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CQ VHF

Ham Radio Above 50 MHz

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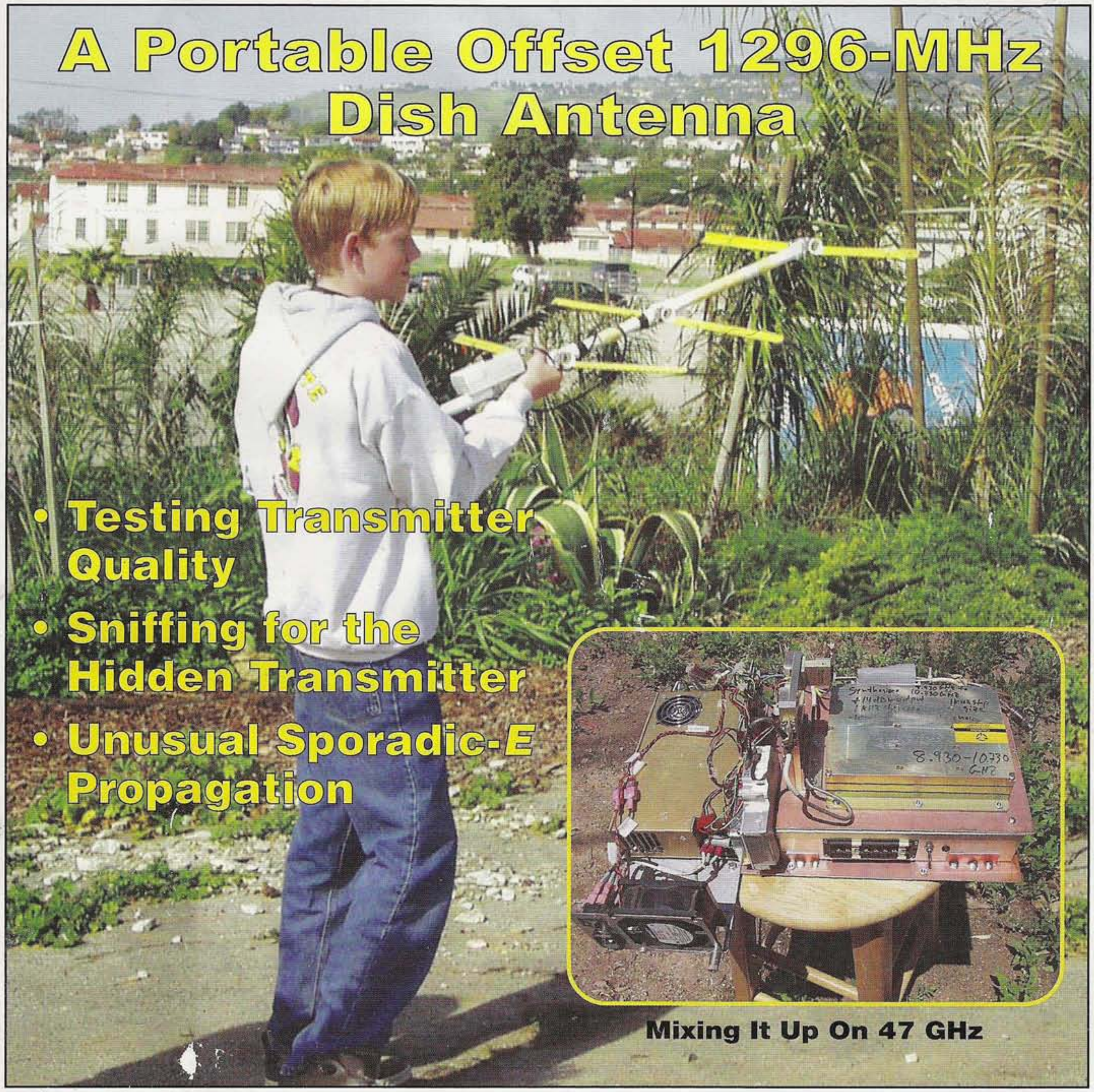

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CQ VHF **Ham Radio Above 50 MHz**

LINE OF SIGHT

A Message from the Editor

Oklahoma City Ten Years Later

It was on April 19, 1995 that this country suffered the worst terrorist attack in its history up until that time. From the very beginning of the aftermath of the Oklahoma City bombing amateur radio was involved. In particular, VHF and above frequencies proved to be the workhorse bands for the huge volume of traffic coming out of the perimeter of the bombsite.

In so many ways amateur radio shone. At the time of the blast, I was the ARRL Section Manager for Oklahoma. It became my responsibility to oversee the deployment of the amateur radio volunteers. It was truly amazing to see the outpouring of volunteers who provided the emergency communications during the nearly three weeks following the disaster. In all, more than 300 hams volunteered their time and equipment for the duration of the operation. My work was made so much easier than it could have been thanks to the ongoing training exercises conducted by local ARES volunteers who worked alongside the Salvation Army's network of amateur radio operators.

Almost from the beginning of the disaster rescue and recovery operations, the critical need for amateur radio involvement became apparent. Immediately following the bombing, cell-phone usage became almost impossible as more and more people used their cell phones to attempt to make calls, thereby jamming the various repeaters on the several networks in the Oklahoma City area. Without cell phones, amateur radio became the primary mode of communications. Hams were stationed at all of the area hospitals, at strategic points within the disaster perimeter, and at key locations throughout the city.

Initially, I was in the Oklahoma City police van providing information to the police as to the whereabouts of the various non-government organizations operating within the perimeter. Later I was assigned to provide communications for a Salvation Army canteen located across the street from the bombsite.

Local repeaters were pressed into constant 24-hour service, which was far in excess of their recommended duty cycles. In spite of this demand, these repeaters continued to perform admirably.

It's been ten years since that horrible Wednesday morning in the middle of April. I wish I could say that what we experienced in Oklahoma was the end of terrible terrorist disasters. However, it's just the opposite. It was the beginning. In the aftermath of the Oklahoma City bombing we still were naïve. We thought that we could do some debriefing for our own hobby interest, never thinking that we would ever be pressed into service with such intensity again.

As we all know, however, on September 11, 2001 we learned that Oklahoma City was but a blip on that radar screen focused on terrorism. What we learned from Oklahoma City proved to be very important. Even so, in the aftermath of September 11th, we found that we had so much more to learn. Thankfully, amateur radio seems to have become an integral part of the fabric of what is now known as Homeland Security.

My wife, Carol, W6CL, and I—and I am sure the vast majority of amateur radio operators who volunteered in the aftermath of the Oklahoma City bombing—will forever have vivid memories of the event. We wish that we could erase them. However, that is not the way with us humans. We who want to work for the good try to make good come out of those memories. One way to do this is to learn more about how we can be of service via our hobby.

New In This Issue

One way that we can learn how we can be of service is by way of reading about others' experiences. With this spring issue of *CQ VHF* we introduce a new column entitled "VHF+ Public Service." Edited by April Moell, WA6OPS (wife of Joe Moell, KØOV, the "Homing In" column editor), the column will cover her more than two decades of public service to our hobby, as well as current events that have a VHF tie-in. We look forward to reading about and learning from her and others who share their experiences with her as the column editor.

Another education source that is new with this issue is entitled "VHF+ Beginner's Guide." Edited by Rich Arland, K7SZ, it will cover basic concepts in VHF communications. For more than 30 years Rich has been writing for amateur radio and radio hobby publications, such as *CQ, QST, Monitoring Times, The Milliwatt,* and *WorldRadio.* Rich will continue to write the "Homeland Security" column for our sister publication, *Popular Communications.*

Also In This Issue

I am one who believes that education is always occurring. An excellent example of this is in this issue's "Homing In" column. As you can see by the cover photo, Joe Moell, KØOV, is making sure that youth are involved in hidden transmitter hunting, which is certainly one great way to introduce youth to our hobby and educate them at the same time. I would like to see articles from you, the readers, that tell of experiences of education in your local schools and how ham radio is being used as a vehicle to promote education of our youth. Speaking of hidden transmitter hunting, in this issue Gordon West, WB6NOA, writes about a new device that makes it much easier to locate the fox.

Other articles in this issue include the following: Continuing with his technical excellence, Leif Asbrink, SM5BSZ, presents part one of another two-part article, this one focused on transmitter quality. Al Katz, K2UYH, writes about an easy-to-construct portable dish antenna for 1296 MHz. Jon Jones, NØJK, covers unusual sporadic-*E* propagation. Ken Neubeck, WB2AMU, writes about conquering the January VHF Sweepstakes Contest from his automobile.

Saying Goodbye

As you will read in the "FM" column, Gary Pearce, KN4AQ, has written his last column for *CQ VHF*. Gary put off starting a magazine for the audio/visual field for quite some time, and he has decided that he needs to shift his priorities to that magazine. Gary has been with *CQ VHF* since its restart three years ago. Gary, we thank you very much for your hard work on the column and we will miss you a lot.

With Gary's departure, we are looking for a replacement columnist who will cover the technical side of FM and repeater operations. Please contact me at <n6cl@sbcglobal.net> if you are interested.

See You At Dayton

Carol and I will be at the VHF banquet the Friday night of this year's Dayton Hamvention®. Also, I am slated to give a talk at the VHF forum on Saturday. We look forward to seeing you at the CQ Communications booth or somewhere else during the Hamvention®. 73, de Joe, N6CL

The "Minor" Spring Equinox Sporadic-E Season of 2005

Winter sporadic-*E* usually occurs in December and January. Here NØJK describes very rare late-winter openings that occurred this year.

By Jon Jones,* NØJK

*"Sporadic-*E *(*Es*) occurrences are very rare during the months of September, October, February, and March, regardless of the zone. The spring equinox is the lower of the two."*

—VHF Propagation, A Practical Guide for Radio Amateurs *(Neubeck, West)*

"Probably the most March VHF Es *that I've seen in 40+ years of this." Pat Dyer, WA5IYX. Post to "Magic Band" Internet chat room March 09, 2005.*

The "spring equinox" 2005 *Es* season may well be one of the best ever recorded. Beginning on February 10th, the 6-meter band was open for *Es* on the 10th, 12th, 13th, 18th, 19th, 20th, 21st, 22nd, 23rd, and 25th. Ten out of fifteen days! The bands took a rest for a few days, then *Es* reappeared daily starting on February 28th and March 1st, 2nd, and the 3rd. Another break, then *Es* again on the 6th, and culminating in a massive 12-hour *Es* opening with TEP (trans-equatorial propagation) links to South America March 9–10.

The minor equinox season started with little hint of what was to come. The first week of February was a slow one for stateside stations, with some weak aurora reported on the 7th by stations in W1 and W7 along the northern tier states. To the south in Central America, the Caribbean, and South America, the TEP season was in full swing. ZP6CW in Paraguay reported FM, 9Y, P4, etc., on February 9th. Some weak aurora was heard on the evening of the 9th. Then on February 10th, *Es* appeared. A 3-hour long *Es* opening was reported along the eastern seaboard between W1, W3, W4 to Florida and Texas.

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Figure 1. On 23 February 2005, NØJK in EM17 worked Rafael, XE2OR/m in DL98 on 50.125 MHz.

On the 12th there were more *Es* occurrences from W1 to W4 and W5 along the Gulf Coast starting at 0040 UTC. As the *Es* opening in the east faded, a secondary *Es* center appeared in the west. Stations in Texas worked Arizona and California for a couple of hours to 0500 UTC. *Es* appeared again in the same day, starting at 1400 UTC between Illinois and Florida. On the evening of the 12th (now February 13 UTC) there were many *Es* contacts reported on 6 meters across the desert southwest between Arizona, Nevada, and California. The daily series of *Es* openings then stopped. Had this been it for February *Es,* it would have been an above-average month. The following are a series of observations that were made by myself, along with additional information from the various 6-meter spotting sites on the Internet. All dates and times are in UTC.

February 18th: Picking Up the Action

A geomagnetic disturbance began on February 17th, and aurora QSOs were reported on 6 and 2 meters on both the 17th and 18th UTC. The morning of February 18th, the spring 2005 equinox *Es* action really picked up. Starting early at 1200 UTC, a loud and widespread *Es* opening occurred over the eastern states. The *Es* waned at 1500 UTC, but then picked up to the west. In Wichita I worked W7RV and K7TOP in Arizona (in grid DM43) with loud, steady signals at 1540 UTC. This was a "summer"-type *Es* opening, not the weak "popcorn"-type *Es* usually encountered in February. The *Es* opening moved west, with K6QXY reporting the W5RP beacon at 1830 UTC. This opening lasted over six hours! In the afternoon there were more Es openings, with WB5KIA and AB5K in Texas and K5UIC in Louisiana working XE1AY (DK79) in Mexico at 2230 UTC.

"Some major Es *events on 6 meters have occurred on rare occasion during the equinox months and usually catch hams by surprise."* – VHF Propagation, A Practical Guide for Radio Amateurs *(Neubeck, West)*

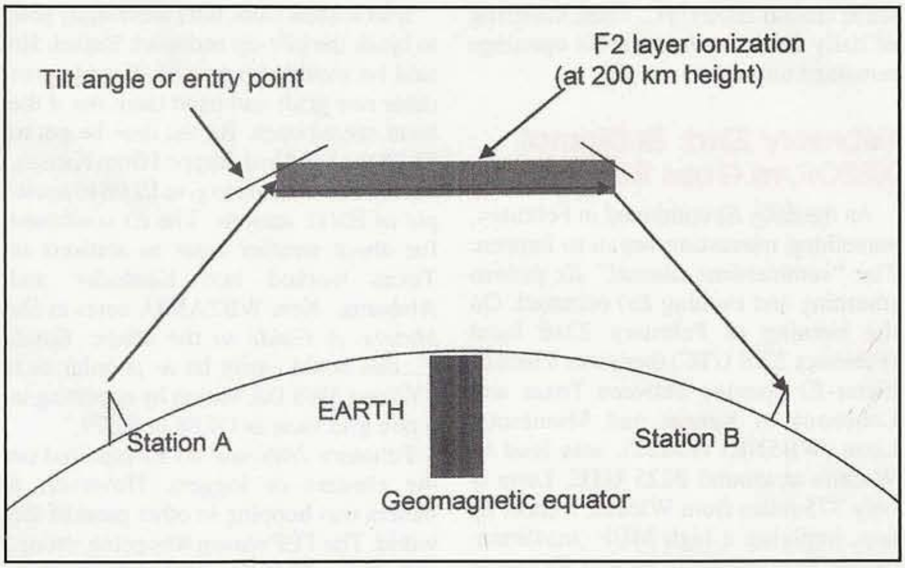

Figure 2. Transequatorial propagation (TEP) appears primarily on 6 meters and on rare occasion on 2 meters in certain parts of the world. (Figure courtesy of Ken Neubeck, WB2AMU)

February 19th: XE2YW DL82, XE2HWB DL44, XE1MEX EK08

Was the *Es* opening on the 18th a one-time event? The next day proved it was not. Starting at 2100 UTC on February 19th, stations in Texas began hearing the W4CHA beacon in grid EL88 Florida. The *Es* opening spread to cover much of the eastern part of the country, with the Gulf Coast in the thick of it. Conditions were good enough on 6 meters for QRP stations to make solid contacts. For example: 50.160 MHz, 2233 UTC, 19 Feb. 2005, N3CR (FN20) works K9HUY (EL86); N3CR uses 10 watts and a quad.

At 2250 UTC, from my QTH in Kansas (grid EM17), I worked XE2YW DL82 on 50.125 MHz. Stations in Oklahoma and Texas also worked Eduardo for a rare new grid, such as: 50.125 MHz, 2254 UTC, 19 Feb. 2005, KD5VHZ (EM15) works XE2YW (DL82).

Bernardo, XE2HWB, DL44 La Paz, Mexico worked into Texas: 50.125 MHz, 2307 UTC, 19 Feb. 2005, WB5KIA (EM13) works XE2HWB (DL44).

At 0134 UTC February 20th Pat, W5OZI, worked XE1MEX (EK08), and 20 minutes later Lefty, K1TOL (FN44), heard the C6AFP/b. Would the *Es* "link up" to TEP on to South America? Not this evening. Single- and double-hop *Es* to the south can sometimes form a "link" on to the trans-equatorial propagation to South America and the South Pacific.

The February 18th and 19th *Es* openings caught many 6-meter operators "by surprise." Who thought there would be any *Es* in late February on the 6-meter band? Word spread quickly on the "prop loggers" and Internet VHF chat rooms such as "DXers.info" that something was up with 6 meters.

February 20th/21st: "Big Ole Summertime" 6-meter *Es* opening

Es reappeared on the 20th, and this time 6-meter operators were ready. The 6-meter band popped open at 1915 UTC between Florida and Texas, with K4RX EM70 working WB5KIA EM13. The *Es* opening grew rapidly over the next hour, and 50-MHz spots scrolled by quickly on the packet clusters. The *Es* opening appeared to involve the whole eastern part of the United States, west to the Colorado border. W1, W2, W3, W4, W5, W8, W9, and WØ call areas were spotted. This was a strong, loud, and steady opening. Occurring on a Sunday, many hams were at home and able to get on the radio. Heard on the band were comments such as "This is just like a June opening." Many mobile stations were getting 59+ reports—e.g., 50.125 MHz, 2211 UTC, 20 Feb. 2005, K4YYL (EM84) works NØJK/M (EM17).

Stations with wire antennas got out like big guns: 50.128 MHz, 2332 UTC, 20 Feb. 2005, N8CJK (EN84) works AG4YO (EM60); AG4YO gets 5/9 report using wire dipole.

The opening went on hour after hour, well into UTC February 21st. Hundreds of 6-meter QSOs were made. By 0350 UTC the *Es* reached Colorado, with KØGU (DN70) hearing the K5AB beacon in grid EM01. The opening was fading for the more easterly stations, though. This was a six-hour long opening for many stations. However, despite some short 6-meter *Es* QSOs—such as AC4TO (EM70) to K5UIC (EM32) at 2008 UTC —no 2-meter *Es* contacts were reported. Also, there were no *Es* links to South America. This may well have been one of the best February 6-meter *Es* openings ever. On February 20, 1996, Ken, WB2AMU, observed a two-hour 6-meter *Es* opening. He considered this to be an unusual opening. Again on February 20, 2001 Ken observed 6-meter *Es* lasting for about three hours in the morning. The February 20, 2005 *Es* opening was over three times as long! Is there something about February 20th and *Es*? Ken wrote that there was a second three-hour *Es* opening that evening, resembling the diurnal summertime *Es* openings. The 2005 event was over six solid hours, starting in mid-afternoon.

What a great day February 20/21 UTC, 2005 was for 6-meter enthusiasts. Many wondered what the next day would bring.

February 21st was a slow one on 6 meters. In the evening (February 22nd UTC) some *Es* openings were reported on 50 MHz by Lance, W7GJ, in Montana to Oklahoma City at around 0150 UTC. AC7XP (DM43) in Arizona worked N7DB (CN85) in Oregon at 0356 UTC. That afternoon VE1YX (FN74) worked KG9Z (EN50), K9FW (EN71), and others at around 2000 UTC. Thus, the string of daily February 6-meter *Es* openings remained unbroken.

February 23rd: *Es* Diurnal, XE2OR/m Goes Roving

As the daily *Es* continued in February, something interesting began to happen. The "summertime diurnal" *Es* pattern (morning and evening *Es*) occurred. On the evening of February 22nd local (February 23rd UTC) there was a nice 6-meter *Es* opening between Texas and Louisiana to Kansas and Minnesota. Leon, WB5NRI (EM22), was loud to Wichita at around 0225 UTC. Leon is only 375 miles from Wichita, a short *Es* hop, implying a high MUF (maximum usable frequency). A second *Es* center formed over Kentucky, and KA6AKH (FM18) worked stations in EM37 and K5SW (EM25). The next morning, following the "diurnal" *Es* pattern, the 6-meter band was again open via *Es* to Texas, Louisiana, and Mexico starting at 1530 UTC. The *Es* was open over some of the same paths as the previous evening—another feature of summertime *Es* openings. I had nice chats with KK4TE (EM50), Smitty W4UDH (EM52), K5AL (EM40), N5QK (EM40), and W5GVE (EM10) in Texas. At 1600 UTC Rafael, XE2OR (DL98), popped up on 50.125 MHz running mobile. Rafael quickly drew a crowd: 50.125 MHz, 1613 UTC, 23 February 2005, NØJK (EM17) works XE2OR/m (DL98, see figure 1)—a big pile-up!

It took a few calls, but I was finally able to break the pile-up and work Rafael. He said he would drive to EL08 and some other rare grids and hand them out if the band stayed open. By the time he got to EL08 the band had dropped from Kansas, but Rafael was able to give EL08 to a couple of EN71 stations. The *Es* continued for about another hour as stations in Texas worked into Kentucky and Alabama. Ken, WB2AMU, notes in *Six Meters, A Guide to the Magic Band,* "…one could easily be as popular as a 3Y5 or a 3W8 DX station by operating in a rare grid such as DL88 or EL79."

February 24th saw no *Es* reported on the clusters or loggers. However, 6 meters was hopping in other parts of the world. The TEP season was going strong, and Eric, FM5JC, reported working 5T5SN for a new country at 0024 UTC on the 24th. If there had been double-hop *Es* from the Midwest, could it have linked on to 5T?

February 25th was another slow day. N8UUP reported hearing WA4VUT (EM50) "via weak *Es*" at 0220 UTC. Therefore, February 25th can be logged as another day of 6-meter *Es* for the 2005 season. February 26th and 27th had no Es either heard or worked. Some wondered if this was the end of the minor *Es* season. After all, March was almost here.

February 28th

To the surprise and then relief of 6-meter operators, *Es* appeared again on February 28th. Graham, KE4WBO (EL96), in south Florida had a strong opening to St. Louis, Missouri around 0045 UTC. Dennis, K7BV/1 (FN31), reported K4OXG (EL98) loud at 0202 UTC. Continuing the "diurnal" theme, the *Es* reappeared the next morning and afternoon. N3ALN (FM19) had K4OXG (EL98) back loud at 1656 UTC. The opening continued with some DX showing up. KB1KHK worked C6ANM on 50125.0 at 1814 UTC. Ed, VP9GE (FM72), in Bermuda worked W4MYA, K8WK, and others at around 1830 UTC. The *Es* opening picked up in the afternoon along the east coast. More DX was worked as K4CIA (FM05) spotted NP3CW (FK68) at 2205 UTC. FM5JC spotted ZD8VHF/b at 2302 UTC, but I noted no stateside spots for this beacon. The opening expanded west with K5BZM (EM18) working K4YMQ (EM63) at 2332 UTC. *Es* continued on to 2359 UTC.

There had now been six days in a row of *Es* on 6 meters in late February—a great "minor" *Es* season. Would it continue on into March?

March 1st: *Es* Appears!

Yes, it did! I worked Ivars, KC4PX (EL98), with a "40 over S-9" signal at 0046 UTC 01 March! The *Es* continued to Florida until 0300 UTC. Chalk up three hours of *Es* for March 2005.

March 2: March Madness—*Es* Links to South America

The next afternoon *Es* "appeared like clockwork" starting at 2314 UTC with

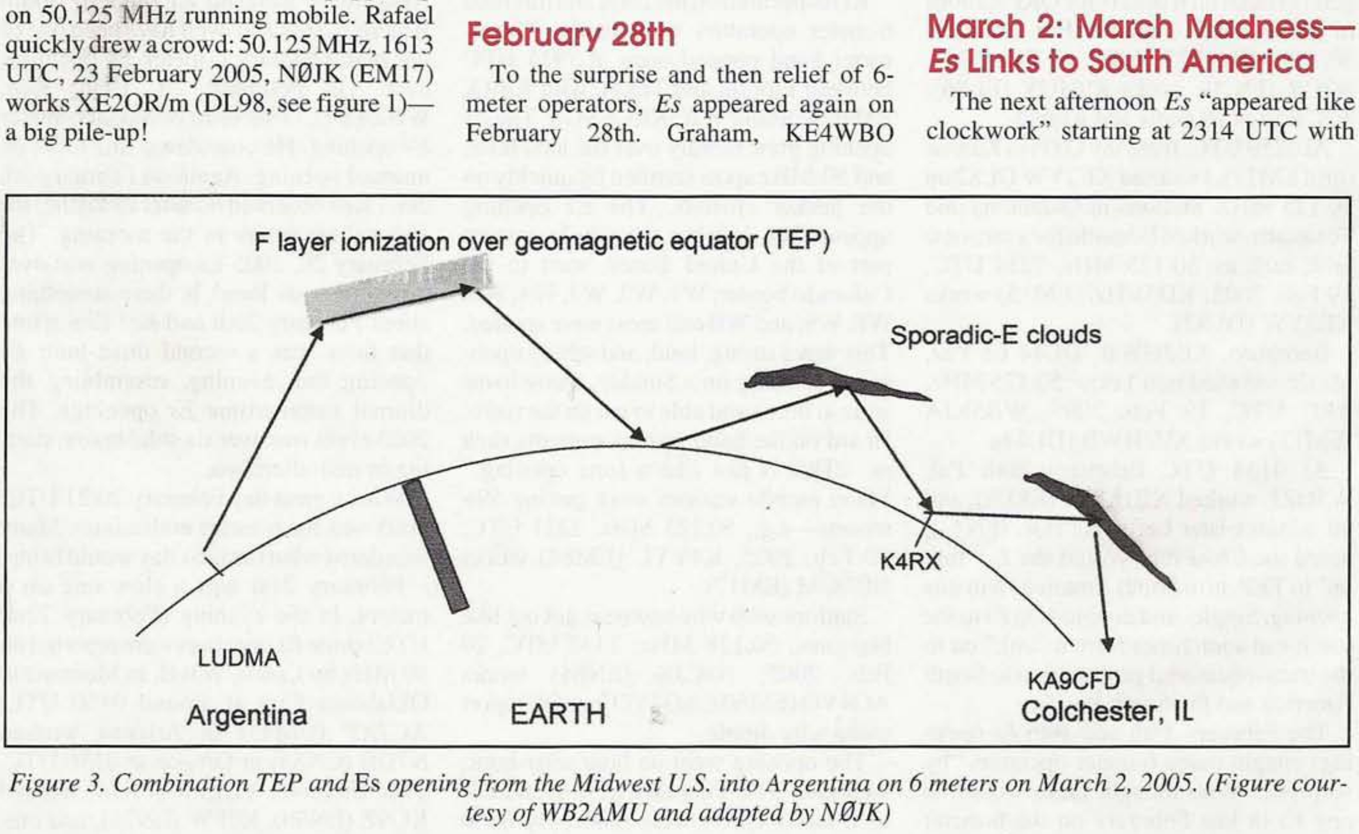

Figure 3. Combination TEP and Es *opening from the Midwest U.S. into Argentina on 6 meters on March 2, 2005. (Figure courtesy of WB2AMU and adapted by NØJK)*

K4RX spotting NP3CW, and K4DD (EM60) spotted the new 6Y5RC beacon 50.025 MHz in Jamaica. K4RX also spotted "CE/Musica" at this time, and Doug, ZP6CW, spotted 9Y4AT/b via TEP. The northern boundary of the TEP zone was likely the southern Caribbean and northern South America. The *Es* spot by K4DD clearly indicated the potential for an *Es* link on to South America via TEP. Indeed, at 2344 UTC ZP6CW spotted K4RX on 50.110 MHz. At 0012 UTC on March 2nd KA9CFD (EN40) worked LU1DMA (GF05)! What an amazing contact, five years from the peak of solar Cycle 23. At 0105 UTC I heard LU1DMA on 50.110 MHz! This may have been multi-hop *Es* linking to TEP propagation. See figure 3 for a graphical representation of this path.

Double-hop *Es* linking to *F2* and TEP has been documented previously. I personally made double-hop *Es* to *F2* QSOs on April 30, 2003. That afternoon had double-hop *Es* from Kansas to Costa Rica, with Keko, TI5KD, very loud on 6 meters. At the same time, the double-hop *Es* linked on to *F2* to LU7WW in Argentina at 1918 UTC.

I also heard HI3TEJ on March 2nd. Ted, HI3TEJ, was working W4 and W5 by loading up an 80-meter Zepp antenna on 6 meters! HI8ROX showed up on 50.120 MHz at around 0215 UTC. Unfortunately, I have a loud cable TV spur on .120 and was unable to copy Rafael very well. Bud, WØEKZ (EM17), did exchange 5 by 5 reports with HI8ROX at this time. This was double-hop *Es*, with the first hop from Kansas landing in the Florida panhandle, then the second hop on to the Dominican Republic. I believe KA9CFD may have had double-hop *Es* to the TEP zone, with the Florida panhandle stations having single-hop *Es* to TEP. By plotting W2GFF's logging, one can see there was an *Es* cloud for K4RX to LU. There were *Es* clouds for the hop from Florida to Illinois. The reports from Florida of the Dominican Republic stations and the Jamaican 6Y5RC beacon spots showed the presence of widespread *Es* clouds south of Florida on March 2nd. The 6Y5RC beacon spots are critical in

(Continued on page 70)

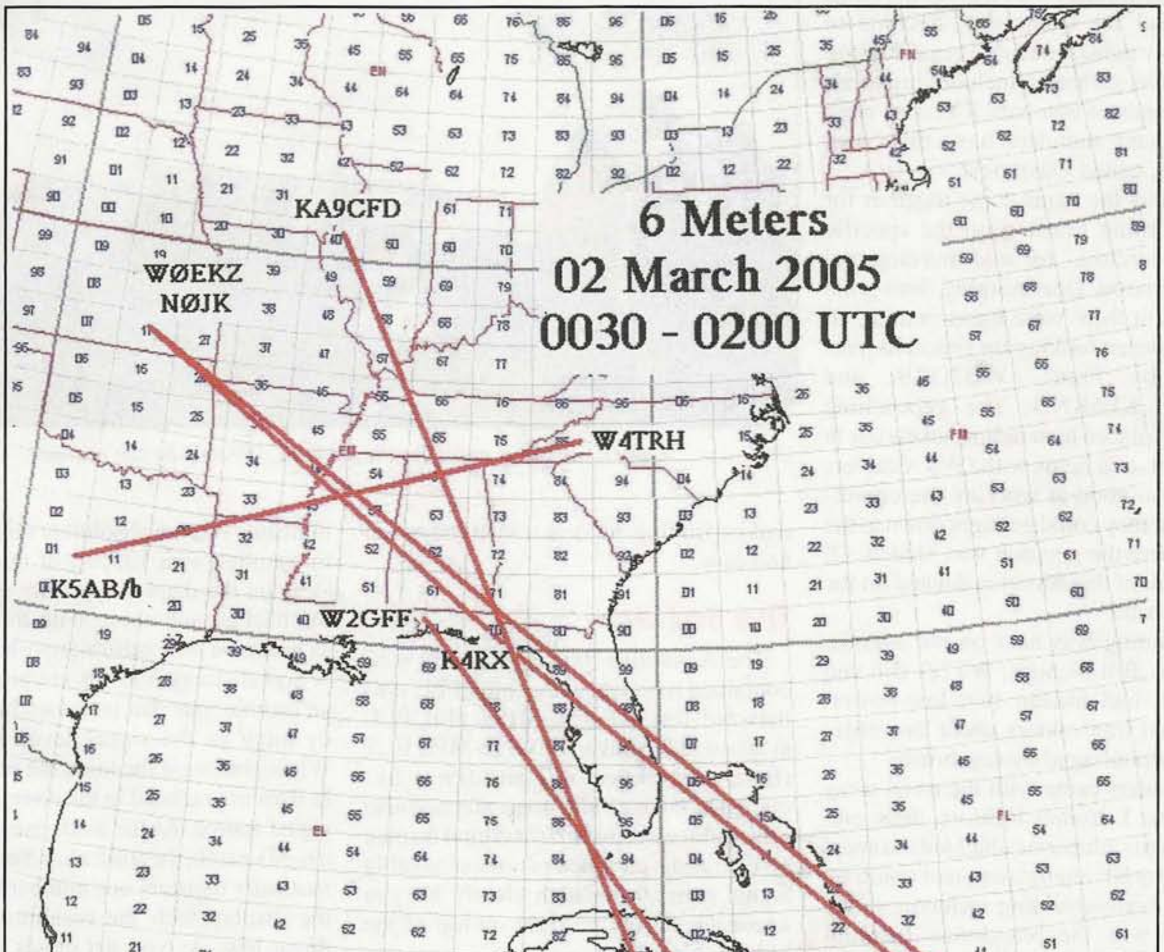

Figure 4. This map of the paths on 6 meters on March shows the value of posting loggings, even if it is not for "DX." Six-meter operators can plot the Es *paths and see if a path may be open.*

Field Testing The Australian Foxhunt Sniffer

Thanks to Aussie VK3YNG, the fox has to be even more clever on future hidden transmitter hunts. In this article WB6NOA describes the latest device for finding the fox.

By Gordon West,* WB6NOA

Every January over a thousand hams head for Quartzsite, Arizona to play radio for a full week. They are RVers. The gathering includes hundreds of thousands of non-ham RVers as well, but the ham attendees have their own activities, called Quartzfest.

Each day the hams come together for their morning briefing on the specific radio "exercises" for mid-morning and mid-afternoon. One morning during the 2004 event there were hams running all over the desert looking for geocachs, presented by Frank, WB7DRB, and Charlou, KE6KNO. The geocaching team had placed ham radio trinkets out in the desert, and hams with GPS receivers became so good at working the coordinates that they could get right down to the bush where the geocach was hidden. Of course, all of this was coordinated on the 2-meter band.

Foxhunting was next on the agenda, hosted by Bill Pienups, WT7Z. Bill and his team had hidden two low-power, sequenced transmitters about two miles away, camouflaged by sagebrush.

Foxhunters came with the usual array of finders: L-tronics locators, three-element beams, elaborate shielded scanners with series RF attenuation, and common HTs for body-shielding techniques. My receiver was the brand-new Foxhunt Sniffer from Bryan Ackerly, VK3YNG. The Sniffer was fresh out of the box. I had never used this equipment before, but I had seen it in action with my pal Jim Ford, N6JF, and also in use at a KØOV session a few months before. I was told by Foxhunt experts that this receiver makes finding hidden transmitters fun and easy.

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Quartzsite hams enjoying the foxhunt. (Photos by the author)

The Sniffer

The Australian Sniffer is a fully self-contained receiver, audio amp, PLL synthesized for 143–150 MHz, plus PLL synthesized to cover 120–123 MHz ELT (Emergency Locator Transmitter) frequencies. It has a built-in speaker and also a daylight-viewable *bright* digital display of operating parameters—most notably signal strength—which clearly let you know when you are right on top of the hidden transmitter.

This most amazing receiver has plenty of sensitivity to hear even the faintest of signals barely detectable on your trusty 2-meter HT. Also, as you get closer to the signal source, the built-in receiver *automatically* steps in 15 dB of attenuation, *automatically* selecting the optimum signal level with accompanying signal-strength readout as you look for the transmitter. A value of 9 on the bright readout indicates you are absolutely on top of the transmitter with 135 dB of attenuation. Zero on the display typically is nothing but background noise, with the receiver as sensitive as a half microvolt.

Signal-strength levels are provided by an audible tone that increases in frequency pitch as the signal level increases. When you begin the hunt, the pitch slowly rises as you head in the direction of the signal source. As the pitch rises to nearly a high squeak, the Australian Sniffer *automatically* registers one number higher on the display with the recalibrated pitch down low. As you get closer, the pitch climbs again, and when you are back at the high squeak, one number higher appears on the display as the pitch starts low again. *You don't need to push any buttons as you get closer to the signal source!*

Quartzfest would test how effective this automatic circuitry is. I planned to use the common three-element Arrow antenna for signal directionality. Body shielding with just a rubber duck could also be used, and as we were mobile, hooking into an outside antenna would give us a clear indication of whether we were heading toward the transmitter or away from it!

When you open up the back of the case to add two alkaline, long-life batteries, you can marvel at all the circuitry Bryan Ackerly has stuffed into this tiny box. Power up the unit and then prepare to enter your specific T-hunt frequency. Buttons 1 through 6 allow storing and recalling memory modes and frequencies, with some frequencies already memorized. I would write in 146.565 as the T-hunt channel. The display will show the last four digits of the selected memory frequency in kilohertz. Pressing and holding the buttons will result in the selected frequency and mode being stored in the selected memory, 1 through 6. The button must be pressed and held until two short beeps are heard in succession. This confirms that the frequency has been entered in memory.

Modes? Modes available are AM reception (A), FM open squelch (U), FM with squelch (F), and signal-strength tone, which reads out on the display. For the advanced T-hunter, headphones may be used where one channel is set to give signal-strength tone and the other channel follows the natural-sounding selected mode. This is useful for hunting different continuous-carrier transmissions where the transmitter's identification is given using either AM or FM modulation. Without headphones, the built-in speaker plays a myriad of low-level whistles as the unit looks around for a signal.

The Quartzfest Hunt

When the hidden transmitters became active on the desert floor, my Sniffer, hooked into the three-element beam, instantly came alive with a signal-strength reading of 1. A quick sweep with the Arrow antenna gave me an unmistakable rise in pitch when the antenna was pointed toward one of the hidden Ts. A minute later, one T went off and another came on, and a quick swing of the three-element antenna gave me a crystal-clear indication that the *other* hidden transmitter was located much closer than the first one (higher number on my display) and 45 degrees east of the first signal. Since this transmitter was closer, yet in the same general direction, we decided to go after it first.

Finding the first transmitter was a snap with the Sniffer. As we drove down a desert road, we used a rubber-duck antenna on the Sniffer inside the vehicle and continuously watched the signal strength go higher. This corresponded with the tone pitch as it went from low to high as we got closer to the signal. But wait . . . the tone was then going down. We hit the brakes, climbed out of the vehicle, put the three-element beam on the Sniffer, and saw that we had to be extremely close to the hidden transmitter, because the signal-strength digital readout was showing 6. This was a 50-milliwatt transmitter, so we simply walked in the direction of the ascending tone and literally went in a straight line right down to the desert bush in which the transmitter was hiding. It was well hidden! We actually had to dig in the sagebrush to finally spot it.

We got to the transmitter just as it was cycling down for the next minute of the other transmitter. A quick sweep with the beam confirmed it would be on the other side of the road and still pretty far away, because signal strength had barely gone from 1 to 2 on the display.

Off we went with the rubber duck back on the Sniffer. When the display went to 4 and then began to drop in pitch, we hit the brakes and backed up 100 yards to a dirt road leading to nowhere imaginable out in the desert. Out of the car we jumped and added

VK3YNG's Foxhunt Sniffer is compact and can also be operated with a rubber-duck antenna!

the beam, and sure enough, down the road and a little bit to the right we went. And as we walked down the road, the tone began to get noticeably higher in pitch, and this confirmed we were headed in the right direction and getting relatively close to the hidden transmitter. With only 3 showing on the display, we continued to walk in the same direction, even though the original transmitter, T #1, was playing its tune miles away.

After 10 minutes of walking with the display numbers flashing between 6 and 7, we knew we were getting close. The beam clearly gave us a peak in pitch in the direction of a large desert cactus. When we got as close as we could, we walked all around the cactus with the beam continuously pointed at the cactus. There it was, nestled in a tiny crevice of the cactus—hidden T #2.

Advanced Features of the Sniffer

For the more experienced T-hunter reading this article and yawning while thinking that the transmitter hunt was too easy, there are plenty of advanced features in the Australian Foxhunt Sniffer. Version 2.2 or later has a special mode for hunting very-short-duration pulsed or "PIP"-like sounding transmitters. This type of signal may only be 40 milliseconds, but it is plenty long enough for the receiver to track it. Pulsed 40-millisecond signals can be used for tracking animals, model rockets, and model planes.

The Sniffer has a peak extend mode which stretches out the received pulse so that its signal level and resultant tone can easily be determined by rapidly swinging the beam. We also found this mode useful in identifying noise sources found in motorhomes and motor yachts. We could actually pinpoint the

(Continued on page 74)

A Small Offset Stress Dish for a Portable 1296-MHz EME Station

Originally published in the *Proceedings* of the 11th International EME Conference (August 6–8, 2004), this article describes an offset dish and mount that was designed for portable EME operation on 23 cm. The antenna and mount can be disassembled into a relatively small, lightweight package that can be carried as luggage on an airplane, yet is equivalent in performance to an about 8-foot diameter parabolic dish.

By Al Katz,* K2UYH

The development of JT44/65 software has generated considerable interest in portable and mini DXpedition activity on 1296-MHz EME.[1,2,3] Most of these DXpedition stations have used single long Yagi antennas because of their small size and low weight. Unfortunately, on 1296 MHz single Yagis have insufficient gain to allow CW contacts with all but the largest stations. CW remains the preferred, if not the exclusive, mode of many EME operators. Even using JT44/65, QSOs are not possible with the smaller 1296-MHz stations. Consequently, a small but higher gain antenna should be of great interest for portable 23-cm EME operation.

One problem with Yagi antennas is that most are linearly polarized, while almost all *regular* 23-cm EME stations use circular polarization. It is possible to produce a circularly polarized Yagi, and this would help. The use of circular polarization would provide an effective gain increase of 3 dB, but even more gain is desirable.

Dish antennas can be fed circularly polarized and provide lots of gain, but they also provide considerable additional weight and size, along with the gain. Stress-dish designs can solve the problem of weight. For small-size dishes feed blockage becomes a problem. At 1296 MHz, particularly for dish diameters of 8 feet and less, feed blockage starts to significantly reduce antenna efficiency. The offset dish concept eliminates the feed-blockage problem. It allows relatively small dishes to provide high-gain efficiency. It thus seems that a circularly fed, offset stress dish would be an ideal antenna for portable 1296-MHz EME operation. This article describes the design of just such an antenna.

