ISSN 1085-0708

CQ VHF

Ham Radio Above 50 MHz

www.cq-vhf.com

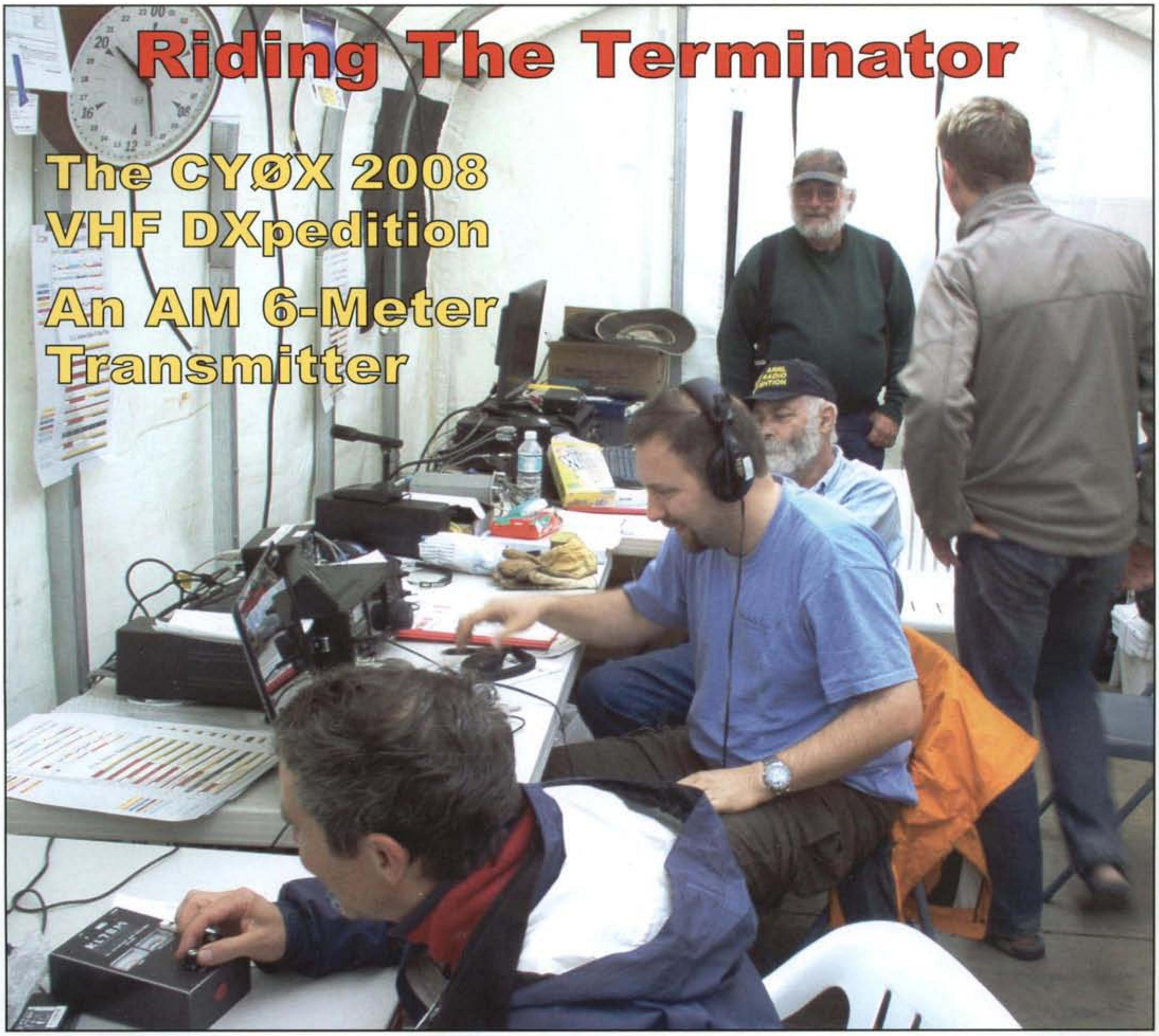
Winter 2009

$7.50

Riding The Terminator

The CYØX 2008 VHF DXpedition

An AM 6-Meter Transmitter



■ VHF/UHF Weak Signal ■ Projects
■ Microwaves ■ Packet Radio
■ Repeaters ■ Amateur Satellites
■ Interviews ■ Plus...Reviews, Product News, and much more!

D-STAR:
CONNECT ACROSS MILES INSTEAD OF METERS!

ANALOG + DIGITAL
All in one!

D-STAR optional

IC-2820H & UT-123

D-STAR UPGRADEABLE 2m & 70cm & GPS MODULE AND ANTENNA

- 50/15/5 Watt Output Power
- RX: 118-173.995, 375-549.995, 810-999.99MHz**
- Analog/Digital Voice with GPS (Optional UT-123)
- 500 Alphanumeric Memory Channels
- Diversity Receive Capable

DIGITAL

D-STAR ready

IC-92AD & HM-175GPS

MILITARY RUGGED AND SUBMERSIBLE

- 5/2.5/0.1 Watt Output Power
- RX: 0.495-999.990MHz**
- Shown with Optional GPS Speaker Mic (HM-175GPS)
- 1304 Alphanumeric Memory Channels
- IPX7 Submersible*

ANALOG + DIGITAL
All in one!

ID-RP2C
REPEATER CONTROLLER

The cornerstone of the D-STAR system. Handles up to four RF modules. Basic in-band or cross-band operation. Linking capabilities through the internet and future 10GHz backbone products.

ID-RP2D
1.2GHZ DATA MODULE

Access point with a data rate of up to 128kbps. Depending on the system setup, set up an email and/or file server for EmComm support. Perfect for web applications or support via internet connection.

ID-RP2V
1.2GHZ DIGITAL VOICE MODULE

ID-RP2000V
2M DIGITAL VOICE MODULE

ID-RP4000V
70CM DIGITAL VOICE MODULE

Finally, commercially available crossband systems! Together, with proper call sign programming in any D-STAR compatible mobile or portable, the Icom D-STAR system will automatically route your signal to any other RF module connected to a common RP2C. With simple system commands, you can direct your communications through any of the RF modules or across the world via the gateway.

Visit your Icom dealer today!
Free literature: 425.450.6088
or www.icomamerica.com

*IP-X7: tested to work after being under 1 meter of water for 30 minutes.
**Frequency coverage may vary. Refer to owner's manual for exact frequency specs.

ICOM

12 STORE BUYING POWER

HAM RADIO OUTLET®

WORLDWIDE DISTRIBUTION

D-STAR EXPERTS!

World's LARGEST HAM RADIO INVENTORY In stock for quick delivery

DISCOVER THE POWER OF DSP WITH ICOM!

IC-706MKIIG All Mode Transceiver

• Proven performance • 160-10M*/6M/2M/70CM • All mode w/DSP • HF/6M @ 100W, 2M @ 50W, 440 MHz @ 20W • CTCSS encode/decode w/tone scan • Auto repeater • 107 alphanumeric memories

IC-7000

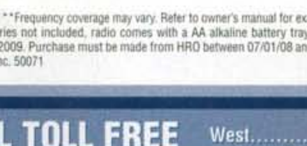
• 160-10M/6M/2M/70CM • 2x DSP • Digital IF filters • Digital voice recorder • 2.5" color TFT display

IC-718 HF Transceiver

• 160-10M* @ 100W • 12V operation • Simple to use • CW Keyer Built-in • One touch band switching • Direct frequency input • VOX Built-in • Band stacking register • IF shift • 101 memories

IC-V8000 2M Mobile Transceiver

• 75 watts • Dynamic Memory Scan (DMS) • CTCSS/DCS encode/decode w/tone scan • Weather alert • Weather channel scan • 200 alphanumeric memories



ID-800H Digital Dual Band Mobile

• 55 watt VHF/50 watt UHF • Wide RX: 118-173, 230-549, 810-999 MHz (cellular blocked on US versions) • Analog/Digital Voice & Data • Callsign squelch • CTCSS & DTCS Encode/Decode w/tone scan

IC-7800 All Mode Transceiver

• 160-6M @ 200W • Four 32 bit IF-DSPs+ 24 bit AD/DA converters • Two completely independent receivers • +40dBm 3rd order intercept point

IC-756PROIII All Mode Transceiver

• 160-6M • 100W • Adjustable SSB TX bandwidth • Digital voice recorder • Auto antenna tuner

IC-7700 Transceiver. The Contester's Rig

• HF + 6m operation • +40dBm ultra high intercept point • IF DSP, user defined filters • 200W output power full duty cycle • Digital voice recorder

IC-2200H 2M Mobile Transceiver

• 65W Output • Optional D-STAR format digital operation & NEMA compatible GPS interface • CTCSS/DTCS encode/decode w/tone scan • 207 alphanumeric memories • Weather alert

IC-92AD Analog + Digital Dual Bander

• 2M/70CM @ 5W • Wide-band RX 495 kHz - 999.9 MHz** • 1304 alphanumeric memories • Dualwatch capability • IPX7 Submersible*** • Optional GPS speaker Mic HM-175GPS

IC-746PRO All Mode 160M-2M

• 160-2M* @ 100W • 32 bit IF-DSP+ 24 bit AD/DA converter • Selectable IF filter shapes for SSB & CW • Enhanced Rx performance

New! IC-7200 HF Transceiver

• 160-10M • 100W • Simple & tough with IF DSP • AGC Loop Management • Digital IF Filter • Digital Twin PBT • Digital Noise Reduction • Digital Noise Blanker • USB Port for PC Control

IC-2820H Dual Band FM Transceiver

• D-STAR & GPS upgradeable 2M/70CM • 50/15/5W RF output levels • RX: 118-173.995, 375-549.995, 810-999.99 MHz**

IC-T90A Triple Band Transceiver

• 6M/2M/70CM @ 5W • Wide-band RX 495 kHz - 999.999 MHz**

IC-91AD Digital Dual Band Transceiver

• 2M & 70CM @ 5W • Independent (dual watch) wide-band RX 495 kHz - 999.999 MHz** • Compliments the ID-800H mobile

IC-V82 2M Transceiver

2M @ 7W • CTCSS/DTCS encode/decode w/tone scan • Also available in a sport version and a 70CM version (IC-U82)

*Except 60M Band. **Frequency coverage may vary. Refer to owner's manual for exact specs. ***Tested to survive after being under 1m of water for 30 minutes. *ᴬAA Alkaline batteries not included, radio comes with a AA alkaline battery tray. *ᶠFor shock and vibration. ✦Icom rebate promotion offers guaranteed through March 31, 2009. Purchase must be made from HRO between 07/01/08 and 3/31/09. Contact HRO for details. CQ FEB 09. The Icom logo is a registered trademark of Icom Inc. 50071

ICOM®

CALL TOLL FREE

Phone Hours: 9:30 AM – 5:30 PM
Store Hours: 10:00 AM – 5:30 PM Closed Sun.

Toll free, incl. Hawaii, Alaska, Canada; call routed to nearest store; all HRO 800-lines can assist you, if the first line you call is busy, you may call another.

West............800-854-6046
Mountain......800-444-9476
Southeast......800-444-7927
Mid-Atlantic...800-444-4799
Northeast......800-644-4476
New England..800-444-0047

Look for the HRO Home Page on the World Wide Web
http://www.hamradio.com

#1 in Customer Service

AZ, CA, CO, GA, VA residents add sales tax. Prices, specifications, descriptions, subject to change without notice.

ANAHEIM, CA
(Near Disneyland)
933 N. Euclid St., 92801
(714) 533-7373
(800) 854-6046
Janet, KL7MF, Mgr.
anaheim@hamradio.com

BURBANK, CA
1525 W. Magnolia Bl., 91506
(818) 842-1786
(800) 854-6046
Eric, K6EJC, Mgr.
Magnolia between S. Victory & Buena Vista
burbank@hamradio.com

OAKLAND, CA
2210 Livingston St., 94606
(510) 534-5757
(800) 854-6046
Mark, WI7YN, Mgr.
I-880 at 23rd Ave. ramp
oakland@hamradio.com

SAN DIEGO, CA
5375 Kearny Villa Rd., 92123
(858) 560-4900
(800) 854-6046
Tom, KM6K, Mgr.
Hwy. 163 & Claremont Mesa
sandiego@hamradio.com

SUNNYVALE, CA
510 Lawrence Exp. #102
94085
(408) 736-9496
(800) 854-6046
Dan, K6DN, Mgr.
So. from Hwy. 101
sunnyvale@hamradio.com

NEW CASTLE, DE
(Near Philadelphia)
1509 N. Dupont Hwy., 19720
(302) 322-7092
(800) 644-4476
Jim, KJ3N, Mgr.
RT.13 1/4 mi., So. I-295
delaware@hamradio.com

PORTLAND, OR
11705 S.W. Pacific Hwy.
97223
(503) 598-0555
(800) 854-6046
Leon, W7AD, Mgr.
Tigard-99W exit from Hwy. 5 & 217
portland@hamradio.com

DENVER, CO
8400 E. Iliff Ave. #9, 80231
(303) 745-7373
(800) 444-9476
John N5EHP, Mgr.
denver@hamradio.com

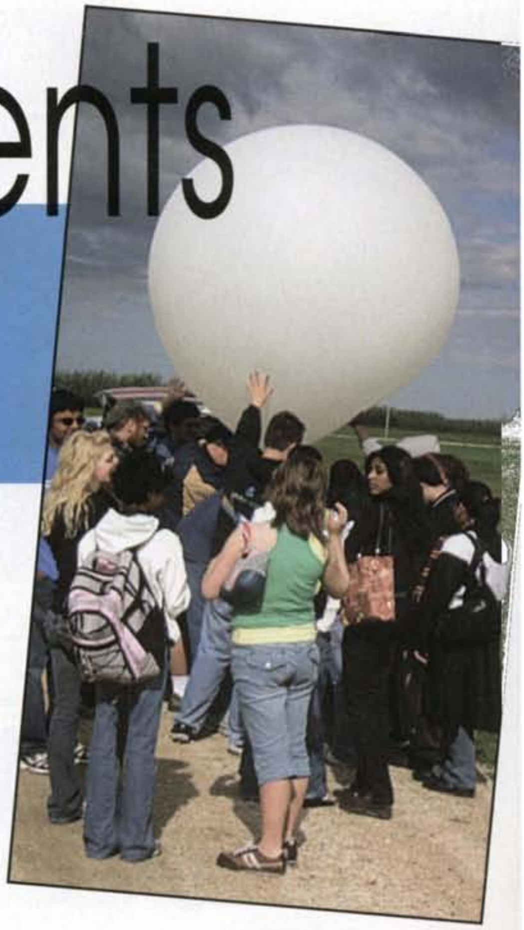
PHOENIX, AZ
1939 W. Dunlap Ave., 85021
(602) 242-3515
(800) 444-9476
Gary, N7GJ, Mgr.
1 mi. east of I-17
phoenix@hamradio.com

ATLANTA, GA
6071 Buford Hwy., 30340
(770) 263-0700
(800) 444-7927
Mark, KJ4VO, Mgr.
Doraville, 1 mi. no. of I-285
atlanta@hamradio.com

WOODBRIDGE, VA
(Near Washington D.C.)
14803 Build America Dr.
22191
(703) 643-1063
(800) 444-4799
Steve, W4SHG, Mgr.
Exit 161, I-95, So. to US 1
virginia@hamradio.com

SALEM, NH
(Near Boston)
224 N. Broadway, 03079
(603) 898-3750
(800) 444-0047
Chuck, N1UC, Mgr.
Exit 1, I-93;
28 mi. No. of Boston
salem@hamradio.com

contents



Winter 2009
Vol. 12 No. 4

FEATURES

A publication of

CQ Communications, Inc.
25 Newbridge Road
Hicksville, NY 11801 USA.

Offices: 25 Newbridge Road, Hicksville, New York 11801. Telephone: (516) 681-2922. FAX: (516) 681-2926. E-mail: cq-vhf@cq-vhf.com. Website: http://www.cq-vhf.com. CQ VHF (ISSN 1085-0708) is published quarterly (4 times a year) by CQ Communications, Inc. Periodical postage paid at Hicksville, NY and additional offices. Subscription prices (all in U.S. dollars): Domestic—one year $25.00, two years $50.00, three years 75.00; Canada/Mexico—one year $37.00, two years $74.00, three years 111.00; Foreign—one year $48.00, two years $96.00, three years 144.00. Government Agencies: Subscriptions to CQ VHF are available to agencies of the United States government, including military services, only on a cash with order basis. Requests for quotations, bids, contracts, etc., will be refused and will not be returned or processed.

Printed in the United States of America.

Postmaster: Please send change of address to CQ VHF Magazine, 25 Newbridge Road, Hicksville, NY 11801.

COLUMNS

DEPARTMENTS

On The Cover: The major 2008 expedition from above the Alaskan Arctic Circle. For details, see the article "Riding the Terminator from 6 Meters Down to 160 Meters," by WB6NOA and KL7BB, beginning on page 24.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

My Wish List for the New Administration

By the time you read this editorial, the new presidential administration will have been in office for less than a month. In my estimation, it is just about the right time for the leadership to receive suggestions for future developments that will further and enhance our hobby's capabilities to meet the demands of our national interest. Below, you will read my wish list for the new administration.

NASA and the U.S. Department of Education

This past November the U.S. Department of Education (DOEd) invited the Amateur Radio on board the International Space Station (ARISS) organization to help celebrate the ninth annual International Education Week (IEW) by coordinating three contacts with the International Space Station (ISS) during IEW, November 17–21. This invitation came, according to ARRL ARISS Project Manager Rosalie White, K1STO, after the DOEd had been tracking ARISS's activities for a long time. The joint venture, which also included NASA and the Department of State, was a resounding success. Among the outcomes were both international goodwill and encouraging scientific education among school students. For more information on the project, go to <http://www.arrl.org/news/stories/2008/ 12/02/10489>.

It is my wish that such programs continue and be expanded. Additionally, it is my wish to see more federal funding directed toward NASA's education programs, such as NASA's Space Grant Consortium. Regular readers of this magazine have already read articles about amateur radio related projects that are being run under the auspices of various colleges and universities across the country. These programs have proven to be sources of producing new amateur radio operators. Regarding these programs, it is my wish that NASA assign an employee full time to publicize projects that are being carried out at various state space grant consortia around the country.

Concerning NASA and education, a paltry few of its programs are reaching down to the common school level. In particular, programs need to be developed that reach the elementary and middle-school levels. Any education administrator will tell you that if you have not captured a student's imagination by the early middle-school years, you run a high risk of losing that student's lifetime positive creativity. Therefore, it is my wish that Congress and the President approve and authorize increased funding to NASA for education-related projects.

FEMA

In the aftermath of the devastating hurricanes and other natural disasters in recent years, regarding communications, FEMA has begun to get its act together. FEMA and the military, along with state and local agencies, are making great strides toward solving interoperability problems.

However, while the government organizations are learning how to effectively communicate with one another, the non-government organizations (NGOs) are beginning to be left behind. While many of us have seen examples of communications vans, trailers, and trucks being operated in the field by the Red Cross, Salvation Army, and the Southern Baptist Hams, these organizations represent only a small fraction of the many NGOs that FEMA has begun to rely upon for disaster recovery work.

For example, the United Methodist Committee on Relief (UMCOR) has been tasked by FEMA to handle $66 million that the U.S. government received from foreign governments in the aftermath of Hurricane Katrina. While this may seem like a lot of money, FEMA restricts its use to direct assistance to those who qualify for such assistance.

What is lacking for UMCOR and other NGOs is a communications infrastructure that is needed by these organizations when they are tasked by FEMA to respond to disasters. While FEMA has the money it needs for solving its communications problems, these NGOs rely on private contributions to fund items such as emergency radio equipment, emergency operations centers (EOCs), as well as radio-equipped emergency vehicles. It is my wish that FEMA find a way to help these NGOs fund their emergency communications equipment needs—preferably through private sources. It is also my wish that FEMA supply expert telecommunications advisors to these NGOs in their efforts to establish their communications infrastructures.

ITAR

Of ongoing concern to experimenters in our hobby is the International Traffic in Arms Regulations (ITAR). Within the amateur radio experimenting community is a growing "ITAR paranoia" as Bill Ress, N6GHZ, comments in his paper "ITAR and AMSAT," which was published in the *Proceedings* of the 2008 AMSAT Symposium. More than one experimenter has walked away from the research and development tables at AMSAT-NA as a result of ITAR paranoia. In particular, cooperation between AMSAT-NA and AMSAT-DL has all but stopped because the Americans do not want to inadvertently break the law that prohibits the exportation of what might be deemed as sensitive research and technology.

The sanctions for violating the regulations can run into millions of dollars, as Boeing found out when it was fined $32 million for its role as successor to the Hughes Corporation, which had (according to the U.S. government) illegally transferred technology to China concerning the January 1995 failed launch of the Long March 2E rocked that was carrying the Hughes-built Apstar 2 spacecraft.

From Wikipedia (see: http://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations) is the following concerning the controversy:

> There is an open debate between the Department of State and the industries and academia regulated by ITAR concerning how harmful the regulatory restrictions are for U.S. businesses and higher education institutions. The Department of State insists that ITAR has limited effect and provides a security benefit to the nation that outweighs any impact that these sectors must bear. Every year, the Department of State can cite multiple arrests of ITAR violators by U.S. Immigration and Customs Enforcement agents. However, many companies and institutions within the affected areas argue that ITAR is stifling U.S. trade and science. Companies argue that ITAR is a significant trade barrier that acts as a substantial negative subsidy, weakening U.S. industries' ability to compete.

It is my wish that under the new administration a new, healthier look at ITAR may emerge that will positively deal with the concerns within our hobby.

My Final Thoughts

Throughout the history of our hobby, we amateur radio operators have been called upon to provide essential communications and technological skills on behalf of our country. In laying out my wish list for the new presidential administration, I firmly believe that should these wishes be granted, once again the hobby of amateur radio will grow in numbers and therefore be able to provide essential communications and technological skills for use on behalf of our country—as well as the rest of the world. Until next time . . .

73 de Joe, N6CL

Alinco gives you Mobiles for all Seasons and for all Reasons!

Work the DX on 6 and 10 Meter FM

- **DR-03T** (pictured) 10 meters
- **DR-06T** 6 meters

- Same key-operations as DR-135-435 series mobile radios.
- EJ-41U internal TNC board is available as an option for 1200/9600bps packet (DR-06T only), no need to remove mic for packet operation.
- DR-03T 10 watts, H(10W)/M(5W)/L(2W) power settings.
- DR-06T 50 watts, H(50W)/M(20W)/L(5W) power settings.
- 100 memory channels
- Front panel data port
- Rear panel DSUB9 computer connection (DR-06T only)
- CTCSS, DCS encode+decode, DTMF encode and Tone-burst are all standards
- Clean, clear Alinco audio
- Super-wide 7 character alphanumeric display
- Wide and narrow FM modes (16K0 & 8K50F3E / DR-03T is fixed for NFM)
- Theft alarm feature
- A large, palm-fitting commercial-grade backlit microphone with an 8 pin metal connector (not a modular plug) as well as direct frequency input and direct multi-function access such as monitor, call channel, power setting,memory to VFO plus more!
- Stays in mode you select (voice/packet) through power off cycles
- Ten autodial memories

Work simplex and the VHF and UHF Repeaters

- **144 MHz DR-135TMkIII** 50 watts, H/M/L power settings
- **220 MHZ DR-235TMkIII** (pictured) 25 watts, H/M/L power settings
- **440 MHZ DR-435TMKIII** 35 watts, H/M/L power settings

- EJ-41U internal TNC board is available as an option for 1200/9600bps packet
- 100 memory channels
- Front panel data port
- Rear panel DSUB9 computer connection
- No need to remove mic for packet operation
- Ignition key on/off feature
- CTCSS, DCS encode+decode, DTMF encode and Tone-burst are all standards
- Clean, clear Alinco audio
- Super-wide 7 character alphanumeric display
- Wide and narrow FM modes (16K0 & 8K50F3E)
- Theft alarm feature
- A large, palm-fitting commercial-grade backlit microphone with an 8 pin metal connector (not a modular plug) as well as direct frequency input and direct multi-function access such as monitor, call channel, power setting, memory to VFO plus more!
- Stays in mode you select (voice/packet) through power off cycles
- Ten autodial memories

Dual Band fun and versatility

- **DR-635T** 144 MHz/440MHz

- VHF/UHF full duplex operation includes V/U and U/V modes.
- Cross-band repeater function (where permitted: standard on DR-635T)
- 200 Memory channels
- H/M/L power output settings- VHF: 50/25/5W UHF: 35/20/5W
- Large 6 character alphanumeric display
- Selectable display color illumination (Blue, Violet or amber)
- Internal duplexer - single antenna connector
- Removable control head can be remotely mounted (requires optional EDS-9 separation kit) or allow transceiver to be inverted for optimal speaker placement.
- Expanded receive range includes FM broadcast band (WFM)
- Power supply voltage display
- Theft alarm feature
- Optional 1200 and 9600 bps packet operation with optional EJ-50U
- Digital voice communications with optional EJ-47U
- Illuminated DTMF EMS-57 microphone allows direct VFO frequency entry and remote control of transceiver
- CTCSS & DCS encode and decode plus four different tone bursts
- CTCSS Tone and DCS scan
- Programmable VFO and Memory scan modes
- "Time Out" timer
- Cable Clone feature
- AM Aircraft band reception
- Temperature Compensated Crystal Oscillator
- Ignition key activated power on/off feature
- Optional Accessories
  EJ-47U digital modulation uint
  EJ-50U TNC unit
  EDS-9 Front-control unit separation kit

Specifications subject to change without notice or obligation. Performance specification apply only to the amateur bands. Permit required for MARS use. APRS is a registered trademark of Bob Bruninga, WB4APR. Check regulations prior to operating full duplex in US.

Distributed in North America by Ham Distributors,
1775 North Loop 336 East, Suite 8, Conroe, Texas 77301
Phone: 936-649-1497 • Fax: 800-824-3128 • email: USrep@Hamdistributors.com

ALINCO
www.alinco.com

The CYØX 2008 Sable Island VHF DXpedition

A special CYØ 2x1 call, rare 6-meter grid square FN93, separate DXCC status . . . together equal big pile-ups! Here VE3IKV tells how he and his partners Dick Hanson, K5AND, and Chris Patterson, W3CMP, tallied more than 4000 VHF QSOs in late June and early July 2008.

By Pete Csanky,* VE3IKV

After our great VFØX summer 2007 6-meter arctic DXpedition to Nunavut Territory (VYØ), Bill, W4TAA, and I were talking about where to go in the summer of 2008. Hopefully, it would be to a location where we could work some Europeans on 6 meters, since up at VFØX we were too close to the north geomagnetic pole and never heard any EU signals or encountered videos on 50 MHz. We received quite a few suggestions to go to CYØ, Sable Island, which counts as a separate DXCC entity and was last activated during the summer sporadic-*E* season by Mike, VE9AA, and company back in 1996.

After making a few phone calls and e-mail inquiries, I found out that the main factor in getting CYØ on the air is the charter aircraft expense—$10,000 to get only 1400 pounds of combined operator, equipment, antennas, and food from Halifax to Sable and back to Halifax. Because it was a DXpedition focused on 6-meter operation, we never got much response from the usual HF DXpedition sponsors, so it looked like we would have to split the air charter costs. Adding in the Sable bunkhouse accommodation fees of $150 each per night, we were looking at around $10K each for the trip. Ouch!

While Bill and I were mulling over the costs, Dick, K5AND, and Chris, W3CMP, expressed their interest in joining us, and with the combined team, turning it into a major 6-meter DXpedition for the summer 2008 sporadic-*E* season.

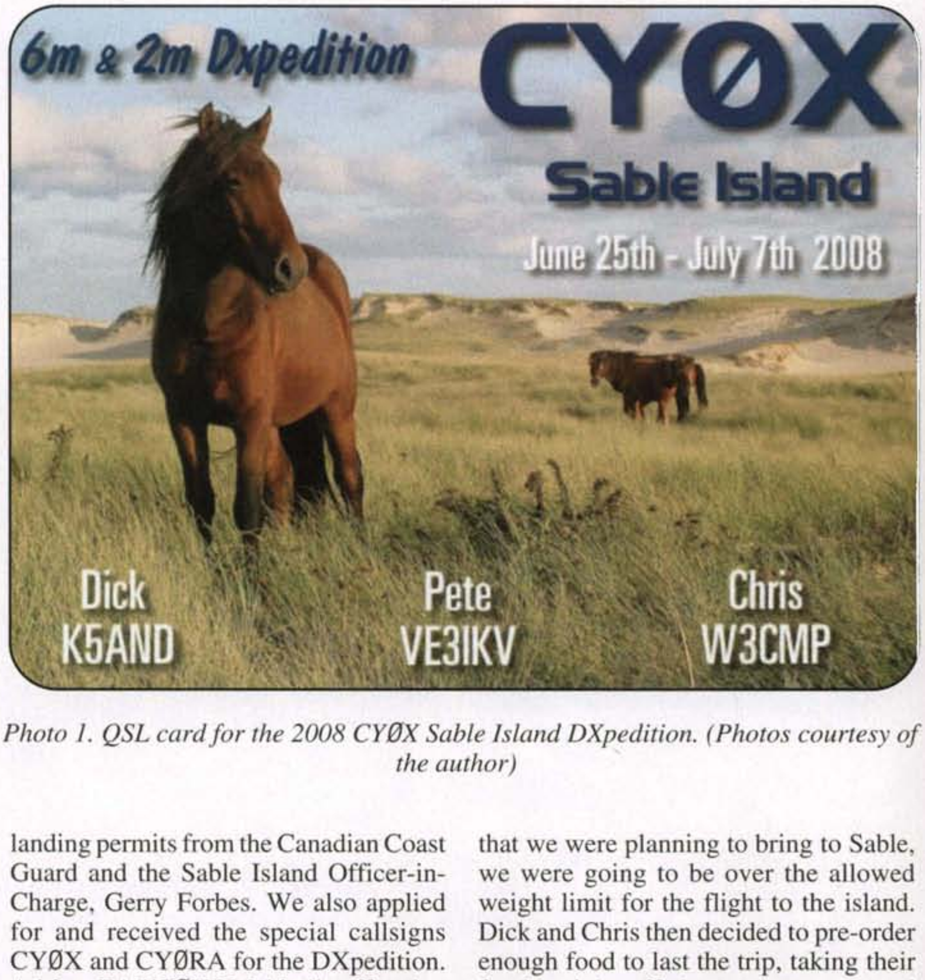


Photo 1. QSL card for the 2008 CYØX Sable Island DXpedition. (Photos courtesy of the author)

Planning and Logistics

Thus, in September 2007 we started the lengthy planning necessary to secure landing permits from the Canadian Coast Guard and the Sable Island Officer-in-Charge, Gerry Forbes. We also applied for and received the special callsigns CYØX and CYØRA for the DXpedition. Adrian, EA5/GØKOM, kindly offered to sponsor the design and hosting of a website for us (http://www.cy0x.com) so that we could keep the 6-meter DX gang informed of our plans and progress.

At this time Bill, W4TAA, reluctantly had to pull out of the CYØX DXpedition plans due to business commitments, leaving Dick, Chris, and me to finalize the details. By spring 2008, it was apparent that after weighing each and every item that we were planning to bring to Sable, we were going to be over the allowed weight limit for the flight to the island. Dick and Chris then decided to pre-order enough food to last the trip, taking their food weight off the total amount and allowing us to also pack Chris's 2-meter station. Next, the charter flights to and from Sable were booked, and travel arrangements were made to get all the gear rounded up and staged at Pete, VE3IKV's QTH near Toronto.

One of the first things that the Sable visitor information sheet talks about is the high probability of fog delaying any travel plans to and from Sable in the

*e-mail: <ve3ikv@cogeco.ca>

Photo 2. We are stowing our gear onboard our plane, a twin-engine Britten-Norman Islander. It is one of the few aircraft that can land on a beach, as there is no airport on Sable Island.

summer months and that the delays can last for several days or even much longer.

The Journey

June 25th, our departure day, miraculously arrived sunny and warm, the perfect day for the $1^1/2$-hour flight out into the Atlantic Ocean to Sable.

We arrived at the air charter hangar to get all of our gear weighed and stowed on board the plane, a twin-engine Britten-Norman Islander, one of the few aircraft that can land on a beach, as there is no airport on Sable. Of course, when we added up all the weight once again, using their scale in the hangar, we were 150 pounds over the limit, and we then had to make on-the-spot decisions as to which items had to stay behind, since there were no guarantees of getting them over to Sable on a second flight. Good fortune was with us once again. Due to the favourable flying weather, the air charter folks could get a second flight over to Sable that day, and we were able to piggyback our left-behind items onto the second flight.

Debbie, our pilot, gave us the pre-flight safety briefing ("The lifejackets are primarily to assist in the recovery of the bodies!") and we soon left the mainland behind. The western tip of Sable showed up on schedule, and we landed smoothly on the beach near the weather station. Gerry Forbes, the OIC, was waiting for us with his 4×4, and we off-loaded all our gear onto the truck for the drive to the Sable guesthouse.

Robby, VY2SS, had a custom 8-element M2 6-meter Yagi on a 40-foot boom that he had used for his CY9SS 2005 St. Paul 6-meter DXpedition, and he generously offered it for our use at CYØX. We put together the 6-meter station first in case there was an opening, but by the time we got everything operational and the big 40-foot M^2 Yagi up on the mast, it was late and there was no sign of activity on the band. We had a satellite internet connection that allowed us to post to the ON4KST 6-meter web page, so we told everyone to look for us in the morning.

The Operation

June 26 started off with our first 6-meter QSO (W1JJ) at 1150 UTC and continued with a number of stateside contacts until our first mainland Europe contact with S59Z at 1738 UTC, followed by I, DL, G, 9H, EI, F, CT, 9A, OK, SP, SM, HI, OZ, HA, GW, VP9, PA, and EA, ending at 2000 UTC. The band then shifted to the Caribbean/South America with KP4, 9Y4, J3, PJ2, YV4, and FM contacts, until 2200 UTC when Europe popped in again briefly with OY3JE in the Faeroe Islands.

We were ready early on June 27, and Europe was already coming through on CW by 0900 UTC. Nick, 5B4FL, was worked at 0930 UTC for our first Asian 6-meter QSO. The EU opening lasted until 1025 UTC and then switched to North America until 1350 UTC, when LZ3RX in Bulgaria opened the band to Europe again with OM, GM, GD, UR, GI, and LA contacts until 1730 UTC. The band then switched back to North America again until 2030 UTC, when K7CW and VE7SL, our first two West Coast stations, went in the log via triple-hop sporadic-*E*. Europe and Africa came booming in on SSB until 2145 UTC, including our first OH contacts in Finland. Six meters stayed open to North

Photo 3. View from the aircraft of the Sable Island coastline.

Photo 4. Robby Robertson, VY2SS, loaned us this custom 8-element M^2 6-meter Yagi on a 40-foot boom which he had used for his CY9SS 2005 St. Paul 6-meter DXpedition.

America until 0200 UTC, for a total of 17 straight hours of operating and over 1200 stations in the log.

IT9RZR in Sicily led the parade of Europeans early (0927 UTC) on June 28th, and we picked up new DXCC entities, including EA6, MUØ, HB9, and LY. Six meters once again opened to Scandinavia, and then at 1400 UTC we added YU, Serbia, and E7, Bosnia. At 1600 UTC, 4X4DK and 4X1FQ in Israel, and SV2DCD and SV8CS in Greece, broke the EU pile-up, and then only 15 minutes later, the path shut down completely and flipped over to North America for the next four hours until 0030 UTC.

Photo 5. On June 26th CYØX is on the air on 6 meters!

The following day, Sunday the 29th, was ho-hum, but we did manage to get QSO number 2000 in the 6-meter log. Chris and Pete went on a hike to the freshwater ponds to look for wild horses and got some great photographs.

On Monday, June 30th, 6 meters opened up to Europe around our lunch time (1600 UTC) via a skewed path peaking toward West Africa, with UY5HF and UR7GG in the Ukraine worked at midnight their local time (2100 UTC). The skewed path stayed open to Europe for six hours, until 2200 UTC. Amazing!

The skewed path opening put another 250 Europeans in the 6-meter log, including LX1JX in Luxembourg for our 6-meter DXCC number 55, and the first ever CYØ to LX 6-meter QSO. However, we were still waiting for the anticipated "killer" 6-meter opening stateside.

Six meters was quiet all day on July 1st, but returned with another morning opening to Scandinavia and central Europe on July2nd, followed by North America until 1700 UTC.

July 3rd and 4th were both quiet on the band, with few stations getting into the CYØX log, but we did manage to work PJ6/K2KW on Saba, VP5/WB2REM, and HK3O for three new ones, bringing our 6-meter DXCC count to 58 entities.

Six opened to Europe again on Saturday morning, July 5th at 1300 UTC for a couple of hours, but the "biggie" to central and western North America failed to materialize. At the 11 AM local-time weather briefing from Gerry Forbes, we got the first hint that our scheduled departure date for Monday "doesn't look good." Dense fog was forecast for the next several days, until a weak cold front "might" come through and bring drier air "later in the week." Sensing our disappointment, Gerry assured us that we should be able to leave "by Labor Day, September 1st," which was not exactly the extended stay we were anticipating!

To make matters worse, Sunday July 6th arrived with rain as well as fog, and we only managed to work 13 stations on 6 meters all day. Dick and Chris stayed busy on the guest-house satellite phone re-scheduling their flights home to Texas and Pennsylvania, respectively, and trying to convince the XYLs that we really *were* trying to leave Sable. Without a single decent opening to them so far, all the USA Midwest and West Coast 6-meter

Photo 6. Some of the wild horses on Sable Island.

ops by now had given up all hope of working CYØX.

At that point, we decided to take down all the 6-meter and HF antennas and pack up all the stations, just in case a decent weather window opened on short notice and we could leave the island.

Pete had brought along Bill, W4TAA's 6M5X antenna as back-up, so he decided late Sunday to unpack it and go ahead and put it up on top of a 20-foot aluminum tower that had been left on the island. The rotators all had been packed, so we used a piece of nylon guy rope attached to the end of the boom to swing the beam.

Monday, July 7th, our original planned departure date, dawned with dense fog, just as Gerry had predicted. Six meters stayed dead all day until 5 PM local (2000 UTC), when just as we were getting ready to cook dinner, it opened to North America with an instant huge pile-up on our 50.108-MHz frequency. By now, everyone had heard via the internet that we were fogged in and they all were calling, hoping for one last chance to get into the CYØX 6-meter log. By the time the band folded at 0100 UTC, there were another 342 very happy W/VE stations in the log. The little 6M5X was working

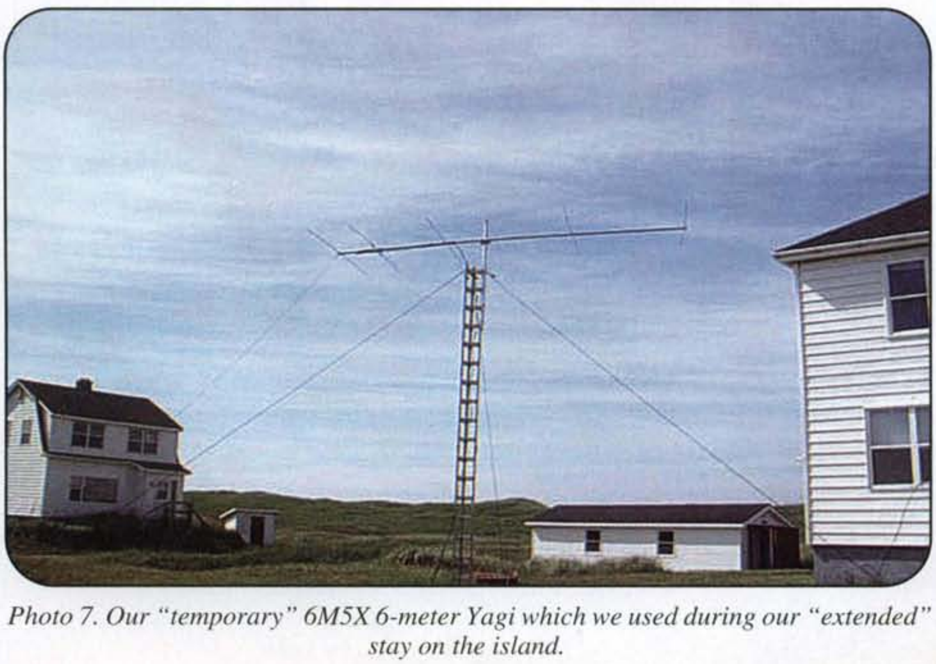


Photo 7. Our "temporary" 6M5X 6-meter Yagi which we used during our "extended" stay on the island.

Photo 8. Some of the more than 250,000 seals on the island.

great, in spite of being only 20 feet high.

Tuesday, July 8th, "The Biggie" finally arrived! The band opened up early in the morning at 1130 UTC to W8s and W9s. Then the Caribbean came in off the side, and we worked Ted, HI3TEJ, some YV4s, and Joe, CT1HZE, off the back of the beam. Then XE2WWW came blasting in S9-plus, and we also connected with VP2MRM on Montserrat. The band stayed open to stateside all day, and finally around 2100 UTC we put a number of anxious WØs in the log, with a very difficult sporadic-*E* path in the "donut hole" between hops. At 2200 UTC the West Coast finally came in on triple-hop when Barry, VE3CDX/W7, in Las Vegas broke the Midwest pile-up on CW!

For the next hour the band went wild. Chip, K7JA, in Los Angeles led the W6s calling in from all over California, and all U.S. call areas went into the log at the same time as VE1s, VE2s, VE3s, and VO1s—with CT1EAT, CT1ESV, and CT1DVV in Portugal calling in off the back of the antenna for good measure—while all the W6s and W7s were shouting "We *love* fog!"

After a QSO with KØEU in Denver, the band finally closed at 0130 UTC. It had been open for 14 hours straight!

Wednesday, July 9th, we awoke at 6 AM to the densest fog yet. With no wind, there would be no flight out that day. At 7:30 AM (06:30 Eastern), Pete turned on the Yaesu FT-650, not expecting to hear any signals after Tuesday's marathon session, and was amazed to hear the band full of loud W1, W2, W3, and W4 beacons below 50.075 MHz! For the next hour and a half, we worked around 30 very surprised early birds. They were extremely strong, S9 +30 dB, with no sign of any sporadic-*E* QSB. There was a huge tropo fog inversion down the Atlantic coastline extending from Sable Island all the way down to Ken, AC4TO, in Tallahassee, Florida! The morning tropo session then started to overlap with yet another sporadic-*E* opening to W4s, W8s, W9s, and even a long double-hop to W5UR in Albuquerque, New Mexico. The sporadic-*E* continued until 1730 UTC, with the expected afternoon break, and then picked up again at 2130 UTC with all call areas except W6 and W7 coming through non-stop until 11 PM local (0200 UTC), when we finally put QSO number 3668 in the 6-meter log!

On Thursday, July 10th, we awoke to still more fog! Oh well . . . there was

Photo 9. While the horses are wild, they were also friendly and curious. Here is one of them coming up to us in our Jeep.

