generator is the easiest setup. The ridge horn works from 1 to 18 GHz. It sure makes changing bands easy when you just have to punch in 2304.1 MHz and then 10368.1 MHz and not even switch antennas. Many of the newest signal generators no longer have a 1000-Hz AM position, but they all seem to have external AM modulation input. Thus, I just hook up a function generator and feed it the 1000-Hz modulation. Sometimes they like square waves and sometimes they like sine waves. I just use whatever gives me the maximum signal level on the HP 415.

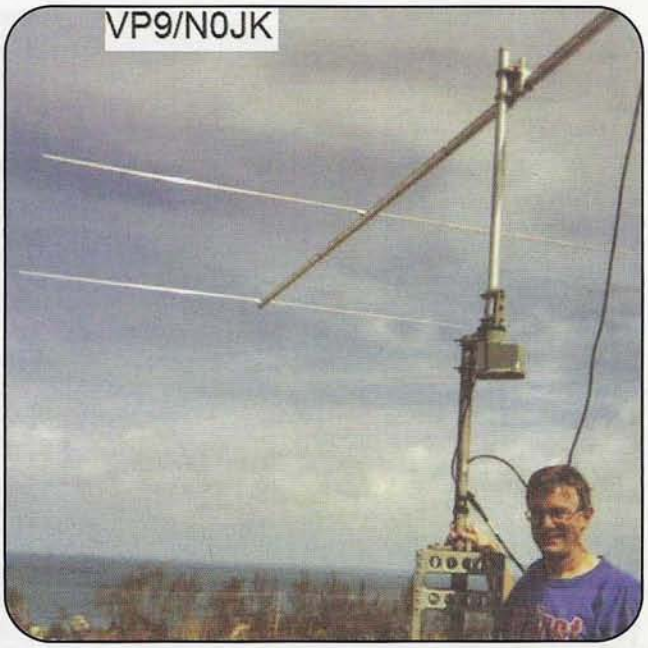
Keep those letters and e-mails coming, gang. You are a great source of information and topics for columns.

73, Kent, WA5VJB

I believe that there is a lack of monitoring of the 2-meter band in general in the weak-signal area around the calling frequency of 144.200 during periods outside of VHF contests. This could be improved by awareness of weather conditions that lead to enhanced conditions. General indications of weather patterns that can lead to potential openings are provided by the Hepburn charts at <http:// home.cogeco.ca/~dxinfo/tropo.html>.

Like 6 meters, 2 meters experiences some propagation conditions that may be misunderstood by amateurs in general. In 2004 CQ published the book *VHF Propagation: A Practical Guide for Radio Amateurs,* written by Gordon West, WB6NOA, and myself (figure 3). This book covers all of the major propagation modes that are seen on the VHF bands, with special emphasis on 6 and 2 meters. An entire chapter of the book is dedicated to tropo, as it is a major mode of propagation on the 2-meter band. An audio CD with samples of different modes of propagation heard on 2 and 6 meters was made to accompany the book.

Two-meter weak-signal activity needs more day-to-day action. If it were not for the contests, and the times when there are some major propagation events, the lower portion of the band would be quiet much of the time.



Here is the simple two-element, 6-meter Yagi setup that Jon Jones, NØJK, used on one of his earliest trips to Bermuda a few years ago. Since then Jon has made several additional trips to Bermuda and has provided hams from both the U.S. and Europe with a chance to work Bermuda on 6 meters. (Photo by NØJK)

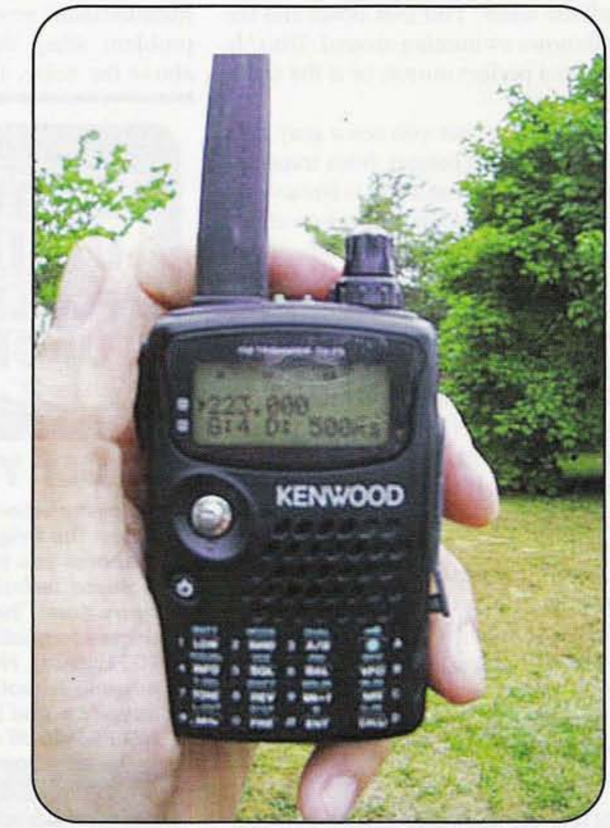
125 cm

Without a doubt, 125 cm, or 222 MHz, is the most under utilized amateur radio band of all, particularly in the area of weak-signal CW and SSB. A fair amount of progress has been made in the area of FM, with a decent variety of radios available over the past decade. However, in the area of weak-signal work there is a significant lack of commercially made CW and SSB gear for the band.

Just like 2 meters, 222 MHz is a good band for tropo enhancement and even for ionospheric skip modes such as sporadic-*E* and aurora backscatter on rare occasions. In fact, with the terrific aurora opening that occurred during the June 2005 VHF contest, a number of stations were able to make several 222-MHz aurora contacts in addition to contacts on the other VHF bands.

Indeed, 222 MHz does seem to generate a small amount of increased activity during the VHF contests held by the ARRL. However, most of the activity is on FM and only in certain areas of the country. When the ARRL publishes the scores for its three annual VHF contests, it shows the band breakdown. On many occasions, even during the September contest, it can be seen that there is a dearth of participation on 222 MHz in many of the major ARRL sections in the northeast and other areas as well.

It would appear that the lack of simple gear for 222-MHz CW and SSB operation has crippled the growth of this band. There was one commercially made single-band weak-signal radio that was made back in the 1980s by ICOM, the IC-375A. This particular radio is very hard to find today, and on e-Bay it can go for several hundred dollars. Transverter kits for 222 MHz are made by Down East Microwave. They are suitable for base-station operation, but perhaps are not quite as easy to set up for mobile or portable operations due to the need for extra wires and modules.



Presently, the only real way many VHF enthusiasts can get on 222 MHz is via the FM mode, either with mobile rigs or HTs such as this Kenwood TH-F6. Until reasonably priced commercial SSB and CW radios become available for 222 MHz, FM will be the dominant mode for this band. (Photo by WB2AMU)

At one point a few years ago I contacted a U.S. ham radio manufacturer with regard to a low-power 222-MHz weak-signal radio. This would have been a very interesting product, but unfortunately the manufacturer ceased operations. Don't expect the Japanese manufacturers to make this type of radio for U.S. hams, as there is no allocation for this band

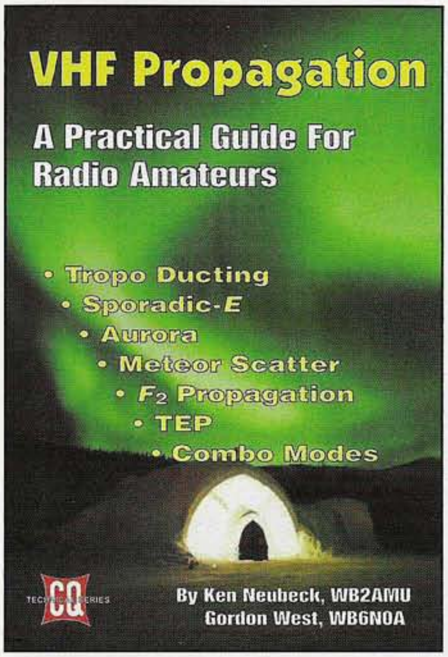


Figure 3. The 2004 VHF propagation book published by CQ and written by Gordon West, WB6NOA, and myself. It provides easy-to-understand details on the different propagation modes that are experienced on the VHF bands. A companion CD is available that has samples of the different VHF propagation modes. Note that the cover photo, taken by Chip Margelli, K7JA, is of an intense aurora, which is a major VHF propagation mode.

in Japan and they do not see a profitable market for a 222-MHz weak-signal radio in the U.S. and Canada.

Thus, no growth can be expected for the 222-MHz band in the weak-signal area, as there is no new gear readily available for SSB and CW. Any growth over the next few years primarily will be in the FM mode.

Two Challenges for the Future

There are many opportunities for the VHF community to promote growth. While the VHF contests are helpful in promoting activity at certain times of the year, there actually has been a leveling off or slight decline in overall participation in these contests. Some rules changes are probably in order to try to stimulate increased participation. Also, everyday activity needs to be increased, and I would like to issue the following two challenges to help improve the growth of VHF activity.

A number of *CQ VHF* readers have mentioned the need for more technical in-depth articles as well as increased focus on the weak-signal modes in this magazine. I would like to redirect the barrel of the gun in the other direction: what information do these readers have that they can share with the rest of the VHF community? It is one thing to send an e-mail or gripe on a chat page about perceived lack of technical or scientific material in a magazine, but there is an opportunity to step up to the plate and deliver some meaningful material! I therefore am issuing two challenges to the VHF community at large:

Challenge 1. Send in articles for *CQ VHF*! Some readers may have exceptional antenna setups on the VHF bands and thus see some consistent paths on 6 and 2 meters. These readers would do well to share this information with the VHF community to reveal some of the amazing capabilities of these bands. Anyone who has interesting propagation information or good technical projects should approach *CQ VHF* about a potential article, too. Don't worry if you need some editing help either, as the editorial staff and writers of the magazine will help you take your information and make it into an article suitable for publication.