Offset Dishes

Offset dishes are just a portion of a parabola of revolution (conventional parabolic dish).[4] The antenna described in this article uses slightly less than a quarter of a conventional dish reflector. By using only part of a normal *full* dish as the reflector, the feed antenna can be moved away from the center of the reflector, where most of the RF energy is located. The feed can be located to one side of the reflector, where little or no RF energy is present, as shown in figure 1. The feed must still be located at the focal point of the parabolic curve. The feed must also have higher gain, since it *ideally* should only illuminate the reflector area. (As noted, the offset dish is only a *fraction*

Photo A. A 7.5-foot offset dish on polar mount. (All photos courtesy of the author)

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e-mail: <a.katz@ieee.org>

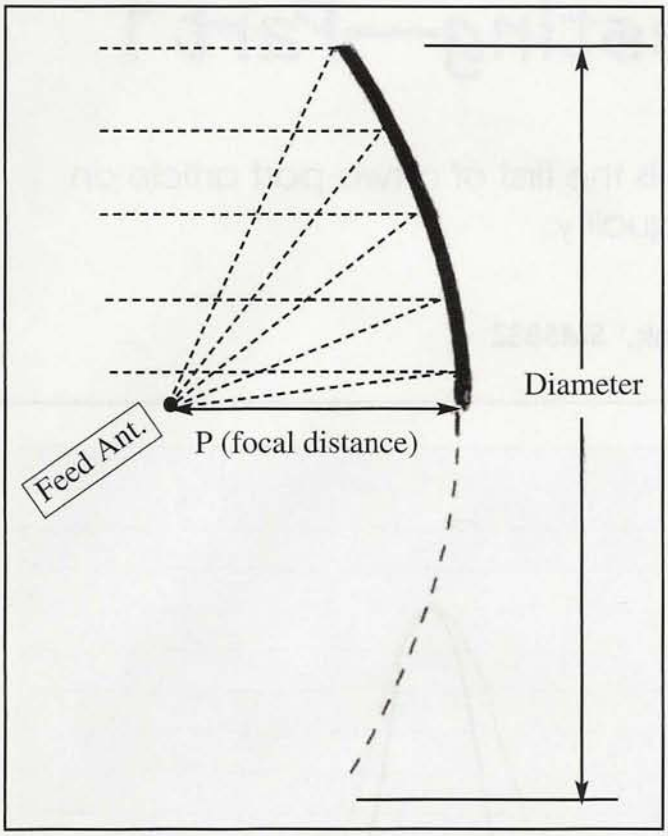

Figure 1. The feed is located to one side of the reflector.

Photo B. The struts are attached to a square plywood center with two bolts.

Photo C. An outside rim is formed from 3.5-foot length of 1/2" × 1/2" modeling strips.

of the full dish. Hence, the feed antenna must have higher gain to produce a smaller beam.) Likewise, a deeper dish (smaller equivalent f/D ratio) should be used for the offset reflector to keep the feed antenna to a reasonable size. The offset dish, besides having greater efficiency than a conventional dish antenna, has an added advantage for EME. It can be mounted with its center of gravity very close to the ground and still fully track the moon. This allows a relatively small mount to be used and makes a polar mount an attractive choice with an offset dish.

Dish Construction

It was decided as a compromise between portability and gain to construct a reflector with a radius of 7.5 feet. This would correspond to a conventional dish of 15 feet in diameter. In the case of our offset dish, only a quarter of a conventional dish's surface is used. This surface was produced from five 7.5-foot lengths of 1/2" × 3/4" wood molding stock, readily available at the local home improvement store. These *struts* were attached to a 1-inch radius wedge-shaped (quarter of a circle) piece of 1/2-inch plywood with two bolts. A 3-foot overlap was used. It would have been preferable to make channels into which the wood struts could be inserted for attachment. I used this method of attachment for the 70-cm, 20-foot portable stress dish I produced more than 20 years ago.[5] This arrangement is stronger and makes assembly and disassembly quicker, but with only five struts the added time was not considered significant.

A rim around the outside of the reflector was made with a 3.5-foot length of 1/2" × 1/2" wood modeling stock with two small (8-32) bolts as shown in photo C. The 3.5-foot length was chosen to produce a reflector with an equivalent (full reflector) f/D ratio of about 0.3. This corresponds to a feed beamwidth of about 90°. (This beamwidth matches a dual dipole feed reasonably well.) Making the reflector deeper using the relation $X^2 = 4PY$, where X is radius of the reflector, Y is the height, and P is the focal distance, will allow a wider beam feed to be used. The dish's focal distance is about 4.5 feet.

The dish's focal length is about 4.5 feet long. A 3.5-foot length of 2" × 3" lumber was used for the main feed support. This piece was attached to the plywood center section using a small wood block. Nylon ropes were run from the feed support to eye bolts at the ends of each strut. The length of these lines was adjusted so that the radius (X distance) of each strut was 7.5 inches. It was discovered that the pull of struts was bending the feed support (and plywood center section). To

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Transmitter Testing—Part 1

Reprinted from *DUBUS** magazine, this is the first of a two-part article on how to correctly measure transmitter quality.

By Leif Åsbrink,† SM5BSZ

The importance of a good dynamic range in receivers is well known among amateurs (see "Receiver Dynamic Range," parts 1 and 2, by SM5BSZ, in the Fall 2004 and Winter 2005 issues of *CQ VHF,* respectively). Receiver dynamic range seems to be one of the important factors behind commercial success or failure of a transceiver model. The quality of the transmitter is, of course, equally important, but transmitter testing does not get the same attention in amateur publications, and methods for transmitter testing are far less satisfactory than currently used methods for receiver testing. There is an obvious reason. The deficiencies in transmitter design that cause unnecessary interference do not create problems to the owner! It is other people—his neighbors on the bands—who suffer from the QRM. It is certainly meaningful to try to improve the standards of amateur transmitters, because today the transmitters are usually the limiting factors, particularly on VHF.

In the previous article of this series[1] the quantity DR_2 was introduced for the two-signal dynamic range of a receiver. The way it is defined, in 1-Hz bandwidth and with 3-dB degradation of the S/N of the weak signal, it makes DR_2 equivalent to transmitter sideband noise. To understand this concept, imagine a receiver that has $DR_2 = 133\ dB_{Hz}$ which is what is required on 7 MHz according to Peter Chadwick, G3RZP, stated in an article in *QEX* magazine.[2] Also imagine a transmitter with a sideband noise level of –133 dBc/Hz. Using that receiver, a strong signal from a perfect transmitter will cause a certain amount of S/N degradation of a weak signal. Assuming the same signal levels for the strong and weak signals, the sideband noise from the noisy transmitter will cause exactly the same S/N degradation to a weak signal in a perfect receiver.

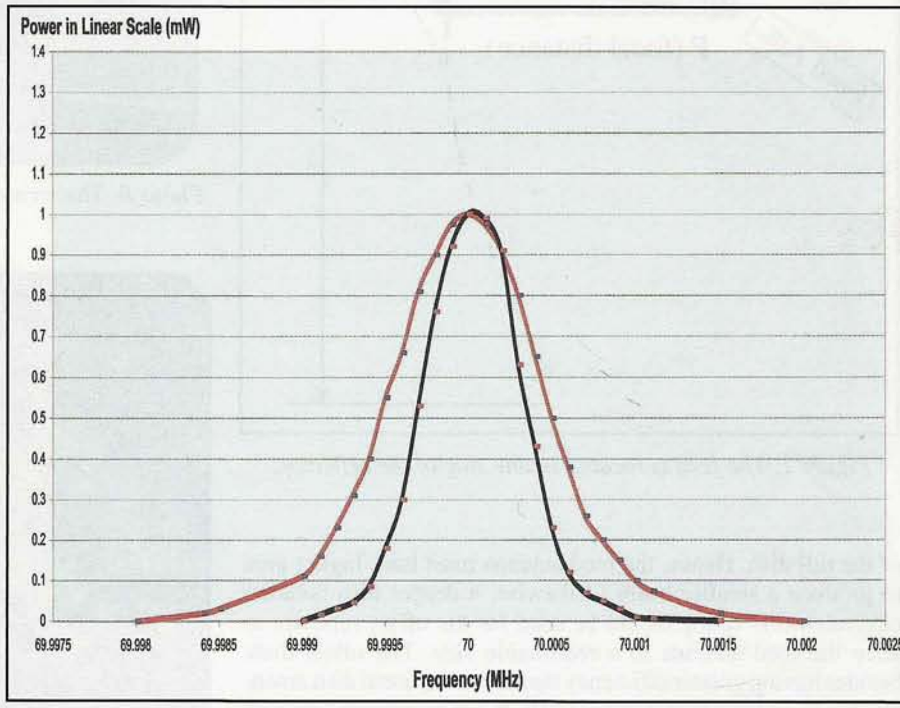

Figure 1. The 1-kHz filters of Tektronix 2753P and HP8591A spectrum analyzers. Numerical integration of these curves gave bandwidths of 722 Hz for the 2753P and 1145 Hz for the 8591A.

A DR_2 dynamic range of 133 dB_{Hz} may be adequate on HF bands, but the situation on VHF is very different. For this dynamic range to be adequate when two 100-watt stations on 144 MHz are beaming towards each other, the stations would need to be separated by as much as 100 km! Thus, it is not uncommon for the VHF amateur to find DR_2 and/or transmitter sideband noise is the limiting factor when trying to work DX. For a typical VHF rig, DR_2 is actually worse than in this example, only between 110 and 120 dB_{Hz} at a frequency separation of 20 kHz. Transmitters are often worse than receivers, even when transmitting an unmodulated carrier.

There is also some confusion about the meaning of the word *test* when it comes to transmitter testing. In a factory one should have a pass/fail test, something that is well defined and produces the same result on the production line as it does in the laboratory. The purpose is simply to find faulty units to make sure they do not reach the market. However, when a transmitter is being tested for a product review, the meaning of *test* is something entirely different. Then one wants a test that reveals all out-of-channel emissions that the test object may produce in real life when operated within the recommendations of the operating manual. Tests done by development engi-

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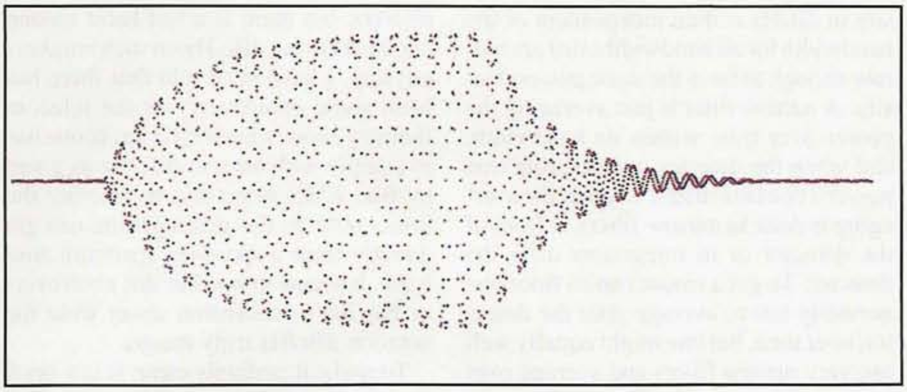

Figure 2. The time-domain waveform of a keyed signal. The keying rate is 110 dots per second, corresponding to about 250 wpm. The waveform is in complex format with I and Q 90 degrees out of phase.

neers are yet another thing. In the development phase one uses a large range of very specific tests on individual building blocks to optimize them separately. Interference can be generated by many different mechanisms, and it is the responsibility of both the development engineer and the review engineer to seek these problems out, using whatever tests are needed to reveal them. While the pass/fail test has only two outcomes, yes or no, the output of product-review testing is a lot of data that should inform the prospective buyer whether the unit in question is suitable for his intended use.

As I see it, the only honest procedure to test the purity of a transmitter's signal for a product review can be described in words such as this: "Connect the transmitter to a spectrum analyzer, and operate it as described in the operator's manual while watching the spectrum. Vary the modulation with pauses and different voice levels for SSB. Observe what happens when the VOX, QSK, or PTT button switches between RX and TX. Note spurious emissions that happen infrequently, and adapt your input to the transmitter to try to make them happen often and repeatedly. In general, operate the transmitter to create the worst-case interference within the limits given by the operator's manual." The output of such a test is the worst-case spectrum and a description of the worst-case modulation input.

One of the main problems in modern transmitters is the ALC, a servo system that is designed to keep the output power below a certain threshold. Any servo system can have stability problems, and the ALC system of a transmitter is no exception. The interference generated can be horrible, but a standardized two-tone test will not show anything at all. It is becoming well known that the simple two-tone test does not reveal much of the real performance of an SSB transmitter. With two constant tones that are separated by 1 kHz, exactly the same maximum power is reached 1000 times each second. With the fast-attack, slow-release ALC characteristic of a typical SSB transceiver, the ALC control voltage will be very close to a DC voltage with just a small saw-tooth-like component superimposed on it. Likewise, the power supplies will be operating under nearly constant load, and their dynamic regulation is not being tested at all. Consequently, the two-tone test will not show many of the problems that may occur during normal usage with voice modulation. It only shows the fundamental linearity of the final amplifier, not the rig as a whole.

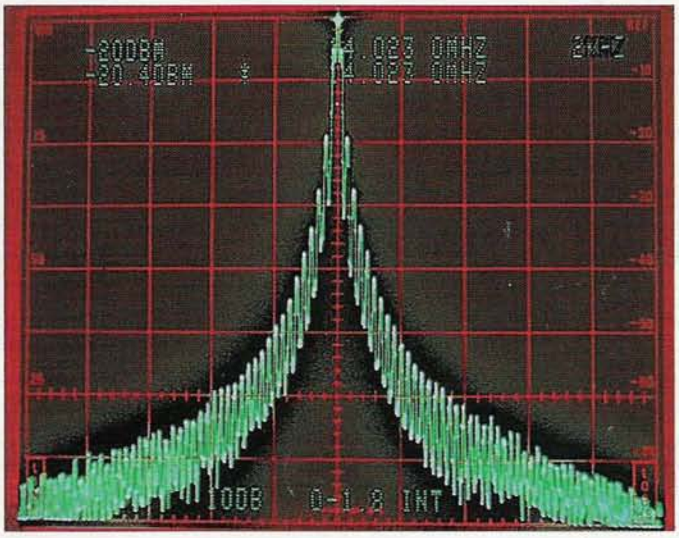

Figure 3. The spectrum of the signal shown in figure 2 as seen on a Tektronix 2753P spectrum analyzer. The scale is 10 dB/div and 2 kHz/div and the filter in use is 100 Hz.

The simple test, just measuring the emitted spectrum while modulating the transmitter as if it were on the air, has a practical problem: Professional spectrum analyzers are not good enough! The sideband noise levels of the oscillators in the spectrum analyzer (a multiple-conversion superhet) need to be substantially lower than those in the transmitter under test, or else you are measuring the test equipment, not the transmitter. The ones I have access to have sideband noise levels of about –100 dBc/Hz at 20 kHz, and the best performance I know of in a commercial instrument is –125 dBc/Hz at a frequency separation of 10 kHz (Rohde & Schwarz FSU series). This problem arises from the need to make professional test equipment broadband from near-DC to perhaps several GHz. However, for testing amateur equipment we do not need broadband coverage, and therefore high-quality measurements are not so difficult, as will be shown below.

There is another problem, however, a more fundamental one which requires some discussion. The interference caused by a transmitter—be it noise sidebands, splatter, or keying clicks—occupies a large bandwidth. The level one will see on a spectrum analyzer depends strongly on the bandwidth, the sweep speed, and the detector used. To produce a good characterization of the interference it will be necessary to make two measurements—one which uses a peak-hold detector in SSB bandwidth and another which uses a detector for the average power in a narrow bandwidth. The two measurements are discussed in detail below.

The Average Power Spectrum

The average power spectrum is what we use to show the sideband noise of an unmodulated carrier. When a carrier is modulated, the total power emitted (averaged over the entire transmission) is typically lower by 3 dB in CW and by 10 dB in SSB. At large frequency separations the average power spectrum will show correspondingly lower levels, but at close separations the average power spectrum may actually *increase* due to the tails of the modulation sidebands.

The correct procedure to measure the average power spectrum is to use a true RMS detector. The resulting power density in dB/Hz is then independent of the bandwidth for all bandwidths that are narrow enough to have the same power density. A narrow filter is just averaging the power over time within its bandwidth, and when the detector is measuring true power it does not matter whether the averaging is done in narrow filters in front of the detector or in integrators after the detector. To get a smooth noise floor one normally has to average after the detector, over time, but one might equally well use very narrow filters and average over a range of frequencies. The results would be identical.

However, spectrum analyzers typically have logarithmic detectors. It seems there are standard procedures that specify that the smoothed reading on a spectrum analyzer has to be below some specified limit. The limit is then not truly in dBc/Hz, but there is a bad habit among engineers to put dBc/Hz on such numbers anyway. I have been told that there has been some controversy in the telecom industry about whether the limits one has to comply with refer to dBc/Hz as given by true RMS detectors, or whether the limits refer to the readings one can get directly from a specified spectrum analyzer. It seems to me that this controversy has led to confusion about what the notation dBc/Hz truly means.

To make it perfectly clear, it is a good idea to express the concept in words. The noise-floor power density in dBc/Hz is the ratio of the noise power in 1-Hz bandwidth to the power of the carrier. The power of the carrier is easy. It does not matter what bandwidth or detector one uses; the spectrum analyzer is calibrated to always show the same level for a pure carrier. The noise

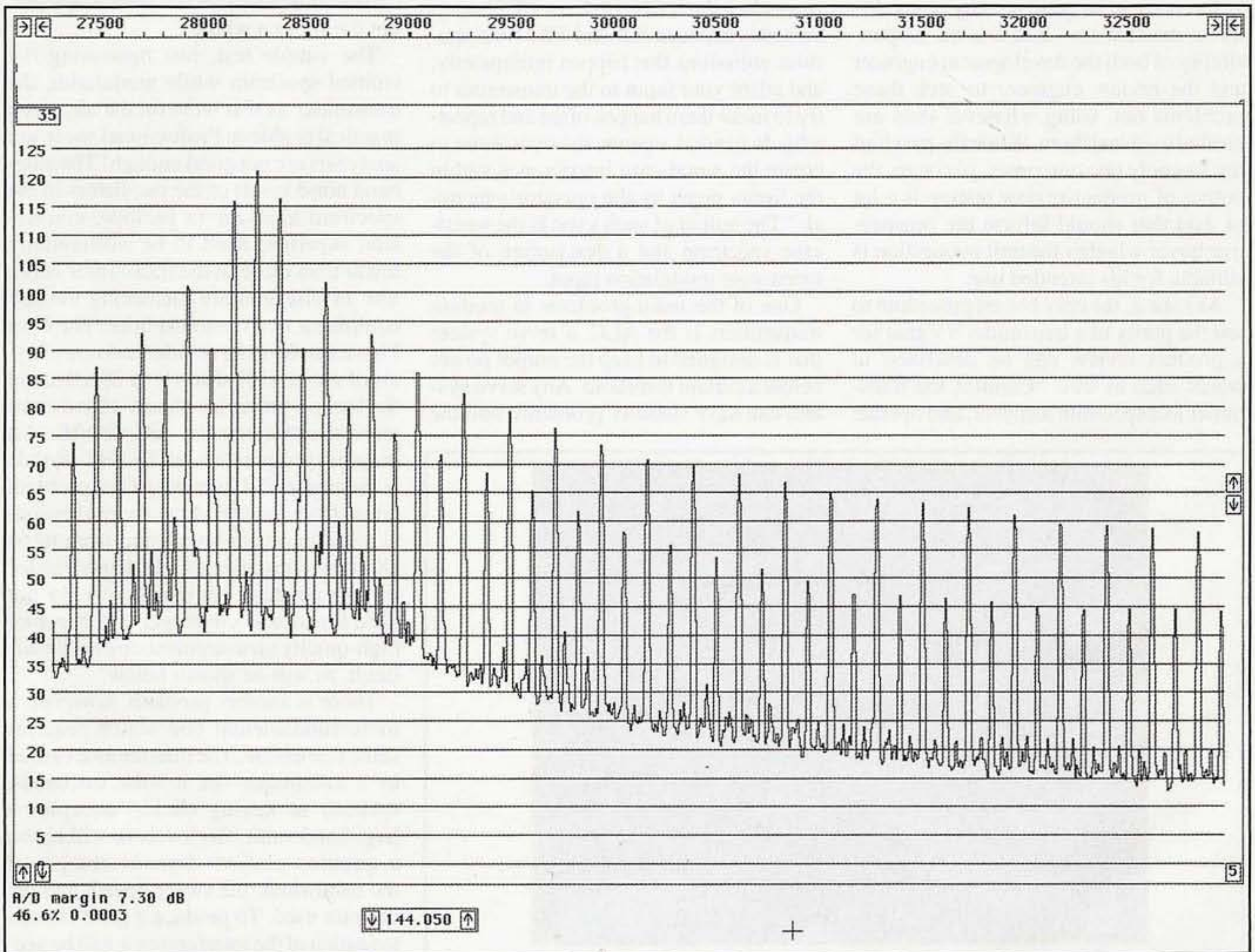

Figure 4. The same signal as in figure 2 as seen on the Linrad screen when zoomed in. The width of this spectrum is about 5 kHz. Here the individual keying sidebands are very visible. Note that the sidebands of even order are weaker. This is because the modulation before RC filtering was a square wave with 50% duty.

power is different. The only way to measure it correctly is to use an RMS detector. A log detector shows a value that is 2.51 dB too low if the signal looks like white noise within the passband. Another thing is that the selected bandwidth of the spectrum analyzer may be different from the true noise bandwidth.

To illustrate the accuracy of sideband noise measurements from standard instruments, I have fed noise and a signal to two different spectrum analyzers, a Tektronix 2753P and an HP8591A. The test signal was a carrier at 70 MHz, –80 dBm from an HP8657A signal generator which was amplified in a deliberately noisy wideband amplifier. The resulting signal had a carrier at –44 dBm with a flat noise floor at –85.0 dBc/Hz as measured by Linrad[3], which uses DSP to provide a true RMS detector after a nearly perfect rectangular filter. Both spectrum analyzers gave noise-floor power densities that did not depend on the bandwidth setting, within a few tenths of a dB. The value obtained from the 2753P was –88.8 dB/Hz, while the result from the 8591A was –86.6 dB/Hz. These were the uncorrected values obtained directly from the carrier and noise-floor levels and the nominal instrument bandwidths. For the 8591A, the bandwidth refers to the –3dB points of a filter that is close to Gaussian, while the nominal bandwidth of the 2753P refers to the –6-dB points of a filter that is relatively flat and has steep skirts. A spectrum analyzer is an excellent instrument to measure its own frequency response, simply by sweeping across a carrier.

Figure 1 shows the responses of the nominally 1-kHz filters in linear power scale. By numerical integration it is possible to find out what bandwidth a perfectly rectangular filter should have to give the same area under the curve as the one observed. (With 10 data points for each kHz, it amounts to taking the sum of all the data points and dividing by 10 to get the noise bandwidth in kHz.) For the 2753P the noise bandwidth turned out to be 722 Hz, while it was 1.14 kHz for the 8591A. The logarithm of these numbers give corrections in dB which add to the 2.51-dB correction for using a logarithmic detector. The theoretical correction for the 2753P was thus +3.94 dB, while it was +1.94 dB for the 8591A. Applying these theoretical corrections, one determines the noise floor of the

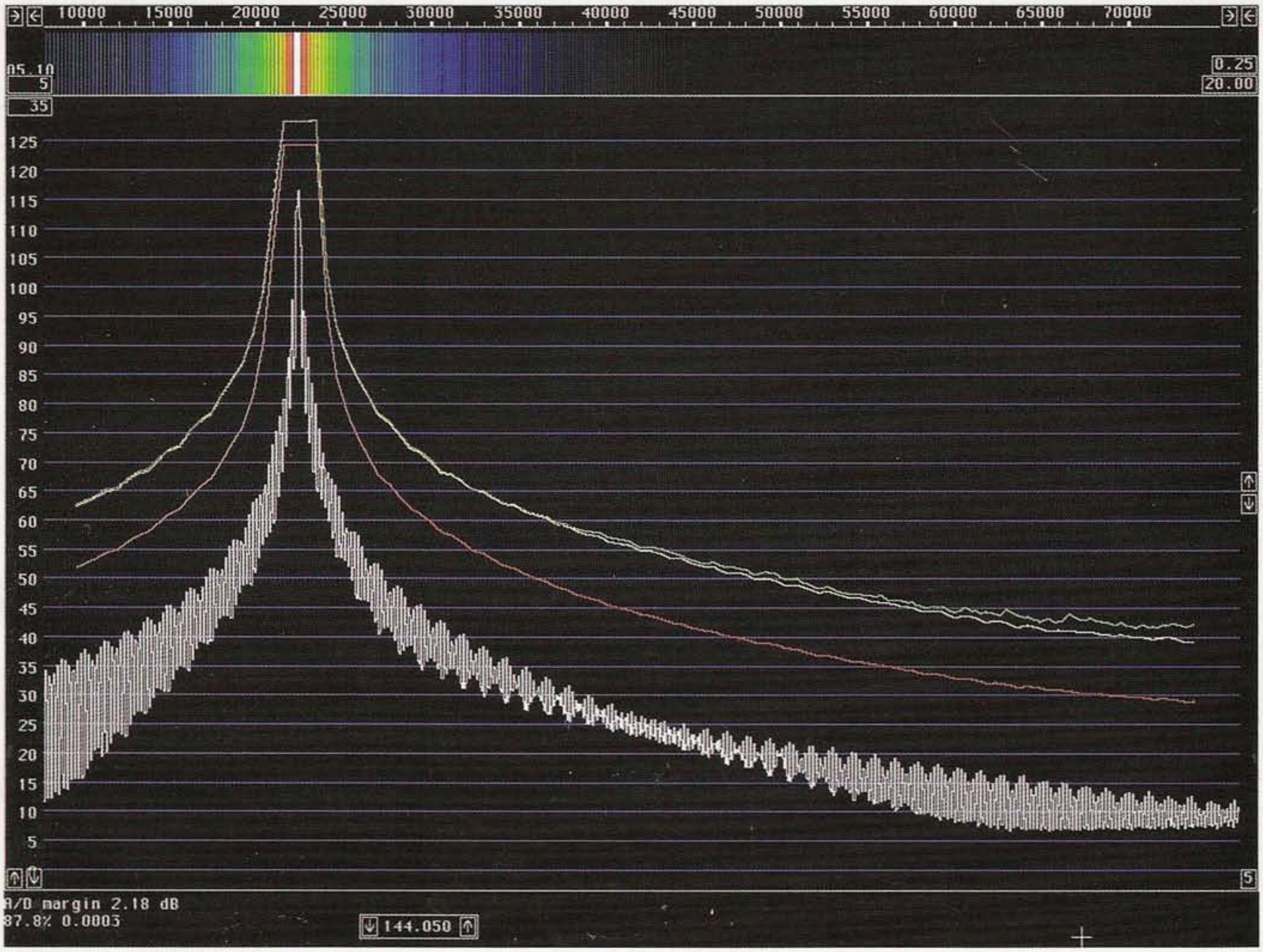

Figure 5. The signal of figure 2 as seen with Linrad in TX test mode. This image shows the spectrum up to 50 kHz above the carrier. The bottom trace is the average power spectrum in an FFT bandwidth of 12 Hz, the same as in figure 4. The screen has only 1024 pixels, so each pixel is the average of 24 FFT bins. This is the reason why the amplitude of the carrier is low. The upper curve is the peak-hold spectrum in 2.4-kHz bandwidth. Very close to it is the average peak-power spectrum. The curve in the middle is the average power spectrum in 2.4-kHz bandwidth.

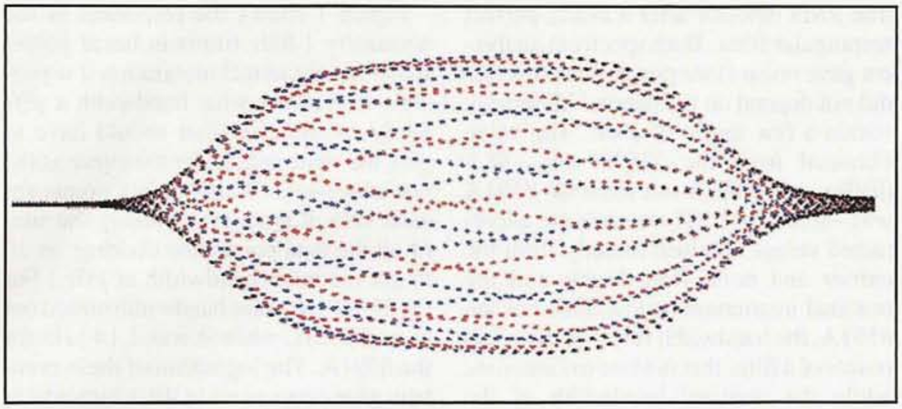

Figure 6. The keying waveform of IC706MKIIG at 144 MHz. The keying is 55-Hz square wave.

above experiment to be –84.9 dBc/Hz from the 2753P and –84.7 dBc/Hz from the 8591A; both corrected values were now in fair agreement with the value –85.0 dBc/Hz obtained from Linrad.

Measurements of amateur transmitters with sideband noise levels in the range –110 to –140 dBc/Hz at a frequency separation of 20 kHz can be done in many ways. Most popular is to use a good crystal oscillator and a high-level mixer to shift the carrier frequency to near zero. The carrier can then easily be removed with a high-pass filter. [4] The noise spectrum is then measured at audio frequency. One will get the noise from both sidebands, so one has to correct by 3 dB for that, as well as for the bandwidth and the detector if something other than an RMS detector is used. This method is used by the ARRL lab in the composite-noise test for *QST* product reviews, but some of the corrections are neglected[4] and the results published in *QST* are more optimistic than the results I find, by about 5 dB.

Another way is to use a good receiver and an attenuator. The receiver should be run in CW or SSB mode without AGC, and the output level should be measured with an RMS voltmeter. This way one gets the signal and noise levels directly, and one just has to know the frequency response of the receiver to calculate the noise bandwidth.

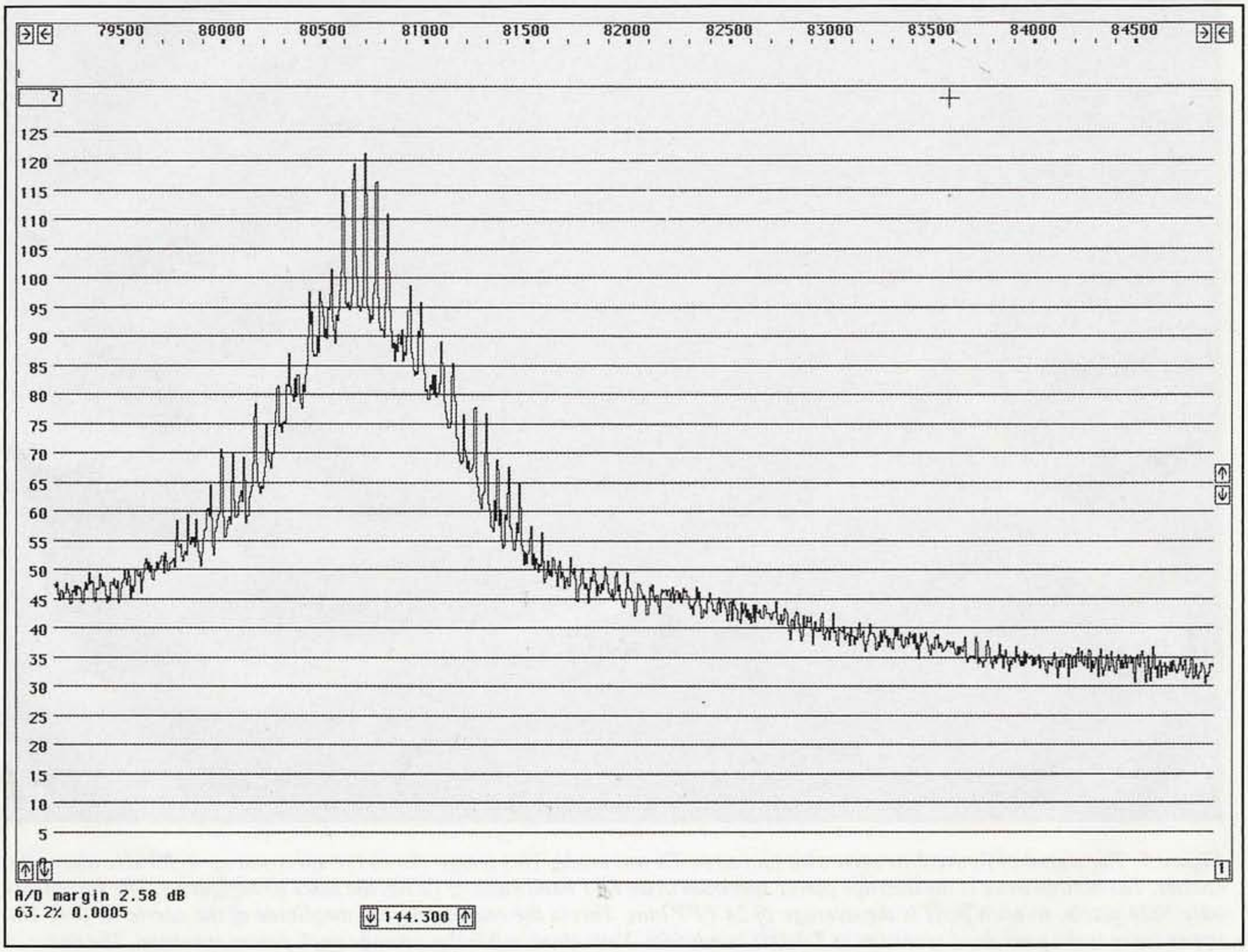

Figure 7. The spectrum of the signal shown in figure 6, an IC706MKIIG keyed at 55 Hz on 144 MHz.

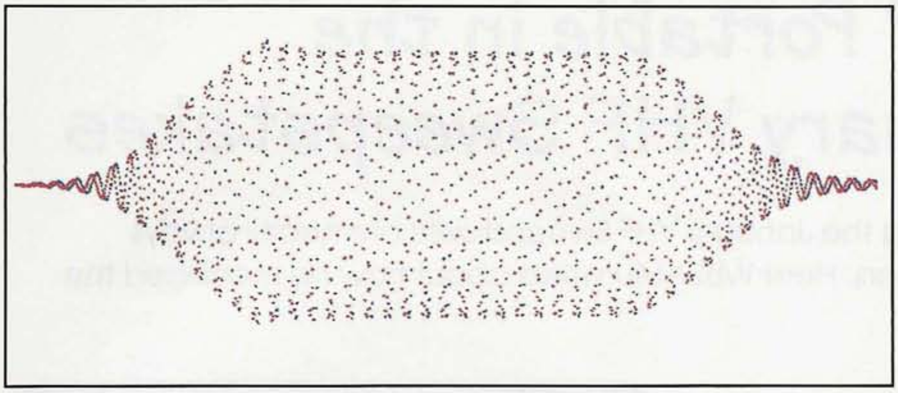

Figure 8. Keyed waveform of the IC706MKIIG at 14 MHz. The reason for this waveform is probably the ALC. It is bad practice (but very common) to use a fast ALC to set the drive power at the desired level. The fast feedback required to bring the gain down rapidly causes wideband modulation that takes the form of keying clicks in CW and splatter in SSB.

By using Linrad with appropriate hardware one can measure spectra directly. The Linrad S-meter uses a true RMS detector. With the WSE converters[5] the noise floor is at –145 dBc/Hz, which is good enough to measure any commercial transceiver on the market today.

It is also possible to use a standard spectrum analyzer such as the 2753P or the 8591A together with a notch filter. When the transmitted signal is centered on the notch, the dynamic-range requirement on the spectrum analyzer becomes much smaller. By reducing the level of the main signal (the carrier for CW, or the wanted sideband for SSB) by about 50 dB, one improves the dynamic range of the spectrum analyzer by a similar amount. This way of doing measurements has the advantage that one can monitor wide frequency ranges and locate spurs and instabilities that occasionally produce signals far from the desired frequency.

The averaged power spectrum is in itself a standardized measurement when given in dBc/Hz. The bandwidth has to be narrow enough to resolve narrowband spurs, but there is no need to specify what bandwidth to use for this particular measurement.

Peak Power Measurements

For white noise, the peak-to-average power ratio depends on the time of observation. For reasonable observation times, the peak power is about 10 dB above the average power regardless of the bandwidth. A carrier or a narrowband spur has the same peak power as average power, but sidebands caused by modulation typically behave differently. In particular, keying clicks are wideband transients that behave like car ignition noise; they have a peak power that increases with the square of the bandwidth. (This is easy to understand, because filters smear a single short pulse out over time by an amount that is inversly proportional to the bandwidth. If the bandwidth is widened from 240 Hz to 2.4 kHz, the keying click will be 10 times shorter. This factor alone would make the pulse power 10 times higher if the total energy content of the pulse was unchanged. However, with 10 times more bandwidth, there is also 10 times more energy in the pulse, so the power will increase with bandwidth by a factor of 100 in total.)

Not only keying clicks behave like this, but also pulses such as those which may occur when the PTT button is pressed. SSB splatter is typically generated when the ALC voltage makes a jump because the drive level is going too high. The abrupt gain reduction causes a wideband modulation that is very similar to a keying click.

Peak power measurements need a standardized bandwidth. I find it natural to use SSB bandwidth, 2.4 kHz or what comes nearest in the available equipment. Well-designed transmitters do not have tails in the modulation sidebands, because they filter the baseband signal well enough, and also they do not have non-linearities that widen the modulation bandwidth by large factors. Just by using a relatively large bandwidth and by looking at the peak power using the maximum hold function of a spectrum analyzer, one can see if a transmitter produces wideband transients even if it happens infrequently. The exact level of the transients is not so important. The really important thing is

(Continued on page 75)

QRP Portable in the ARRL January VHF Sweepstakes

The weather conditions during the January VHF Sweepstakes are nearly always problematic for many operators. Here WB2AMU writes about how he managed the weather challenge.

By Ken Neubeck,* WB2AMU

Almost like the certainty of death and taxes, for many stations in the northeast one consistent fact regarding the ARRL January VHF Sweepstakes is that it always seems to fall on a weekend when it snows! In fact, that almost seems more reliable than the *Farmer's Almanac.*

In the Summer 2004 issue of *CQ VHF,* Bob, KØNR, in his excellent article "QRP Operation in VHF Contests," covered some of the statistics of participation in this category for the VHF contest. He also described some of the tactical setups of those who do QRP operations.

The reasons many give for operating QRP include the challenge, available radios, the thrill of operating outdoors, and the chance to be more competitive. All of these reasons are why I have chosen this category for all three yearly ARRL VHF contests over the past ten years. I also would like to add that the emotional side of it is much more than can be described in statistics. Imagine the freedom that most VHF radio operations have by using smaller antennas that can easily be carried in most cars. In addition, I usually try my best to place in the top ten for the U.S./Canada in the single-operator portable category, a feat that is not always possible when both weather conditions and propagation are not equal throughout the country.

I have done most of my QRP portable operations during the VHF contests from different hills on Long Island, New York, with Bald Hill in the center of Suffolk County being my general preference. The highest hills on Long Island are around 250 feet above sea level. There is a Vietnam memorial on Bald Hill, and I usually conduct my operations from the parking lot near some trees. Both the south shore of Long Island, where the bays are, and the north shore of the island, where the Long Island Sound is located, can be seen from this spot. I have secured annual permission from the county to do radio operations at this site, as there have been some security concerns as well as loitering issues at this location in the past. It is truly good when amateur radio operations can be a beacon of proper use of a park facility.

The VHF Sweepstakes

As there typically is bad weather during the January event, my first goal is to survive. My second is to make sure that I don't drain the batteries too quickly, and my final goal is to make some contacts on the VHF bands! Usually I am successful, although in the past I have needed a battery jump a few times from visitors to the park.

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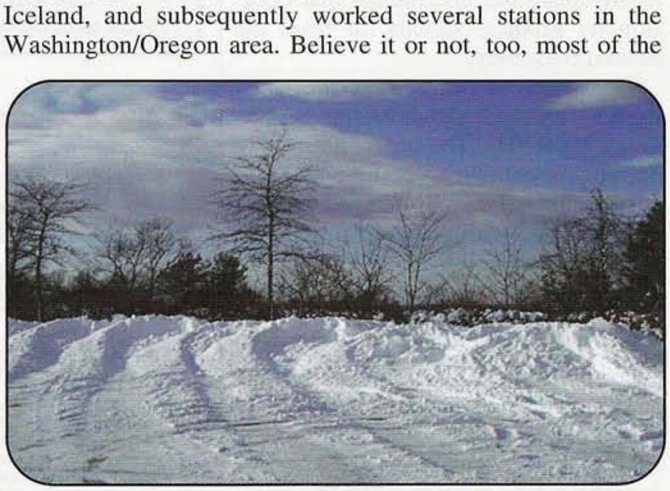
Here is WB2AMU's QRP setup on one of the hills on Long Island at the beginning of the January 2005 VHF Sweepstakes just before the blizzard began. The 2-meter beam is in the umbrella stand in front of the car, and the two-element, 6-meter beam is in the tree to the left. After 45 minutes the action cooled down, and it seemed like a good time to cease operation, given that over 15 inches of snow would fall overnight. (Photos by Ken Neubeck, WB2AMU)

The January contest does see different propagation conditions at times. In the 2000 contest I witnessed a brief aurora opening and I worked K2AXX in FN12 via aurora. In the 2002 contest I had *F2* conditions where I heard the beacon from Iceland, and subsequently worked several stations in the Washington/Oregon area. Believe it or not, too, most of the



A view of the parking lot of the public park where the hill is located. It had been partially plowed when WB2AMU returned to the site on the Sunday afternoon of the contest.

time during the January contest, usually for about an hour, sporadic-*E* does make an appearance. In 2004 I actually had a DX contact on 6 meters when VP9GE from Bermuda came booming in for an hour at the beginning of the contest via a sporadic-*E* opening.

Every year, no matter which weekend in January the ARRL chooses for the Sweepstakes, whether it is the third or the fourth weekend, it is always cold with snow on the menu for much of the northeast U.S. This streak has been continuous, going back to 2000, according to my records. Perhaps the ARRL should consider going into the almanac business with regard to picking weekends with snowstorms!