Photo 10. The "Gator," our transportation between the guest house and the Jeep.

Photo 11. The welcome sight of Debbie piloting our plane in for a landing at "Sable International Airport."

always the guest-house satellite TV, and now the XYLs were more convinced than ever that we are in no hurry to leave the island. The band couldn't *possibly* be open again. However, when we turned on the 6-meter radio, we found that *it was*! There were more W1s, W2s, W3s, W4s, and W5s calling, and even KS7S in southern Arizona came through at 1400 UTC (7 AM his time). Jay, WXØB, "Mr. Stackmatch," called in from Array Solutions in Texas to say hi!

Like clockwork, the mid-afternoon break occurred again between 1600 UTC and 2200 UTC, so all three of us took another stroll and stretched our legs on the island.

At 2200 UTC Thursday evening, after dinner, the band re-opened again, and we had more W2s, 3s, 4s, 5s, 8s, and 9s calling, and even Bill, KØHA, came in on double-hop from Nebraska. Later that evening, at 0141 UTC, the band finally closed with AJ9C on CW for 6-meter QSO number 3941!

Friday, July 11th, the cold front came through with dry air and the day was sunny and warm, finally with no fog, but we were *still* stuck on Sable because our pilot Debbie was unavailable. Gerry gave us our daily WX briefing at 11 AM and said it "looks good" for the Saturday flight off the island.

The band was totally dead, and remained that way all day Friday. We left the 6-meter beacon on, but nothing came through either from Europe or North America, so we took one last tour of the island before our departure. We took down the 6M5X Friday evening and tallied up our "fogged-in" QSOs with just 100 watts and the "temporary" 5element antenna—1309!

Departure

Saturday, July 12th, the day dawned bright and sunny again and we packed all our stuff in the "Gator" that would transport it between the guest house and the Jeep.

We drove off to the beach landing strip with all of our gear in the Jeep and watched Gerry lay down the location of the "runway" in the sand and then put the wind sock up on a pole on the front bumper. Sable Island International Airport was ready for incoming air traffic, and we were ready to go home!

Final Totals

- 3941 QSOs on 6 meters, in 60 DXCC entities and 45 USA states
- 3750 QSOs on HF (20 and 40 meters), in 80 DXCC entities
- Only 7 QSOs on 2 meters via tropo, meteor scatter, and EME because of RFI from weather-station computers, water in the antenna balun, RFI to island equipment when running over 50 watts, etc.
- 2-meter stations worked: VE9AA, VE1KG, VE1HD, WZ1V, WA1T, K1WHS, and W5UN.

Photo 12. From our take-off we have a farewell view of Sable Island's coastline.

The WinCube Project

In this article we see how Manitoba (Canada) high school students have become involved in pico-satellite construction, amateur radio, and high-altitude balloons.

By Stefan Wagener,*[1] VE4NSA, Jeff Cieszecki,[1] VE4CZK, Barbara Bowen,[2] Wayne Ellis,[3] and Norm Lee[4]

The WinCube Project is a cooperative effort among Manitoba high schools, the Manitoba Satellite Interest group (MSIG), the Faculty of Engineering at the University of Manitoba, Maples Collegiate Space Exploration Academy, the Manitoba Aerospace Human Resources Coordinating Committee, and numerous aerospace industry partners.

Through a mentorship program, Manitoba high school students will be involved in the design, construction, and launch of a pico-satellite with technical support provided by aerospace faculty and engineering students. Basic system design and construction experience for the high school students is provided by the construction and launch of high-altitude balloon payloads. Students learn first-hand about space mission design, telecommunications, programming, electrical and mechanical engineering, and amateur radio through a summer camp program, ongoing workshops, and courses.

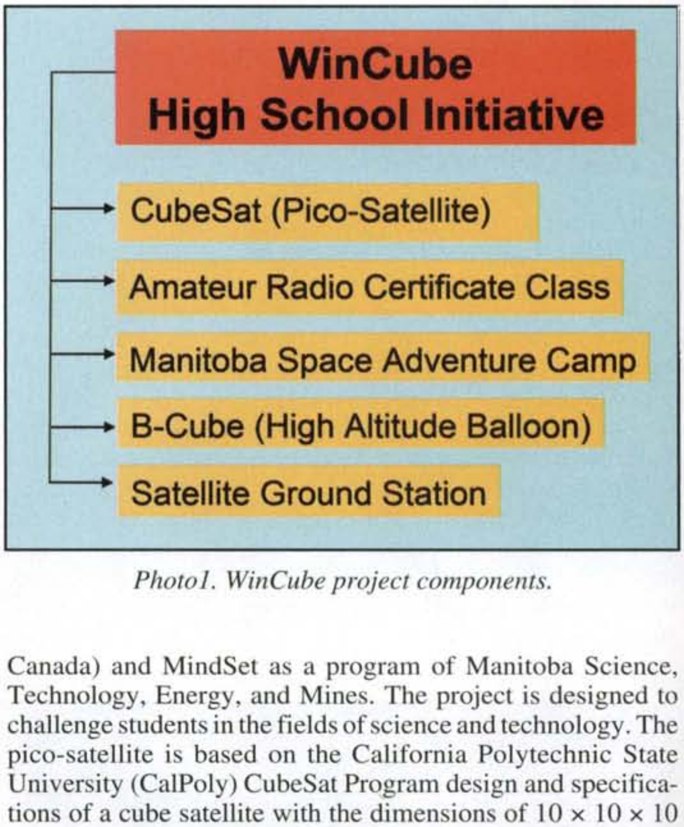


Photo1. WinCube project components.

WinCube

The WinCube project (photo 1) is a multi-facetted approach of exposing high school students to amateur radio, aerospace, science, and technology. Its core areas involve a satellite project (CubeSat), an annual summer space camp, a high-altitude balloon project (B-Cube), and annual amateur radio classes combined with hands-on construction projects, as well as the operation of existing and future amateur radio satellites through a new satellite ground station.

The CubeSat Project

The CubeSat Project was initiated in the spring of 2006 by the Manitoba Satellite Interest Group (MSIG) Inc., and MindSet, the Manitoba Network for Science and Technology, to provide Manitoba High School students with the opportunity to be involved in the design, construction, and launching of a pico-satellite.

Initial funding for the project was obtained through NSERC (Natural Sciences and Engineering Research Council of Canada) and MindSet as a program of Manitoba Science, Technology, Energy, and Mines. The project is designed to challenge students in the fields of science and technology. The pico-satellite is based on the California Polytechnic State University (CalPoly) CubeSat Program design and specifications of a cube satellite with the dimensions of 10 × 10 × 10 cm and a maximum mass of 1 kg. These small, relatively inexpensive satellites are capable of real data gathering as demonstrated by their utilization by universities and space researchers as an economical method of research.

To achieve this lofty goal of creating and launching a pico-satellite, a number of key factors needed to be put into place for the high school students:

- Mentorship through aerospace industry and university students
- Gaining experience in payload design and construction through high-altitude balloon work (B-Cube Project)
- Defined educational goals
- Amateur radio certification and ground station operation

For high school students to create a CubeSat, the Faculty of Engineering at the University of Manitoba with assistance by Bristol Aerospace provided initial design support for the satel-

**1158 Gordon Edward Crescent, East St. Paul, MB, R2E 0H2 Canada*
[1]Manitoba Satellite Interest Group (MSIG), Inc., WinCube Project Team
[2]Manitoba Aerospace, WinCube Project Team
[3]AppSpace Solutions, WinCube Project Team
[4]MindSet (Manitoba Network for Science and Technology), WinCube Project Team
(Originally published in the 2007 AMSAT Symposium Proceedings*)*

lite. This was necessary to meet the CalPoly specifications for a space-worthy satellite. A Preliminary Design Review (PDR) Report was created by a cohort of fourth year Engineering Students at the University of Manitoba during the 2006–2007 school year.[1] The PDR proposes the design of the satellite and includes:

- Structure
- Electrical Power
- Communication System
- Command and Data Handling
- Attitude Control
- On-board Science
- Integration and Testing

The "on-board science"[1] will be responsible for gathering scientific data that will be transmitted back to Earth for analysis. The high school students will contribute directly to the science component. When the CubeSat is in orbit, participating high school students will communicate with the satellite via amateur radio. Data gathered will be processed and published by the high school students.

High school students will also take an active role in the construction of the CubeSat. Starting in the fall of 2007, students will be mentored by University of Manitoba Engineering graduate students during the next phase of construction and testing of the satellite utilizing the new University of Manitoba space lab. To prepare the high school students for the satellite construction, they will gain experience in satellite design by constructing and testing a scientific payload for a high-altitude balloon launches. The high-altitude balloon work is referred to as B-Cube.

Manitoba Space Adventure Camp

It is necessary to increase students' basic knowledge of space studies and related concepts before they begin their work on a satellite. Students in the program range in grades from 10 through 12. Students must have the basic concepts and vocabulary necessary to understand space science. A "space camp" experience is provided to bridge students' knowledge of high school physics and the concepts and vocabulary they will encounter during their CubeSat experience. The Manitoba Space Adventure Camp, as it is called, has been held for two years at the Canadian Forces School of Aerospace Studies, 17 Wing, Canadian Forces Base Winnipeg. It is designed to make high school students more aware of science and technology as it relates to aerospace. The Manitoba Space Adventure Camp actually involves two separate camps: a first-year camp and an advanced camp for returning students who continue their participation in the CubeSat project. While most of the activities take place at the Canadian Forces School of Aerospace Studies, students also have the opportunity to build and launch model rockets, operate satellite navigation devices, participate in a research balloon launch, and work with amateur radio via satellites. Other activities include tours and lectures, geocaching, and various lab sessions (http://appspacesol.com/spacecampmain.html).

Photo 2. Manitoba Space Adventure Camp, 2007, successful ARISS contact with the ISS.

The key event of the 2007 Manitoba Space Adventure Camp was the successful "school" contact with the International Space Station (ISS), which took place on July 12, 2007 (photo 2). The maximum elevation of the ISS was 70 degrees and the contact lasted for over 9 minutes. Astronaut Clayton Anderson answered 18 questions on a variety of issues, and some of students who took part in the 2006–07 winter amateur radio class had their first ISS QSO as certificate holders (http://www.msig.ca/iss%20contact.html).

B-Cube (High-Altitude Balloon) Project

The CubeSat student design team from the University of Manitoba and MSIG identified a number of key engineering areas for the satellite. As stated earlier, the technical expertise required for a space-ready satellite is beyond the skill set for most high school students and science teachers, and since the first year of satellite design is primarily theoretical, real-life, hands-on project developed to provide a basic understanding of the intricacies of payload design and fabrication. High school students are given the challenge to create a payload for a high-altitude balloon. Some of the similarities between the B-Cube payload and the CubeSat are taken from the Preliminary Design Review (PDR) Report by the University of Manitoba's Satellite Team[1]:

- Payload Frame
  - * Structure
  - * Thermal Design
  - * Passive/Active Thermal Control Systems
- Electrical Power
  - * Power Budget
  - * Active/Standby Mode
- Communication
  - * Requirements
  - * Amateur Radio Use
- Antennas
- Command and Data Handling

The CubeSat once constructed will undergo a number of tests to evaluate its space readiness, including exposing the craft to a hard vacuum, extreme temperatures, and vibrations. For the B-Cube, testing will include physical impacts, cold temperatures, and systems tests. The

B-Cube tests can all be carried out at each high school by the students.

Payload Frame. The engineering points listed are those that only apply to the B-Cube design concept. For example, in designing the B-Cube payload frame, students must take into consideration temperature drops and how the electronics within the payload react as the balloon reaches a potential altitude of 30 km and external temperature drops as low as –60° C.

Areas for consideration in the B-Cube structure by high school students include the material for the walls (aluminum, foam core, foam insulation)[2], type of adhesives for the structure walls (silicon adhesive, hot glue, loop-form attachtment, aluminum tape) and the dimensions of the structure. Students may need to refine payload dimensions to effectively contain all equipment necessary for the balloon launch, yet limit the mass of the structure to the overall 1-kg payload mass. The design of the B-Cube structure must also allow for the venting of the internal volume to adjust to external atmospheric pressure changes, internal heat loss/gain, and possible moisture damage from clouds.[2]

Electrical Power. High school students will also learn about electrical power budgets in the design of their B-Cubes. The B-Cube payloads are expected to operate for 2.5 hours of flight and run an audio beacon upon landing for an extended period of time to aid with ground retrieval. The choice of batteries will also require investigation and testing for suitability.

Communication. Communication plays a key role in the tracking and data gathering of both the satellite and the B-Cube payload. The high school students are required to obtain their amateur radio certificates, since balloon-to-ground communication will utilize amateur radio frequencies similar (VHF, UHF) to those planned for the satellite. The certification will allow the students to communicate directly with the future CubeSat while in orbit via a ground station located in Winnipeg. First-hand application of amateur radio operation is done by having the B-Cube payloads tracked by a GPS radio beacon that is transmitting on 144.390 MHz based on APRS (Automatic Position Reporting System). The students will use amateur radio transceivers and computer software to track and retrieve the balloon payloads.

Command and Data Handling. Command and Data Handling of the B-Cube payloads will be done with Basic Stamp chips. The Basic Stamp is reliable and uses PBasic programming. Students will create programs that meet the needs of their mission designs. This includes the timed operation of a balloon flight termination device, as well as the control of on-board cameras. Future projects will involve real live ATV transmissions.

Photo 3. B-Cube-1 ready for launch.

B-Cube payloads are tested for impact survival. Students construct a number of prototypes of payloads that contain a mass that places the test container to a total of 1 kg. Payloads are first tested by dropping them (e.g., off the school roof) to evaluate the structure's impact survivability. Payloads are then dropped off with various dimensions of parachutes, comparing the time of descent. The third drop test involves a drop from an elevated altitude with the use of a kite or a tethered balloon. The payload is released via a cut-down mechanism (termination device), and the payload floats to the ground with the use of a parachute, again recording the time of decent and the altitude from which it was dropped. In all of these tests, students are determining the relative strength of the payload structures and the best dimension of the parachute design for optimal results versus mass constraints.

A key component for any payload is to be able to operate in extreme temperatures. Both the WinCube and B-Cube must have measures taken to allow the operation of the electrical system at all times during flight. In the case of the B-Cube, extreme drops in temperature are an issue, as low as –60° C. The B-Cube payload can utilize either an active or passive thermal control system, to be determined by the students. One possible test for temperature is to place an operational payload in a cooler filled with dry ice [2] or a freezer. In either case, the payloads should be running during the tests, with internal and external temperatures of the payload continuously monitored.

In order to help high schools in Manitoba and beyond to engage in a high-altitude balloon project (independent of the satellite project), funding was obtained from the Canadian Space Agency (CAS) to design and construct a ready-to-be-assembled B-Cube kit. Currently, preliminary prototypes of the kits are being developed and tested. These kits will be available in the beginning of 2008. This "plug and play" approach is very important for many science teachers in order to quickly incorporate such a project into the ongoing science curriculum of their schools and guarantee a certain level of success.

One of the key elements of high-altitude balloons using APRS is the possibility to closely work with local amateur radio operators for the purpose of testing payloads, radios, balloon tracking, and recovery. These "balloon chase" events are very popular and significantly enhance the working relationships of local hams with high school students and teachers (photo 3).

Educational Goals

Educational goals for the WinCube project were developed from the Common Framework of Science Learning Outcomes (Pan-Canadian Framework) written by the Council of Ministers of Education, Canada (CMEC).[3] General Learning Outcomes (GLOs) from the Pan-Canadian that apply directly to the WinCube Project include skills, communication, and teamwork.

Pan-Canadian GLO for Skills includes planning investigations to record and analyze data using a variety of techniques. For the B-Cube payload design or the science component of the satellite, students will develop the function of these payloads while attempting to address a scientific issue.

The GLO for Communication and Teamwork involves the effective communication with others in regard to issues and ideas, and comes up with a strategy that has a consensus to move forward. For the B-Cube component, students will work as a team to design a payload within a high school. The satellite will require students from participating high schools to discuss and agree upon what the science component will accomplish once in orbit.

Specific Learning Outcomes (SLOs) from the Pan-Canadian Framework found in the WinCube Project include Initiating and Planning; Performing and Recording; Analyzing and Interpreting.

Initial BCube payload designs will be very basic—simply to launch and retrieve a payload. Subsequent payload designs will have more specific scientific goals. The SLO of Initiating and Planning involves the investigation of practical problems and issues and the creation of scientific investigations to gather data. The SLO of Performing and Recording will have students carry out experiments while controlling variables, effectively collecting and compiling data. With data collected, students will analyze evidence, provide conclusions, and display information using a variety of formats as part of the SLO Analyzing and Interpreting.

Further educational opportunities include ongoing certification in amateur radio and potentially high-powered rocketry. During the 2006–2007 school year, participating high school students took part in classes for amateur radio certification. Amateur radio is a key component of the WinCube project which allows students to track their B-Cube payloads and communicate with amateur radio satellites, including the WinCube CubeSat. The amateur radio course will again be offered during the 2007–2008 school year.

A planned additional course that was to be offered to participating students in the fall of 2007 was a junior certification in high-powered rocketry. The rocketry course would provide students with a better understanding of the physics of launching payloads into space.

Conclusion

The WinCube is now in its second year and has integrated a number of different projects under one umbrella. The combination of these projects makes the WinCube idea novel and exciting for all participating partners. In addition, such a multi-faceted approach has been very appealing for external funding groups and agencies and will be used to further enhance our ability to deliver these programs to high schools in Manitoba and beyond.

Acknowledgments

Our special thanks and appreciation go to the Winnipeg Amateur Radio Club (WARC), ARISS (Amateur Radio on the International Space Station), the 17 Wing (Winnipeg). We gratefully acknowledge the financial support provided by NSERC, CAS, and MindSet and thank the following individuals for their great involvement and support: Alan Thoren, VE4YZ; Steve McFarlane, VE3TBD; Dieter Schliemann, KX4Y; Greg Linton, VA4GL; Albert Sousa, VA4AS; Geoff Bawden, VE4BAW; Fred Venema, VE4FV; Gerry Baker VE4GTB; Rory Winters, VE4RJW; and Melanie Rennie.

Notes

1. Shambrock, J., W. Whaley, B. Klimenko, P. Wheatley, D. Boyd, S. Tully, J. Eady, C. Bosecke, J. LaRue, T. vanBeek, R. Le Neal., University of Manitoba Win-Cube Project 2006-2007 Preliminary Design Review, Winnipeg, Manitoba, 2007.

2. Koehler, Chris, "BalloonSat: Mission to the Edge of Space," *Proceedings* of the 16th Annual/USU Conference on Small Satellites, Logan, Utah, August, 2002.

3. Council of Ministers of Education, Canada (CMEC), Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum, Council of Ministers of Education, Canada, Toronto, 1997.

The Basement Laboratory Group: A Pioneering VHF Club

Part 3 – A Year to Remember

In Part 1 of this series on the Basement Laboratory Group (Summer 2008 issue) WA2VVA featured Carl Scheideler, W2AZL, and his well-known converter. In Part 2 (Fall 2008 issue) WA2VVA featured his father, Walt Morrison, W2CXY. In this part there are excerpts from a special Christmas tape recording that his father prepared for Ralph "Tommy" Thomas, W2UK/KH6UK, who at the time was residing in Hawaii.

By Mark Morrison,* WA2VVA

This, the third article on the Basement Laboratory Group, has two sections. The first section gives a brief history on aurora, VHF scatter communications and in particular items of interest from the year 1956. The second section is selections from a transcript of a Christmas tape WA2VVA's father put together for Tommy Thomas, W2UK/KH6UK, when he was living in Hawaii. It includes a number of VHF pioneers telling their own VHF stories in 1956. Most of the guys on the tape are no longer with us. Even so, their words to Tommy provide both relevance and history for us today.

The History

For the members of the Basement Lab Group the year 1956 was a year of anticipation, not just for the upcoming sunspot/aurora cycle, and the opportunity to participate in the International Geophysical Year (IGY), but also for the chance to communicate with Ralph "Tommy" Thomas, W2UK. Just one year earlier, RCA had relocated Tommy from New Brunswick, New Jersey to the Hawaiian Island of Oahu. It was there that Tommy would join the ranks of an elite group of radio men—those who once served as Engineers-in-Charge of the Marconi Transpacific facility.

In this remote location, Tommy was removed from anything approaching the VHF bands he left back east. In letters written to Walt Morrison, W2CXY, Tommy expressed interest in getting back on the VHF bands, even though little activity existed there at the time. In order to encourage Tommy, Walt produced an audio tape as a Christmas greeting from Tommy's friends back home.

Walt sent a form letter to over two-dozen VHF pioneers, asking each to prepare a 10-minute audio tape of what they had accomplished in 1956 and what they hoped to accomplish in 1957. The final master, which Walt spliced together from all the tapes returned to him, is a reflection of the early days of VHF radio not just from the perspective of those living it, but *when* they were actually living it!

Presented on the following pages is a brief history of those days, followed by transcripts taken directly from Walt's Christmas tape.

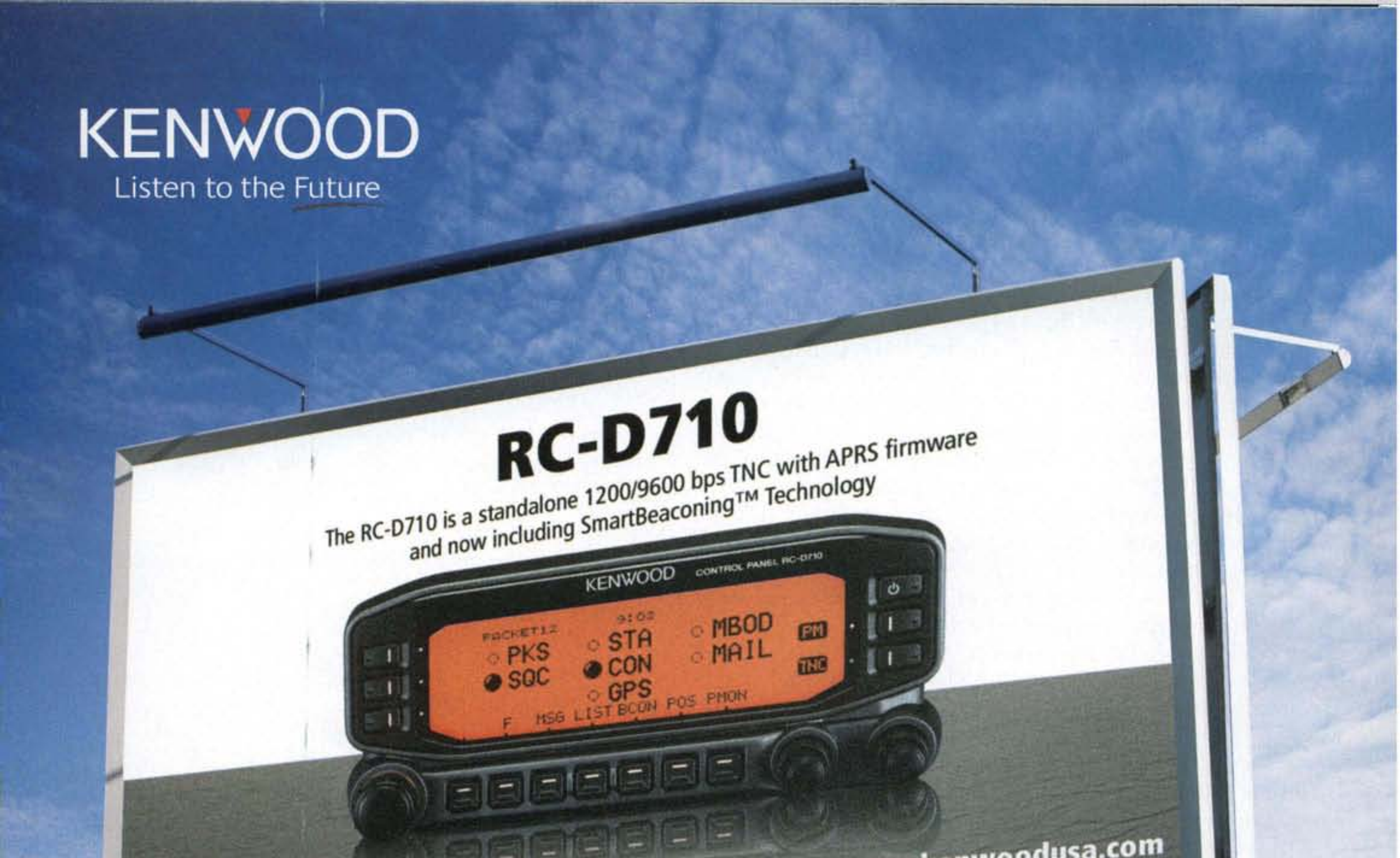
Background History of the VHF Ham Bands

Aurora: Although astronomers have been counting sunspots for thousands of years, the potential for sunspots to interrupt everyday life on Earth was not appreciated until the widespread use of telegraphy came into being. In 1856 *The New York Times* reported how a huge aurora caused interference with telegraph circuits all across the nation and described how the aurora "took possession" of telegraph offices, causing "all sorts of fantastical and unreadable messages" to be received. Numerous other references to aurora-induced Earth currents finding their way into the telegraph wires, and disrupting railroad operations, can be found in the literature.

When the discovery of radio-wave propagation came on the scene years later, it was also discovered that the aurora affected the radio-wave propagation as well. The need to understand this phenomenon became one of commercial interest as well, because telegraph networks and railroads depended on reliable communications. By the late 1800s the link between sunspot numbers and the aurora was generally recognized, as was the 11-year sunspot cycle.This meant that radio operators, telegraph operators, and railroad operators all could expect service disruptions on a regular cycle.

Although aurora initially was blamed for interfering with communications, VHF enthusiasts would later exploit this natural phenomenon as a means of extending the VHF horizon. Indeed, the solar cycle that peaked in 1948 led to the amateur

**5 Mount Airy Rd., Basking Ridge, NJ 07920*
e-mail: <mark1home@aol.com>


KENWOOD
Listen to the Future
RC-D710
The RC-D710 is a standalone 1200/9600 bps TNC with APRS firmware
and now including SmartBeaconing™ Technology
KENWOOD
Listen to the Future
www.kenwoodusa.com
TM-G707A
TM-V7A
TM-D700A

discovery of 50-MHz transequatorial (TE) propagation in 1947, a form of propagation that allows VHF signals to bridge the oceans between the Northern and Southern Hemispheres. This discovery was big news, because VHF signals were thought to be limited to line-of-sight propagation and not able to travel over the horizon.

The Demise of Channel One and the Rise of Long-Range VHF Propagation: With the advent of high-power television stations, more evidence suggested that VHF signals could indeed propagate over the horizon. The unexpected co-channel interference that resulted with fixed, mobile, and amateur allocations all in the same band prompted the FCC to eliminate shared services in 1949. Ever wonder what happened to TV channel 1? By 1950, Cornell researchers Booker and Gordon had developed the theory of VHF scattering.

The quest for reliable long-distance communications led to commercial and military interest in VHF scattering. The most ambitious project was that of the Collins Radio Company. In 1950, Collins began experimented with powerful transmitters on 49.8 MHz to see if VHF scattering might prove reliable for over-the-horizon communications. The earliest experiments used transmitters on the order of 30 kW for a path between Iowa and Sterling, Virginia. As a result of these experiments, a new form of VHF propagation was discovered, that of VHF Ionospheric Scattering. With sufficient power, and sensitive enough receivers, communications was reliable over 90 percent of the time at distances over 1000 miles!

It is interesting to note that over-the-horizon VHF propagation was actually predicted by Marconi as early as 1932, as the result of his own experiments with microwaves. However, the necessary high-power transmitters and ultra-sensitive receivers would not be available until the development of radar decades later. Until that time, Marconi stuck to the low frequencies and used up to 300 kW to set the standard for reliable communications in his globe-girdling network of stations, including the one managed much later by Tommy at Kahuku.

One important difference between the Marconi and Collins circuits was that geomagnetic disturbances actually enhanced the ionospheric signal while interfering with the Marconi signal. Had it not been for the development of satellite technology just a few years later, Marconi's network may well have been replaced by a comprehensive scatter system. Indeed, Marconi was one of the big players in early scatter technology.

The relative immunity of scatter communications to geomagnetic disturbances made it ideal for use in polar regions, where the aurora was a common occurrence. To this end, ionospheric as well as tropospheric scatter systems were a critical element of the Defense Early Warning System, or DEW line.

It is interesting to note that many of the 28-foot Kennedy "tropo dishes" that were used in DEW-line operations later played an important role in amateur moonbounce experiments. In the early days, both Sam Harris, W1FZJ, and Tommy Thomas, W2UK, used such dishes, and even today moonbounce authorities such as Al Katz, K2UYH, still put them to good use.

Although the "Collins Colossus" was a loosely kept secret, with magazines such as *QST* and *CQ* expressly prohibited from mentioning it, many amateurs using 6-meter gear knew that something was happening because of the curious signal that was always there.

By 1956, the publishing ban was lifted, and Ed Tilton, W1HDQ, suggested in the January 1956 issue of *QST* that amateurs should do more to exploit this propagation mode using

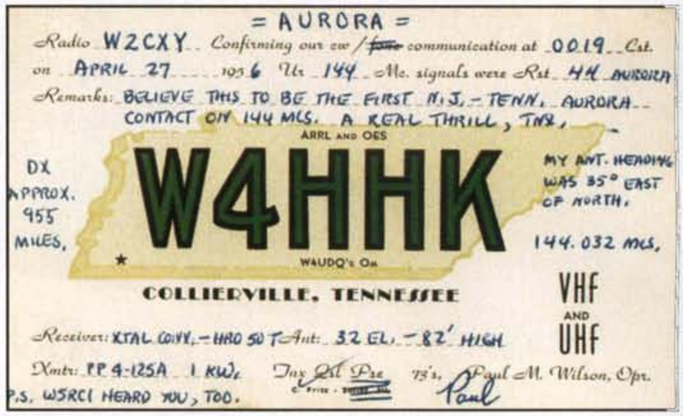


Figure 1. The QSL card of W4HHK documenting the April 27th contact with Basement Laboratory Group member Walt Morrison, W2CXY.

their own 6-meter gear. He mentioned how his own experiments with Paul Wilson, W4HHK, using only modest power, had already generated some good results.

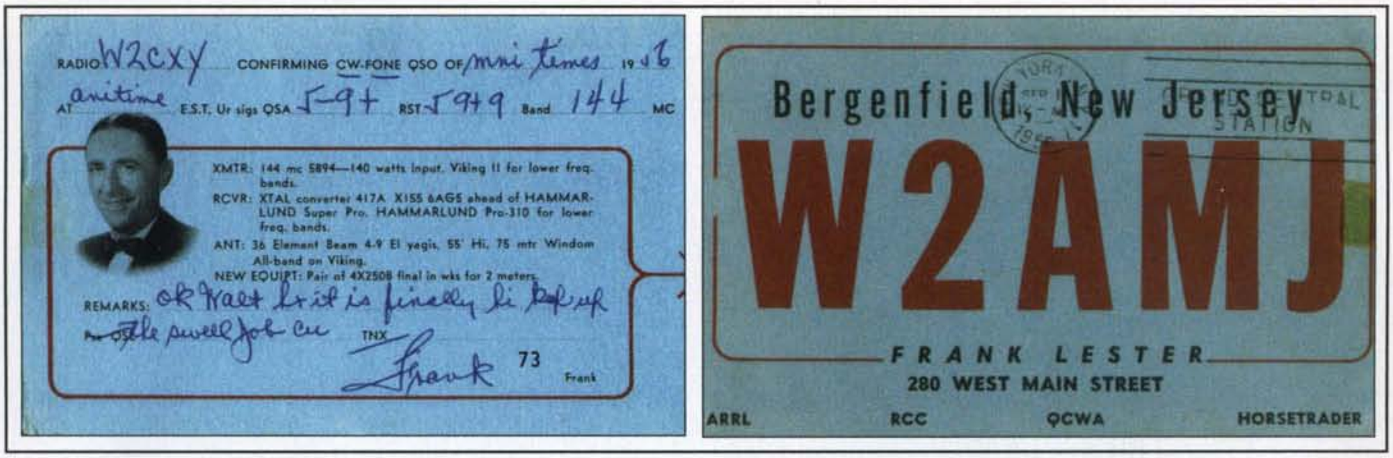
In March 1956, Mark Moynahan, W2ALJ, published a comprehensive article on the subject in *QST* magazine. Mark explained how the ionospheric scatter signal is always there, and "barely perceptible against the background of cosmic noise."

It was in 1956 that the number of amateurs operating on VHF frequencies was ever growing and with the peak of the next sunspot cycle expected in 1957, many were looking to improve their "states worked" and "best DX" totals. Weak-signal operators already established with high-power meteor-scatter and aurora stations were in a good position to investigate VHF ionospheric scatter, especially those with 6-meter gear. Reports of England coming through on 6 meters only added to the excitement!

Ed Tilton was particularly concerned that amateurs weren't making the most of their assigned VHF frequencies and continued his encouragement of readers to give 6-meter ionospheric scatter a try. In February 1956, Ed reported that in addition to Paul Wilson, W4HHK, Walt Bain, then W2WFB and now W4LTU, would "welcome skeds with stations at suitable distances from Ithaca." Tilton described Walt's station as having a 1-kW final and a stacked Yagi array for 50 MHz.

When scientists invited amateurs to participate in the IGY, Tilton once again encouraged amateurs to get in the action, taking advantage of the increasing number of sunspots and the opportunity for amateur radio to contribute to our scientific understanding. After all, if not for radio amateurs pushing the limit in the late 1940s, TE might not have been discovered. Furthermore, with so many more VHF stations on the air in 1956, who knew what discoveries might lie ahead.

In the spring of 1956 strong aurora activity swept the nation, with April and May bringing optimum conditions for VHF communications. Tilton's "The World Above 50 Mc." column in the July 1956 issue of *QST* quotes Paul Wilson, W4HHK, as saying the April 26–27 session was "the best aurora in my v.h.f. experience." It was reported that Paul worked an impressive string of 2-meter stations all the way from the Midwest (W8SVI, W8PT, and W8DX) to the East Coast (W2CXY, W2PAU, W2AMJ, W2AZL, W4RUE). Figure 1 shows the QSL card of



Figures 2 & 3. Paul's contact with Frank Lester, W2AMJ, of Bergenfield, New Jersey was called by QST *"one of the longest 2-meter aurora hauls ever reported." Shown are two parts of the distinctive foldout QSL card of W2AMJ.*

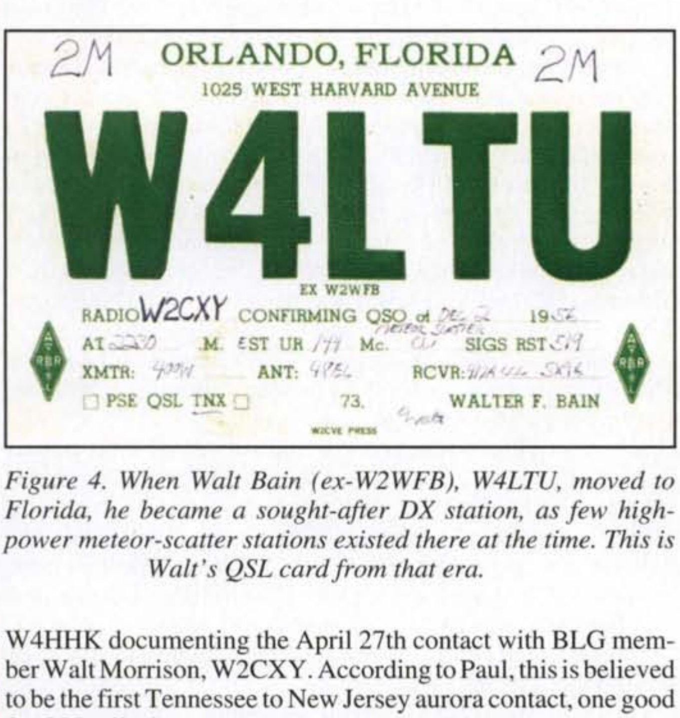


Figure 4. When Walt Bain (ex-W2WFB), W4LTU, moved to Florida, he became a sought-after DX station, as few high-power meteor-scatter stations existed there at the time. This is Walt's QSL card from that era.

W4HHK documenting the April 27th contact with BLG member Walt Morrison, W2CXY. According to Paul, this is believed to be the first Tennessee to New Jersey aurora contact, one good for 955 miles!

However, as impressive as that contact with W2CXY was, Paul's contact with Frank Lester, W2AMJ, of Bergenfield, New Jersey was even better, as Frank lived several miles farther north of Walt. *QST* called this "one of the longest 2-meter aurora hauls ever reported." Figures 2 and 3 show the distinctive foldout QSL card of W2AMJ.

The same aurora also helped Walt Bain, then W2WFB, of Ithaca, New York, log 91 two-meter stations in six call areas and 17 states during the April 26th opening alone! Later that year, when Walt relocated to Orlando, Florida, he picked up his original W4 call, W4LTU. Those familiar with meteor-scatter communications will recognize W4LTU as the author of two classic *QST* articles on the subject, both of which are current even now. When Walt moved to Florida, he became a sought-after DX station, as few high-power meteor-scatter stations existed there at the time. Figure 4 shows Walt's QSL card from that era. Walt Bain exhibited that true amateur spirit as he unselfishly helped other stations across the United States and Canada pick up Florida as their best DX.

The Christmas Tapes

The year 1956 proved to be an exciting year, first with the announcement of a new VHF propagation mode, ionospheric scatter, then with some of the best aurora sessions in modern history, followed by an invitation from the scientific community for amateur radio operators to participate in the IGY. It was also the year in which many an amateur got started in 2-meter meteor-scatter operations, following the path blazed by W2UK and W4HHK. As interesting as it is to read about those days, it's quite another to listen to those who lived it tell their stories. Thanks to Walt, W2CXY, an important chapter in amateur radio history has been preserved. What follows are transcripts taken from Walt's 1956 Christmas tape to KH6UK giving an eyewitness account of 1956. Sit back and "listen" as many of our VHF pioneers tell the story of 1956 in their own words.

Walt Morrison, W2CXY, Chatham, New Jersey: Hello there, this Walt again, W2CXY, as if you didn't know. It's late December of 1956. The holiday season is upon us and Christmas is almost here. Christmas is also the reason for this tape. Many words can be used to describe what follows, but fortunately the tape speaks for itself.

Walt Bain, W4LTU (ex-W2WFB), Orlando, Florida: Hi Tommy, this is Walt Bain. I used to be W2WFB up in Ithaca, NY. I worked you quite a few times there, mostly on CW. I'm down in Orlando, Florida here right now and the new call is W4 "Love, Tear, Uncle." I got my old W4 call back [see figure 4] and you may have heard we've been doing some meteor work from down here that turned out real well. We've made five contacts so far. That's just about the only contacts to be made down here.

I didn't get set up in time for the *Perseids* shower but during the *Orionids* I worked W9WOK, W3GKP, and W2ORI there. WOK and ORI there it was on the long over dense burst. On WOK the burst lasted for about 100 seconds and John's signal was running S9 on the meter there. If I had the presence of mind to flip on the modulator we could have made it the first phone contact on meteor I guess. Let's see, it was GKP that was the other over dense.

Incidentally, Smitty was having transmitter trouble at the time. He had a measured power of 15 watts I believe into the antenna at the time I worked him. I could just barely read him here but he was getting good signals from me. And I worked John up there, ORI, to give him his 27th state I believe. That was on short under dense pings with lots of repeats. And then it was during the *Taurids* I worked 2NLY there I guess for the first Jersey Florida. Then during the *Andromedids*, just recently, I worked 9KLR. Just getting ready for start *Geminids* skeds here and want to pick up a few more, hi!

I wonder how things are out there, Tommy. I wonder if you hear from much of the old gang there. I wonder if you hear from a mutual friend of ours here, 2OPQ up there, old Fran. I understand you're trying to get set on 2 meters there and work across to the mainland there. I sure hope you can do it there. I guess that's kind of a long haul for meteor scatter. I guess you're aiming toward the lunar angle. I want to get in on that a little bit too. I'm going to run some tests with 2NLY here after the first of the year. [More on those tests in a future article.] I got a 48 element here now, four long Yagis spaced 2 wavelengths and I'm running 400 watts here now. When I left Ithaca I had to give back my borrowed plate transformer but hope to get a KW final on here pretty soon and then work some real DX, hi.

Activity is pretty poor down here. There's the usual Gonset crew that congregates up on their prescribed frequency up on the high end and works with their vertical whips and so forth and that's almost the extent of it, although there are a few stations scattered around at 50 to 100 watt class I guess, but aside from the meteor work the only out of state contacts I've made are into Alabama and into Cuba. CL2VY is on down there with a good setup and I've even worked Georgia, hi!

Well I guess that's just about it from here Tommy. Thanks an awful lot for the QSO. I never thought I'd have to work you this way but since you went way off into the Pacific there why I certainly wouldn't want to have to go down on 20 meters or anywhere there, hi! So Merry Christmas there Tommy. If you get back in the states maybe we'll be working you direct sometime. In fact, maybe we can work you out in KH6 there if we get working on this lunar reflection stuff. 73s for now there Tommy, from Walt, W4LTU, ex-W2WFB.

Lawrence Lewis, W2ALR, Lockport, New York (see figure 5): KH6UK this is W2ALR at Lockport, NY calling. Hello Tommy. Very pleasant to be talking with you again on tape. Congratulations on winning the 1955 ARRL award on the meteor burst with Paul. Very, very good work. I hope you keep it up on moonbounce.

Working for Sylvania Electric Products in the Military systems Division has involved some travel and consequently I didn't get all the projects done this summer that I'd hoped to. A 64-element beam for normal use every day and a 128-element beam for moonbounce. Though I did collect the necessary parts to put together the 128-element antenna, I think we'll be able to do that throughout the winter and some of it next spring.

In the shack we've obtained a wire recorder and managed to record some of the better auroras and some of the meteor scatter skeds with 2ORI and 4LTU, Walt, ex-W2WFB, who's now in Orlando, Florida. I expect John will tell you all about that. All we can say is that we listened.

Am storing in the shack now a 75A2. One of the local lads has gone away to college and consequently we've been able to use a 75A2 for about the last 6 months. And it's been very, very pleasant. It's a terrific receiver compared to what we've been

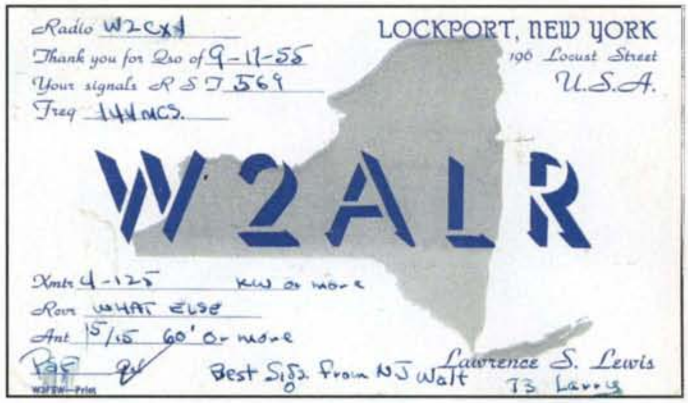


Figure 5. The QSL of Larry, W2ALR, sent to Walt, W2CXY, for a contact on 144 mc in 1955.

using and makes working DX on 2 meters an awful lot easier. I'm afraid if he ever takes it away from me I'm afraid I'm going to have to break down and get something of that order.