Challenge 2. There have been requests from the readership for building-project articles. *CQ VHF* would be more than happy to present these projects. For many hams, available time is a major problem, as it takes coming up with a design, building it, troubleshooting, and then writing about the project. I remember building a 6-meter beacon from a Haywood/ DeMaw design and modifying it with different components. This took several weeks of construction and troubleshooting, resulting in an article in the first incarnation of *CQ VHF* some years ago. It was hard to find spare time on a daily basis to work on this project, and I imagine that many of others fall into the same category.

Thus, I would like to issue the following challenge: Someone out there build a QRP 222-MHz CW transmitter for under $250. If you can build such a transmitter with parts that can be readily purchased, and can make it on the order of 2 watts or more, we would be most interested in hearing from you. I am willing to help you develop a design and subsequent article; my contact information is on the first page of this article.

There are receivers in most of the HF plus VHF radios that cover the VHF bands, so a 222-MHz transmitter with a transmit/receive switch would be an ideal companion for these radios. This would go a long way toward increasing activity during the VHF contests and during certain band openings!

If you have ideas for technical articles and/or building projects and have been sitting on the sidelines, take this opportunity to take the plunge and contribute to the growth of VHF weak-signal activity by sending in your material! ■

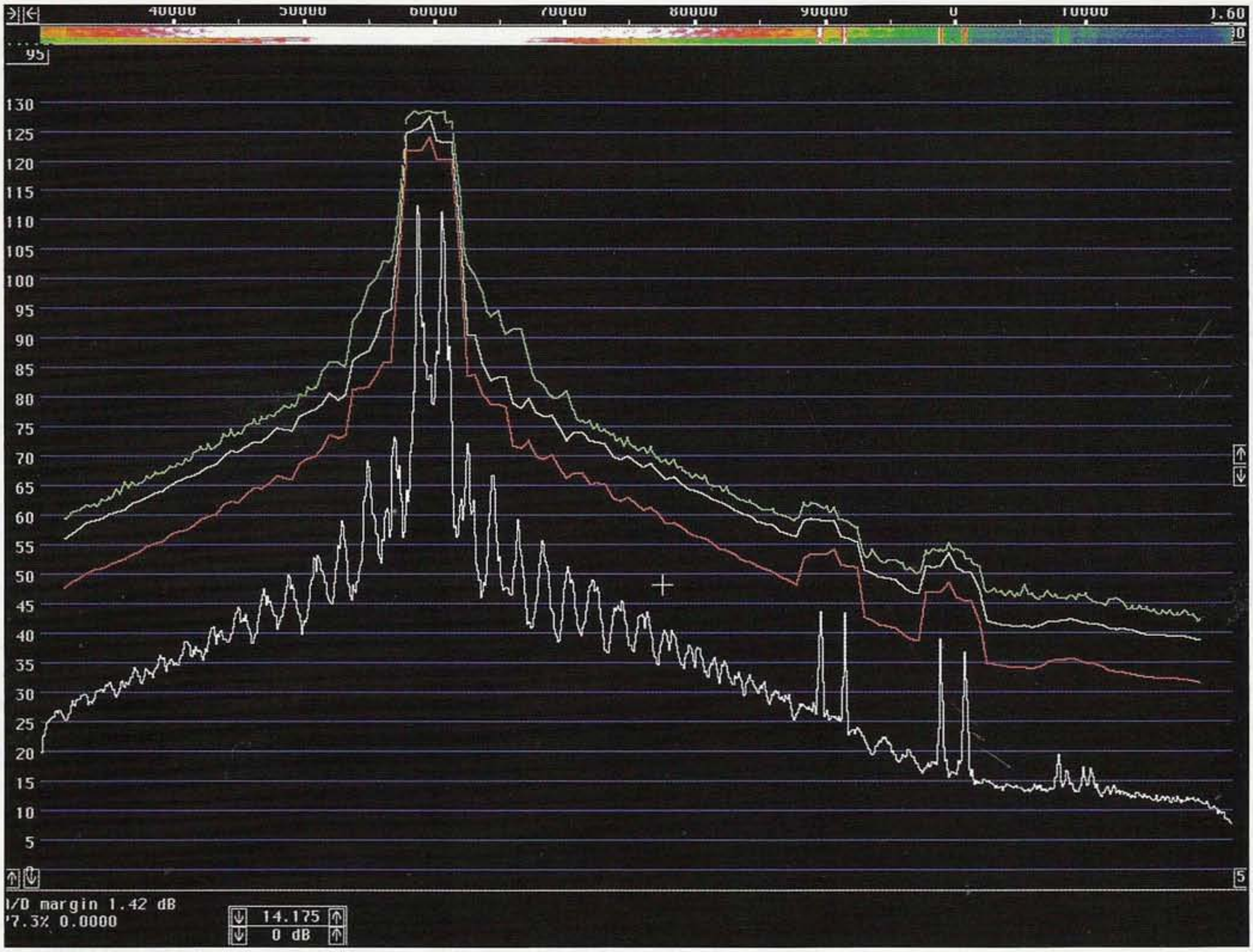


Figure 20. Worst-case spectrum on 14 MHz of an FT1000D in SSB mode, generated by the "Y/Ü" sound. Linrad in TX test mode.

wise the interference generated becomes a problem. Unfortunately, this is a problem in many transceivers. In fact, it is a problem in most of the transceivers I have looked at. For a detailed discussion, take a look at <http://www.sm5bsz.com/dynrange/alc.htm>.[12]

Using ALC to provide voice compression on SSB is a bad habit from old times. It was not a good idea back then, and it is really stupid in modern equipment. The ALC causes a lot of terrible splatter for no good reason at all. I have been told that amateurs want to watch the ALC meter to be sure the rig operates at full power. It would be much better to remove the control function and instead detect the drive level and show that on the meter. Driving the power amplifier slightly into saturation is not quite as bad as adding wideband modulation through the ALC. There could be some safety circuitry to protect the amplifier if necessary; this could work like the current ALC systems do, but it should be set for a somewhat

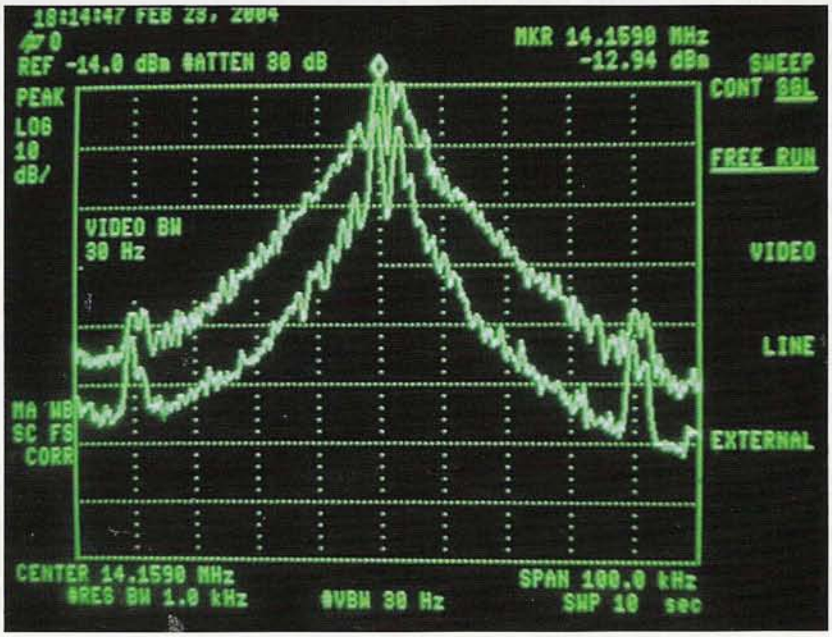


Figure 21. Signal similar to figure 20, but here as it looks on the HP8591A. A notch filter is used to remove the main signal, and the upper scale line is 35 dB below the peak level of the SSB signal.

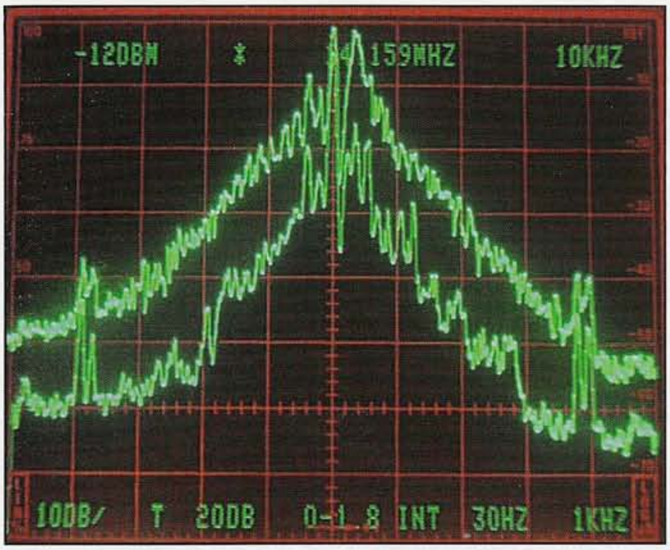


Figure 22. Signal similar to figure 20, but here as it looks on the TEK2753P. A notch filter is used to remove the main signal and the upper scale line is 35 dB below the peak level of the SSB signal.

higher level that should never be reached in normal operation. Modern transceivers with computer control could easily set the drive level right for each band and mode without adding wide-band modulation . . . if amateurs wanted it like that.