In 2005 matters were no different, as the dates for the contest (January 22 and 23) were targeted by the weather service to have a major snowstorm in the form of a nor'easter. As I have always done, I kept a close eye on the weather forecast during the preceding week, and I wondered how I was going to do any kind of portable operation during a major snowstorm. In the past I had encountered significant snow but had been able to work around the storm by leaving the site during the worst of it. For the 2005 event it looked much worse than any of the previous years, as the storm was supposed to start early Saturday afternoon and continue into Sunday afternoon, pretty much wiping out much of the VHF contest!

Adventure in Blizzard Land

Just before noon on Saturday the snow started coming down lightly in the New York metropolitan area. After only an hour there was some accumulation of snow coating the roads. It was getting bad, but I still wanted to attempt a QRP portable operation in the contest, as I had a ten-year streak of being in this category for the January event. At 1:30 PM, prior to the 2 PM contest start time, I decided that I would make a short expedition to the hill but in a streamlined fashion, with just 6 and 2 meters.

As part of my effort to streamline, I decided to forgo the three-element MFJ 6-meter Yagi antenna that I generally use. There would have been at least ten minutes of assembly time, and I figured that this would be pretty difficult to do with the snow coming down. Instead, I opted for my simple two-element, homemade, portable Yagi antenna; I hung that from a nearby tree branch. The three-element, 2-meter MFJ Yagi likewise was quick to set up, with 10 feet of mast sections that I planted into a weighted umbrella stand. Setup took about five minutes, with about two minutes to spare before the contest.

It was refreshing to hear a lot of signals when the contest began, particularly on 2 meters. I was surprised to see that there were actually a few rovers who were adventurous (or crazy) enough such that they were driving through the different grids in the area. I worked N1QVE/R in FN31 during the first hour of the contest. While at my location it was bad with the snow, at least I was settled in one spot. Imagine being a rover who has to drive to multiple locations and deal with the very poor road conditions and visibility of a major blizzard!

Six meters was not very crowded when the contest started, yet conditions on 2 meters seemed very good with loud signals. There actually seemed to be a bit of tropo enhancement working, which is not really that unusual for January, as there are various fronts hanging around that are available for creating ducts.

After 45 minutes, there were not too

The WB2AMU mobile. While covered in snow, it was poised for QRP portable action with the three-element, 2-meter Yagi in the front of the car and the two-element, 6-meter Yagi hanging from the branch on the left. 440 MHz was accomplished with a 12-element Yagi that was switched with the 2-meter Yagi on the mast, and 220 MHz FM was accomplished using a 5-watt HT with a rubber-duck antenna.

Here the three-element, 2-meter Yagi is facing west from Bald Hill on Long Island (grid FN30) just moments prior to WB2AMU working W2FU (grid FN13) on CW in western New York via an apparent tropo-ducting enhancement on 2 meters.

many more stations to work on 6 and 2 meters, and I decided not to tempt the storm conditions any further, as snow was reaching the 3-inch accumulation mark. Teardown was quick, and it took an additional 10 minutes to get home. Then for the next 24 hours the snow came down in furious fashion, topping 2 inches per hour at times, until a final accumulation of 15 inches was reached in my area of Long Island. Higher accumulations were reached farther east of me and in some of the New England states.

Hearing the weather forecast overnight made me initially give up any thoughts of returning to the hill on Sunday, as it was predicted that the snow would continue to fall into Sunday afternoon. It seemed that my adventure of 45 minutes on the air on Saturday was probably going to be the extent of my effort in the 2005 contest.

As it turned out, the snow finally stopped coming down during mid-morning on Sunday. I spent the next three hours digging out of my driveway and helping some friends dig out as well. I thought that maybe in the latter part of the afternoon I would have the opportunity to take a second crack at the hill to take pictures and operate on the VHF bands. At 1:30 PM the roads, while still very poor, were at least passable for me to make a slow trip back to my portable location. This time I brought my antenna for 432 MHz with me as well.

I was very happy at a second chance at the hill after the snow stopped and the roads were somewhat passable. Exactly 24 hours after I left the hill the first time, I arrived there again and quickly searched for a suitable spot to plant and hang my antennas amidst all of the snow that had been piled up by the plows that passed through. Of course, I had my choice of anywhere in the parking lot, as there was no one there except for a few photographers and sledders passing through.

There were some definite 2-meter enhancements working, most likely the result of different weather fronts in the area. I managed to contact N1JEZ in FN44 on the band on SSB, and a short while later, W2FU in FN13 on CW. It was kind of an eerie feeling hearing these far-away signals on 2 meters while operating in the snow. As I only had 220 MHz on my HT, I worked two stations in FN31 (K1TEO and WB2SIH) running just 5 watts with a rubber-duck antenna. Based on my past experience, I suspect that I might have been the only station on Long Island using 220 MHz during the contest.

I might add that the temperature on both days was well below the freezing mark, with Sunday being a crisp 16°F. Luckily it was not windy, and I was bundled up with extra layers of clothing, a very important thing to remember when operating portable outside in the winter. Ice on the parking lot was also a concern, and I did slip once. One of these years I hope we get a January VHF contest in the northeast without snow, ice, or wind!

The Results

In all I made 32 QSOs with 11 multipliers over four bands for two separate one-hour sessions on the hill. I was just happy to have made any contacts at all, given the adverse weather conditions! Two meters was clearly the best band here, as I made 20 QSOs on that band.

Overall, the level of participation was down from previous January event. No doubt the snow created some havoc for some stations with regard to travel, and in some cases there may have been power loss. Rover activity was probably limited to the very beginning of the contest and the very end, when there were fewer issues involving travel.

Some Final Thoughts and Analysis

The main advantage of operating at a somewhat remote location is the lack of overhead power lines and subsequently less power-line noise. This year, because of the snow affecting the power lines, power-line noise seemed to be a major problem for many stations operating on 6 and 2 meters during the contest. A number of stations in nearby grids could not copy me because they had high levels of power-line noise on their receivers. I found out later from the various chat pages that several stations had power-line noise in all directions and were severely limited in making contacts during the contest.

Another thing that I have found very interesting is the fact that quite often 2 meters may have some enhanced conditions that very often go unnoticed unless there is a VHF contest or an event such as Field Day going on. The exception is when there is a strong sporadic-*E* opening such as the one which occurred on July 7, 2004 or some of the aurora openings of the past year. Word spread rapidly about these openings on the internet spotting sites. Quite often, however, and almost on a regular basis, there are some decent tropo enhancements on 2 meters (as well as on 220 and 432) that occur and are not taken advantage of in many locations in the U.S. and Canada. VHFers perhaps do not frequent the band as much as they should, particularly the lower part of the band, where most of the weak-signal activity occurs. It would be great if on a daily basis more VHFers gave a short call on 144.200 MHz and checked for beacon activity for such tropo enhancements.

Also, it is a well-known fact that some of the categories in the ARRL VHF contest have been seeing a decline in participation over the past ten years. I can remember some the significant efforts back in the 1990s, when Zak, W1VT, and others ran QRP portable and tens of thousands of points were accumulated. There are many reasons for the decline in activity: aging of the ham population in general, rules format, and the limited interest in VHF contesting in general. I also think that a major reason is the amount of effort it takes to transport equipment to a portable location as well as find a suitable location that is available to the public.

The survey in Bob, KØNR's article mentioned previously shows that most QRPers usually only operate three or four bands in VHF contests. When you are going to a portable location, it does become quite an effort to bring equipment for more than four bands, particularly when you need transverters. It is much easier when you only have to bring one or two radios for a QRP effort. Maybe the ARRL should determine whether the current VHF contest should truly be called a VHF contest (6 and 2 meters, and 220, with possibly 432 MHz) instead of adding UHF and the microwave bands! (Remember, there are several dedicated microwave contests sponsored by the ARRL throughout the year.) I also have noted in the results of many of the VHF contests that in the New York City/Long Island section there are no listings of any stations using bands higher than 432 MHz. It appears that it is somewhat of a chore to find that right location for setting up a operation on those UHF and microwave bands in a metropolitan/suburban area.

Also, the ARRL Contest Advisory Committee should seriously consider increasing the value of each 220-MHz contact (such as making these contacts worth 3 points instead of 2). As I look over the scores from the past VHF contests, it seems that the most common band mix used by stations is 6 meters, 2 meters, and 432 MHz (designated as "ABD" for the band listing in the contest results). Again, in the New York City/Long Island section there are at most two stations operating on 220 MHz for any of the three ARRL VHF contests. I imagine that this might be a situation that exists in other areas of the country as well. While it is very difficult to get a 220-MHz SSB or CW transceiver, FM is a fairly viable mode and operators should pursue this more during a contest event.

Every January's VHF Sweepstakes is an adventure, and the 2005 event was particularly so with the occurrence of a major blizzard here in the northeast. You have to be a bit fanatical—or even nuts (!)—to participate in a contest in that kind of situation in a rover or portable category, but I can tell you it is an experience very different from just operating in the comforts of a home QTH! ■

By Rich Arland,* K7SZ

VHF+ BEGINNER'S GUIDE

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

Setting Goals and Gathering Information

Welcome to the "VHF+ Beginner's Guide," the newest addition to *CQ VHF* magazine. My name is Rich Arland, callsign K7SZ, and I will be your host as we explore how to enjoy the VHF and UHF world on a frugal budget. The purpose of this column is to enlighten the newcomer to the VHF bands on how to choose gear, set up a station, build and erect antennas, and find radio-related bargains to keep costs down while wringing the maximum performance from the station.

By way of introduction, let me briefly give you my biography. I am a 59-year-old retired USAF Master Sergeant, with a wife (the beautiful and talented Patricia) of 24 years, four grown children, and five (soon to be six) grandchildren. During my 20-year Air Force career in long-haul and tactical communications, I spent almost 15 years overseas operating amateur radio from locations such as the Azores (CT2BH), Japan (KA2AA, prior to reciprocal licensing), England (G5CSU), and Germany (DA2NE). Currently I teach vocational electronics at the State Correctional Institution-Dallas (Pennsylvania) to incarcerated male inmates. Part of my job with the Department of Corrections is technical service countermeasures (TSCM). In addition, I am a DoC/PA State Police certified hostage negotiator, and will be receiving my FBI certification sometime later this year.

I was first licensed in 1963 as KN7YHA, upgraded to Technician Class the following year, and eventually worked my way up to Extra Class in 1987 (and, yes, I can still copy CW at close to 30 wpm!). I had a chance to grab a vanity call in 1996, and I retired the K7YHA callsign in favor of a 1X2 call: K7SZ.

Some of you might recognize my callsign and/or name as being associated with QRP (under 5 watts amateur radio), and to that I must plead, "Guilty as Charged!" In 1965 I joined the QRP Amateur Radio Club International and have been an advocate of QRP for the last 40 years. I have written for the radio hobby press for over 30 years, starting with *The Milliwatt* magazine in 1974. I wrote the QRP column for *Worldradio* magazine for a few years in the late 1980s and early 1990s and switched to the satellite column for another several years. I have also written technical articles for *Monitoring Times Magazine, CQ, QST, The QRP Quarterly, The Homebrewer,* and *CTM Magazine.* For four years I wrote the "QRP Power" column for *QST,* and I have written five books on low-power communications; the current one, *The ARRL's Low Power Communications, the Art and Science of QRP* is selling quite well, with the proceeds going to finance my ham radio hobby. Currently I write the "Homeland Security" column for our sister publication, *Popular Communications.*

Over the years I have had many stations all over the U.S. and overseas. I have had my share of gear, both new and used. I love to restore older vacuum-tube radio equipment, thereby preserving a piece of radio history for future generations to marvel at and enjoy. My current "Boatanchor" collection consists of an R-600 Zenith Transoceanic receiver; a most-rare Zenith "Global" receiver; Hallicrafters S-38 (six-tube model from 1946), SX-71, SX-62A, S-51, S-120, and SX-117 receivers; a National NC-57 (W3NQN's original receiver from 1947); an HT-44 Hallicrafters transmitter (matches the SX-117); a Drake 2B receiver; a Heathkit HW-202 2-meter FM rig, HW-101 HF Xcvr, SB-301/401 Twins, HR-10B receiver; Johnson Viking Adventurer (these last two were my original Novice station radios); and a few dozen other rigs that have gone through the K7SZ shop to be traded for "needed" gear over the years.

While not officially cataloged as "Boatanchors," since they are solid-state rigs, I recently obtained the entire ensemble of "Bookcase Radios" (circa 1980–85) from ICOM: the IC-202, 215, 402, and 502 transceivers, which cover 2 meters, 70 cm, and 6 meters, respectively. My upcoming purchases will include a Yaesu FT-221R, a first-generation 2-meter multimode transceiver; an Elecraft K2 transceiver (kit with a host of options) and a set of their transverters for 6, 2, and 1$^3/_4$ meters; and a Ten-Tec Paragon HF transceiver for HF DXing and contesting and to use as an IF with VHF+ transverters.

Money, Money, Money

Ham radio can be a very expensive hobby. So much so, that often marital relationships become strained and budgets get scuttled all for the sake of the radio hobby. This is not a good thing. As noted earlier, my writing money offsets my participation in ham radio. If it weren't for this expendable income, I would be hard-pressed to find a way to afford the various aspects of the amateur radio hobby. Therefore, this column is dedicated to helping anyone interested in the VHF+ bands set goals, obtain gear, and get a station on the air that will fulfill the assigned goals while keeping expenditures under control.

VHF+—What is it?

Traditionally, VHF starts at the upper end of the 10-meter band (30 MHz) and stops at around 300 MHz. Here it changes names and becomes UHF (300 MHz to 3 GHz), then SHF, and finally EHF, as we go up through the 70-cm band (432 MHz) and into the microwave regions of the spectrum. To sum up things and keep the ends nice and tidy, it is easier to refer to all VHF, UHF, SHF, and EHF ham radio operations as VHF+.

Why go up in frequency when the HF bands are available and they provide worldwide communications on a daily basis? Sometimes it is predicated on the class of license. For many, many years, the Technician Class ham license was the stopping point for those folks who did not acclimatize well to the CW requirement of 13 and 20 wpm for the higher classes of amateur radio licenses. Techs had everything above 30 MHz, so why worry about the code just to get onto the low bands? In the early to mid 1970s 2 meters FM became very popular, so localized, interference-free communications became a reality to the holders of Technician Class licenses. Also, during that time Project OSCAR (Orbital Satellite Carrying Amateur Radio) became do-

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able on a budget, so a Tech licensee could have fun DXing via the low Earth orbit (LEO) birds.

For others it was the challenge of developing new gear and new modes in the microwave bands that held an attraction. The VHF+ region offers huge amounts of spectrum for experimentation by technically inclined radio amateurs. It wasn't all that long ago when if you wanted to get on 2 meters you had to build most, if not all, of your station. I can still remember the 2-meter homebrew station that the ARRL touted in one of their reprint articles well into the 1970s. If you were not involved with FM voice transmission modes in the 1970s, it was almost mandatory to build your own transverters to gain access to 6 meters, 2 meters, 1$^{3}/_{4}$ meters, and 70-cm SSB/CW modes for weak-signal work.

All this experimentation had a price: knowledge. That's right; those hardy radio amateurs who started exploring the VHF+ bands became quite knowledgeable about the specialized circuits used in VHF and UHF radios, as well as the specialized construction techniques needed to make these homebrew rigs, antennas, and accessories perform at these frequencies.

Fortunately for us, all this information has been preserved in magazines such as *QST, CQ, Ham Radio, QEX,* and *Communications Quarterly.* Even though some of this information is quite dated, it is still valuable and thankfully, most of it is still available to us via the CD ROM versions of these great publications. What? You don't have all of *QST, Ham Radio, QEX,* and *Communications Quarterly* on CD? Shame on you! Well, let's make that one of your initial goals: start collecting VHF+ data in the form of CDs of these outstanding publications. The more information you have on hand, the easier it is to make decisions about whether it is more cost effective to build or buy a piece of gear, accessory, or antenna.

Setting Goals

So far I have mentioned "goals" several times. Setting goals is an important process that allows us to make a list of objectives to fulfill an ambition. It provides us with a logical, step-by-step process of how to get from point A to point B. Setting goals also provides us with discipline. We become focused on achieving the goal, and the plan seems to "fall together" like it was meant to happen.

Earlier I mentioned an upcoming purchase of a Ten-Tec Paragon HF transceiver. Around my birthday (early March) I found a nice used Paragon on eBay. Several of my good friends have Paragons, and they had been my sounding board regarding the pros and cons of buying and using this first-generation Ten-Tec synthesized HF transceiver. My buddies had convinced me that buying a Paragon made good sense in that they are reasonably priced, great performers, and can be computer controlled (a must at the K7SZ station). The Paragon receiver is extremely quiet, with low phase noise, a must for use on transverters. The beautiful full break-in keying (QSK) that is a trademark of all Ten-Tec transceivers is also part of the total package. Although big (by today's standards), the Paragon is a solid, cost-effective performer.

Taking all of the above into account, I started closely watching the bidding on this excellent rig, hoping to put in a winning bid of around $750 to $800.

Unfortunately, I was unable to submit a winning bid without going above what I had set aside from my writing money for radio purchases. Sure, I could have grabbed some cash from the family budget and repaid it within a few weeks, once a royalty check arrived, but that was *not* the deal I had struck with my wife. Rather than become obsessed with buying a Paragon on eBay, I decided that another Paragon would be listed in the future and by that time I would have amassed the necessary funding from my writing to be assured of winning the auction.

Discipline: Goals instill discipline. While Patricia would undoubtedly not have said a word had I raided the family budget to bid on the Paragon, *I* would have known that I had not abided by one of my principal goals—using my writing money to finance the radio hobby. Once you break discipline it is easy to become complacent and then all the goal setting in the world is for naught. Then you lose focus of your ultimate objective, in this case to own a world-class HF transceiver that would also function as an IF strip for transverters for use on the VHF+ bands.

Setting goals, especially with regard to money, is a great way to ensure that you obtain what you really want and not just buy radios and accessories "willy-nilly" on a whim just because you might need it some day. This not only saves money, it saves space in the shack, and I don't know anyone who has enough room to just stockpile gear for use "some day." At this point I am reminded of a line from a *Star Trek* episode, "Amok Time," where Mr. Spock, after killing Captain Kirk in mortal combat, confronts his concubine's suitor with the words: "Having is sometimes not as fulfilling as wanting" (or something to that effect). Many times I have let lust for a radio overcome my better judgment and have regretted purchasing that particular rig for one reason or another. Yup, I like goals a lot. It keeps me from making costly mistakes.

Doing Homework

Chalk it up to being a teacher by trade, but doing research (homework) is one great way to avoid buying a piece of gear, either new or used, that turns into a bad decision in the long run. There have been thousands upon thousands of words written in the form of product reviews describing the traits of various pieces of gear, accessories, and antennas. All the major ham magazines have product review pages, and in the past the ARRL has published two volumes of reviews from the pages of *QST* of the last 20–25 years. Basically, there is no excuse for not knowing about a rig, station accessory, or antenna before plunking down your money or plastic. This is not to say you can't get a "lemon," but the chances of buying a rig that does not do what you want is greatly reduced when using product reviews to guide your choice of station components.

Another great method of obtaining information on a piece of gear is to ask how other hams who have purchased the same piece of gear like it. In the case of my Ten-Tec Paragon, Tim Cook, NZ8J, and Vic Klein, WA4THR, both absolutely love this rig and have in-depth knowledge regarding its inner workings. Both of these technically adroit radio amateurs have pulled maintenance and mods on their Paragons and stood ready to answer my questions regarding specifics about this radio. Buying a Paragon, in my instance, was not an ill-informed choice at all. Not only did I read the product reviews in back issues of several ham magazines, I also had two individuals provide me with all sorts of interesting insights into this radio and how it works.

For me, obtaining a Paragon was a cost-effective way of killing two birds with one stone. On one hand I would have an excellent HF rig that was up to the task of doing some serious DXing and contesting, and on the other hand it would function as a low-noise IF strip for the VHF+ bands.

Let's Recap

In this first installment of this column I have introduced myself and we have covered two of the basics for assembling a successful VHF+ station on a budget: namely, setting realistic goals and gathering information (research) on the gear we intend to use to get the job done.

With that in mind, and being a teacher to the bitter end, here is your assignment: If you are new to the VHF+ arena, first think about what you want to accomplish, then think about the dollar limits you are going to be restricted to, and make up a simple set of *realistic* goals for your first VHF+ station.

Hint Number One: Springtime is 6-meter time. Six is "the Magic Band" for sure. In mid-February 2005 there was a 6-meter opening in the late afternoon on a weekend, and using the IC-502 6-meter SSB/CW rig running only 3 watts PEP to a discone scanner antenna that was not even supposed to cover the low end of 6 meters, I worked a dozen stations in southern and middle Florida and South Carolina in about an hour and a half. My signal reports varied from 51 to 59+ during this time! This was with only 3 watts PEP to a non-resonant antenna about 3 feet above the roof of my house!

Total cost of the rig was $130 (used on eBay), and $60 for the discone scanner antenna, which pulls quadruple duty on 6 meters, 2 meters, and 70 cm and feeds my scanners! Fun? You have absolutely *no* idea! The really great part was explaining my station to the other guys I was working (most of whom were running 100–500 watts to rotatable Yagi antennas) and hearing their comments of utter disbelief!

Now I am not out to convert the readers of this column to QRP. Far from it, as several installments of this column will cover building "brick" amplifiers for several bands.

Hint Number Two: Summertime is ARRL Field Day time and VHF/UHF contest time. Anybody want to give some serious thought to putting together a mobile/portable contest station to support a local club's FD efforts or to go "roving" during contests?

Next time I will share my goals for a cost-effective three-band VHF+ contest station using three ICOM IC-X02 series "Bookcase Radios" as exciters and homebrew antennas for 6 and 2 meters. Until then, have fun and do your homework! 73, Rich, K7SZ

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

A Complete Ground Station for AO-51

On June 29, 2004, AO-51 was launched. Since that time it has been checked out in most of its modes and mode combinations. These modes and combinations are controlled by the command station to maintain the health of the satellite and to satisfy the desires of the users. The current mode schedule is posted at <http://www.amsat. org> and should be referred to frequently for updates.

Normally, six days per week the satellite operates simultaneously in two modes: Mode VHF/UHF (V/U) Analog and Mode V/U Digital (low data rate). The digital downlink also carries the telemetry stream used to monitor the health and welfare of the satellite.

On Wednesdays UTC the satellite is usually in Experimental Mode and may be in any of several possible modes as set up by the command station. These modes can be combinations of different RF uplinks and downlinks, different digital data rates, different power levels on the uplink and/or downlink, and different control procedures (with or without PL tones). Uplinks have been checked out on 10 meters (HF), 2 meters (V band), 70 cm (U band), and 23 cm (L band). Downlinks have been verified on 70 cm (U band) and 13 cm (S band). Operations at data rates of 9k6 baud and 38k4 baud have been verified. Higher data rates are possible within the satellite architecture for future verification. The 9k6 and 38k4 modulations are FSK. The satellite also supports PSK-31 utilizing the HF uplink.

As you can see, a ground station to cover all of the possible combinations seems formidable. Here we will attempt to break down these combinations, categorizing them by their effects on the various elements of a satellite station. We will also attempt to illustrate how the station can be put together incrementally and gradually built up to full capability. It will also be pointed out that the station can be customized to utilize as much of your current station as possible. This column is not intended to "scare you off." Many hours of enjoyment are possible with AO-51 and a very simple, inexpensive station. It only becomes more difficult when you try to do it all at once.

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Station Computer and Software

These days a good station computer is essential for operating on a satellite as sophisticated as AO-51. The operating system can be Windows®, Mac, or Linux, but more software is readily available for Windows®. One could argue that a computer is not needed to actually operate the analog modes, but even these modes require knowledge of when the satellite will be above your horizon and where the satellite is at any given time. A station computer running a suitable satellite tracking program is the best solution, even if it is only used to make the predictions and print them out to take along with you on portable operations. As much as some of us hate to admit it, connectivity to

Figure 1. AO-51 basic mode V/U base station.

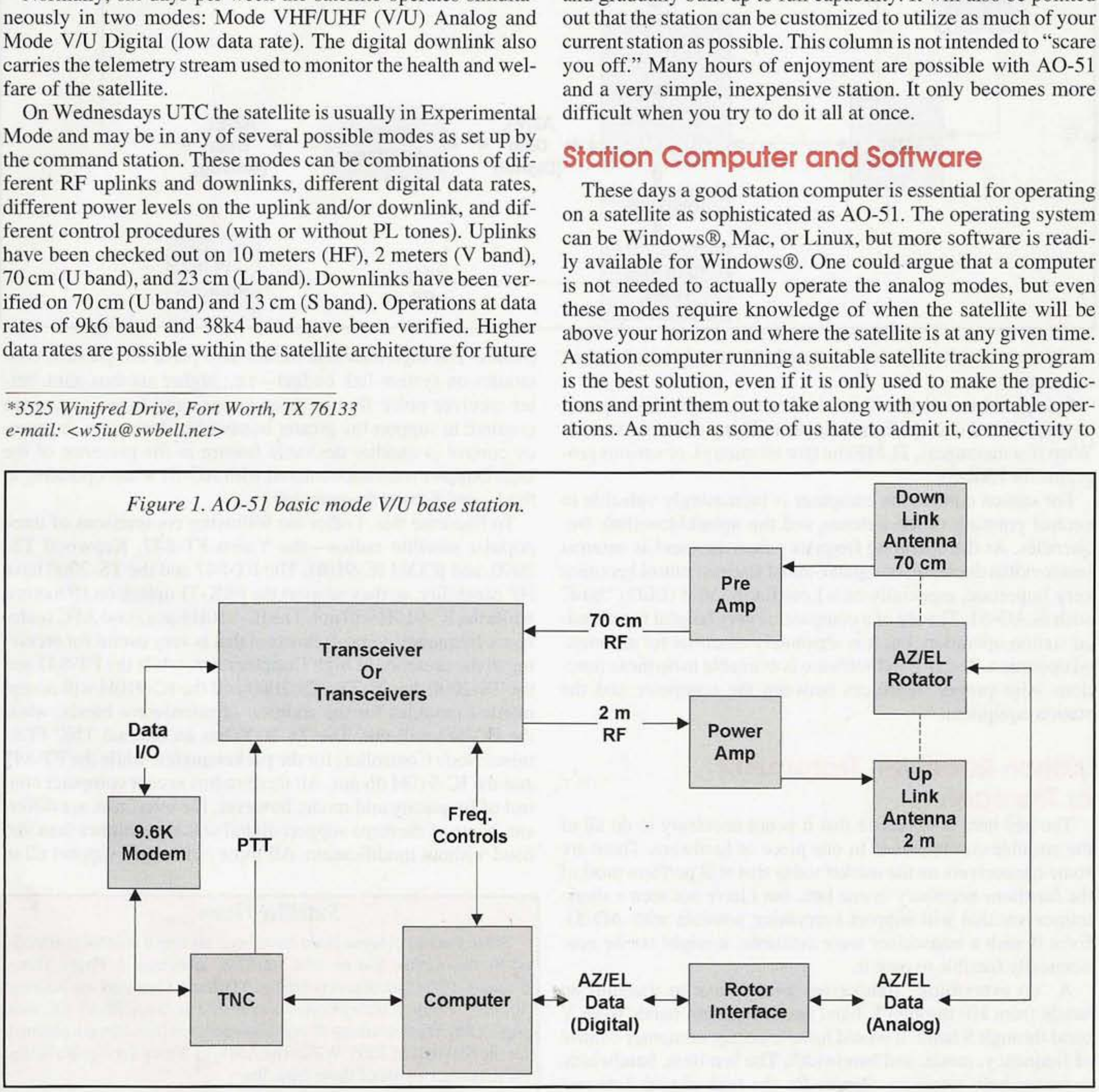
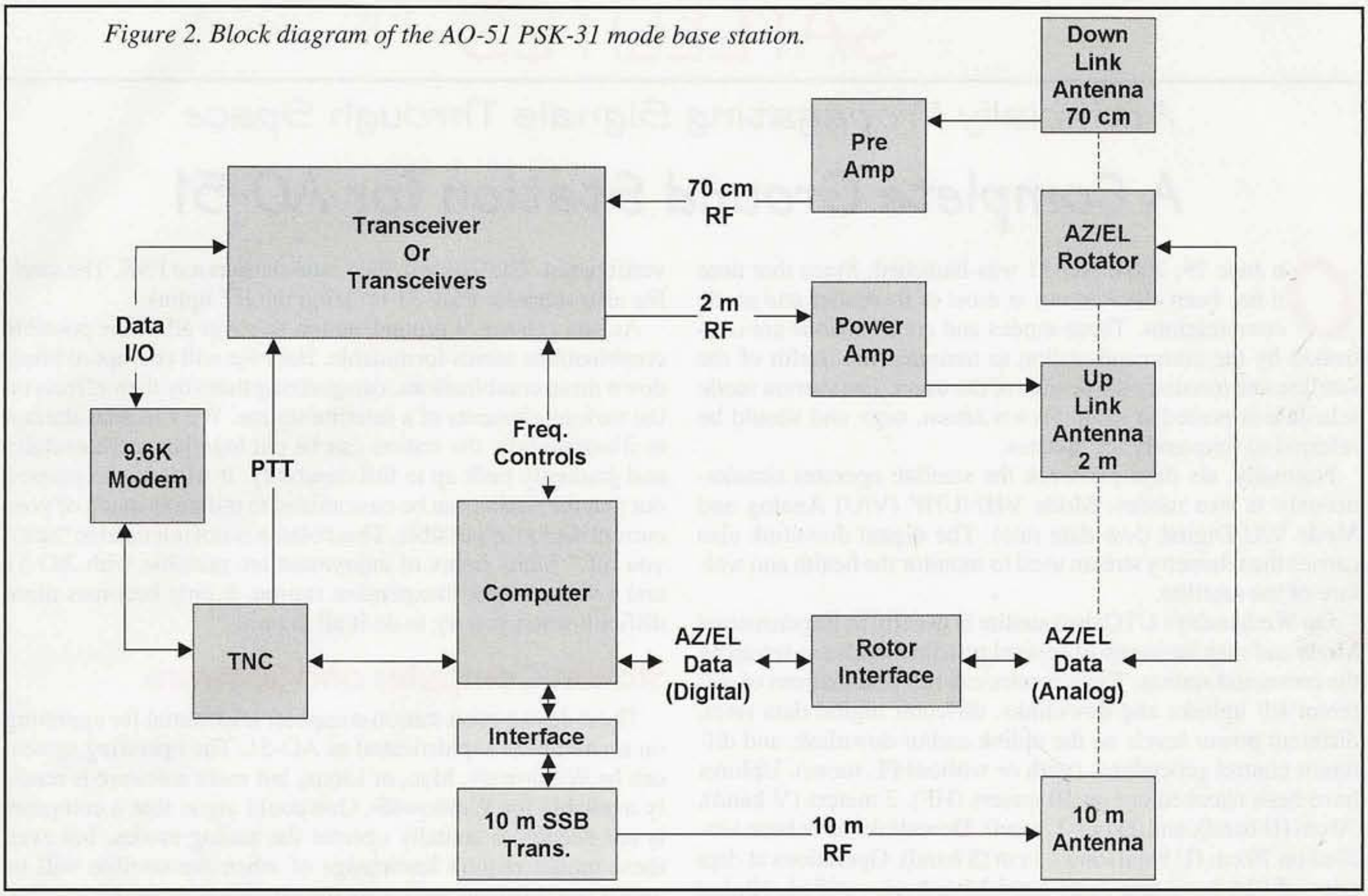


Figure 2. Block diagram of the AO-51 PSK-31 mode base station.



the Internet is essential to keep up with the mode schedule and other news.

For operation with the digital modes, the computer is required to prepare and decode the messages utilizing software such as Wisp (for messages), TLMEcho (for telemetry), or various programs for PSK-31.

For station control the computer is increasingly valuable to control pointing of the antenna and the uplink/downlink frequencies. As the operating frequency increases and as antenna beamwidths decrease, computer-aided station control becomes very important, especially on a Low Earth Orbit (LEO) "bird" such as AO-51. The aid of a computer is very helpful for attended station operation, but it is absolutely essential for automated operation. Today good software is available to do these functions with proper interfaces between the computer and the station equipment.

Station Receiver, Transmitter, or Transceiver

The key here is to realize that it is not necessary to do all of the possible combinations in one piece of hardware. There are some transceivers on the market today that will perform most of the functions necessary in one box, but I have not seen a single transceiver that will support everything possible with AO-51. Even if such a transceiver were available, it might not be economically feasible to own it.

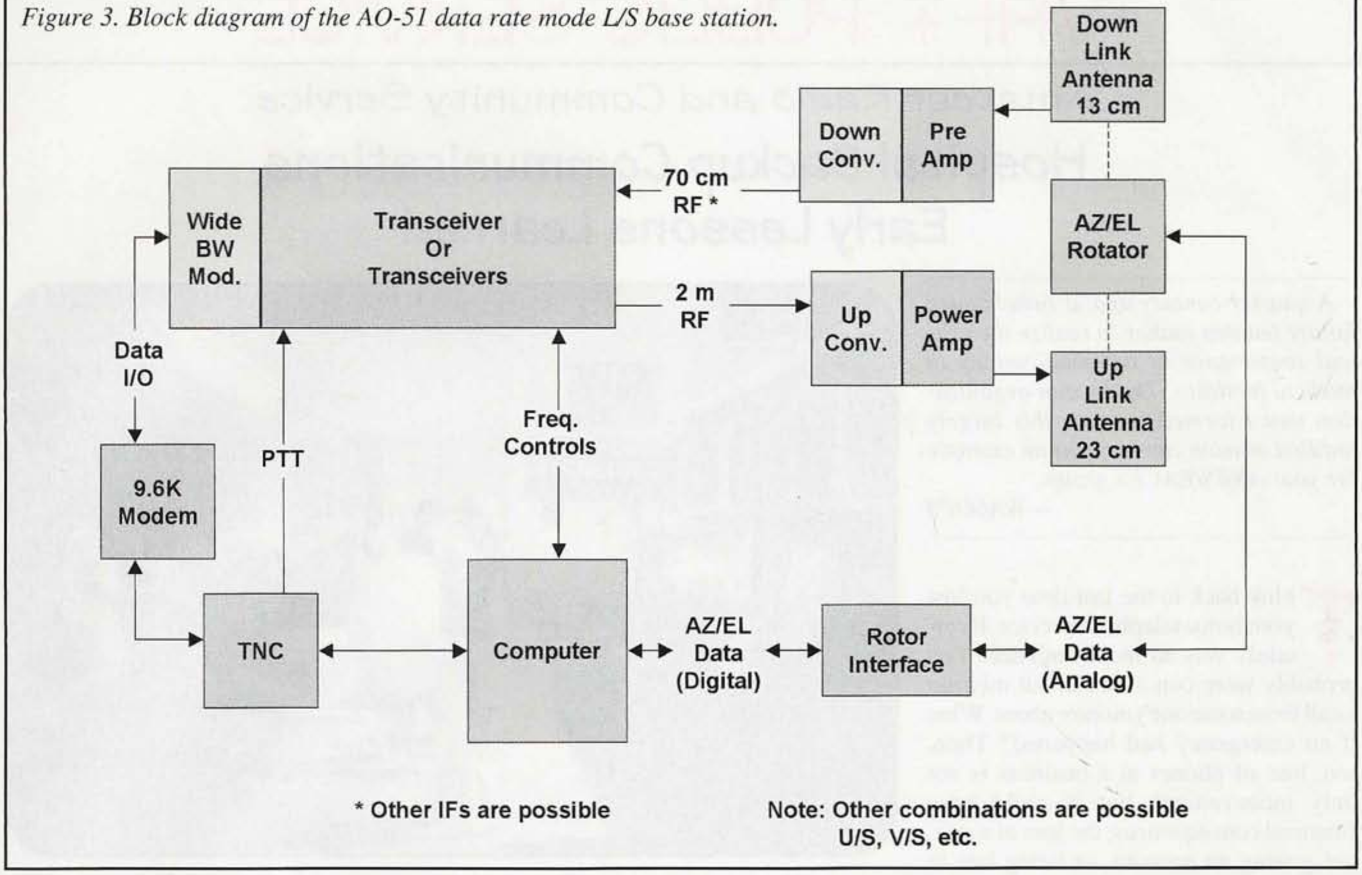
A "do everything" transceiver would have to transmit on bands from HF through L band and receive on bands from V band through S band. It would have to accept computer control of frequency, mode, and bandwidth. The last item, bandwidth, is particularly tough to support for the high digital data-rate modes. The high data-rate modes also place the greatest constraints on system-link budget—i.e., higher antenna gain, better receiver noise figure, more power, and lower losses are required to support the greater bandwidth. Automatic frequency control is another desirable feature in the presence of the high Doppler rates encountered with AO-51 when operating at the L- and S-band frequencies.

To illustrate this, I offer the following comparisons of three popular satellite radios—the Yaesu FT-847, Kenwood TS-2000, and ICOM IC-910H. The FT-847 and the TS-2000 have HF capability, so they support the PSK-31 uplink on 10 meters, while the IC-910H will not. The IC-910H has a good AFC (automatic frequency control) function that is very useful for receiving in the presence of high Doppler rates, while the FT-847 and the TS-2000 do not. The TS-2000 and the IC-910H will accept internal modules for the addition of microwave bands, while the FT-847 will not. The TS-2000 has an internal TNC (Terminal Node Controller) for the packet modes, while the FT-847 and the IC-910H do not. All three radios accept computer control of frequency and mode; however, the interfaces are different. None of the three support digital data rates higher than 9k6 baud without modification. All three radios will support all of

Satellite News

Since the last column there have been no major meetings attended by this author and no new satellites launched. A Phase Three Express (P3E) meeting was held in Marburg, Germany on January 30, 2005. A report with pictures is available on the AMSAT-DL web page: <http://www.amsat-dl.org>. Several new launches are planned for the first half of 2005. Watch the AMSAT News Service Bulletins for announcements of these launches.

Figure 3. Block diagram of the AO-51 data rate mode L/S base station.



the basic AO-51 V- and U-band functions. All three radios can be used with internal or external accessories to support all functions except the highest data-rate mode.

Software Defined Radio technology currently offers the best hope of one radio to support all functions, but even this technology will work best with some external accessories. For example, uplink and downlink frequency conversions for the microwave bands are best done at or near the antenna. Receiver front ends (pre-amplifiers) are best placed at the antenna even on the V and U bands due to feedline-loss considerations.

Remember, if all you want to do on AO-51 is operate the V/U modes, a dual-band HT (or two single-band HTs) will suffice. Virtually all HTs will work, provided they cover or can be modified to cover the frequency range (70-cm band consideration). Full-duplex operation is desirable but not absolutely necessary. Even the digital modes are supported by the Kenwood TH-D7.

Most modern mobile, dual-band radios will support the basic V/U modes. The Kenwood TH-D700 is particularly good due to its built-in digital capability.

Antennas

For starters, the Arrow dual-band Yagi is very popular for working the V/U modes. It is possible to get by with even less on "QRP Day." If you want to seriously work the digital modes, I highly recommend circularly polarized Yagis for the V and U bands with Az/El rotors and mast-mounted pre-amps.

For the L and S bands it is easy to obtain a lot of antenna gain, but it's not so easy to keep the antennas pointed at a rapidly moving satellite. Small dishes, loop Yagis, and helicals work well. The S-band downlink is very strong, and even the feed from an AO-40–class dish has been used successfully.

Automatic antenna control is very desirable, especially for the digital modes, when you either want full automation or you are busy running the computer keyboard while the pass is in progress. To do automatic antenna control an interface between the computer and the antennal rotors is necessary. For years, the Kansas City Tracker was the most popular; however, it is now out of production and will not plug into the slots in newer computers. Rotator interfaces are now available to support both parallel and USB ports. Tracking programs such as Nova and SatPC32 do a good job with these newer interfaces.

Digital Interface

Last but not least, for full function capability the station must have a digital interface. This can be one of the older DSP-based modems or a TNC and a 9k6-baud (or higher) modem that supports the G3RUH protocol. A variety of this equipment is available, and I recommend acquiring a copy of the AMSAT Digital Satellite Guide to help choose and set up this capability. In the cases of the Kenwood TH-D7 HT, the TM-D700 mobile units, and the TS-2000 base station, the 9k6-baud capability is built in.

Summary

I hope I have not scared you off with the high-level discussion of station capabilities required to work AO-51 and other satellites. Remember, you can do it with an HT and an Arrow antenna, but for full function you need more. Also remember that the closer you come to equipping your station for all functions of AO-51, the better off you will be for future satellites such as SETI Express, P3E, and Eagle.

73, Keith, W5IU

By April Moell,* WA6OPS

VHF+ PUBLIC SERVICE

Amateur Radio and Community Service

Hospital Backup Communications Early Lessons Learned

A quarter-century ago, a switchboard failure led this author to realize the critical importance of communications in medical facilities. The special organization that I formed to serve this largely unfilled mission can serve as an example for your ARES/RACES group.
—WA6OPS

Mark Shapiro, K6OGD (center), is in the middle of the action as HDSCS participates in one of its first Orange County mass-casualty drills back in 1981. He is alerting the hospital command post of the arrival of patients by bus and ambulance. (All photos by Joe Moell, KØOV)

Think back to the last time you lost your home telephone service. It certainly was an inconvenience. You probably were concerned about missing a call from someone you care about. What if an emergency had happened? Then, too, loss of phones at a business is not only inconvenient, but it could have financial consequences: the loss of a sale, not getting an account, or being late in getting important information.

Now think about such a communications loss in a hospital, particularly one which provides acute and emergency care to the community. A failure of telephones in a hospital isn't just an inconvenience or a potential financial loss; it is a patient care emergency. Time-critical calls are placed between units and to physicians and services outside the facility every day.

Even though I had worked in the hospital environment for several years, I didn't appreciate this fact until the phones in my workplace failed in 1979. It didn't take an earthquake or other major disaster to suddenly put patients at risk due to a communications failure that day. It also didn't take a major disaster for amateur radio to become a key communications resource.