Some of our other activities: I've built a 6-meter transmitter, 100 watts to a 9903. Using a crystal controlled cascade converter for receiving in the 75A2. Modulator 6146's and a 4 element beam on another 30 foot telephone pole. ... Today is Sunday the second of December. Just this morning I missed an opening into England on 6 meters. I don't believe anybody worked, but W2WII of Geneseo was heard in England by G5 baker dog, or something like that. We've got 20 states now Tommy, on 2 meters this is. I was heard in North Dakota here a little while ago. I heard him and he heard me. We both called each other and I think his call was WØSYJ, but didn't connect. Heard Florida, by way of 2ORI's meteor scatter skeds and heard Iowa a couple of nights ago on aurora.

No tropospheric openings around here at all this summer Tommy. I've worked as far as Illinois and down through that area. I heard Paul on once this year on a tropospheric opening but by far and large the majority of openings we've had this year have been on aurora and a majority of DX was worked on meteors I think. The aurora, I don't know, maybe it's a false impression but lately here we've had some aurora almost every week. I think maybe this shows a trend upward with the sunspot cycle to lots more aurora.

Dick Cotton, W8DX, Detroit, Michigan (see figure 6): Hi Tommy, this is Dick Cotton, W8DX, of Detroit, Michigan. Sure miss the signal of W2UK in there when the aurora is on. There's

Figure 6. The QSL card of Dick, W8DX, sent to Walt in 1954.

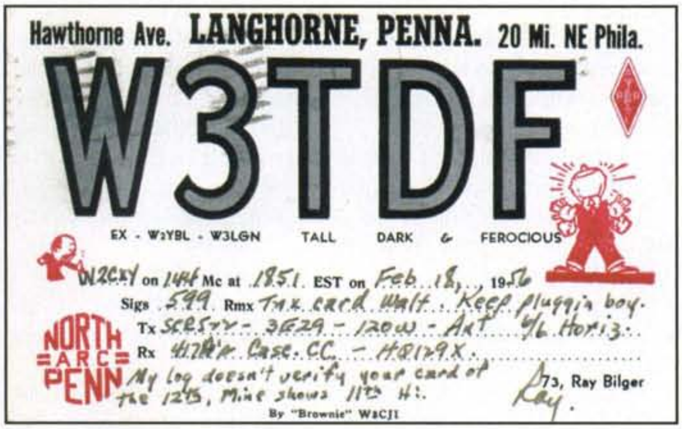


Figure 7. Ray, W3TDF, sent this card to Walt for a 144-mc contact in 1956.

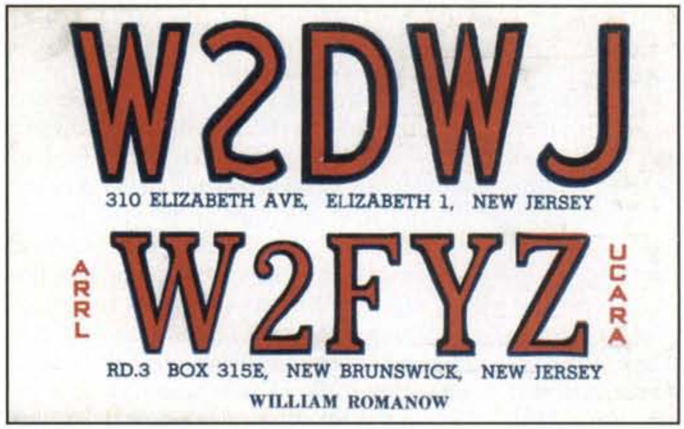


Figure 8. Bill, W2DWJ, of Elizabeth, New Jersey contributed to the Christmas tapes of 1956.

been a lot of aurora this year. I worked over 150 stations in 23 states by aurora alone in the past year, including 30 W1s in all six New England states. New Hampshire and Maine were new states of course and I've also added Nebraska in the westerly direction. Heard North Dakota and South Dakota also on aurora but no luck on contacts. Direct openings are rather scarce this past season and no new states were heard or worked that way.

I'm still running 1 kW to a pair of VT-127As and narrow band FM on phone. I have a 45 element beam up for 144 which was pictured in April 1956 *CQ*. Also have 350W on 220Mc and a 30 element beam. And 50W on 432 with a 45 element beam which is a scaled down version of the 2 meter job. I'm still working on my ham TV here but not on the air as yet. The camera is working fine but the modulator and the sync troubles are plaguing me as well as lack of time. Want to wish you a Merry Christmas and I'd sure like to hear your signals out here in Detroit. And I hope we can hear W2UK on again sometime. This is W8DX of Detroit.

Ray Bilger, W3TDF, Langhorne, Pennsylvania (see figure 7): Glad to get this chance to talk to you and Helyne. … We're running meteor scatter skeds with W4LTU all this week December 9th to 14th or something like that. Well, when are we going to get together, you and I, and start making schedules on 6 meters? The way that 6 has been open it "oughtn't" to be too long, boy! Say the word when you're ready.

This guy Walt, 2CXY, boy he is a rough character! I've been trying to take him in the contests, Tommy, as far as section multipliers are concerned, but I can't seem to top that boy. I don't know. You've got a pretty good protégé there holding down the fort until you get back.

By the way, still running the same 100 watts here.… Same old beam, 6 over 6, no changes… The old 417A converter is really doing a bang up job, A-1, 100 percent!

Bill Romanow, W2DWJ, Elizabeth, New Jersey (see figure 8): We're still running a hundred watts here. We've picked up the sockets and we're thinking of the 4×150s per *QST* there, only we'll double up. We've got all our antennas on one boom here and we built up a 50-element beam similar to Walt's there. Two-twenty activity is pretty good around this area but 420 there's just a few but they're coming up. We picked up two states this year I think in the early part of the year on aurora. But that was it. When you saw in *QST* where AMJ worked 4HHK I picked up Wisconsin. I missed HHK so we still have to get him.

Frank Lester, W2AMJ, Bergenfield, New Jersey (see figures 2 and 3): Calling KH6UK, KH6UK, KH6UK, this is W2AMJ. W2 April May June, the spring station at Bergenfield, northern New Jersey via W2CXYs tape recorder wishing you and yours a very, very Merry Christmas and Happy New Year.

Nothing too much to report. We've been able to get out of the back yard a little bit with the hundred watts. Have added trigonal reflectors to the old 28-element beam which you undoubtedly saw in the October issue of *QST* and have plans for completing a new California Kilowatt, and I mean California, using a pair of CX300s, the new ceramic tetrodes being talked about by Eimac recently. But at the rate I'm going

I imagine it will be sometime in the reasonably early part of 1957 before we'll be able to fire it up.

I actually ordered a tape recorder to make up a little recording for you but it's still on the way and Walt on this nice Sunday morning of December 16th is making the tape for me via 2 meters and off the back of the beam! I just got through talking to Matt, W1EY(?) who is starting to play with sideband and was running a big total of about 9 watts input to a Class A linear up there in Fairfield, Connecticut and coming down here to Bergenfield in nice shape. I also want to extend for everybody else up here that isn't on the tape wishes to you for a Merry Christmas, happy and prosperous 1957, including Tony, VE3DIR. I don't know whether Walt is going to get a tape from Tony or not. If he does, I imagine it will have to be by other means than this since the band hasn't been good enough for Walt to cut a tape from Tony directly. I don't know whether you know it or not, but he's going to take the "fatal step" in I believe April of next year and the picture of his "better half to be" was in a recent issue of *CQ*.

I can't think of anything else much to tell you except that naturally we're all hoping that one of these days KH6UK will come "bopping through" on 2 meters and by that time maybe I'll have the new final running and we'll work two-way the long way around! I guess that's about it. It looks like I've "gassed on" here for 3 minutes wandering along. So once again, here's hoping that you're enjoying the Hawaiian atmosphere out there and not drinking too many "poi eyes" I think they're called. So without further ado Tommy, I want to once again thank Walt for putting this down on the tape and we'll close once again by wishing you a very happy, prosperous, etc., healthful of course, 1957. W2AMJ through the courtesy of W2CXY who is cutting this tape via 2 meters is now off and clear and turning it back to you Walt.

Carl Scheideler, W2AZL, Plainfield, New Jersey: Well, OK Tommy, we'll be seeing you and we'll be working you on 2 one of these days, Tom, we hope. And don't sell the old meteor scatter stuff short with your friend there in California [W6NLZ]. You ought to try that with him one of these days on a good shower. The possibility is there, boy. So anyway, we'll sign with you now and see you next Thursday if the Lord is willing; 88s to Helyne and 73s to you and I hope "Santy Claus" is good to you.

Telephone Conversation

What follows is a transcript of a phone conversation among the following hams in December of 1956: Paul Wilson, W4HHK, Collierville, Tennessee (see figure 1); Tony Sheppard, VE3DIR, Toronto, Canada (see figure 9); and Walt Morrison, W2CXY, Chatham, New Jersey

Paul: You were up out whooping it up last night, were you? It looked like they were doing the same on NBC last night. Yes, we had several "boo boos." Some queue leader going through the projector and things like that on the station break. And we closed out with Steve Allen's Tonight Show and having a good time... "dB" [an affectionate name for Paul's wife] baked a bunch of goodies and we nibbled on goodies all evening, nothing exciting. Won't be able to climb if I eat too much! ... One thing I've been concerned about, the phasing line that goes from each 16 element bay down to the matching transformer is this 400-ohm TV lin e...so I suspect I might improve things by replacing those phasing lines with new ones and trying to overhaul the whole feedline ...When I can get around to it, before I can do any replacing, I've got to rig some sort of platform or mast to enable me to get up above the top of the tower about a few feet to be able to reach to the point where I have to solder, because without a little preliminary scaffold work I can't begin to reach it. It's not a matter of just going up there and replacing it but I think when I do that I'll probably hear a little better and maybe transmit a little better.

Tony: Well, all you've got to do is get "dB" to climb to the top and stand on your shoulders!

Paul: I don't know if she'd go for that or not!

Tony: I've been kidding her about getting to the top of one of those hundred-foot sticks and she sounds kind of leery about the whole thing!

Walt: By the way, who does climb those-hundred foot sticks?

Paul: Well, I do because I have to, and my partner GYS. And they're really steady. The two towers are nine feet apart, half wave on 6, and each guy station is cross braced one to the other with a framework of 1 inch steel angle. They're like a ladder, you know. And the two towers make a big ladder. It's quite rigid and steady. And, well, I haven't written you since, but just the other day we finished putting up all the booms, so all 24 elements are up there now. But the phasing lines are not connected to anything. I've got to mount the matching transformer and a couple of junction boxes so to speak and then we're in business.

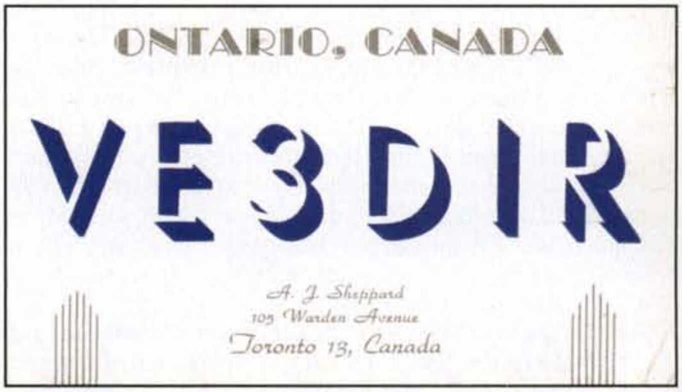


Figure 9. Tony Sheppard, VE3DIR, was a participant in a December 1956 phone conversation among W4HHK, W2CXY, and VE3DIR.

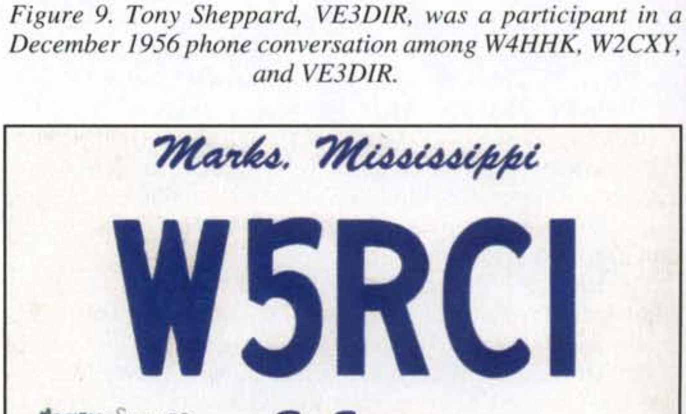


Figure 10. According Walt, W2CXY, in 1956 aurora sessions were very interesting and numbered 48 in his particular part of the country, with the best sessions observed probably around April or May, when Rex Turner, W5RCI was hearing Walt and other East Coast W2s.

Tony: Never mind all this hogwash about 6, how about the Long John on the top for 2!

Paul: Well, that'll come later! Because it should be a near perfect location, of course there's the power line coming in, but except for that only an occasional tractor. There's nothing within a mile. In your direction there's just a gentle slope downhill, Oh for at least a mile.

Tony: See, that's what I mean. You've got to get rid of all that 6 meter stuff! Now, if you put up a Long John for each element that you've got on 6, well that might be something!

Paul: What I hope is to have some sort of reliable scatter circuit with the boys up east so I don't have to depend on the telephone. Judging on what the 4 element did here ... it might do pretty good, but time will tell.

Tony: Yeah, well, come on Walt, needle him a bit about 2 for goodness sakes! We've got to work 4RFI for Tennessee these days.

Walt: Yeah, I thought he was going work a lot of VHF bands but he's a converted 6 meter man, I can see that!

Paul: Merry Christmas Tommy and Helyne, this is Paul, your old "Tennessee turtle" speaking... "dB" is sawing little logs right now.

Tony: And the same from me too!

Tape Ending

What follows is a transcript of how Walt ended the tape in December of 1956:

W2CXY: Back to Chatham, New Jersey now. Much has been said, and much has still to be done. At this end, in recapping the work of 1956, tropospheric openings of any great magnitude on 2 meters were practically non-existent. Aurora sessions were very interesting and numbered 48 in this particular part of the country, with the best sessions observed I think somewhere's around April or May, when Rex Turner, W5RCI (see figure 10) was hearing this station and other East Coast W2s.

Progress by the gang included several new kW amplifiers, larger antennas, and more 417 converters resulting in a lot of crowding at the low end of the band, receiver overloading, and cross modulation being quite a common occurrence, especially between stations within a 15 or 20 mile range radius. Nothing new on exclusive CW segment for the band, something to look forward to working on in 1957. Many of the gang picked up some new states via the buzz [aurora] sessions. Some worked some W8s for the first time in Ohio or Michigan. Some worked W9s in Illinois and Wisconsin. No WØs were heard at this end, in this particular area at any rate, neither were any W5s except perhaps by Brownie, W2PAU, who was ... hearing W5RCI during that April or May buzz session.

The program for 1957 includes a more efficient final amplifier, about which you heard a little bit tonight, a monster, circularly polarized antenna for moonbounce work and in connection with this latter item. Are there any takers?

(Editor's Note: When we were in the final stages of editing this article at the end of December, word reached us that Rex Turner, W5RCI, who is one of the pioneers mentioned in this article, was expected to live for only a few days. In response to this sad news, special arrangements were made to e-mail a copy of this article to him in hopes that it would provide him with some comfort during the remaining days of his life.)

Riding the Terminator From 6 Meters Down to 160 Meters

A major amateur radio operation from above the Alaskan Artic Circle took place for the first time in many years this past July during the Alaska Convention. Adding to the special aspect of the event was gaining permission to use the call W1AW/KL7. Amateur radio activities took place from HF to microwave frequencies. Here is the story.

By Gordon West,* WB6NOA, and Bill Balzarini,† KL7BB

In our ham radio hobby, it is rare when you actually get to both see and operate inside the natural medium that supports our RF signals and takes them to faraway places. Such is the case in the far north of Earth's Arctic Circle. Alaska's Arctic Circle just happens to be one of the places on Earth to which people can actually drive. Because of the summertime conditions, the Alaskan Arctic Circle has a full day of the sun's effect on radio propagation. Sunrise, sunset, full daylight, and twilight are the active times in which the 66° 33' N latitude location offers operators of radio equipment a full-day possibility of having their signals reach somewhere far away, DX locations. Depending on the ham bands used, the RF signals can take multiple hops to reach exotic distant locations.

Dalton Highway Arctic Circle road sign. (Photos courtesy of the authors)

The magic becomes evident when astronomy programs are put to the task of showing (from an outer-space perspective high above any Earth location) the difference between day and night. It is along that magical line where the direction of the RF path really jumps out and gives a very clear picture as to where the paths are pointing. It is best to make 24 one-hour incremental prints of each day's activity to help with the visualization during the middle of the night, when one is very tired from logging 6- to 10-plus straight hours of contacts.

Also, in that part of the far north, one does not want to spend very much time outside alone, adjusting the direction of a beam antenna, as one could become "dinner" for some foraging bear. It is a fact of life in that area of which one must be very cautious.

Just as with other types of DXpeditions, the signals may not be very strong at the start. It helps considerably that just one station finally receives that all-important first contact and creates a big fuss that alerts all of the masses to follow. Many contacts can follow that first effort, and once everyone has figured it out, you are on the fast track to running QSOs just as fast and furious as you can hear and log them!

I wrote down all of the contacts using pen and paper with a glance at the clock for time. The contact rate was slow enough to use to the closest minute for the log on phone contacts. The CW guys were all electronic in the logging and operational parts of the process. It was very impressive to see the fully automated logging and exchanges with that many stations calling from all over the world.

Once we were really "rocking and rolling," the hourly heading print-outs became the best tool of the operation. A quick glance at the log to see if another hour had gone by—and a fast peek into the sunrise-sunset one-hour pages—confirmed that once again it was time to go outside and redo the beam heading. Before going outside, there was the obligatory quick look to see if anything big and black was moving about the camp, lest we had a false sense of security of no bears in the camp and perhaps turning the beam would not be successful.

It was quite scary on our last night in camp, when one of the operators, Jim Adkison, WL7NJ, went outside for some

**CQ VHF Features Editor, 2414 College Dr., Costa Mesa, CA 92626*
e-mail: <wb6noa@cq-vhf.com>

†1414 South 324th St. #B-209-105, Federal Way, WA 98003-8444
e-mail: <kl7bb@yahoo.com>

Bill Balzarini, KL7BB, Calex Gonzalez, KL2BT, and Richard Tweet, KL2AZ, inside the weather port at the 2008 Alaska Convention.

air and spotted a big, black, 4-foot high "blob" jumping into the brush from behind his truck, only 150 feet from the operating positions. After all, however, it is their territory and we were strangers and intruders. It took Jim about two minutes to calm down and check out the operation, and then settle back into the contact mode with Asia and the Far East.

The "terminator," for those of us in the lower 48, is ten minutes of DX sunrise and sunset excitement nearly halfway around the world. However, for the recent W1AW/KL7 July-August two-week special-event operation as part of the Alaska 2008 Convention, riding the terminator on Alaska's Arctic Circle was a daily 20-plus hour blast in the Land of the Midnight Sun.

From the definition in Chapter 20.15 of the *ARRL Handbook*, the gray line consists of paths that can be considered a special form of long-path propagation that takes into account ionospheric configuration, along the twilight region between day and night. The gray-line DX propagation window supports the best of daytime and nighttime long-range contacts as one operator watches the sunset while the other operator is beginning to wake up to sunrise. Many times chordal "waveguide" propagation also takes place.

Inside the Alaskan Arctic Circle, the terminator between night and day allowed the ten W1AW/KL7 operators to literally "ride DX" throughout the many hours of spectacular sunsets and sunrises, from 6 meters on down to 160 meters.

"Back in the late '70s, I knew there was some exciting high-frequency nearly continuous propagation in June, July, and August during my electronic radio tech days with the Columbia Wards fisheries in Bristol Bay," comments Bill Balzarini, KL7BB, who, long before the event, accurately predicted the possibility of fabulous DX for the Arctic Circle team.

"From 2 MHz to 18 MHz, that band of frequencies was our only HF radio link between canneries and our fishing fleets using a traditional long-wire antenna. After 9 PM local Bristol Bay Alaska time, I would switch the long wire antenna over to my HF radio and begin to hear late-evening foreign stations coming in on many 20- and 15-meter frequencies—nearly nonstop—for hours on end. Because we were just past a minimum of solar activity, the customary 20-meter band condition of being dead-after-dark was an anomaly of great signal strength in the high latitudes throughout Alaska," adds Balzarini.

Anchorage Amateur Radio Club, KL7AA's tower and generator at the W1AW/KL7 operation during the 2008 Alaska Convention.

Balzarini reports that these fabulous all-night band conditions were well known by famous DXer Chip Margelli, K7JA, operating at Rush Drake, W7RM's QTH from Foul Weather Bluff in the middle of Washington State's Puget Sound. "From the Bluff, the mega-station operators enjoyed great DX along with Coca Cola and chocolate chip cookies all night!" reports KL7BB, and confirmed by Chip, K7JA. KL7BB concludes, "May through August is the best time in KL7-land to enjoy sunset to sunrise DX."

Thirty years later, Balzarini suggested the DX possibilities at the Arctic Circle as one great way to celebrate the 2008 ARRL Alaska State Convention. He proposed this mini-DXpedition special event station to the W1AW/KL7 planning committee, which included: Richard Tweet, KL2AZ, Alaska Convention co-chair; Scott Honaker, N7SS/KL7; Roger Gollub, WBØCMZ/KL7; Calex Gonzales, KL2BT; BruceMcCormick, KL7BM; Mike O'Keefe, KL7MD; John Orella, KL7LL; along with several others.

Heather Hasper, KL7SP, the other Alaska 2008 Convention co-chair, agreed that it was an interesting idea. However, she recalled that the only road to the Arctic Circle, Old Pipeline Haul Road, followed the Alaska pipeline and was limited to only those with proper security clearance. The good news is that the formerly restricted road, now called the Dalton Highway, which runs from Fairbanks to the Arctic Circle and beyond, is now open to public access for over 500 miles of raw wilderness all the way up to the Arctic Circle.

"Just be sure to slow down to prevent windshield damage from flying pebbles," commented the husband and wife team of Janet, KL7MF, and Chip Margelli, K7JA, when I traveled with them to Coldfoot, Alaska, 60 miles beyond the Arctic Circle. Rental cars are told to stay off the road, but there was

Scott Honaker, N7SS, in front of the W1AW/KL7 operating tent during the Alaska Convention.

no limitation to hams with personal trucks, trailers and towers, and hundreds of pounds of operating equipment for the two-week W1AW/ KL7 run, concurrent with the Anchorage, Alaska 2008 Convention.

ARRL Executive Vice President Dave Sumner, K1ZZ, was presented the idea of a W1AW/KL7 special-event station. With input from ARRL Northwest Division Director Jim Fenstermaker, K9JF, and a nod from ARRL President, Joel Harrison, W5ZN, the Arctic Circle Convention expedition was approved.

"At the Arctic Circle in August, twilight at sunset and twilight at sunrise would last for hours on end for extraordinary gray-line terminator DX contacts. We weere actually skirting the *back side* of the gray-line terminator, being within the constant twilight side of the terminator, never seeing total darkness that would otherwise negate the gray-line DX path," explains Bill Balzarini, KL7BB. He adds, "Our summertime tilt of the Earth, this far north at the Alaskan Arctic Circle during August, gave us nearly eight hours of twilight DX.

A Stepp-IR Yagi allowed the operators to sort out the DX—one direction Europe, and 180 degrees out VK-ZL and Asia. Even though there was the constant auroral oval (unseen because there was no darkness), stateside contacts were easy by pointing the beam southeast.

Even though the first day they operated "barefoot," once their station got noticed and posted to the internet, the pile-ups continued nearly 24/7. Around 0600 UTC, Europe became a wall of white noise with thousands of stations

Richard Tweet, KL2AZ, and Scott Honaker, N7SS, at the HSMM microwave dish during the convention.

Front to rear: Mark Kelliher, KL7TQ; Calex Gonzalez, KL2BT; and Roger Gollub, WBØCMZ, at the W1AW/KL7 station.

calling. "Asia would start around 1000 hours UTC, with stations to the southwest peaking as they entered and exited their local brief terminator," adds Balzarini.

An interesting point that the many W1AW/KL7 team members made was keeping track of the DX potential stations' local time. There was not much DX if the distant stations were snuggled in their sacks during their 3 AM local sleep time.

On one weekend day, the Alaska operation coincided with IOTA, and one foreign ham didn't quite put the KL7 prefix into perspective and demanded to know what island the operation was on. "Look on most maps, and off the California coast to the southwest and you will find our KL7 Island plugged in, because they couldn't get us on the map," was the comment made by the W1AW/KL7 operator. Now that I think about it, I, too, have seen the Alaska "island" listed off southwestern California!

"Unlike the customary Arctic 'flutter,' our gray-line DX stations would remain strong for as long as the terminator was over the distant station. It was quite selective, and with the Stepp-IR vertical, with 24 radials, we could hear stations to the east and west come into view as the gray-line terminator would pass over their stations. Furthermore, the closer to the equator the station was located, the more brief the contact," adds Balzarini.

ICOM America supplied most of the HF equipment, as well as 2-meter D-STAR radios. All bands were on the air, from 6 meters on down, as well as the VHF and UHF bands. Jim Fenstermaker, K9JF, and Dave Sumner, K1ZZ, with the ARRL, were among the first contacts on CW. It was a 14-day operation, with Anchorage clubs operating for the first week and Fairbanks clubs taking over for the second week special convention event. A tradeoff of equipment was

Roger Gollub, WBØCMZ/KL7
Silent Key

By Bill Balzarini, KL7BB

This story is about Dr. Roger E. Gollub, M.D., and how in many ways he was the real-life version of the popular *Northern Exposure* television doctor Joel Fleishman played by Rob Morrow. Dr. Roger Gollub was tragically killed on November 19, 2008 in a dog-sled and snowmobile accident in Kotzebue, Alaska . Dr. Gollub, a pediatrician, was out in Kotzebue performing his medical work for the [Alaskan] Indian Health Service.

Dr. Gollub was taking a ride-of-a-lifetime dog-sled trip and had a chance to ride on the runners for the full experience of mushing in the still of the dark winter Arctic Circle night with the crisp cool Bearing Sea coast air rushing past his face for that extra nip and bite that says you're deep inside of Alaska's winter wonderland.

Dr. Gollub was born in New York and went to medical school in St. Louis. While there, he also studied and received his WBØCMZ license.

It is through Roger's passion for ham radio that I had the wonderful experience of watching him talk all over the world this past July from Alaska's Arctic Circle special-event ham radio station. With the callsign of W1AW/KL7, Roger had many thousands of foreign radio operators from all over the world calling and trying to work him through the deep pile-ups that sounded like the loud roar of Seahawks fans cheering at the stadium during a home game.

Roger was very interested in how to get more youngsters into the hobby of ham radio, and he was very becoming heavily involved with the activities of the Anchorage Amateur Radio Club, KL7AA. The excitement he had that fired his imagination at the Arctic Circle operating event is evident in his own words for the Sweepstakes ham radio operating contest for November 15–16, 2008. He expressed that the working knowledge and momentary notoriety of the 66° 33' N. event gave him the confidence to expand into having two ham radio stations active and on the air for the November contest right there in Anchorage.

His specialty was to use his gentle, delicate hands to run the Morse code keyer paddles to put out the callsigns and language of "original digital" continuous-wave CW to the anxious foreign ham operators who were lucky enough to be copied in the sea of ionospheric chaos. With all of his years of training at the key of his many radio stations, he was able sort out the most complex patterns. Another one for the logbook surly made many happy people around the world this past July.

Roger also had a zest for fishing each year. The year 2008 found him and his wife down on the Kenai for July Salmon. While he was on the Alaskan Arctic Circle, he was eating one the last of of a dozen jars of the 2007 catch that he and his wife had put up. He figured that it was time to get ready for the 2008 catch and the 2007 batch had to go. What better way to enjoy the last of the fish than to take it with him to the Arctic Circle. He gave me a chance to try many of the remaining different samples of he and his wife's special varieties of seasoned smoked salmon, all put up in those tiny little jars. Yummy is the only word that come to mind for the Alaskan delicacy.

accomplished halfway between Anchorage and Fairbanks, which was a classic example of distant amateur radio organizations coming together to make the Arctic Circle project happen. Just imagine that the ham bands were open to exotic DX locations for 20-plus hours per day, and this took place during the time when the sunspot activity was *zero*!

The VHF side of this operation was not as prolific as the low bands. The 6-meter operation was on the air each morning from about 5 AM to 7 AM in an attempt to work stations on the west coast of the USA. The ICOM 756PROIII was used with the KW amp into the Multiband Stepp-IR beam aimed SE in order to be into the gray-line terminator as it approached and traversed the west coast of the Americas. No contacts were made during that time. The operation was mostly inside the gray-line terminator zone, so the operators noticed almost no aurora effect which you would normally hear if you are outside looking in. They were not inside the auroral zone, but rather just outside the edge and the band conditions were very calm and settled. Because this late-July 2008 window was during the time when the Sun was producing zero sunspots, there was no pulsing Sun energy thumping the Earth's *E*- and *F*-layers. That is a good thing, however, mostly for hot HF band conditions.

The operators described the 6-meter band as being just as normal as if you were in a great "out in the country" home location with great equipment and no man-made noise—no cracks, pops, snaps, or other buzzing. "It was surprisingly smooth, like warm butter spread over a fresh-baked slice of hot bread just popped out of the oven," adds Balzarini. Unfortunately, except for a few syllables coming over the calling frequency of 50.125 MHz, the 6-meter effort was a total washout.

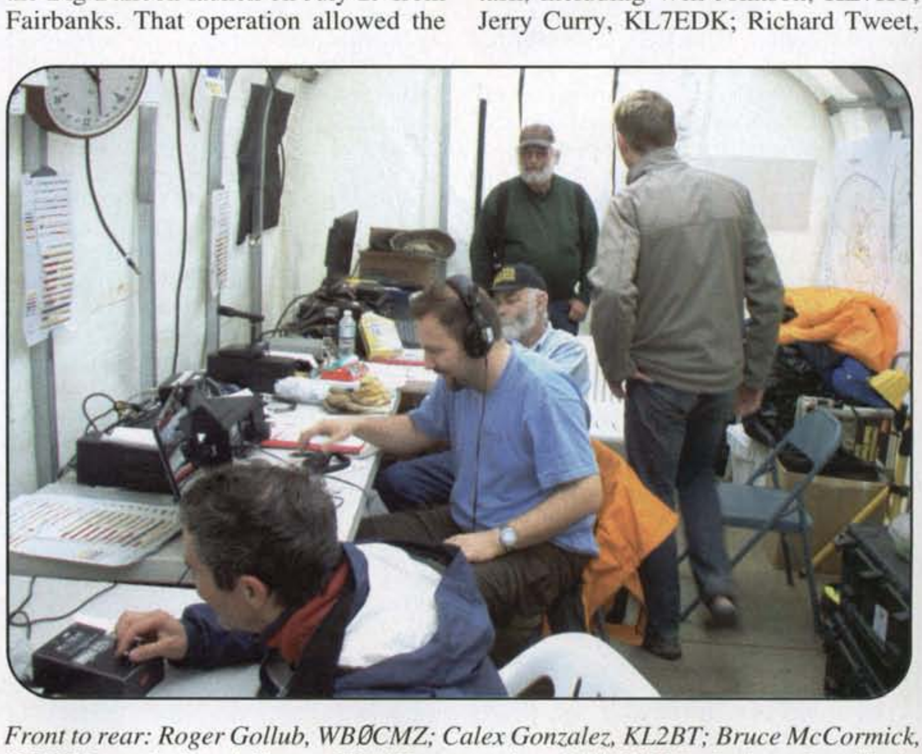
On the other hand, the 2-meter operations were done on several levels over the various times when the supporting groups and operators could be on site, that being Anchorage and Fairbanks. The main talk-in frequency was on 146.52 MHz simplex with a simple ground-plane antenna. The 145.100-MHz D-STAR Net was local and ran on simplex. History was made history as W1AW/KL7 was the first station to run D-STAR from the Alaskan Arctic Circle.

One of the hams from the Fairbanks area made contact with W1AW/KL7 from his float plane as he was flying supplies farther up the road to a remote bush fishing camp on a lake. On his way back he flew a giant circle overhead of the entire Arctic Circle setup, all the while talking with everyone on the ground on 146.52 FM simplex. Many of our operators posed for a group picture all holding ICOM D-STAR 2-meter radios.

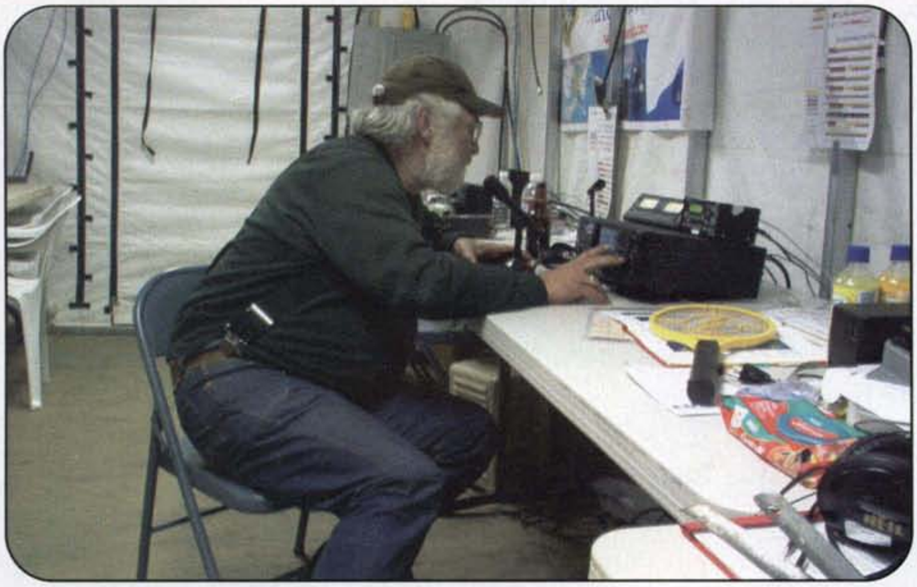
Various hams operating D-STAR on the Arctic Circle, posed in front of the W1AW/KL7 operating tent.

The operators from Fairbanks also supplied their satellite equipment and packet gear. Contacts were attempted through the Big Balloon launch on July 29 from Fairbanks. That operation allowed the many other hams in the state a chance to work all over on VHF. See: <http://www.bear.437am.com/> for all of the energy and equipment that was put into this project, and the BEAR 2 balloon sidebar.

As for our microwave operation, we were on the Hughes.net system which was supplying us with our high-speed internet connection for data and pictures on the Alaskan Arctic Circle. Thanks go to many people who stepped up to the task, including Will Johnson, KL7KT; Jerry Curry, KL7EDK; Richard Tweet,



Front to rear: Roger Gollub, WBØCMZ; Calex Gonzalez, KL2BT; Bruce McCormick, KL7BM; and Jim Adkson, WL7NJ, operating W1AW/KL7 during the Alaska Convention, as well as a visitor from Holland whose back was to the camera.



Jim Adkison, WL7NJ, operating from the W1AW/KL7 station.

KL2AZ; and Scott Honaker, N7SS. Their collective efforts and talents made the equipment work and helped with setting and aligning with the other equipment that was just a few degrees up over the horizon. The entire team then had a fantastic way to communicating to the outside world as to how well the operation was progressing from setup to when we were on the air. Even regular tourists to the Arctic Circle camping area were treated to the router's WiFi 802.11 wireless signal. It was quite an enhancement to being out among the Alaskan bears.

BEAR 2 Balloon Launch

The Balloon Experiment And Research (BEAR) Program at the University of Alaska Fairbanks BEAR 2 Balloon was launched at 10:11 AM on July 29, 2008, as scheduled in conjunction with special-event station W1AW/KL7. One of the payloads on the balloon contained the packet (digipeater) system which allowed amateur radio operators from across the state to communicate with each other.

Unfortunately, the APRS beacon signal was lost about 30 minutes into the flight. Along with its loss was the ability to track the balloon's flight path. While the APRS signal was erratic and unreliable, the digipeater worked exceptionally well, resulting in plenty of packet traffic among local hams and the special-event station manned by Bob Kreiser, WL7GK, as well as statewide ham-to-ham contacts.

Through monitoring of packet traffic—as well as Jerry Curry, KL7EDK, sending test messages during the tail end of the flight—it was determined that the digi was usable for the entire duration of the flight. Based on these observations, it was also determined that the flight lasted approximately 3 hours and 40 minutes.

The digipeater packet system performed exceptionally well and was a big hit for all who used it. Packet contacts on the digi included Fairbanks, W1AW/KL7, Chicken, Tok, Anchorage, Kenai Peninsula, Nilkiski, Delta Junction, McGrath, and others.

Although the packet system remained functional for over $3^1/2$ hours while in flight, there was no way to receive APRS position reports. Therefore, the organizers presumed that the balloon would be permanently lost.

On Sunday, September 28, big-game hunter Jaret Owens was guiding a hunting party (Ron Rockstad) in the remote area of the West Fork of the Little Delta River (Healy D1 quadrangle) when he spotted something blue and yellow on top of a nearby peak. Being curious, he hiked up to the location and noted the BEAR 2 parachute and payload capsules. Fortunately, all the capsules had ownership and phone numbers written on the outside, so Jaret called Jerry Curry, KL7EDK, and later called Dan Wietchy, KL1JP, on his satellite phone informing them about his find. After returning to Fairbanks several days later, Jaret met with Jerry in order to return the balloon remnants. Obviously, the BEAR launch team has been very excited about the recovery of BEAR 2.

This sidebar is a summary of two reports on the BEAR 2 balloon that appear on the BEAR website: <http://www.bear.437am.com/bear2index.htm>.

A Nostalgic 6-Meter Radiotelephone Station

Do you remember the good old days of AM modulation? If you do, then you will appreciate the fact that there are others who do, too, and are doing something about their nostalgia. Here K8VBL describes what one group in western Michigan is doing and how to build a station in order to join them the next time the band is open in that direction.

By Thomas Turner,* K8VBL

Radio amateurs are fortunate to have been allocated the 6-meter band, 50–54 MHz, because "Magic Band" signals in this part of the radio spectrum are propagated by every known mode. In fact, the cause of sporadic-*E*, one of the most interesting modes of propagation, remains to be discovered. In this period of low sunspot activity, the beginning of Cycle 24, *F2* propagation is rare. Sporadic-*E* is seasonal, centered around the equinoxes (early summer and late December).

To maintain interest in the "Magic Band" during periods of minimal DX propagation and promote experimentation, the West Michigan Six Meter Net was formed. The net meets Tuesday evenings at 9 PM local time on 50.3 MHz SSB. Net control stations in Kalamazoo conduct the net as a round-table, with over 20 stations checking in. At around 9:30 PM the net shifts to 50.4 MHz AM. Many of the AM stations check in using a 1950s-vintage Heathkit "Sixer" transceiver, also known as the "Benton Harbor Lunch Box." A "WAS" certificate (Worked All Sixers!) is issued to those who use a "Sixer" to contact six other "Sixers."

*Apple Hill Farm, 8530 N. Branch Rd., Watervliet, MI 49098

How About a Homebrew 6-meter AM Transmitter?