The linearity of the power amplifiers typically is good enough. The results obtained in two-tone tests do not correlate at all with the splatter generated. The intermodulation products typically are far below the ALC sidebands with real-voice signals. In a two-tone test, the peak power is reached with a repetition rate of about 1 kHz, causing the saw-tooth waveform of the ALC to have a frequency of 1 kHz with very low amplitude. Therefore the two-tone test essentially shows the power amplifier linearity. However, testing with a real voice into the microphone shows what signals other band users really will have to cope with—and that is often something quite different and much worse.

I have used the IC706MKIIG as an example of how the spectra in Linrad test screen relate to the time-domain waveforms. Changing from Morse code to SSB does not make any fundamental difference, except that it becomes much harder to look at the time-domain waveform. The IC706 produces splatter on 14 MHz that seems to have the same origin in the

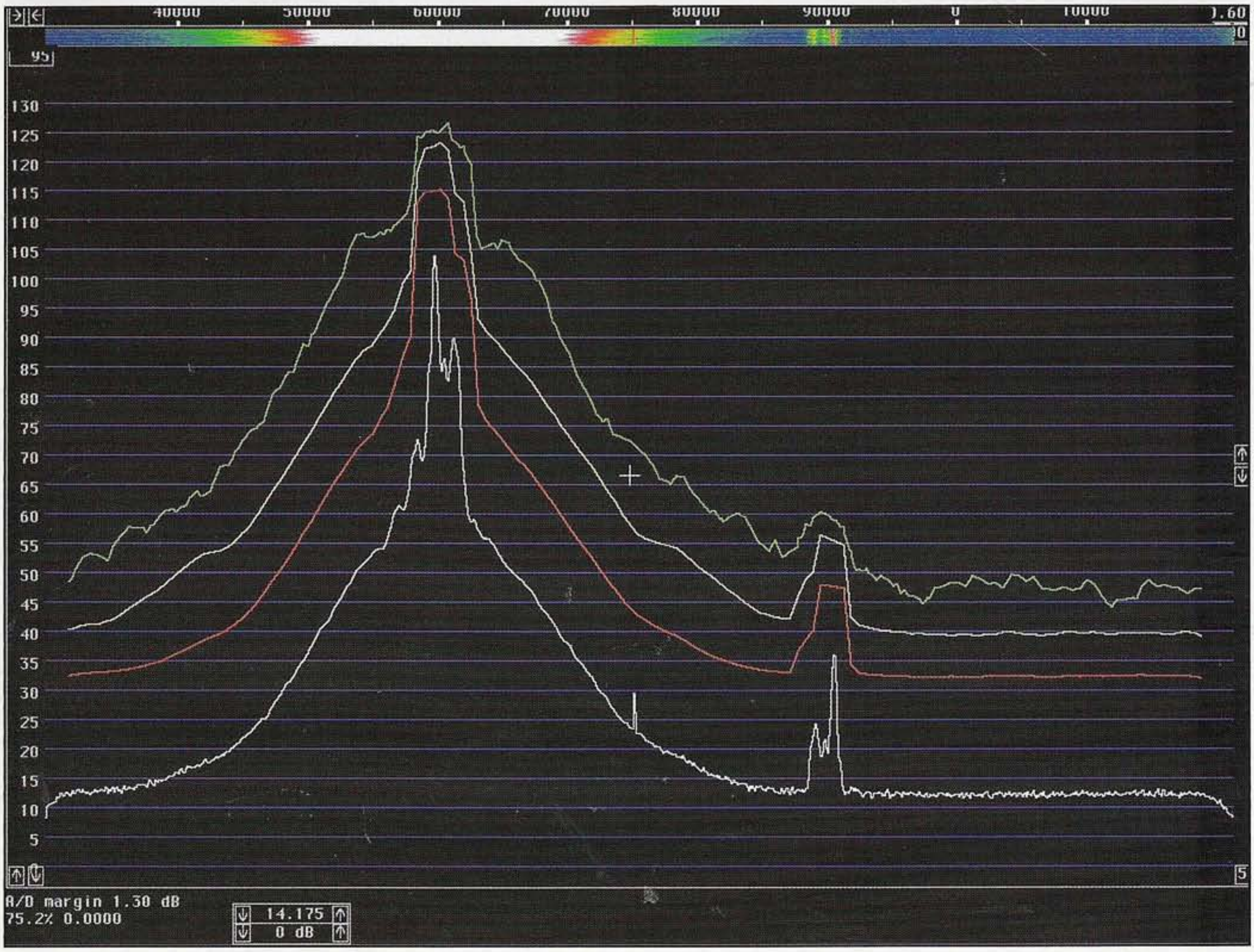


Figure 23. Worst-case 14-MHz spectrum of an IC706MKIIG in SSB mode.

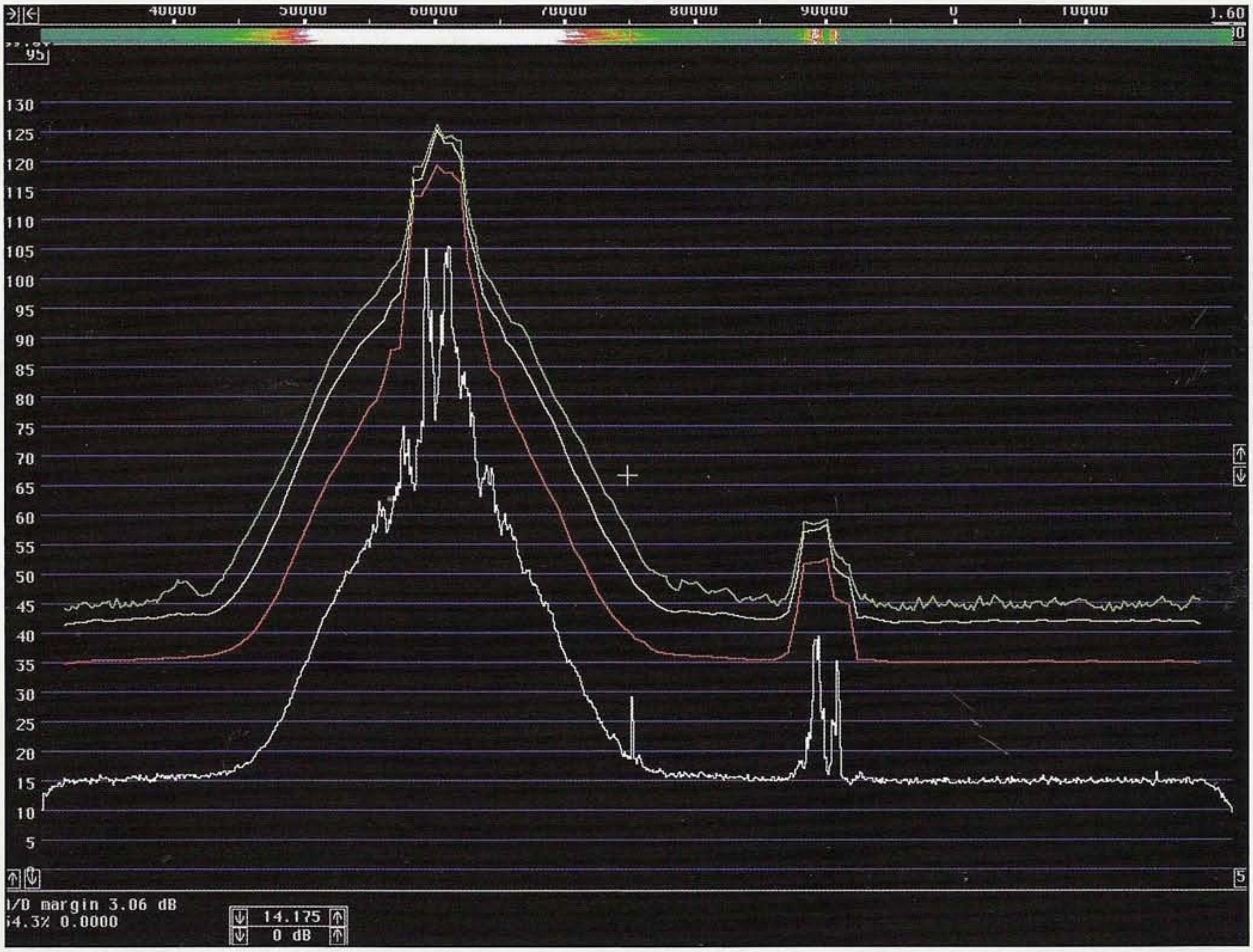


Figure 24. 14-MHz spectrum of an IC706MKIIG in SSB mode with the "Y/Ü" sound into the microphone.

ALC loop as the keying clicks (see later discussion about figure 23). Another example is the FT817, which is shown in figure 16. This particular unit must be regarded as faulty. I would not be surprised if the error is incorrect adjustment in the ALC circuit, but I did not have the time to look closely.

I do not think it would be difficult at all to eliminate the problems with the IC706MKIIG and the specific FT817 illustrated above. It probably amounts to reducing the gain a little to make the ALC less active. That is in theory. In real life it may be hard to do anything with miniaturized boxes such as these transceivers. I have never looked inside, so I do not know.

The peak-power spectra in SSB bandwidth show the quality of transmitters in a way that is honest for the customer who tries to find out which transceiver to buy.

The measurement is extremely easy with an FFT-based analyzer such as Linrad and the WSE converters as explained above. Just connect the transmitter to the WSE converter input through an attenuator and operate as normal. Linrad will catch the spectrum.

As for the average power spectra, it, of course, is also possible to use a standard spectrum analyzer such as the 2753P or 8591A together with a notch filter.