At the time, I was the Director of Occupational and Recreational Therapy at St. Jude Hospital in Fullerton, California. Because we live in earthquake country, my husband (Joe Moell, KØOV, editor of the "Homing In" column in *CQ VHF*) and I kept our radio equipment handy at work so we could quickly contact one another if the earth shook. My trusty Drake TR-33 was in my desk drawer and my ARES card was in my wallet. What training I had was as a result of performing Red Cross communications during some brush fires. The hospital had an HF ham station, used for "Rehab Radio" with patients as part of the hospital's rehabilitation programs. I was ready for an emergency . . . so I thought.

When I realized that the entire hospital had no working phones, I grabbed my TR-33 and headed for the administrator's office, thinking I could help. I quickly realized that I didn't really know what I was offering. The ham station in the basement would be of no help, being far from the switchboard and only on the HF bands. That wouldn't help with unit-to-unit communications nor with contacting the local physicians in their offices.

As I reached the administrator's office, the hospital's chief engineer was in the doorway. I showed my rig and offered, "Would you like me to get some radio operators in to help?" The administrator looked rather quizzically at me for a moment and then said, "Well, I'm not sure we need to do that." The engineer countered with, "Maybe it wouldn't hurt to let some of them come in." I looked over at the administrator and he nodded.

I quickly made my way through the front entrance and, outside the building, made a call on the ARES repeater. Fortunately, someone I knew answered from his home and volunteered to get help. All I could tell him was that the hospital had no phone service. I waited anxiously in front of the lobby entrance. Eventually, amateur radio operators started arriving, some having heard my plea on the radio and some having been called by the ham who first answered me.

The phones stayed down for about two hours. The radio operators arriving throughout that time had widely varied levels of preparedness. Many I knew. Some I didn't. Their radios served as their identification as I thanked them for com-

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ing and directed them into the hospital and on to the switchboard.

Some responders had only their big 1970s-vintage HTs, one brought in a pull cart with a mobile rig on it, and another had a large briefcase, like a salesman. For most of the outage the radio operators were busy trying to get communications established at hospital units that the switchboard operator deemed most important. One left the hospital after 20 minutes because his only HT battery had died. A few unit-to-unit messages were handled. Then the phones came back on line.

A Great Response, However ...

Hospital staff members were very impressed that volunteer radio operators could and would come to their facility to help in the middle of a weekday. However, I was breathing a sigh of relief, realizing that it was a rather haphazard response. Most operators on site, including me, weren't well prepared. It took too long to get reliable internal communications established. The operators weren't ready for an extended outage, if it had occurred. Also, except for me, no operator had any familiarity with the medical environment, other than perhaps as a former patient. For instance, I was a bit uncomfortable about the hams on a nursing unit not knowing what "stat" meant (it means "now"), and not having any idea what communications would be needed if a Code Blue (life-critical emergency) occurred.

At that point, I had little chance to think all of that through, because accolades had started to come my way. An article appeared in the local paper about what I had done with my radio to get ham operators to help, with a photo of me holding my TR-33 while standing in front of the hospital. I was quite pleased, because I had done what I had been told by ham leaders was important: "Get publicity for amateur radio."

The Emergency Department supervisor was quite intrigued by what had happened on the day of the phone outage. She came to my office, and I ended up presenting a tutorial on amateur radio to her. She was extremely interested in that, especially as I talked about ARES and how we had helped out in wildfires. I showed her articles from amateur radio publications about responses after tornadoes and hurricanes.

That same Emergency Department supervisor also served as the hospital's disaster coordinator. The next thing I knew, she was asking me to put a group of hams together to help the hospital in an upcoming Orange County disaster drill. My only involvement with disaster planning at that time was to prepare my department for what would happen in our area if a major mass-casualty incident occurred. Our rehabilitation rooms would become holding areas for early discharged patients and less-injured patients awaiting further treatment. My involvement was soon to change.

I contacted our area EC (emergency coordinator) at the time, Ralph Swanson, WB6JBI, to discuss what had happened. With his support, I selected seven ARES members to help. On the morning of the drill we all gathered in the east lobby, near the switchboard. That area became the hospital's Emergency Command Post as the drill got under way. Since I knew the facility, I then escorted each ham to locations requested by the disaster coordinator.

The simulated scenario began. Notification of incoming ambulances came via landline and a newly installed county-wide VHF voice and signaling system known as HEAR, the Hospital Emergency Administrative Radio. Within an hour St. Jude was receiving a large number of victims from the simulated disaster scene. As employees acted out real-time use of the Emergency Department, X-ray, Laboratory, and Surgery suites, the hams relayed important information between key locations. Our ham outside of the Emergency Department door proved to be a big help, because he provided ambulance arrival information that the command staff had not been able to rapidly ascertain in previous drills.

Soon over 20 drill patients were in the facility, and more were coming. A bottleneck developed in the hallway outside of Surgery, where there was no telephone. I was asked about putting a radio operator in that location to communicate directly with the Emergency Department. My facilitator/oversight role suddenly disappeared. I reported to the Surgery desk. A nurse quickly joined me, and we went into the hallway by the elevator. The Emergency Department communicator was asked to inform us any time there was a decision to send a patient down to Surgery.

On numerous occasions the medical staff used third-party communications on our radios, deciding whether a patient needed to come directly to Surgery, could be temporarily taken to the Intensive Care Unit, or should be brought into the Recovery Department and monitored until a surgical suite became available. This made a huge improvement in getting the overload of patients prioritized. Surgery staff members were thrilled.

We all learned a great deal that day. The hospital learned that hams are a communications resource that can be deployed where needed most inside the hospital. The hams learned what it was like to work directly with hospital staff and how an understanding of the medical environment is crucial to best provide communications related to patient care. Although the hospital leaders were impressed with our effort, we realized that to become an integral part of the disaster plan more education and training would be a must.

From One to Seven

Orange County Emergency Medical Services Agency geographically divides hospitals into color-coded response groups for disaster planning. Representatives of hospitals and fire/paramedic agencies in each group meet regularly to plan their required mass-casualty drills and to critique them. Seven hospitals in north Orange County, including St. Jude, made up the Brown Net grouping in 1980.

Pleased with our drill performance, St. Jude's Disaster/Safety Coordinator asked me to come to the next Brown Net Disaster Committee meeting to talk about what had happened in the phone outage and what we did in the drill. Once again, I was ready to wave the banner of amateur radio, but I still had not quite grasped the bigger picture. With great enthusiasm, I touted the value of amateur radio in the aftermath of disasters such as the 1964 Alaska earthquake and recent tornadoes in the Midwest. Then I described the phone outage and what we did in the drill. Every hospital representative in attendance had questions, but the question that launched me on a 25-year path was "We don't have an April working at our hospital. How do we get hams when we need them?"

Surrounding Orange County Board of Supervisors Chair Bill Campbell (holding the proclamation) are HDSCS members attending the 2005 Orientation and Review Workshop. To the left of Supervisor Campbell is Jay Thompson, W6JAY, winner of Newsline's Young Ham of the Year 2003 and ARRL Hiram Percy Maxim Award 2004. Jay has been a member of HDSCS since 2000. To the left of W6JAY is April Moell, WA6OPS. Standing at the far right is Ralph Swanson, WB6JPI, a charter member of HDSCS who was ARES EC for Orange County when the group was formed.

As the meeting ended, all seven hospital representatives wanted amateur radio operators to be on call for their facilities. The disaster coordinator from a hospital at the eastern boundary of the county, along the banks of the Santa Ana River and downstream from Prado Dam, had an even greater concern. "We're pretty far away from the major part of the county," he said. "Who will think of helping us in an earthquake or other disaster when all the phones are out? We have the new HEAR radio, but sometimes it goes down and it certainly could be inoperable after an earthquake."

I realized that I had just done a great sales pitch, but I didn't really have a "product" to provide. I wasn't prepared to tell these hospitals just how amateur radio would support them, so I started by giving them my name and phone numbers and said I would get back to them with a plan. In the meantime, they could call me in the event of a communications problem.

I wasn't very comfortable with that response. What if I wasn't around when communications failed? If I got an emergency call, was I going to just jump on the repeater again and ask for help? Yikes! What if it was at 2 AM? Would I know the responding hams? Would they be prepared? How would we be activated by hospitals if there was an earthquake and all the phones went down?

I asked for a follow-up meeting with the ARES area EC to explain what I was being asked to do. He quickly appointed me as an assistant EC to organize a response plan for the requesting hospitals. We had already learned some lessons that would start us on our planning, but the "How do we get hams?" question troubled me. The other question, "Who will think about our hospital in a major disaster?" bothered me even more.

My own hospital had an HF station and I had my 2-meter radio with me on the day we lost our phones. However, just having some equipment at hospitals would not constitute a plan. Finding hospital employees with an amateur radio license wouldn't be an adequate plan either. I'd already encountered one hospital employee with a ham license, but he wasn't active in the hobby and had no equipment at the time. We had known about the drill well in advance, and the hams were already on site at the start of the simulation. That didn't test how we would be activated for an actual mass-casualty incident, nor did it test what it would be like to activate, get into the hospital, and get started in real time.

County of Orange

Hospital Disaster Support Communications System Volunteers

25 YEARS OF SERVICE TO ORANGE COUNTY

WHEREAS, the Hospital Disaster Support Communications System is a specialized entity of the Amateur Radio Emergency Service (ARES) in Orange County; the Amateur Radio Emergency Service is the national public service and emergency communications branch of the American Radio Relay League (ARRL), which is the largest national association of Amateur Radio devotees; and

WHEREAS, a disruption in telephone service at a large hospital in Fullerton in 1979 and the remarkable and inspiring reaction of the Amateur Radio operators to that emergency was the impetus led to the creation of the Hospital Support Communications System, which commenced operations twenty-five years ago; and

WHEREAS, the Hospital Disaster Support Communications System began with seven support facilities and has expanded to encompass all of the acute care receiving hospitals in Orange County and other critical medical facilities; and

WHEREAS, all members of the Hospital Disaster Communications System are FCC-certified Amateur Radio operators who have their own portable radio equipment ready to respond to nearby hospitals; member equipment preparedness is imperative because almost all HDSCS activations entail backup of communications among entities within the facility; and

WHEREAS, HDSCS volunteers provide important and valuable services to the people of Orange County; they work diligently to ensure that emergency personnel are able to maintain communications during disasters and crises; and

WHEREAS, the efforts of HDSCS volunteers allow for staff, suppliers, and outside organizations, such as blood banks, the American Red Cross, and county Emergency Medical Services agency to maintain their communications ability; and

WHEREAS, HDSCS supports thirty-four hospitals and health care facilities throughout Orange County by maintaining regular contact with them to ensure that they will be able to cooperate with each other and coordinate each of their individual communications and disaster plans during a crisis; and

WHEREAS, HDSCS volunteers have the capability to provide both internal and external communications when telephone service disruption occurs; and

NOW, THEREFORE BE IT PROCLAIMED THAT SUPERVISOR BILL CAMPBELL does hereby recognize the Hospital Disaster Support Communication System Volunteers for their 25 years of dedicated service to the residents of Orange County and offers his sincere best wishes for their future endeavors.

March 5, 2005

BILL CAMPBELL
Chairman of the Board
Supervisor, Third District

This proclamation from the Orange County Board of Supervisors was recently presented to HDSCS in recognition of 25 years of service to the citizens.

Orange County ARES needed a robust activation procedure for the hospitals. I was around much of the time, but not 24/7/365. There had to be persons in addition to me as primary points of contact. Whom could I rely on to come help at a hospital? Having been through the phone outage, I knew well that there was a wide range of preparedness, knowledge, and experience among hams. Being a patient care person, I knew the hospitals' concerns for privacy. I also knew that a hospital is a specialized and technical environment. It was obvious that education would be important for radio operators wanting to help there, to avoid mistakes or misunderstandings. In a hospital, PTT does not mean "push to talk." "Quad" does not refer to an antenna.

The early lessons had indeed been learned and now it was time to get to work. A special group of amateur radio operators interested in this aspect of the Amateur Radio Emergency Service had to be formed. An activation procedure had to be devised for each hospital to use. Response to multiple hospitals in major area-wide disasters had to be planned. Training had to take place so that responders would be prepared and knowledgeable.

There was plenty to do, but little did anyone realize what lay ahead. We had far more yet to experience, learn, and accomplish.

Fast-Forward to 2005

The Hospital Disaster Support Communications System (HDSCS), a special ARES group, now has agreements to provide backup communications for all of the acute receiving centers and some other specialty hospitals that are part of Orange County's mass-casualty plan. We have participated with hospitals in communications drills 136 times. On 86 occasions since the first time in 1979, we have stepped in to provide communications when telephones failed or became overloaded in isolated and area-wide emergencies.

The yearly HDSCS Orientation and Review Workshop has just concluded as I write this. This all-day session takes place on a Saturday at the county's Emergency Operations Center. Basic concepts and procedures are reviewed, and detailed information about functioning as a communicator in the hospital environment is presented. We also teach basic personal and equipment preparedness as members bring in their disaster "Go-Kits" for show-and-tell.

The workshop is always a great day of learning, camaraderie, and good food at the "disaster potluck." However, this year was a bit different, as we celebrated the 25th anniversary of the establishment of HDSCS. In previous years, HDSCS has been honored at our workshop and other events by visits and award presentations from mayors, county officials, state legislators, and U.S. Congressmen. This year there was something more. Employees from several hospitals made a non-workday trek to the EOC just to say thank you to the group for their continued service in phone outages, the 2003 Placentia train collision, earthquakes, and so forth.

Huntington Beach Hospital staff and a physician arrived with a huge cake and special plaque. Our support was particularly fresh in their minds, because six weeks before HDSCS had responded to a power and phone outage caused by a nearby traffic accident that downed a power pole. For over three hours we kept critical units within the hospital in constant contact. A few staff members had cell phones and business-band walkie-talkies, but they still wanted, used, and appreciated their amateur radio resource.

The emergency communications needs of hospitals are different in many ways from those of Red Cross, SKYWARN, and other agencies that ARES traditionally serves, but hospitals' communications are no less important than communications for any of them. In future installments of this series, I will have much to say about alerting plans, equipment and personal preparedness, effective drills, and other special considerations for medical communications support. Start thinking and planning how your club or ARES or RACES group can respond quickly and effectively when a communications emergency puts patient lives at risk.

73, April, WA6OPS

About the Author

April Moell, WA6OPS, is founder and leader of the HDSCS, a 75-member group that provides emergency backup communications for 34 medical facilities in Orange County, California. She presents this series of articles in the hopes that hams around the country will take on the important mission of providing rapid-response support for every hospital in their hometowns. More information about HDSCS is at <www.hdscs.org>.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Cheap Yagis for 2450 MHz

This time, at the suggestion of one of our readers we take the Cheap Yagi construction projects to 2450 MHz (photo A). While this is not the highest frequency for which I have built a Yagi (that is still 10,300 MHz), it is the highest frequency for a "Cheap Yagi" construction project.

The design was more challenging than I had thought it would be. I try to keep all dimensions to .1 inch accuracy. Yes, I've seen published 20-meter beam designs with dimensions to .0001 inch, but that's ridiculous. Also, the 2.4-GHz ISM (Industrial, Scientific, and Medical) band is 83 MHz wide. That is pretty wide for a long Yagi, but after several tries I have two Cheap Yagis that fit the bill.

When things get small, little things become big things. Just how the ends of the elements are cut makes a difference (figure 1). My prototype wouldn't tune up until I cleaned up the jagged ends of the elements. A few quick strokes with a flat file—or in my case, a second on the belt sander—fixed the problem. The antennas covered here have similar dimensions (figure 2 and Table I), and

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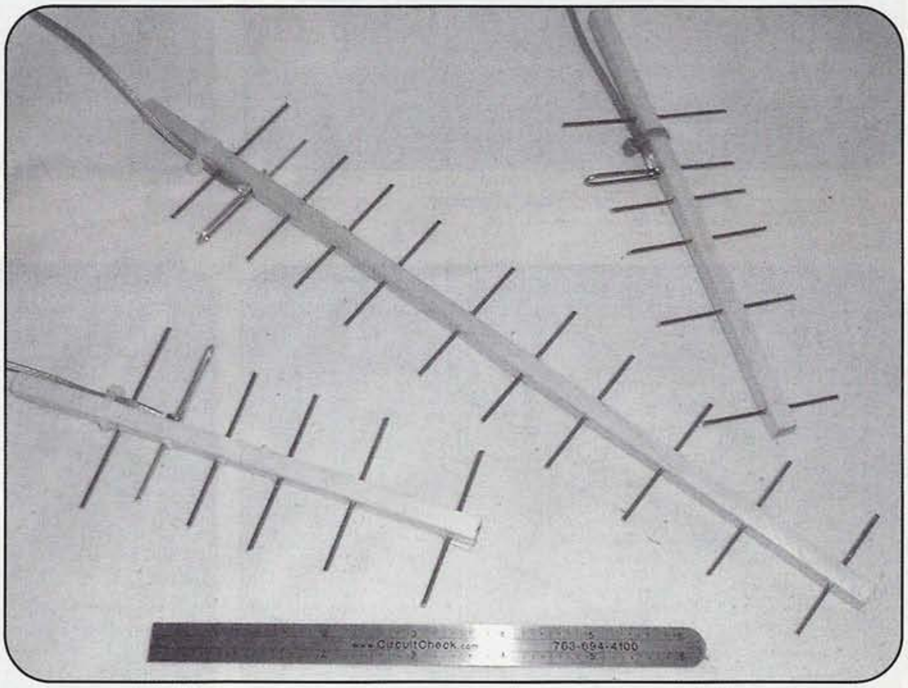

Photo A. 2400-MHz Cheap Yagis.

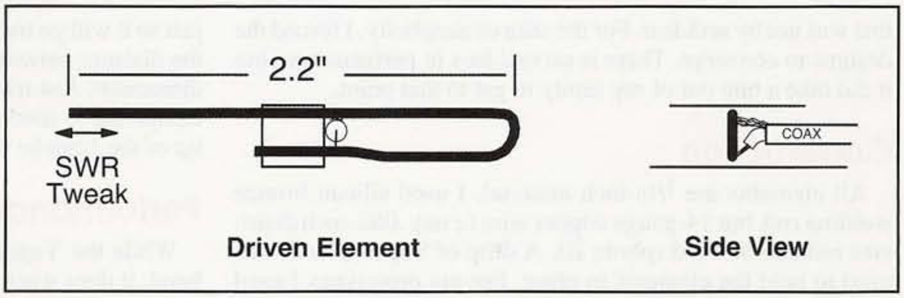

Figure 2. Driven element of both the 6-element and 11-element versions.

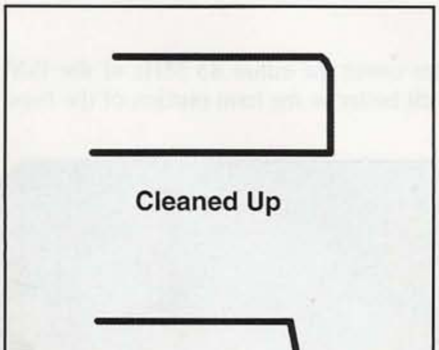

Figure 1. Element ends.

	Ref	DE	D1	D2	D3	D4	D5	D6	D7	D8	D9
6 elements											
Length	2.4	*	2.1	2.1	2.0	1.9	—	—	—	—	—
Spacing	0	.6	1.3	2.1	3.0	4.2					
11 elements											
Length	2.4	*	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.8
Spacing	0	.6	1.3	2.1	3.0	4.2	5.2	6.2	7.3	8.5	9.8

Driven element is per figure 2 for both Yagis.

Table I. Dimensions (in inches) of the 6-element and 11-element Cheap Yagis.

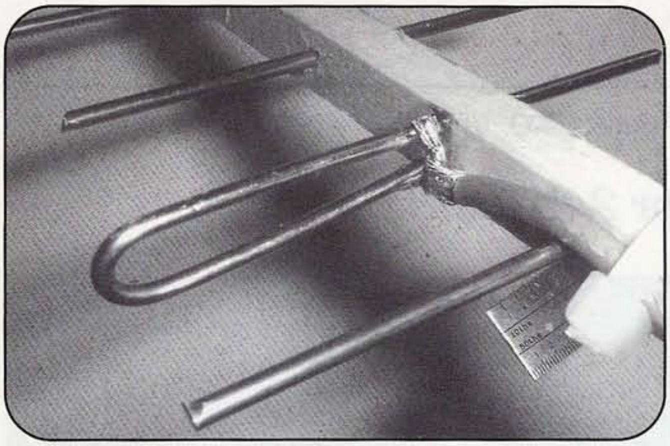

Photo B. The driven element.

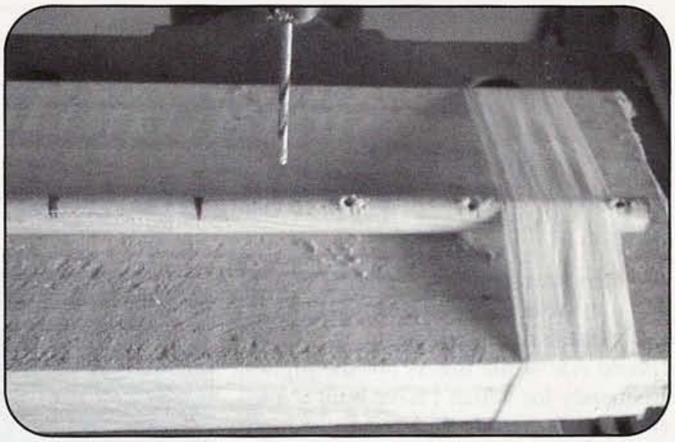

Photo C. Dowel drilling.

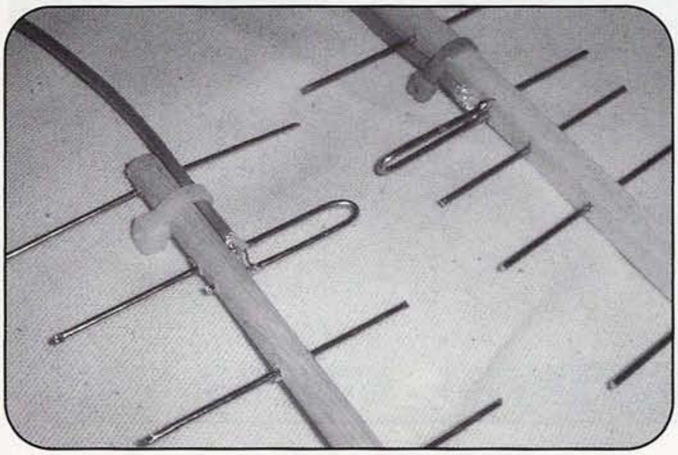

Photo D. Rotated driven element.

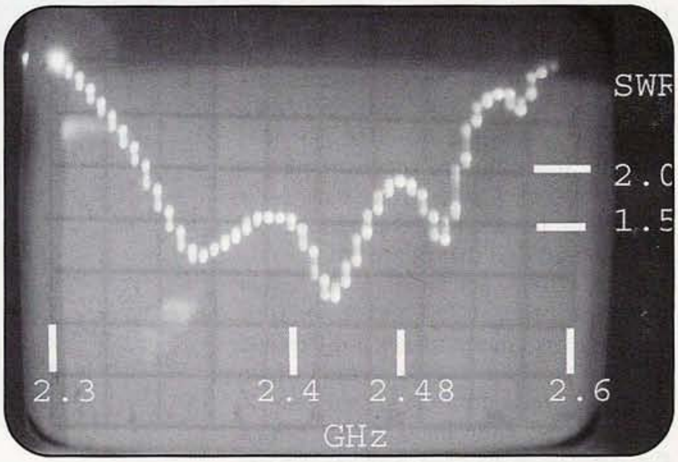

Photo E. Network-analyzer plot of the 11-element antenna.

that was not by accident. For the sake of simplicity, I forced the designs to converge. There is no real loss in performance, but it did take a bite out of my sanity to get to that point.

Construction

All elements are 1/16-inch material. I used silicon bronze welding rod, but 14-gauge copper wire or any .062-inch diameter rod can be used (photo B). A drop of Super Glue® was used to hold the elements in place. For my prototypes I used 1/4-inch-square wood from the local home-improvement store, as it's much easier to drill.

If you do insist on using 1/4-inch dowel, taping it to a block of wood makes it much easier to drill the elements in a straight line (photo C). You also will need to use a lot of glue to hold the driven element in place, or flip it 90 degrees when using dowel (photo D). There are several technical reasons for not wanting to flip the driven element. It creates quite a bit of uncertainty as to exactly where the phase center of the element is. However, it can be done. Note the flipped driven element on the PC-board version later on.

The shield of your 50-ohm coax goes to the center of the driven element. The center of the coax goes to the inter tip of the J element. Yes, they are offset slightly and not exactly in the center of the J, but that has been allowed for in the final dimensions. The bend in the end of the J is going to end up .2 to .25 inch wide just so it will go back into the boom. The radius of the bend, and the distance between the tip and body of the J are not a critical dimension. Just make it fit and you'll be okay. If you have the equipment to measure return loss or SWR at 2.4 GHz, the free tip of the J can be trimmed for best SWR (photo E).

Performance

While the Yagi does cover the entire 83 MHz of the ISM band, it does work a bit better in the ham portion of the band

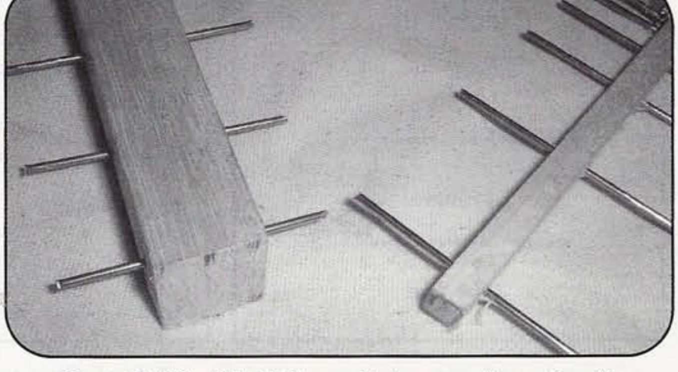

Photo F. "But I built it exactly to your dimensions!"

top and bottom of the board, but the back lighting shows the elements well.

Thus far I have developed nine different PC-board Cheap Yagis from 434 MHz to 5800 MHz with over 10,000 of the 915-MHz versions in the field. In general, start with a design for a free-space Yagi (figure 3). Shorten the elements about 30% and reduce the element-to-element spacing about 20% when you generate the PC-board artwork. These are general factors, and that .062-inch thick PC board looks a lot thicker to a 11-GHz radio wave than it does to a 400-MHz radio wave (photo H). Also, the E_r of the fiberglass tends to drop as you go up in frequency. While the fiberglass board may have a E_r rating of 4.0, that is usually measured at 1 MHz and drops to 3.7 or 3.8 in the GHz range. All these factors really cause problems when designing PC-board log-periodic antennas from 400

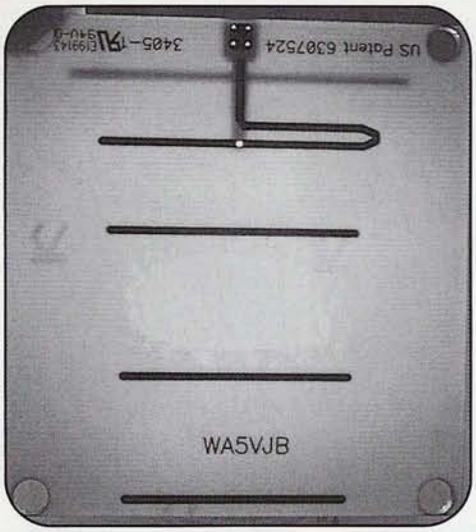

Photo G. A 5-element Cheap Yagi etched on PC board.

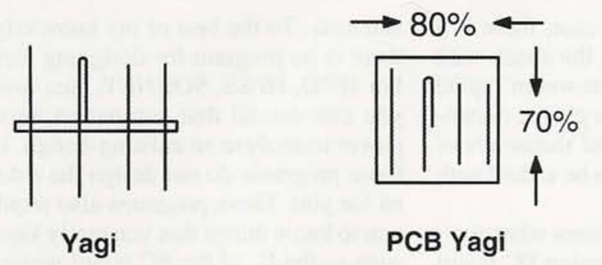

Figure 3. Free-space Yagi and PC-board Yagi.

and has good performance in the AMSAT portion. How about this antenna for a small S-band AMSAT station? Gain varied over the band, but ran between 12 and 13 dBi for the 11-element antenna and 9.5 to 10.5 dBi for the 6-element version.

Wood

Since wood doesn't conduct electricity, many seem to assume it has no effect on the antenna. Well, that's not entirely true (photo F). Wood contains cellulose and moisture, and these give the wood an E_r, or dielectric constant.

When light travels through water or glass, it travels more slowly. The same is true when a radio wave travels through plastic, air, wood, etc. The E_r of wood varies quite a bit between dry balsa wood and damp teak, but through typical construction woods, the radio wave travels at about half the speed it does in air. Wood around a wire is a bit more complex, and the effect varies greatly with wavelength. However, for 1 inch of wood you need to make the element about one-tenth inch shorter to allow for the effects of the wood. That's no big deal on 2 meters, but above 400 MHz or so a very thick boom can kill a Cheap Yagi. Now just put the Yagi in/on a dielectric material, and you quickly learn about E_r effects.

A Cheap Yagi Etched on PC Board

Photo G shows a Cheap Yagi etched on PC board. Taking the photo was not a lot of fun, since there are elements on the

Photo H. PC-board log-periodic antennas from 400 MHz to 11 GHz.

MHz to 11 GHz. In my case, there is a big box of prototypes in the shack with trimmed elements that just weren't quite right. However, once you get the dimensions right, thousands and thousands of high-quality antennas can be etched with high repeatability.

I've been asked many times what computer program I use to design PC-board antennas. To the best of my knowledge, there is no program for designing them. For IE3D, HFSS, SONNET, etc., users, you can use all that computing horsepower to analyze an existing design, but those programs do not design the antenna for you. These programs also require you to know things that you rarely know, such as the E_r of the PC-board material over an octave of frequency.

Last, I don't have the space here to explain, but you *cannot* accurately frequency sweep log periodics with these programs. I'm waiting for the e-mails to come pouring in, but you cannot accurately frequency sweep a PC-board log periodic antenna with these programs. This is a road I and others have been down!

Are you planning to be at the Dayton Hamvention®? If the timing belt on my car doesn't break, I should be in slot 915 selling 915-MHz PC-board antennas. I'll be happy to show you some of the 200-plus 13 MHz to 11 GHz antennas that I have designed.

E_r for Quad Builders
Bare Wire vs. Insulated Wire

Making that quad antenna designed for bare #12 copper wire out of insulated #12 copper wire moved it down in frequency about 5%, didn't it? Your 147-MHz quad resonates in the 130s, and the element spacing now is all wrong. You can compensate for this. Make the elements about 95% as long, but the smaller elements won't couple quite as well, so the element-to-element spacing has to be changed as well. In theory, all of this can be incorporated into the new design—that is, when you know the E_r of the plastic (see main text below)! Just try going down to the local hardware emporium and asking the clerk for the E_r of the #12 insulation when measured at 147 MHz. Be prepared for that "deer in the headlights" stare. The electrical wire insulation materials are optimized for voltage puncture, UV exposure, moisture resistance, flexibility, etc. The dielectric constant of the insulation is not controlled from batch to batch or manufacturer to manufacturer. Thus, a quad design using insulated wire might not be able to be replicated by others.

Next Time

Next time I'll cover why you don't want to use a 1/4-wave antenna with those new RF transceiver chips from Chipcon, RFM, Micrel, etc. This applies to many ham rigs as well. I'm also trying again to come up with a 6-meter Cheap Yagi. It's a mechanical, not an electrical, problem.

As always, some of my best ideas for this column come and from your e-mails and questions.

73, Kent, WA5VJB

QUARTERLY CALENDAR OF EVENTS

Contests

May: Spring Sprints. These short duration (usually four hours) VHF+ contests are held on various dates (for each band) during April and May. May's dates and times are as follows: Microwave, May 7, 6 AM to 1 PM local time; and 50 MHz, May 14, 2300 UTC Saturday to May 15, 0300 UTC Sunday. Sponsored by the East Tennessee Valley DX Assn., more information can be found at <http://www.etdxa.org>. Click on the VHF/UHF link.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs from 6AM on May 7 to 12 midnight on May 8 (36 hours). The object is for worldwide club groups of amateurs to work as many amateur stations in as many locations as possible on bands from 2 GHz through Light. Rules are at: <http://www.ham-radio.com/sbms/club_contest/2GHzUp.pdf>.

The **Six Meters Marathon 2005** is open to all amateur radio operators worldwide. The objective is to work as many DXCC entities as possible on 6 meters between 7 May (0000 UTC) and 7 August (2400 UTC). Results will be continuously updated at <http://www.50mc.tk>. For details contact Hannu Saila, OH3WW, e-mail: <marathon@saila.org>.

June: European Worldwide EME Contest. Sponsored by *DUBUS* and REF. The EU WW EME contest is intended to encourage worldwide activity on moonbounce. Multipliers are DXCC countries plus all W/VK/VE states, giving equal chances for stations from N. America, Europe and Oceania. The rules reward random QSOs, but do not penalize skeds on 2.3 GHz or above. Winners (1st places) receive a free subscription to *DUBUS* magazine. The contest dates and bands are as follows: Second weekend: 144 MHz, 2.3 GHz, and 3.4 GHz, 14-15 May, 0000 to 2400 UTC; and third weekend: 432 MHz and 5.7 GHz, 11–12 June, 0000 to 2400 UTC. Contest entries *must* be sent no later than 28 days after the end of the third weekend (i.e., in the mail or e-mail by July 10, 2005). Mail address: Patrick Magnin, F6HYE, Marcorens, F-74140 Ballaison, France. You can also e-mail your contest entry in ASCII format to: <f6hye@ref-union.org>. For additional rules and general questions contact: <info@dubus.de>. Complete rules can be found at: <http://www.marsport.demon.co.uk/EMEcont2005.pdf>.

Six Club Contest: The Major Six Club Contest is anticipated to be the first weekend in June, 2300 UTC, June 3 to 0200 UTC, June 6. These dates need to be confirmed by the sponsor. All logs are due 30 days from ending date of the contest and they go to <w4wrl@aol.com>. For further information go to: <http://6mt.com/contest.htm>.

ARRL June VHF QSO Party: The dates for this contest are 11–13 June. Complete rules are in the May issue of *QST* and on the ARRL website (http://www.arrl.org). For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu). For weeks in the run up to the contest, postings are made on the VHF reflector announcing Rover operations and grid expeditions. This is a great opportunity to introduce the hobby and the VHF+ bands to your friends.

SMIRK 2005 QSO Party: Sponsored by the Six Meter International Radio Klub, this will be held 0000 UTC June 18 tol 2400 UTC June 19. It is a 6-meter only contest. All phone contacts within the lower 48 states and Canada must be made above 50.150 MHz; only DX QSOs may be made between 50.100 and 50.150. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Send a legal-size SASE for a copy of the log forms. Log requests and logs (send entries by August 1) should be sent to Pat Rose, W5OZI, P.O. Box 393, Junction, TX 76849-0393. For more info go to: <http://www.smirk.org>.

Quarterly Calendar

May 1	Moderate EME conditions
May 8	New Moon Moderate EME conditions
May 14	Moon apogee
May 15	Good EME conditions
May 16	First Quarter Moon
May 22	Moderate EME conditions
May 23	Full Moon
May 26	Moon Perigee
May 29	Moderate EME conditions
May 30	Last Quarter Moon
June 5	Poor EME conditions
June 6	New Moon
June 11	Moon Apogee
June 12	Good EME conditions
June 15	First Quarter Moon
June 19	Moderate EME conditions
June 21	Summer Solstice
June 22	Full Moon
June 23	Moon Perigee
June 26	Good EME conditions
June 28	Last Quarter Moon
July 3	Poor EME conditions
July 6	New Moon
July 8	Moon Apogee
July 10	Moderate EME conditions
July 14	First Quarter Moon
July 17	Poor EME conditions
July 21	Full Moon and Moon Perigee
July 24	Very Good EME conditions
July 28	Last Quarter Moon
July 31	Poor EME conditions
August 4	Moon Apogee
August 5	New Moon
August 7	Moderate EME conditions
August 13	First Quarter Moon
August 14	Poor EME conditions
August 19	Full Moon and Moon Perigee
August 21	Very Good EME conditions
August 26	Last Quarter Moon
August 28	Very poor EME conditions

—EME conditions courtesy W5LUU

Field Day: ARRL's classic, Field Day, will be held on June 25–26. Complete rules can be found in *QST* and at <http://www.arrl.org>. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, great sporadic-*E* openings can occur. This is one of the best club-related events to involve new people in the hobby.

July: CQWW VHF Contest. This year's CQ WW VHF Contest will be held from 1800 UTC July 16 to 2100 UTC July 17. Complete rules can be found elsewhere in this issue on page 58.

The **Mid Summer Six Club Contest** is expected to be held from 2300 UTC, July 15 to 0300 UTC, July 17. These dates need to be confirmed by the sponsor. All logs are due 30 days from ending date of the contest and go to <w4wrl@aol.com>. For more info go to: <http://6mt.com/contest.htm>.

August: The **ARRL UHF and Above Contest** is scheduled for 6–7 August. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 20–21. The second weekend is September 10–12. Complete rules for both contests can be found in the July issue of *QST*.

Conventions and Conferences

May: The 2005 **West Coast Space Symposium** will be presented by Project OSCAR and The College of San Mateo May 7th in San Mateo, California. Topics include: Satellite Basics, Software Defined Radio, Digital Modes on Amateur Satellites, Satellite Tracking, Dish Feed Designs, 10 GHz and Above, Amateur Radio on the ISS, Orbital Debris Mitigation, Satellite Launch Options, and Youth and Amateur Satellites. Donation $15; Students $8 (includes lunch and parking). Registration starts at 8 AM. Presentations start promptly at 9:00AM. Talk-in frequencies 7–9 AM on 147.300+ and 441.950+ PL 100. Additional information: <http://www.ProjectOSCAR.net>.

Dayton HamVention®: The Dayton HamVention® will be held at the Hara Arena in Dayton, Ohio, May 20–22. For more information, go to: <http://www.hamvention.org>. Your editor is scheduled to be a speaker at the VHF forums.

June: Ham-Com. The annual Ham-Com Hamfest will be held June 3–5 in Arlington, Texas. The North Texas Microwave Society will present a microwave forum. For more information, see the Ham-Com website at <http://www.hamcom.org/>.

July: This year's **Central States VHF Society Conference** will be held July 28–31 at the Sheraton Hotel, Colorado Springs, Colorado. For more information, go to: <http://www.csvhfs.org>.

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 for their forthcoming conferences:

The 39th annual **Central States VHF Society Conference**, July 28–31 at the Sheraton Hotel, Colorado Springs. The deadline for submitting final papers will be around May 31. Submit your papers and your desire to make a presentation as soon as possible to Technical Program Chair Joe Lynch, N6CL, at <n6cl@sbcglobal.net>.

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*. Presentation at the conference is *not* required for publication. Submission of papers is due by August 9th. Send to: Maty Weinberg, ARRL, 225 Main St, Newington, CT 06111; or via e-mail: <maty@arrl.org>.

Microwave UpDate: The following is from Chip Angle, N6CA, Technical Program Chairman: The 2005 Microwave UpDate will be held this year in the Los Angeles area October 27–31. Interested authors are invited to present a paper(s) for the 2005 conference. You don't have to give a talk to have your paper included in the conference *Proceedings*.

(Continued on page 71)

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Transmitter Hunting—A Youth Magnet

"For its future health, amateur radio needs more newcomers, especially young people." You probably have heard and read that opinion often. Chances are you have expressed it yourself. Better yet, maybe you are acting on it.

Hats off to the hams who talk up and teach ham radio in schools, Scouting, and other organizations for youth. Getting kids on the air, explaining about radio propagation, building code oscillators, and sending Morse code are some of the traditional techniques that have worked for decades. For the most part, these are classroom activities. Wouldn't it be ideal to include an outdoor ham-radio-related activity that exercises kids' bodies as well as their minds?

I believe that to get youngsters excited about our hobby there's nothing better than on-foot hidden transmitter hunting, also called foxhunting, foxtailing, and radio-orienteering. It combines good physical exercise with the technical challenge of using radio gear. There's the intrigue and adventure of discovering hidden objects with radio direction finding (RDF), plus the challenge of navigating with a map and compass. It lets kids express their natural competitive urges.

Jamboree-on-the-Air, an annual national Scouting event on the third weekend of October, is an ideal time to introduce Scouts to foxhunting.[1] There are also other Scouting events where amateur radio and transmitter hunting can play an important role. Some hidden transmitters in the trees would make a great activity for any Camporee.

Art Goddard, W6XD, arranged for an amateur radio display at a Scout-O-Rama in Long Beach, California during June 2003. That was the start of what has become an annual tradition. Art wisely suggested that the display include a variety of ham activities, including transmitter hunting.

Southern California Scout-O-Ramas are a sort of "activity fair" where Scouts learn from other Scouts about specialized activities of their troops, such as rockhounding and the Pinewood Derby. Non-Scout organizations such as ham radio clubs are allowed to display at the discretion of the Scout Council. It requires a large city park to hold it all.

The annual Long Beach Scout-O-Rama now features a virtual five-ring circus of amateur radio activities, including QSOs, emergency communications (see sidebar), CW, and transmitter hunting. Scouts receive a certificate for completing any activity, with endorsements for each additional activity, all counting toward their amateur radio merit badge.

It took five of us just to keep up with the interest in foxhunting at the 2004 event. Helping me were Marvin Johnston, KE6HTS; Jay Thompson, W6JAY; Richard Thompson, WA6NOL; and Tom Gaccione, WB2LRH. We placed seven low-power transmitters out of sight within 100 yards of the display. All were on different frequencies in the 2-meter band. Each of us accompanied Scouts, usually two of them at a time, as they learned RDF and tracked down a fox or two.