Using a loaner "Sixer" with about 2 watts output into my 3-element Yagi (*CQ VHF*, Winter 2006 issue), the West Michigan Six Meter Net proved to be a lot of fun and a good way to meet some interesting people. Then I thought, why not build a 6-meter AM rig with a little more power? A look in my junk box revealed all the necessary parts, including a half-bushel of 6L6 tubes from my dear, bygone days of the '50s repairing juke-box and electric-organ amplifiers. These tubes, dubbed the "poor man's 807 or 6146" were introduced in the spring of 1936 by RCA (*QST*, May and June 1936) as the first of the beam power tubes. *Radio* magazine for April 1937 carried an article "The Bi-Push Exciter" by W. W. (Woody) Smith, W6BCX, Editor. Using two 6L6 tubes in a push-push doubler connection, the 80- through 10-meter exciter soon became very popular. A bi-push is very efficient because it gives a pulse of power every half-cycle to a plate tank circuit tuned to the second harmonic of the grid (input) circuit. Excellent rejection of other harmonics is provided also. The newer 6L6GC tubes have about half as much input and output capacitance as the older type, and function well at 50 MHz. Design parameters selected for the transmitter were: simple oscillator and power amplifier using common

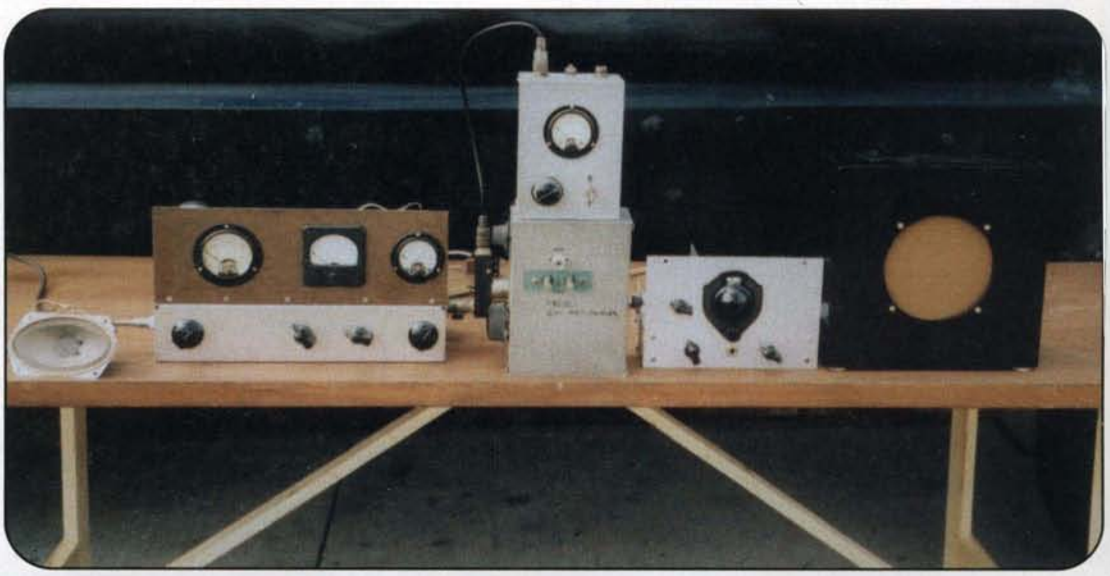
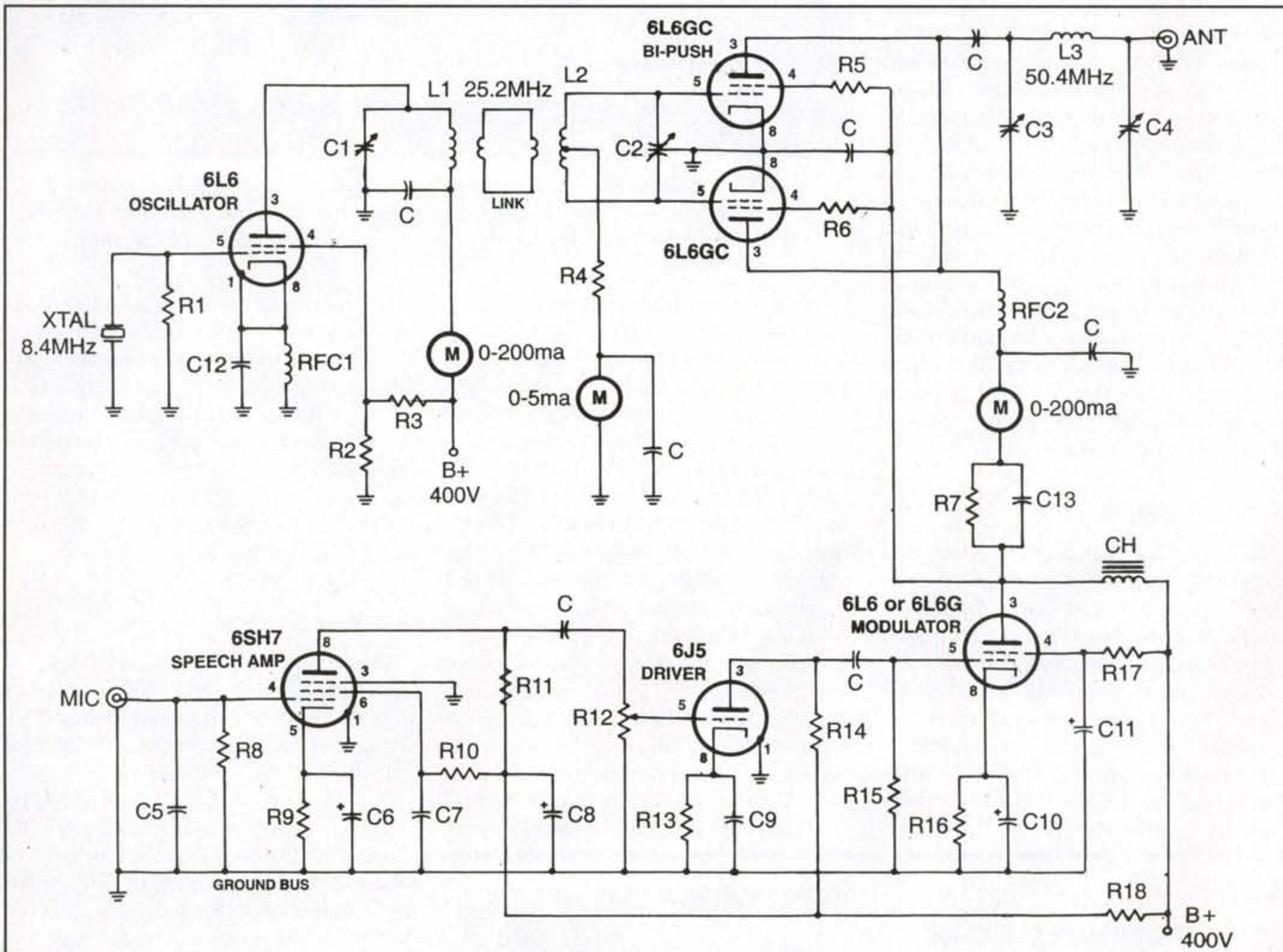


Photo A. The 6-meter radiotelephone station. Left to right: speaker-microphone, transmitter, antenna coupler and SWR meter, receiver, and speaker. (Photos by the author) tubes, and amplitude modulation using the Heising (see sidebar) principle.

Crystal Oscillator

After trying several crystal oscillators, a 6L6 circuit shown in the 1938 *Jones Radio Handbook* was selected, providing good third harmonic output from an 8.4-MHz crystal. This circuit utilizes the capacitance of the metal shell of a 6L6 to its plate as a feedback capacitor by connecting pin 1 to the cathode, pin 8. If a 6L6G (glass tube) is used in place of the older metal type, a capacitor of about 15 pF must be connected from cathode to plate to provide the necessary feedback. Although this circuit works a crystal harder than a rented mule, RF crystal current, as measured by connecting a 60-ma pilot lamp (#48 or #49) in series with the crystal, proves that the current is below 80 ma. Crystal current above 80 ma may fracture an FT-243 type crystal. Oscillator plate current runs about 65 ma at 350 volts.

To provide good harmonic energy, the 6L6 oscillator tank circuit should be low capacitance. Output from the 6L6 oscillator tank, 25.2 MHz, is taken via link coupling to the push-pull input tuned circuit of the bi-push doubler. Link coupling is simple, is the most efficient means of power transfer between two tuned cir-



Parts List—Transmitter

C: 0.002 μF 1 KV
C1: 50 pF variable
C2: Dual section 50 pF variable
C3: 50 pF variable
C4: 250 pF variable
C5: 100 pF
C6: 10 μF 25V
C7: 0.1 μF
C8: 10 μF 450V
C9: 1.5 μF
C10: 10 μF 25V
C11: 10 μF 450V
C12: 250 pF
C13: 2 μF

R1: 50K 1/2W
R2: 65K 20W
R3: 6k 10W
R4: 75k 1/2W
R5, R6 : 33K 1/2W
R7: 1K 10W
R8: 1meg 1/2W
R9: 1.8K 1/2W
R10: 500K 1/2W
R11: 220K 1/2W
R12: 500K pot
R13: 2.7K 1/2W
R14: 100K 1/2W
R15: 500K 1/2W
R16: 500 ohm 5W
R17: 20K 10W
R18: 10K 1W

RF Coils (see text)
L1: 19 turns #14, 1/2 inch ID, 1 3/8 inches long
L2: 24 turns #14, 1/2 inch ID, 2 inches long
L3: 7 turns #14, 1/2 inch ID, 5/8 inches long

Chokes
RFC-1, RFC-2: Ohmite Z-50 (see text for construction details)
CH: About 10 Hy, 150 ma (not critical)

Figure 1. Schematic of the 6-meter transmitter.

cuits, provides excellent rejection of spurious and harmonic frequencies, and avoids RF return current from stage to stage through the chassis. All oscillator ground returns are made with short leads to a single point on the chassis.

Power Amplifier

A split-stator variable capacitor is used in the push-pull input circuit to assure balanced drive of over 2 ma to the 6L6GC grids. A 33-ohm resistor is connected in series with each screen-grid lead to help balance the tubes and prevent spurious oscillation. A pi-network output tank circuit provides good impedance match from the parallel-connected or bi-push 6L6GC plates into a nominal 50-ohm coaxial antenna feeder. Output capacitance is about 150 pF at resonance, giving low shunt reactance to any spurious frequency components in the transmitter output. Plate current runs about 80 ma at 325 volts. Carrier output power is 12 watts to match the 7 watts of audio from the 6L6 modulator tube, although with 350 volts on the oscillator and 400 volts on the bi-push, power output is 20 watts.

Modulator

Heising plate-screen modulation was chosen because it is very simple, requiring only a common audio-frequency choke of non-critical value (such as a power-supply choke from a junk TV set) as a common impedance between the 6L6 class "A" modulator tube and class "C" RF amplifier. In the Heising system, if the modulator and RF amplifier utilize the same plate potential, 100% modulation of the carrier cannot be achieved. To raise the percent modulation, a 1000-ohm 10-watt resistor bypassed for audio frequencies by a 4-μF paper cap reduces the plate voltage to the power amplifier.

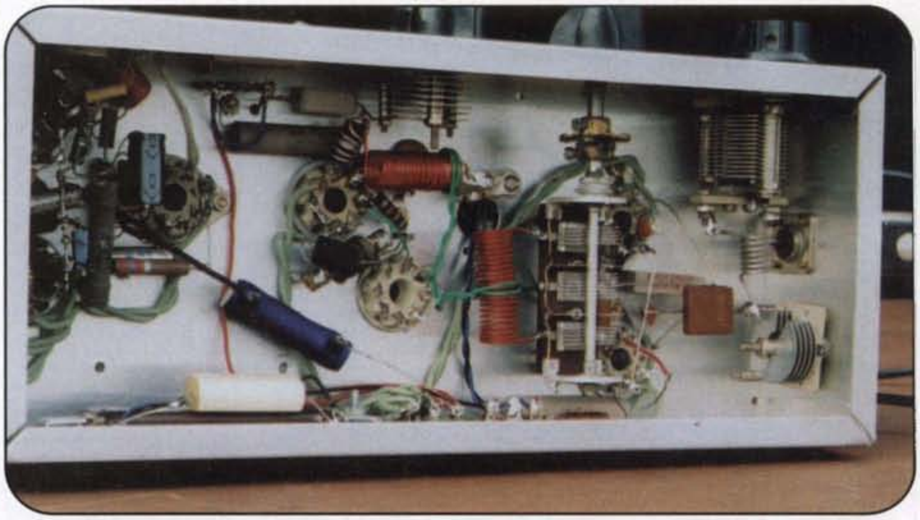


Photo B. Underside of the transmitter with the modulator on the left, oscillator in the center with its plate coil link-coupled to the push-pull grid coil with split stator cap, and the pi-net output coil with tuning and loading caps on the right.

A crystal microphone that delivers about 50 millivolts peak output was planned to be used. Therefore, a voltage gain of 360 was needed to swing the 6L6 modulator grid to the limit of its cathode bias, 18 volts. Design of the 6SH7 speech amplifier, voltage gain 230, and 6J5 driver, voltage gain 14, was taken directly from the *RCA Tube Manual, Resistance Coupled Amplifier Data.* To conserve sideband power while maintaining speech intelligibility in the audio spectrum of 500–2500 Hz, the following modulator design parameters were chosen: A 4-meg-ohm resistor at the 6SH7 grid limits bass response (higher value mic load resistance increases bass). Bass response and hum are further limited by use of small-value coupling caps of .002 μF. Treble response is limited by a 100-pF cap from the 6SH7 grid to ground. This bypass cap also keeps RF out of the modulator input. Audio gain is controlled by a 500K audio-taper pot (from a junk AC-DC radio) between the speech amp and 6J5 driver tube.

Power Supply

Power requirements for the transmitter and modulator are 350 to 400 volts DC at 200 ma. A power transformer and filter choke from a junk tube-type TV set easily fills the bill, with four 1000-piv silicon diodes in a bridge rectifier circuit. To maintain B+ voltage regulation, the choke should have a DC resistance of 200 ohms or less. One section of filter in the power supply is sufficient; additional filtering for low-level modulator stages is provided by the modulator's decoupling circuit. Power supply filtering consists of a choke input followed by two 40-μF 350-volt filter caps in series to B–, each cap shunted by a 100K 2-watt resistor for voltage equalization.

My power supply has a 120-watt Variac connected to its 120-volt primary to adjust the power-supply output voltage to 350 VDC. The send-receive switch is in the 120-volt line to the Variac. When the switch is turned to TRANSMIT, the power supply is energized and a Dow-Key relay is also energized and switches the antenna from receiver to transmitter.

New Product:

The TEN-TEC RX-400

TEN-TEC is now shipping the new RX-400 HF/VHF/UHF receiver. This latest addition to TEN-TEC's product line continues its tradition of offering lower cost real-time DSP in a commercial-off-the-shelf package that delivers the performance of mil-spec and tactical receivers in a much more affordable price range. It tunes 2 MHz to 3 GHz, scans 100 channels/sec., and has detection of bandwidths up to 300 kHz. The user can program mission-specific AGC characteristics. Wideband IF output provides 6 MHz of bandwidth. the receiver includes both TCP/IP and RS-232 interfaces. It has a compact 1/2 rack.

This new model joins thousands of TEN-TEC's HF receivers already in 24/7 government/commercial service worldwide. For more information visit <http://www.tentec.com/>, e-mail Product Manager, <TomSalvetti@tentec. com> or call him direct at 304-884-7601.

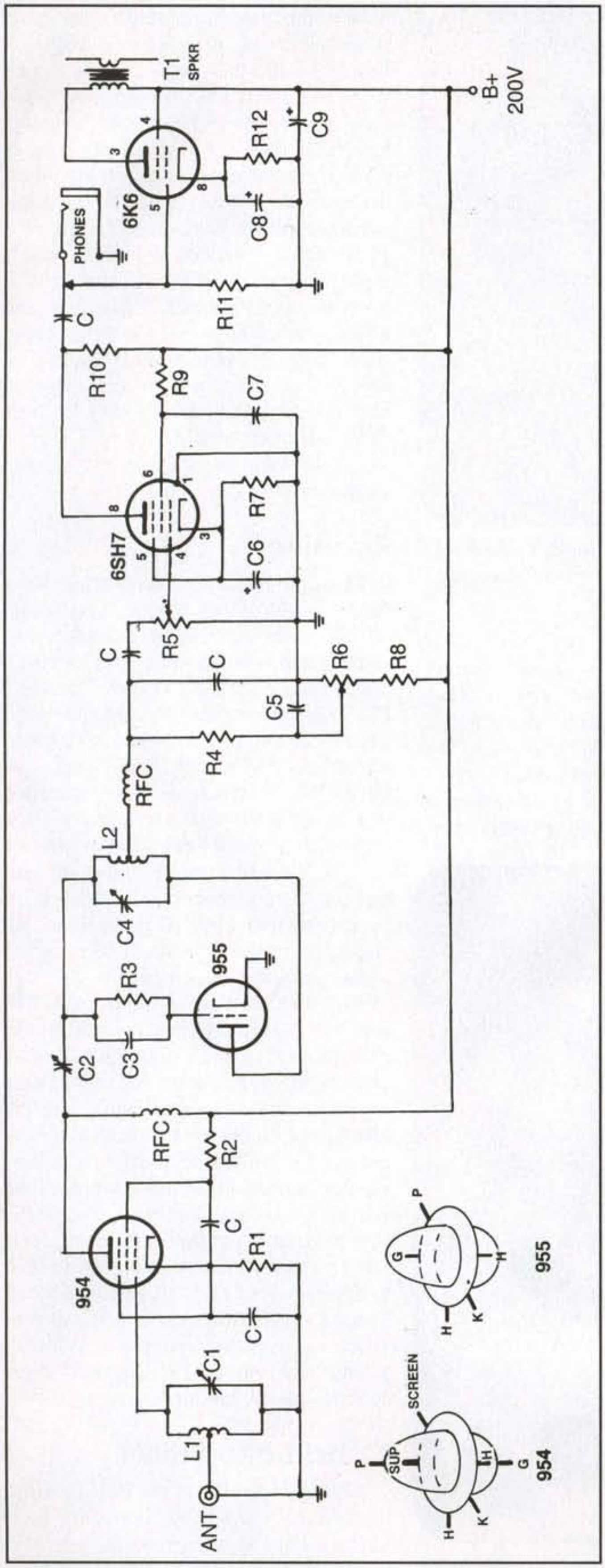


Figure 2. Schematic of the 6-meter super-regenerative receiver.

Auxiliary contacts on the Dow-Key mute the receiver. A separate 6.3-VAC heater transformer provides 4 amps to the transmitter's tube filaments.

Construction Hints and Tune-Up

A suitable chassis can be salvaged from a vacuum-tube TV set or from one of those huge, old console radios. A pressed-wood panel with holes cut with a coping saw will hold the meters.

All leads that carry RF must be short. RF ground connections in each stage should be made to a single point on the chassis. In the modulator section, all ground connections should be made to a common ground bus. This may consist of a length of #14 wire, grounded only at the modulator input (mic connector) and extending to the 6L6 modulator tube. Thus, cathode and grid returns of all three tubes in the modulator section connect to this ground bus to avoid hum currents and audio frequency feedback. Decoupling of the speech amp circuit is provided by a 10K resistor and 10-µF electrolytic cap.

It's best to first build the oscillator and get it working. At the oscillator plate current dip of 65 ma, a #47 pilot lamp with a two-turn loop, coupled to the B+ end of the oscillator plate coil, should glow to near full brilliance. With an 8.4-MHz crystal, oscillator output should be the third harmonic, 25.2 MHz.

Next, build the bi-push final amplifier and couple its grid coil to the oscillator with a twisted length of hook-up wire and two-turn link wound over the low RF potential point on each coil. With B+ off the amplifier, when the grid circuit cap is tuned to resonance, the oscillator should deliver about 2 ma grid drive to the push-pull grids. Now when B+ is applied to the amplifier with a 50-ohm dummy load, the bi-push plate current should

Parts List—Receiver

C: 0.002 µF 500V
C1: 15 pF variable
C2: 10–50 pF trimmer
C3: 50 pF
C4: 15 pF variable
C5: 0.1 µF 200V
C6: 10 µF 25V
C7: 0.1 µF
C8: 10 µF 25V
C9: 20 µF 350V

R1: 1.5K 1/2W
R2: 150K 1/2W
R3: 5 to 10 meg ohms
R4: 27K 1/2W
R5: 500K pot
R6: 100K pot
R7: 1.7K 1/2W
R8: 250K 2w
R9: 470K 1/2W
R10: 220K 1/2W
R11: 500K 1/2W
R12: 400 ohms 1/2W

Coils (see text)
L1: 16 turns #14, 1 1/4 inches long. Antenna tap 2 turns from ground end.
L2: 18 turns #14, 1 3/8 inches long. Center tapped.

RFC: Ohmite Z-50 (see text for construction details)

T1: Output transformer, 7.5K 6K6 plate to 4-ohm speaker. Not critical.

Photo C. Rear view of the transmitter: 6L6GC bi-push finals on the left, metal 6L6 oscillator tube, Heising modulation choke, and 6L6G modulator tube on the right.

dip to about 80 ma when the plate circuit cap is tuned to resonance and the loading cap is opened to about one-third mesh. Speaking into the microphone should *not* cause the plate current to flicker, but an RF voltmeter connected across the dummy load should show voice peaks, indicating that the modulator is working.

What? You don't have a crystal microphone? An excellent electro-dynamic mic can be made from a PM speaker and output transformer from a junk AC/DC radio. The output transformer was designed to match the nominal 4-ohm speaker impedance to the plate impedance of the audio output tube, typically a 50L6 or some such beam tetrode. In its new role as a mic, when you speak into the cone, the transformer will step up the voltage generated by the speaker to 100 millivolts or so to drive the transmitter's speech amplifier. The speaker-mic can be left in the original radio plastic cabinet, left open, or a small wooden box can be built to protect it. A one-pound coffee can stuffed with toilet tissue for acoustical damping, and holes punched in its lid, makes a suitable mic enclosure for a small speaker. I've received good reports on audio quality with such a setup, but it's easy to overdrive the modulator. Speak in a normal voice and keep the speaker-mic about 8 inches from you.

Receiver

The time-honored super-regenerative detector circuit of Major Armstrong, which is considered to be one of the most remarkable radio circuits ever devised, was selected for the receiver. To match the 955 acorn triode tube self-quenched detector to a nominal 50-ohm coax antenna feeder, a 954 acorn tuned RF stage was added. The best receiver noise figure that can be achieved with a tetrode RF stage at 50 MHz is about 4 dB. Triodes in a cascode circuit will do better if they are neutralized, but ambient noise on the 6-meter band is such that a 4-dB noise figure RF stage generally will reach the noise level.

Acorn tubes, developed by RCA in 1934, quickly revolutionized UHF receiver design. Acorns are still available, although a 6AK5 and 6C4 will serve as well. In operating the receiver, as the regeneration control is advanced, the 955 acorn detector begins to "supe" at a plate potential of only 4 volts. Due to the low voltage, radiation of super-regenerative energy is minimal; however, despite the buffering action of the RF stage, the hiss can be heard on a nearby receiver tuned to 6 meters. A 6SH7 high-gain audio amp followed by a 6K6 power pentode provides loud-speaker reception. A headphone jack mutes the speaker when 'phones are plugged in.

Construction Hints

ARRL Handbooks of the 1930s, particularly the 1936 edition, contain a good discussion of super-regenerative receiver design. Salient points are: All detector ground connections to a single point on the chassis, low-C tuned circuits for both

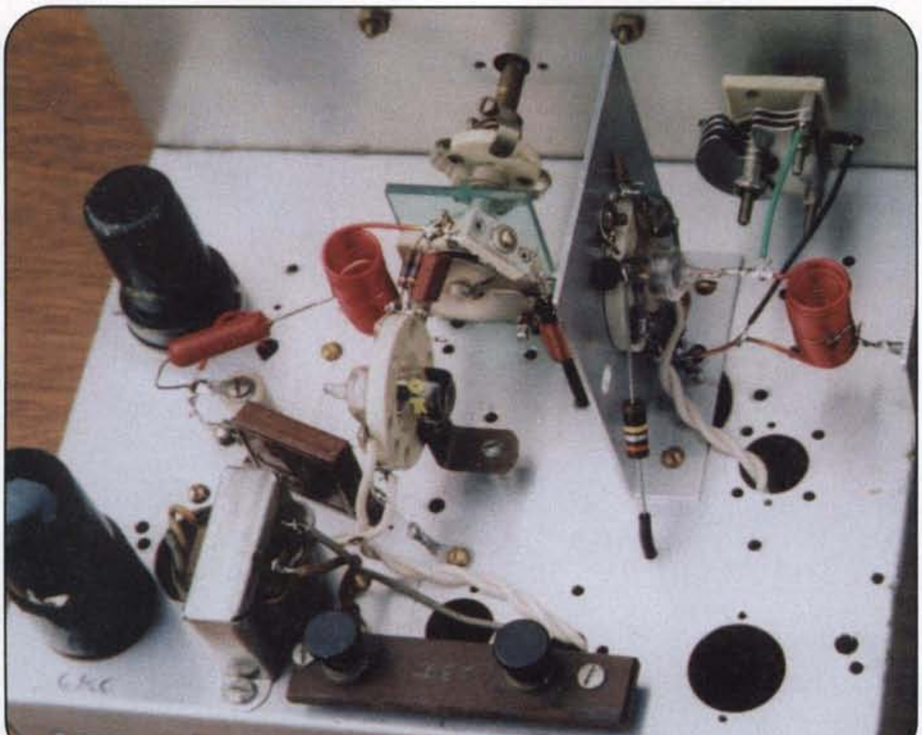


Photo D. The 6-meter super-regenerative receiver. Lower left is the 6K6 tube audio output; upper left, the 6SH7 audio driver; center is the 955 acorn detector tube with its center-tapped grid coil; next is 954 acorn RF stage and its antenna coil.

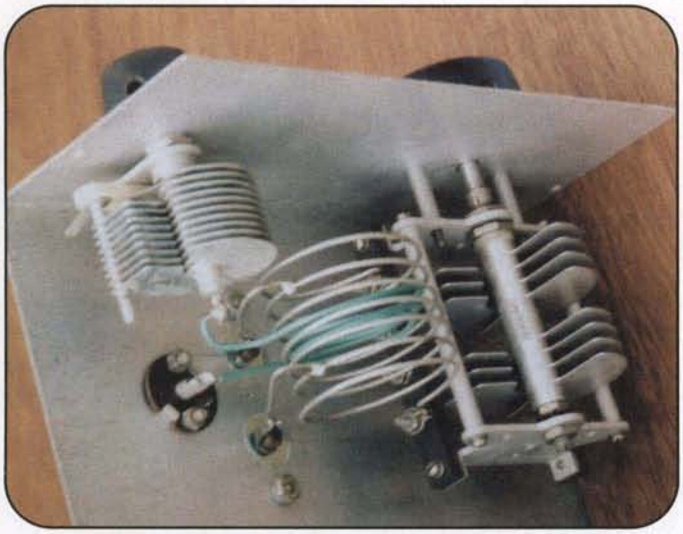


Photo E. The balanced antenna coupler (design from ARRL VHF Handbook*s)*

RF stage and detector, and heavy loading of the detector by the RF stage. The most critical component in a super-regenerative detector circuit seems to be the grid leak. Typical values are 2 to 10 meg-ohms. Experiment with various grid leak values to give the smoothest transition into super-regeneration when the control pot is advanced. Receiver power supply requirements are 180 to 250 VDC at about 50 ma and 6.3 VAC at 1.5 amps.

The coils for both transmitter and receiver are wound of bare #14 wire stripped from "14-3 Romex." The wire is wrapped around into the threads of a 1/2"-13 machine bolt. Then the coil is "unscrewed" from the bolt and stretched until the turns are spaced about one wire diameter. Stretching the coil to a longer length will increase its inductance (lower the tuned circuit resonant frequency) and vice-versa.

RF chokes for both transmitter and receiver are made by close-winding 45 turns of #30 enameled wire on old-style (5/16 inch diameter) 2-watt carbon resistors of 100K ohms (or more). Winding length is one inch. Solder the winding ends to the resistor axial leads. Coat the chokes with clear finger-nail lacquer to hold the wire in place. This design, shown in "G.E. Ham News," Jan.–Feb. 1949 (Vol. 4 #1) p. 6, approximates the "Z-50" RF chokes that were produced by the Ohmite Mfg. Co. The chokes can also be wound on 5/16-inch diameter sections of plastic pen barrel.

Conclusion

A completely homebrewed amateur rig, from microphone to antenna, is a fun project that will spark hours of discussion on the air. Although the Heising modulation system works well, the 1000-ohm resistor in series with the RF amplifier wastes carrier power, and the modulator is limited to a class A stage. Plate modulation could easily be incorporated by using an old TV power transformer as a modulation transformer. The high-voltage center-tapped secondary could be connected to the push-pull plates of the modulator tubes in an efficient class AB-1 circuit, with the 120-volt primary connected between the class C amplifier plate and B+.

The remarkable super-regenerative receiver has surprising sensitivity, and gives an "automatic volume control" action to amplitude-modulated signals. CW code signals cannot be satisfactorily received, but FM signals can be received by slightly detuning the receiver to provide "slope" detection. What? SSB on a super-genny? Yes. My 100-kHz crystal calibrator puts out signals every 100 kHz throughout the 6-meter band. The SSB portion of the West Michigan Six Meter Net is conducted on 50.3 MHz. By tweaking the 100-kHz oscillator frequency and adjusting the signal injection level into the receiver's antenna terminal, I'm able to copy SSB transmissions on my super-genny quite well.

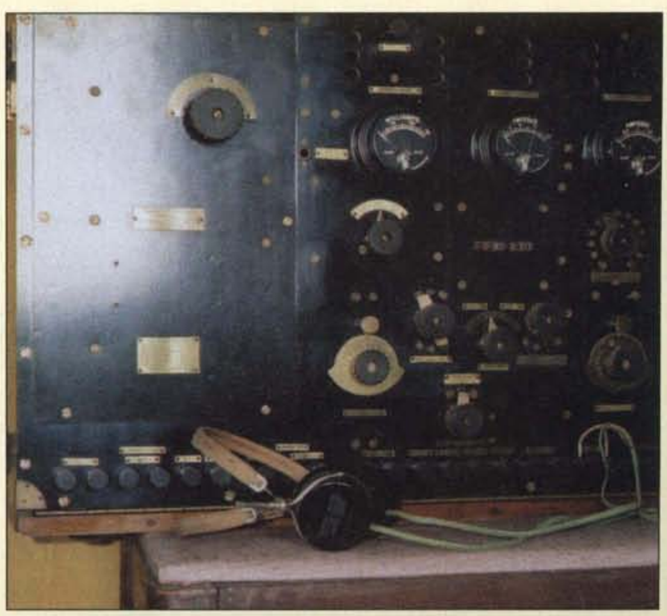
The Birth of Audio Modulation and the Radio Transceiver

In 1917, the US Navy contracted with Western Electric Co. to design and build radiotelephone transmitter-receivers. These "transceivers," first used for communication between submarine-chaser ships, were the first radios to use voice modulation of a CW carrier. They were built at Western Electric's Hawthorne Works in Cicero, Illinois. Two hundred of these CW 936 transceivers were installed on combat vessels. The constant current modulation principle was developed by Electrical Engineer Raymond A. Heising (M.S. University of Wisconsin,1914). Any one of five fixed frequencies between 500 and 1500 kHz could be selected by the radio operator. The receiver was a simple tuned-radio-frequency type without regeneration, as an oscillating regenerative detector radiates a signal that could be DFed by the enemy.

These "sub-chaser" transceivers heralded the beginning of radio broadcasting and long- and short-distance radiotelephony. They were in general use by the Navy until 1930.

The CW 936 set in the photo was purchased many years ago at a radio surplus shop on Courtlandt Street in New York City. The Courtlandt-Vesey Street "Radio Row" area of lower Manhattan later became the site of the World Trade Center.

Source of CW-936 information: Capt. L. S. Howeth, *History of Communications-Electronics in the United States Navy,* Bureau of Ships, 1963, p. 254.



CDE/Hy-Gain Rotors How to Keep 'em Turning – Part 1

What is a beam without a rotor? What good is a broken rotor? W9FX has spent years repairing the CDE/Hy-Gain rotors. Here in part 1 of this two-part article, he shares his knowledge of rotor repairs. Next time he shares his knowledge of repairing the control box.

By Brad Pioveson,* W9FX

Bell-shaped rotors (or rotators, if you prefer) are as much a part of amateur radio as Morse code keys and microphones. Having the ability to remotely turn one's directional antenna and reliably knowing in which direction the antenna system is pointed when you release the switch is fundamental to being able to successfully work local stations or DX on HF, VHF, UHF, and microwave frequencies alike. What will you do when the rotor malfunctions? When—not if—it happens to you, you might find yourself grabbing the nearest ham radio dealer's catalog (or visiting the dealer's internet website), only to find that new rotor prices are a lot higher than they used to be—ouch! You might consider sending the rotor off to a shop that specializes in such work. That, too, can be a costly proposition, and you're without a rotor for days or weeks. Usually, if Murphy has anything to say about it, the rotor is either inoperative or out for repair during the biggest 6- and 2-meter *Es* openings of the past decade.

If you're looking to save both time and some money, aren't afraid to get your hands a little dirty, and have the ability to use a VOM, soldering iron, and common hand tools, this article is for you, as it will show you exactly how to take these rotors apart, install the most commonly needed new parts, and, reassemble the unit. Simple controller repairs will also be covered in Part 2. Armed with this information, some new parts, and your sweat equity, your trusty "antenna twirler" will once again be ready to provide you with many more years of trouble-free service.

*301 Kirsch Street, Benton, IL 62812
e-mail: <w9fx@verizon.net>

For the purposes of this article, a "typical" CDE/Hy-Gain rotor will be the subject of the repair. The candidate is a CDE Ham II model. The same techniques, same tools, same parts[1], are used in the Ham M Series 3 and 4[2], the Ham III, the Ham IV, and the Ham V models. Additionally, the information also applies to the smaller TR-44, CD-44, CD-45, and CD-45 II units—with differences noted in the text where necessary. To save endless references to all these models, I'm going to refer to all of these rotors collectively as the "Ham X" series.

There are components in the Ham X rotors that need to be replaced after several years of service. This article is based on the assumption that your Ham X will need the following components replaced when you drag it onto your bench: azimuth potentiometer, terminal board, and bearings. This is not to say that other problems won't occur with your rotor. Spur gears have been known to lose teeth; final (ring) gears, especially the cast-aluminum type found in the older Ham X and CD/TR units can break; brake wedges have been known to fracture under extreme loads; and motors and/or their pinion gears will, although rarely, give up the ghost. The most common failures—and the replacement of the failed components—are discussed in this article. First, we'll examine the rotor units, then we'll look at a few of the more frequently occurring controller problems.

By the Numbers

The most common single failure item in the Ham X series of rotors is, undoubtedly, the azimuth potentiometer. Failure can present itself in a number of ways. Intermittent controller meter indications (needle "jitter") are the usual first symptom of a potentiometer problem. The design of the azimuth potentiometers has changed a little over the years, but until just the past few years the design featured a copper wiper-arm/moving-contact assembly that rode on top of the resistance wire wound around a molded, synthetic form. Oxidation of the copper wiper resulted in poor conductivity; hence, "meter jitter" was seen in many cases. Additionally, the resistance wire abraded the soft copper of the wiper, and even-

Tools
- Vise, "Bench Mate," or similar device
- VOM or multimeter with leads
- 5/16-inch diameter nut driver or socket
- 1/4-inch diameter nut driver or socket
- Soldering iron and rosin core solder
- Needle-nose pliers
- Phillips screwdriver
- Flat-blade screwdriver
- Rags or paper towels
- Degreasing compound

Parts
- Azimuth potentiometer Hy-Gain part #5023100
- Terminal board Hy-Gain part #5146510
- 10 ea. #6 × 1/2-inch stainless-steel machine screws
- Bearings (98 ea. For Ham X; 49 for CD/TR) Hy-Gain part #5033501
- Bearing retainers Hy-Gain part #5011300
- Grease, approximately two tablespoons of white lithium or other low-temperature lubricant

Table 1. Tools and parts required for the rotor project.

Photo 1. Turn the rotor upside down with the "Vee" of the mast bracket facing away from you, securing the rotor in a vise (see step 1). (All photos by the author)

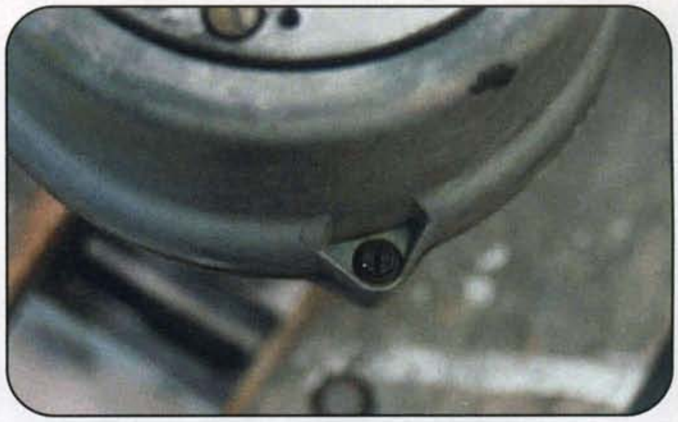


Photo 2. Remove the four #12-24 screws that hold together the upper and lower halves of the rotor (see step 2).

Photo 3. Lift the brake housing (or retaining ring for the TR/CD rotors) straight up away from the rotor. The plastic spacer may come off and remain inside the brake housing (see step 3)

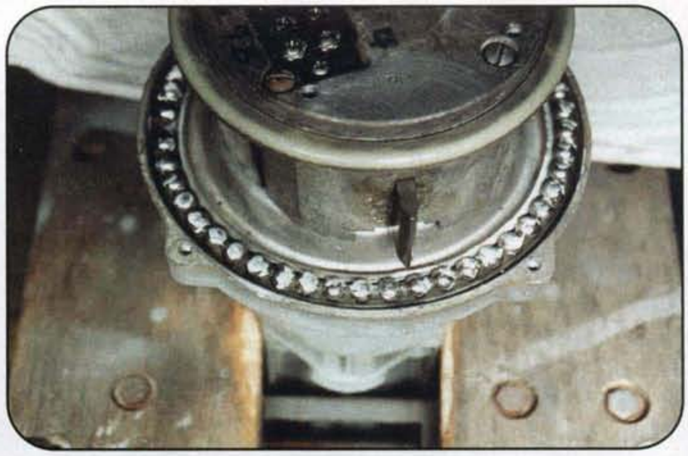


Photo 4. The plastic spacer (there is no spacer in the TR/CD units) may remain on the rotor unit, and it must be removed from the rotor or housing and set aside for cleaning and inspection (see steps 3 and 4).

tually completely ground off the end of the wiper arm, resulting in complete potentiometer failure. Hy-Gain has addressed these problems with the latest design change to the potentiometers. Since about mid-2005, the OEM potentiometers' wipers are equipped with a silver-plated rivet affixed to the end of the wiper. The rivet makes contact with the resistance wire, thus eliminating both the abrasion and oxidation problems (silver oxide is conductive).

Almost as common, and certainly the most frustrating, source of failure of these potentiometers is an operator-induced wiring error at the controller. It's easy to transpose wire colors on the 8-position terminal board and in so doing inadvertently apply 26 VAC to the potentiometer. Instant failure is the result as the potentiometer's winding melts. The smoke, however, isn't readily apparent, as it's released on top of the tower.

Another item that commonly fails, especially in older Ham X rotors, is the 8-position terminal board. That's the terminal board found on the bottom of the unit where you wire up the 8-conductor (7-conductor for TR/CD units) cable to the controller. The early units used a phenolic board with plated hardware. Few of these are still usable after 35 or 40 years of service. More modern units consist of a black plastic barrier strip. These plastic factory replacements hold up better than their predecessors, but unfortunately, they are still equipped with cadmium-plated steel screws. After a few years, or months in the case of corrosive environments, the plated hardware rusts. Intermittent or open circuits are usually the result.

The solution to the terminal board hardware rusting problem is to purchase a factory-new terminal board, and once it's in hand, remove all the screws, throw them away, and, replace them with equivalent-size (#6) stainless-steel hardware. The expenditure of a couple of dollars at the local hardware emporium is an investment that will repay you with years of future rotor service without wiring and/or conductivity issues at the terminal board!

Finally, if your rotor has been in service for some time, and especially if you live in a coastal area, your rotor will probably benefit from the replacement of its 98 (or 49 in the TR/CD series units) bearings. These plated steel balls will rust, and the aluminum/ferrous-oxide reaction can seriously erode the aluminum races of the rotor housings.

OEM Hy-Gain replacement parts are readily available from

Photo 5. The bearing set, one of two. This one is caked with dirt and grease (see step 5).

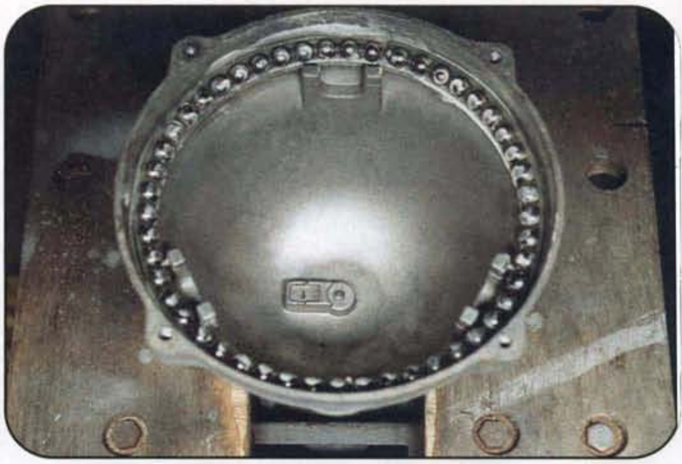


Photo 7. The upper housing with bearing set in place (see step 7).

Photo 6. The ring gear shown in place (see step 6).

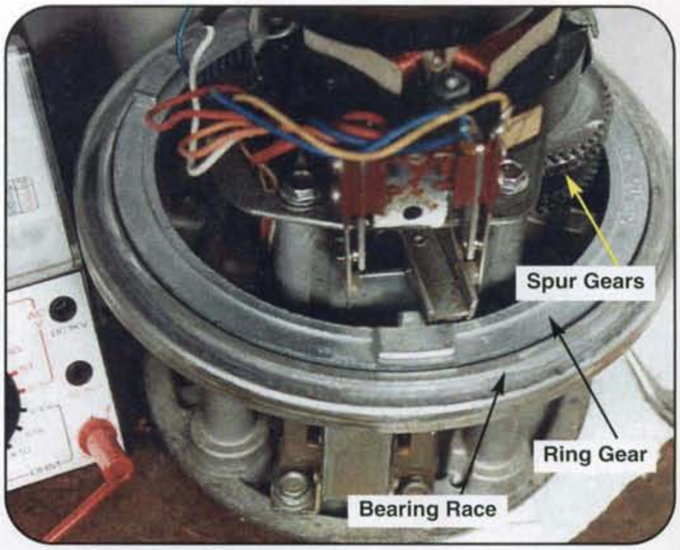


Photo 8. The spur gears, ring gear, and bearing race (see step 11).

both Hy-Gain[3] and 'The Rotor-Doc."[4] Manuals for current models of Hy-Gain rotors can be downloaded for free from the Hy-Gain website. Manuals for older CDE/CDR and Hy-Gain rotors are available for download from the BAMA website.[5]

Table 1 is list of tools and parts that will be needed for this project. *Note:* Disassembly and reassembly of the rotor will take place with the rotor in an inverted position. To do otherwise leads to a rather frustrating chase for the dozens of 3/8-inch diameter steel bearings housed within the rotor clattering to the floor of your workspace.

Following are the steps for repairing the rotor:

1. Turn the rotor upside down, with the "Vee" of the mast bracket facing away from you. Secure the rotor in a vise or similar holding device (photo 1).

2. Using the 5/16-inch diameter nut driver or socket, remove the four #12-24 screws that hold together the upper and lower halves (lower ring on the TR and CD rotors) of the rotor (see photo 2).

3. Lift the brake housing (or retaining ring for the TR/CD rotors) straight up, away from the rotor. Note that the plastic spacer may come off with and remain inside the brake housing (photo 3), or, it may remain on the rotor unit (photo 4). In either event, separate the spacer from the rotor or housing and set it aside for inspection and cleaning. (There is no spacer in the TR/CD rotors)

4. Once the brake housing (or retaining ring) is out of the way, you will see the lower bearing set exposed. Removal of this bearing set is quite easy, but if done carelessly it can lead to much frustration as you chase the 3/8-inch diameter steel ball bearings across your shop floor! Referring again to photo 4, if you carefully insert a flat blade screwdriver under the plastic bearing retainer, you can then grasp the bearing retainer with one hand. Lift it carefully, straight up. As you lift it, grasp the bearing retainer with your other hand so that you're supporting the retainer in two places, approximately 180 degrees apart. If you've done your job well, and the retainer is not damaged or stretched, the balls will stay in place.

5. Lay the bearing set on a flat surface; a workbench with a few paper towels or rags will minimize the mess (photo 5).

6. Grasp the bottom of the rotor assembly (as you're looking at it, it's now the top surface) and lift it straight up and out of the bell housing. Turn it over and place it on your work sur-

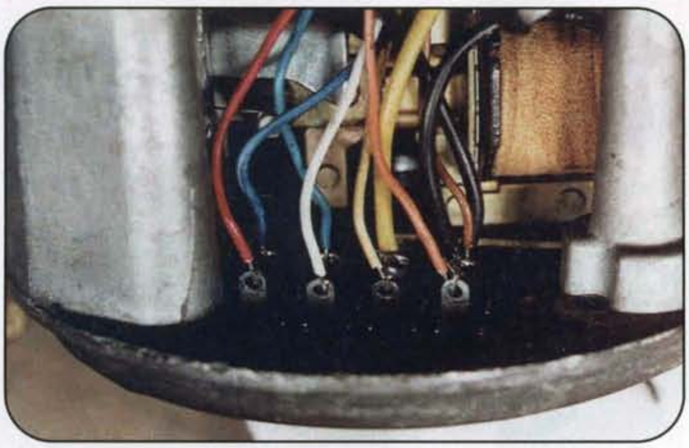


Photo 9. Terminal board and wiring viewed from the side of the rotor unit (see step 14).