Measurements Using Notch Filters

The standard instruments from Hewlett Packard and Tektronix, the HP8591A and the TEK2753P, have different filter shapes as discussed above. Hewlett Packard uses Gaussian filters, which give faster response, while Tektronix uses more rectangular filters which allow better visibility for sideband noise. Figures 17 and 18 show what the screens look like at a resolution of 1 kHz when these instruments are fed with the signal from a low-noise crystal oscillator. The Linrad screen in "TX test mode" with a bandwidth of 2.4 kHz is shown in figure 19.

The crystal oscillator used for figures 17 to 19 has a sideband noise of about –169 dBc/Hz, so these figures directly give the limitations of the instruments. Amateur transceivers produce sideband noise at about –125 dBc/Hz when emitting an unmodulated carrier. It is obvious that neither the 8591A nor the 2753P can be used to check their performance directly. However, many transceivers emit splatter that is easily seen on the screen of these standard instruments. That is not because the instruments are especially good. It is because so many amateur transmitters are so bad.

Comparisons Among Transceivers on SSB

The FT1000D allows proper operation in SSB mode. When operating according

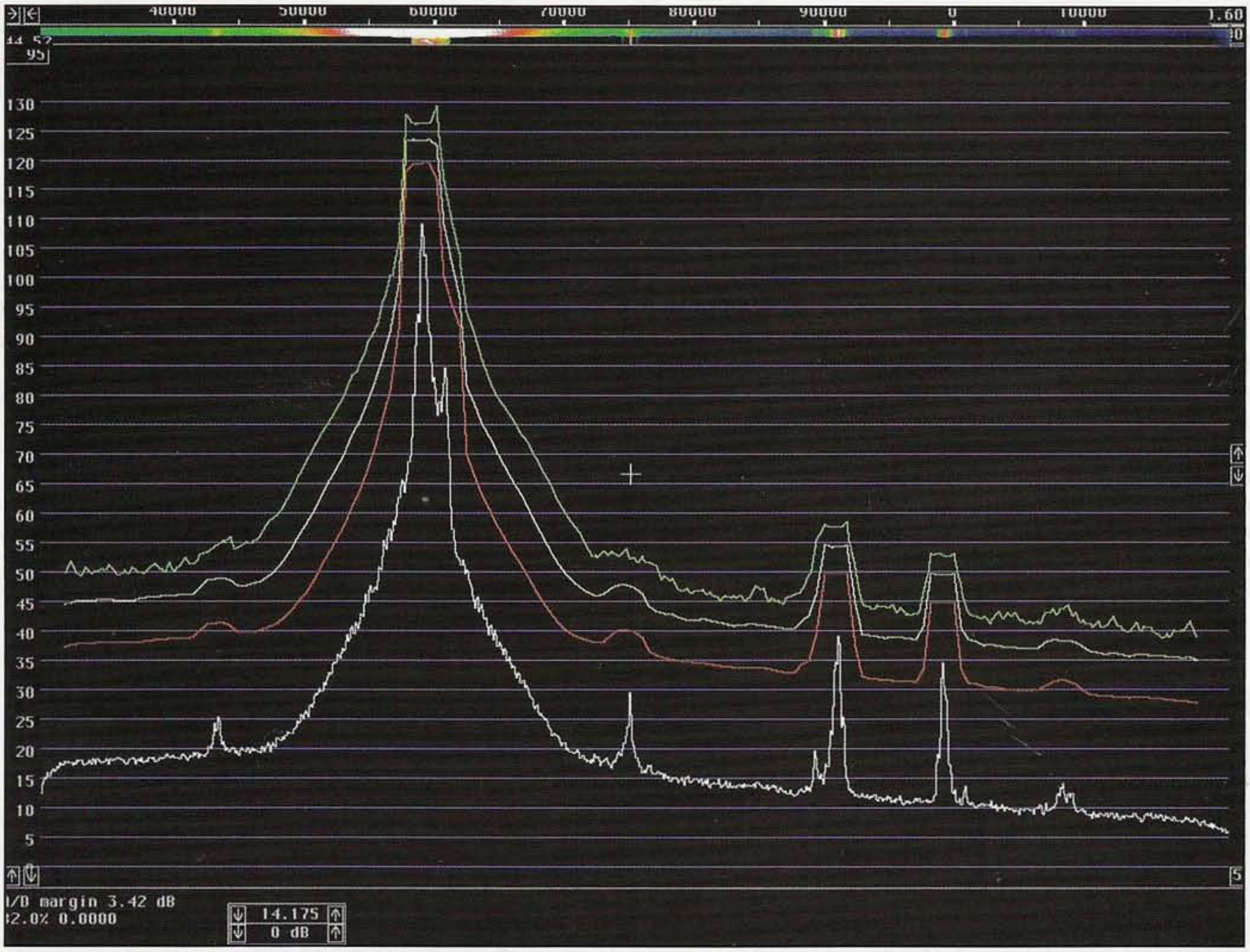


Figure 25. 14-MHz spectrum of an FT1000D with the "A-A-A-A" sequence into the microphone.

to the manual, the speech processor is used to set compression to 10 dB and the ALC circuit adds another 3 to 5 dB of compression, with some wideband splatter as a consequence. However, one can set the drive level to a point just below where the ALC starts acting, and then the speech processor can be used to set the desired compression, about 15 dB. For details, see <http://www.sm5bsz.com/ dynrange/alc.htm>[12], where you can find SSB spectra of the FT1000 that are representative of normal usage. Unfortunately, the transmitter amplifier is noisy, when the gain is not turned down by the action of the ALC. The sideband noise produced by inadequate noise figure in the transmit amplifier is at –116 dBc/Hz for a steady carrier at a frequency separation of 20 kHz. When operating according to the manual, the sideband noise is at –120 dBc/Hz because of the reduced gain due to the ALC. The obvious solution would be to make a modification that provides a constant voltage that gives a permanent gain reduction.

The FT1000D typically produces a very clean spectrum when one speaks into the microphone like one would do in a QSO, but there are occasional outbreaks of splatter. Such splatter peaks seldom occur; it happens when I say a sound right between "Y" (as in YES) and the German "Ü" (as in ÜBER) into the microphone. This particular sound happens to generate essentially two sine waves that are separated by nearly 2 kHz. As a consequence, the ALC does not generate any distortion to the waveform because the maximum power repeats at a rate of 2 kHz. This particular interference is generated by the cross-over distortion in the power amplifier and/or driver stages as will be shown below. The purpose of transmitter testing is to find the weak spots of each transmitter and to characterize them so that users can minimize the problems and manufacturers will be able to improve the equipment. The weakest spot (worst-case interference) of the FT1000D is that rare "Y/Ü" sound, which is a selective phenomenon and not a big problem in actual usage. For representative spectra in normal voice again see <http://www.sm5bsz.com/dynrange/ alc. htm>.[12] The worst-case interference of the FT1000D is shown in figure 20. Figures 21 and 22 show the same as seen with the standard instruments from HP and Tektronix with a notch filter that removes the desired SSB signal.

Figures 20 to 22 show the same thing. All three show the peak-hold spectra and the average-power spectra. In SSB mode the important information comes from the peak-hold spectra, because the average power spectra are difficult to obtain in SSB mode on a sweeping analyzer. It is not so easy to keep producing the worst splatter level by voice for the long duration of a single sweep at a video bandwidth of 30 Hz, but the peak-hold measurement is straightforward and easy in SSB mode on all three instruments and the average power spectrum is inconsequential to produce for a continuous carrier.

At a frequency separation of 20 kHz, the peak splatter level is –60 dB relative to the peak power in the Linrad 2.4-kHz measurement. The 8591A gives –63 dB in a bandwidth of 1.14 kHz, while the 2753P gives –66 dB in a bandwidth of 722 Hz. The splatter is neither pulses nor white noise, so it is unclear how the peak amplitude relates to the bandwidth. The results indicate that the character of the splatter in this case is like white noise with a level of –60 dB in 2.4-kHz bandwidth.

The worst-case speech waveform is different among different transmitters. Figure 23 shows the worst-case emissions from an IC706MKIIG. This rig suffers from the ALC problems that were discussed above in conjunction with figures 8 to 11 as judged from the similarity of the spectra. This particular rig does not produce much interference with the "Y/Ü sound; instead, the worst-case interference is produced by the sequence "A-A-A-A-A," with the short "A" sound repeated at a rate of something like 5 Hz with less than 50% duty. The spectrum is displayed in figure 23. Note that the peak power in the neighbouring channels is not even 20 dB below the power of the main signal, most probably due to the ALC malfunctioning. The IC706MKIIG splatter drops rapidly with increasing frequency separation and it is obvious that the mechanism is different compared to figure 20.

Figure 24 shows the IC706MKIIG with the "Y/Ü" sound into the microphone. As expected, the splatter that is probably generated by the ALC is absent, the spectrum looks very clean and the cross-over distortion causing the problems in the FT1000D is obviously insignificant in the IC706MKIIG. Figure 25 shows the FT1000D with the "A-A-A-A" sequence into the microphone. The rig is operated according to the operating manual with full ALC. As shown in [12] the spectrum is even narrower without the ALC.