Certificate of Accomplishment
presented to
in recognition of participation in the following activities:
Visit Approved Amateur Radio Station
Two-Way Contact via Amateur Radio
Simulated Emergency Communications
Amateur Radio Transmitter Hunt
Send Name Using International Morse Code
Scout-O-Rama June 5, 2004
Heartwell Park, Long Beach, CA
ARRL Amateur Radio www.arrl.org
Amateur Radio Operator

This certificate, initialed and signed by the display activity leaders, helps Scout-O-Rama attendees qualify for a radio merit badge.

I usually introduce kids to foxhunting by asking if they have seen nature specials on TV, where researchers follow the movements of radio-tagged animals. The idea of learning to do tracking like that appeals to them. I tell older kids about how RDF locates downed aircraft and mariners in distress.

I show them the 2-meter beam antenna and tell them how it's like the TV antenna or satellite dish on their roof, because it has to be aimed at the transmitting station to get a good picture. When it's aimed that way, we then know the direction to the station.

You probably have forgotten how difficult it is to hold onto even a medium-weight object for a while when you are eight years old. Thus, the lighter the RDF set, the better. If possible, the antenna should be balanced so that it rests on the hand and arm instead of pulling the wrist down. A Yagi with hand grip behind the reflector is fine for an older Scout, but in the hands of a grade-schooler it will tend to droop so that it points to the ground instead of out towards the horizon.

One-piece assemblies of antenna, attenuator, and receiver are easiest for adults, especially when dealing with maps. However, it may be better for a child to carry the radio in one hand and the antenna in the other, to balance the weight.

It's possible to get bearings by turning the beam and observing the quieting of an FM signal, but that's not intuitive for chil-

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e-mail: <k0ov@homingin.com>

dren. They will catch on much faster with an S-meter of some kind. The one on your handie-talkie is okay, but it forces the Scout to keep eyes on it instead of watching where he/she is going and looking for the foxbox. Audible signal-strength indication is better.

A tone-pitch S-meter makes it easy for both you and the Scout to know the direction of greatest signal intensity as you walk along, especially if the audio tone comes out of a speaker. Headphones are less desirable in that respect, although I have successfully used split earphones, one for me and one for the Scout. As long as we stay close and don't get tangled in the cords, it works. However, I prefer the speaker.

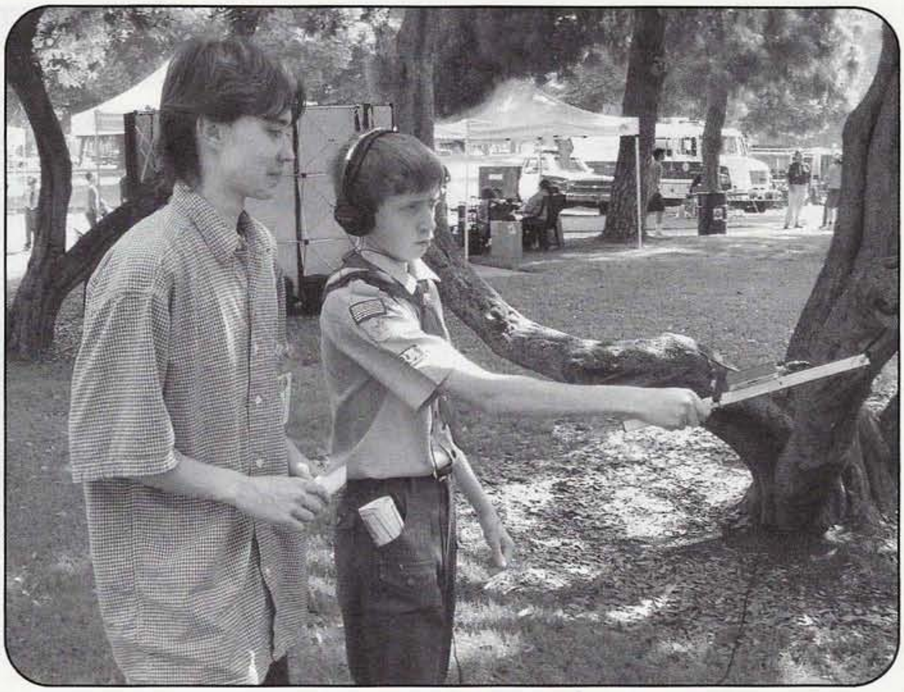
It isn't necessary for the beginner foxes to transmit continuously. Save batteries and make the hunt more interesting by programming the foxes to be on for about 7 seconds and then off for about 15 seconds.

With an audio-pitch S-meter it may be helpful for the helping ham to carry a separate HT tuned to the fox frequency, so both of you will know without a doubt when the fox turns on and off. I exclaim "It's on!" when the transmission starts, to alert the Scout and impart a sense of urgency about immediately getting a bearing. That gets him or her more and more excited as the hunt progresses.

After being instructed that they should hold the antenna straight out and turn their bodies to get the bearing, most kids will tend to turn 90 degrees or so as the signal increases, then stop. You probably will have to remind them several times to turn all the way around before they get into the habit. Teach them to turn past the point of maximum signal, then sweep back and forth to detect the exact point of maximum strength.

The older they are, the faster the kids will catch on. Some 7-year-olds won't get the hang of it at all. Others will naturally have the knack. They will catch on to RDF immediately, find the first fox quickly, and be eager for more. They will do even better the second time; you may not need to help out at all.

Don't pass up the opportunity to explain RDF technology when appropriate, using very simple terms. Scouts sometimes ask why an antenna with metal pieces of different lengths is directional, transmitting (and receiving) most of the radio energy forward. I use a simple flashlight (or lighthouse) analogy, explaining that the driven element where we



Jay Thompson, W6JAY, winner of the Newsline Young Ham of the Year and ARRL Hiram Percy Maxim Awards, instructs a Scout about RDF at the Long Beach Scout-O-Rama. (Photo by Joe, KØOV)

launch or extract the signal is like the light bulb. The Yagi director acts like a lens to focus the signal, while the reflector acts like a mirror to reflect forward the energy that goes toward it.

With several transmitters active in a small park, QRM can be a problem. A spur 40 dB down on another fox frequency will be loud and clear when you are close to it. Therefore, your foxes should be as "clean" as possible, even though they are QRP. When you and the Scout find one, have him or her move 20 feet away from it before trying to get a bearing on the next fox's frequency, to minimize desense effects.

The 2-meter band is the obvious choice for beginning foxhunts because there is so much equipment readily available. Gain antennas for 2 meters are of a reasonable size and weight. Signal reflections aren't much of a problem in a park setting. Another option is the 70-cm band, where antennas dimensions are one-third that of 2 meters, but multipath is more evident.

Scouting events are just one possibility for foxhunting fun with youth. I have put on impromptu transmitter hunts for our church's youth group and at a community band picnic. At such outdoor events parents are grateful to have activities that get their kids out of their hair for a while and dissipate some of their youthful energy, so seize the opportunity.

Hunting Foxes in the Classroom

Winnie Hennigan, KA6OFZ, teaches ham radio topics to her fourth grade students in Santa Barbara, California as part of the Gifted and Talented Education (GATE) program. With help from her OM Jay, WB6RDV, her students have just learned to track radio transmitters.

Jay's first task was to teach the kids to properly point and turn a 2-meter Yagi antenna to get bearings. "I lined up four students side by side with their hands behind their backs," Jay told me. "Then I put a miniature transmitter in one of the students' hands. The student with the RDF set, standing a few feet in front of them, was asked to turn the antenna and determine which of the four was holding the transmitter."

Then it was time to go outside and find the three miniature transmitters. Jay sent out four students in each hunter group, and instructed them to share an RDF set among them. Each time the fox came on, a different member of the group was to be the lead hunter, holding the RDF set as the others helped.

Is it in the tree? This Scout is using my 2-meter on-foot RDF set, which has a handle at the exact balance point to avoid wrist fatigue. Helping him is Tom Gaccione, WB2LRH. (Photo by KØOV)

Frank Shannon, KR6AL, helps Carol Blake, KF6LQQ, an adult Handi-Ham Radio Camp attendee, learn the basics of VHF RDF. (Photo by Pat Tice, WAØTDA)

A different set of challenges confronted Marvin Johnston, KE6HTS; Frank Shannon, KR6AL; and Dennis Schwendtner, WB6OBB, as they brought foxhunting to students at Radio Camp at Malibu, California in early March. This annual event at Camp Joan Mier, sponsored by the Courage Handi-Ham System[2] of Minnesota, brings together persons of all ages and varying degrees of disability. Campers without ham licenses get help in studying for their tests. Those with their tickets try out adaptive equipment and learn new operating activities.

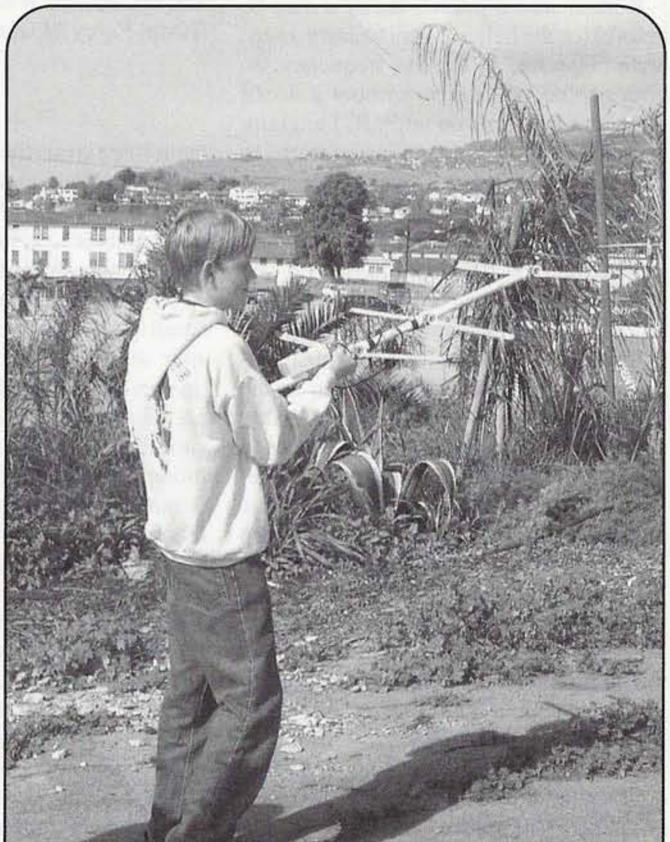
Many of the campers are visually impaired, but RDF sets with tone-pitch signal-strength indicators make it easy for them to get bearings and navigate to the radio foxes. "To help them in the last few feet, we put audible beepers on them," Marvin explains. "They could then get right up and touch them. Our biggest problem was that the grass made it tricky for some of the campers in wheelchairs."

Ham radio doesn't have to be part of the formal curriculum for students to enjoy RDF and learn from it. The proof is at Palos Verdes High School (PVHS) near Los Angeles. Dan Welch, W6DFW, a regular mobile "T-hunter," is using ham radio and transmitter hunting to train future engineers and scientists there.

Twenty years ago W6DFW and I worked for the same aerospace company. Now he is an independent contractor for a variety of electronic enterprises. Each of us got our start toward an engineering career from an early interest in radio.

"As a little kid, I was bugging all the hams in the area," Dan recalls. "If I saw an antenna, I knocked on the door. I met some interesting people, including Don Wallace, W6AM, at his old home by the Virginia Country Club in Long Beach. By fifth grade I was puttering with electronics. I built a number of radios with #30 vacuum tubes. I used to hang out at a local ham's place, chatting on CW and AM."

Dan didn't get his own ham license until long after he grew up, but he made up for lost time by guiding almost every member of his family into the hobby, including his son and grandson (see photo). He has also helped many other young people enter the world of science and technology. He started by becoming a volunteer at the California Academy of Mathematics And



Andy Bradford, one of the Road Warriors, gets a bearing atop a hill at Angel's Gate Park. (Photo by KØOV)

This Fox Talks

I am often asked what to use for transmitters at foxhunts in small parks and schoolyards. The possibilities are many. A page on my website (http://www.homingin.com) describes ways to adapt your handie-talkie or other low-power transmitter for the purpose. See my "Homing In" column in the Summer 2004 issue of *CQ VHF* for ammunition-can foxbox ideas.

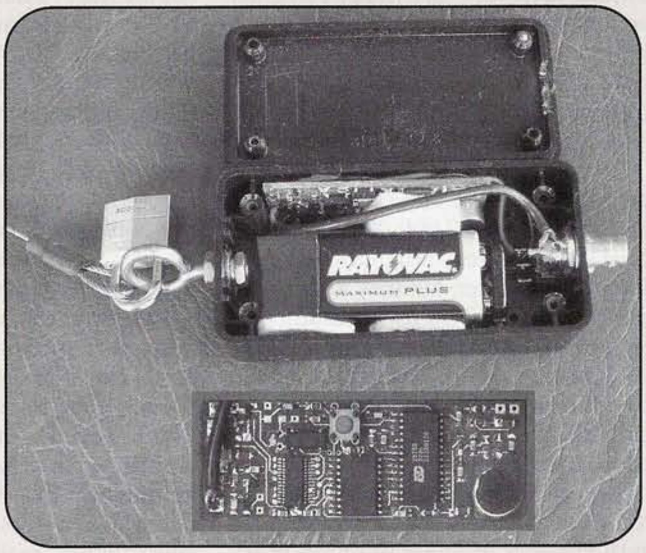
For those who want to buy small, ready-to-go foxes, I suggest the new SquawkBox by Bob Simmons, WB6EYV. On one small circuit board, Bob has packaged a 50-milliwatt 2-meter transmitter, a voice record/playback chip with microphone, and a PIC microcontroller to time the transmissions. Just press the button, record your "Come find me!" message, and the SquawkBox will repeat it at one of 16 time intervals. Select from 15-second to 30-minute transmission spacing with four solderable straps.

The standard SquawkBox frequency is 146.565 MHz, used for hidden transmitter hunts in many cities around the country. Changing the crystal or the program jumpers on the ICS525-02 synthesizer will move the output frequency, but care must be taken to maintain purity in the output. The 146.565 unit that I checked on a spectrum analyzer easily met FCC limits for spurs and harmonics.

A standard 9-volt battery will power a SquawkBox for several hours, even with very short spacing between transmissions. Board and battery fit nicely in a 4" × 2" × $1^{1}/_{8}$" plastic box, as shown in the photo. It would also be easy to camouflage the board inside a . . . well, I'll keep my ideas secret for now. Let's see what you think up.

To demonstrate and practice international-style radio-orienteering (ARDF) with "MOx" CW messages and IARU-rules timing, Bob has designed a similar board called MicroHunt. It has a Morse generator program in the PIC to replace the voice chip. See Bob's website (http://www.silcom.com/~pelican2/SQUAWK_BOX.htm) for more on both units.

—Joe, KØOV



It's easy to make drop-and-run hidden transmitters with WB6EYV's SquawkBox. The circuit board (inset) is only $2^{1}/_{2}$" × 1". I secure this mini-fox with piano wire and a small padlock to prevent theft.

With a little help, these Handi-Ham Radio Campers found the transmitter in the traffic cone. Left to right are Frank Shannon, KR6AL; Bryan Gorman, KB3KUQ; Jared Hunter, KG6WBR; and Helen Karnes, KF6JOV. (Photo by Pat, WAØTDA)

Science (CAMS).[3] It's a four-year magnet high school with a mission to increase the USA's pool of graduates in those disciplines.

"One of the things they do at CAMS is match students with adults having expertise in their areas of interest," says W6DFW. "I ended up mentoring four kids at one time. I worked closely with a science instructor, Graham Robertson, until he had to leave. They had a restriction on the number of years that anyone could teach there before being cycled out to another school."

Graham is now at PVHS, where students are learning radio and electronics as part of a 21st-century challenge. W6DFW is very involved, as I learned from him at a PVHS display during the WESCON electronics trade show.

This Car Drives Itself

In 2003 the federal Defense Advanced Research Projects Agency (DARPA) issued a challenge to industry and academia: Create an autonomous vehicle that can navigate from Point A to Point B with no human in control. The first entity to complete the DARPA Grand Challenge would win a million dollars. Expecting only a few proposals from large aerospace firms and top universities, the sponsors were amazed to receive 106 applications. One of them was from PVHS.

Graham Robertson is primary instructor of the special class of gifted tenth, eleventh, and twelfth graders who are determined to win the purse. Calling themselves the Road Warriors, they tore into a donated Honda Acura and added sensors, actuators, and Linux computer equipment, ending up with the Doom Buggy. It reached the finals and participated in the 2004 official 200-mile race from Barstow, California to Primm, Nevada. No vehicle made it all the way.

The second DARPA Grand Challenge race will take place on October 8, 2005, this time with a $2,000,000 prize. The Road Warriors are redesigning the Doom Buggy to do better, but they are now up against 194 other teams. In addition to some parents with background in science and engineering, Graham has brought in experts to help the class, including a systems design consultant. W6DFW was tapped to teach basic electronics.

"I am the official instructor for this part of the class," says Dan. "I give lectures and homework. We meet five times every two weeks. First I covered AC-DC theory. We got into transistors a little bit and now we're doing some RF concepts. RDF fits into that category, but they aren't using it for the project because they aren't allowed to have any transmitters or receivers on the vehicle except for the emergency stop system. They can't even have any real-time telemetry or video coming back to them during the race."

Dan asked me to put on a weekend transmitter hunt just for the Road Warriors and I jumped at the chance. He said to expect as many as 25 students. Dividing them into teams of two would require about a dozen RDF sets. I didn't have nearly that many, so I called Mark Hayden, KF6DSA, an electronics instructor in the Community Education Center of Pasadena City College (PCC).

In 2001, KF6DSA taught a special multi-weekend class on RDF to seventh and eighth graders as part of the NASA Pre-college Science Academy (PSA). Besides learning all about transmitters, receivers, propagation, and signal tracking, each student built his or her own tape-measure Yagi and offset attenuator from parts kitted by Mark's assistant, Phil Barnes-Roberts, WA6DZS.

Phil used the attenuator circuit at my "Homing In" website (http://www.homingin.com>. He modified the layout to fit in a larger plastic box, making construction easier. "For safety and consistency, we drilled the attenuator cases before the students got them," says Mark. "We also pre-cut the perfboard and drilled holes for potentiometers and BNC connectors. Everything else was done by the students. They

Non-students participating in the Road Warrior class foxhunt were Dan Welch's son Mike, KG6FWH, and grandson Daniel, KG6WAP, who earned his ticket at age 7 last year. (Photo by KØOV)

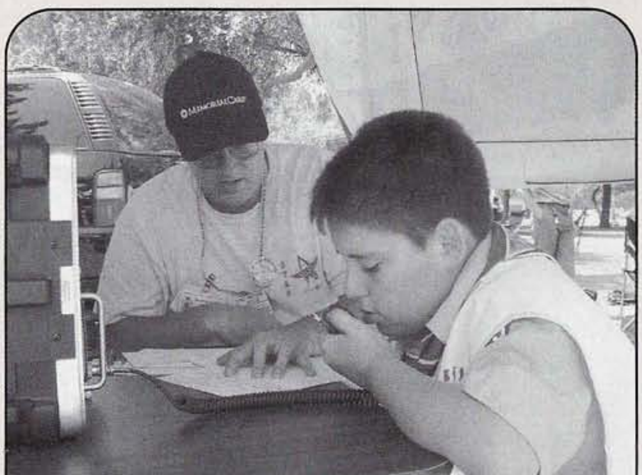
Show Off Emergency Comms, Too

In addition to transmitter hunting and on-the-air QSOs, the annual Long Beach Scout-O-Rama dramatically introduces young people and their parents to amateur radio's potential for disaster communications. Scouts are invited to send simulated emergency messages from stations set up by the Hospital Disaster Support Communications System (www.hdscs.org), an ARES group dedicated to helping 34 medical facilities in Orange County when their phones fail or become overloaded.

When a Scout arrives to participate, he or she is assigned to one of the HDSCS communicators at the simulated hospital Command Post. In our scenario, the hospital has suffered earthquake damage and regular communications are down. HDSCS members at their home stations are playing the parts of Red Cross, county Emergency Medical Services (EMS), and other hospitals. The Scout at the mock Command Post makes an amateur radio call to the appropriate entity and sends the message. Subjects include blood requests, patient transfer coordination, and status reports to EMS.

"Scouts are excited to try emergency radio operations and take it very seriously," says April Moell, WA6OPS, who leads HDSCS and organizes this part of the display. "They learn about message priority as well as the jargon of hospitals and amateur radio. They also find that it takes a little effort to coordinate talking and using the mic button. Last year one boy came back twice to ask if he could send another message." (He could.)

Joe Moell, KØOV
Assistant Coordinator, HDSCS



Wearing an HDSCS communicator's vest, a Scout sends a simulated emergency message on 2 meters under the guidance of HDSCS member Dennis Kidder, WA6NIA. (Photo by KØOV) built the antennas completely by themselves, including cutting the PVC pipe and the tape measures."

PCC retained the antennas, attenuators, and scanner receivers when the class ended, so I was able to borrow them for the Road Warrior hunt. Between work on their autonomous vehicle and the rainiest Los Angeles winter in over a century, it was difficult to schedule a date. We finally had an opening in February. The site was Angel's Gate Park, the same location as the ARRL Southwestern Division convention hunts in 1995, 1999, and 2003.[4]

I scattered nine foxboxes throughout the 130 acres. I did not expect anyone to find them all, but having a large number helped spread out the students. They went out in pairs, with one RDF setup per pair. Each team was given a list of frequencies with the foxes in a different order, so they were less likely to be hunting for the same fox at the same time.

Two teams did the best, finding five transmitters in the allotted 90 minutes. Considering that international champion foxhunters take about an hour to find five required foxes in a forest, that's very good. "They found it interesting and challenging," Dan reported later. "One of them remarked, 'I learned that a chain-link fence can make a mighty long antenna!'"

"I would love to see some of these kids get into ham radio," Dan continued. "I think some of them will. I decide where to go with the electronics lessons, so in the coming weeks I will introduce the hobby, bring in a rig, throw up an antenna, and let them try it. I'm sure some will jump on it."

The Road Warriors have completed the required video demonstration of their 2005 DARPA challenge vehicle. If it passes review, DARPA officials will be visiting PVHS and the other candidates about the time this magazine reaches your mailbox. After the visits the agency will select 40 semi-finalists. The 20 finalists will be selected after a qualification event at California Speedway in late September. Watch newspapers and the DARPA Challenge website[5] to see if the Road Warriors are among them.

Are you using hidden transmitter hunts to help develop the next generation of radio amateurs? If so, please let me know about it. Your foxhunting stories and photos are always welcome. Send postal or electronic mail to the addresses on the first page of this column.

73, Joe, KØOV

Notes

1. See "A Foxhunting Jamboree," an article at the "Homing In" website, <www.homingin.com>.
2. <www.handiham.org>
3. <http://www.cams.csudh.edu/>
4. See "Homing In: Win Foxhunting Prizes, Mobile or On Foot" in the Winter 2005 issue of *CQ VHF*.
5. <http://www.darpa.mil/grandchallenge/>

Register Now for the 2005 USA Foxhunting Championships

Radio foxhunters of any age and at any skill level are invited to compete at the fifth annual USA Championships of Amateur Radio Direction Finding (ARDF), August 1 to 6, 2005. This year's national championships are being combined with the Third IARU Region 2 (North and South America) ARDF Championships and are being hosted by the Albuquerque Amateur Radio Club (AARC).

Besides separate on-foot direction finding competitions on the 2-meter and 80-meter bands, there will be opening ceremonies, practice sessions, a sightseeing day, and a closing banquet with awards presentations. The event center will be on the campus of the University of New Mexico, where competitors will be housed. Bus transportation to the competition sites will be provided. Entry fees will cover the competitions (including transportation to and from the sites), housing, and meals.

Although most participants will be licensed hams, the championship courses are open to anyone of any age, with or without a ham ticket. Here is your chance to learn from the best. Visiting radio-orienteers from outside the USA and IARU Region 2 (North and South America) are expected. Competitors will be divided into five age categories for males and four for females, with medals for top finishers in each category. Stateside winners will also be considered for positions on ARDF Team USA to the 2006 World Championships in Bulgaria.

AARC's official website for the 2005 USA and IARU R2 championships, <www.ardf.us>, is now online with a downloadable registration form as well as details about housing, rules, frequencies, and the climate of central New Mexico. To get an idea what it's like to participate in the USA Championships, see my "Homing In" column in Summer 2004 *CQ VHF* and a first-person article by Sam Vigil, WA6NGH, entitled "The US 2004 ARDF Championships: A Beginner's Adventures" in the November 2004 issue of *CQ* magazine.

Joe Moell, KØOV
ARRL ARDF Coordinator

By John Champa,* K8OCL

HSMM

Communicating Voice, Video, and Data with Amateur Radio

The Hinternet on UHF

Digital Video Coming to the 440-MHz Band

In our previous column we wrote about the use of typical HSMM (high-speed multimedia) gear (IEEE 802.11 modulation operated under Part 97 regulations and power limits) in helping to deal with last year's tsunami and other natural disasters. We listed the elements of a survival kit recommended by Oklahoma Baptist hams. An old high school classmate, Thomas Barnes, reviewed the list and recommended some additions. Tom is a military historian and a Vietnam veteran who was with the First Infantry Division—"The Big Red One"—so we thought we should pass along these additions:

1. Duct tape. It makes a great way to seal long pants over boots to keep out mosquitoes, not to mention its value for the temporary repair of nearly everything else. One roll can be shared, so not everyone needs to take a roll.

2. Scissors. Take a good pair made of stainless steel, which will not rust in a wet tropical climate.

3. Personal sewing kit.

4. Repair kit for eyeglasses.

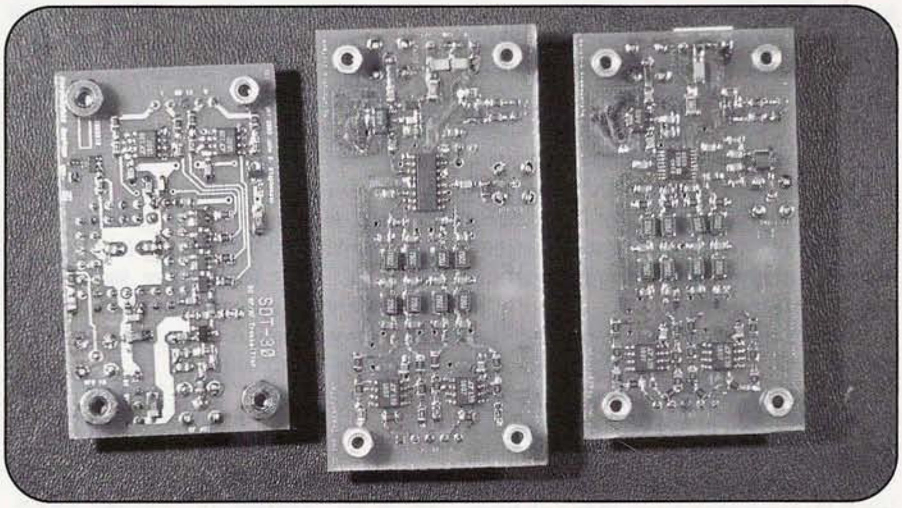
5. Maglite® brand flashlight. This is the type that will continue to work even if it is run over by a tractor/trailer.

6. A lot of batteries for the flashlight. If not used, they can be bartered.

7. An emergency supply of toilet tissue.

HSMM Testing

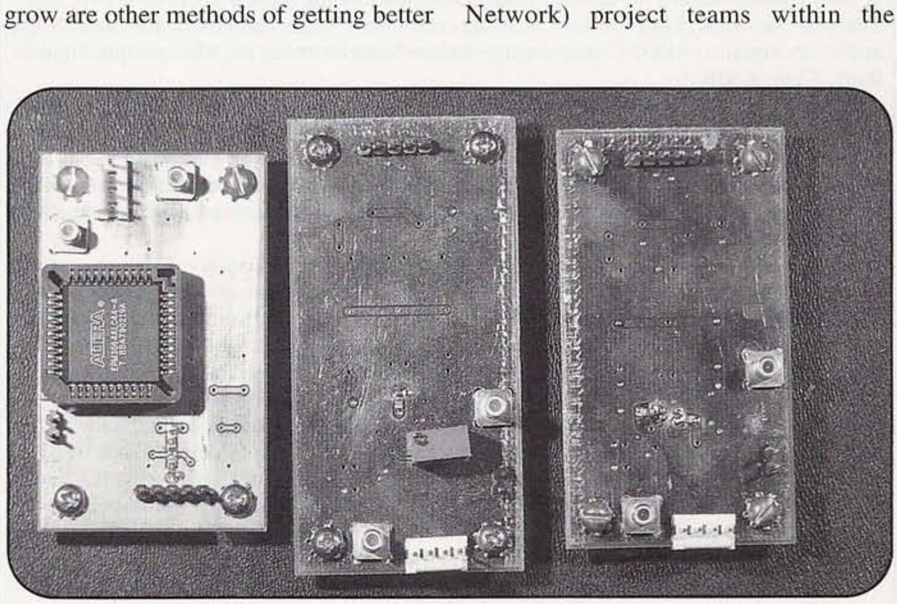
Until now all of our discussions regarding HSMM radio within amateur radio have been about the use of inexpensive COTS (commercial-off-the-shelf gear) used for RLANs (radio-based local area networks). This gear is one of the IEEE 802.11 standard radios with the addition of an outside antenna and perhaps a BDA (bi-directional amplifier, usually in the 1.8-watt range made especially for HSMM by the FAB Corporation (http://www.fab-corp.com/).



Bottom view of the Orthogonal Frequency Division Multiplexing (OFDM) modem. (Photos courtesy of John, KD6OZH)

Some linked HSMM radio repeaters now cover an entire community. However, what is clearly needed for amateur radio's national high-speed digital network ("The Hinternet") to continue to grow are other methods of getting better range than the 2.4-GHz ham band normally allows. How do we do that and still get the high-speed data rates we need?

During one of the periodic teleconferences held by the ARRL HSMM Working Group it was decided to form several RMAN (Radio Metro Area Network) project teams within the



Top view of the OFDM modem.

*Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458
e-mail: <k8ocl@arrl.net>

Working Group to answer this question. Two of these teams have made great progress: the RMAN-VPN Team, which will be featured in our next column, and the RMAN-UHF Team, which uses the lower ham bands, such as 440 MHz, for much longer range network links.

The Working Group's RMAN-UHF Team project leader is John Stephensen, KD6OZH. John has developed a modem designed to use OFDM (Orthogonal Frequency Division Multiplexing) modulation, which can be used with conventional ham gear (amplifiers and antennas) in the 440-MHz ham band. Technical details regarding the OFDM modem design can be found in the March/April 2005 issue of *QEX* (pp. 26–35) and at <http://www.arrl.org/ hsmm/>. The alpha test equipment photos of the OFDM modem included with this article were provided by John.

OFDM modem testing is expected to begin this summer at four locations in the United States:

• Livingston County, MI—HSMM Experimenters team leader Jon Harris, KC8WAZ (jonharris2@comcast.net)

• Emmaus, PA—HSMM Experimenters team leader Carl Stevenson, WK3C (wk3c@wk3c.com)

• College Station, TX—Hinternet infrastructure specialist Gerry Creager, N5JXS (N5JXS@arrl.net)

• Fresno, CA—RMAN-UHF Team project leader John Stephensen, KD6OZH (KD6OZH@verizon.net).

What does all of this have to do with digital video on the 440-MHz band? The OFDM modem is expected to be able to operate at a maximum data rate of 2.4 megabits per second (M/bps). Initially, we will be doing link quality testing. Later, to push the outside of this envelope for the tests, the open-source ITU-T standard software video and audio CODEC (coder-decoder) of H.323 will be used. This should produce excellent full-color and full-motion video for some wonderful two-way high-speed digital QSOs with outstanding audio quality, too. In addition, the OFDM modulation will only occupy 2 MHz of a local ATV channel. This compares favorably with the present 6 MHz used by analog ATV, so the spectrum efficiency is much better. We have designated this test mode as ADV (Amateur Digital Video) to distinguish it from DATV (digital ATV), which is mostly an image mode based on MPEG CODECs used by European ATV experimenters.

73, John, K8OCL

By Gary Pearce,* KN4AQ

FM

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

The Simplex Test

Last fall a couple of local ARES ECs (Emergency Coordinators) pulled a trick on their members during the annual ARRL SET (Simulated Emergency Test). They yanked the plug on all the primary and backup ARES repeaters and let the members scramble as best they could to recover and get some communicating done on simplex. The result was pretty interesting. There was less chaos than I might have predicted, but still plenty of on-the-job learning. Few hams in my area are dedicated to simplex. Some occasionally use it, but most hams here rely heavily on repeaters. How is it in your area?

Only a few key people had advance knowledge of the scenario developed by Wake County, North Carolina EC Tom Brown, N4TAB, and Durham County EC John LeMay, KB4WGA. I wasn't one of them. The scenario included tornados, flooding, EOC evacuations, multiple repeater failures, and simplex operation. Tom had announced in advance that the exercise would rely on simplex and cross-band repeating, but didn't add any details. Wake and Durham counties are adjacent to one another, with Durham lying northwest of Wake. The cities of Raleigh and Durham and suburbs form one large metropolitan area about 40 miles in diameter. An emergency that affects one town will likely affect the other, or at least bring ARES volunteers out for mutual aid.

I tuned into the primary wide-area ARES/SKYWARN repeater on 146.88 MHz. This is a wide-coverage machine 1400 feet up a TV tower, and it provides about a 60-mile radius of coverage for mobiles across terrain that is fairly flat. I switched on my radio at the scheduled 9 AM start time to find the operation already under way, with KB4WGA reporting a tornado touchdown in Durham County.

I didn't have an official part to play in the test, so I decided to act as a scribe, to monitor and take notes on everything I could hear, and not to intercede in the actual operation. I live near the border between the two counties, and with a 17-foot dual-band vertical just above the roof of a two-story house, I'm in a fairly good position to hear simplex stations throughout both counties. I could have jumped in and provided good relay capability, and modesty does not prevent me from saying that I've done a ton of that kind of thing in the past—enough, I thought, such that I didn't need any more practice. However, many new hams in the area did need the experience. There were other leaders who could give them guidance. I thought the best contribution I could make was to just listen and transcribe the operation as I heard it, so we could take it apart later and learn what worked and what didn't.

It turns out that this taxed my *station,* which can monitor two HF and five VHF or UHF frequencies at once (more if you count HTs), and my *ears,* which can't monitor five frequencies at once if they're all active. In this test sometimes they were. Thus, I missed a few things, but I think I caught the essence of the test.

Durham County, North Carolina Emergency Coordinator John LeMay, KB4WGA (right), operates the radio during the annual ARRL Simulated Emergency Test. Assisting in the test, and behind John, is David Snyder, W4SAR. (Photos by KN4AQ)

I'll give you the play-by-play. Callsigns have not been changed to protect the innocent. I think we learn as much as or more from the things that go wrong as we do from the things that go right, and I'll include both. I have nothing but praise for everyone's participation. *Thank you* to the local hams, and all hams everywhere who participate in drills and real activations, for taking time to join this activity!

The Play-by-Play

After announcing the start of the drill with the tornado touchdown at 8:58 AM on 146.88, KB4WGA moved to Durham's local 145.45 repeater and began an ARES net. Virginia Enzor, NC4VA, started a SKYWARN net on 88. Then I logged my first critical comment. *Minutes* had gone by with a lot of dire

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weather warnings and nary a "this is just a drill" to be heard since the initial broadcast. Denyse Walter, K4DAW, later reported that she was running errands with her mother and just tuned in for a few minutes. Her mom was very concerned about all the tornados, and in the time they were listening no one said "drill." Finally, N4TAB said it. Meanwhile, the check-ins started rolling in on the Durham 45 machine. N4TAB appeared there to see if they needed Wake ARES assistance.

9:06—KB4WGA asks if there were any Durham AECs (assistant ECs) who could begin the telephone-call tree. Jerry Gualt, KI4CCB, says he can do it. Later he reports that no other AECs were available, and that on the general call-up he got some answers, a few wrong numbers, and lots of recordings, but no volunteers. (Great, though, to have a bunch of new "KI4" hams involved. Many of you just eat up this kind of activity!)

9:07—KB4WGA reports a tornado touchdown at a school near the Wake County line. He asks for a SKYWARN liaison, and Sterling Damron, KD4KVG, volunteers from Fayetteville. Sterling is an enthusiastic SKYWARN volunteer, but Fayetteville is 65 miles from the local-coverage Durham repeater and his signal is weak. A shallow fade will take him out completely, so he might not have been the best choice as liaison, but he holds up okay while relaying information back and forth to the 88 SKYWARN operation. I guess you go to SET with the army you have, too.

9:11—KB4WGA asks for volunteers to go to the school hit by the tornado. At first there's no response. Finally. someone volunteers and heads out. On 88 Bob Woodson, WX4MMM, reports a funnel cloud in north Wake County.

9:13—On 88 N4TAB asks if anyone can travel to the Wake County EOC, which is being activated. Bob Conder, K4RLC, and Liz Stanley, KF4UQZ, respond. K4RLC is dispatched.

9:18—Wayne Blackwell, KD4SLQ, appears on the Wake County ARES primary repeater on 145.39 asking if Wake ARES is active. Ronnie Reams, WA4MJF, who has even more radios than I do and is always monitoring everywhere, replies that Wake ARES is on 146.88. What Ronnie missed was that the 88 repeater had just gone down. Later we learn that control operator Danny Hampton, K4ITL, turned off 88 as part of the exercise.

There is some confusion about the role of the 39 machine. It's supposed to be the primary county ARES repeater and the backup SKYWARN repeater. However, few hams look to it first for ARES; everyone flocks to the big 88 machine. Wayne gets a gold star for showing up there quickly. There's no way for me to tell how many of the ARES hams on 88 have missed the cue or don't know to switch to 39, since there's no roll call. At this point, Wake ARES hasn't been officially activated anyway, but SKYWARN should be on the move.

9:19—KB4WGA asks for a volunteer to take over NCS on the Durham 45 repeater. A station offers, but says he isn't familiar with this net's protocols. John accepts him anyway and says, "Just take check-ins." KI4CCD reports no response from any AECs on the call tree. Another ham volunteers to help with the "all-members" telephone call-up. They split the list and go to work.

9:24—So far no one within range of my station has used 146.88 simplex to announce the move to 145.39 for those who either don't know to move or don't realize the repeater is down. This area does not have a tradition of operating simplex on failed repeater output channels. In other areas that is standard procedure.

9:25—On 39 N4TAB announces that Wake ARES is mobilizing to support Durham ARES and is moving to the secondary backup 147.195 machine to leave 145.39 clear for SKYWARN, which has been receiving simulated storm and damage reports. A few stations begin to appear on 195, while NC4VA moves the SKYWARN net to 39.

9:27—One of the Durham call-tree volunteers has been confused about which list he's supposed to be using. KB4WGA gets him on the right track.

9:28—N4TAB informs Durham ARES that 88 is down, and ARES/SKYWARN activity is split between 39 and 195. Wake County ARES AEC Mark Gibson, N4MQU, begins taking ARES check-ins on 195.

9:33—KB4WGA asks for a Durham volunteer to travel to a Rougemont command post about 15 miles north of the city. No takers.

9:37—N4TAB asks N4MQU if he can re-deploy to the Wake County EOC in downtown Raleigh. Mark says he can, and Liz, KF4UQZ, picks up net control on 195.

9:38—Ronnie, WA4MJF, talks to N4TAB on the #3 Wake County ARES backup machine, 146.64, informing him that he can't operate on 147.195. Ronnie is running a commercial radio that doesn't have that frequency programmed. As Tom is trying to tell Ronnie to remain on 64, I turn the 64 repeater off in an unscripted move. Tom calls me on the phone and applauds.

9:43—The 145.39 repeater goes off the air, courtesy of K4ITL. KB4WGA announces on 45 that the Durham EOC has been destroyed by a tornado, and communications is being relocated using the new DFMA (Durham FM Association) MCU (mobile communications unit).

9:44—The 147.195 repeater goes down, also courtesy of K4ITL. Wake County is in radio silence, with 88, 39, 64, and 195 all off the air. KF4UQZ calls for any stations on 195 simplex. On 88 simplex Frank Bridges, AE4MY, announces that Wake ARES is moving to 146.52 simplex. A few operators begin to appear there. KF4UQZ announces on 195 simplex that operators should go to the 146.64 backup and is told that 64 is also down, so move to 52 simplex. Note that there is no listed Wake County ARES simplex channel (this was fixed as a result of the SET).

9:53—More stations appear on 52 amid some doubling and confusion, as not all stations can hear one another. There is no net control yet. Vaden Holmes, N4DIL, appears with a big signal on 52 from south Raleigh and relays some traffic between N4MQU and N4TAB. Vaden has an 80-foot tower with his antenna on top and becomes the de facto net control.

9:59—NC4VA has moved the SKYWARN net to the KD4RAA/K4JDR linked UHF system, where it remains until the end of the exercise. With six repeaters linked full time, this network provides excellent coverage of the area. However, UHF is pretty much out of the way around here, and few stations appear on the net.

A station whose innocence I *will* protect calls me on the phone to ask for help unlocking his radio, which he somehow accidentally locked so none of the front-panel buttons work. That sends me scrambling through manuals until I find the cryptic key sequence that does the job. I'll also protect the name of the manufacturer, since all suffer from this menu overload to one degree or another.

10:01—KB4WGA announces that the 145.45 repeater has failed and Durham ARES is moving to 146.52. John an-

Tom Brown, N4TAB, Wake County, North Carolina EC.

nounces this on the 45 repeater, which is actually still working and is never really turned off. The Wake repeaters were actually turned off for a short time, which risks their unavailability for an actual emergency, but simulates the problem of repeater failure more accurately.

10:04—N4TAB notes that N4DIL has the best 52 simplex signal in Wake County. Vaden says this is his first ARES activity, so he's not all that sure what he needs to do. Meanwhile, here he is in the spotlight as the one station everyone can hear, and he relays messages between stations who are out of simplex range of one another.

Come to think of it, there are precious few strong simplex signals appearing. Later, many operators will note that they do not have effective simplex base stations. I suspect antenna restrictions are a key factor. I'm able to hear some of the Durham simplex stations appearing on 52. The channel is becoming busy and I hear a fair number of collisions.