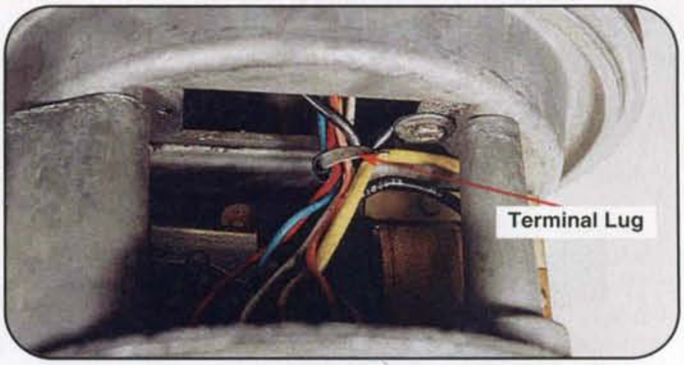


Photo 10. The terminal lug (see step 16).

face. The ring gear may dislodge itself at this time. That's OK; remove it completely and set it aside. If it stays in place (photo 6) that's OK, too, as we'll be removing it soon.

7. Using the same procedure outlined in step (4), remove the bearing set from the bell housing (photo 7).

8. The bell housing may now be removed from the vise. Remove the old lubricant with a degreasing compound. Dry the housing and set it aside.

9. Remove the old lubricant from the brake housing (or retaining ring for the TR and CD rotors). Use a stiff brush to clean the residue from between the teeth of the brake housing.

10. Set the brake housing (TR- and CD- series rotors, the retaining ring) aside.

11. Using a small, flat blade screwdriver, gently lift the ring gear out of the motor/gear base unit. You may have to move the ring gear (by manually rotating the top left spur gear) to allow the ring gear's protrusions to safely pass by the spur gear set (photo 8).

12. Clean and degrease the ring gear and set it aside.

13. Clean and degrease the rotor unit's upper and lower races and gear race.

14. Turn the rotor unit on its side to allow access to the terminal board (photo 9).

15. Over time, it is possible that the insulation may no longer be the same color as it once was; it fades over time and with exposure to the some lubricants. At the terminal strip end, blue can appear to be white, as can green, yellow, and orange! Make

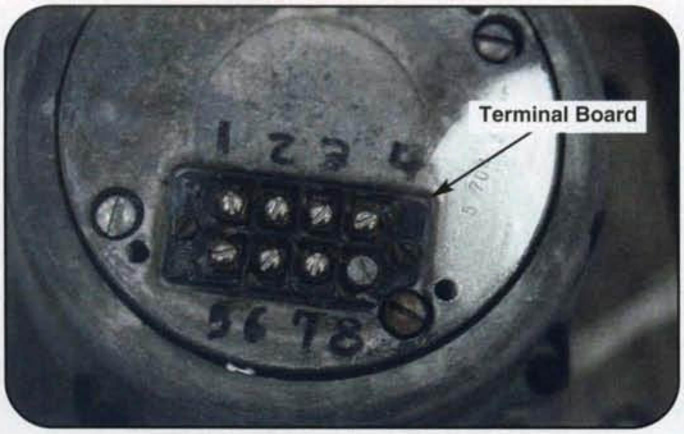


Photo 11. The terminal board (see step 18).

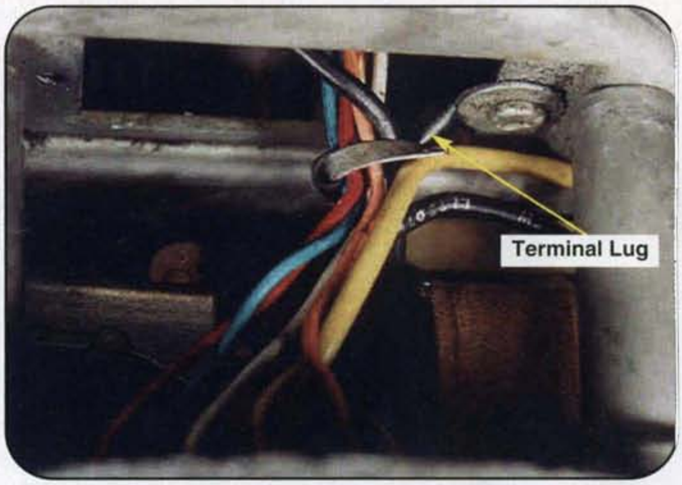


Photo 12. Secure the lugs in place with the solder lug as shown (see step 21).

yourself a chart of wire colors and terminal numbers so that you can properly rewire the new terminal strip. The color code that CDE and Hy-Gain used when they built your rotor is:

1 – Brown, Black, Black (black from rotor motor and black from brake solenoid)
2 – Large Yellow wire (from brake solenoid)
3 – Green
4 – Blue
5 – Orange
6 – Small Yellow
7 – White
8 – Red

Note that terminal 2 on TR and CD series rotors has *no* connection, and that terminal 1 on TR and CD series rotors only has two (one each, Brown and Black, wires connected).

16. Using the needle-nose pliers and soldering iron, carefully unsolder each of the wires from the terminals. If you need more room to work, you may bend the terminal lug that's used as a wire guide to allow the wires to be fanned out a bit photo 10).

17. Clean up the wire ends as necessary and prepare them for reconnection to the new terminal board.

18. Using a flat-blade screwdriver, remove the two screws that hold the old terminal board in place. Discard the old screws and terminal board (photo 11).

19. Set the new terminal board in place, making certain that the notch molded into one corner of the terminal board is situated as shown in photo 11. Install the new terminal board using the two stainless-steel, Phillips-head machine screws.

20. Working in sequence, and starting with terminal 1, attach and then solder the wires to the new terminal board.

21. Secure the wires in place with the solder lug as shown in photo 12.

22. Turn the rotor unit back upright on your work surface and orient it so that the wire connections on the old potentiometer are facing you. See photo 13.

23. Unsolder the green wire from the potentiometer. Using the needle-nose pliers, slide the insulating sleeve (if it's present) down the white wire to expose the soldered connection on the right potentiometer connection. Unsolder the white wire.

24. Using the 1/4-inch diameter nut driver or socket, remove the #6 nuts and star washers that retain the potentiometer. Note that you may have to move the wiper of the potentiometer in

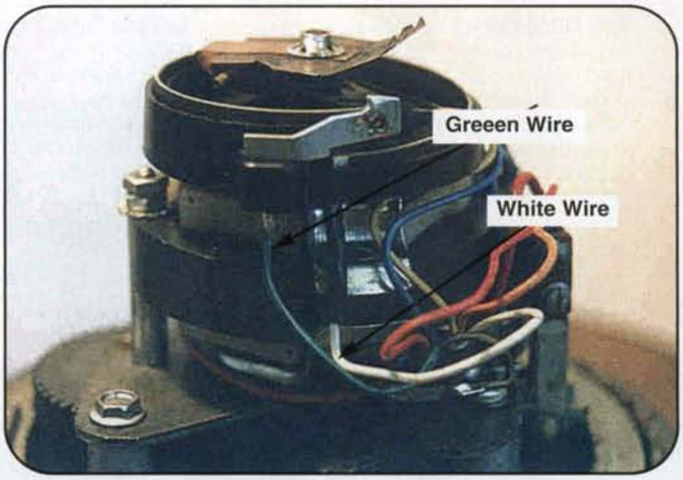


Photo 13. The green and white wires (see steps 22 and 23).

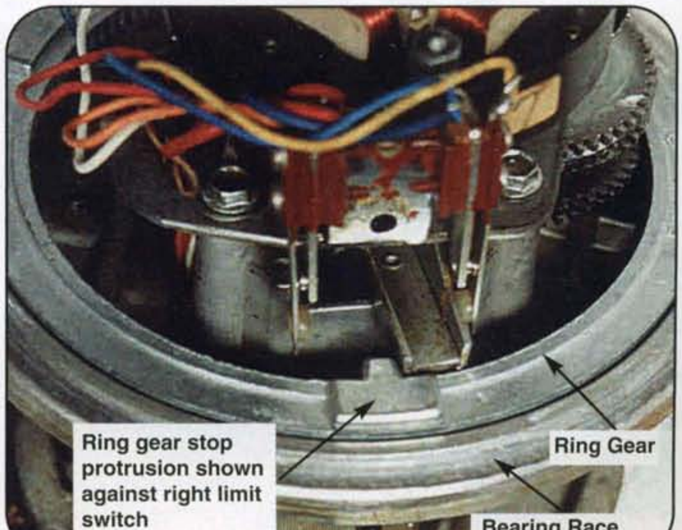


Photo 14. Set the ring gear in place such that the stop protrusion in located as shown (see step 29).

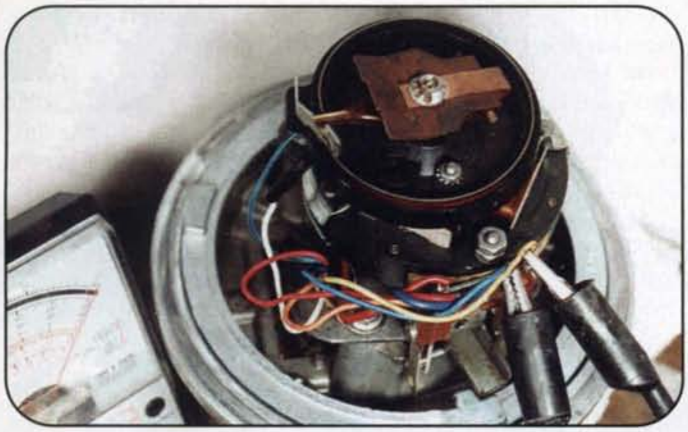


Photo 15. Set the VOM to ohms or continuity and attach the meter's leads to the terminals of the right-hand limit switch (see step 30).

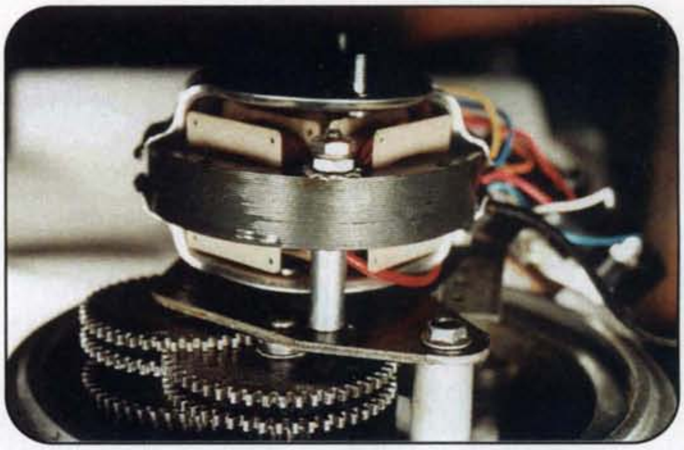


Photo 16. Turn the upper spur gear to move the ring gear (see step 31).

order to allow your socket or driver to fit onto the nuts. Once the hardware has been removed, lift the old potentiometer straight up and off the motor studs. There is a copper strap on the bottom side of the potentiometer that may resist being pulled off the motor stud. It can be "helped" with a screwdriver or with the needle-nose pliers.

25. The new potentiometer has three mounting holes. Only two of these will be used. Turn the potentiometer so that you are looking at its bottom side. There will be one hole on the left side of the potentiometer and two holes on the right. Rotate the copper grounding strap so that it aligns with the upper hole on the right side. Turn over the potentiometer and place it on the two motor studs, making certain that the copper strap is properly seated on the right-hand motor stud.

26. Secure the potentiometer using one of the star washers and nuts previously removed. Tighten firmly, but do not overtighten these nuts, as too much torque will damage the potentiometer's plastic housing! Again, you will have to carefully move the wiper arm to allow your tools to gain access to the both retaining nuts.

27. Solder the green wire to the left-hand potentiometer connection and the white wire to the right-hand connection. Note that the new potentiometer has a much shorter soldering lug than your old one might have had, and you may have to pull up a bit of the white wire to have enough to reach the new, shorter lug. Once you've completed the soldering, looking down at the top of the rotor, *rotate the potentiometer's wiper to the extreme counterclockwise (CCW) stop.*

28. Apply a thin layer of grease to the ring gear. Also, at this time, apply a thin layer of grease to the gear race—that is, the "groove" in which the ring gear rides, in the rotor unit assembly.

29. Set the ring gear in place. Try to orient the ring gear such that the stop protrusion is located as shown in photo 14. Note that some care and, often wiggling, is necessary to allow the ring gear to clear the upper spur gears and drop into place. The gear, when properly seated, should sit fully down in the race, and the ring gear's teeth should fully engage the mating teeth of the final spur gears. If you can rotate the ring gear with your fingers after you've set it in place, it isn't installed correctly. It should only move when you rotate the entire gear train!

30. Set your VOM to ohms or continuity, and attach the meter's leads to the terminals of the right-hand limit switch

Photo 17. Note that the potentiometer's wiper arm points to your left. There is a thin layer of grease around the bearing surface. (See step 33.)

Photo 18. Lightly lubricate the bearing sets (see step 37).

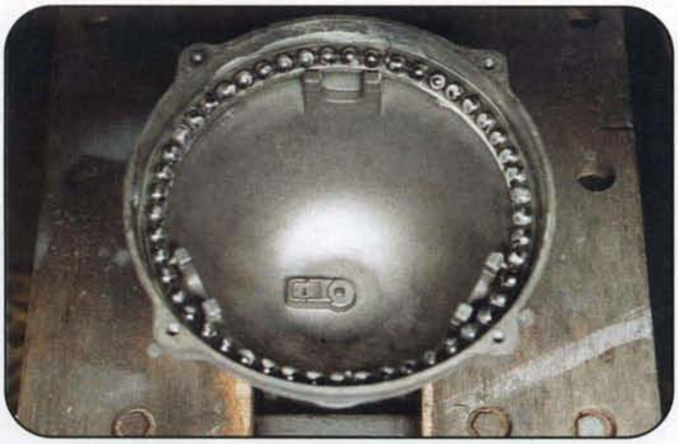


Photo 19. The bearing is set in place, flange up, and the sockets are engaged by the ring-gear mating protrusions (see step 38).

(photo 15). You should see continuity (zero, or nearly zero ohms) on the meter.

31. With your fingers or thumb, turn the spur gear shown in photo 16 counterclockwise until the stop protrusion of the ring gear contacts the arm of the right-hand limit switch and just opens it, as seen on your VOM.

32. Set the rotor unit aside.

33. Place the upper housing in the vise, again. The "Vee" of the mast bracket should be pointed away from you, and at the top of the inside surface of the bell housing, the fixture that contacts and drives the potentiometer's wiper arm should be pointed to your left. See photo 17.

34. Apply a thin layer of grease to the inside bearing surface of the upper housing.

35. Apply a thin layer of grease to the bearing race inside the brake housing (retaining ring on the TR and CD series rotors).

36. Lay out the new bearing retainers on a flat surface. The flanges of the retainers should be down. Each retainer will hold 49 ball bearings. Place one ball in each retainer slot. (For TR and CD series rotors, one bearing goes in every other slot.)

37. Using a finger, apply a very small dollop of grease on each of the balls in both bearing sets. We're looking for lubrication here, not trying to drown the bearings in grease! See photo 18.

38. Turn over one of the bearing sets so that the flange is facing up. Using both hands, carefully pick up this bearing set and set it in place inside the upper housing. See photo 19.

39. Check the rotor unit to make certain that the potentiometer wiper is still at the extreme CCW stop and that the ring gear has not moved and is still holding the RH limit switch in the "open" position. Grasp the rotor unit with both hands, taking care not to allow the ring gear to fall out of position, turn it over so that the ears of the potentiometer wiper are facing your left, and lower the rotor unit into the upper housing. The dogs on the ring gear should drop into the sockets cast into the upper housing. It may take you more than one try to accomplish this, and if so, be certain to check, before each attempt, that you have not changed the positions of the ring gear or potentiometer wiper or that one (or more) of the bearings has become dislodged from the retainer and is now lying loose in the housing! If you have successfully engaged the sockets with the ring gear dogs, you will not be able to turn the rotor unit (the part you just lowered into position); it will be solidly locked in place. If, however, the unit moves (in one direction or the other), remove the rotor base and try again, as you missed the dogs.

40. Once the rotor unit has been seated in the upper housing, apply a thin film of grease to the exposed race on the bottom of the rotor unit. Again, using both hands, set the remaining bearing set in place. This bearing set should have the *flange down* (photo 20).

41. Install the plastic spacer on the bottom of the rotor unit. See photo 20.

42. Using a finger or two, depress the brake wedge enough to slide the brake housing past it and onto the rotor unit (again see photo 20). Once the brake housing has been lowered in place, it is engaged by the brake wedge and you cannot turn the brake housing to align the bolt holes of the upper and lower housing halves. To do this, the brake must be electrically disengaged. (TR and CD series rotors have no brake. The retaining ring may simply be set in place and rotated, as necessary, to align bolt holes and the screws may be installed at this time.)

43. Attach wires or jumpers from the rotor controller's terminals 1 and 2 to terminals 1 and 2 of the rotor and disengage the brake (on Ham-II/III/IV controllers, this involves pressing and holding the center lever switch. On Ham-M controllers, this involves pressing and holding the lever switch to the left or right of center). With the brake disengaged, you may rotate the brake housing and align the bolt holes. If you have properly aligned the bearing retainer flanges and the ring gear is properly seated in the housing sockets, there should be no appreciable gap between the upper and lower housing halves of the rotor (photo 21). If, however, there is a gap of 1/16 inch or greater, disassemble the rotor, find the problem (which is usually that one, or both, of the bearing sets has been installed upside down), and correct it.

44. With the brake still disengaged, install and tighten the four #12-24 screws that hold the upper and lower halves of the rotor together (photo 22). *Do not over-tighten these screws, as failure to heed this warning will result in stripped threads in the upper housing.*

45. With the rotor still in the vise, remove power from the controller and attach the remainder of the control wires to the

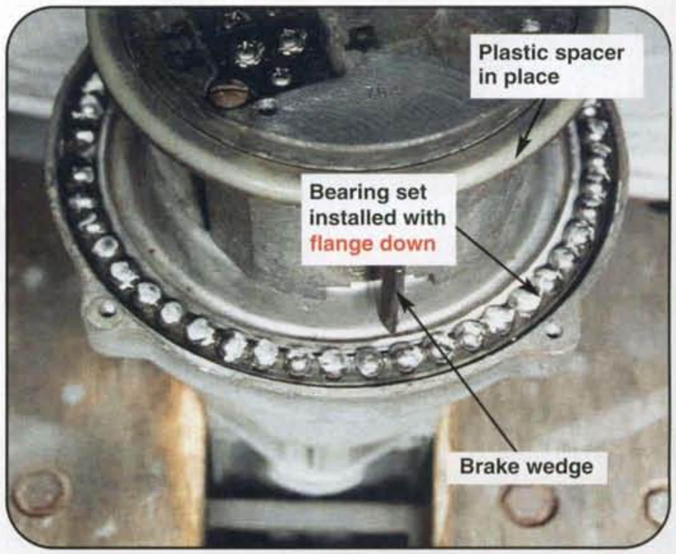


Photo 20. The plastic spacer is in place, the bearing set is installed with the flange down, and the brake wedge is in position (see steps 40, 41, and 42).

Photo 21. There is no appreciable gap between the two halves of the housing (see step 43).

appropriate terminals. Apply power to the controller and operate the rotor through a full 360-degree rotation. The meter should, initially, show full CCW ("South" on a typical indicator unit) and move smoothly to the opposite end of travel limit switch. At the end of rotation, the unit should shut itself off as it contacts (and electrically opens) the limit switch.

46. Congratulations! You've completed your work!

About Quick-Disconnects

There are those folks who believe that the convenience of having either Cinch-Jones connectors or round Amphenol connectors in the rotor with mating connectors installed on the cable outweighs the potential for water intrusion into these types of quick-disconnects. I am a strong proponent of using the standard 8-position terminal board at the rotor. Neither Cinch-Jones nor Amphenol connectors are easily waterproofed, and water intrusion into either of these connectors will lead to trouble. The circular Amphenol connectors, in particular, are troublesome. They are difficult to assemble, require a special, expensive, and, proprietary tool to disassemble (remove the contacts), and, they aren't really designed to handle the amount of current that the rotor's circuits can demand.

Here's an eye opener: I had a Ham III rotor disassembled on my bench one afternoon and wondered how high the AC current in the brake solenoid circuit would go if the brake wedge became fouled—if it couldn't move, in other words. Using a clamp-on AC ammeter, I measured 15+ amps of 26-VAC current flowing between terminals 1 and 2 of the rotor's wiring.

Photo 22. Prepare to align the bolt holes in the housing halves before installing the four housing screws (see step 44).

My suggestion, for those who wish to have a quick-disconnect near the rotor, is to use an OEM 8-position terminal board retrofitted with stainless steel hardware at the rotor. Construct a short pigtail of rotor cable. Equip one end of the pigtail with one of Press Jones's (The Wireman, Inc.) model 352 "8 pole molded connector, male and female set, heavy duty, weather proof."[6] Install the mating connector on the end of the cable that leads down the tower. Wire the 8 conductors of the rotor pigtail to the terminal board, cover the terminals and exposed copper wire on the terminal board with silicone grease (not silicone caulk!), and mount the rotor on your tower. Use spacers between the rotor and the tower mounting plate to allow water to run off and not make contact with the terminal board. For spacers, you can use stacked (stainless-steel) flat washers over the 1/4-inch diameter mounting hardware, or, you can use 5/16-inch or 3/8-inch diameter hex nuts. A 1/4-inch air gap here can make a lot of difference in the longevity of your electrical connections to the rotor. Hy-Gain also makes and sells a manufactured spacer to accomplish this task.

In Part 2 we will cover solving problems with the controller.

Notes

1. The gear trains of the various models differ, but bearings, potentiometers, and wiring are the same in all cases
2. The Ham M Series 1 and 2 rotors are unique in that their electrical wiring differed greatly from subsequent models.
3. <www.hy-gain.com>
4. <www.rotor-doc.com>
5. <http://bama.sbc.edu> and it's mirror site <http://bama.edebris.com/manuals/>
6. <http://www.thewireman.com/rotorp. html#351>

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Transmitter Hunters Track Rockets in the Desert and Plan to Meet in Boston

Six months before I got my first ham radio license, I tuned my little Hallicrafters S-38D receiver to 20 MHz and heard the faint beep-beep signals that ushered in the space age. I was fascinated by rockets such as the one that put Sputnik into orbit, how they were propelled and how they were guided.

For me and for many others, that fascination continues into the 21st century. Tens of thousands have built and launched their own rockets, big and small, with help from organizations such as the National Association of Rocketry (NAR).[1] As it has gained in popularity, rocketry has become safer. The days of metal shells and mixed liquid propellants have given way to cardboard, plastic, fiberglass, and carbon-fiber frames with solid fuel sticks that can be purchased at hobby stores.

Serious "model rocketry" enthusiasts usually progress quickly into "high power rocketry" with motors that are too powerful to be purchased in shops. They don't achieve orbit, of course, but the really big ones can experience over 30 G's on liftoff, fly at super-sonic speeds, top out at heights of 15,000 feet or more, and parachute down several miles from the launch site. Since they aren't inexpensive, builders want to retrieve them. That's where amateur radio and transmitter hunting enter the picture.

Surrounded by their high-power rockets, Mark Melnyk (left) and Rob Foth, KE6YGF, carefully prepare seals that hold the solid fuel sticks in place. (Photo by Joe Moell, KØOV)

I'm Over Here

Some hobbyists outfit their craft with sound sources that activate on impact and beep loudly. Everybody possesses direction-finding equipment for audio, but range is limited to several hundred feet, and less if the wind is blowing strongly. Since anyone nearby can hear the beacon, rocket-napping isn't unheard of.

Over the years, a few companies have offered radio tracking systems using unlicensed transmitters on the 88–108 MHz FM broadcast band. However, the range of a Part 15 compliant transmitter on those frequencies is quite limited, especially in locations where the band is full of mountaintop transmitters running tens of kilowatts of effective radiated power. Licensed hams have much better alternatives. They can build their own mini-transmitters or buy them ready-to-use in the uncrowded 222- and 433-MHz bands.

Last spring Robert Foth, KE6YGF, of Glendora, California, brought me up to date on high-power rocketry and amateur radio for tracking. Rob had attended an on-foot international-rules transmitter hunt that I put on at Gladstone Park in 2005. He and his family took second place that day, but Rob was more interested in using radio direction finding (RDF) for "punching holes in the sky," as he puts it.

According to KE6YGF, "Our high power rockets cost hundreds, if not thousands, with their onboard altimeters and other costly systems. With the extreme altitudes they can achieve, I think having a tracking system is a must!"

At Rob's invitation, I visited a session of the Rocketry Organization of California (ROC)[2] at Lucerne Dry Lake, east of Victorville, California. Members gather there once a month to send rockets toward the heavens. When I arrived at 8 AM, 26 launch pads had been set up and members were busily assembling rockets of all sizes.

Of the dozen or so small groups that set up their sunshades in the desert that day, I saw only three that were using RDF for recovery. Two groups had 222-MHz transmitters and matching receivers from Communications Specialists of Orange, California.[3] I reviewed CommSpec's miniature "ditters" in Homing In in Spring 2008 *CQ VHF*.

**P.O. Box 2508, Fullerton, CA 92837*
e-mail: <k0ov@homingin.com>

The BeeLine 433-MHz transmitter and quarter-wavelength antenna are dwarfed by a handie-talkie. The SMA antenna connector is a factory option. (Photo by KØOV)

Rob and Mark pack the Daisy Cutter's main parachute with help from Mark's son Jacob. The chute is powdered with talcum so it slides out easily. Inside is the BeeLine transmitter. (Photo by KØOV)

Rob has selected the BeeLine UHF transmitter by BigRedBee LLC of Lake Oswego, Oregon.[4] It puts out up to 16 milliwatts on a user-selected frequency between 420 and 450 MHz. Designed especially for rocket use, it operates for over 24 hours on a featherweight lithium-polymer cell. The entire shrink-wrapped battery/transmitter package weighs 30 grams (about an ounce).

With BigRedBee's serial port adapter and free software, BeeLine owners can use a PC with RS-232 port to reprogram the output power, frequency, and audio-tone parameters. The software also sets the user's CW callsign and an on-off sequence. BigRedBee owner Gregory Clark, K7RKT, sells this little rig only to licensed hams.

Rob told me about his initial experience with the BeeLine: "From the factory, it is set to operate at 433.920 MHz.[5] The callsign is sent in Morse every 30 beeps. Each beep is approximately 30 milliseconds long with 5-second pause between beeps. Not having time to configure the Beeline before the first launch, we used these default settings."

KE6YGF continued, "After launch, we thought we were tracking a strong but slightly distorted signal from the rocket. We drove over a mile with the bearing remaining constant. Only later did we figure out that our rocket had stopped transmitting and we were tracking something else, perhaps some kind of data transmitter on Big Bear Mountain. Luckily, a fellow rocketeer found our rocket while searching for his.

"After that, we changed the frequency and configured the Beeline for a much longer and more distinctive beep sequence. We also tested it on the ground first. With the Beeline in the rock-

Launch Control for Rocketry Organization of California is well equipped. The system can fire multiple rockets simultaneously for "drag races." (Photo by KØOV)

A high-power rocket lifts off at Lucerne Dry Lake. Launchers have sliding rods that aim rockets toward the sky, to land away from the observers. (Photo by KØOV)

et, one of us drove across the lake bed, intermittently stopping to set the rocket on the ground and see if the other still received a good signal at the launch area. This seemed to work well out to about 1.5 miles.

"The next launch was at night. The rocket landed about a half mile away and was easily tracked. Without an attenuator, we lost directionality when we were within about one-hundred feet away. At that point, I switched from the Yagi to the rubber duck on the receiver and tried some body-shielding and frequency-offset techniques. That got us within about 30 feet. Soon our flashlights and my Scout troop discovered the large parachute draped across the bushes."

Start the Countdown

The day of my visit was a big day for Rob, who was hoping to become certified as a Level 2 rocketeer by NAR. Like the third-party rules for ham radio, certified rocketeers are permitted to watch over uncertified persons as they launch, but most enthusiasts want to become certified themselves. There are many similarities between this certification and the VE program in ham radio. First, Rob had to take a multiple-choice, 33-question test on rocket design and construction, FAA, and fire-protection regulations, propellant storage and use, and other safety issues. He had studied the material from a question pool available online. The test was given and graded on the spot. Then he had to demonstrate proficiency by successfully firing and recovering his high-power rocket under the watchful eyes of a Level 2 holder, who would give final approval for his certification.

As Rob was sweating out his written test, his friend Mark Melnyk was assembling the first rocket, carefully inserting the fuel stick into the motor cylinder and sealing with new O-rings. Depending on motor size, each fuel stick costs $20 to $70. When Mark had it ready, he and Rob paid their fee, filled out a flight card, and took Daisy Cutter to a pad in the second row.

Rob and Mark's rockets are capable of mile-high altitudes. For a successful flight, the rocket must ignite and achieve the desired altitude, the parachute must open, and all parts must safely return to Earth and be recovered. If a full-size parachute were to open at one mile up, the descent would be so slow that the wind might carry it into the mountains. Therefore, Rob and Mark use a two-stage parachute system. A drogue chute opens at apogee and the rocket casing drops rapidly toward the ground. Then an altitude sensor fires a small gunpowder charge to open the main chute to slow the descent for landing. The altimeter also records the maximum-achieved elevation of the flight.

ROC has a well-planned procedure that efficiently executed the several dozen launches that I saw that Saturday. Groups of rocketeers attached their crafts to rods or rails on the pads and wired up the igniters. Then they retreated behind the firing line and Launch Control took over. On the public-address system, the controller announced the owner's name and rocket name, fired off the rocket, checked to make sure that the chute safely deployed, and then moved on to the next in rapid sequence until the pads were empty. After that, it was safe for the next group to go out, and so on.

Rob and Mark verified that the BeeLine was functioning before they left it on the pad. The predicted maximum altitude was about 6000 feet, so this flight was covered by ROC's blanket 8000-foot FAA clearance and they did not need special approval. The launch and ascent of Daisy Cutter was flawless. They got good bearings as it drifted down, and then they set off across the lake bed to retrieve it.

To track the BeeLine, Rob uses a 7-element Yagi (model 440-7) from Arrow Antennas in Cheyenne, Wyoming.[6] Arrow antennas are so named because the elements are made from aluminum arrow shaft material, which is significantly lighter than ordinary tubular aluminum of the same diameter. The signal into Rob's receiver is almost overpowering when the rocket is aloft, but drops dramatically once it reaches the ground. With the chute, it's easy to spot the rocket on the lake bed at a distance, but Rob knows that he needs to add attenuation to his system for close-in triangulation if the rocket were to be carried by winds into a vegetated area.

Rob passed his test and prepared Thunder Child for his certification flight, using the same altimeter and recovery transmitter that was on Daisy Cutter earlier. By then, the winds had picked up and the only rockets being launched were either small ones that wouldn't drift far or larger ones with recovery transmitters. Thunder Child shot up out of sight and the transmitter told Rob that it was coming down toward the northwest. With the binoculars they saw it land and headed out to pick it up, about a mile away. All the parts were together, so Rob was able to show everything and get his certification.

Rob's only complaint about the BeeLine tracking system regards the supplied lithium-polymer battery charger. He wrote, "It is a 'universal' type, which means that it does not fit any single application well. It comes with alligator clips that cannot connect directly to the battery pack. The user must either add his own connectors or insert small wires into the battery pack connector and then clip to the wires, creating a shorting hazard. Because the charger has non-polarized connectors, there is a test button to check the battery for proper polarization before

It's going that way! Rob and Mark are following the strong UHF signal just after launch. (Photo by KØOV)

plugging it into power. Another of the buttons on the charger allows you to reverse the polarity of the color-coded alligator clips. The red clip could be positive or negative!"

Since my visit, Rob and Mark have continued to advance their knowledge of rocketry. KE6YGF writes, "We have each built smaller diameter rockets that can easily fly over 10,000 feet. One of Mark's can exceed Mach 1 in the first few seconds of flight. Because these are impossible to visually track, I have purchased a second BeeLine. They are cheap insurance that we can locate expensive rockets in the miles of featureless desert playa. I am also experimenting with attenuators to help me keep radio-tracking when I get very close."

Properly packaged, the Beeline transmitter would be ideal for short-range, on-foot 70-cm foxhunts. Arnold Nelson, N6APA of Napa, California machined a rugged metal enclosure for his unit that is about 1" × 2" × 1/2" on the outside. He programs it for a 30-second on, 30-second off sequence for transmitter hunts of the Silverado Amateur Radio Society. Arnie calls it "The Littlest Fox."

Blue Hills of Beantown

I have good news for on-foot transmitter hunters in northeastern states. For the first time, our annual national championships of Amateur Radio Direction Finding (ARDF) will be close to you. Make plans now to be in Boston the first weekend of June for the Ninth USA ARDF Championships, which will be combined with the Fifth ARDF Championships of International Amateur Radio Union (IARU) Region 2 (North and South America).

Beginners and experts will gather on Friday for practice and equipment checks. Next will come two days of intense competition, Saturday on 2 meters and Sunday on 80 meters. Courses will be in the Blue Hills Reservation, a 7000-acre open space that straddles Interstate 93. It is about 10 miles south of the Old North Church in downtown Boston, which is another place that you will want to visit while you are in the "Cradle of Liberty."

This reservation is the largest conservation land within a major metropolitan area. It has 125 miles of trails that go

It's easy to follow the signal directly on the dry lake bed. There's no worry about staying on the road. (Photo by KØOV)

Vadim Afonkin, KB1RLI, will organize and host the 2009 USA and IARU Region 2 Championships near Boston. This photo shows him at the 80-meter starting line of the 2007 national championships near South Lake Tahoe, California. (Photo by KØOV)

through forests, marshes, swamps, and meadows, as well as an Atlantic white cedar bog. There are lots of hills, but altitude won't be a problem this year. The highest point in the park is only 635 feet above sea level.

Plenty of lodging and food options are close to the reservation. Expect daytime high temperatures in the 70s. As always, scheduled championship sites are off limits to anyone who will be competing, to avoid any unfair advantage of familiarity. Stay out of the reservation from now until the first day of competition.

Another first this year is the juxtaposition of championship ARDF and classic orienteering. Our ARDF event will take place at the same time as a local session (called a "B-meet") of the New England Orienteering Club and will use NEOC's excellent maps. Classic orienteers and radio-orienteers will share the finish area, but the ARDF start-point and electronic scoring will be separate. Flags at the hidden transmitters will have different markings from the orienteering controls to avoid confusion.

Besides reducing costs for everyone, the inclusion of ARDF

Vadim nears the 2-meter finish line of the 2008 ARDF World Championships in South Korea, where he won fifth place in his age category during the 80-meter competition. (Photo by Jay Hennigan, WB6RDV)

at the NEOC meet will expose orienteers and local Scouts to our radio sport. As always, the USA Championships are open to anyone who can run or walk through the forest while carrying RDF gear for 5 to 10 kilometers. A ham license is not a requirement. For the awards, competitors will be separated into age and gender categories in accordance with IARU rules. Category winners may qualify for positions on ARDF Team USA for the 2010 ARDF World Championships in the islands near Dubrovnik, Croatia.

Organizer and host of this year's national championships is Vadim Afonkin, KB1RLI, of Brookline, Massachusetts. Vadim learned ARDF as a youth in his native Russia. There he met a YL named Nadia, who later immigrated to America and became the first member of ARDF Team USA to win a medal at the World Championships.[7]

"My callsign in Russia was UZ3AYT," Vadim told me. "I started in 1982 and won my first bronze medal at the USSR championship in 1983. I became a member of the Soviet team in 1984 and ran at international competitions and later in military championships. I came to the USA in 1994 and brought my equipment. But I could not find any ARDF activity here, so I gave up. In one of my moves, my receivers got lost. Years later, Nadia called and told me about the new ARDF activity. She urged me to get involved. I had to get new equipment, but I did it."

Vadim first participated in USA's national championships in 2003 near Cincinnati, where he won silver and bronze medals in the five-fox M21 category. He has competed in M21 at every USA championships since then and has achieved the best five-fox time of all stateside participants in every one. As a member of ARDF Team USA, Vadim traveled to the World Championships in 2004 (Czech Republic), 2006 (Bulgaria), and 2008 (South Korea). In Korea, he took fifth place worldwide in the M40 category on 80 meters.

Our annual ARDF championships are an ideal opportunity to watch and learn from the best radio-orienteers in the country, as well as visiting experts from around the world. Each person competes as an individual; there is no teaming or person-to-person assistance allowed on the courses.Using GPS as a navigation aid is also forbidden.

Competitors are responsible for bringing their own direction-finding sets. Extra gear might be available for loan from other attendees, but inquire ahead of time. Receivers must not radiate signals that can be heard by others. Transmitting on the course is forbidden, except in emergencies.

Even if you aren't up to the challenge of a big-forest foxhunt, chances are that someone in your family or circle of friends is. Tell them about the opportunity and offer to help with RDF equipment and local practice sessions. All the basics are on my website[8], including the international rules and hidden-signal parameters. You will get equipment ideas for both competition bands and you can also determine your own age category. The pages of photos from our previous championships will help you decide what gear to carry (the lighter, the better) and what to wear.

Let's make this the biggest year ever for ARDF!

73, Joe, KØOV

Notes

1. <http://www.nar.org>
2. <http://www.rocstock.org/>
3. The new URL is <http://www.com-spec.com/rocket/index.html>
4. <http://www.bigredbee.com>
5. In the southern California band plan, this frequency is in the visual carrier range for NTSC ATV signals.
6. <http://www.arrowantennas.com>
7. The story of Nadia Scharlau's medal at the ARDF World Championships is in "Homing In," Fall 2006 *CQ VHF*.
8. <http://www.homingin.com>

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Vivaldi Project

The most basic of beam antennas is the Vee beam. We just start with a dipole and form the elements into a V. Make the elements longer and longer, and the gain goes up. Make the elements really long, and there are advantages to tapering the separation between the wires. There also advantages to making the wires very fat and tapering the diameter, but we'll skip that this time and look at a sheet-metal version of the Vee beam.

Vivaldi Project

In photo A we have the a few of the Vivaldi antennas I have developed for various applications from 900 MHz to 35 GHz. The Vivaldi is one of a family of exponential antennas that work over a very broad range of frequencies. The basic antenna scales up or down very easily.

In photo B is a Ridged Horn. The ridges give a very broad frequency response to the horn. This model is rated at 2–18 GHz, but works from 1–20 GHz. In a way, we can think of a Vivaldi as a Ridged Horn minus the horn!

In figure 1 is the template for a Vivaldi antenna. If you just copy this template, your finished antenna will work from about 7 to 15 GHz or so. Ahh ... but if you put it on a copier, set the image to 200%, you get a template for a about a 3-to 10-GHz version . If you are really good working with small parts, set the copier to 50% and you have the template for a 10- to 25-GHz model. Your limits are the size of the sheet metal and your ability to trim very fine dimensions. The antenna is fed at the narrow end of the slot. Using sheet tin or sheet brass is nice because you can solder to it. For lower frequency designs it is possible to use sheet aluminum and attach some solder lugs, but using a material to which you can solder is nice.

*1626 Vineyard, Grand Prairie, TX 75052
e-mail: <wa5vjb@cq-vhf.com>

Construction

My homebrew Vivaldi started with a 5-inch wide paper copy of the template. I cut the outline with scissors and stuck it on some old .031-inch PC board. As you

Photo A. Vivaldi antennas from 900 MHz to 35 GHz. (Photos and figures by the author)

Photo B. Ridged horn antenna.

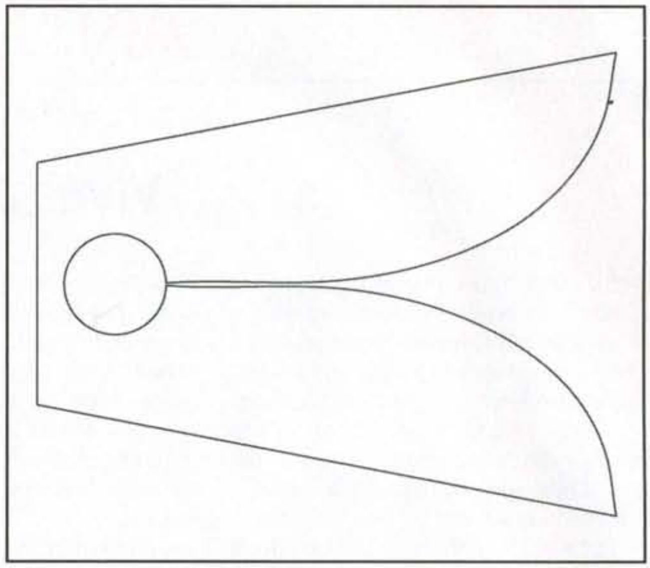


Figure 1. The Vivaldi antenna template.

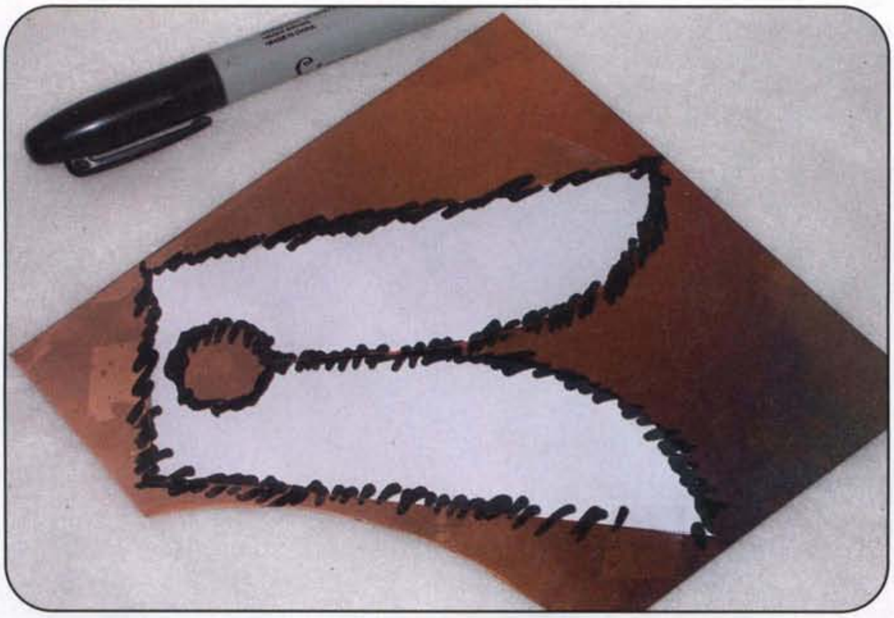


Photo C. Marking the template.