Figures 24 and 25 show very clearly that the waveform that one transceiver can not handle well is no problem at all for the other transceiver. It seems like almost every transmitter has its own peculiarities. Figure 26 shows the spectrum of a TS-520. For this rig there is not a single sound that could be found to make the worst interference, although the spectrum shape varies with the different sounds. Figure 26 shows the word "Echo" repeated rapidly. Saying several other words as well will lift

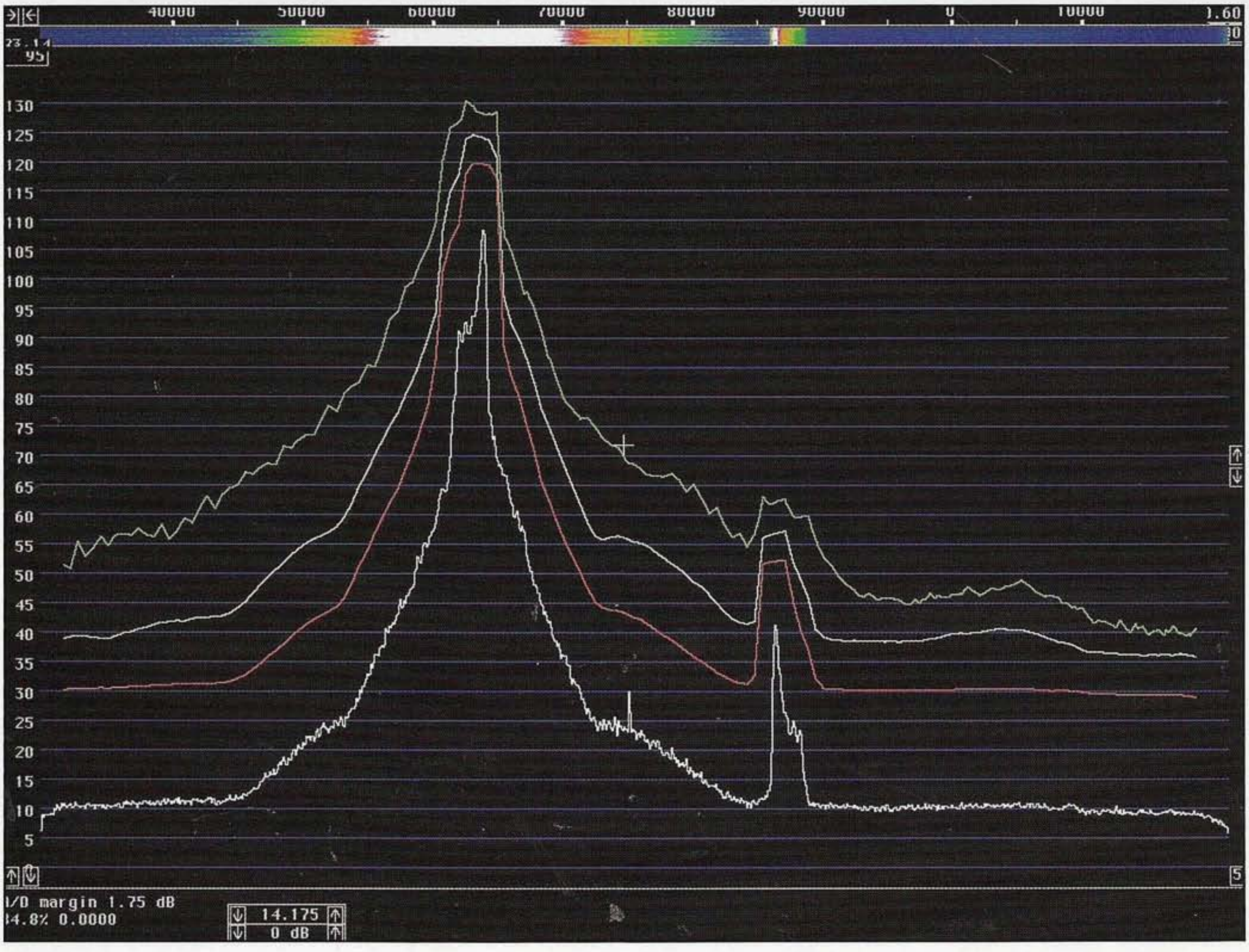


Figure 26. 14-MHz spectrum of a TS-520 with the word "Echo" repeated into the microphone. The unit is operated with ALC at about 25% of the ALC range.

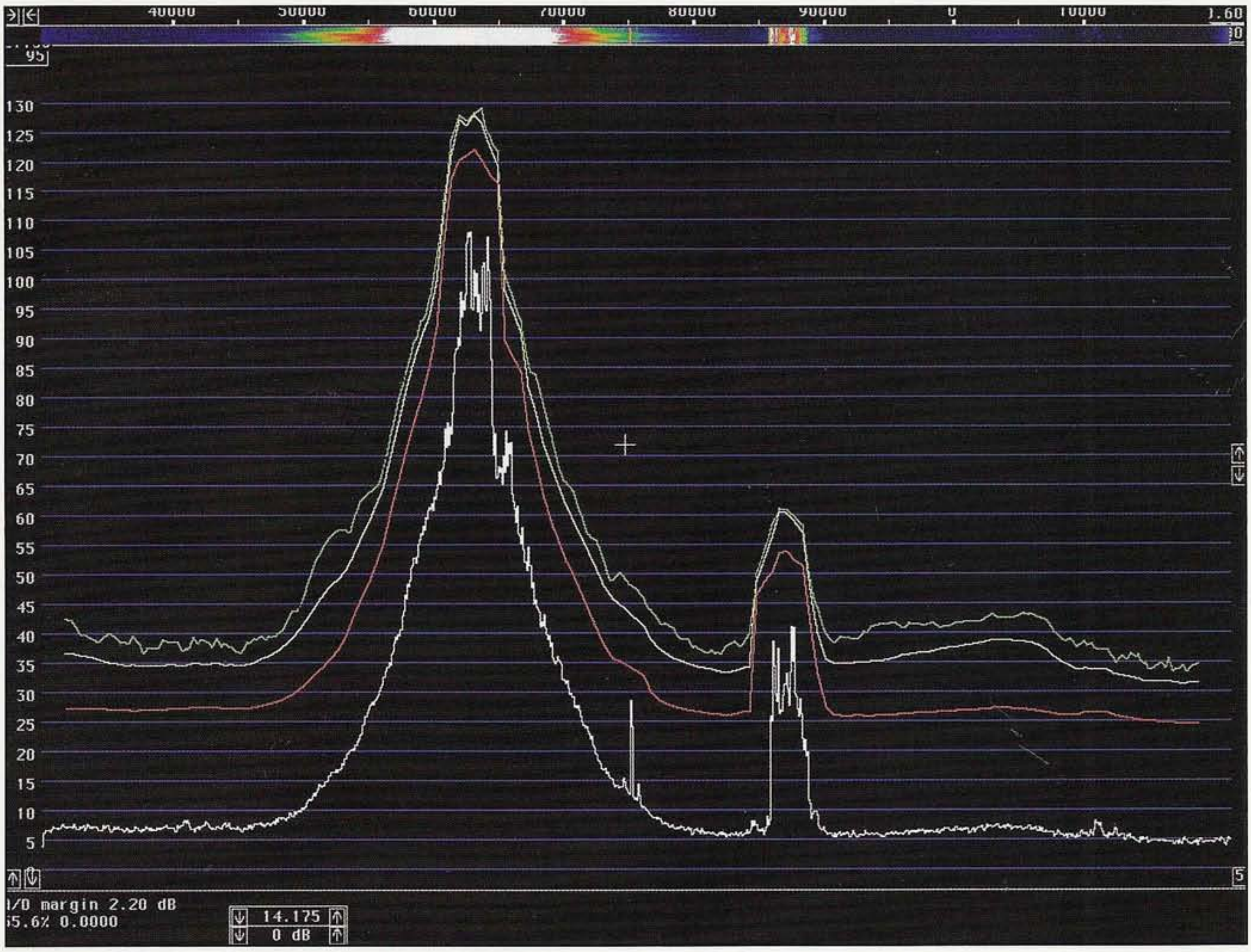


Figure 27. 14-MHz spectrum of a TS-520 with the "Y/Ü" sound into the microphone. The unit is operated without ALC but with full output power.

the peak hold spectrum a bit higher, but not very much. The interference in the TS-520 is caused by the ALC, which was peaking about 25% of the ALC range according to the meter. By slightly mistuning the PA drive so that the ALC meter does not move at all, and setting the mic gain higher to give the same average output power, the splatter generated by the ALC can be removed. Operated this way the TS-520 emits a very clean signal. The difficult test cases, the "Y/Ü" sound and the "A-A-A-A" sequence are shown in Figures 27 and 28. Saying the word "Echo" into the microphone does not cause more splatter than the "A-A-A-A" sequence when the ALC is disabled.

Conclusions and Discussion

Testing transmitters is a far more complicated task than testing receivers. It is complicated in the sense that it is very difficult to set up a standardized test that has a chance of being generally accepted and that would be relevant as a figure of merit for the spectral purity of a modulated transmitter.

From a practical point of view it is very simple, however. Just modulate the transmitter in every possible way that is in accordance with the instruction manual. Collect the peak-hold spectrum in an SSB bandwidth and present the graph with some notes on which kind of modulation the rig has difficulties with (if any). Not only spectra at full power should be investigated. Some rigs send out massive wideband pulses when the PTT is pressed or released, while others emit high levels of wideband noise during silent periods in SSB when the ALC does not reduce the transmitter gain. With a wideband FFT spectrum analyzer it is easy to find the peculiarities of a transmitter and measure the worst spectrum.

The measurement can also be made with standard instruments if a notch filter is added to extend the dynamic range. It just takes some more time, because with a sweeping analyzer a single transient will affect only one frequency at any given moment.

A modern transceiver should provide a peak-hold spectrum like the old TS-520 in figures 27 and 28, or better. However, this is very far from what the measurements actually show, because transmitter quality is not receiving its due share of attention. Once this problem does begin to receive some thoughtful attention, it will be very easy to make improvements. Aside from silly things such as emitting a very short pulse at full power when the PTT is pressed, most problems can be eliminated by reconfiguring the ALC and by making sure there is an amplitude clipper at the right side of the SSB filter—the input side.