N4TAB asks Wake AEC David Crawford, KF4VXJ, to relay a message to K4RLC to meet him on 40 meters, 7210 kHz. David does, and replies that Bob lost his 40 meter antenna and will need to meet Tom on 80 meters, 3927 kHz. I tune my HF rig, adding yet another speaker to the mix. Tom and Bob hook up with good signals on HF. Tom is heading to the North Carolina Emergency Management Central Branch EOC in Butner.

I'll pause here to note that many other Wake, Durham, and surrounding county repeaters are still working. We're pretty much ignoring them, as the edict was to move to simplex. However, would operators know how to find them, set their tones, and operate through them if needed? This lack of repeater flexibility has been an ongoing problem for local hams, but one this exercise would not test.

10:07—N4TAB announces that the Wake County EOC in downtown Raleigh is flooded and is being evacuated to the Wake County Commons complex on Poole Road. This is southeast of town, in the opposite direction of Durham County, and will shortly present a communications problem.

10:10—KB4WGA arrives at the temporary Durham EOC at Durham County Stadium and starts setting up the DFMA MCU. He announces that the Durham simplex net will move to 146.535 to avoid the conflict with Wake County on 52. N4DIL relays the move to Wake ARES stations. N4MQU asks N4DIL if he could use some help and heads to DIL's home.

At this point, I still have no idea how many operators are out in the cold, having lost their connection through area repeaters and either don't have enough antenna to participate on simplex or just don't know what frequency to tune. A few stations are checking in on simplex, maybe more of them in Durham than in Wake. A station in Hillsborough, west of Durham County, comes up on the still-working 145.45 repeater and asks where the activity went. He's told "535" and asks, "Where's that?" He's told it's 146.535 simplex. He switches over, but is able to hear few stations from that distance.

10:17—KB4WGA is having trouble with intermod from a powerful paging transmitter on a Durham hospital just down the street from his staging area. He's having intermittent trouble hearing some stations on simplex, either 52 or 535.

10:21—WA4MJF and his wife Sherry, KB4EXL, take their personally financed and built mobile com unit to Wake County Commons to set up emergency communications. KF4VXJ is dispatched to help. Vaden, N4DIL, who has been handling all the relaying on 52, is fried, and asks Liz, KF4UQZ, to take over as net control in Wake. Liz picks it up, but doesn't have nearly the coverage Vaden did.

10:22—K4ITL turns the 88, 39, and 195 repeaters back on, and I turn 64 back on at about 10:30. No one notices for a long time, and when some stations appear and ask where the activity is, they are directed to simplex. No one thinks to pull the operation back to the repeaters. This is not surprising; most operators are assuming the repeaters are still "off for the drill." However, that had not been specified as part of the operation. In real activations in the past, I've seen repeaters go down, operation shift to less desirable facilities, and not move back because no one was checking to see if the main repeater was back up. The lesson: Check the repeaters now and then!

10:24—KB4WGA has the Durham MCU up and running. He's still getting intermod, but is in contact with his field stations.

10:31—Durham MCU tries to reach *any* Wake ARES official on 52. No answer. Lowell Tieszen, KK4PH, in Durham tries to relay with a better signal into Wake County, but still no answer. Am I the only one hearing them? I decline to intervene, but I do slip down to 40 meters and cue N4TAB to listen to this failure. Liz, KF4UQZ, hears me and spills the beans on 52. Now N4DIL is hearing KK4PH, but thought others were hearing them okay. He relays that KK4PH wants a test of Wake-Durham communications and tells Liz to switch to 535 and call Durham EOC.

This is a problem. Liz lives in southeastern Wake County. She has a nice home station, but can't reach the Durham MCU on simplex. Meanwhile, I notice another problem. 52 and 535 are only 15 kHz apart. That's not far enough to avoid adjacent channel interference, and I'm getting hit by N4DIL's strong signal while trying to listen to the Durham activity on 535. Later AE4MY would report he was having the same problem. The solution will be for simplex stations to avoid the "15 kHz splits," with Durham ARES picking another frequency. Wake ARES might find something better than 52, the National Simplex Frequency, as well.

10:45—N4MQU arrives at N4DIL's home and activates the station as NC4WC. He makes contact with the Durham MCU, amid some doubling with other stations trying to check in. Following Durham's request for a communications check, he tries to get KB4EXL at Wake Commons to contact the Durham MCU on 52, but I can hear that Durham has already switched back to 535. I keep silent.

10:53—Bob, K4RLC, is dispatched to Wake County Commons to assist. He gets lengthy directions on 52. Later a station will suggest that all the direction-giving should have been done on another frequency. A very good point. However, over the years I've seen that we do not have much coordination of simplex frequencies besides 52 (and don't really have a lock on that). Changing frequencies often sends one or both stations off to a black hole from which they sometimes never emerge.

10:56—KF4VXJ announces that the Wake County Commons MCU can't reach the Durham MCU on simplex. NC4WC says there's a lot of doubling and tripling on 52, and stations should go through net control. K4RLC is still getting directions to the Commons.

11:02—N4TAB calls NC4WC on 52 and announces that he's arrived in Butner. NC4WC asks him to call the Wake MCU. They can't make contact. NC4VA is still holding down the fort for SKYWARN on the UHF link system. WX4MMM and one or two other stations are all that check in.

11:07—NC4WC repeatedly calls for N4TAB on 52, but I can hear that Tom is on 535 talking to Durham MCU.

11:08—Mike Murphy, WA4BPJ, checks in on 52. NC4WC asks him to sweep for more check-ins. Mike does, but no replies. Too bad Mike wasn't around earlier. He has a great simplex station in North Raleigh and would have added a lot to coverage.

11:09—K4RLC gets final directions into Wake Commons, still on 52. Jose Guzman, KD4JWF, files a rare SKYWARN report on the UHF linked system.

11:26—Wake EC N4TAB announces the end of the exercise, and that there will be a critique on 146.88 at noon.

Critique

Most of the problems that I noted in the play-by-play were picked up by other stations in their net comments. My contribution to the net was that this exercise was all "fire-drill"—that is, it was all logistics on getting people on the right frequency or in the right location, or both. The hams carried no "client" traffic. What would they have done if Wake County Emergency Management had loaded them down with urgent messages for Durham County? Somehow, I expect, they would have adapted and gotten the traffic flowing. Meanwhile, all the churning they did was valuable. People were learning a lot in a short period of time. However, the real value of it will be measured in the changes they make now, and how they respond next time.

As N4TAB put it, "Next time we'll try to make a different set of mistakes."

Another Wake County ARES Test

Wake County ARES followed up in February with a smaller simplex test on their regular weekly net, just asking all stations to listen on the 146.88 repeater input to see and report how many stations each operator could hear. Once again, there were only a few stations with good simplex base stations, something I'd define as at least a ground-plane antenna mounted above the roof and a typical 45-watt radio. Many had indoor antennas, and some had only handheld radios with nothing better than the rubber duck. Several hams stated their intention to improve their simplex coverage. Again, though, antenna restrictions in many neighborhoods and for apartment-dwellers will make this difficult.

They also announced two simplex channels as primary and secondary simplex. The Wake ARES web page is <www.wakeares.org>.

The Need for Flexibility

How realistic is the need for good simplex coverage? Is it likely that all repeaters in one area will go down at once? No, it would be very rare. The only example I can think of was during Hurricane Andrew, which knocked down everything in south Florida, and if you were there, your simplex station would have been included. However, simplex would have been the first VHF capability to be resurrected. I'm sure a few of you out there have some examples you can add to this.

I think the lesson is more about flexibility, being ready for a variety of circumstances. Riley Hollingsworth, K4ZDH, the FCC's top amateur radio rules enforcer, says that ham radio cannot be stopped. However, if one repeater tower going dark stops *you,* then you have some work to do, whether it's improving your station or just getting to know all the repeaters in your area a lot better.

APRS Voice Alert Works for N1RWY

In the Winter 2005 *CQ VHF* column I passed along an idea for on-the-road monitoring called APRS Voice Alert, initiated by Bob Bruninga, WB4APR, the "father" of APRS. The column drew a testimonial from Jason Baack, N1RWY, who wrote:

> I travel the east coast several times a year from Florida to Maine, and ham radio follows me along the way. In the past two years, driving between FL and ME I have had exactly two conversations on 146.52.
>
> On 144.390 (100 Hz tone) in "voice alert" mode I have had over three dozen conversations (moving to 146.52 or .58). This does not include the few dozen keyboard-to-keyboard (or key pad on the mic) text conversations I have had as well from folks seeing me on their APRS screens.
>
> As you said in your article, you do have four potential QSO guarantees while using the 'voice alert" system. Best of all, it is passive and it works.

A quick review: On the road, monitor the APRS packet frequency 144.39 with 100 Hz CTCSS decode turned on. If you have an APRS beacon in your vehicle, set it to encode/decode 100 Hz as it beacons, and turn up the volume so you can hear. In theory, any time you hear your speaker open with a burst of packet containing 100 Hz, it will be from another station ready and willing to have a voice contact with you. Call the station, using voice and 100 Hz on 144.39, and quickly move to a more appropriate simplex channel. You won't know his or her callsign unless you have a packet display running.

Echolink/IRLP and Tsunami Communications

December's tsunami disaster in the countries ringing the Indian Ocean brought out heroic communications efforts by hams. As it is here in America, much of the communications was handled on VHF/UHF FM. We don't get to hear that, of course, but Internet linking systems such as Echolink and IRLP are changing that equation.

I wasn't able to spend time listening to amateur radio, or my computer, in the immediate aftermath of the disaster. I'm glad to report that my freelance audio/video engineering business has taken a big upsurge, but it's reduced the time I have to play on the radio. Thus, I didn't hear the activity first hand they way I did when Echolink played the ham's role in recovering *Columbia* shuttle debris or during the spate of hurricanes that hit the southeast last summer. However, there are some accounts of the new capability on the web.

Tyson Schultz, N7ZMR, vacationed in the area this past March and logged this on his website (www.geocities.com/timbercutter/tsunami/index.html):

> When this first happened I remembered that there is a high-level Echolink node (http://www.echolink.org) in nearby Phuket. I logged my computer into that node and began listening to 145.550 MHz simplex. This had become the Royal Thai Coast Guard tactical frequency for operations for a number of reasons.
>
> The complexity of the disaster caused a total gridlock of the usual communication systems and the need for communications to be established between these remote areas and headquarters in Bangkok. Running on VHF and linked to the Internet proved to be the most reliable form available.
>
> With this system in place we were able to hear the rescue operations live from the scene, as the first helicopter arrived at Phi Phi island it was around 10 PM Thailand time, dark. With my wife sitting in to translate the conversation for me we could hear the helicopter pilot talking to people on the ground who were trying to guide the aircraft to the beach with their flashlights so he could land. The pilot surveyed the area with a spotlight and said he could not land anywhere safe because the debris and broken poles with wires attached would be too dangerous. You could hear how desperately the people wanted him to land, but all the pilot could do was circle and advise them on what needed to be done so he could land at a later time. He told them to remove some broken palm trees from the tennis court; that is where they would try to land when morning came. After circling for nearly an hour, the pilot reported to Bangkok HQ via Echolink (1000 miles to the north) that he had the metric equivalent of only 600 lbs. of fuel and had to return back to Phuket air base.

The armchair quarterbackers on eham and the qrz.com message boards questioned how Echolink could help in a disaster area, as theoretically all Internet service is wiped out. Details are often sketchy, and hams have been known to exaggerate both their capability and results in emergency communications. However, this VoIP communications system isn't designed to be the channel into the heart of a disaster area. It feeds the stations on the periphery, where there is power and Internet, but where radio channels are clogged. Hams have the organizational capability to move traffic, and the VoIP networks let them use radio where radio is most effective, and the Internet where that's the best choice. Another tool in the kit.

VoIP has the added advantage of letting us listen in from the rest of the world. Most of us won't be able to help, but you never know where a missing puzzle piece might come from.

KN4AQ Leaves FM Columnist Position

Sadly, for me anyway, this must be my last regular FM column in *CQ VHF.* The reason is simple—time. I freelance and produce my own projects in audio/video (or "multimedia," as they say today). I'm not the world's best time manager, and I have a couple of projects that are far behind schedule. Each column requires several hours that I must take from that work. Columns that require research—mostly telephone interviews or extensive e-mail—take even more time. Today I'm supposed to be training on a new video editing program I've installed, and then editing a program I've been shooting over the past year. I thought about telling Joe, N6CL, I was leaving without writing this quarter's column, but I just couldn't do it. I wrote the simplex test story for a local club newsletter and figured that with a simple rewrite it would be valuable and interesting for a wider audience. The rewrite took six hours (I'm not the fastest writer, either).

I think FM and repeaters deserve regular attention. I'm glad *CQ VHF* wanted to include this column, and I appreciate that N6CL asked me to do it. Some of us old timers in FM remember how the "traditional" hams tried to relegate us to second-class status in the early days—not "real" ham radio—until FM became the most popular mode. It may be the "utility mode" now, but there are still challenges ahead. I hope to contribute to them in the future.

73, Gary, KN4AQ

CQ's 6 Meter and Satellite WAZ Awards

(As of March 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	IKØPEA	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

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>*

Announcing:

The 2005 CQ World-Wide VHF Contest

Starts: 1800 UTC Saturday, July 16, 2005
Ends: 2100 UTC Sunday, July 17, 2005

I. Contest Period: 27 hours for all stations, all categories. Operate any portion of the contest period you wish. (*Note:* Exception for QRP Hilltopper.)

II. Objectives: The objectives of this contest are for amateurs around the world to contact as many amateurs as possible in the contest period, to promote VHF, to allow VHF operators the opportunity to experience the enhanced propagation available at this time of year, and for interested amateurs to collect VHF Maidenhead grid locators for awards credits.

III. Bands: All authorized amateur radio frequencies on 50 MHz (6 meters) and 144 MHz (2 meters) may be used as authorized by local law and license class.

IV. Class of Competition:

For all categories: Transmitters and receivers must be located within a 500 meter diameter circle or within the property limits of the station licensee's address, whichever is greater. All antennas used by the entrant must be physically connected by wires to the transmitters and receivers used by the entrant. Only the entrant's callsign may be used to aid the entrant's score.

1. Single Op—All Band. Only one signal allowed at any one time; the operator may change bands at any time.

2. Single Op—Single Band. Only one signal allowed at any one time.

3. Single-Op All-Band QRP. There are no location restrictions – home or portable – for stations running 10 watts output or less.

4. Hilltopper. This is a single-op QRP portable category for an all-band entry limited in time to a maximum of 6 continuous hours. Backpackers and portables who do not want to devote resources and time to the full contest period are encouraged to participate, especially to activate rare grids. Any power source is acceptable.

5. Rover. A Rover station is one which is manned by no more than two operators, travels to more than one grid location, and signs "Rover" or "/R" with no more than one callsign.

6. Multi-Op. A multi-op station is one with two or more operators and may operate 6 and 2 meters simultaneously with only one signal per band.

Stations in any category, except Rover and QRP Hilltopper, may operate from any single location, home or portable.

V. Exchange: Callsign and Maidenhead grid locator (4 digits, e.g., EM15). Signal reports are optional and should not be included in the log entry.

VI. Multipliers: The multiplier is the number of different grid locators worked per band. A "grid locator" is counted once per band. *Exception:* The rover who moves into a new grid locator may count the same grid locator more than once per band as long as the rover is himself or herself in a new grid locator location. Such change in location must be clearly indicated in the rover's log.

A. A rover station becomes a new QSO to the stations working him or her when that rover changes grid locator.

B. The grid locator is the Maidenhead grid locator to four digits (FM13).

VII. Scoring: One (1) point per QSO on 50 MHz and two (2) points per QSO on 144 MHz. Work stations once per band, regardless of mode. Multiply total QSO points times total number of grid locators (GL) worked.

Rovers: For each new grid locator visited, contacts and grid locators count as new. Final Rover score is the sum of contact points made from each grid locator times the sum of all grid locators worked from all grids visited.

Example 1. K1GX works stations as follows:

50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

35 QSOs ($35 \times 2 = 70$) and 8 GL's (8 multipliers) on 144 MHz

K1GX has 120 QSO points ($50 + 70 = 120$) $\times$ 33 multipliers ($25 + 8 = 33$) = 3,960 total points.

Example 2. W9FS/R works stations as follows:

From EN52: 50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

From EN52: 40 QSOs ($40 \times 2 = 80$) and 10 GL's (10 multipliers) on 144 MHz

From EN51: 60 QSOs ($60 \times 1 = 60$) and 30 GL's (30 multipliers) on 50 MHz

From EN51: 20 QSOs ($20 \times 2 = 40$) and 5 GL's (5 multipliers) on 144 MHz

W9FS/R has 230 QSO points ($50 + 80 + 60 + 40$) $\times$ 70 multipliers ($25 + 10 + 30 + 5$) = 16,100 total points

VIII. Awards: Certificates suitable for framing will be awarded to the top-scoring stations in each category in each country. Certificates may also be awarded to other top-scoring stations who show outstanding contest effort. Certificates will be awarded to top-scoring stations in each category in geographic areas where warranted.

Geographic areas include states (U.S.), provinces (Canada), and countries, and may also be extended to include other subdivisions as justified by competitive entries.

Unique, handsome plaques will be awarded to the highest scoring stations. For more information on the CQ VHF Contest Plaque Program see <http://www.cq-amateur-radio.com>.

IX. Miscellaneous: An operator may sign only one callsign during the contest. This means that an operator cannot generate QSOs by first signing his callsign, then signing his daughter's callsign, even though both callsigns are assigned to the same location.

A station located exactly on a dividing line of a grid locator must choose only one grid locator from which to operate for exchange purposes.

A different multiplier cannot be given out without moving the complete station at least 100 meters.

Making or soliciting QSOs on the national simplex frequency, 146.52 MHz, or your country's designated national simplex frequency, or immediately adjacent guard frequencies, is prohibited. Use of commonly recognized repeater frequencies is prohibited. Recognized FM simplex frequencies such as 146.49, .55, and .58, and local-option simplex channels may be used for contest purposes.

Aeronautical mobile contacts do not count.

Contestants should respect use of the DX window, 50.100–50.125 MHz, for intercontinental QSOs only.

UTC is the required logging time.

X. Log Submissions: Log entries must be submitted by September 1, 2005 to be eligible for awards. Submit your electronic log in the Cabrillo format created by all major logging programs. Send via e-mail attachment to <cqvhf@cqww.com>. Subject line: Callsign [used in the contest] only.

Those using paper logs are urged to utilize "web forms," which allows you to transcribe your logs for entry on-line and automatic Cabrillo submission. Web forms can be found at <http://www.b4h.net/cabforms/cqwwvhf_cab.php>.

For those without web access, paper logs may be submitted to: CQ VHF Contest, 25 Newbridge Road, Hicksville, NY 11801 USA. Questions may be sent to <vhf-questions@cqww.com>.

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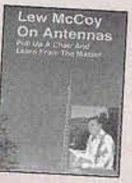

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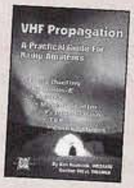

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By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Nearing the Cycle Minimum

As we move ever closer to the predicted end of solar Cycle 23, sometime between the end of 2006 and the middle of 2007, we expect a relatively quiet sun. We are not seeing the same level of activity that is typical of peak years. However, with the shedding of its complex magnetic structures, the sun continues to give VHF enthusiasts moments to enjoy. The frequent occurrence of coronal holes during March and April brought just a bit of life to 6 meters. Looking at the spots on the OH2AQ DX Summit (http://oh2aq.kolumbus.com/dxs/), a number of North American spots revealed aurora and sporadic-*E* (*Es*)during periods of elevated geomagnetic activity. For example, on April 5, 2005 a number of spots were made not only of Au/*Es* between eastern Canadian and eastern United States stations, but also of video Au/*Es* from Europe into the eastern United States. The estimated planetary *K*-index (*Kp*) rose to 7 for two of the three-hour reporting periods on April 5 due to a solar wind speed over 600 km per second with a moderately southward pointing magnetic orientation. While large auroral events are not common this late in the cycle, enough coronal-hole activity continues to pepper the season with weak auroral propagation openings.

What's even more apparent, however, is that the sporadic-E activity for 2005 promises to be noteworthy. Early in April, reports even on the west coast of North America showed *Es* activity above normal for this early in the year.

On March 30th, Dave Bernhardt, N7DB, in Boring, Oregon (CN85), reported on the VHF reflector (http://www-w6yx.stanford.edu/vhf/), "As I write this report, 6 seems to have died at the moment (0312Z). The opening today was not that unusual for *summer*! You had to look up at the calendar to see how unusual conditions were today. Normally 6 meters is dead from mid-January until late-April/early-May in the Pacific Northwest. Sure, there may be a brief opening here or there, but not one that lasts hours. Besides some very strong signals today, the other interesting characteristic was the time of day that things broke loose. First signals heard here were about 1900Z. Not much unusual today with the solar flux nor geomagnetic activity that I can tell at the moment. Is this an indicator for this year's summer *E* season? We shall see. Another unusual item about most of the contacts today is that they were along the northern tier. Usually we do not see much along this path until later in the *E* season."

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Sporadic-*E*

Sporadic-*E* propagation is an exciting but mostly unpredictable mode related to "clouds" of highly ionized, dense, small patches in the *E* region of the ionosphere. Ten-meter operators have known *Es* propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. *Es* events may last for just a few minutes up to several hours and usually provide an opening to a very small area of the country at any one time.

While there is still a great opportunity for a deeper exploration and understanding of *Es*, a lot has already been learned and observed since it was first discovered in the 1930s. *Es* is known to occur more frequently in latitudes nearer the equator and to peak near the solstices, but it is especially strong in the late spring through the summer.

Over the years, thousands of contacts via sporadic-*E* propagation have been logged on 50, 144, and 220 MHz (not to mention the great amount of supporting evidence from the reception logs of FM and TV station DX hobbyists). In July 1983, the first two-way transatlantic 50-MHz *Es* contacts were made between British and American stations. These contacts were made with only a few watts of RF and spanned the Atlantic Ocean. Since then, many contacts have been made between Hawaii and the east coast of North America, and Japan and the west coast. These proved that *Es* propagation is not limited to one-hop distances. Contacts spanning these great distances were not limited to 50 MHz, but were had on 144 MHz. Even 220 MHz has shown path distances of over 1500 km. (For an interesting discussion regarding normal *E*-layer propagation as compared to *Es*, see <http://www.uksmg.org/elayer.htm>.

Scientists are still pursuing the multiple causes of sporadic-*E*. As far back as 1959, ten distinct types of sporadic-*E* and at least nine different theories of causation were offered. The classification of distinct types has been retained, but since the 1960s the wind-shear theory has become one of the most accepted theories.

Wind shear occurs when the wind blows at different directions and speeds as you go higher up in the atmosphere. Simply, the wind-shear theory holds that gaseous ions in the *E*-layer are accumulated and concentrated into small, thin, patchy sheets by the combined actions of high-altitude winds and the Earth's magnetic field. The resulting clouds may attain the required ion density to serve as a reflecting medium for VHF radio waves. Newer research has revealed a strong correlation between *Es* formation and the passage of the Earth through the trail of debris left by passing comets. The elevated levels of comet "dust" present in the atmosphere as we pass through these comet trails during the summer seem to become concentrated at the *E*-layer heights. With wind shearing and magnetic alignment, highly dense clouds of this debris form, spawning sporadic-*E* propagation.

During periods of intense and widespread sporadic-*E* ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

With the early reporting of *Es* in April, the 2005 *Es* season could very well be exciting. How can we know when a Sporadic-*E* opening is occurring? Several

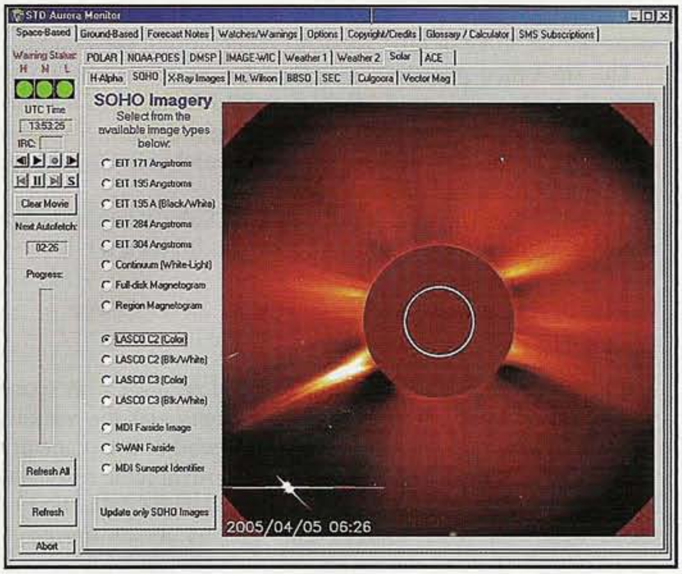


Figure 1. Screen capture of the Solar Terrestrial Dispatch's "Aurora Monitor" software program. This capture shows the SOHO LASCO C2 image from April 5, 2005. The program allows you to follow real-time space weather that impacts aurora conditions.

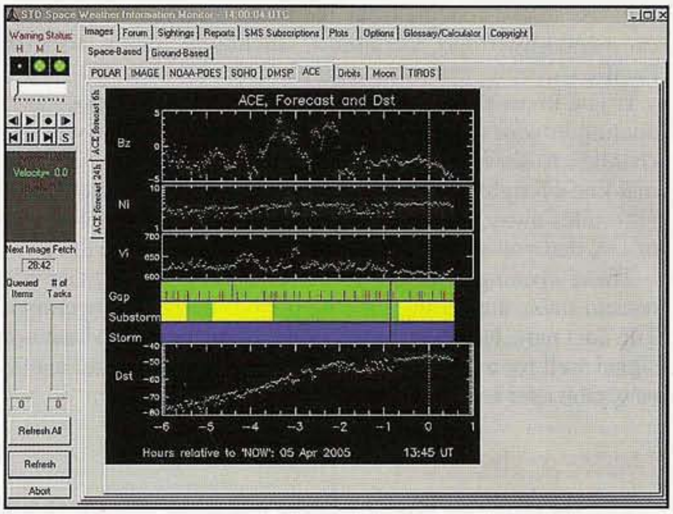


Figure 2. The Solar Terrestrial Dispatch's SWIM (Space Weather Information Monitor) software is a fully customizable browser of space weather information. Not only does it allow you to view real-time images and data graphs, but it also has alert features as well as SMS messaging. This screen capture shows the solar wind data captured on April 5, 2005.

e-mail reflectors have been created to provide an alerting service. One is found at <http://www.gooddx.net/> and another at <http://www.vhfdx.net/sendspots/>. These sporadic-*E* alerting services rely on live reports of current activity on VHF. When you begin hearing an opening, you send out details so that everyone on the distribution list will be alerted that something is happening. They, in turn, join in on the opening, making for a high level of participation. Of course, the greater number of operators on the air, the more we learn the extent and intensity of the opening. The bottom line is that you cannot work sporadic-*E* if you are not on the air when it occurs.

In addition to live reporting, there is a very powerful resource available on the Internet. Check out <http://superdarn.jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time data 24-hour overview, you can view the day's ionization activity at the northern polar region. You can also view live radar displays of the same area. These graphs help identify *Es* clouds existing in the higher latitudes. One use for this would be the detection of a variation of *Es*, known as auroral-*E*.

For a great introduction to mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://www.amfmdx.net/propagation/Es.html>.

Tropospheric Ducting

Scattered reports of tropospheric openings have been made during March and April, but we typically don't see widespread tropospheric ducting until summer. In tropospheric ducting, radio waves are trapped in a type of natural wave-guide between an inversion layer and the ground or between two inversion layers. Ducting causes very little signal loss, and often signals are only heard at each end of the wave-guide. Ducting via the troposphere can propagate signals great distances, such as from Hawaii to California. However, this ducting depends on large weather systems that are more common during the late summer. With the early reports, though, it is worth watching for this mode of propagation.

The term *tropospheric ducting* refers to the stratification of the air within the troposphere. When layers form within this region of air, the refractive index between each layer causes a refraction of VHF and UHF radio waves. If the layers form in just the right way and at the right height, a natural wave-guide is created. A tropospheric duct develops. Ducting is most likely to occur over water during high-pressure, anticyclonic conditions, when the air is relatively still.

As with most matters of propagation, it is not always possible to determine whether tropospheric propagation is ducting or non-ducting. Ducting usually has characteristics like those of sporadic-*E* propagation in that the distant station will be noticeably stronger than closer stations that are not accessible by the duct. Tropospheric ducting results in surprisingly strong signals for the distance. Ducting typically is very geographically selective. Normally stations working a duct are quite close together in space, at both ends of the duct.

Another important issue when trying to decide the mode of propagation across the VHF bands is whether it could have been ionospheric, such as by sporadic-*E*. Generally, sporadic-*E* will be much stronger on similar bearings when you listen to lower frequencies. If there is no sign of any enhancement of propagation on lower VHF frequencies, you usually can be quite confident that the mode was tropospheric.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition also occurs over the Atlantic. There is a great resource on the Internet which provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://www.iprimus.ca/~hepburnw/tropo_xxx.html>, including maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the openings. The duct may, however, move slowly, causing you to hear one signal well for a few hours to then have it fade out and another station take its place, from another area altogether.

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May. It will peak during the morning of May 5th, but start around April 19th. This shower is expected to have a peak rate of up to 60 per hour this year. It is expected that the shower will have a broad period of maximum activity, starting as early as May 3rd and extending out to May 10th. Also, because of the low radiant, the meteors tend to have long ionized paths, making for strong signal reflections. Look for 6- and 2-meter openings off the ionized meteor trails.

There are some other showers in May that may yield some propagation. These include the *Epsilon Arietids,* which should peak on May 9th; the May *Arietids,* peaking on May 16th; the *Omicron Cetids,* peaking on May 20th.

June has a few showers, as well. The *Arietids,* which is active from about May 29th through June 19th, has a peak that tends to blend with the *Zeta-Perseids* shower, which starts around May 20th and lasts until early July. These two showers may combine this year to produce a very strong radio event around June 9th.

July has only minor showers. These showers typically have not yielded much radio activity. For more information on them 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 upcoming showers.

TE Propagation

A seasonal decline in TE (transequatorial) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an approximate right angle.

The Solar Cycle Pulse

The observed sunspot numbers from December 2004 through February 2005 are 17.9, 31.3, and 29.1. The smoothed sunspot counts for June through August 2004 are 41.7, 40.2, and 39.3, all showing the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from December 2004 through February 2005 are 94.6, 102.4, and 97.3. The smoothed 10.7-cm radio-flux numbers for June through August 2004 are 107.2, 105.9, and 105.

The smoothed monthly sunspot numbers forecast for May through July 2005 are 18.7, 17.0, and 15.8, while the smoothed monthly 10.7-cm is predicted to be 82.4, 79.8, and 77.6 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A*-index (*Ap*) numbers from June through August 2004 are 14.0, 13.8, and 13.8, showing an overall plateau in geomagnetic activity during the summer season of 2004. The monthly readings from December 2004 through February 2005 are 11, 22, and 11.

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

Keeping a Pulse on Space Weather and Propagation

For those of us who want to keep a close watch on space weather by viewing the latest solar images and the various instrument readings such as solar wind speed or the planetary *K*-index, the Internet has proven to be an invaluable resource. As I have mentioned before, I created a website collection of these near real-time images and graphs at <http://prop.hfradio.org/> (for cell phones and wireless devices with Internet browsing capabilities use <http://wap.hfradio.org/>). Others have created similar pages. The folks at the Solar Terrestrial Dispatch (http://spacew.com/) have not only created online resources, but also provide a few computer programs that can be quite useful. Known for their powerful propagation forecast and modeling software, Proplab Professional Version 2.0 at <http://www.hfradio.org/swp_proplab/> (they are working on a new graphical version) has also created an Aurora Monitoring Software program as well as a more exhaustive SWIM program. SWIM, or Space Weather Information Monitor, is like a Swiss Army knife. It not only comes with an exhaustive default collection of resources, but allows you to customize the program and even add new resources.

Both the Aurora Monitoring Software and the SWIM program act as a dedicated "browser" of space weather information. They automatically download current solar images, space weather data, and other information, and organize all of this into a self-contained package that is easy to use. They even have alerts that can aid in spotting conditions that might trigger the kind of propagation you are hoping for. Take a look at both packages. The Aurora Monitoring Software is at <http://hfradio.org/swp_stdaum/>, and SWIM is at <http://www.hfradio.org/swp_swim/>.

Also don't forget to follow the research and online collection of Dr. Volker Grassmann, DF5AI. His excellent Amateur Radio Propagation Studies website (http://www.df5ai.net/) is a library of cutting-edge research and a wealth of knowledge on the VHF world of propagation.

Feedback, Comments, & Observations Solicited!

I'm hungry! I need your feedback. How is this column helping you? Are there questions that you would like to see me explore further? Do you have exciting research that would be helpful to other readers? Please send your reports, questions, and ideas to me via e-mail, or drop me a letter. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http:// hfradio.org/forums/>. Up-to-date propagation information is at my propagation center at <http://prop.hfradio.org/>, or at <http://wap.hfradio.org/> for wireless devices. Until the next issue, happy VHF DXing!

73 de , Tomas, NW7US

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Components for 10-GHz and Up Transceivers

Well, here we are. I never thought I would be talking about working 47-GHz using some sophisticated junk-box parts. However, surplus material is available, and with a diligent search of surplus outlets you can obtain components that can be assembled into a working transverter as will be described here. This was our first attempt. It's rather crude, but it works, which shows that the construction of a simple homemade mixer for 47 GHz is possible.

It was not an overnight collection binge that started the effort, but rather a slow process aimed in this direction. Collecting material for a project takes time, especially when you are not ready to sell the family farm to purchase the parts needed. Most of the material used in this project can be obtained in ready-made kit form, and the kits are quite good. However, that is costly. We chose another avenue, and that was to sit and wait for the parts to come our way. The idea was to slowly gather the components to construct a microwave transverter. All you need is some luck in locating key parts and the time to find the components needed. Take, for example, my first SSB transceiver for 10 GHz.

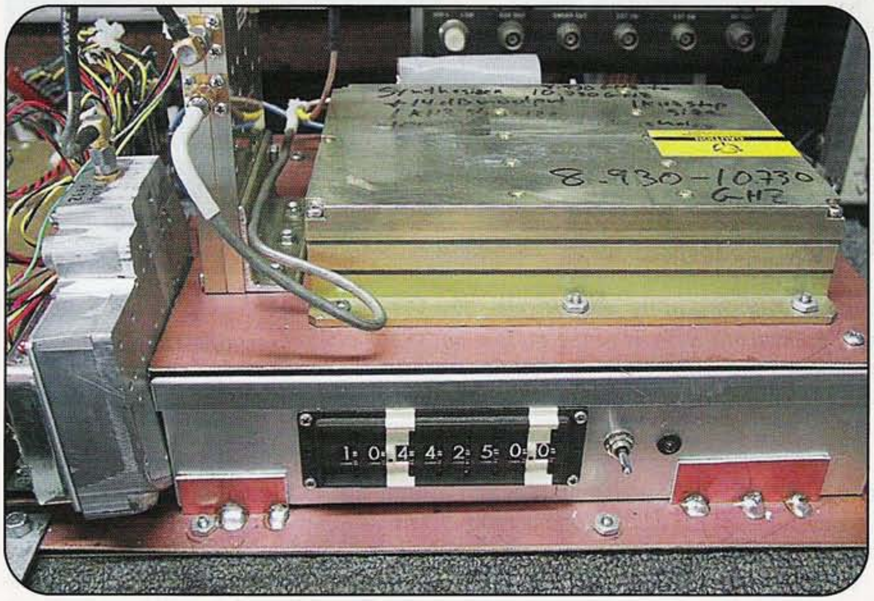


Photo A. Front view of 47-GHz rig. The synthesizer is at the top right, sitting on top of the BCD controller chassis. The synthesizer is capable of operation from 8930 to 10730 MHz with +14 dBm output. Frequencies in as fine as 1-kHz steps are set throughout the frequency range and are controlled by BCD switches on the front panel in conjunction with the 10-MHz internal clock oscillator. Close-in phase noise of the synthesizer is better than –90 dB.

An SSB Transceiver for 10 GHz

The SSB rig was assembled using a surplus TVRO RF preamp, a mixer found at a local swap meet, four SMA relays, and a Frequency West microwave "brick" oscillator. Additional material included a 10-watt TWT (traveling wave tube) power amp and TR switching control with time delay for transmit relays. The time-delay control board was the idea of Kerry, N6IZW, and he designed it with receiver protection circuitry, allowing the TX relays to be slow to operate and fast to release, with the reverse for the RX relays. This way the receive preamp was protected from the transmitter by switching times. It allowed the receive relay to release from the antenna before it operated the transmitter relay. This circuit was constructed dead-bug fashion, although I made a circuit board for it. I never installed it, though. The 10-GHz rig is still wired that way after ten years. I should have revamped the circuit with PC boards, making it more reliable and better looking as well.

This rig has withstood the test of time. It has even survived my grandsons' tinkering with it. I had mounted the 10-GHz rig in an old BC221 surplus WW II frequency-meter case in my grandsons' tree fort in our backyard, pointing it at a local mountain for reflection contacts on 10 GHz. With their sandbox under the fort, the kids filled the outdoor case with about 25 pounds of sand. Needless to say, some shaking out was needed and I thought it was a goner. It took a while to dump all the sand and vacuum it out, but it's still working just fine now, with a lock on the case. This little episode demonstrated certain reliability in construction even back then in my early years of putting surplus parts together. I still can imagine the effort it took to haul all that sand up into the tree fort and dump it carefully into the muffin-fan exhaust hole. There still is sand embedded in the RTV used to harden the circuit boards, using the RTV like a potting compound to protect the wiring and component parts. The rig is still switched by the original four SMA relays

*Member San Diego Microwave Group, 6345 Badger Lake Avenue, San Diego, CA 92119
e-mail: <clhough@pacbell.net>

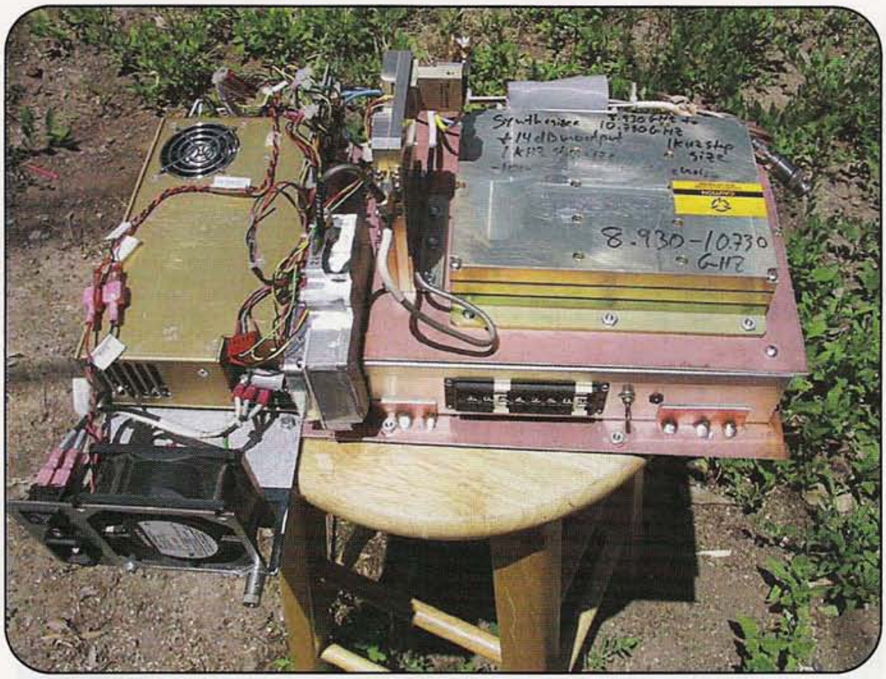


Photo B. Top view of the 47-GHz rig. The Verticom synthesizer is to the right. The 2640-MHz synthesizer is at the bottom left in the aluminum cutout shield compartment. The Pecom 23-GHz TX module is just above the 2640-MHz synthesizer. The switching regulated power supply is to the far left, with the cooling fan in front of the power supply.

controlling a TWT 10-watt amplifier and a series of two RF preamps (one preamp to drive the TWT).

The unit was a collection of quite a few components all scrounged from surplus dealers or swap meets and assembled over time.

The 24-GHz Transceiver

Establishing a station on 24-GHz SSB was quite unexpected, as my steady hands and eyesight are not that of my younger years. I put off that project until the time was right and waited to collect parts the economical way. However, a most unlikely set of circumstances presented itself in the form of a transverter that was sold as part of an estate sale. I could not turn down the offer of a complete transceiver fully modified from surplus. It was a 24-GHz Pecom unit modified by Sam Lutweiler, K6VLM (SK), of the San Bernardino Microwave Society (SBMS). Obtaining the completed transverter would help in tracing out his conversion details.

I undertook this project, as I was involved in helping to obtain quite a large quantity of these surplus Pecom units. We obtained two different types of transverters that were what we call high side LO (local oscillator) injection and low side injection. The low side injection had a capability of operation at 23.525 GHz unmodified in the TX module. (This TX module will become a critical component of a rig for 47 GHz.) To put things in perspective, I was still tracing the circuitry of these units from our surplus haul at the time when Sam had already modified two Pecom transceivers for 24.192 GHz and had installed one on top of his roof for operation. We had a long phone call with Sam describing the modifications he developed. I tried to take notes and keep up with him. I wish I had used a tape recorder to record Sam's conversion technique, as the next I heard he had passed away. That left us to put together the hardware and notes to document his conversion.

Of primarily interest were the modification and construction techniques used by Sam in his conversion. Sam had accomplished this conversion with great success. As complicated as Sam's process seemed to me at the time, it demonstrated his deep understanding of conversion process for the Pecom units. We were fortunate enough to obtain a transceiver and a box of papers, which had some raw conversion details on procedures he had used in his modification process. For example, Sam's test sketch showed his scheme to mix two signal generators, one at 18 GHz and the other at 6 GHz, to align filters on the PC boards, as he did not have a 24-GHz generator.