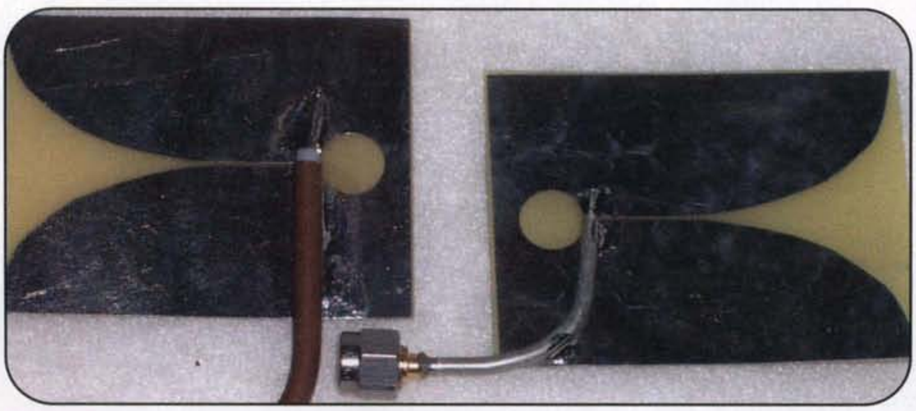


Photo D. Attaching the coax.

can see in photo C, I marked the edges and then cut it out. There are much better template marking techniques out there, and you are welcome to use your favorite transfer method. Next I cut the PC board again with scissors. The antenna doesn't care if it's single- or double-sided PC board. This also works for thin sheet metal. Then I took a few swipes with a file (sandpaper works, too). The antenna should not have sharp points sticking out along the curves. Sharp points can cause spikes in the SWR. Again you want the gap to be very narrow and the taper in the gap to be smooth.

I used simi-rigid coax to feed my PC-board versions in photo D and in the homebrew version, but any type coax that can be soldered can be used. This is usually one of the Teflon® insulation coax types. When soldering the coax, you want the shield right up to the gap, and the center conductor bent right down to the other side of the gap. The leads need to be very short, as we are talking many GHz here!

Testing of the finished antenna in photo E looked pretty good. In figure 2 is the return-loss sweep of the homebrew Vivaldi. The 5-inch version worked down to just under 1 GHz and still looked good at 6 GHz, the maximum frequency of my analyzer. Except for that spike at 1.8 GHz, the return loss is in the –10 dB to –20 dB range. Therefore, this one had a better than 2:1 SWR over the entire 1–6 GHz range—well, except at 1.8 GHz.

Again, the frequency limits are set by the how narrow you can make the slot opening, and the size of the flare opening. When we test them on an antenna range, the Vivaldi antennas have gain well below the frequency range shown in Table 1, but the return loss, or SWR, is high. Normally a Vivaldi antenna is fed 1/4 wave from the end of the slot. However, changing the slot to a circle greatly expands the SWR range of the Vivaldi.

There are other tricks to feeding this Vivaldi variation. If you have size limits, but need to use the antenna lower in frequency than in Table 1, you can move the feed forward as shown in photo F. You are getting the antenna to have a good SWR lower in its band, but the high frequency response pretty much goes away. This way you can make a 2- to 8-GHz version work at 1.5 or even 1.3 GHz, but above 3 GHz or so the SWR gets pretty high. It works, but you really need to measure the SWR when looking for that sweet spot and you are optimizing the antenna for one frequency.

Now on the high-frequency end, the limit is how accurately you can form the curve and the gap between the two sides. To improve the SWR on the high end you may need to block off part of the back as I have shown in photo G. I find small pieces of aluminum or copper tape are handy here, but again you really need to be able to measure the return-loss response or SWR using test equipment while tweaking the antenna. Now it is the low-frequency response of the antenna that is going to suffer. However, you can really lower the SWR/return loss on a narrow-frequency band.

Width of the end	Approx. Freq. Range
3/4 inch	18-35 GHz
1 1/2 inches	10-25 GHz
3 inches	4-20 GHz
5 inches	1-6 GHz
12 inches	400 MHz to 2 GHz

Table 1. The frequency limits of the Vivaldi antenna are set by the how narrow you can make the slot opening, and the size of the flare opening. When we test them on an antenna range, the antennas have gain well below the frequency range shown here, but the return loss, or SWR, is high.

Uses

These antennas make a nice test for a

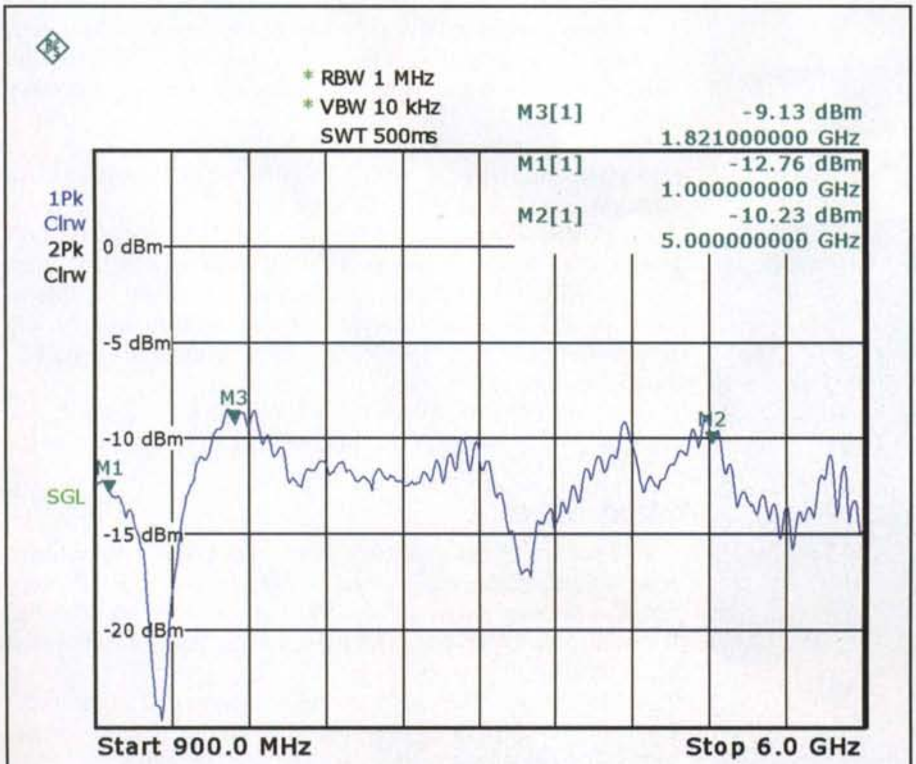


Figure 2. Return-loss plot of the homebrew Vivaldi antenna.

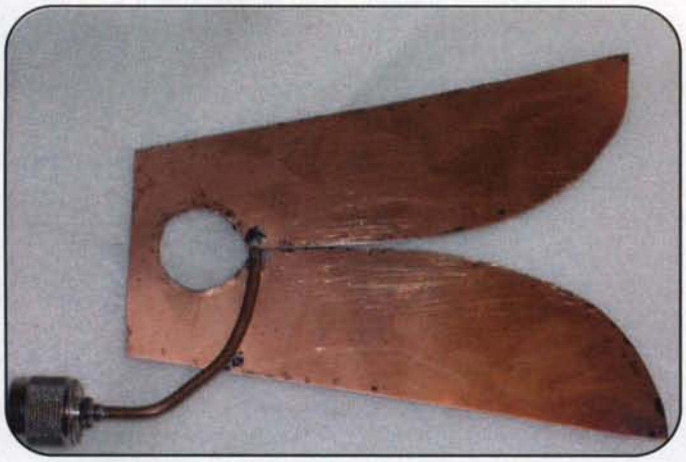


Photo E. The finished homebrew 1- to 6-GHz Vivaldi.

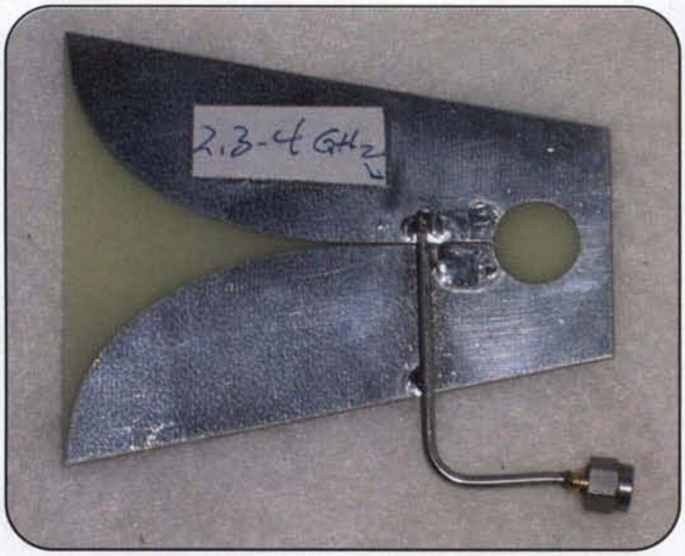


Photo F. Moving the feed point.

Photo G. Changing the high-frequency matching.

Photo H. Very broadband dish feed.

frequency counter or a spectrum analyzer. They also make a good broadband dish feed like the one in photo H. I recommend adjusting the focus for best gain at the highest frequency at which you plan to use the dish. The phase center of the antenna does move around with frequency, but if you optimize the feedpoint for the high end of the band, there is little phase error at the low end.

For the digital crowd, a 5- to 6-inch version can work as a 915 MHz, 2400 MHz, 3.4 GHz, 4.9 GHz, 5.2 GHz, and 5.8 GHz antenna or dish feed, all at the same time.

For AMSAT we are working on a circularly polarized version of the Vivaldis. Using two Vivaldis mounted in X fashion and fed with a special phase shifter, we just might be able to work up a 2- to 6-GHz circularly polarized dish feed for the next generation of AMSAT birds or a combined L-Band/S-Band dish feed.

Also, last time we talked about UWB, or Ultra Wide Band, signals in this column. Vivaldi's make great UWB antennas!

Next Time

I've run out of column room at this point and I have several more Vivaldi tricks to talk about, so next time we will talk more about improving the return loss/SWR at particular points in the band and how to add your own personal touches. Also, I'm sure other topics will pop up.

As always, we like your antenna questions and suggestions for column topics. Just drop me an e-mail at <wa5vjb@cq-vhf.com> or you can visit <www.wa5vjb.com> for other antenna projects or even Vivaldi antenna templates. You, our readers, provide some of the best topics for columns.

73, Kent, WA5VJB

hy-gain® ROTATORS

. . . the first choice of hams around the world!

HAM-IV

HAM-IV **$649.95**

The most popular rotator in the world!

For medium communications arrays up to 15 square feet wind load area. *New* 5-second brake delay! *New* Test/Calibrate function. *New* low temperature grease permits normal operation down to -30 degrees F. *New* alloy ring gear gives extra strength up to 100,000 PSI for maximum reliability. *New* indicator potentiometer. *New* ferrite beads reduce RF susceptibility. *New* Cinch plug plus 8-pin plug at control box. Dual 98 ball bearing race for load bearing strength and electric locking steel wedge brake prevents wind induced antenna movement. North or South center of rotation scale on meter, low voltage control, max mast size of 2¹/₁₆ inches.

HAM IV and HAM V Rotator Specifications	
Wind Load capacity (inside tower)	15 square feet
Wind Load (w/mast adapter)	**7.5 square feet**
Turning Power	800 in.-lbs.
Brake Power	**5000 in.-lbs.**
Brake Construction	Electric Wedge
Bearing Assembly	**dual race/96 ball bearings**
Mounting Hardware	Clamp plate/steel U-bolts
Control Cable Conductors	**8**
Shipping Weight	26 lbs.
Effective Moment (in tower)	**2800 ft.-lbs.**

TAILTWISTER SERIES II

For large medium antenna arrays up to 20 sq. ft. wind load. Available with *DCU-1 Pathfinder* digital control (T2XD) or standard analog control box (T2X) with *new* 5-second brake delay and *new* Test/Calibrate function. Low temperature grease, alloy ring gear, indicator potentiometer, ferrite beads on potentiometer wires, *new* weatherproof AMP connectors plus 8-pin plug at control box, triple bearing race with 138 ball bearings for large load bearing strength, electric locking steel wedge brake, North or South center of rotation scale on meter, low voltage control, 2¹/₁₆ inch max. mast.

T-2X **$799.95**

T-2XD **$1229.95** with DCU-1

TAILTWISTER Rotator Specifications	
Wind load capacity (inside tower)	20 square feet
Wind Load (w/ mast adapter)	**10 square feet**
Turning Power	1000 in.-lbs.
Brake Power	**9000 in.-lbs.**
Brake Construction	Electric Wedge
Bearing Assembly	**Triple race/138 ball brngs**
Mounting Hardware	Clamp plate/steel U-bolts
Control Cable Conductors	**8**
Shipping Weight	31 lbs.
Effective Moment (in tower)	**3400 ft.-lbs.**

CD-45II

CD-45II **$449.95**

For antenna arrays up to 8.5 sq. feet mounted inside tower or 5 sq. ft. with mast adapter. Low temperature grease good to -30 F degrees. *New* Test/Calibrate function. Bell rotator design gives total weather protection, dual 58 ball bearing race gives proven support. Die-cast ring gear, stamped steel gear drive, heavy duty, trouble free gear train, North center scale, lighted directional indicator, 8-pin plug/socket on control unit, snap-action control switches, low voltage control, safe operation, takes maximum mast size to 2¹/₁₆ inches. MSLD light duty lower mast support included.

CD-45II Rotator Specifications	
Wind load capacity (inside tower)	8.5 square feet
Wind Load (w/ mast adapter)	**5.0 square feet**
Turning Power	600 in.-lbs.
Brake Power	**800 in.-lbs.**
Brake Construction	Disc Brake
Bearing Assembly	**Dual race/48 ball brings**
Mounting Hardware	Clamp plate/steel U-bolts
Control Cable Conductors	**8**
Shipping Weight	22 lbs.
Effective Moment (in tower)	**1200 ft.-lbs.**

HAM-V

HAM-V **$1099.95** with DCU-1

For medium antenna arrays up to 15 square feet wind load area. Similar to the HAM IV, but includes *DCU-1 Pathfinder* digital control unit with gas plasma display. Provides automatic operation of brake and rotor, compatible with many logging/contest programs, 6 presets for beam headings, 1 degree accuracy, auto 8-second brake delay, 360 degree choice for center location, *more!*

AR-40

AR-40 **$349.95**

For compact antenna arrays and large FM/TV up to 3.0 square feet wind load area. Dual 12 ball bearing race. Automatic position sensor never needs resetting. Fully automatic control -- just dial and touch for any desired location. Solid state, low voltage control, safe and silent operation. 2¹/₁₆ inch maximum mast size. MSLD light duty lower mast support included.

AR-40 Rotator Specifications	
Wind load capacity (inside tower)	3.0 square feet
Wind Load (w/ mast adapter)	**1.5 square feet**
Turning Power	350 in.-lbs.
Brake Power	**450 in.-lbs.**
Brake Construction	Disc Brake
Bearing Assembly	**Dual race/12 ball bearings**
Mounting Hardware	Clamp plate/steel bolts
Control Cable Conductors	**5**
Shipping Weight	14 lbs.
Effective Moment (in tower)	**300 ft.-lbs.**

HDR-300A

HDR-300A **$1499.95**

For ***king-sized*** antenna arrays up to 25 sq.ft. wind load area. Control cable connector, *new* hardened stainless steel output shaft, *new* North or South centered calibration, *new* ferrite beads on potentiometer wires reduce RF susceptibility, *new* longer output shaft keyway adds reliability. Heavy-duty self-centering steel clamp and hardware. Display accurate to 1°. Machined steel output.

HDR-300A Rotator Specifications	
Wind load capacity (inside tower)	25 square feet
Wind Load (w/ mast adapter)	**not applicable**
Turning Power	5000 in.-lbs.
Brake Power	**7500 in.-lbs.**
Brake Construction	solenoid operated locking
Bearing Assembly	**bronze sleeve w/rollers**
Mounting Hardware	stainless steel bolts
Control Cable Conductors	**7**
Shipping Weight	61 lbs.
Effective Moment (in tower)	**5000 ft.-lbs.**

ROTATOR OPTIONS

MSHD, $99.95. Heavy duty mast support for T2X, HAM-IV and HAM-V.
MSLD, $39.95. Light duty mast support for CD-45II and AR-40.
TSP-1, $34.95. Lower spacer plate for HAM-IV and HAM-V.

Digital Automatic Controller

DCU-1 **$749.95**

Automatically controls T2X, HAM-IV, V rotators. 6 presets for favorite headings, 1° accuracy, 8-sec. brake delay, choice for center of rotation, crisp *plasma* display. Computer controlled with many logging/contest programs.

AR-35 Rotator/Controller

AR-35 **$89.95**

For UHF, VHF, 6-Meter, TV/FM antennas. Includes automatic controller, rotator, mounting clamps, mounting hardware. 110 VAC. One Year Warranty.

NEW! Automatic Rotator Brake Delay

RBD-5 **$29.95**

Provides automatic 5-second brake delay -- insures your rotator is fully stopped before brake is engaged. Prevents accidentally engaging brake while rotator is moving. Use with HAM II, III, IV, V, T2Xs. Easy-to-install. Includes pre-assembled PCB, hardware.

http://www.hy-gain.com

Nearest Dealer, Free catalog, To Order . . .

800-973-6572

Voice: 662-323-9538 **Fax:** 662-323-6551

hy-gain®

Antennas, Rotators & Towers

308 Industrial Park Road,Starkville, MS 39759, USA

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Old and New Science

During solar Cycle 23's approximately eleven years, scientists have worked with increased passion and resources to discover everything possible about the Sun, space weather, and geophysical and ionospheric phenomena. They've been busy launching many new satellites and other research spacecraft, building new models to better fit the resulting data, and discovering many new and revealing facts in the mix of all of the rich and new data.

One amazing discovery involves the magnetic connection between our Sun and Earth. The reigning model described a process whereby solar material (charged solar matter) may enter into our atmosphere, triggering aurora and creating geomagnetic disturbances. Conventional understanding of the process required the magnetic orientation of the magnetic field lines of the solar wind to be oriented "southward" in relationship to Earth's magnetosphere before solar material could effectively enter through a "hole" in the resulting reconnection of the two magnetic-field structures. As the two fields became aligned in this way, it is called "reconnection." When a reconnection occurs, it allows material on the solar wind to "ride" the field lines down toward Earth's northern and southern magnetic poles. If the orientation is "northward," then this reconnection between the Sun's and Earth's magnetic fields would not occur, and solar material would be deflected around the Earth by the magnetosphere. As a result, the magnetosphere is stretched far out into space away from the sun (see figure 1). The new discovery radically alters this model.

During February 2007 NASA launched five spacecraft for the primary goal of exploring macroscale interactions during ionospheric and geomagnetic substorms. This project is called THEMIS, the acronym for Time History of Events and Macroscale Interactions during Substorms, and it is the fifth medium-class mission under NASA's Explorer Program. The University of California, Berkeley's Space Sciences Laboratory managed the project development and is currently operating the THEMIS mission. Swales Aerospace, Beltsville, Maryland, built the THEMIS satellites.

Scientists, using THEMIS, discovered a breach in Earth's magnetic field ten times larger than anything previously thought to exist. However, the breach itself is not the biggest surprise. Researchers are even more amazed at the strange and unexpected way it forms, overturning long-held ideas of space physics.

"At first I didn't believe it," says THEMIS project scientist David Sibeck

*P.O. Box 9, Stevensville, MT 59870
e-mail: <nw7us@arrl.net>

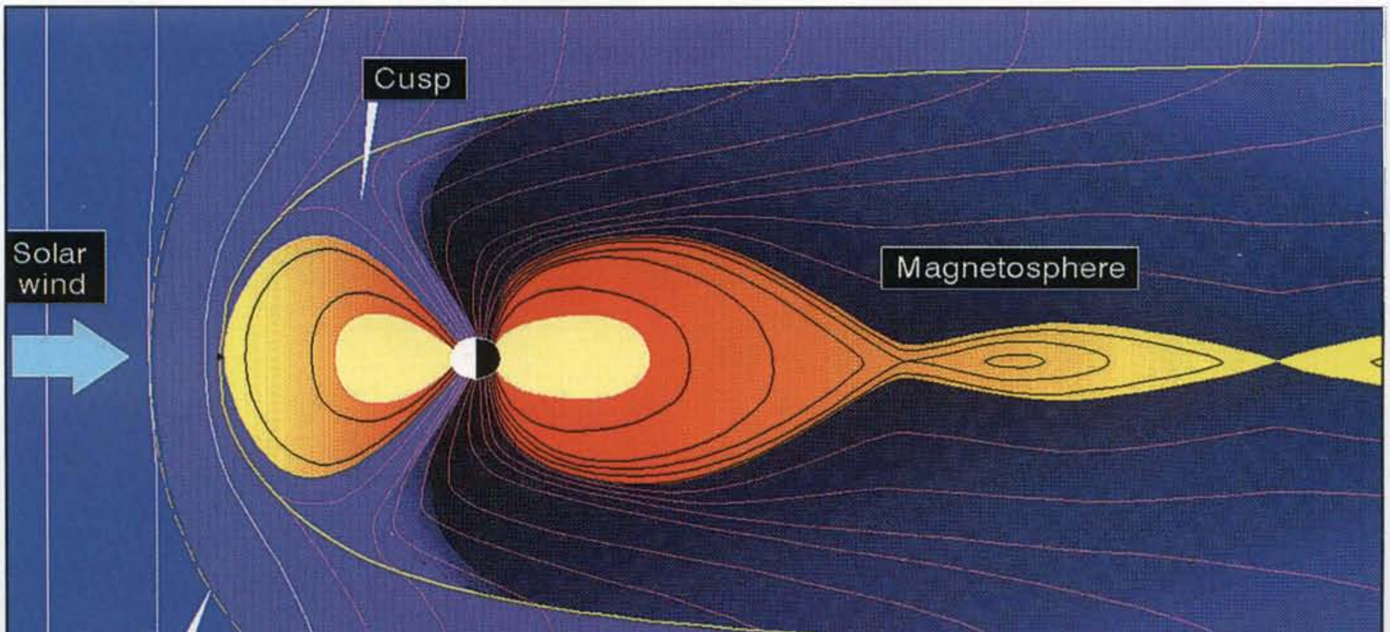


Figure 1. Earth's magnetic field gets stretched out into a comet-like shape with a tail of magnetism that stretches millions of miles behind Earth, opposite from the Sun. The Sun has a wind of gas that pushes Earth's field from the left to the right in this drawing. (Credit: NASA)

of the Goddard Space Flight Center. "This finding fundamentally alters our understanding of the solar-wind–magnetosphere interaction."

The big discovery came on June 3, 2007, when the five probes serendipitously flew through the breach just as it was opening. Onboard sensors recorded a torrent of solar-wind particles streaming into the magnetosphere, signaling an event of unexpected size and importance.

"The opening was huge—four times wider than Earth itself," says Wenhui Li, a space physicist at the University of New Hampshire who has been analyzing the data. Li's colleague Jimmy Raeder, also of New Hampshire, says, "10^{27} particles per second were flowing into the magnetosphere—that's a 1 followed by 27 zeroes. This kind of influx is an order of magnitude greater than what we thought was possible."

There was little warning that this event was about to happen. A complex bundle of magnetic fields from the Sun, along with a "cloud" of solar material, rode the solar wind and wrapped itself around the magnetosphere and "cracked" it open. The cracking was accomplished by means of magnetic reconnection. Magnetic conduits over the Arctic and Antarctic quickly expanded; within minutes they overlapped over Earth's equator to create the biggest magnetic breach ever recorded by Earth-orbiting spacecraft (see figure 2).

The size of the breach took researchers by surprise. "We've seen things like this before," says Raeder, "but never on such a large scale. The entire day-side of the magnetosphere was open to the solar wind." (See figure 3.)

The circumstances were even more surprising. Space physicists have long believed that holes in Earth's magnetosphere open only in response to solar magnetic fields that point south. The great breach of June 2007, however, opened in response to a solar magnetic field that pointed north.

When the solar-wind magnetic fields are oriented northward, it is referred to as a "positive IMF," for a positive Interplanetary Magnetic Field index. A southerly-oriented IMF is a negative index. This data is reported as the "B sub Z (B_Z) index."

The solar wind bombards the Earth's magnetosphere almost directly above the sunlit equator where Earth's magnetic field points north. If a cloud of solar plasma arrives on the solar wind with a northwardly-oriented magnetic field, the two fields should reinforce one another, strengthening Earth's magnetic defenses and slamming the door shut on the solar wind.

"So, you can imagine our surprise when a northern IMF came along and shields went down instead," says Sibeck. "This completely overturns our understanding of things."

This finding reveals that northern IMF events, while not actually triggering geomagnetic storms, create favorable conditions for these storms by loading the magnetosphere with plasma. A loaded magnetosphere is primed for auroras, power outages, and other disturbances that can result when, say, a CME (coronal mass ejection) hits.

The years ahead could be especially lively. Raeder explains: "We're entering solar Cycle 24. For reasons not fully understood, CMEs in even-numbered solar cycles (such as 24) tend to hit Earth with a leading edge that is magnetized north. Such a CME should open a breach and load the magnetosphere with plasma just before the storm gets under way. It's the perfect sequence for a really big event."

Sibeck agrees: "This could result in stronger geomagnetic storms than we have seen in many years."

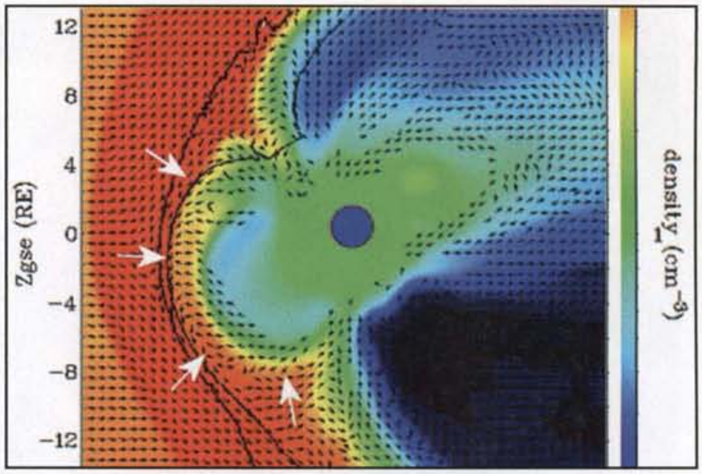


Figure 2. A computer model of solar wind flowing around Earth's magnetic field on June 3, 2007. Background colors represent solar-wind density; red is high density; blue is low. Solid black lines trace the outer boundaries of Earth's magnetic field. Note the layer of relatively dense material beneath the tips of the white arrows; that is solar wind entering Earth's magnetic field through the breach. (Credit: Jimmy Raeder/UNH [University of New Hampshire])

That's great news for the VHF weak-signal enthusiasts, since this can result in many strong aurora-mode propagation openings during this new solar cycle.

In the next issue, we'll look at more of the "new" science coming out of the current research from THEMIS and other space weather projects.

Propagation Outlook for February through April

Because of the nature of the Earth's orbit around our Sun, we have two seasons each year when any adverse space weather has a greater influence on causing geomagnetic disturbances: The first is known as the Spring Equinoctial season, and the second is known as the Autumnal Equinoctial season. These are the two times during the course of the Earth's orbit around the Sun when the Earth is in just the right position to be most influenced by solar activity.

The Spring Equinoctial season peaks between March and April of each year. Because we're in the very start of solar Cycle 24, it is likely that we will have significant geomagnetic disturbances this year, triggering the sort of auroral activity known to bring about VHF activity.

What is the Aurora?

Aurora is a direct result of solar plasma interacting with gasses in the upper atmosphere. Aurora occurs during geomagnetic substorms. During these substorms, solar-wind plasma resulting from coronal mass ejections can rain down into the atmosphere. Gasses in the atmosphere start to glow under the impact of these particles. Different gasses give out various colors. Think of a neon sign and how the plasma inside the glass tube, when excited, glows with a bright color. These precipitating particles mostly follow the magnetic-field lines that run from Earth's magnetic poles and are concentrated in circular regions around the magnetic poles called "auroral ovals." These

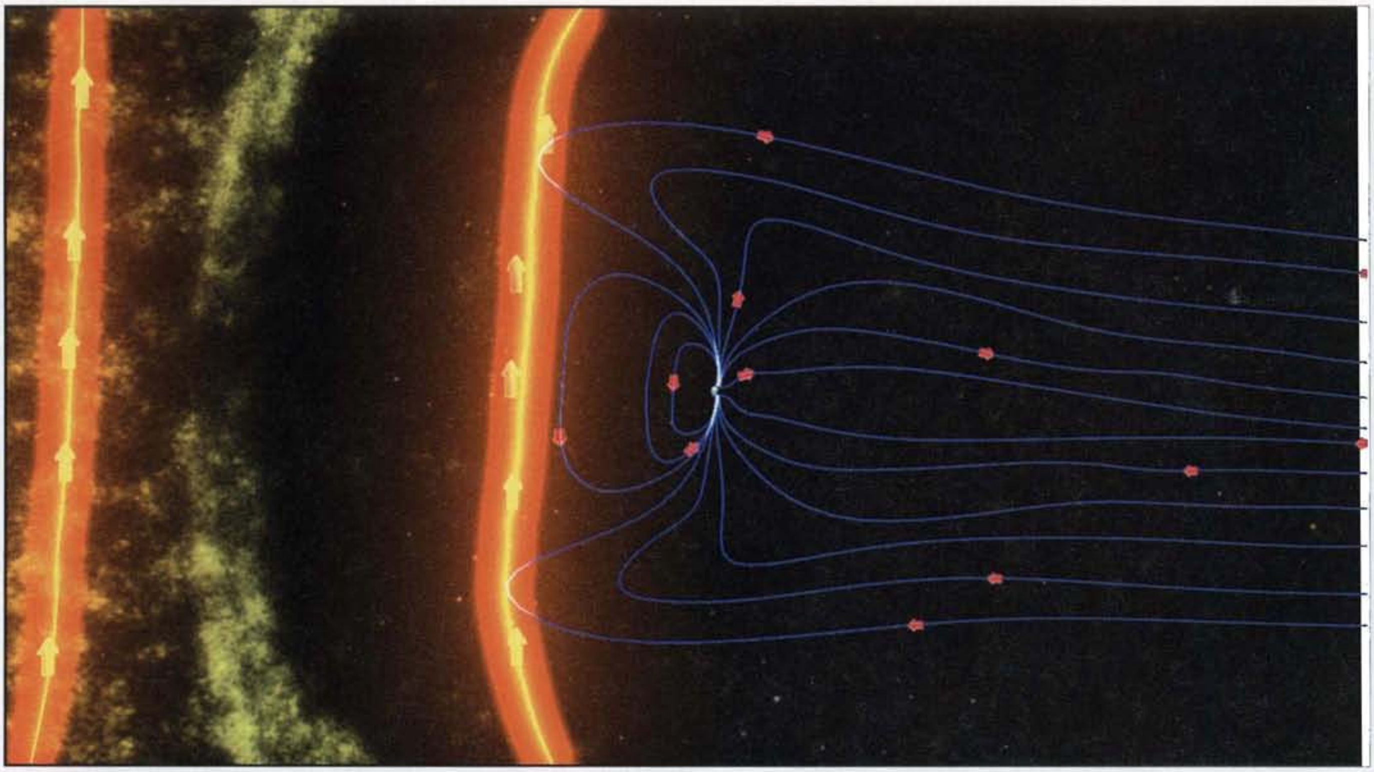


Figure 3. Earth's magnetic field, which shields our planet from severe space weather, often develops two holes that allow the largest leaks of the solar particles. (Credit: NASA/Goddard Space Flight Center)

bands expand away from the poles during magnetic storms. The stronger the storm, the greater these ovals will expand. Sometimes they grow so large that people at middle latitudes, such as California, can see these "Northern Lights."

Because the Earth's magnetic dipole axis is most closely aligned with the Sun's solar-wind spiral in April and October, the interaction between the solar wind and the Earth's magnetosphere is greatest during these two seasons. This is why aurora is most likely to occur and strongest during the equinoctial months. When you see the solar-wind speed increase to over 500 kilometers per second, and the Bz remains mostly negative (the IMF is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K*-index (*Kp*).

This year, the Spring Equinoctial season will be active, with a few strong geomagnetic storms. If we do experience moderate to storm-level activity due to recurring coronal holes, look for aurora-mode propagation. The higher the *Kp*, the more likely you may see the visual aurora. However, you don't have to see them to hear their influence on propagation. Listen for stations from over the poles that sound raspy or fluttery. Look for VHF DX. Sometimes it will enhance a path at certain frequencies, while other times it will degrade the signals. Sometimes signals will fade quickly and then come back with great strength. The reason for this is that the radio signal is being refracted off the more highly ionized areas in the *E* region of the ionosphere that are energized by this aurora. These ionized areas ebb and flow, so the ability to refract changes, sometimes quickly. I've observed the effect of aurora and associated geomagnetic storminess even on lower HF frequencies.

Radio Aurora

If there are enough solar particles flowing down the Earth's magnetic-field lines and colliding with atmospheric atoms and molecules, ionization occurs. This ionization may be sufficient to reflect VHF and lower UHF radio waves, generally between 25 and 500 MHz. This usually occurs in conjunction with visual aurora, but the mechanism is a bit different and it is possible to have one (visual or radio) without the other.

Using radio aurora, the chances of contacting stations over greater distances than would ordinarily be possible on the VHF frequencies is increased. Like its visual counterpart, radio aurora is very unpredictable. The thrill of the chase draws many VHF weak-signal DXers to work auroral DX.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval, and the possible intensity of the aurora. When the *K*-index is higher than 5, most operators in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and

Florida. Your magnetic latitude can be found using the map at <http://www.sec.noaa.gov/Aurora/globeNW.html>.

Meteors

While there are no major meteor showers during February and March, April has a few meteor showers worthy of note. These are the *Lyrids*, the *Puppids*, and *Aquarids*.

The *Lyrids* peak on April 22 at 1100 UTC. While this shower peaks at about 18 meteors per hour, or about one per every five minutes on average, it can provide some good radio bursts. It is possible to see the hourly meteor rate (ZHR) reach as high as 90 per hour. The debris expelled by comet Thatcher as it moves through its orbit causes the *Lyrids*. It is a long-period comet that visits the inner solar system every 415 years or so. Despite this long period, there is activity every year at this time, so it is theorized that the comet must have been visiting the solar system for quite a long time. Over this long period, the debris left with each pass into the inner solar system has been pretty evenly distributed along the path of its orbit. This material isn't quite evenly distributed however, as there have been some years with outbursts of higher than usual meteor activity. The most recent of these outbursts occurred in 1982, with others occurring in 1803, 1922, and 1945. These outbursts are unpredictable and one could even occur this year. The best time to work this shower should be from midnight to early morning.

The *Puppids* shower is another minor event and is best observed south of the equator. The rate can be around 40 per hour, but this may not play out this year. The peak occurs April 23 at 1600 UTC.

The *Aquarids,* however, while more prominent from tropical regions, can be a rich shower this year. The peak is in May, but the shower starts around April 19. The rate can be between 40 and 85 per hour. This year expectations are for the periodic peak, so this could be a player for meteor-scatter propagation.

The Solar Cycle Pulse

The observed sunspot numbers from September through November 2008 are 1.1, 2.9, and 4.1, showing a slow yet steady rise in the activity of the new sunspot cycle, Cycle 24. The smoothed sunspot counts for March through May 2008 are 3.3, 3.3, and 3.5. The smoothed numbers will likely show little improvement until the average covers the very last months of 2008.

The monthly 10.7-cm (preliminary) numbers from September through November 2008 are 67.1, 68.3, and 68.6. The smoothed 10.7-cm radio flux numbers for March through May 2008 are 69.5, 69.6, and 69.7. As with the smoothed sunspot numbers, the smoothed flux numbers will show little improvement until they include the last months of 2008.

The smoothed planetary *A*-index (*Ap*) numbers from March through May 2008 are 7.4, 7.1, and 6.9. The monthly readings from September through November 2008 are 5, 6, and 3. It has been noted that the overall geomagnetic condition has been much quieter during the minimum period between solar Cycles 23 and 24 than the last few prior solar cycle minimums.

The monthly sunspot numbers forecast for February through April 2009 are 18, 21, and 25. That's really great news, as we'll likely see improvement in *F*-layer propagation higher and higher in the radio spectrum. The monthly 10.7-cm radio flux is predicted to be 74, 77, and 79 for the same period. *(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)*

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you.

You are also welcome to share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

By Bob Witte,* KØNR

FM

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

A Look Inside D-STAR Modulation

For the Winter 2006 issue of *CQ VHF,* I provided an overview of D-STAR radio technology. At that time, the technology was just starting to emerge onto the amateur radio scene, and the amateur radio community was just starting to understand how the technology worked. By now there are quite a few D-STAR repeaters on the air, and many radio amateurs have experienced D-STAR communications on the VHF and UHF bands.

As D-STAR enthusiasts have gotten their hands on the hardware, they have been experimenting with the various features. In typical ham fashion, the techies are reverse engineering and tinkering with the ICOM D-STAR equipment and in some cases even creating their own D-STAR designs.

Block Diagram

In this column we'll examine the modulation scheme used in D-STAR, focusing on the signal-processing chain from the microphone to the modulator (figure 1). For digital modulation, we need to get the microphone audio into digital form and properly modulated onto the carrier, similar to analog modulation. In Figure 1, we see that the microphone audio is boosted by an amplifier to a suitable level for driving an *analog-to-digital (A/D) converter.* The A/D converter samples the microphone audio and converts it into a series of digital numbers that represent the microphone waveform. The digitized audio is fed into the *vocoder,* which processes the waveform, still in digital form, to reduce the number of bits per second needed to represent the voice waveform. The vocoder drives the digital modulator circuit, which for D-STAR is a *GMSK (Gaussian Minimum Shift Keying)* modulator (more on that later). At the output of the GMSK modulator, we see the modulated GMSK signal, which drives the RF transmitter chain.

*21060 Capella Drive, Monument, CO 80132
e-mail: <bob@k0nr.com>

GMSK

Before we dive into the topic of GMSK, we first need to review some other forms of digital modulation. One basic form of digital modulation is Frequency Shift Keying, or FSK. Radio amateurs have used FSK for decades, including using it to send radio teletype signals (RTTY) on the HF bands. The concept is simple: When the digital signal is a logical zero one frequency is output, and when the digital signal is a logical one a different frequency is output. The receiver on the other end has a demodulator circuit that detects the two frequencies and outputs the recovered digital signal accordingly.

A special type of FSK that is a little more efficient in terms of bandwidth is called Minimum Shift Keying (MSK). MSK uses a frequency shift that maintains a specific relationship between the frequency of a logical zero and the frequency of a logical one: *The difference between the two frequencies is one half of the bit rate.*

Mathematically, this can be expressed in terms of the *modulation index*:

$$m = \Delta f \times T$$

where:
$\Delta f = |f_1 - f_0|$
T = period of one bit

For MSK, the modulation index is 0.5.

Figure 2 shows this graphically, with a logical one creating a sine wave that just fits into one bit period. In this example, a logical zero has a higher frequency that fits *one-and-a-half cycles* into the bit period. Notice that the phases of the sine waves are controlled to prevent any phase discontinuities. Any discontinuities in the waveform result in a wider signal bandwidth, something that we want to avoid.

Conceptually, MSK can be created by driving an FM modulator with the digital signal, while maintaining a modulation index of 0.5. (The practical circuit implementation is likely to be more complicated than this, but we'll ignore that detail in this article.) The sharp edges of the digital input will tend to create a wide-bandwidth signal, so a shaping filter is often used to round out the waveform. When a *Gaussian filter* is used, the modulation is called *Gaussian Minimum Shift Keying,* or GMSK (figure 3).

Many different modulation formats have been developed for modern digital communications systems, each with their

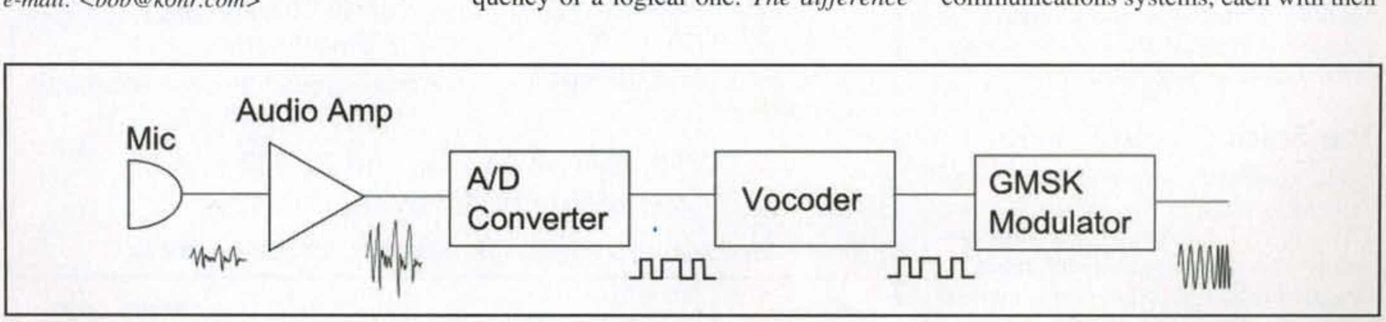


Figure 1. The simplified block diagram of a D-STAR modulation system.

own advantages and disadvantages. GMSK has some attractive properties that make it a good choice for mobile radio, including D-STAR. Compared to other digital modulation schemes, GMSK is relatively simple, resulting in a lower system cost. GMSK signals have constant amplitude, which means that GMSK is insensitive to amplifier nonlinearities. Higher efficiency Class-C amplifiers can be used to boost the signal without degrading the modulation format. (This is not true of some other digital modulation techniques.) GMSK also has good spectral efficiency, which is to say it packs a large chunk of digital information into a small bandwidth. The most common digital cell-phone format in use today (GSM) also uses GMSK.

It turns out that GMSK has quite a bit in common with good old analog FM. Both modulation formats produce a constant-amplitude signal, which makes them less susceptible to amplitude variations, including noise. All of the modulating information exists in the form of frequency/phase, and they both can use Class-C amplification.

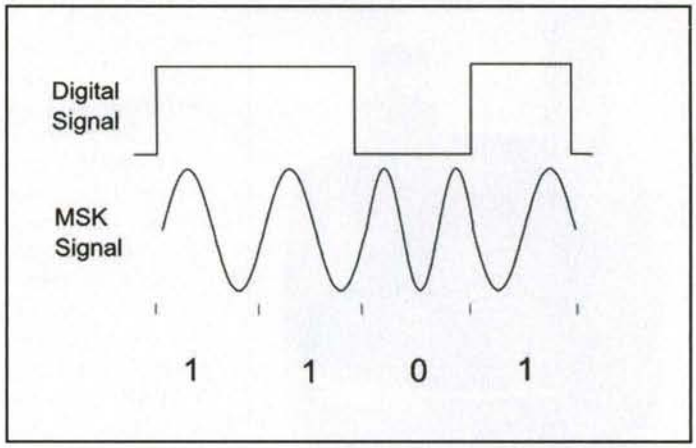


Figure 2. Example waveforms for MSK modulation, with a digital input signal and the resulting MSK signal.