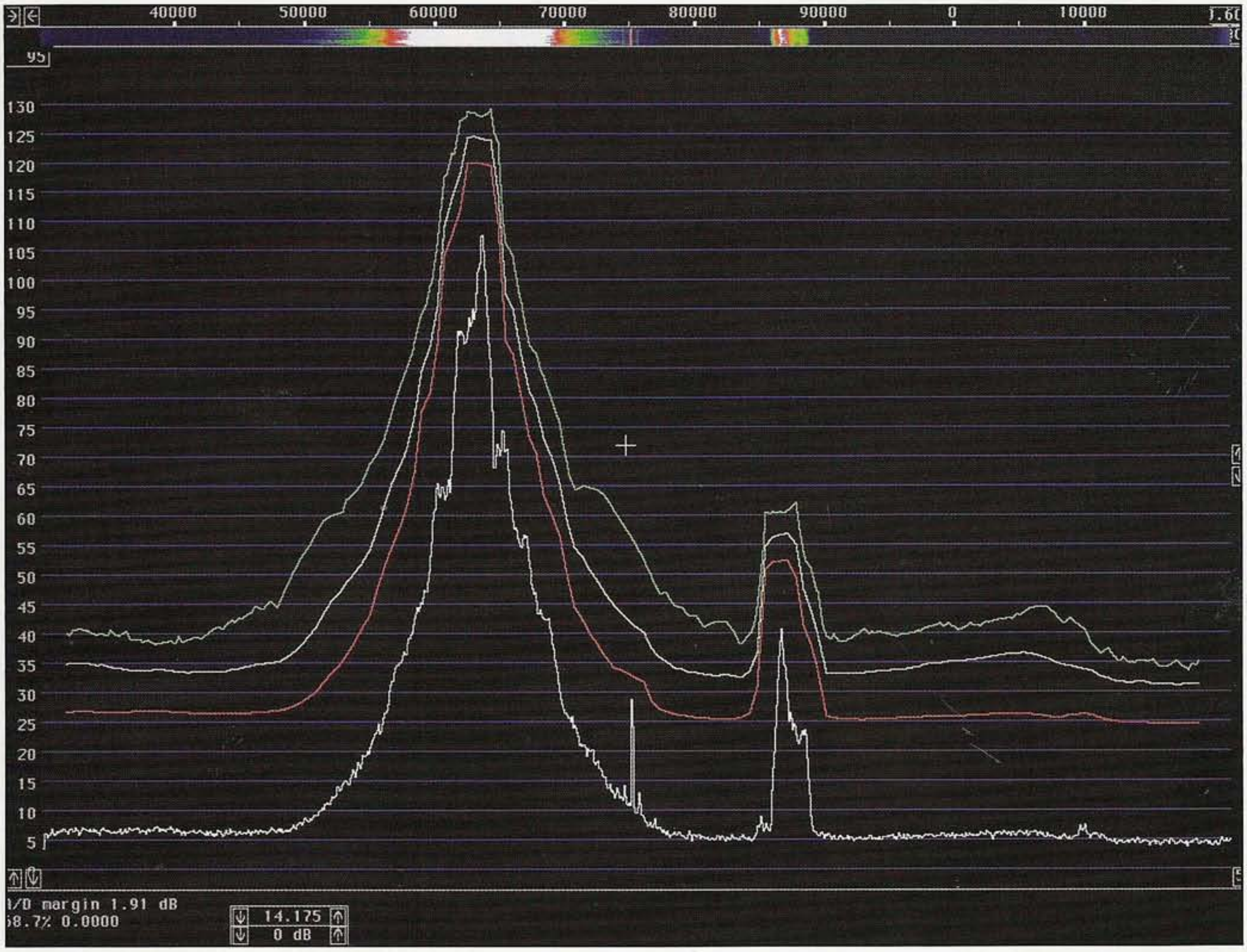


Figure 28. 14-MHz spectrum of a TS-520 with the "A-A-A-A" sequence into the microphone. The unit is operated without ALC but with full output power.

There is also a need for some care to avoid excessive noise figures in the first transmit amplifier after the SSB filter to prevent high levels of wideband noise (as in the FT1000D, for example [see figure 25]).

Two peak-hold spectra, one in CW mode and another in SSB mode, will provide all the relevant information about transmitter spectral purity that is needed for a product review.

The test engineer might want to show some more spectra, probably different for each transmitter, because there may be specific events, such as pressing the PTT button, that make the spectra absolutely horrible. It then makes sense to show the spectrum as it looks when such events have been excluded from the time-frame of the measurement. Likewise, it may be relevant to show spectra with VOX or QSK off in case they differ significantly from the spectra when they are enabled. Such differences are due to design inadequacies that would be easy to correct, so the place where these measurements should first be made is in the manufacturer's design laboratory!

There is an element of arbitrariness in the peak-power spectra. Finding the special sound to make the FT1000D emit the horrible spectrum of figures 20 to 22 was not so easy. The first test—saying "Aaaaa, testing, testing, one, two, three" a few times—did not show anything unusual. If I had been satisfied with that, the outcome would have been a result such as the one in figure 25. However, by trying various other phrases as well as speaking at several different voice pitches, it was not difficult to find a much worse peak-hold spectrum. Once I knew there was something to look for, it then was fairly easy to find the exact sound to produce worst-case interference.

The FT1000D used for this article has a normal two-tone test result, as one can see in figure 29. It is a delicate balance, however, and by making the two tones slightly different in amplitude one can get much worse high-order intermodulation. By increasing the separation between the tones one can also get a slightly worse result. Such a modified two-tone test is displayed in figure 30. Note that it is very similar to figure 20. The high-order intermodulation that the FT1000D suffers from does not change when the output power is reduced, unlike the low-order components. The high-order intermodulation is caused by insufficient bias current, and stays at the same level with respect to the peak power from about 20 watts to full power. However, at the same time the low-order intermodulation changes drastically.

At a power level of about 1 watt the FT1000D spectrum looks like figure 31. Note that the third-order intermodulation product is only about 22 dB below the peak power. This is a very sig-

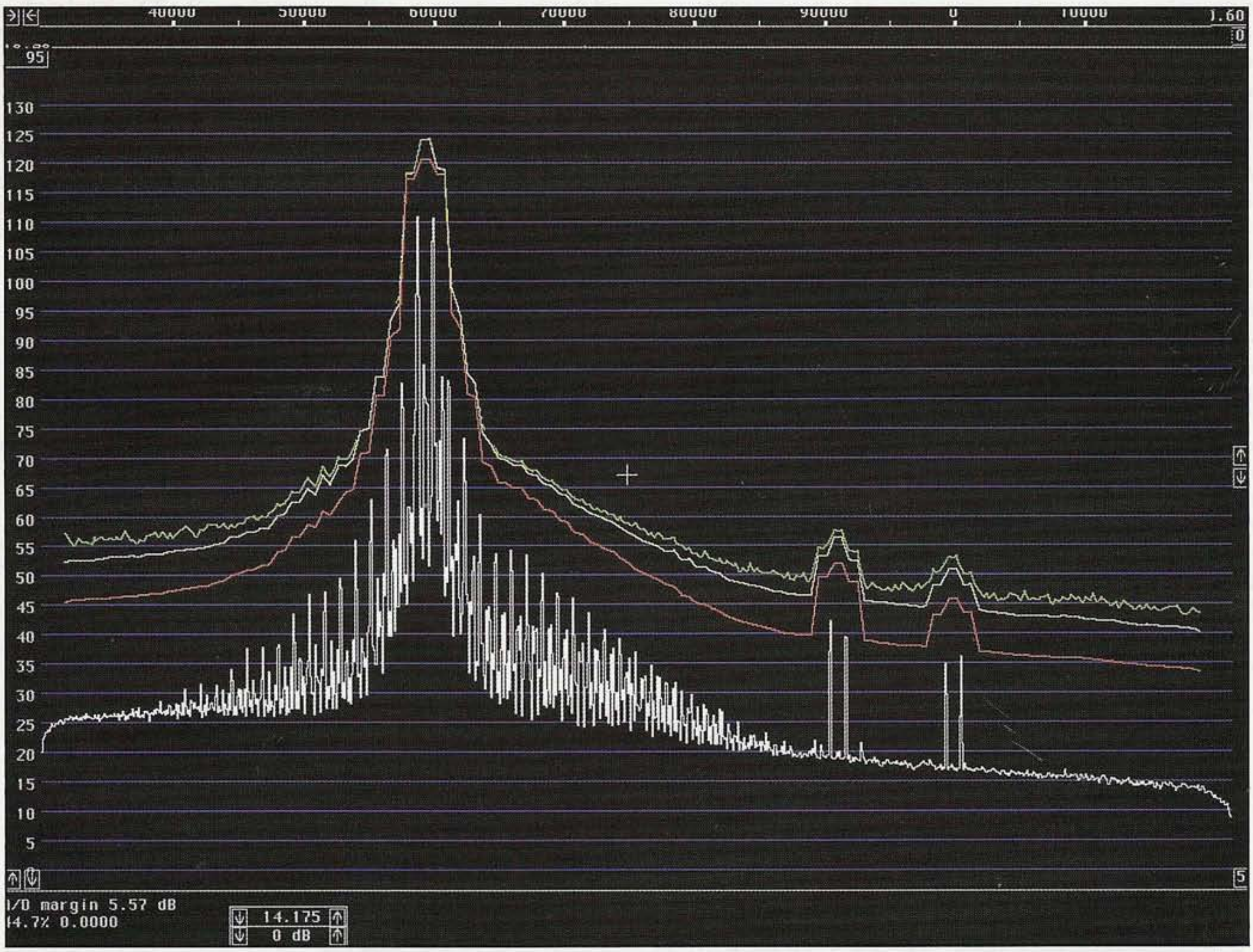


Figure 29. Standard two-tone test for the FT1000D. The tones are 700 and 1900 Hz.

nificant distortion of the signal, well visible in the time domain, as one can see on the oscilloscope trace in figure 32. At the zero crossings the envelope should have its steepest slopes, but as can be seen in figure 32, the slope is only about 50% of its correct value, which means that the amplifier gain is about 6 dB lower than it should be at output voltages about 20 dB below a power level of 1 watt. This kind of distortion is commonly referred to as cross-over distortion, since it is equivalent to cross-over distortion in hi-fi amplifiers, where the name is fully appropriate.