Making a 47-GHz Transverter

In the meantime, Kerry, N6IZW, also was working out his conversion methods on the Pecom modules for a 24-GHz transceiver, and he observed another use for the TX module. He saw the relationship of the frequencies used in the unmodified 23-GHz transmit module. In its original configuration it was driven by a 9-GHz LO and had an IF frequency of nearly 3 GHz. This observation presented some interesting possibilities for its use on 47 GHz. With a 10.44250-GHz LO drive, which is doubled in the Pecom TX module mixer, and with IF drive of 2.640 GHz, an RF output of 23.525 GHz is produced. This method allows the Pecom TX module to operate nearly stock, driving a final output mixer, doubling the drive (23.525 GHz × 2 = 47.05 GHz). This was used with a 2-meter IF of 145 MHz, giving 47.195 used with the final mixer doubler circuit. (This mixer doubler is home constructed and nothing special, showing Kerry's thinking out of the box with this harmonic generator, or mixer.)

LO driving the two anti-parallel diodes attached to a section of 141 coax, or on the back of an SMA connector by themselves, makes a great harmonic multiplier. Adding the fine wire makes an RFC (radio frequency choke) to couple to the IF port of a mixer for an IF frequency used at 2 meters.

A little figuring revealed that by using components on hand the following could be constructed and given a try. Working backwards, if we used 47.05 GHz for an LO, that divided by 2 equaled 23.525 GHz (the Pecom TX unit driver output). We had 2.620-GHz Qualcomm DRO (dielectric resonant oscillator) synthesizers on hand, and we used a modified one for 2640 GHz to be the IF input driver on the Pecom TX converter. That meant that 23.525 GHz, the TX output, minus 2.640 GHz equaled 20.885 GHz, which is twice the input drive LO to the TX module. Dividing that by 2 equals 10.44250 GHz. Other frequencies are possible as well. It just depends on what you have on hand.

This IF synthesizer is a surplus Qualcomm DRO PLL board and is available from the author, should the stock fre-

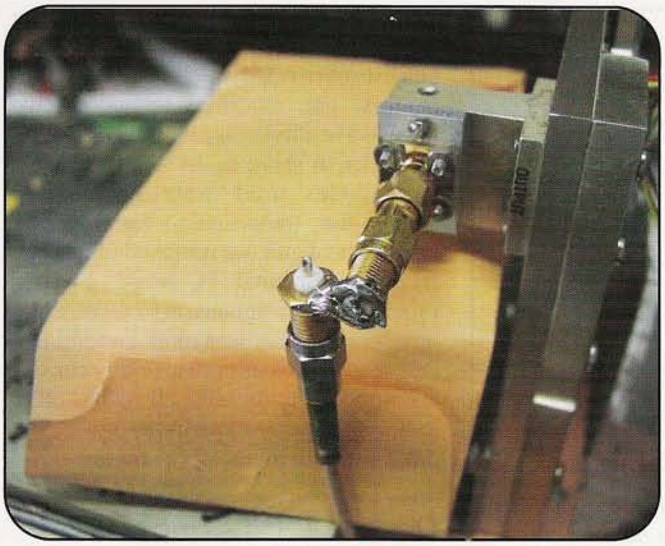


Photo C. Close-up of the 47-GHz system mixer showing the tiny diodes (you can barely see them) and IF cable (145 MHz) and SMA connector pointing downward in the original test configuration. This was the first design.

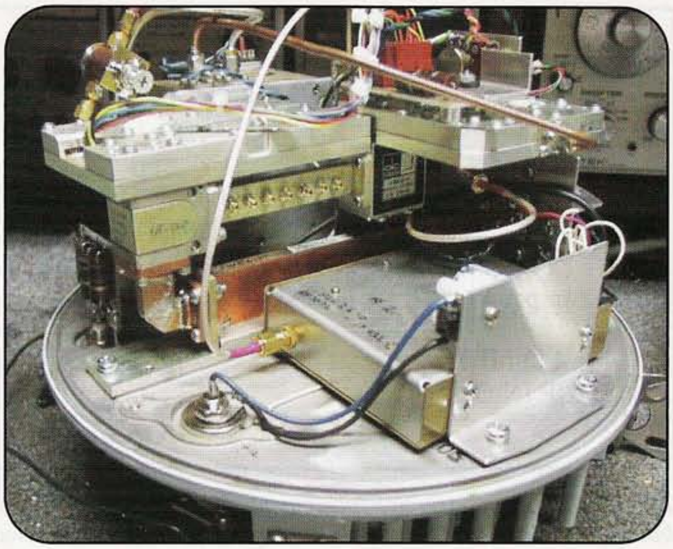


Photo D. Side view of the modified Pecom 24-GHz rig completed by Sam, K6VLM. In the center is same 23-GHz TX module used in 47-GHz rig. The module behind the TX unit on the multi-screw waveguide receive filter is the receiver module.

quency work out for your LO and IF drive requirements. Stock, it functions on 2.620 MHz and is quite easy to convert in the range of ±50 MHz of the original 2620-MHz frequency. As we needed 2640 MHz, it proved to be quite easy. With a DRO synthesizer, not every desired frequency is easy to modify to a new frequency. Some synthesizers are more flexible than others.

The DRO synthesizer was an easy fix for the IF drive required. However, the 10-GHz synthesizer we obtained from surplus was the crown jewel and could be termed unobtainable. It was manufactured by Verticom and is capable of 1-kHz parallel, simple BCD (board chip definition) switching of frequency from 8.3 GHz to 10.7 GHz in 1-kHz frequency steps (its Verticom part number is MTS-2000), a very lucky find. (Note that there have been many Verticom synthesizers on eBay, but all I have observed is model 1500, which has a 150-kHz step (or other unknown frequency steps, and they require suitable serial programming with a processor or stamp board). If you find an MTS-2000 synthesizer in a frequency range suitable for your rig, I suggest you grab it.

Other than the power supplies, dish antenna, synthesizer, or source of a local oscillator and a mixer for 47-GHz, this rig could be constructed with the major item being the TX module from the 23-GHz Pecom transmitter. Using a flexible synthesizer that can be set up in 1-kHz steps made the main LO task simple. A Frequency West brick or other LO could be used here. We used the Agile Verticom Synthesizer, as it was in the junk box and it operated from 8.930 GHz to 10.700 GHz—just right for the required 10,442.50-MHz LO drive. Used with the Qualcomm 2.620-GHz synthesizer (now modified to 2.640 GHz; Pecom IF In/Out) it gave an output at 23.525 GHz right in the normal operation range of the TX module. With 100-mw (+20 dBm) drive (Pecom output) at 23.525 GHz to inject into the LO port of a home-built mixer constructed from two anti-parallel diodes (doubler), this gave us 47.05 GHz.

Using a 145-MHz multimode transceiver as the IF RX/TX source produced an operational frequency of 47.195 GHz. The 2-meter transceiver was set to 250 mw output, 1/4 watt, and an 8-dB attenuator was attached between the transceiver and the microwave mixer. This reduced the transmit power to +7 dBm output drive to the IF mixer port. Total mixer power being used was the LO at +20 dBm; IF drive on transmit of +7 dBm seemed a little high, but we went for the gusto and when tested it seemed to function very well. Besides, we had replacement diodes in the form of PC boards from surplus material to obtain new mixer diodes should that be needed.

A trial at Kerry's QTH during the San Diego Microwave Group's monthly meeting was our show-and-tell portion of the system check. It was a "go for the gold" effort. The first test on the workbench at 2 feet initially showed that something was very wrong. We were receiving signals every 25 kHz up and down the band. A check with the spectrum analyzer traced it to my 2-GHz synthesizer DC power supply 10-volt line. It seems that the 7810 10-volt voltage regulator was oscillating and needed better filter cap action. Replacing the 10-mFd bypass cap with a 100-mFd cap removed the offending ripple on the DC feed and greatly cleaned up the synthesizer output.

Testing the transverter over this 3-foot path proved simple and produced a great note for CW, almost as good as you can get. As a simple test we tried SSB on Kerry's 2-meter multimode IF driver. I switched to SSB on my Yaesu FT-817 and clarity was just as good as 40 meters during the best of times.

This was a contact on 47 GHz, and what fun it was. It was like putting together your first crystal-detector set.

Just for added fun we decided to increase the distance, as we were using AC power supplies for the rigs. We patched in a 75-foot extension cord and walked out of the garage and down the driveway still operating SSB between Kerry and myself. Signal levels were still in the S8+ region. Moving the 10-GHz synthesizer 10 kHz in frequency (it is multiplied by 4 in the rig) moved the IF frequency 40 kHz, as expected.

Also, later that evening Kerry placed a 40-GHz waveguide in the system to

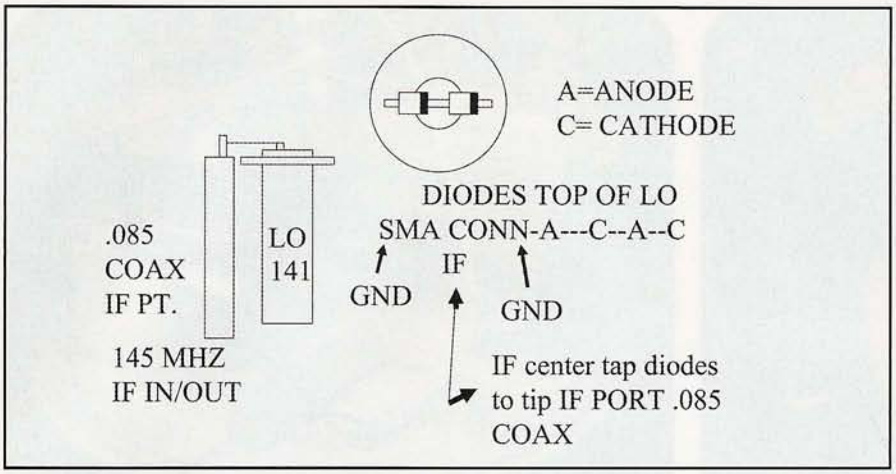


Figure 1. Mixer construction /placement of microwave diodes on the back of the SMA bulkhead connector. Use the shortest possible lengths. We used a bare mixer for a short SSB contact on 47-GHz at a meeting of the San Diego Microwave Group. This mixer, while not an optimum design, is shown here to demonstrate how simple a mixer can be. It's just a starting point in design and it worked.

ensure that it was not 23-GHz overload of the receive mixer and that signals were still functional, proving to our satisfaction that we really were on 47 GHz. After all, we had to use these procedures, as we did not have 47-GHz test equipment and an alternate method had to be used to demonstrate what was going on.

It took time and effort, but the transceiver was assembled all from surplus parts. Several issues still remain, though. Small dish antennas are needed to allow greater operating range. DC power supplies should be added to make the rigs portable. The AC switching power supplies initially were used because they supplied +5 volts, in addition to +15 volts, and these were adjusted to 5.2 volts and 15.6 volts on the +15-volt supply for the YIG (yttrium iron garnet) synthesizer requirements. A bank of voltage regulators for –5 volts, and +10 and +12 volts DC for other circuit requirements, was derived off the switching power supply's + and – 15-volt output taps. It's a little crazy to use a switching power supply capable of 40 amps at 5 volts, but it is good for our power needs and it was in the junk box.

This multi-voltage output power supply made the power-supply issue only a matter of connectors and a slight voltage readjustment to up the 5- and 15-volt lines a few tenths of a volt for synthesizer requirements. Other changes might be to remove the synthesizer control BCD switch box and hard wire the YIG synthesizer control circuitry, greatly reducing the size of the rig. There are lots of possibilities, as there are still other junk boxes to check or we just might find what we are looking for if we sit back and wait for it to land in our lap.

The power supply, like most other items, was obtained surplus from a local scrap-metal junkyard. The Pecom transceiver was obtained surplus for $20 from another scrap-metal yard in the Sunnyvale, California area. The Verticom synthesizer was obtained surplus as well, a find about which I am still amazed. I feel very lucky that we were able to obtain it for our microwave group. Like all rare items, it was one of several key items used in the construction of the converter for 47 GHz—easier than a Frequency West brick.

I forgot to mention the dish reflector we first used. It was a flashlight reflector from a RadioShack lantern. Later reflectors used were stoplight reflectors of the 6- to 8-inch variety, and the latest is a Pecom 39-GHz commercial reflector about 12 inches in size.

One of the photos shows the synthesizer sitting on top of the BCD switch controller for the parallel input control to the synthesizer programming data lines. Inside the controller is an external 10-MHz OCXO (oven-controlled crystal oscillator) reference oscillator. Next to the muffin fan on the bottom left is the Qualcomm DRO synthesizer set to a fixed 2640 MHz. The module standing on its edge is the Pecom TX transmitter module for 23 GHz.

The 47-GHz mixer is the part of the system that was home built. The mixer consists of two SMA bulkhead coax connectors, one modified to accept two microwave diodes on its back face and the other to serve as 145-MHz IF port. The diodes used were scrap from Qualcomm transceivers for 14-GHz. Using a heat gun, we removed the diodes from the original PC-board 14-GHz mixer. The performance at 47 GHz, while not the very best, was quite good in this frequency application, especially considering the cost. As with all of the other material we picked up for this project, the diodes for the mixer were surplus.

Mixer Modification

The bulkhead SMA connector's Teflon® is cut off flush with the back of the SMA flange. Also, the center conductor of the SMA connector is cut off nearly flush with the back of the connector. Next a second SMA connector is soldered to the first connector to make the structure rigid. Use .141 hardline to support both connectors and form the mixer towards the focus point of a small dish.

The mixer is not difficult to construct. Two diodes are required. One diode is soldered one end to ground and the other end to the nub of the center conductor of the SMA connector centered about a straight line from 9 o'clock to the center pin (anode to ground, cathode to the center pin). The second diode is soldered anode to center pin in line from the center pin to 3 o'clock and cathode grounded. Leads should be kept as short as possible, with the diode lying flat against the flange back of the SMA connector.

To test to see if the diodes survived the handling and soldering, measure with a VOM on diode check or use the X10 scale of a VOM. Measure from center pin to ground and you should see a diode junction forward resistance. Reverse the meter leads and you should see the same junction resistance to ground on the second diode, which is connected in an anti-parallel configuration. Now with the two diodes connected and testing good, make the IF port by connecting a single strand of the finest gauge wire you can find. I used a single strand of 110-volt AC lamp cord and soldered one end of this single strand to the diode center connector. The other end was soldered to the IF port, which is constructed out of .085 hardline. Make connection to the center conductor of the .085 hardline coax IF port. The other end of the .085 coax has a SMA connector for IF connection. This is the 2-meter IF port. The drive from the Pecom TX module output at 23.525 GHz is the input LO port of the mixer.

The RF port is somewhat unconventional. It is focused, the RF mixer diodes and IF port all directed to a small reflector dish for testing. On Kerry's rig he had a 4-inch dish, and he pointed the mixer diodes into the focus point of the dish for testing. The diodes and SMA connectors were supported by .141 coax hardline, positioning the mixer diodes to the focus point of the dish. This was the first-cut design and has been improved through the great efforts of Don Nelson, NØUGY.

The improved design consisted of drilling a hole in the LO SMA connector to couple the IF port out. The circular waveguide was placed over the diodes and soldered to the top of the LO SMA connector to create a rigid structure, coupling to a circular waveguide and small 47-GHz splash plate at focus. For full details on this improved mixer, look on the web at <http://www.ham-radio.com/sbms/sd/projindx.htm>.

The mixer also has harmonic-generating possibilities. Driving it at much lower frequencies into a single or even two diode arrangement works very well. This mixer has been shown to have great harmonic-generating capabilities. Frequency markers from lower frequency oscillators have been observed as high at 10 GHz and low at 24 GHz. The diodes used were "fly spec" size diodes (quite small). They were used in commercial applications for 14 GHz, so they already exhibited great microwave capabilities and were in a Stripline package, which permitted us to solder them to the back of a SMA connector.

This was the simplest test and evaluation. The next test came from Don, N0UGY, who put quite a bit of time into improving the mixer and making a mixer waveguide output to cut off the 24-GHz LO feed and only pass the 47-GHz signal-mix product from this simple mixer.

The waveguide was .188 ID diameter hobby brass tubing telescoped into a second section of brass tube stock. This slightly larger brass tube stock fit the OD diameter of the .188 ID stock and was soldered around the diode mixer and SMA connector rear, enclosing the mixer diodes in a launch sort of short section of brass tubing. The end of the .188 diameter tubing was a long section of tube length, and two slots were cut into the tube end. A very small splash plate was soldered onto the far end of the small tubing. The splash plate was placed at the dish focus point in a more conventional design.

My thanks to Don for his efforts in making this great improvement to Kerry's original mixer design. I don't want to cover all the design notes Don provided, but rather I'll let him release his improved design.

Kerry and I have made contacts over 1 km during the 10 GHz ARRL contest with lots of signal to spare. Improvements have been made, incorporating 8-inch stoplight reflectors with greater distance capabilities, and plans are in the works to adapt a better dish antenna from a 39-GHz Pecom system that we have on hand. The junk box delivers again.

Summary

Even though we made use of some sophisticated components, I hope we have shown that a project can be successfully and inexpensively completed using surplus components, items in a junk box or two, and homebrew construction. As always, if you any questions, please e-mail me at <clhough@pacbell.net>.

73, Chuck, WB6IGP

OP ED

One Reader's Opinion

The Good Old Days?

By John Mollan,* AE7P

Many newspapers around the U.S. print a page entitled "Op Ed." This usually runs opposite the editorial page; hence its name. Sometimes the name takes on a double meaning, when the author has a viewpoint opposite to the editor's. Its purpose is to give a writer an opportunity to express a view or propose an idea for discussion in a longer format than what is normally found in a letter to the editor. There are many views and ideas floating around in the world of VHF that are worth considering and discussing. Please note that the views expressed herein are those of the author and do not reflect the views of CQ VHF *or its editorial staff.*
—N6CL

When we were children, we often heard grandpa speak of the "Good Old Days." It was a time when you knew your neighbors. Things were simpler. People were more honest. Apparently, life was better. While nostalgia is never viewed with 20/20 hindsight, it is often entertaining to view those early days of radio and the excitement they provided.

It is not necessary to go back 60 or 80 years to view some of these times. Just 30 years ago things were happening that would revolutionize ham radio. The early 1970s would witness the introduction of solid-state 2-meter transceivers, simple mobile operation, and the dominance of the repeater.

Until that time 2-meter communications were highly experimental. A variety of modes and equipment could be seen. Converted taxicab radios brought some static-free FM activity to the band. There were a variety of AM transceivers around and a few souls on CW and SSB. Some hams had converted GE Progress Line (Prog Line) transceivers for use on the band. There were even some Heath "Twoers" still in use. Most of the existing rigs were tube-type, quite heavy, and awkward to operate. Nearly all were crystal controlled.

Mobile operators could be spotted by the halo antennas mounted on their back bumpers. Horizontal polarization dominated 2-meter operation. Nearly all communication was point to point and the horizon marked the limit of communication in many cases.

FM operators soon established some simplex calling frequencies. The first in common use was 146.94 MHz, which was used by most hams with FM capability. A mobile operator using this frequency was nearly assured of a response if he put out a call. Hearing an out-of-town mobile operator always brought about a reply and often an invitation for dinner.

The 1970s-vintage Heathkit 202.

Because of the limited range of simplex operation, many clubs and individuals began erecting repeaters on nearby hilltops, water towers, or nearly anyplace that gave some height advantage. The granddaddy of all repeater frequencies was 146.94 MHz with an input frequency 600 kHz lower. This was known to all as the "three-four-nine-four" repeater. Soon a number of other repeaters would appear in the 146–147 MHz section of 2 meters, spaced 60 kHz apart to prevent interference. This was one of the first successful instances of channelization in the ham bands. Nearly all repeaters were open, with carrier-operated receivers.

During this same period, a number of manufacturers introduced a variety of mobile, crystal-controlled FM transceivers. Most rigs ran 10 watts, enough for repeater operation in metropolitan areas. The number of channels varied from less than 10 to a whopping 22. A separate crystal was used for transmit

Because of its hot receiver, the ICOM IC-22A was the envy of all.

*e-mail: <ae7p@arrl.net>

The Gonset 2-meter Sidewinder.

and receive on each frequency. The cost of purchasing all 44 crystals for a 22-channel radio might exceed the cost of the radio itself! A number of manufacturers advertised their 2-meter equipment in ham magazines. Some of this manufactured equipment was converted from commercial or aviation use. Many of these manufacturers no longer make ham equipment. Because of its hot receiver, the ICOM IC-22A was the envy of all at the time.

Most of the early FM transceivers were easy to operate. My first rig, a Genave GTX-10, had three knobs (volume, squelch, and channel) and no meters. Even the microphone was hard-wired in!

With just a half-dozen common repeater pairs installed in his radio, a ham could drive across nearly any section of the United States and receive a prompt answer to his (or her) "monitoring" call. If there was anyone listening to the frequency, you would receive a friendly response and an opportunity to chat. New friends were made and there was much excitement about this new mode. You soon found out where certain hams "hung out."

As the years passed, the number and sophistication of transceivers and repeaters multiplied. Devices to limit access, such as PL tones, were installed. Radio manufacturers soon developed synthesizers that would cover the entire band and several modes. Power levels increased. Soon you could operate on any frequency of your choice. Some radios covered more than one band! Features that were unimaginable in the 1970s were soon offered on the most basic radios. Consequently, the most essential accessory to possess was the operating manual for your radio!

However, as the level of technical sophistication has increased, the actual amount of communications between strangers has declined. Today an out-of-town operator may have difficulty discovering the frequency and access tones of a local repeater. Even if the repeater is accessed, most "monitoring" calls do not get a response. It is only in the more sparsely populated areas of the country that one can routinely receive a response when a repeater is accessed. A call on the simplex calling frequency of 146.52 MHz rarely is answered.

What made those "Good Old Days" of the '70s so special? It was not the price of the equipment. Today's 2-meter radios can run circles around those early rigs at a fraction of the cost. Perhaps we are victims of our own technical sophistication. It is the feeling of camaraderie among hams that seems to be the missing element. Perhaps the number of hams on the air has made the hobby less exciting. Perhaps we are just "too busy" to deal with strangers. Perhaps we should just remember those simpler times. ■

confirming the first-hop *Es* link from the Florida panhandle area on to TEP. The stateside reports showed extensive *Es* over the southeast USA. Thus, conditions were favorable for multi-hop *Es* links to the TEP zone. I believe the northern boundary of the TEP zone on March 2nd was along a line extending from KP4, HI, and 6Y. This boundary may have been farther south, as ZP6CW did not spot any KP4s. KE4WBO (EL96) spotted the YV4AB beacon at 0300 UTC. That is two-hop *Es* from Florida. One wonders if it could be perhaps even two- to three-hop *Es* for the TEP links.

The map in figure 4 shows the value of posting loggings, even if it is not for "DX." Savvy 6-meter operators can plot the *Es* paths and see if a path may be open. Tim Havens, W4TRH's DXers.info site has a map utility built in. I use it along with plotting my own maps during openings.

The 6-meter band closed to Florida at around 0300 UTC. It remained open out west to Arizona from WØ until after 0700 UTC! K7TOP spotted the WBØRMO beacon (EN10) at 0737 UTC! Had 6 meters gone mad?

The 6-meter *Es* continued the afternoon of March 2nd. With the DX contacts reported, and the potential to work new countries, interest was now very high among 6-meter DXers. The *Es* openings were reported started at 2230 UTC and were mainly between Texas, Florida, etc. On to March 3rd, and the *Es* continued until after 0530 UTC! Most activity was among W4, W5, W6, W7, and WØ. I did not see any "*Es* link"-type contacts spotted. Driving home from Salina, Kansas that evening, I had nice chats with KK4TE (EM50) and WØMTK (DM59) while mobile near McPherson, Kansas on Interstate I-135. There were 20+ hours of *Es* so far for March 2005.

On the afternoon of March 3rd there were more 6-meter *Es* openings for the western states and Mexico. Starting at 1815 UTC, stations in California, Arizona, and XE2MX worked Oregon and Washington State. The opening for the western states continued past 2200 UTC, with KE7V (CN88) working W7JLC (DM34) at 2204 UTC. March 4th, UTC, there were scattered *Es* openings from AD6W (DM06) to KC7UUN (DN53) at 0250 UTC. Add another five hours of *Es* to the total.

On the afternoon of March 5th on into March 6th, a minor geomagnetic storm began with aurora worked along the northern tier states. No *Es* QSOs were spotted that I could find. Aurora activity usually "dampens" mid-latitude *Es*. The next morning, however, the aurora seemed to "spark" the *Es* again.

March 6th: More *Es*

Es began at around 1400 UTC between W1, W3, W8, and W9 and Florida and the Bahamas. This opening continued to around 1800 UTC. That afternoon and evening more aurora was reported.

March 7th: LW3EX Spots W3DOG/b

March 7th was mostly quiet for *Es*. *F2* and TEP were going strong for the South Americans. At 2310 UTC, Walt, LW3EX, spotted the W3DOG beacon in FM28. Could this perhaps have been an *Es* link to TEP?

March 8th: *Es* to Costa Rica from Florida, ZP and PY to Florida

On March 8th, K4RX had ZP6CW at 599 at 0038 UTC, along with PY1RO. Were these *Es* linked or direct TEP? On this date KD4ESV was hearing the TI2NA beacon in via *Es* at 0134 UTC. Sam, KD4ESV's *Es* spot might suggest an *Es* link for Terry, K4RX's South American contacts.

March 9th: *Es* Arizona to Mexico

Barry, K7TOP (DM43), in Arizona, worked XE1KK and XE1MEX at around 0255 UTC, along with some 5-land stations in EL16 and EL17. Remember the diurnal pattern and the fact that *Es* may often form at the same spot the next day? This opening "foreshadowed" the massive *Es* and TEP opening that occurred March 9th and 10th. That opening is the subject of another article.

Summary to Date of March 2005 *Es*

Historically, March is the month with the fewest *Es* openings reported. For years, Pat Dyer, WA5IYX, has kept a detailed log of FM commercial broadcast-band stations he has heard via *Es*. Reviewing his loggings, there have been many years with *no Es* heard during the month of March. March is truly the "doldrums" for *Es*. For the 1990s decade, Pat reports March *Es* only in 1996 for two days and 1998 for one day. For the '80s, Pat observed 495 minutes of *Es* in March 1983. The other months of March in the 1980s had either no *Es* or only very brief (less than 1 hour) openings.

Pat's loggings are for the 88 – 108 MHz FM broadcast band. There may be some *Es* openings that do not reach 88 MHz or above, so Pat's log may miss those 6-meter *Es* openings where the MUF barely gets above 50 MHz. Pat's data may not always be an accurate indication for the 6-meter band. However, I believe it gives a good overall estimate of the *Es* openings that would support 50-MHz propagation.

For March of 2005 I estimate from 0000 UTC March 1st to 0300 UTC March 9th there were over 35 hours of 50-MHz *Es* worked in the continental United States. From research based on past 6-meter reports and WA5IYX's detailed commercial FM broadcast logs, the first nine days of March 2005 appear to have had more 50-MHz *Es* than any other March recorded. In addition, the *Es* formed links to TEP to South America. Thus, terrestrial DX over thousands of miles was possible on 6 meters over five years after solar Cycle 23's peak with a solar flux below 100.

What is Causing All the Off-Season *Es*?

Good question. I do not know the answer. Indeed, scientists do not have a detailed explanation for how *Es* openings form nor a detailed method of predicting it. They do have some understanding of the mechanisms. Ken, WB2AMU, and I are developing an article for *CQ VHF* about "aurora-associated *Es*." I observe that many of the 2005 "off-season *Es*" openings occurred a day or two after minor geomagnetic storms with aurora. It seemed as if the aurora "sparked" the *Es*. Read our article and "you decide." In addition, Ken notes that 1996 (which had several major off-season *Es* events) "was a quiet year in terms of geomagnetic activity, particularly the first three months of that year, when the *K*-index did not exceed 4." January 2005 was a very active month, with many CMEs (coronal mass ejections) and the largest proton storm of solar Cycle 23. There have been numerous minor aurora events in February and early March. Suppose the January 2005 CMEs and proton event "seeded" the *E*-layer with additional metallic ions? Ken notes the influx of metallic ions to the *E*-layer helps form *E* clouds. The minor geomagnetic storms may have "pushed" and "aggregated" the metallic ions to the mid-latitudes, where wind shear could then form conventional *Es* after the geomagnetic field settled down.

Another idea is that the Earth's geomagnetic field is changing, and it may influence the *E*-layer. In the April 2005 issue of *Scientific American* is an article on how the Earth's geomagnetic field has changed since 1980. It is not uniform over the Earth. The authors of the article speculate as to whether we are "overdue" for the Earth's geomagnetic field to "flip"—that is, to reverse polarity. Perhaps changes going on in the Earth's magnetic field are influencing the *E*-layer. ■

Notes

1. Ken Neubeck, WB2AMU, and Gordon West, WB6NOA, *VHF Propagation, A Practical Guide for Radio Amateurs* (Hicksville, New York: CQ Communications, 2004).

2. Ken Neubeck, WB2AMU, *Six Meters, A Guide to the Magic Band,* revised 2003 (Sacramento, California: WorldRadio Books).

3. Pat Dyer, WA5IYX, VHF Propagation website page: <http://home.swbell.net/pjdyer/index.html>.

4. Tim Havens, W4TRH, "DXers.info" site: <http://www.dxers.info>.

QUARTERLY CALENDAR OF EVENTS

(from page 41)

Electronic submissions in Word, WordPerfect, or text format accepted by e-mail or CD. Usual drawing formats also accepted with paper(s). Cutoff date for inclusion in the *Proceedings* is September 5. Send an e-mail or write to: Chip Angle, N6CA, P.O. Box 35, Lomita, CA 90717-0035; e-mail: <n6ca@ham-radio.com>. Contact Chip as soon as possible with an abstract or a general idea to help the conference plan activities. Details go to: <http://www.microwaveupdate.org.>

Meteor Showers

May: This month's minor showers include the following and their possible radio peaks: *e-Arietids,* May 9, 0700 UTC; May *Arietids,* May 16, 0800 UTC; and *o-Cetids,* May 20, 0700 UTC. This information courtesy the International Meteor Organization and its website at <http://www.imo.net>.

June: Between June 3 and 11, the *Arietids* meteor shower will once again be evident. This is a daytime shower with the peak predicted to occur on June 8th. Activity from this shower will be evident for around eight days, centered on the peak. At its peak you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak. At its maximum it produces around 40 meteors per hour. On June 28 the *Delta Aquarids S* shower is expected to peak. The *Bootids* are expected to make a showing between June 26 and July 2, with a predicted peak on June 27. On June 29 the *Beta Taurids* is expected to peak. Because it is a daytime shower, not much is known about the stream of activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this shower seems to favor a north-south path.

July: This month there are a number of minor showers. The most intense, the *delta-Aquarids,* is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 28.

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1700–1930 UTC August 12.

For more information on these and other meteor shower dates, please see <http://www.imo.net>.

Photo D. The dish is attached to the feed support by a 2" × 2" block.

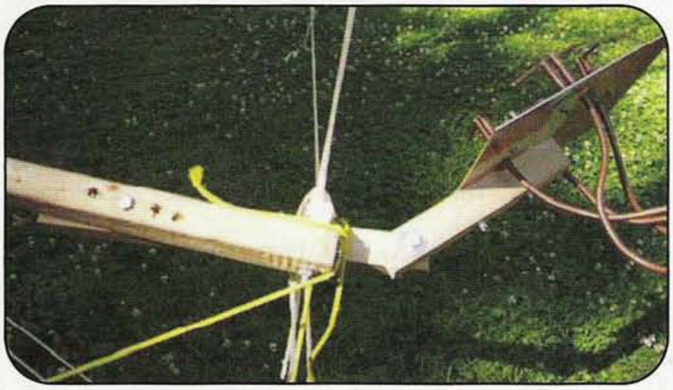


Photo E. The feed is mounted using several supports to allow optimum positioning.

counter this effect, a second 3-foot length of 2" × 3" was added in the direction opposite to the struts and at a right angle to the feed support. The feed support was guyed to this to add support to correct its bending, as shown in photo D. The feed support was also used for attaching the dish to the mount.

Feed Antenna

Orthogonal dual dipoles with a quadrature hybrid to produce circular polarization were used as the feed antenna. Dual dipoles were chosen because of their relatively small size. (An IMU horn would be an excellent choice for a feed antenna but would add significantly to the feed's size and weight). The feed was attached to an about 1-foot length of 2" × 2". This was attached to a second approximately 1.5-foot length of 2" × 2" using a single 3/8-inch bolt, which was in turn attached to the feed support by another single 3/8-inch bolt. Extra mounting holes were drilled in the feed support to allow the position of the feed to be raised or lowered. This arrangement provided several degrees of freedom in adjusting the position of the feed for optimum performance. Feed-mounting details are shown in photo E.

Polar Mount

The offset dish can easily be mounted with a conventional Az-El mount, but also lends itself to polar mounting. Polar

Photo F. The base of the polar mount is made from six 4-foot lengths of 2" × 3" lumber.

Photo G. A 1-inch diameter pipe nipple is used for the polar axis.

mounts have two axes of rotation. The main axis is the polar axis, which is aligned with the North Star. This axis is elevated to an angle equal to the latitude and pointed to true north. The moon can usually be tracked for many hours by changing only the polar axis. This can be advantageous when manually tracking the moon, as is common for portable operation. The other axis is declination. For amateur-size dishes, the declination needs to be set only once a day. It was decided to use a polar mount.

The polar mount was constructed from six 4-foot lengths of 2" × 3" lumber. The centers of two of these lengths were attached to a third length to form a base as shown in photo F.

Bolts and nuts were used to attach the lumber. A hinge was secured to one end of the third length, and the end of a fourth length was attached to the other side of the hinge. Two additional lengths were attached on opposite sides to the other end of the base (third length) using a single long 3/8-inch bolt. These two lengths can be moved up and down. The fourth length is positioned between these two lengths. It can be secured at any desired angle (90° latitude) by bolting the open ends of the two lengths together as shown in photo F.

Photo H. Aluminum screening is tied to the struts using wire.

A 1-inch long, 1-inch diameter pipe nipple was used for the polar axis. This nipple was attached to a short (about 1.5 feet) length of 2" × 3" using a pipe flange, and this short length was attached to the dish's feed support with a single 3/8-inch bolt. The angle between the short length and the feed support is the declination angle of the mount and can be set using the 3/8-inch bolt. The rotation of the pipe flange on the nipple is used for the polar rotation. A second pipe flange was used to attach the other end of the nipple to the polar mount. This second pipe flange is attached near the top to one of the two parallel members of the polar mount as shown in photos F and G.

One of the limitations of this polar mounting arrangement is that the dish cannot rotate through zenith. The mount blocks the dish. The solution to this problem is to unbolt the dish and flip it 180°. This switch takes only a minute or two and allows horizon-to-horizon moon track except the right near zenith.

Covering

The dish is covered with aluminum screening. This material is available in the U.S. in 3-foot wide by 25-foot long rolls, which is sufficient to cover the dish, for relatively low cost. The screening was first rolled over the top of the stressed dish and cut to the required size. The remaining screening was flipped over to match the cut end with the shape of the dish and rolled over the center portion of the dish. This process was repeated a third time for the bottom section (photo H). One of the extra corner pieces from the top was used to cover the small remaining area at the bottom (vertex) of the reflector. The screening is attached to the struts using small gauge (~ #24) wire. The wire is run through the mesh and around the struts and then wrapped (tied) together. The process of attaching the mesh takes only a few minutes. The aluminum mesh can be removed and rolled around the 4-foot 2" × 3" members from the mount during transport/shipping.

Testing

The offset dish was originally constructed in a single weekend for use on a very hastily planned DXpedition to Bermuda. As events turned out, the power amplifier to be used failed two days before departure and plans for 23-cm operation had to be cancelled. I did test the dish for sun noise, however. The dish appeared to work as planned and yielded >8 dB of sun noise. This was >3 dB more than the 15-foot loop Yagi that was to be our backup antenna.

Conclusion

The offset dish described in this article is not considered a final design. It is intended to be a starting point that can be modified and tailored to specific station needs using available materials. It does offer a relatively inexpensive and simple way of obtaining an antenna for portable EME operation on 1296 MHz. It provides performance equivalent to about an 8-foot diameter parabolic dish, yet can be disassembled into a small, lightweight package. ■

Notes

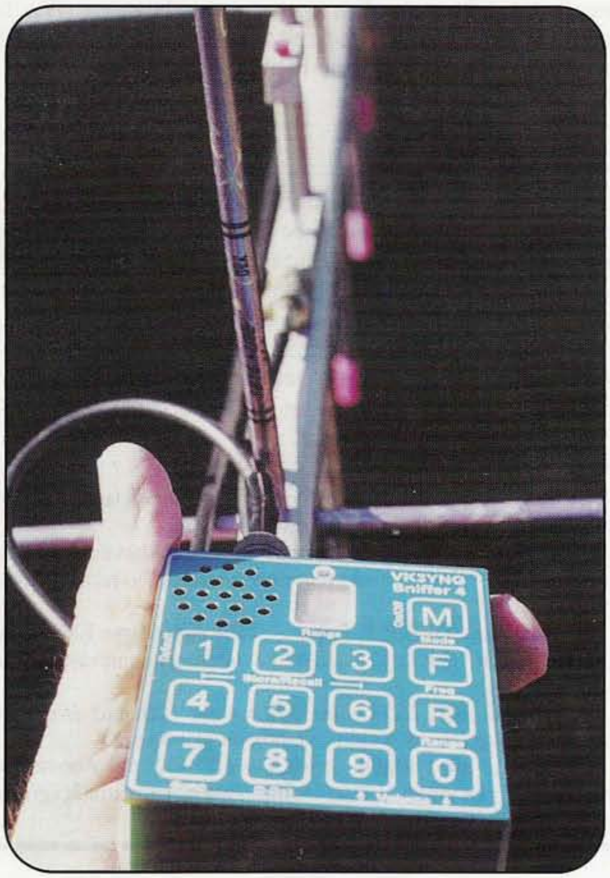
1. A. Katz, "Small Station EME on 70 and 23 cm Using JT44/65"; <http://www.nitehawk.com/rasmit/jt44_50.html>.

2. B. Fritsche, "DL3OCH Report," "432 and Above EME Newsletter," May 2003; <http://www.nitehawk.com/rasmit/NLD/eme0403.pdf>.

3. B. Fritsche, "DL3OCH Report," "432 and Above EME Newsletter," March 2004; <http://www.nitehawk.com/rasmit/NLD/eme0305.pdf>.

4. P. Wade, *W1GHZ Online Microwave Antenna Handbook,* Chapter 5; <http://www.w1ghz.cx/antbook/app-5a.pdf>.

5. A. Katz, "20' Portable Stress Dish," "432 and Above EME Newsletter," October 1980; <http://www.qsl.net/pa3csg/Boek/BoekH3/art3-8.htm>.



The Sniffer with an Arrow antenna.

A peek inside the Sniffer shows all the circuitry contained in this tiny box.

sound of high-frequency interference by tuning into these broadband signals using the Sniffer on 121 MHz AM.

Okay, want more? The #7 sync button is used to synchronize the receiver for use in international-style ARDF (Amateur Radio Direction Finding) foxhunting for a 1-minute-cycle, five-transmitter system. When the sync mode is on, the Sniffer will generate three short beeps, giving a 10-second warning that the current transmitter's cycle is about to end. If the Sniffer is currently receiving at range 1 or lower, at 4 seconds before the completion of the current transmitter cycle the Sniffer will broadcast a number of beeps corresponding to the number of the transmitter in the cycle that is about to commence. The pitch of these beeps is set slightly lower than the 50-second beep. The display also briefly flashes the number of the next transmitter. This way you know where you are in the 5-minute cycle.

In the band-scan mode the Sniffer will hunt for the highest signal between two frequencies stored in memory channels 5 and 6. The highest signal found is stored in Channel 4. The scan will ignore any signals within approximately 10 kHz of the frequency stored for Channel 1, and the signal must be detectable at range 2 or higher to be stored. This is useful when there are many hidden Ts on many different frequencies.

There are many other features in the Sniffer that can make your T-hunting more precise. You can select how fast the rising or falling tone reacts when it goes over scale. You can check to see how long your receiver has been turned on and also double check remaining battery power. The volume control lets you set the volume exactly where you want it, with or without earphones. You can even select four levels of filtering, depending on what mode you are sniffing. In other words, for the expert, advanced ARDF operator the unit has many functions in addition to those a beginner would use.

The Simple Approach

The equipment can also be configured specifically for beginner groups who want simple operation and no problems if they accidentally push a button. That is what we did for our introduction of foxhunting to the Malibu Handi Ham organization last March. We had Handi Ham members quickly finding the hidden Ts. Some were visually impaired. Others had total hearing loss; they went by numbers as well as the feel of the difference in pitch coming out of the small speaker.

Antennas

The three-element Arrow antenna for 2 meters worked great with the Sniffer. Arrow also make a three-element model for 121.5 MHz ELT rescue work. Don't try to use a 146-MHz Arrow antenna on 121.5 MHz, as the frequency span is too far away.

Remember, too, that you can use body-shielding techniques with just a little rubber-duck antenna or a telescoping whip and do the "T-hunt twirl" to find the body null in the direction of the hidden transmitter.

Summary

To learn more about what Bryan Ackerly, VK3YNG, has developed, go to his web page, <http://www.foxhunt.com.au>, or e-mail him at <backerly@bigpond.net.au> and include the word "Sniffer" in the subject line. Bryan is a one-man expert who builds and markets these Sniffers, so give him a couple of days to respond to your questions. Follow his specific details on how to order the Sniffer for overseas shipment to the U.S.