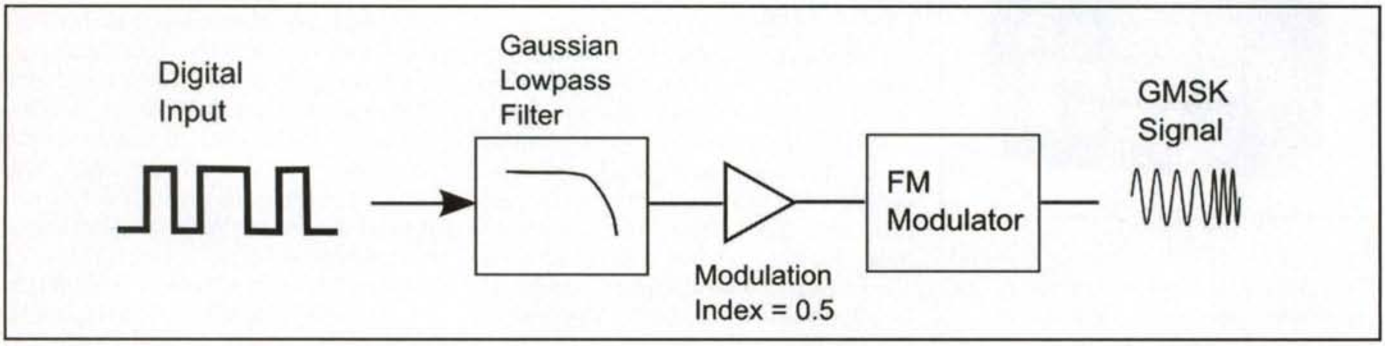


Figure 3. Simplified block diagram of the GMSK modulator.

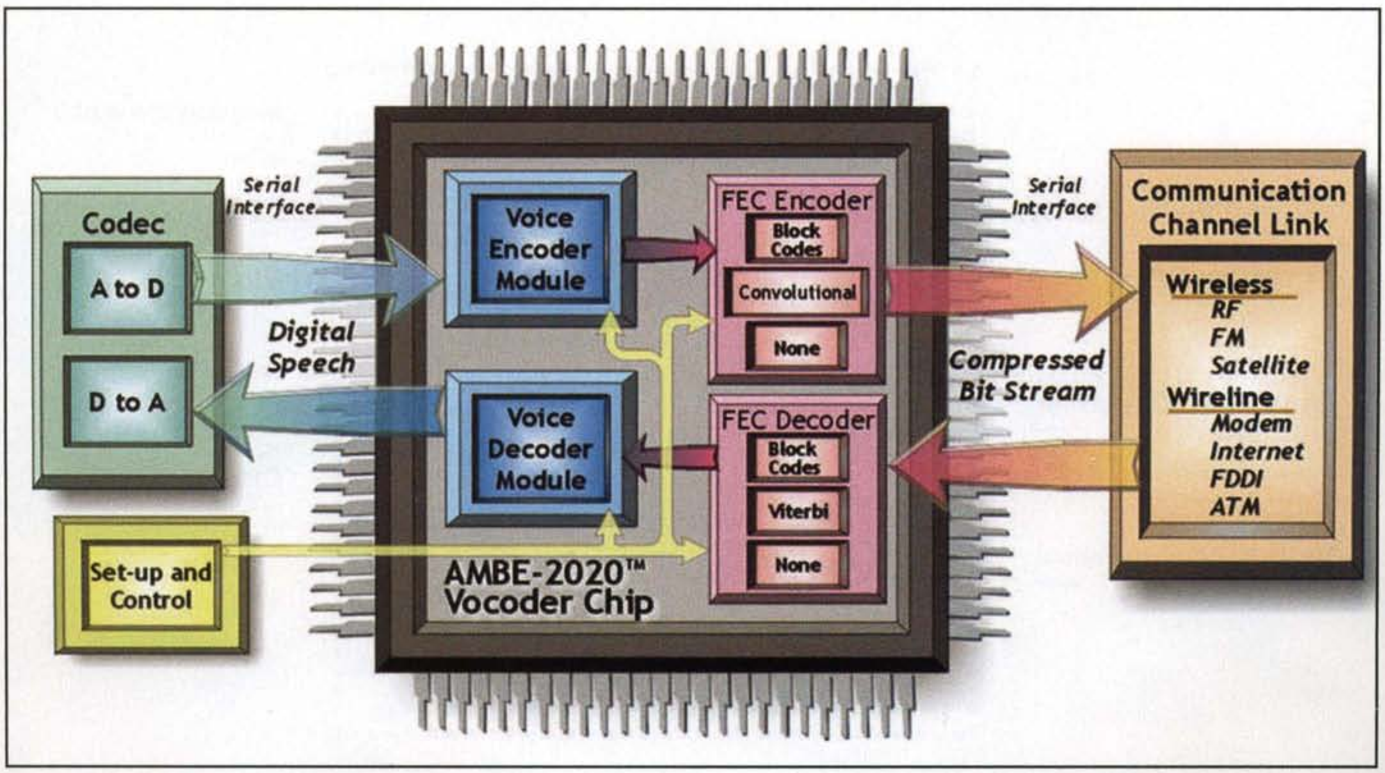


Figure 4. Block diagram of the AMBE-2020™ Vocoder. (Courtesy of DVSI, used with permission)

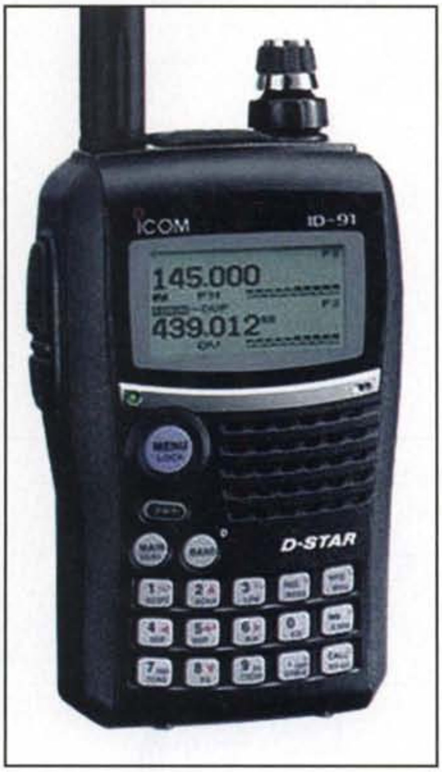


Figure 5. The IC-91AD is a dualband D-STAR handheld transceiver from ICOM. (Photo courtesy of rigpix.com)

One might be tempted to think that GMSK signals could pass through a conventional FM repeater, but in most cases this is unlikely. Conventional repeaters are set up for analog signals, rolling off the low-frequency response as they pass through the repeater, which distorts the D-STAR waveform. Some hams have been successful tweaking the frequency response of their repeater receiver-to-transmitter path for the express purposes of passing D-STAR signals, but your normal FM repeater will mostly likely not pass D-STAR. (The repeater may key up if carrier access is in use.) Just to be clear, D-STAR signals *cannot* be demodulated by conventional FM radios. D-STAR sounds like white noise on an FM receiver.

Vocoder

The previous discussion describes how digital bits get modulated onto the RF signal, but we also need to pay attention to the number of bits per second we feed into the GMSK modulator. This has been one of the major challenges of radio communications using digital modulation—to keep the bit rate low enough to travel down a narrowband channel while still maintaining voice quality. The nominal bandwidth for the DV form of D-STAR is 6 kHz wide and the A/D converter samples at 8 kHz. It is the job of the vocoder to cram 8 kHz worth of samples into this 6-kHz bandwidth. The vocoder takes the digitized analog signal and compresses it into the minimum number of bits required to keep it intelligible.

D-STAR uses the AMBE-2020™ Vocoder from Digital Voice Systems, Inc (DVSI); see figure 4. This vocoder uses a proprietary algorithm (Advanced Multi-Band Excitation, or AMBE®) to convert the 8-kHz sampled audio into a 3600-bps bit stream for D-STAR voice. This stream is combined with the 1200-bps data stream to produce the combined voice + data DV signal at 4800 bps. (We won't go into much detail here about the 1200-bps data stream other than to say that it can support a low-speed data connection simultaneously with the digital voice transmission.) In general, vocoders use the characteristics of human speech to create advanced compression algorithms to produce an intelligible and recognizable voice signal at the other end of the channel.

Like all vocoders, the AMBE-2020 has a noticeable "digital" sound to it, similar

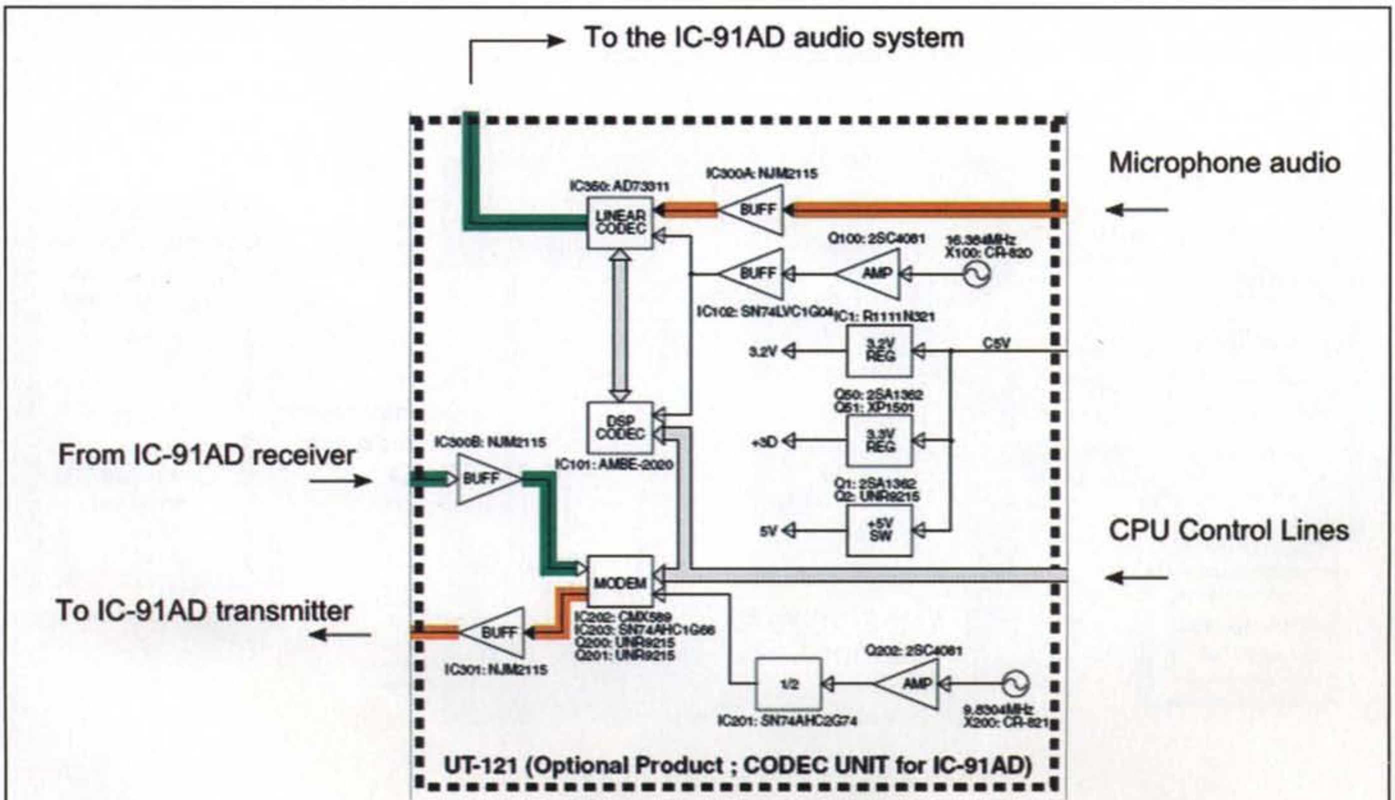


Figure 6. Block diagram of the UT-121, the D-STAR board used in the ICOM IC-91AD. (Copyright ICOM, used with permission)

References

"D-STAR Digital Voice for VHF/UHF," *CQ VHF*, Bob Witte KØNR, Winter 2006.

Wireless Communications–Principles and Practice, 2nd Edition, Theodore S. Rappaport, Prentice Hall, 2002.

"Digital Modulation in Communications Systems–An Introduction, Application" Note 1298, Agilent Technologies, 2001. <http://cp.literature.agilent.com/litweb/pdf/5965-7160E.pdf>.

"Practical GMSK Data Transmission," Fred Kostedt and James C. Kemerling, <http://www.sss-mag.com/pdf/gmsk_tut.pdf>.

AMBE-2020™ Vocoder Chip User's Manual, Version 4.92, Digital Voice Systems, Inc., Copyright 2006. <http://www.dvsinc.com/manuals/AMBE-2020_manual.pdf>

The Utah VHF Society D-STAR web page: <http://utahvhfs.org/dstar.html>.

AD73311: Low Cost, Low Power CMOS General Purpose Analog Front End, Analog Devices data sheet, 2000. <http://www.analog.com/static/imported-files/data_sheets/AD73311.pdf>.

CMX589A High-Speed GMSK Modem, MX-COM Inc. Data Sheet, 1998.

Dstar_digital Yahoo Group: <http://groups.yahoo.com/group/dstar_digital/>.

to a typical digital mobile phone. To my ear, the sound quality is plenty good enough, although I agree that it doesn't sound quite as good as analog FM. These are *not* high-fidelity coding systems and are not very effective at handling anything but speech signals. Vocoders usually include special modes for capturing common signaling tones such as DTMF signals. The Utah VHF Society recently published some test results from transmitting non-voice signals over D-STAR, in an attempt to educate the amateur radio community about the characteristics of vocoders. (See the Utah VHF Society website listed in the References box.)

The AMBE-2020 implements *Forward Error Correction (FEC)*, which inserts redundant bits into the data stream so that errors introduced in the channel can be corrected. This is a common technique used in digital communications that allows the communication system to tolerate and correct low levels of errors in the digital transmission. Low levels of Bit Error Rate (BER) can cause a slight twang in the vocoder algorithm, but as the Bit Error Rate (BER) increases, the FEC will struggle to compensate, eventually falling apart. This gives us the experience of "going digital" when the audio breaks into a wacky, digitally-distorted noise.

Some hams have criticized the use of a proprietary vocoder in an amateur radio system. They argue that the spirit of amateur radio is experimentation and the choice of this vocoder gets in the way of that objective. For example, it would be really useful to implement the AMBE algorithm in software so that it can be deployed on a PC. Since the algorithm is protected by DVSI patents, the only legal choice is to buy the chip from DVSI. Some people have claimed that the chip is unaffordable, but they are available for approximately $20 each, a reasonable price for an IC of this complexity.

Typical D-STAR Design

Let's take a look a typical D-STAR design, the ICOM UT-121, which is the D-STAR board used in the IC-91AD (figure 5). (This board is also the option that adds D-STAR to the IC-91A transceiver.) The block diagram of the UT-121 is shown in figure 6. At the top of the diagram, we have the Analog Devices AD73311, labeled "Linear Codec," which is a general-purpose mixed-signal interface circuit. It contains the A/D converter used to digitize the microphone audio, and the D/A converter for converting the received bits back into analog form to drive the speaker. Our discussion of figure 1 was about the transmitter path only, but there is an equivalent signal-processing chain that operates in the opposite direction—decoding the GMSK signal and extracting the original transmitted analog voice signal. The UT-121 has both of these signal-processing chains, with the major chips supplying functionality for both transmit and receive.

Near the left center of the diagram we see the "DSP Codec," which is the AMBE-2020 vocoder. The digitized audio from the AD73311 is fed to the vocoder to be digitally compressed and passed along to the GMSK modem chip below. The AMBE-2020 also decompresses the received bit stream and passes it along to the AD73311 to be converted back to analog form. The GMSK modem chip, the CMX589, is labeled "Modem" in figure 6. This chip provides the GMSK transmit modulation and receive demodulation functions and interfaces to the RF sections of the transceiver. The other circuits shown in figure 6 are system clocks and power supplies required to support the ICs on the D-STAR board.

Summary

This article provides a basic look at the modulation scheme used by D-STAR and the key circuits that make it work. My thanks goes to the many hams who are experimenting with the D-STAR mode and sharing their knowledge. One gathering point for these hams is the dstar_digital Yahoo! Group.

Thanks for taking the time to read another one of my columns on the *Utility Mode*. I always enjoy hearing from readers, so stop by my blog at <http://www.k0nr.com/blog> or send me an e-mail.

73, Bob KØNR

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

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

An Exciting Time in Amateur Radio
The Basics of 2 meters and the FM Mode

Welcome to the new "Beginner's Guide" column in *CQ VHF*. My name is Rich Arland, callsign K7SZ, and I have been playing this ham radio game for over 45 years. However, that doesn't mean I know everything! As a matter of fact, there isn't a day that goes by when I don't learn something new about radio, the hobby, and/or computers and IT technology.

What an exciting time to be a radio amateur! Technology is growing exponentially and our hobby is changing daily. The days of stringing up an end-fed wire and working CW contacts has been enhanced by the technological explosion associated with our hobby. Don't get me wrong, as I have had (and continue to have) a lot of fun on the HF bands using QRP (less than 5 watts output power) and simple antennas to work some fantastic DX. However, there is real excitement on the VHF/UHF bands and the associated "magic black boxes" that have opened a vast new world of communications that could only have been dreamed about a brief 10–15 years ago. Back in the late 1960s and early '70s, how many of us could have envisioned *Star Trek* type "communicators" that look very much like our present-day cell phones? Ditto with our PCs and wireless networks that literally are everywhere! Technology is the name of the game in today's radio hobby.

Technology can be formidable and quite intimidating, especially for a newcomer to our hobby. It can also be quite a challenge for us old timers, who grew up on vacuum-tube theory and power supplies that could kill you! My job, as editor of this column, is to help radio amateurs who are just starting out in the hobby or transitioning from HF to the VHF/UHF bands better understand the current trends and technologies that make the VHF+ arena such a great place to be.

*25 Amherst Ave., Wilkes Barre, PA 18702
e-mail: <k7sz@arrl.net>*

Above all, this is *your* column. I welcome input on the content and direction of the column from you, the reader. My e-mail address is <k7sz@arrl.net>, so feel free to write to me and let me know what you want me to cover in future issues of *CQ VHF*.

On a personal note, I am all for taking the least expensive road to meet a particular communications task. That means buying used gear, scrounging parts (along with "dead" gear) for simple (and sometimes complex) homebrew projects for the shack. This includes recycling old TV antennas, computer equipment, and even TV antenna rotors! Not only does this tack save you money (and with the current state of our economy that is a very attractive idea), but it gets you, the newcomer to VHF+, to take a proactive part in your pursuit of the hobby. After all, ham radio is a technical hobby, so don't be afraid to become fully immersed in building accessory projects for your station. The QRP crowd that I still hang out with is positively overcrowded with avid homebrewers, proving that the art and science of "rolling your own" gear is not a lost art! The same can be said of the VHF+ operators. As a matter of fact, it seems that the higher in frequency you go, the more you encounter a whole group of homebrew aficionados. Don't worry if you can't tell the difference between the ends of a soldering iron. We'll address that, too, in this column!

With the FCC's doing away with the CW requirement for obtaining a ham ticket, the pathway to ham radio has become much easier over the last several years. While I do not agree with those who believe that CW is an archaic method of communications, I do respect their opinion. In reality, using CW is an art in itself, and while not necessary to obtain a license, it is a good thing to master, since there are times when voice and data modes are not reliable, but CW will still get the message through.

The influx of new Technician class license holders to the VHF/UHF spectrum has been astounding. New FM repeaters are popping up all over. The "challenge" to becoming operational on the 2-meter FM band is directly related to the size of your bank account. A 2-meter handheld costs about $125 and allows the user to access simplex and local repeater channels with very little outlay of cash and virtually no commitment to external antennas, feedlines, etc. On the other end of the spectrum is the serious VHF/UHF DXer/contester who has a ton of money invested in top-of-the-line transceivers, mast-mounted receiver preamplifiers, high-power RF linear amplifiers, hardline coaxial transmission line, tall towers, and stacked arrays of antennas. You and I are most likely somewhere in the middle of these two extremes.

Often we tend to trivialize 2-meter FM operations. My first exposure to 2-meter FM was during college in the late 1960s. I picked up a converted Motorola "luggable" transceiver that, with a full set of batteries, weighed in at around 15 pounds! It was a single-channel radio set *but it was a Motorola!* The thing ate batteries like mad—two 45-volt B+ batteries plus several D cells for filaments and bias supply. All in all, it was an "adventure" to lug around that old Motorola. My mobile rig at that time was a converted RCA dual-channel commercial FM set that came out of service on the local taxi company frequencies. Today, when I look at my little Yaesu VX-150 2-meter synthesized HT, I fondly think back to my early days in FM. We have come a long way, that's for sure.

It took quite a few years for 2-meter FM to become popular. Autopatch repeaters became fashionable during the mid-1970s, and making telephone calls via the repeater from your mobile was ultra-cool! Today, 2-meter FM operations are the backbone of ham radio, especially in the ARES (Amateur Radio

Emergency Service) and RACES (Radio Amateur Civil Emergency Service) arenas. The fact that hams can provide mobile/portable communications to aid in the mitigation of natural and/or man-made disasters is something we all can take pride in. Without 2-meter FM, that facet of our hobby would be hard-pressed to provide top-notch emergency communications for the Red Cross, the Salvation Army, and local and regional EOCs (Emergency Operations Centers), not to mention the Department of Homeland Security.

CQ VHF has a long history of providing coverage in the radio hobby press of VHF FM communications with a special emphasis on EmComm (emergency communications). Since this is a beginners' column, let's begin with the ham radio version of the old country "Party Line" from the early days of the telephone.

Two-meter FM literally is found in almost every ham shack on the planet. If you want to get an idea of the proliferation of VHF/UHF repeaters that are active in the U.S. and Canada, procure a copy of the ARRL's "Travel Plus for Repeaters" and compile a list of active repeaters within a 50-mile radius of your home. It is staggering . . . down right frightening at times! Many of these "machines" have backup power along with extensive features geared specifically toward the EmComm mission. APRS (Automatic Position Reporting System) repeaters have blossomed all over the country, allowing hams running APRS software to keep tabs on stations as they move across the country and in outer space! Yup, the ISS (International Space Station) has been tracked by terrestrial APRS stations in real time.

D-Star, the newest digital FM radio system to come from Japan, offers EmComm operators the advantage of a digital radio system for passing emergency traffic and data that would be laborious using standard analog FM systems.

Those areas of the country that suffer recurring large-scale disasters, such as the floods in the Midwest and the California wild fires each year, have extremely active ARES/RACES groups. If you are interested, and I hope you are, contact the ARRL, 225 Main Street, Newington, CT 06111, for information about ARES/RACES EmComm support groups in your particular area.

Recently, my wife Patricia, KB3MCT, and I relocated from northeastern Pennsylvania to Dacula, Georgia, in Gwinnett County. Both of us were active in the Luzerne County ARES group in our former area, and when we arrived in Dacula, we immediately set out to find the local EmComm group and volunteer our services. It turns out that the local 2-meter repeater, 147.075 (+600 kHz, PL: 82.5 Hz) is the place to be on Monday evenings. The Gwinnett Amateur Radio Society has a club net at 2000 hours local time followed by an ARES net at 2100 hours local. The thing that immediately struck both of us was the total professionalism displayed by the net control stations, or NCS (they use two, one the primary NCS and a backup NCS for training purposes), and the people checking into both of these nets. Later I found out that the Gwinnett ARES group is the largest in the state and has an extensive training program for aspiring emergency communicators *before* they can be deployed in support of a local served agency during an emergency. In a word, the Gwinnett ARES group takes EmComm very seriously!

Gwinnett County has been divided into several sections, with Gwinnett ARES members assigned to one of these sections. In the event of a real-world emergency or disaster, this method assures that the right, properly trained people are in place at the right time and in the proper location to be of maximum usefulness to the professional disaster response teams. There are even two specialized teams, one that deploys to the Gwinnett County EOC and one that handles the mobile ARES comm facilities.

Trivialize 2-meter FM ops all you want, but this type of emergency readiness is something to be proud of. Historically this group of EmComm operators has an outstanding professional relationship with their served agencies and has become an integral part of the Gwinnett County disaster mitigation plans.

OK, so what have we learned so far? First, the exposure that the majority of new radio amateurs have to VHF+ is relegated to 2-meter FM operations. This band and the associated equipment to become operational are well within the confines of the most frugal of budgets. New 2-meter FM gear costs around $125 upwards, depending upon power and features of the radio gear. Antennas are manageable and, in a pinch, a 2-meter groundplane antenna can be made from coat hangers (talk about dirt cheap!).

Two meters is the modern-day version of the old-style party-line telephone. Many non-hams have the local simplex and repeater frequencies plugged into their scanner receivers, so understand that what you say on 2 meters FM has an enormous audience.

The fact that 2 meters is so vastly populated by radio amateurs and the frequencies are similar (propagation wise) to EMS/fire/police frequencies makes 2 meters FM *the* band for ham radio emergency communications. Additionally, part of your licensing requirements dictate that you are supposed to provide emergency communications when and where needed. Therefore, becoming properly trained in net operations and EmComm procedures is paramount to becoming active with a local ARES/RACES group. Here again, the ARRL has stepped in and offers on-line emergency communications certification, so there is no reason not to be trained and participate when needed. Check the website <www.arrl.org> and follow the links to the League's EmComm courses.

Setting aside the EmComm aspect of 2-meter FM operations for a moment, let's explore one of the more amazing things you can engage in on 2 meters. Did you realize that you can contact the International Space Station or work 2-meter FM DX via AMSAT-OSCAR 51, a LEO (low Earth orbit) amateur radio satellite, using nothing more complicated than a dual-band VHF/UHF handheld radio along with a manually pointed Yagi antenna? Literally, for well under $300 you can assemble a very simple VHF/ UHF dual-band SatCom (satellite communications) Earth station! You can even do it much cheaper than that if you can scrounge or buy a used VHF/UHF HT and make the antenna yourself! That should hammer home the idea that 2 meters FM isn't just for ragchewing anymore!

OK, gang that wraps it up for this installment. I hope that you newcomers to the VHF+ arena are ready to get intimately familiar with this aspect of the radio hobby. We barely covered the basics of the 2-meter band and the FM mode of communications. In addition to FM, there is VHF/UHF weak-signal work and satellite communications using SSB/CW, and digital modes using FSK. Then there is the digital radio explosion, APRS (Automatic Position Reporting System), and a whole host of other ingenious operating modes to explore. So tighten your seat belt, 'cuz we're gonna have some fun!

73, Rich, K7SZ

By Miguel Enriquez, KD7RPP

ATV

Amateur Television for Fun and Education

ATV Gives Impetus To New Math/Science Curriculum

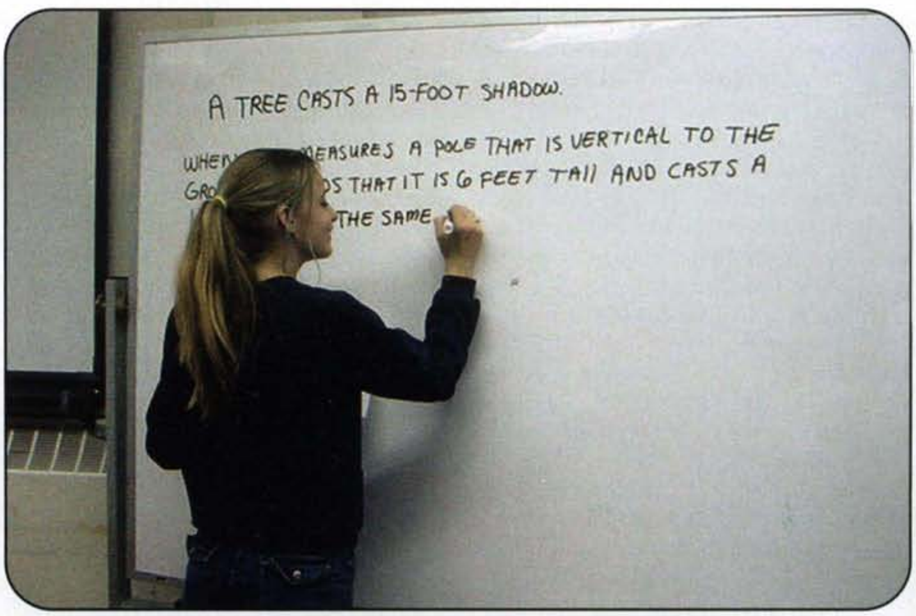
The successes that the Pueblo Amateur Radio and Underwater Robotics Club have had in past two years using ATV in the classroom provided some recent interesting developments for the way we teach math here at Pueblo Magnet High School in Tucson, Arizona. I had been approached earlier in the school year by Tucson Unified School Administrators who wanted to explore the possibility of designing a curriculum that would employ ham radio and other wireless technologies to teach math and science. What the administrators had in mind when they first proposed this new venture was extending to the general population the fun and advancements in math test scores the Pueblo ARC students were experiencing.

My initial reaction to their request was "I'm not sure how that would work." However, as I thought about the possibilities, I realized that their request was not one of adding electronics to the existing math and science curriculum, but rather the request was for the creation of an entirely new curriculum. My first thought was to run to the internet to see if such a curriculum with specific references to state standards existed. There was none.

My second thought was to unashamedly copy someone else's model; I found none. The best I came up with was a curriculum Mark Spencer, WA8SME, ARRL Education and Technology Coordinator, had written. That was very useful to me but lacked references to state standards. I next looked to see if anyone was making headway with the melding of ham radio with state standards. I had recently received an e-mail from a fellow ARRL Education and Technology

*c/o Pueblo Magnet High School Amateur Radio Club, 3500 S. 12th Ave., Tucson, AZ 85713
e-mail: <enriquezma@cox.net>

Edith, Sara, and José Velasco review ham-radio/math-lesson presentation material prior to videotaping.



Edith spell checks her math problem on the whiteboard before instructing how to easily compute the height of an antenna using shadows.

Program Instructor, Nathan McCray, (K9CPO, in which he reported success with a proposal he had made to his own school district for the use of ham radio in the classroom. Nathan, an assistant principal with the Vion School District #6 in Wisconsin, had painstakingly juxtaposed amateur radio activities to Wisconsin State Standards in such a way that it made sense to a member of his school board.

I then set about copying as much of Nathan's proposal as was relevant to Arizona State Standards. The going was easier than I believed it would be. My initial presentation to the TUSD administrators who had first contacted me was met with "This is good. This we can do." For the following six weeks I used every spare moment I could find refining that curriculum proposal.

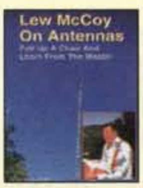
The upshot was that the one class I had been asked to teach on a trial basis has now become a full-time job for me this year. The good news is that the school will now support our ham radio and ATV activities with resources and support from technology education funding sources, where before we relied solely on donations to the Pueblo ARC for operating expenses. The good news is that we are now also planning to offer a ham radio course during summer school this year for students coming to Pueblo Magnet High School in August 2009.

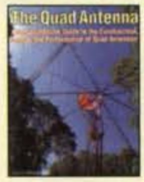
And the best news is that we will have a laboratory setting, of sorts, this year where we can demonstrate to the general public what we hams have known for over a hundred years—that ham radio is not only fun and practical and relevant, but that it can be used to help our students perform better in school by making their education more relevant and practical.

A lot of work still remains to be done, and I have until August of 2009 to fine-tune the new ham radio and wireless technologies curriculum before we start using it. However, in the meantime we will continue having fun with ham radio while adding more ATV activities to our daily classroom lesson delivery.

What I failed to mention earlier was that the reason I was approached in the first place to write such a curriculum was because the local community in TUSD is aware of the exciting activities our ATV station is providing for our students and had noted the significant improvements those students are demonstrating.

73, Miguel, KD7RPP





By Mark Thompson, WB9QZB

DIGITAL RADIO

Digital Technology on VHF, UHF, and Microwaves

Hosting a Digital Conference

Those of you who read *CQ VHF* Editor Joe Lynch, N6CL's "Line of Sight" editorial will have noticed in the Fall 2008 issue that Joe covered the ARRL/TAPR DCC (Digital Communications Conference) in Chicago. I was the local co-host of the 2008 DCC in Chicago along with Kermit Carlson, W9XA. In this issue I will discuss planning and organizing a digital conference.

History

In the mid-1980s I became involved and active in packet radio. Packet radio grew dramatically from the mid-1980s through the mid-1990s. In many areas local packet clubs were established. In the Chicago area CAPRA (Chicago Area Packet Radio Association) was established to educate hams about packet and build backbone links. CAPRA grew quite quickly, like packet radio, and had monthly meetings.

Because packet was a new technology, many hams were very interested in learning about it. CAPRA hosted packet forums at local hamfests, and in 1990 CAPRA sponsored a packet radio day on a Sunday in October. We invited Kantronics to present at the event. A CAPRA member, George Dorner, W9ZSJ, was a dean at a local community college and arranged for the club to use an auditorium for the event. We didn't require registration in advance and were astounded when 200 hams participated in the event. In 1992 and 1994 we hosted the event again in conjunction with Kantronics.

The first TAPR annual meeting was held in 1995 in St. Louis. In 1996 TAPR and the ARRL jointly organized the first annual DCC in Seattle.

In 1997 we submitted a proposal to TAPR to host the 1998 DCC. While we had never hosted a national event before, we did have some experience with hosting the well-attended Kantronics packet days a few years earlier. Carl Bergstedt, K9VXW, and I were the local co-hosts.

The first task was to find a hotel at which to hold the DCC. We worked with TAPR to determine the hotel requirements for a DCC. One critical objective was to keep the hotel cost affordable for both the TAPR organization and the attendees. The annual W9DXCC DX conference held their event at a Holiday Inn in northwest suburban Chicago. We visited the hotel and met with its conference representative. The hotel seemed to meet TAPR's requirements and we recommended the hotel to TAPR.

At that point, TAPR took responsibility for negotiating the contract with the hotel. As local co-hosts, we worked with TAPR to assist in logistics. The DCC was well attended, with the the ARRL, FCC, and major manufacturers present. In fact, Kenwood debuted its first prototype of a packet/APRS HT at the second annual APRS national symposium at the DCC. The agenda and presentation audio of the 1998 DCC are available at <http://www.tapr.org/conf_dcc1998.html>.

After the 1998 DCC conference, packet radio and packet clubs in most areas began to decline. However, new digital technologies such as PSK31 were developed and introduced at subsequent DCCs.

In early 2007 we decided it was time to bring the DCC back to Chicago. Although the local CAPRA club was no longer active, Kermit Carlson, W9XA, agreed to be a local co-host with me. We submitted a proposal to TAPR to host a future DCC, and the TAPR board decided we could host the 2008 DCC. We reviewed with TAPR the 2006 and 2007 DCCs to better understand their requirements.

Kermit had experience with the local W9DXCC DX conference. A few years earlier, W9DXCC had moved to a different Holiday Inn a few miles closer to O'Hare Airport, and this included a free airport shuttle. I visited the hotel and met with the conference representative. It was obvious the hotel met TAPR's requirements for a DCC, including the cost objectives. I connected TAPR Vice President Steve Bible, N7HPR, with the hotel to negotiate the contract.

At previous DCCs the local host typically handed off the remainder of the planning and organizing to TAPR. However, Kermit and I decided we wanted to make this DCC one of the best ever. Therefore, we took a more active role in terms of promotion, local logistics, and planning the technical and introductory sessions. Kermit's participation in the W9DXCC conference included arranging the audio-visual equipment. Ron Steinberg, K9IKZ, owns an A/V business and annually deploys an outstanding array of A/V equipment at the W9DXCC conference.

The DCC was scheduled after W9DXCC in order to not conflict with it or any local hamfest. Kermit worked with Ron to store the A/V equipment at the hotel after W9DXCC and redeploy it at the DCC the following weekend. Not only did his save both the W9DXCC and the DCC conferences money, but it provided the DCC with a level of professional A/V equipment not used at previous DCCs. Kermit and Ron's execution of the A/V equipment was flawless, and both the TAPR Board of Directors and attendees agreed it was the best ever A/V presentation at a DCC.

I worked to promote the DCC both nationally and locally. We actively solicited hams to submit papers for inclusion in the conference *Proceedings* and to present them at the DCC. A number of firsts occurred at the 2008 DCC: The new mode WINMOR was debuted, and the first D-STAR Friday Night Get Together was held. Some of the most significant innovators in D-STAR technology presented at the DCC and the Friday night event. Prior to the DCC, Kermit and TAPR President Dave Toth, VE3GYQ, configured the D-STAR repeater equipment donated by ICOM and got the internet gateway up and running so hams in the hotel could make worldwide D-STAR contacts.

I believe that it is important for hams of all levels of digital experience to attend

*P.O. Box 457, Palatine, IL 60078
e-mail: <wb9qzb@yahoo.com>

the DCC. Therefore, we scheduled a separate introductory track on Saturday with several presentations covering HF Digital Voice, D-STAR, and HF Digital Data Modes.

Both ICOM and Kenwood, as well as other participants, demonstrated their digital equipment at the DCC. Joe Lynch, N6CL, provided every attendee with a copy of *CQ VHF* magazine, and ICOM provided an IC-91AD FM/D-STAR HT as a prize at the Saturday night banquet.

We invited Hap Holly, KC9RP, of the RAIN Report to attend the DCC. He interviewed many of the presenters for his weekly RAIN Report. You can hear these interviews over the course of the year at <http://www.therainreport.com>.

We invited Gary Pearce, KN4AQ, of Amateur Radio Video News to record the DCC sessions. Gary recorded nearly every session and is editing them into a set of DVDs for release in early 2009. You can learn more about Amateur Radio Video News at <http://www.arvideonews.com>.

We are exploring streaming the DCC to the internet. Because there is a registration fee for those who attend the DCC, there also would be a fee for the online registrants. However, it would allow those who cannot travel to the DCC to be able to see a DCC in real time. Even so, it should be stressed that one of the major benefits of the DCC is to actually attend and talk with other attendees.

Typically, every year the DCC moves to a new location approximately from the eastern part of the country to the Midwest to the West Coast. The TAPR Board of Directors decided to do another first and return the DCC to Chicago in 2009. This will make the planning of the DCC significantly easier and let us focus on promoting the DCC and soliciting papers and presentations to make it an even better DCC this year.

I encourage everyone who has an interest in digital voice and data communications to attend the DCC. If you have experience using digital technology or innovating new digital ideas, please consider submitting a paper to be included in the *Proceedings* and perhaps present your paper at the DCC. You can learn more about the 2009 DCC at <http://www.tapr.org/dcc.html>.

I look forward to seeing many of you at the Dayton Hamvention® in May and also at the DCC in Chicago in September.

73, Mark, WB9QZB

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

The 2008 AMSAT Space Symposium and Annual Meeting

In my last column I mentioned the 2008 AMSAT Space Symposium in Atlanta, Georgia. It occurred too late to make the last column deadline. Also, I nearly missed it this year due to a travel commitment with members of my church, but I managed to get there for the Saturday afternoon and evening sessions plus Sunday morning's Field Ops Breakfast and other activities.

I usually attend the Board of Directors Meeting, but it was held before the symposium while I was still traveling with the church group. A new slate of officers was elected by the BOD, led by a new President, Barry Baines, WD4ASW. Barry is a long-time BOD member and has served in various capacities over the years. In my opinion, he is an excellent choice for the times. These are trying times for AMSAT with a turnover in engineering personnel, another re-location of the laboratory coming up, increasing pressure for a High Earth Orbit (HEO) satellite, and no affordable launch opportunities. Barry is forming teams to tackle these challenges and the effort is well under way.

I arrived as Frank Bauer, KA3HDO, AMSAT V.P. for Human Spaceflight and ARISS International Chairman was giving his presentation on ARISS (Amateur Radio on the International Space Station). This has been a good year for ARISS, with school contacts approaching the 400 mark since launch in 1998. Work is progressing satisfactorily on SuitSat II and other projects.

The Saturday banquet speaker was Dan Shultz, N8FGV. Dan has worked for many years on the Hubble Telescope and gave an absolutely fascinating account of Hubble's history and preparations for the Hubble repair mission next year. Dan's dry humor and knowledge kept the audience's attention riveted on the topic and even kept me awake while I was suffering from a severe case of jet lag.

The annual Field Ops Breakfast was chaired by Gould Smith, WA4SXM, AMSAT V.P. of User Services, and was well attended. Gould outlined the progress made in 2008 and the plans for 2009. The AMSAT Field Ops are Area Coordinators who form the "first line" representing AMSAT at hamfests, radio club meetings, AMSAT nets, "Elmering," and other functions. It is always a challenge for field ops to present a positive image to the amateur radio public and others regarding amateur satellites when the average ham thinks that satellites and satellite communications are beyond their comprehension and their pocket book. This is particularly difficult in these times of no affordable High Earth Orbit launches as well as no HEO satellites currently operational.

*3525 Winifred Drive, Fort Worth, TX 76133
e-mail: <w5iu@swbell.net>

AMSAT is always looking for additional Area Coordinators to help in this effort. We still do not have Area Coordinators in several states, and we could use more in some of the larger metropolitan areas. In some areas, we have Area Coordinators on the books who are no longer active. These Area Coordinators need to be replaced. In case you haven't recognized it already, this is a "shameless plea" for help. All that is required to become an Area Coordinator is a love for amateur satellites, a willingness to learn and keep abreast of the topic, and some time to devote to attending and making presentations at amateur radio club meetings, hamfests, etc. Your reward is the satisfaction of a job well done and sharing your favorite avocation with your peers. After all, AMSAT is an "Equal Opportunity Exploiter."

AMSAT History Lessons

AMSAT's 40th Anniversary: The first amateur radio satellite, OSCAR-1, was launched on December 12, 1961, just over four years after Sputnik-1 on October 4, 1957. The Project OSCAR Group in California built and coordinated this launch. By 1969 the needs of the amateur radio satellite community had outgrown this operation, and a group of devoted satellite people in the Washington, DC area formed the Radio Amateur Satellite Corporation, or AMSAT. The year 2009 marks the 40th anniversary of the formation of AMSAT. To celebrate this anniversary, the 2009 AMSAT Space Symposium and Annual Meeting will be held in the Washington, DC and Baltimore, MD area in October 2009. This should be a gala occasion and worthy of your attendance. I attended the AMSAT 30th anniversary event hosted by the same group in 1999 and thoroughly enjoyed it. Please put it on your calendar now! Additional 40th anniversary activities are being planned for the Dayton Hamvention® and other functions in 2009.

At the same time and place, the ARISS broup will be hosting an ARISS Operations "Face-to-Face" meeting. It will be an excellent chance to meet and greet both AMSAT and ARISS people. ARISS Operations people are the worldwide, day-to-day mentors, planners, and coordinators for ARISS. They normally meet at least once a week via teleconference and are in constant touch by e-mail. This will be the first "Face-to-Face" meeting of this group.