Personally, I think that excessive high-order intermodulation is a direct consequence of the standardized two-tone test, because of the unbalanced emphasis that it gives to the lower (third and fifth) orders. The relatively low level of the third-order intermodulation visible in the standardized two-tone test may well be a consequence of design engineers tweaking the bias current of the PA and perhaps the driver stages for optimum third- and fifth-order performance without regard to any other consequences. The normal third-order intermodulation can be described as loss of gain at maximum power, as the envelope is flattened slightly at the maximum power. By deliberately setting too low a bias current to create a loss of gain at the zero crossings as well, one can add another third-order intermodulation component that is in antiphase and thus reduces the total third-order intermodulation. Such techniques are well known and often are used to take advantage of rigid type-acceptance test protocols, but the adverse consequences for wideband splatter are visible as increased levels of higher order intermodulation, even in the standard two-tone test. If the FT1000D had been designed to produce good results in the peak-hold spectrum, the bias current would have been just a little higher. The third-order intermodulation in the two-tone test would have been a little higher too, but the higher order components would have been much lower—and that is what matters most to other band users.

I have been told that the FT1000D is known to produce very clean SSB signals on the bands—"one of the best rigs." Knowing about the cross-over distortion, amplifier noise, and ALC modulation from which it suffers, and how easy it could have been to eliminate all these problems at the development stage, the conclusion is that the current state of the art in amateur radio transmitters is highly unsatisfactory. Bad design is not limited to careless keying.

Besides the test of the purity of modulated emissions, a product review should also include a measurement of the sideband noise of the unmodulated carrier, since it gives interesting information about the quality of the frequency-generating circuits. The levels of the noise sidebands are easily measured with good accuracy using standard instruments and a notch filter. It is not safe to assume that the reciprocal mixing test in RX mode tells us everything; the TX signal path is different, so a separate test is needed, and a comparison with the two-signal dynamic range of the receiver may give interesting information. In fact, it is quite common for transmitters to be much noisier than receivers, and most often this is due to silly design errors that could be easily rectified. The main requirement now is to escape from the fixation on receiver performance—that problem is now essentially solved[2]—and begin to give transmitter performance the share of attention that it deserves.

Notes

1. Leif Åsbrink, SM5BSZ, "Receiver Dynamic Range," *DUBUS* 4/2003, pp. 9–39, and *DUBUS* Book *TECHNIK VI*, pp. 348–378. Also see <http://www.sm5bsz.com/dynrange/rig_compare.htm> and links from there, plus the Fall 2004 and Winter 2005 issues of *CQ VHF*.

2. Peter E. Chadwick, G3RZP, "HF Receiver Dynamic Range: How Much Do We Need?" *QEX*, May/June 2002, pp. 36–41.

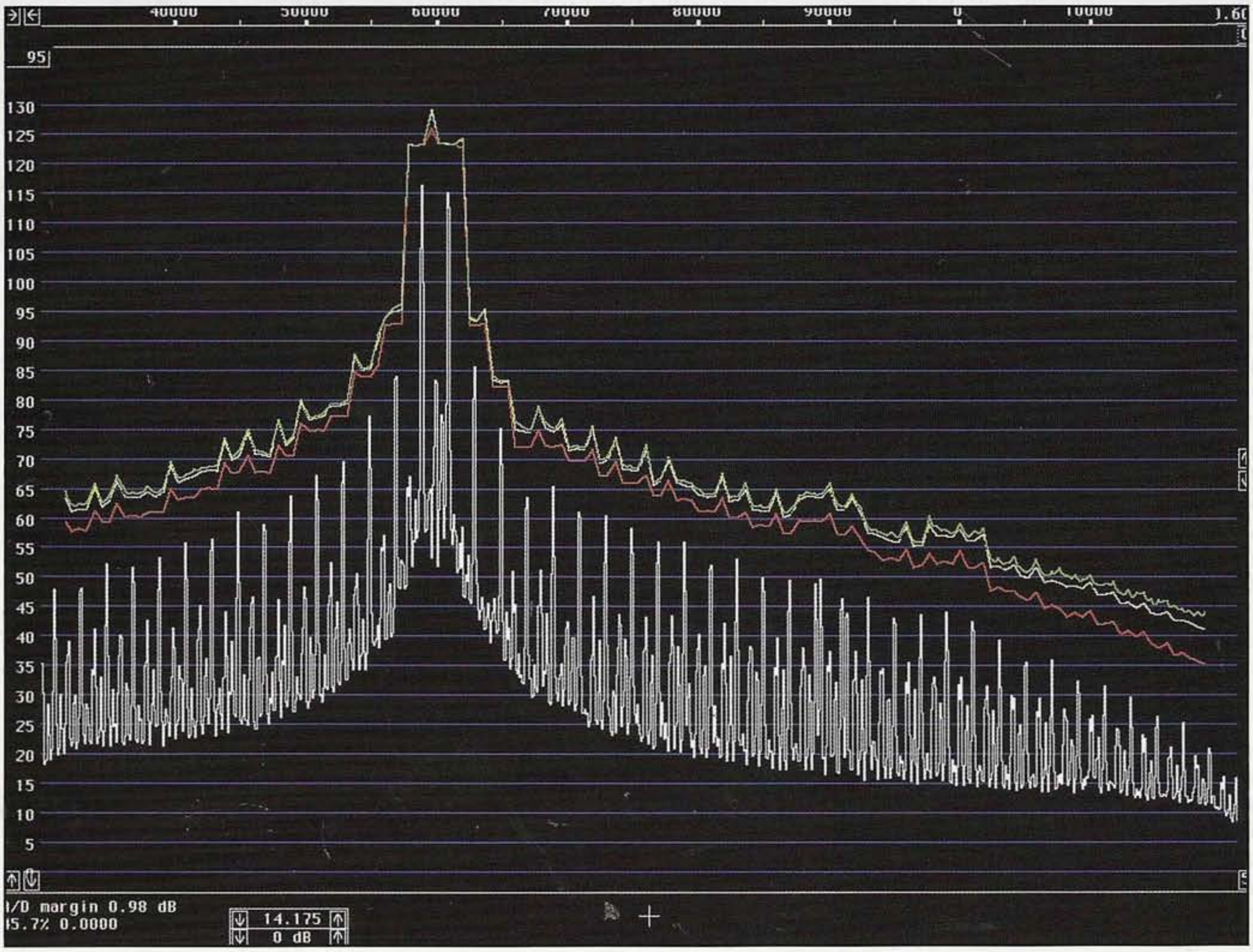


Figure 30. Slightly modified two-tone test for the FT1000D. The tones are 400 and 2400 Hz. The amplitude ratio is adjusted for worst high-order intermodulation.

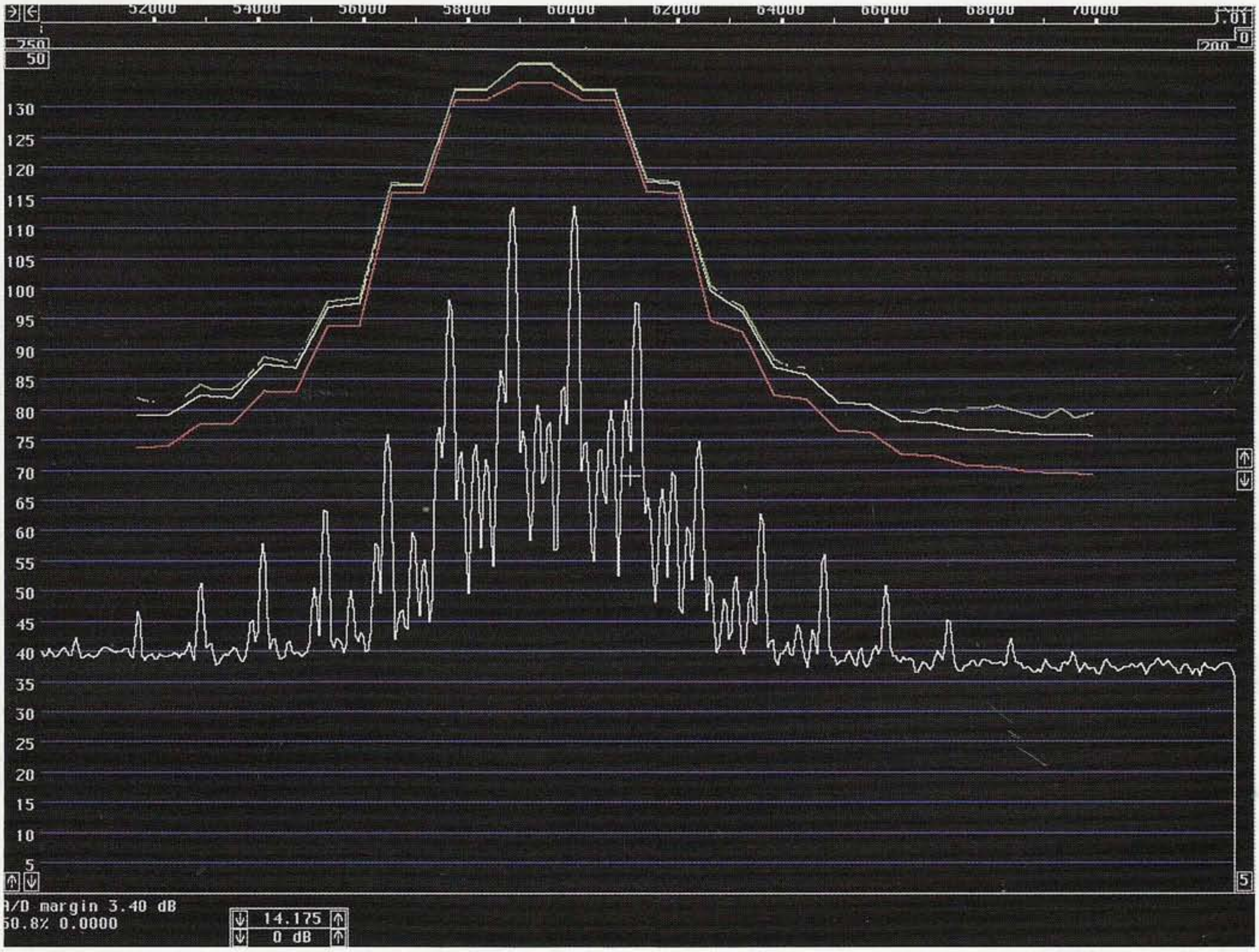


Figure 31. Two-tone test for the FT1000D at about 1 watt peak power. The tones are 700 and 1900 Hz.