I have exchanged several e-mails with Bryan, and he is a down-to-earth T-hunter who wants to put both fun and new technology into the art of finding the hidden transmitter. As for me, I use the Sniffer for noise detection when I'm not out in the desert at Quartzsite enjoying the fun! ■

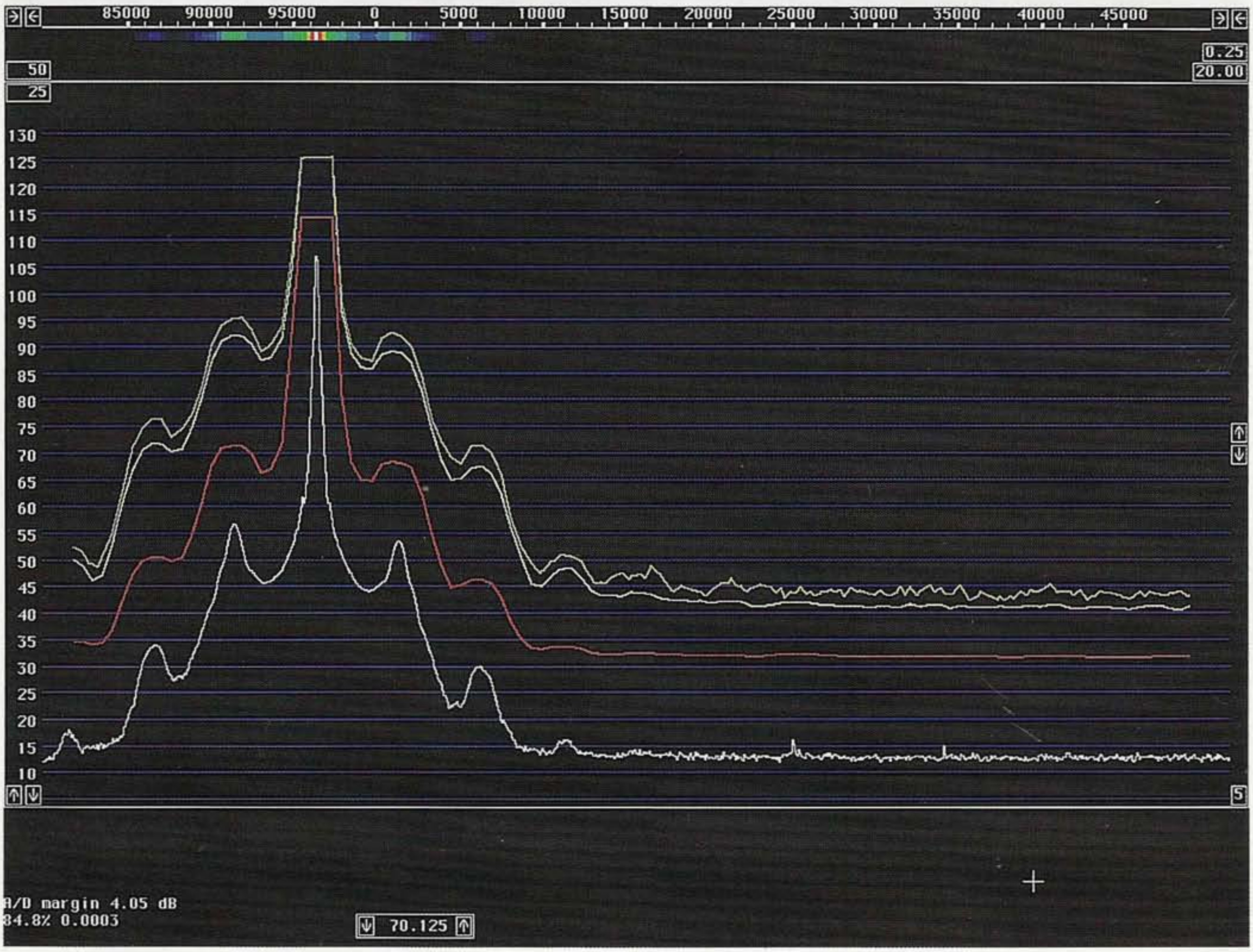


Figure 9. The spectrum of a IC706MKIIG on 14 MHz. The keying speed is 55 Hz and the duty cycle is about 25%. The keying clicks disappear if the key-up time is made very short. The mode is BK with a long delay time to ensure QSK is inactive.

that they should not occur at all! Any observation that they *do* occur is an indication of a design error. Compared to that, whether they are observed in a bandwidth of 1 kHz (2753P), 2.4 kHz (Linrad), or 3 kHz (8651A) is really not very important. This illustrates the difference mentioned earlier between a production or type-acceptance test, and a development or review test. The first needs strict protocols and calibrated equipment. The second does not; it only needs resourcefulness to seek out bad performance caused by design errors, and an unwillingness to accept poor performance.

Keying Waveforms and Key Clicks

To illustrate what this all means I have made some measurements on keyed CW waveforms. Figure 2 shows the time-domain waveform of a keyed signal at 14 MHz, and figure 3 shows the same signal as it looks on the 2753P screen at a resolution bandwidth of 100 Hz.

Figures 2 and 3 were produced with a HP8657A signal generator by feeding the AM modulation input with a square wave through an RC filter. These waveforms are identical to the waveforms that have been presented for many years as "the optimum keying waveform" in the *ARRL Handbook*. This is incorrect, because simple RC shaping is inadequate; good transmitters use much better solutions.[6] The problem is that the keying clicks only decrease by 12 dB each time the frequency offset is doubled. It may not look so bad in figure 3, but the limited dynamic range of a normal spectrum analyzer does not really show what this signal sounds like on the bands . . . the keying sidebands extend on and on. The 2753P spectrum shows the average power in 100-Hz bandwidth, but the peak power is higher—and it increases by 6 dB for a doubling of the bandwidth.

Figure 4 shows the same signal as it looks on the zoomed-in Linrad screen. The keying waveform has the same time for key up as for key down, the separation between the keying clicks is 4.5 ms, and every second pulse is a key down while the ones in between are key up. The key-up pulse and the key-down pulse are equal in amplitude, but they are opposite in phase.

When the FFT spectrum is computed over a long period of time, there will be many pulses within the computation time slot. As a result, one will not see the spectrum of an individual pulse; one will see narrow spectral lines that are separated by the pulse repetition frequency. Every second spectral line is weak, because every second pulse is in antiphase.

Another way of thinking about figure 4 is that it shows the carrier and the mod-

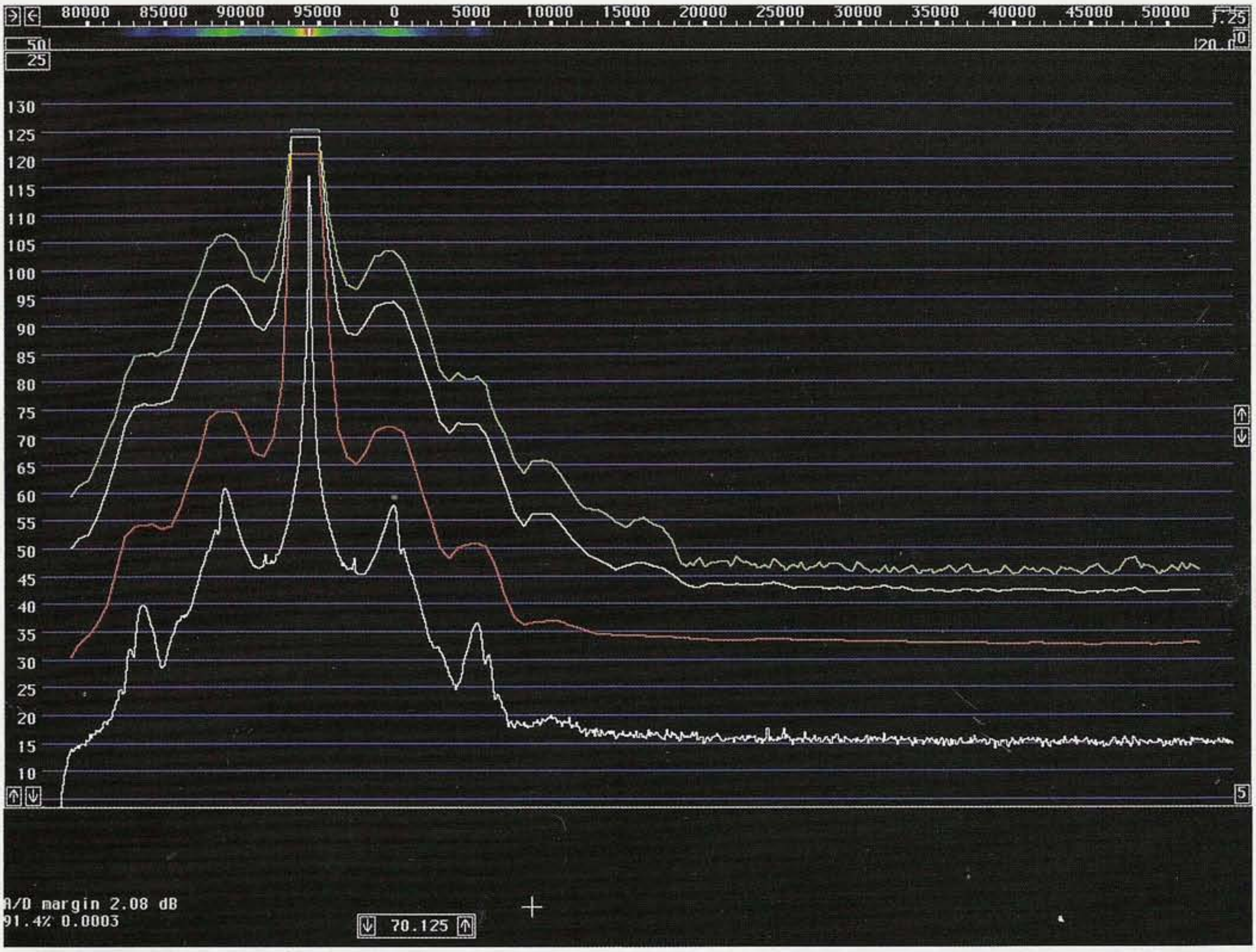


Figure 10. The spectrum of the IC706MKIIG when hand-keyed at 14 MHz in full break-in mode.

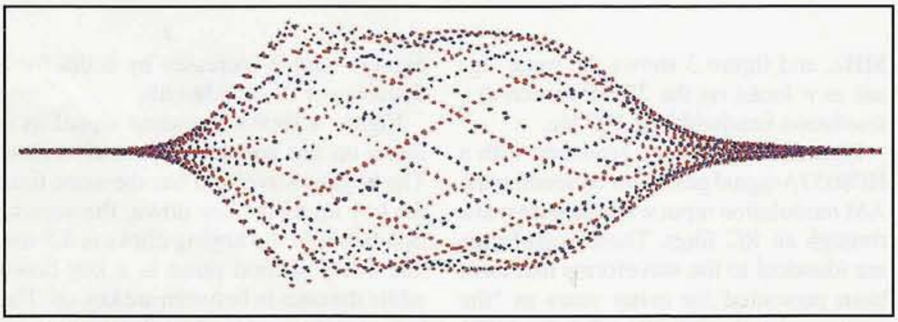


Figure 11. The time-domain function of the IC706 when keyed in full break-in mode. In this mode the ALC loop has to make a large gain adjustment at every key down, as compared to the semi-break-in mode of figure 8, and therefore the amplitude gets modulated by an oscillatory behavior in the ALC loop, corresponding to nearly 15% AM modulation at a frequency of about 5 kHz. This is the cause of the sidebands visible in figure 10.

ulation sidebands of an AM transmitter that is 100% modulated with a square wave that has first been filtered through a single RC time constant. The sidebands are symmetrical, so the keying clicks are equally bad at both sides. The sideband spectrum at each side of the carrier is, of course, the spectrum of the modulating signal, namely the keying waveform. A perfectly symmetric square keying waveform does not have any even harmonics, so as one would expect, the keying sidebands corresponding to even-numbered harmonics of the keying waveform are weaker than those of the odd-numbered harmonics. As expected, the amplitude of the side carriers decrease by 12 dB each time the frequency separation is doubled, because that is the rate at which the overtones to a square wave roll off in a simple RC filter.

When keying at 250 wpm, the 23-dB bandwidth is about 600 Hz according to the *ARRL Handbook.*[7] One-hundred times further out, at 60 kHz, one consequently would expect the level of the keying clicks to be 40 dB lower or at –63 dB relative to the desired signal. This is a terrible QRM level! High-speed CW stations absolutely should not use this primitive RC shaping for keying waveforms!

At lower speeds the keying sidebands are more closely spaced and there are obviously fewer keying clicks in a given time. Also, the sidebands will smear out, and dashes and word spacings will form components of lower frequencies that make the spectrum look very different in high resolution. When the bandwidth of the spectrum analyzer is set wider, several of the keying sidebands will pass through the filter simultaneously. These signals have a particular phase relation and they add to form pulses—one for each make or break of the Morse code. In a wide bandwidth, the spectrum does not depend on what is being keyed. The average noise level created is simply proportional to the keying rate (the number of clicks per second), but the peak noise level is independent of the keying rate. Each key up or key down is a separate event that produces a wide-spectrum pulse that is unaffected by other keying events.

Figure 5 shows the Linrad screen in "TX test mode." This is a mode I added to Linrad in order to have all the transmitter measurements done simultaneously. Here one can see the average spectrum and the peak hold spectrum at the same time. There is also an averaged peak spectrum with a time constant of about 1 second. Transmitters occasionally may emit short splatter bursts depending on the modulating voice. The peak hold will just go to the peak value the first time, and one will not see how often it happens unless the reset button is pressed each time. The averaged peak spectrum with a 1-second time constant shows these splatter bursts well, and it helps to find out how to speak into the microphone to make them really bad. One can then record the average and the peak hold spectra for evaluation in a worst-case situation.

As can be seen in figure 5, the peak power of the keying clicks is 87 dB below the peak power at a frequency separation of 50 kHz, while the average power is 98 dB below the peak power. The bandwidth is 2.4 kHz, so the average interference power is –132 dBc/Hz. The reason for much better results than expected as shown in figure 11 in the *ARRL Handbook*[7] is that the keying for this test is far softer than one would use in real life at a dot rate of 110 Hz (132 wpm, 660 lpm).

This dot rate used in figures 2 to 5 is quite realistic for CW meteor scatter, but such a high speed was chosen primarily to allow both the rising and the falling edges to be seen in detail in figure 2 and to make the spectral lines well separated in figures 3 and 4.

The *ARRL Handbook* claims that the simple RC filter used here would be appropriate for keying rates on the order of 30 wpm if it were implemented in an amateur transmitter. However, the discussion of figures 2 to 5 shows that keying a transmitter like this is not acceptable. Using a simple RC filter at high keying speeds will cause excessive and completely unnecessary bandwidth and too much interference to fellow amateurs. At a modest keying speed the time constants can be made five times longer and then the spectrum will be five times narrower, so the keying clicks will produce an average power level of –132 dBc/Hz at a frequency separation of 10 kHz. This is similar to normal sideband noise levels, so it would not be a problem if the keying were perfect otherwise.

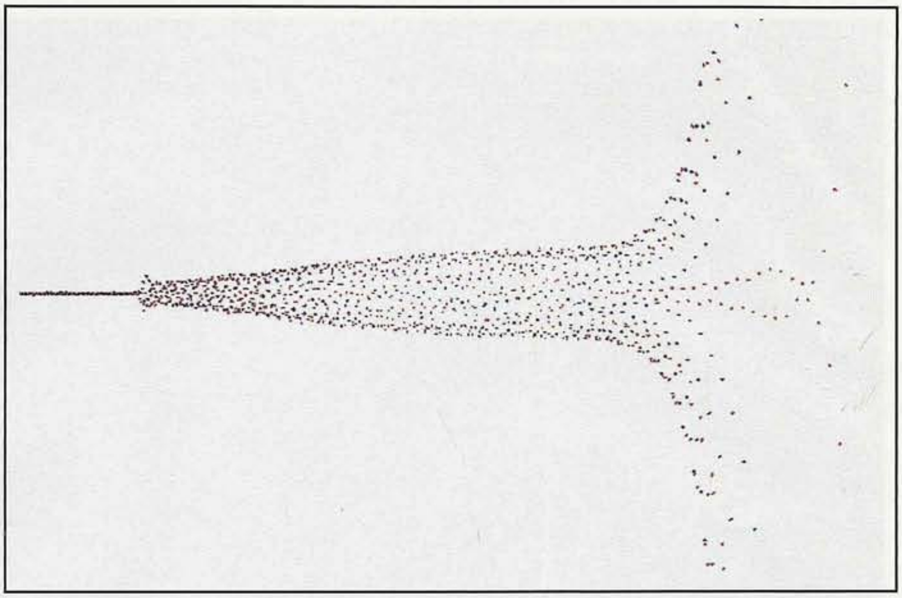


Figure 12. The onset of the keying waveform in full break-in mode for the IC706MKIIG at 14 MHz. The magnification is 40 dB relative to figure 11.

There is still another problem, however: The output RF voltage has to follow the keying voltage strictly proportionally all the way from zero. Any non-linearity will increase the bandwidth. In a typical form of non-linearity, the output voltage to the antenna will be zero, not only for zero keying voltage; it will stay zero for small values of keying voltage and only then start to grow linearly. The output is identical to the output that would be obtained from a perfect AM modulator that is fed from a non-linear amplifier with distortion at the onset of the waveform. This is similar to cross-over distortion in audio amplifiers, which creates harmonics of modest amplitudes but extending to a high order. In other words, this kind of non-linearity will increase the levels of the keying clicks, particularly at large frequency separations. A similar effect can be obtained by feeding a keyed signal through unkeyed class C amplifiers. Considering the levels of high-order suppression for sidebands required in amateur radio, all of these effects are significant.

A good linear relationship between the voltage output from the keying filter and the RF voltage at the antenna therefore is very important. I have discussed the shortcomings of the simple RC filter in detail so that you can understand the basic problems. What you see in figures 2 to 5 is real-life data produced by actually keying an RF signal. The theory, of course, is well known and predicts exactly what one can see from the figures. A detailed theoretical treatment is presented in Kevin Schmidt, W9CF's article "Spectral Analysis of a CW Keying Pulse."[8] The very basic facts are as follows: *Each individual key-up and key-down transition generates a full-amplitude, full-spectrum click. The only thing that is "worse" about HSCW is that there are simply more clicks.* The meaning of "full-spectrum" here is, of course, the full frequency response of the keying filter, mirrored around the carrier, and broadened by any distortion due to the non-linearities between the keying waveform and the RF-output voltage waveshape.

The problem with using very-high-speed CW for meteor scatter is that one has to modify the keying circuits for much shorter time constants in order to have any keying at all, thereby making the rig awful at *all* keying speeds. To avoid this it may be much better to key

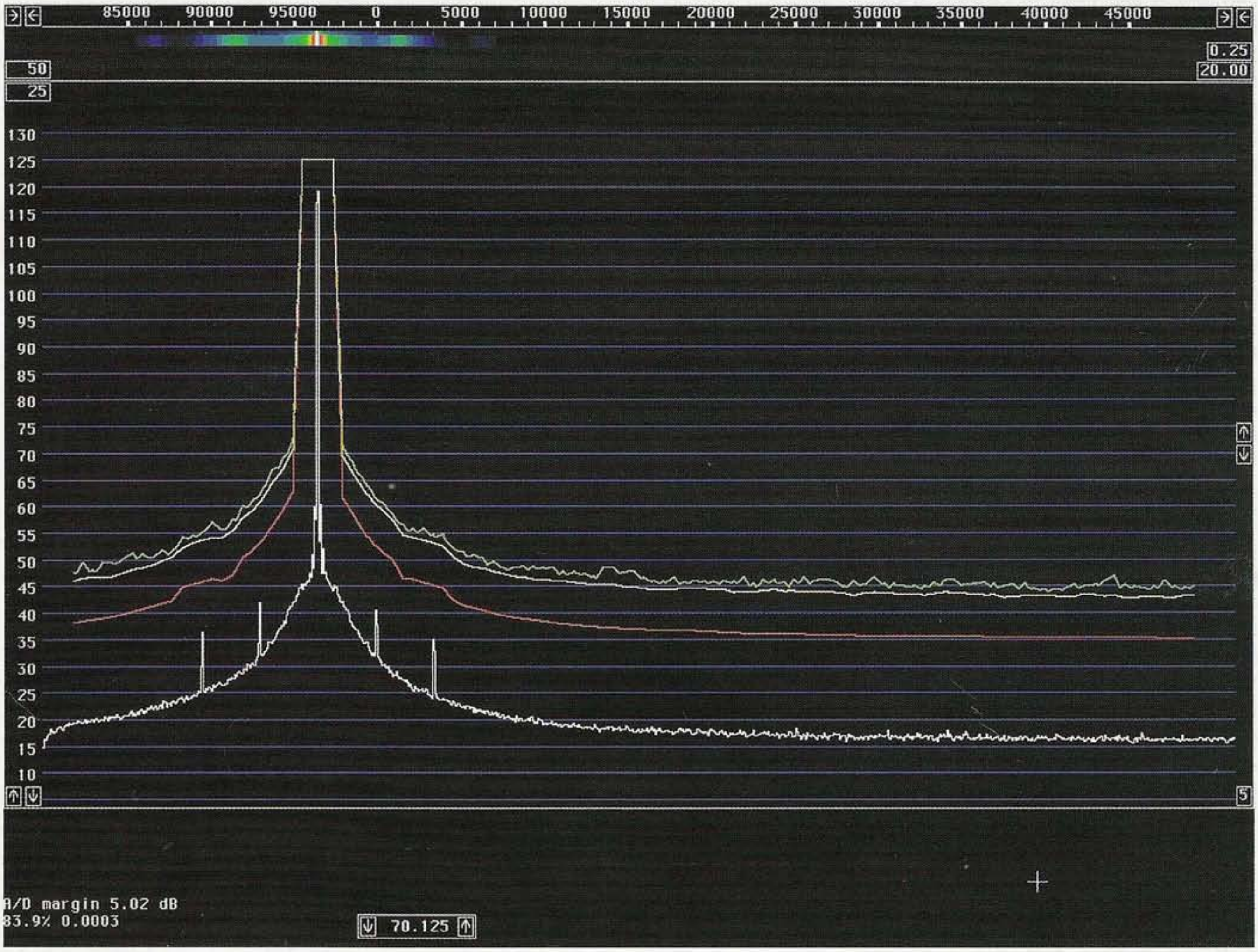


Figure 13. The IC706MKIIG without keying on 14 MHz, for comparison with figures 9 and 10.

an audio tone and feed it into the SSB microphone input. The SSB filter will then limit the bandwidth to 1.8 kHz. By setting the drive level properly so that ALC circuits do not distort the waveforms, one can produce excellent HSCW.

It is not necessary to look at both the time domain and the frequency domain to decide if the keying is okay or not. One can look at either the time domain in figure 2 or the frequency domain in figure 4. Both of them contain all the information, because both are generated from the same RF signal and one is the Fourier transform of the other. (A few details here: Actually, the time function is the backwards transform of the frequency spectrum, but forward and backward transforms differ only in the phase. Otherwise it is the same algorithm. Also, figure 4 is not really the Fourier transform; it is the power spectrum of the transform, but the relevant information is still there.)

A signal that is wide in the frequency domain is narrow in the time domain and vice versa. The width in the time domain is the width of the envelope; the sinewave under the envelope gives the frequency of the signal, which gives the peak position in the frequency domain. The Fourier transform is a linear transformation, which means that a signal can be split into several parts that sum up to the signal itself. The sum of the Fourier transforms of all the parts will then sum up to the transform of the total signal. A single Morse code transition like the rising edge in figure 2 has a spectrum that looks like a line that joins all the peaks of the spectral lines in figure 4 but with smaller amplitude. When the Fourier transforms of many such individual transitions are summed, the phase of all of them will be equal at frequencies corresponding to frequency offsets that are multiples of the repetition rate. At frequencies in between the contributions from the different pulses cancel because they have opposite phases. As explained in W9CF's "Spectral Analysis of a CW Keying Pulse"[8] the width of the time function is the width of the transition from on to off or off to on. The length of the key-down and key-up periods will only affect the repetition rate and the spacing of the sidebands in the frequency domain.

An exponential RC-generated rise time such as in figure 2 gives a spectrum that rolls off by 12 dB per octave. However, the optimum shape of the pulse for a Morse code dot is a Gaussian. The Gaussian shape is special, because it is the mathematical function that minimizes the width simultaneously in both the time domain and the frequency domain; the Fourier transform of a Gaussian is another Gaussian. (This is why the HP8591A uses Gaussian filters. They allow the fastest possible sweep without loss of amplitude accuracy. The TEK2753P with its more rectangular filters has to sweep more slowly, but it allows much better viewing of weak signals close to a strong one.) For a single transition, key down or key up, the optimum shape is a Gaussian "error function." This is an S-shaped function that avoids the sudden transitions and will produce a Gaussian spectrum shape with the fastest possible roll-off—10 dB per 30-Hz increase in the frequency separation at typical amateur keying speeds. (For details see note 8, equation 20, and figure 5.)

Modern rigs typically generate CW by keying a signal which is then passed through the SSB filter, and therefore the keying clicks should not reach outside the bandwidth of the SSB filter. This is one way of producing nearly ideal rise and fall waveforms. One example is the ICOM IC706MKIIG, which generates the waveform of figure 6 on 144 MHz when keyed at 55 Hz. A comparison with figure 2 immediately shows that this keying is much better. The envelope looks like the output of a higher-order filter, and it does not have the steep onset of a square wave filtered through an RC filter.

The spectrum of the keyed IC706MKIIG corresponding to figure 6 is shown in figure 7. In a comparison between the keyed spectrum and the continuous carrier of this station, one can find that the interference level from the keyed rig is below the interference of the unkeyed carrier at frequency separations above 700 Hz.

That is the point where the keying clicks disappear into the sideband noise of the unkeyed carrier. Note that the keying sidebands fall off at a rate of about 12 dB for every 200 Hz, while the simple RC filter gives sidebands that fall off by about 12 dB for a doubling of the frequency separation. At large frequency separations this makes a big difference, and the keying spectrum of figure 8 is much narrower than the spectrum of figure 4, by much more than the factor of 2 that would be produced by the simple difference in time constants.

It is quite clear that excellent keying is possible—very low keying clicks in combination with a waveshape that sounds sharp and clear and also has the potential to go to high keying speeds. The simple RC filter belongs to the era of cathode-keyed vacuum tubes; there is no reason

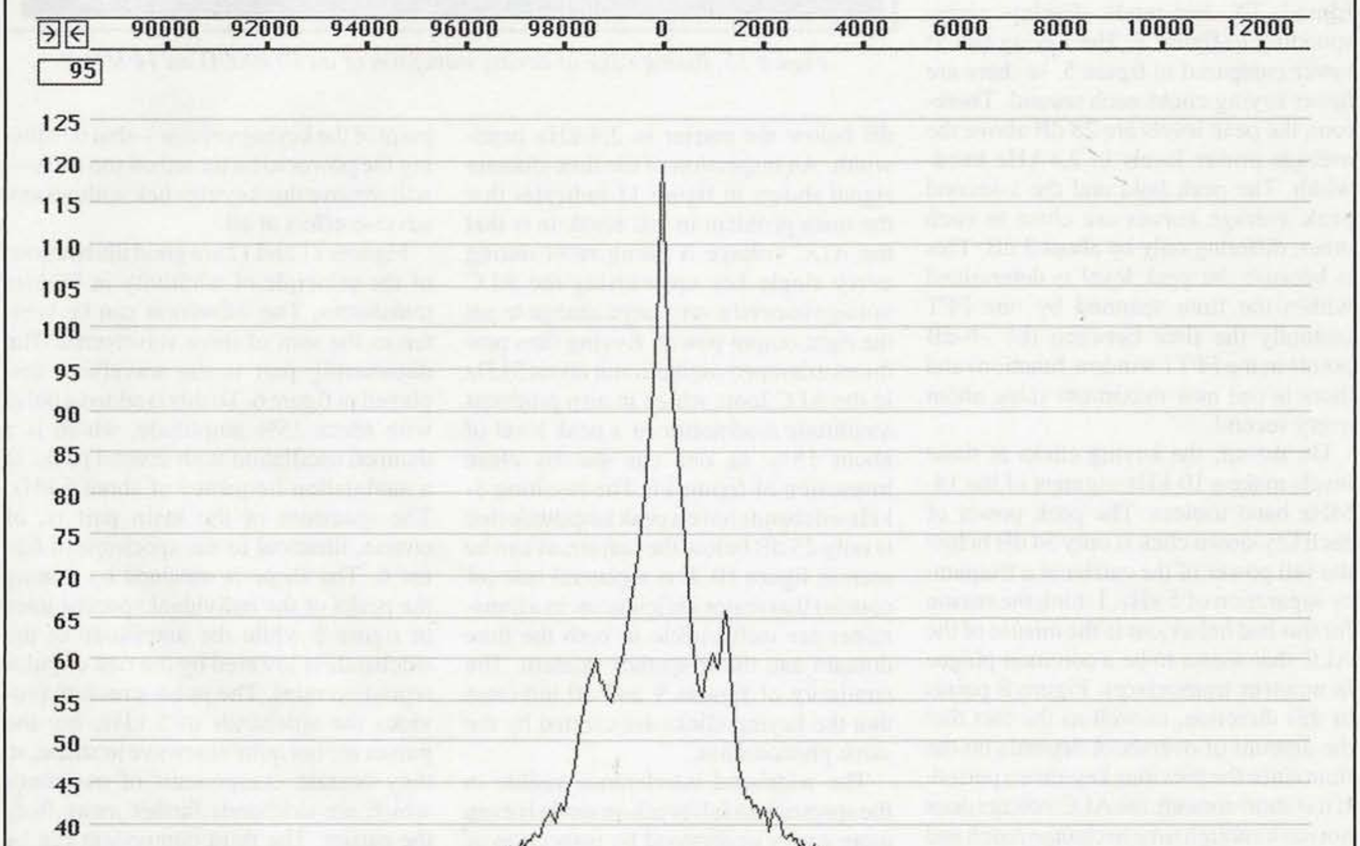


Figure 14. Expanded average-power spectrum of a keyed FT1000D on 14 MHz. The keying is 50% duty with 25 dots/sec. The FFT bandwidth is 50 Hz.

to use such a primitive filter in modern equipment—no reason, that is, except for poor design.

Effects of ALC

The discussion about CW waveforms up to this point was intended to show principles of normal keying. In the real world there are additional complications. Figures 8 and 9 show the time-domain waveform and the spectrum of the same IC706MKIIG when it is keyed on 14 MHz. One clearly can see something happen that reduces the output power, after it has risen above the steady-state value it will have during most of the key-down time. Most probably this is the ALC setting the power at the desired level, but with some overshoot.

The spectrum shown in figure 9 is the Linrad TX test-mode display corresponding to figure 8. The keying rate is lower compared to figure 5, so there are fewer keying clicks each second. Therefore, the peak levels are 25 dB above the average power levels in 2.4-kHz bandwidth. The peak hold and the 1-second peak average curves are close to each other, differing only by about 3 dB. This is because the peak level is determined within the time spanned by one FFT (actually the time between the –6-dB points in the FFT1 window function) and there is one new maximum value about every second.

On the air, the keying clicks at these levels make a 10-kHz segment of the 14-MHz band useless. The peak power of each key-down click is only 34 dB below the full power of the carrier at a frequency separation of 5 kHz. I think the reason for this bad behaviour is the misuse of the ALC that seems to be a common plague in amateur transceivers. Figure 8 points in this direction, as well as the fact that the amount of overshoot depends on the time since the previous key-down period. If it is short enough, the ALC voltage does not have enough time to change much and therefore the gain adjustment becomes very small each time a new pulse arrives.

The keyed waveform of the IC706MKIIG in full break-in mode is much worse than that shown in figures 8 and 9. The spectrum is shown in figure 10. This level of keying clicks is not acceptable at all. Not only is the close-range interference level worse than in normal (semi-break-in) mode, there is also a wideband component with a flat spectrum that has peak power levels 75 dB below the carrier in 2.4-kHz bandwidth. An inspection of the time-domain signal shown in figure 11 indicates that the main problem in full break-in is that the ALC voltage is being reset during every single key up, causing the ALC voltage to need a very large change to get the right output power. Keying then produces a damped oscillation at about 5 kHz in the ALC loop, which in turn produces amplitude modulation at a peak level of about 15%, as one can see by close inspection of figure 11. The resulting 5-kHz sidebands have a peak amplitude that is only 23 dB below the carrier, as can be seen in figure 10. It is a general rule (of course) that major deficiencies in a transmitter are well visible in both the time domain and the frequency domain. The similarity of figures 9 and 10 indicates that the keying clicks are created by the same phenomenon.

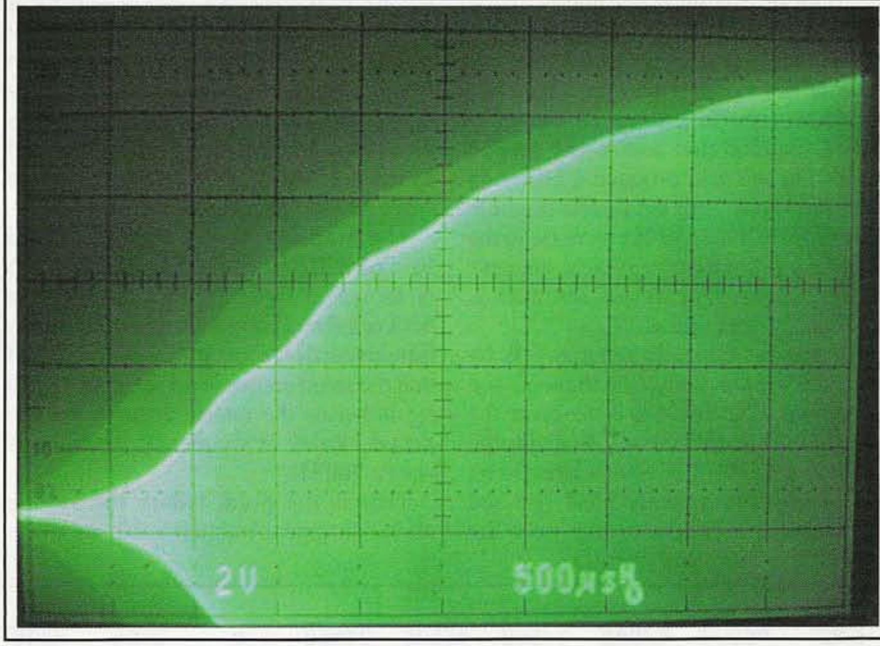


Figure 15. Rising edge of keying waveform of an FT1000D on 14 MHz.

The wideband interference visible in the spectrum in full break-in mode is even more easily understood by inspection of figure 12, which shows the time-domain function at the start of every dot or dash, magnified by 40 dB relative to figure 11. At the moment when the antenna relay contact switches the antenna to the TX, the dot/dash has already started and the power is already at about –70 dB relative to full power. The cure for this problem is easy. The keying is obviously done in at least two stages and they do not have their zero points at the same point on the keying waveform. Just changing the zero point of the keying voltage—that is, causing the power to be turned on too early—will remove this keying click without any adverse effect at all.

Figures 11 and 12 are good illustrations of the principle of additivity in Fourier transforms. The waveform can be written as the sum of three waveforms. The dominating part is the waveform displayed in figure 6. To this is added a pulse with about 15% amplitude, which is a damped oscillation with several peaks at a modulation frequency of about 5 kHz. The spectrum of the main part is, of course, identical to the spectrum of figure 6. The shape is obtained by joining the peaks of the individual spectral lines in figure 6 while the amplitude of the sidebands is lowered by the rate of pulse repetition rates. The pulse structure provides the sidebands at 5 kHz, but the pulses are not quite sinewave in shape, so they contain components of overtones which are sidebands farther away from the carrier. The third component can be seen in figure 12 only. It is a small pulse with very short risetime. The risetime is probably much shorter than one can see in figure 12, because the display is limited by the bandwidth of the Linrad system. This pulse gives a click that has the same amplitude over the entire spectral range, and it is this component of the total waveform that is responsible for the wideband clicks.

When looking at a waveform in the time domain, the bad part is any place where the second derivative of the envelope is large—in other words, any place where there is a sharp corner. Such places occur at the onset of both key up and key down in the simple RC-shape keying shown in figure 2, but there are no such points in the much better waveshape of figure 6. Large second derivatives may also occur when an amplifier saturates or when the transmitter gain is changed abruptly because of ALC action. Badly designed QSK is another source of large second derivatives, as we see in figure 12.

Figure 13 is a reference spectrum at 14 MHz for the unmodulated IC706MKIIG used for this article. It is neither especially good nor bad, –122 dBc/Hz at 20 kHz, but the difference in the spectra when the carrier is keyed is horrible. On 144 MHz, on the other hand, there is no visible difference between the keyed and the unkeyed spectrum at frequency separations above about 700 Hz, as was pointed out in the discussion of figure 8.

Another transceiver that has a poor reputation for key clicks is the FT-1000 range of transceivers. As often happens with such problems, opinions range from "All [models of] FT-1000 as shipped from the factory click excessively and needlessly" to the complete opposite—denial that any such problem exists. As seen with the eyes of a VHF weak-signal enthusiast, the FT1000 is not so bad, but on crowded HF bands the keying clicks present a real problem to fellow amateurs.

It is (like always) not difficult to adjust components for reasonable rise and fall times. Modifications, sound-clips, and composite spectra of these transceivers before and after modifications can be found on the Internet.[9–11] It seems as if normal variations in component parameters and perhaps other differences cause some difference in rise and fall times for the FT1000 range of transceivers. The unmodified FT1000D I used for this article has a somewhat softer keying compared to that used in reference 9.

The peak hold spectrum in 2.4-kHz bandwidth is excellent, but the high-resolution average-power spectrum reveals clicking sidebands at ±1.2 kHz from the carrier as can be seen in figure 14.

The sidebands are caused by AM modulation on the rising edge, something that is well visible on the oscilloscope, as can be seen in figure 15.

As can be seen from figure 15, the AM modulation starts at an amplitude corresponding to about 5% of the full carrier amplitude. This means that the modulation sidebands at Y' 1.2 kHz appear at about 30 dB below key-down power. The AM modulation lasts about 2 ms, which is 5% (–13 dB) of the keying period time. One therefore would expect the keying click sidebands at –43 dB in a 500-Hz wide filter. In the frequency domain, figure 14, the level is about –60 dB in 50-Hz bandwidth in fair agreement with this rough estimate. At frequency separations above 1.8 kHz there are no key clicks at all, only the carrier sideband noise, which is 50% below its normal level due to the keying at 50% duty.

The 1.2-kHz keying click sidebands of the FT1000D are not at all affected by the ALC. These sidebands are produced by AM modulation in the keying circuitry and the spectrum does not change when the output power is reduced. ■

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.
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>

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Blame It on Rio

"I think I'm seeing something," the intrepid Argonaut† stated on the closed signal verification e-mail list, and then proceeded to post a string of numbers representing date, time, right ascension, declination, frequency, and amplitude. "Anybody care to confirm?"

For a day and a half the e-mails flew freely, with half a dozen amateur radio telescopes trained on the same slice of sky, seeking a consensus. Ultimately, I was asked to proffer an opinion. "On a scale of zero to ten," I confidently proclaimed, "we can give this one a three."

An arbitrary attempt at quantification? Hardly! I was rating a detection on the Rio Scale, SETI's newest metric for assessing the importance of any claimed detection. It's my hope we will join our professional colleagues around the world in making the Rio Scale our measurement standard.

The Rio Scale is an ordinal scale between zero and ten used to quantify the impact of any public announcement regarding evidence of extraterrestrial intelligence. The concept was first proposed in Rio de Janeiro, Brazil (hence its name) by Ivan Almár and Jill Tarter in a paper presented at a major SETI meeting in October 2000. Under their leadership, members of the International Academy of Astronautics worked for two years to refine and perfect the Rio Scale in order to bring some objectivity to the otherwise subjective interpretation of any claimed extraterrestrial intelligence detection.

The Rio Scale was officially adopted by the international SETI community at the October 2002 World Space Congress in Houston, Texas. Within a month The SETI League was applying it to amateur observations. By December we had used it to discredit a blatant hoax. If it continues to catch on as well as the Richter Scale has for earthquake severity, then the public will have little doubt as to the importance of future SETI detections.

Anyone can do a Rio Scale analysis of any SETI signal detection, be it current, historical, or hypothetical. One merely needs to answer four questions about the class of the reported phenomenon, the type of discovery, the estimated distance to the source of the phenomenon detected, and the credibility of the person or organization reporting the data. Crunching the resulting numbers yields a single integer, zero to ten, which we can then report to one another and to the press.

If you have access to the internet with a JavaScript-enabled browser, you are invited to try your hand at an interactive Rio Scale Calculator. Browse to <http:// iaaseti.org> and follow the Rio Scale links. Radio buttons enable you to quickly enter the particulars of the detection being analyzed. The calculator software computes the resulting Rio Scale value for the event under study. Members of the scientific community and the press can use this tool for estimating Rio values during analysis of SETI candidate events, and are encouraged to assign Rio Scale values in quantifying their estimates of the importance of any reputed detection.

Rio	Importance
10	Extraordinary
9	Outstanding
8	Far-reaching
7	High
6	Noteworthy
5	Intermediate
4	Moderate
3	Minor
2	Low
1	Insignificant
0	None

The Rio Scale is an ordinal scale between zero and ten used to quantify the impact of any public announcement regarding evidence of extraterrestrial intelligence. Each numeric Rio Scale value correlates to a subjective measure of an event's importance, from None to Extraordinary.

The Rio Scale is a tool for dynamic, rather than static, analysis. Throughout the life of any candidate SETI event, as research is conducted and verification measures pursued, new information is constantly being made available which will impact our perceptions as to the significance and credibility of the claimed detection. Thus, the Rio Scale value assigned to any SETI detection can be expected to change significantly (either upward or downward) over time. In the case of the Project Argus detection already cited, during the course of a week's observations the assigned value slid from three down to zero, when the source of the signal was finally traced to terrestrial interference.

This one wasn't ET calling home—but it might have been. When "The Call" is finally intercepted and we assign it a high Rio Scale value, I'm willing to bet the detection will have been made by a SETI League member. 73, Paul, N6TX

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†A participant in Project Argus, The SETI League's all-sky survey.

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