3. <http://www.sm5bsz.com/linuxdsp/linrad.htm>

4. Mike Gruber, WA1SVF, "Improved Transmitted Composite-Noise Data Presentation," *QST*, February 1995. p. 59.

5. <http://www.sm5bsz.com/linuxdsp/optrx.htm>

6. Doug Smith, KF6DX, "On the Occupied Bandwidth of CW Emissions," <http://www.doug-smith.net/downloads.htm>. There is also a copy at the SM5BSZ home page: <http://www.sm5bsz.com/others/occbw.htm>.

7. *The ARRL Handbook*, 1994. Figure 11 is on p. 9-9.

8. Kevin Schmidt, W9CF, "Spectral Analysis of a CW Keying Pulse," <http://fermi.la.asu.edu/w9cf/>. There is also a copy of this article at the SM5BSZ home page: <http://www.sm5bsz.com/others/click.pdf>.

9. <http://www.w8ji.com/keyclicks.htm> and <http://www.w8ji.com/keyclick_mp.htm>

10. <http://www.qsl.net/n1eu/Yaesu/MPclicks.htm>

11. <http://www.qth.com/inrad/kits.htm>

12. <http://www.sm5bsz.com/dynrange/alc.htm> ■

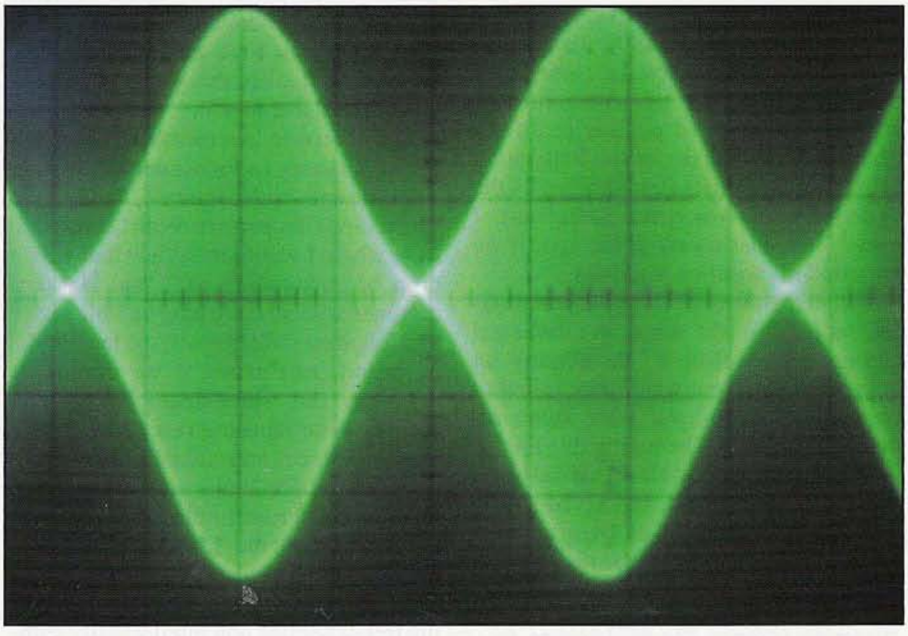


Figure 32. Two-tone test for the FT1000D at about 1 watt peak power. Same signal as in figure 31, oscilloscope trace of the 14-MHz RF signal.

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Remembering W8FIS, the Father of SETI

It grieves me to report the passing of a legend, and an honored friend. I have been informed by his son Bert that Professor Philip Morrison, co-author of the world's first serious scientific paper on SETI, passed away quietly at home on Friday, April 22, 2005. He was 89 years of age.

Dr. Philip Morrison, Institute Professor and Professor of Physics at the Massachusetts Institute of Technology, was a distinguished theoretical astrophysicist and a pioneer in the search for extraterrestrial intelligence through radio communication. He authored scores of books, produced television documentaries, and lectured tirelessly around the world, despite the physical limitations imposed upon him by post-polio syndrome. In one of his many roles as a science educator, Dr. Morrison served on the board of advisors for the television science series "NOVA." In another role, he was columnist and book reviewer for *Scientific American.* In yet a third, it was Phil Morrison who chaired NASA's early study groups on SETI.

Along with most of the bright young physicists of his generation, Phil Morrison spent the war years working on the Manhattan Project, the development of the first atomic bomb. Unlike many of his Los Alamos colleagues, he went on to become a staunch pacifist, anti-war activist, opponent of nuclear proliferation, and a co-founder of the Federation of Atomic Scientists (later known as the Federation of American Scientists). I asked him, just a few years ago, if he regretted his wartime activities.

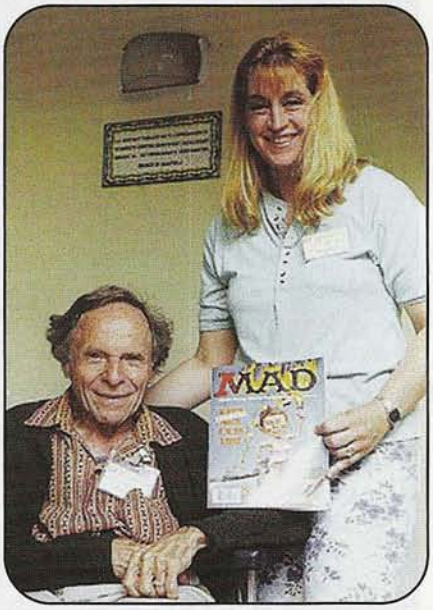
"On the whole, no," was his paradoxical reply. "At the time, we believed Germany was close to developing an atomic bomb. Even when they failed to do so, ending the war with Japan remained a priority. The regrettable bombings of Hiroshima and Nagasaki did bring that conflict to an end, and saved countless tens of thousands of lives on both sides. My only regret is the dark period that followed."

**Executive Director, The SETI League, Inc., <www.setileague.org>*
e-mail: <n6tx@setileague.org>

Undeniably one of the patriarchs of SETI, Professor Morrison had long since gone inactive on the ham bands when in 1959 he coauthored "Searching for Interstellar Communications" in the British science journal *Nature.* His boyhood interest in amateur radio had motivated his interest in exploring the feasibility of microwaves for interstellar communication. During SETI's Golden Age, he inspired a whole generation of engineers and scientists, including the founders of The SETI League, to think beyond human limitations.

On a personal note, my own SETI interests were motivated by following in Phil Morrison's footsteps (albeit from a distance of 30 years). As an electrical engineering undergraduate at the Carnegie Institute of Technology, I had the privilege of operating W3NKI, the campus ham radio station Phil had founded three decades prior. From Carnegie Tech, Phil went on to earn a Ph.D. from the University of California, Berkeley. Many years later, so did I. Phil encouraged my SETI League efforts from the start. He did me the great honor of writing the jacket blurb for my hypertext book *Tune In The Universe!* (copyright © 2001, ARRL), contributed generously to The SETI League of his time and financial resources, and over the years became a close friend and mentor.

Phil Morrison is remembered as much for his modesty as for his energy. Nearly a decade ago, on November 7th, my wife Muriel and I happened to be in Cambridge MA, where I was to interview that year's crop of outstanding MIT and Harvard graduate students. We rang up Phil's wife and longtime collaborator, the late Phylis Morrison, and asked if we could get together. She immediately suggested their favorite Japanese restaurant, where we met, dined, and talked until closing time, whereupon Phil insisted on picking up the check. From the restaurant, the four of us went to the Morrisons' modest Cambridge flat, where we proceeded to sit up half the night, engaging in one of the free-wheeling and intellectually stimulating conversations for which the Morrisons were noted.



Phil Morrison and the author's wife, Muriel Hykes, share their favorite technical journal, at a BioAstronomy Conference in Italy in 1996.

A week later, having returned home, I began working on an essay which was to include a mention of Phil and his contributions to the art and science of SETI. In order to get my facts straight, I thumbed through my well-worn copy of David Swift's *SETI Pioneers* to Phil's biography and was shocked to read his date of birth—November 7, 1915. We had spent the whole evening of his 80th birthday together, and neither Phil nor Phylis had said a word about it!

I rang up Phil, and asked, "Why didn't you tell me it was your birthday?" He replied, "Because if you had known, you might not have come."

My last telephone conversation with Phil Morrison occurred seven weeks ago, as I write this, following the death of my own father (they were of the same generation). I expressed concern for Phil's health, and we made plans to celebrate his 90th birthday, next November 7th. A father figure to many of us, Phil Morrison's death leaves a void that can never be filled—but I feel compelled to try. When I grow up, I want to be just like Phil Morrison. 73, Paul, N6TX

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