25th Anniversary of Amateur Radio Human Spaceflight: In 1983, Owen Garroitt, W5LFL, flew on the Space Shuttle Columbia during mission STS-9 and carried amateur radio equipment with him. He made many contacts on this mission, including one with King Hussein of Jordan, JY1. I was one of the eager participants in this operation and planned

"The year 2008 was historic for AMSAT and ARISS. The year 2009 will be even bigger. Take part in the planned activities and plan to make 2009 the year you become active on the "birds" or increase your activity if you have not been very involved."

to make a contact as well. One of the local television stations covered the attempt from my ham shack. Only the "big guns" in the U.S. were successful. We learned first hand about the FM "capture effect" on this mission, but everyone had fun anyway. This was the start of 25 years of successful manned spaceflight operations on board the Space Shuttle, MIR, and ISS.

Just 25 years later, Owen's son Richard Garriott, W5KWQ, flew on the ISS to celebrate this occasion. His ten days in space created a memorable event in late October 2008. He made several hundred voice QSOs, a number of school contacts, several special event contacts, and sent down a number of SSTV pictures.

Richard's flight started the 25th anniversary celebration that was being carried on throughout the end of 2008 and into January 2009. Special modes and operations were being exercised on the ISS to commemorate this event and initial reaction has been very positive as of this writing.

If you made any kind of contact with the ISS during this event, details of how to apply for special certificates can be found at <http://www.ariss.org>.

Ten Years of Operation on the ISS: As mentioned above, the first elements of the ISS were launched in 1998, and 10 years later it is nearly complete. During this time nearly 400 school contacts have been made between students and the astronauts. The 400th contact is scheduled to occur in January 2009. In addition to the school contacts, several of the astronauts have taken a special interest in making many hams happy with a space contact, and contacts have been made on all continents, all states, and over 130 DXCC countries. The ISS has also been used as a digipeater, a cross-band voice repeater, a launch platform for other satellites (PCSAT, SuitSat, etc.), and will be used even more in the future. Starting in 2009 the crew will be increased from the current three to a full complement of six. The additional crew members will have a definite impact on amateur radio operation. This will present a challenge to the scheduling of operations.

Summary

The year 2008 was historic for AMSAT and ARISS. The year 2009 will be even bigger. Take part in the planned activities and plan to make 2009 the year you become active on the "birds" or increase your activity if you have not been very involved.

Don't forget to support AMSAT in its education and fundraising efforts so that we can continue to put more "birds" on the air. In particular, support Phase IIIE, Eagle, and the Intelsat Phase IV Ride Share projects so that we can get back into the HEO satellite business.

'Til next time!

73, Keith, W5IU

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Tracking Beacon

No matter how many APRS trackers you may have on a balloon flight, there is always a chance that they all will fail. In that event, it's a good idea to have some backup. In those situations a low-cost, low-power transmitter can really save the day. This circuit also makes a great hidden-transmitter foxhunt device.

One of my favorite gadget supply houses on the internet is called SparkFun Electronics (www.sparkfun.com). Almost everything needed to build this tracking transmitter can be found on this website. The transmitter module we will be using is an 8-milliwatt transmitter module that operates on 434 MHz and currently costs just $3.95. There are only four leads on the module: Vcc, Ground, Data (the on/off control line), and the antenna output. It's a natural for sending a Morse Code message since you can key it on and off with just one input line that can be controlled by a logic signal from a microcontroller. The module is listed under the "Wireless" section and is called the RF Link Transmitter – 434 MHz, order number WRL-08946. One nice feature of using this module is that it's operating at a license-free power level and can be used as a radio-control (R/C) and model-rocket locator.

*12536 T 77, Findlay, OH 45840
e-mail: <wb8elk@aol.com>

The Arduino Controller

The brain behind the tracking transmitter is based on the Atmel AVR Mega168 microcontroller and is called the Arduino Stamp (SparkFun #DEV-08164). The Arduino is similar in appearance and size to the classic Parallax Basic Stamp but is programmable in the C language. This is a very powerful system and a great way to learn the basics of C programming. The Arduino system puts all the low-level items that make C programming tedious into the background and provides you with loads of high-level routines for performing A-to-D conversions, timing delays, serial communications, and digital I/O with very simple and easy-to-use commands. The best part of the system is that the Arduino development software is totally free (www.arduino.cc).

In addition, no expensive external programmer is needed, since you can program the Arduino Stamp via a serial connection (via the internal bootloader program in the microcontroller). Keep in mind that the Arduino Stamp has logic level serial connections so you will have to use a serial converter IC such as the MAX232 to interface to your computer. However, SparkFun does carry a useful USB module that will connect to the Arduino Stamp with just two serial lines and a common ground. It's called the Arduino Serial USB Board and is SparkFun item #DEV-08165. The Arduino website shows how to hook up the USB converter board to the Arduino Stamp on a prototype board (http://arduino.cc/en/Guide/ArduinoMini). Photo A shows my prototyping setup of the complete tracking transmitter, which includes the USB module to program the circuit. See figure 1 for the tracking beacon schematic.

Tracking Beacon Program

The easiest way to generate Morse Code is via a lookup table based on the

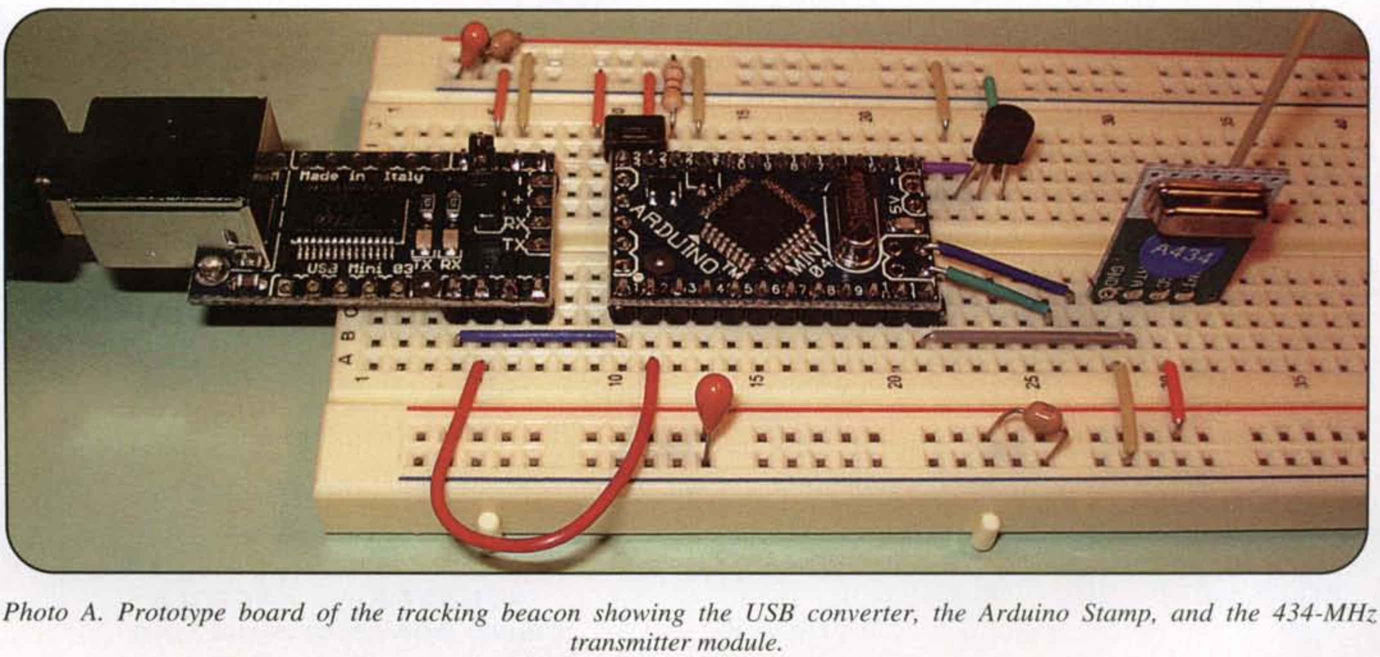


Photo A. Prototype board of the tracking beacon showing the USB converter, the Arduino Stamp, and the 434-MHz transmitter module.

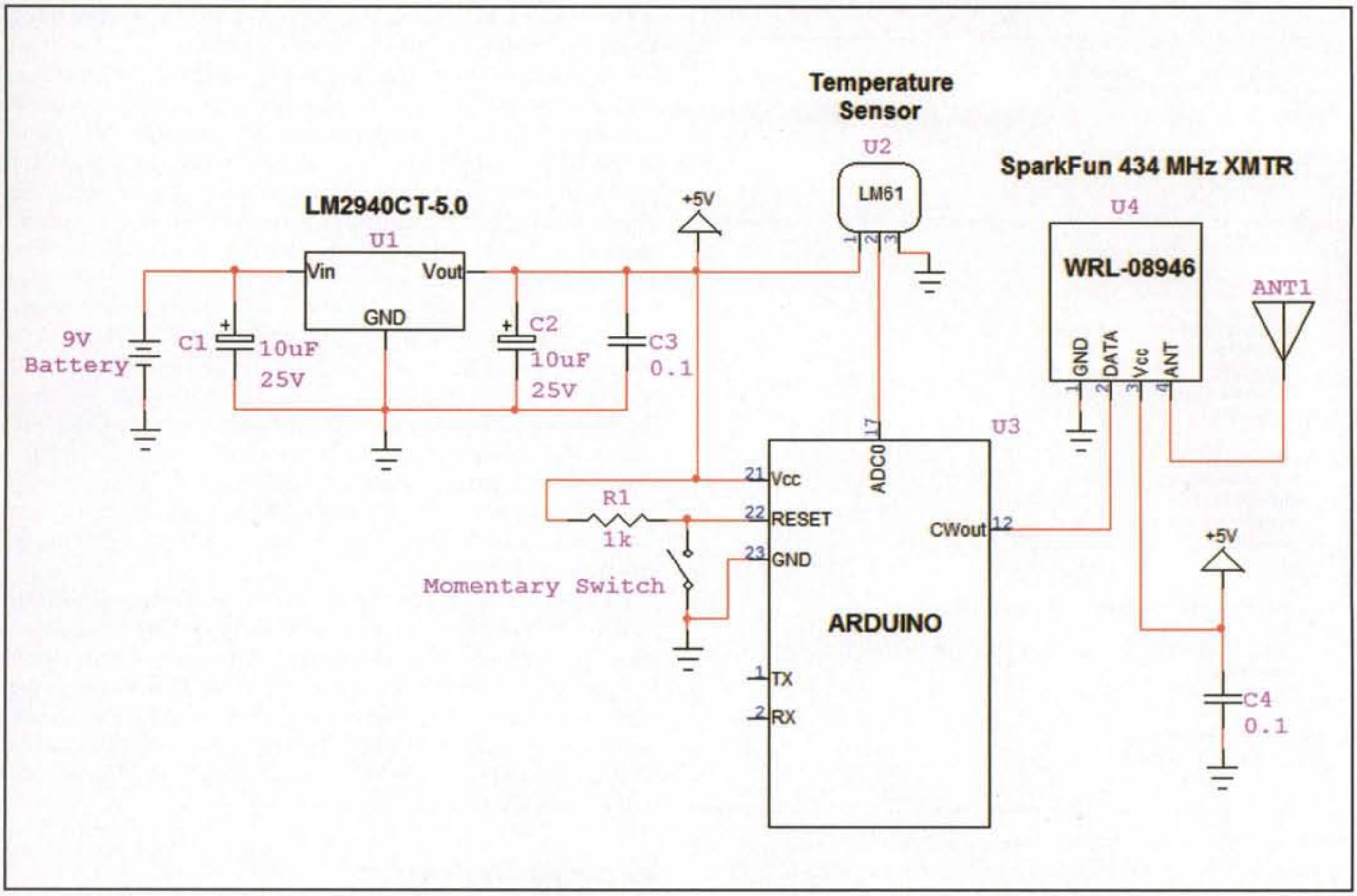


Figure 1. Schematic of the tracking beacon.

ASCII value of the character you want to send. The trick is to enter the data for each character so it can handle a variable length Morse Code output. This is done by entering an 8-bit character so that a 1 is a DIT and a 0 is a DAH. Then you have to append a last 1 bit to be the "end of character" flag. Since we will be shifting out the 8-bit data associated with each Morse Code character to the right, we'll have to enter the Morse Code data from right to left. To send the Morse character, you shift the 8-bit value one bit at a time to the right and check to see if the LSB (least significant bit) is a 1 or a 0 and then send out the appropriate DIT or DAH. For example, the number "2" in Morse Code would be represented as 00100011 (hint: you have to think right to left). When the leftmost one-bit gets shifted right to the least significant bit (LSB), the total 8-bit value now is just 1 and is used as the end-of-character flag and is not transmitted out. Once you get past the mind-warping effect of entering Morse Code data from right to left

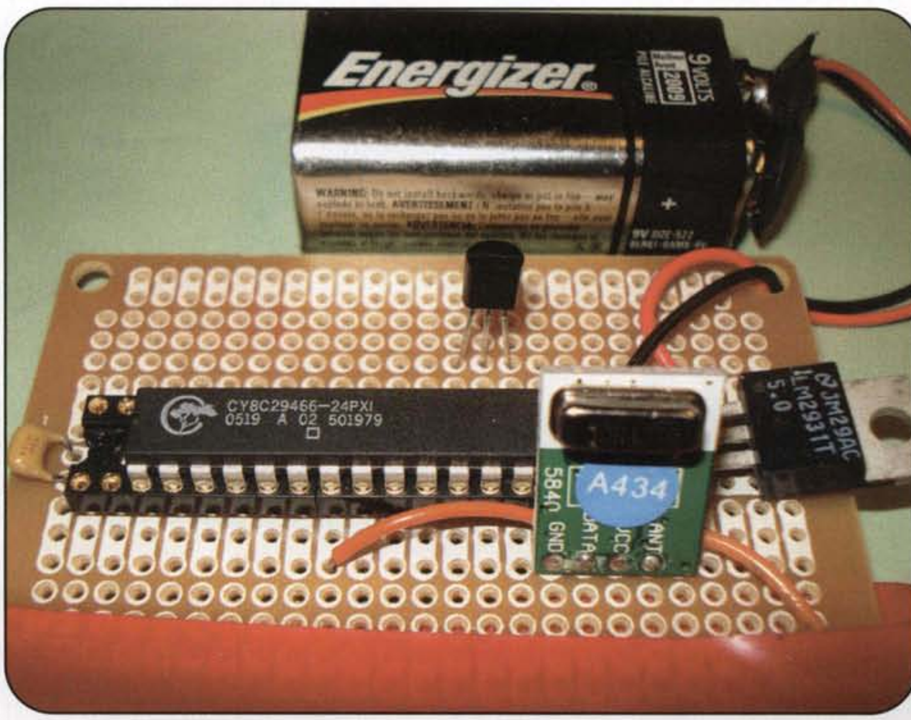


Photo B. Flight-ready version of the tracking beacon.

```
//**************************************
// CW output function  - keyed CW
//**************************************
void sendcw(int cwchar)
{
 morse = morse_table[cwchar-0x20];
while(1){

   if(cwchar == ' '){ // if SPACE character then delay 500 mSec between words
     delay(500);
     return;
   }

   if (morse & 0b00000001){ // compare LSB [ 1=Dit  0=Dah ]
     digitalWrite(cwoutPin, HIGH);
     delay(100); // Dit timing - 100 msec
     digitalWrite(cwoutPin, LOW);
     delay(100);
   }
   else{
     digitalWrite(cwoutPin, HIGH);
     delay(300); // Dah timing - 300 msec
     digitalWrite(cwoutPin, LOW);
     delay(100);
   }

   morse = morse >> 1; // shift right to see if Dit or Dah

  if(morse == 1){ // if the value is 1 then end of CW character
     delay(200);
     return;
   }
 } // End of Morse while loop
} // End of SENDCW routine
```

Figure 2. The C routine to send keyed Morse Code. the full program can be downloaded at <http:/www.wb8elk.com/>.

```
// CW output function - AM modulation version *
void sendcw(int cwchar)
{
 morse = morse_table[cwchar-0x20];
while(1){
   if(cwchar == ' '){ // if SPACE character then delay 500 mSec between words
     delay(500);
     return;
   }
   if (morse & 0b00000001){ // Compare LSB [ 1 = Dit  0 = Dah ]
      for(tone=0;tone<100;tone++){ // Dit timing
          digitalWrite(cwoutPin, HIGH);
          delayMicroseconds(500);
          digitalWrite(cwoutPin, LOW);
          delayMicroseconds(500);
      }
     delay(100);
   }
   else{
      for(tone=0;tone<300;tone++){ // Dah timing
          digitalWrite(cwoutPin, HIGH);
          delayMicroseconds(500);
          digitalWrite(cwoutPin, LOW);
          delayMicroseconds(500);
      }
     delay(100);
   }
   morse = morse >> 1; // shift right to see if Dit or Dah
   if(morse == 1){ // if the value is 1 then end of CW character
     delay(200);
     return;
   }
 } // End of Morse while loop
} // End of SENDCW routine
```

Figure 3. sendcw() routine modification for AM modulation.

in the lookup table, this does give you an easy way of sending variable-length characters without a lot of fuss.

Just change the callsign section to your call or message, load it into your Arduino Stamp, and you're ready to go. It will send your callsign and message along with the A/D value of the LM61 temperature sensor. The entire C program for keyed and AM modulated Morse Code complete with the Morse Lookup table can be downlaoded from the "Projects" section of the following website: <http://www.w8elk.com/>. The sendcw () routine for keyed CW is shown in figure 2.

One thing to consider is that you will have to use a multimode radio capable of CW mode. Also, the 434-MHz module does drift in frequency with temperature. Using insulation will help to control the temperature changes and therefore will slow the frequency drift. Surprisingly, just three layers of small-cell clear bubble-wrap will act as a greenhouse effect and will minimize temperature problems. This technique also helps to keep your tracking beacon lightweight. My last few beacons have weighed in at under three ounces when used with a lithium 9-volt battery.

There is one trick that can be written in software to eliminate the drift problem. You can turn the transmitter module on and off rapidly enough to create an AM modulated audio tone. See figure 3 for the AM modulation code modification for the sendcw() routine. This will allow the use of radios and scanners that can receive AM mode. You may have to slightly retune a bit during the flight, but the audio tone of the Morse Code will remain the same.

Receive System

To receive on the ground, I recommend as a minimum a three-element Yagi (such as the 70-cm Arrow). It also will help to include a 70-cm preamp (I use the Advanced Receiver Research P432VDG; <www.advancedreceiver.com>). Once on the ground, I've been able to hear it out to over a mile or two away (10 miles or more when up in a tree). With the low power output, it's easy to home in on it via signal strength and walk right up to it using direction-finding (DF) techniques. I've had good reception out to over 100 miles downrange during a flight.

Time to Fly

You won't have to fly the USB converter module, so I just use the breadboard prototype to program the Arduino Stamp and then put the Arduino into the IC socket on the tracking transmitter board with attached antenna for flight. (See photo B for an example of the flight transmitter. This version used a PSoC microcontroller, which has a steep learning curve. I use the Arduino Stamp in its place for an easier implementation.) The antenna is just a half-wave wire dipole held in place by a small wooden-dowel rod.

You can download the code for the tracking trasnmitter from the "Projects" sectionof the following website: <http://www.wb8elk.com/>. There you will also find variations for AM modulation, Hellschreiber mode, as well as a number of other tracker circuits that include pressure altitude and GPS encoding with RTTY, Morse Code, and MFSK modes.

73, Bill, WB8ELK

CQ's 6 Meter and Satellite WAZ Awards

(As of January 1, 2009)

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	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	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
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32
84	DF3CB	1,2,12,18,19,32
85	K4PI	17,18,19,21,22,23,24,26,28,29,30,34,37,38,39

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
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

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

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

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

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

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Beckoning Beacons, Part 2

In last quarter's column, we discussed the challenges of calibrating amateur and professional SETI receiving stations (please see box with figures A and B). We concluded that a narrow-band signal from space, such as the S-band telemetry beacon aboard NASA's Pioneer 10 spacecraft, would be ideal for this purpose. Unfortunately, that particular beacon now is not only beyond the edge of our solar system, it is also beyond the range of reception by even Earth's most sensitive radio telescopes. In 2001, the nonprofit, grass roots SETI League sought to create a Pioneer 10 surrogate for use by radio astronomers around the world.

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

Radio amateurs have successfully been bouncing microwave signals off the rough lunar surface and detecting their echoes back on Earth since 1960. In 2001, SETI League members exploited the EME (Earth-Moon-Earth) path from W2ETI, their club station in New Jersey, for the benefit of radio astronomers worldwide. As seen in figure 1 and reported in *QST*[1], W2ETI's weak EME signal on 1296 MHz, its frequency precisely calibrated to atomic-clock accuracy, was first detected at the 20-watt level by the Arecibo Observatory in Puerto Rico, the world's largest radio telescope. The beacon subsequently was copied by a handful of radio amateurs possessing state-of-the-art stations, including a few reception reports logged during ARRL EME Contests, although its low power limited its utility, restricting reception to only the best equipped stations. Clearly, more power was needed to turn this facility into a truly universal calibration source.

More Power Needed

Over the next two years, the author and station trustee Richard Factor, WA2IKL, upgraded the W2ETI beacon to automatic tracking, remote monitoring, and unat-

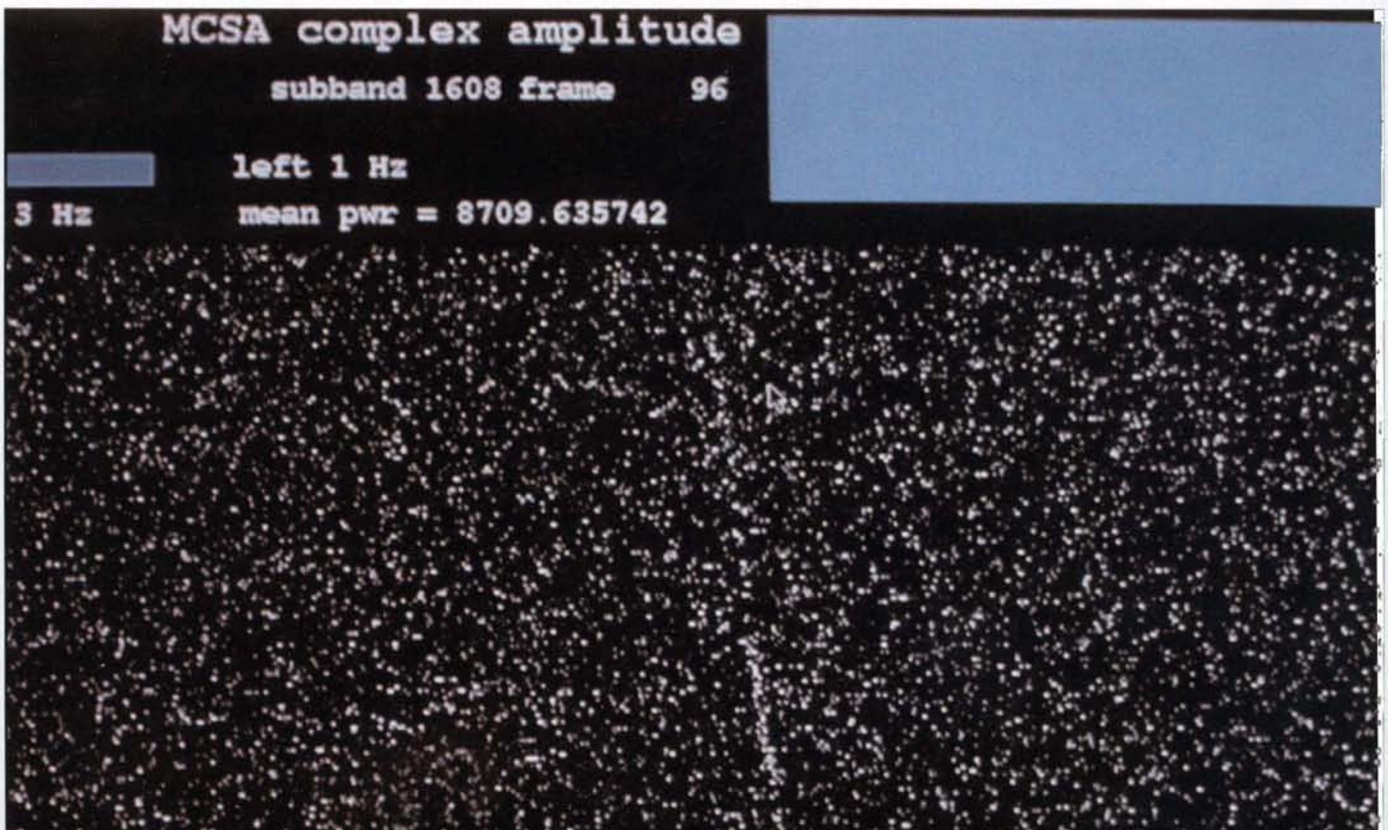


Figure 1. First Light of W2ETI QRP EME Beacon, as received at Arecibo by N6UDK, March 2001.

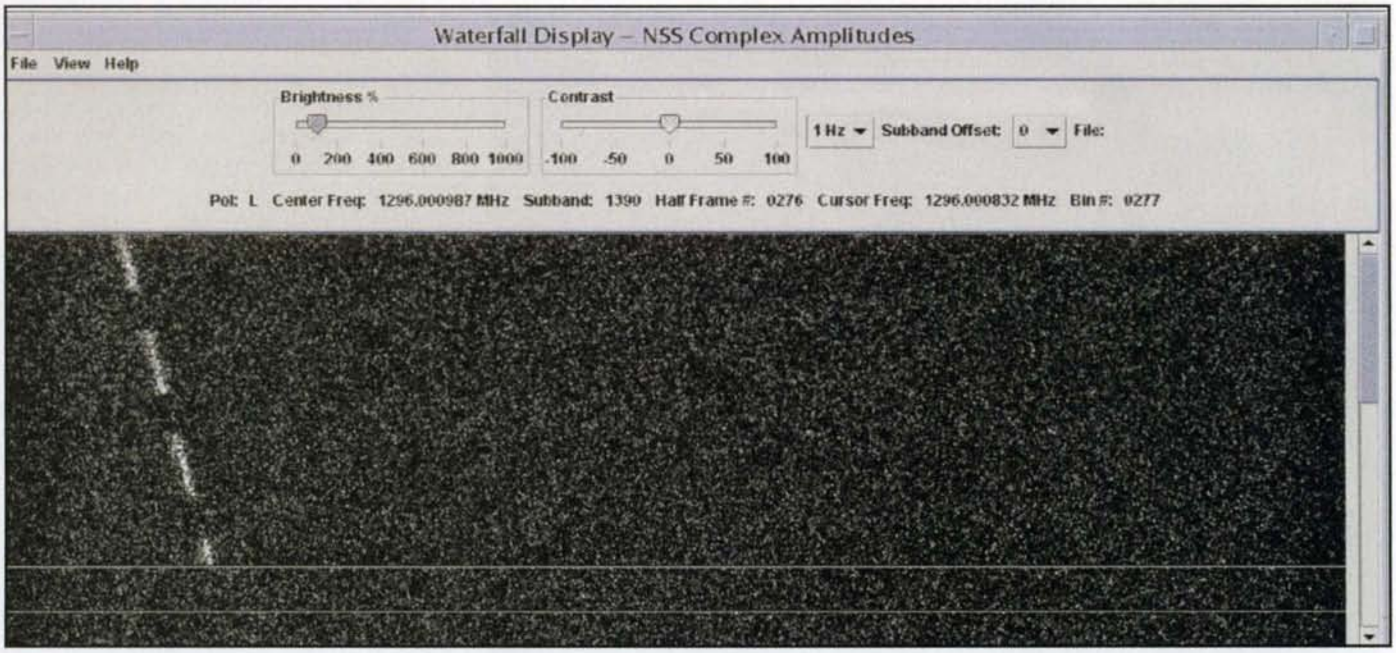


Figure 2. W2ETI's QRO CW signal received at Arecibo, March 2003.

tended QRO operation, with the addition of a solid-state power amplifier. Two years after "first light," calibration tests were repeated with Arecibo at the 100-watt level. The resulting CW signals, depicted in figure 2, were received clearly not only at Arecibo, but also by a host of radio amateurs, on dishes as small as 3 meters in diameter. At the 200-watt level the beacon transmitter was able to provide continuous signals, detectable by typical amateur radio telescopes around the world, any time the Moon was above the horizon at the station's New Jersey QTH.

Unfortunately, the reliability of the solid-state amplifier left

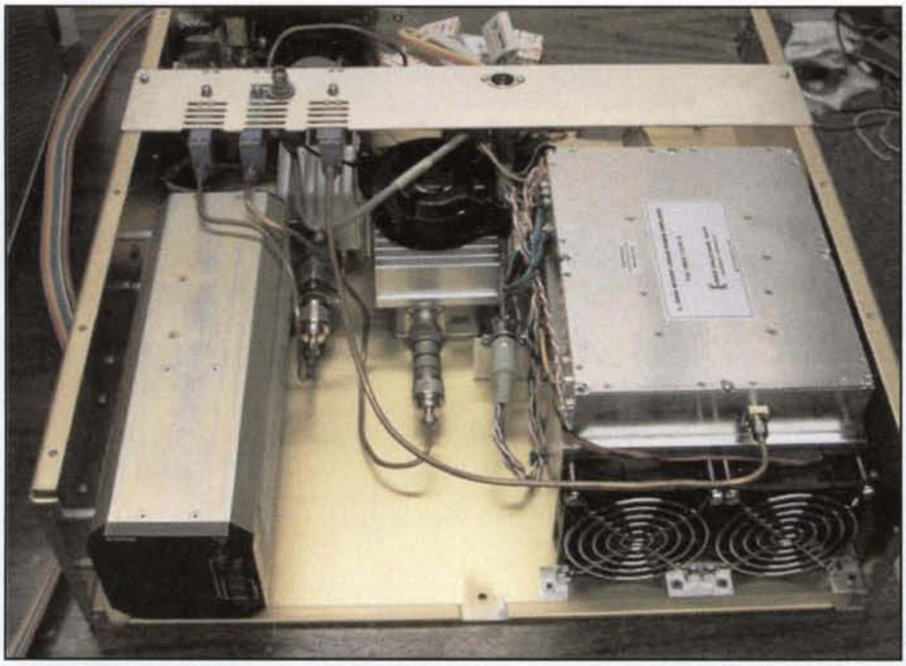


Figure 3. Kunhe MOSFET power amplifier installed in W2ETI EME beacon.

much to be desired. The amplifier incorporated 16 Mitsubishi M57762 RF modules in its final stage. These modules proved quite unreliable, especially when used continuously 12 hours per day. Having replaced several such modules over the period of a year (at a cost of roughly $100 U.S. each), we began studying alternatives to this particular solid-state power amplifier.

The SETI League was spared the expense of replacing more RF modules in the spring of 2004 by a lightning strike that damaged the fragile power amplifier beyond repair. Two years of total redesign followed. The beacon was returned to service in March 2006. The completely refurbished beacon gained a new $^1/_2$-kw MOSFET power amplifier, the MKU 13500 A (see figure 3), ordered from Kunhe Electronics in Germany. WA2IKL has added a completely repackaged exciter, atomic and GPS frequency standards, new control computers and

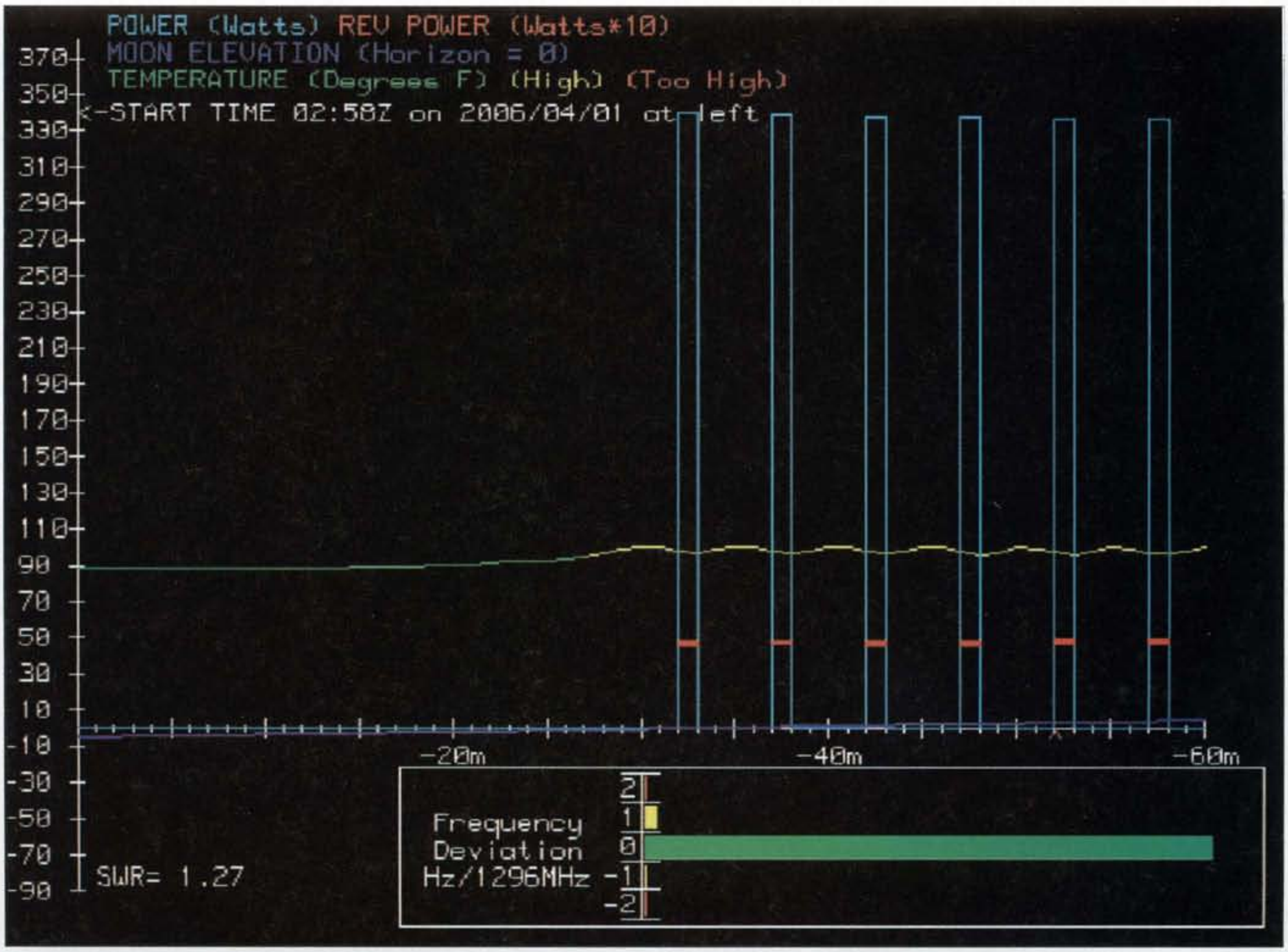


Figure 4. W2ETI Remote Telemetry displays beacon forward and reverse power, cooling air temperature, and frequency for the most recent hour, updated once per minute.

Correction

In Part 1 of "Beckoning Beacons," Dr. SETI's Starship, in the Fall 2008 issue of *CQ VHF*, we inadvertently published incorrect figures, figures that should have gone with Part 2 in this issue. The correct figures for Part 1 appear here as figures A and B. The figures that go with Part 2 are labeled 1 through 4 in this column. We apologize for any confusion.

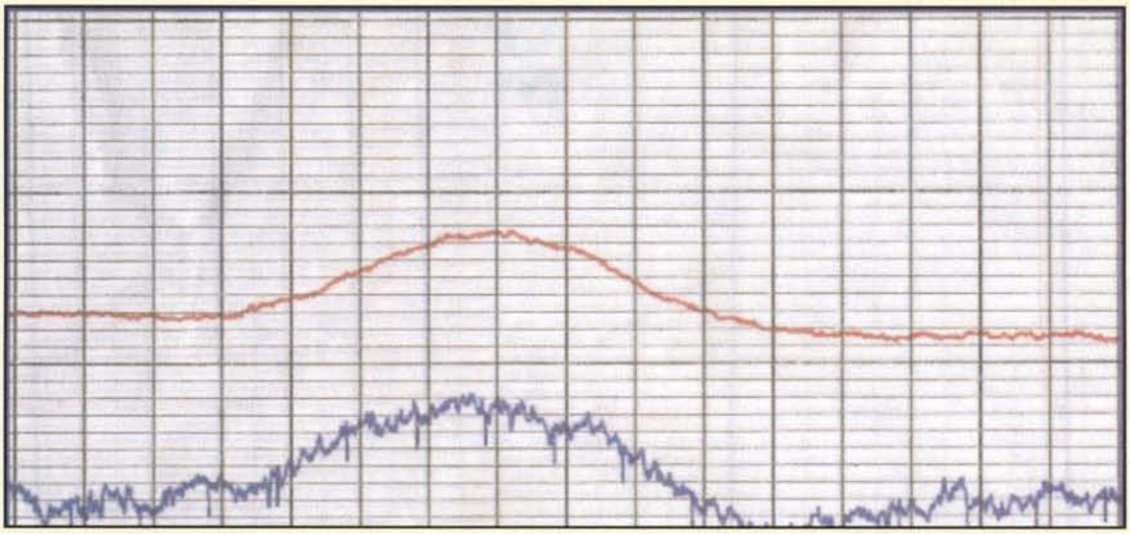


Figure A. Drift-scan sweep of Quasar 3C273 about 3 dB out of the noise.

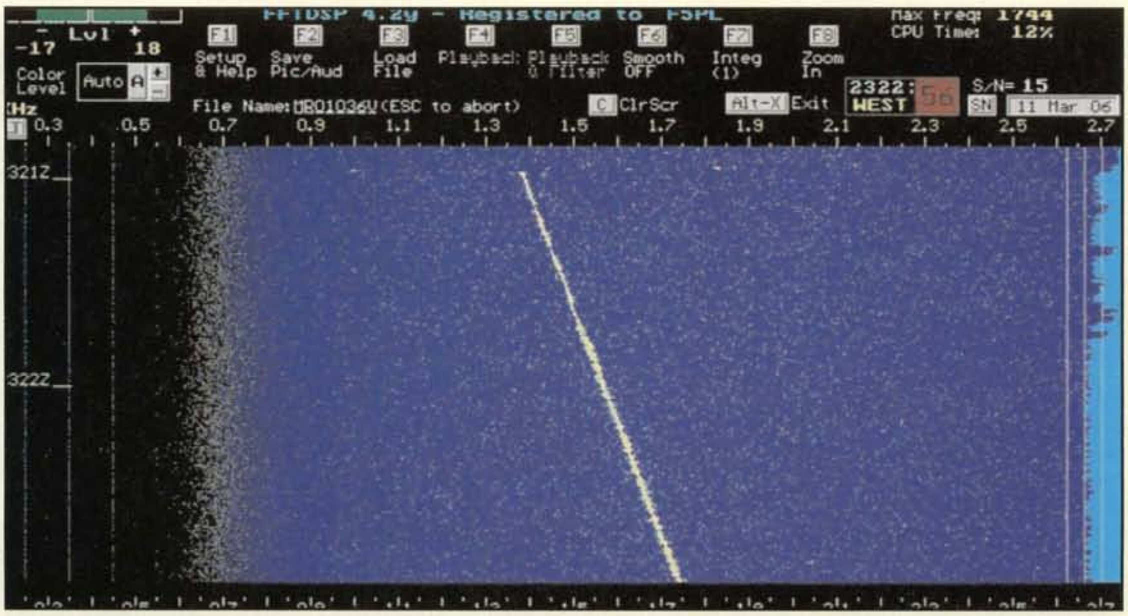


Figure B. Mars Reconnaissance Orbiter beacon received by F5PL from Martian orbit.

associated software, new power supplies, and a 3-kw UPS. The resulting beacon appears robust and reliable, offering amateur radio telescopes around the world precisely calibrated test signals emanating from a known spot in space.

An important feature of the renovated EME beacon is the use of remote monitoring via the internet. Any user can track transmitter power (forward and reflected), PA cooling air temperature, and frequency (in real time) by logging on to www.setileague.org/eme. As seen in figure 4, one hour of history, updating once per minute, is displayed.

The Next Step

Plans are under way to replace the existing quad helix antenna array with eight loop Yagis from Directive Systems of ME. The resulting improvement in gain promises to make the W2ETI 1296-MHz beacon accessible even to entry-level SETI, satellite, and EME stations.

Note

1. Shuch, H. Paul, N6TX, *2001*, "A Moonbounce Odyssey," *QST*, Vol. 85 (11): pp. 38–43, November 2001.

QUARTERLY CALENDAR OF EVENTS

Current Contests

The **European Worldwide EME Contest 2009**: Sponsored by DUBUS and REF. The EU WW EME contest is intended to encourage worldwide activity on moonbounce. Information for this contest is available at the following website: <http://www.marsport.org.uk/dubus/EUEMEcontest2009.pdf>.

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. Please check with the "VHF Plus" column in *CQ* magazine for a future announcement.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs the second weekend of May. Rules are available at: <http://www.ham-radio.com/sbms>.

Conference and Convention

Southeast VHF Society: The 13th annual conference will be hosted in Charlotte, North Carolina, April 24–25, 2009. For information on registering for the conference, check the society's website: <http://www.svhfs.org/>.

Dayton HamVention®: The Dayton HamVention® will be held as usual at the Hara Arena in Dayton, Ohio, May 15–17. For more information, please see the website: <http://www.hamvention.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, e-mail, etc., please contact the person listed with the announcement. The following organizations and/or conference organizers have announced calls for papers for their forthcoming conferences:

Southeastern VHF Society Conference: Technical papers are solicited for the 13th annual Southeastern VHF Society Conference to be held in Charlotte, North Carolina on April 24–25. Papers and presentations are solicited on both the technical and operational aspects of VHF, UHF, and Microwave weak-signal amateur radio. In general, papers and presentations on non-weak-signal topics such as FM repeaters and packet will not be accepted, but exceptions may be made if the topic is related to weak signal. For example, a paper or presentation on the use of APRS to track rovers during contests would be considered.

The deadline for the submission of papers and presentations is March 2. All submissions should be in Microsoft Word (.doc) or alternatively Adobe Acrobat (.pdf) files. Pages are 8-1/2 by 11 inches with a 1-inch margin on the bottom and 3/4-inch margin on the other three sides. All text, drawings, photos, etc., should be black and white only (no color). Please indicate when you submit your paper or presentation if you plan to attend the conference and present there or if you are submitting just for publication. Papers and presentations will be published in the conference *Proceedings.* Send all questions, comments, and submissions to Program Chair Steve Kostro, N2CEI, at <svhfs2009@downeastmicrowave.com>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

February 1	Moderate EME conditions.
February 7	Moon perigee.
February 8	Very good EME conditions.
February 9	Full Moon.
February 9	Lunar eclipse.
February 15	Poor EME conditions.
February 16	Moon last quarter.
February 19	Moon apogee.
February 22	Poor EME conditions.
February 25	New Moon.
March 1	Moderate EME conditions.
March 4	Moon first quarter.
March 7	Moon perigee.
March 8	Excellent EME conditions.
March 11	Full Moon.
March 15	Poor EME conditions.
March 18	Moon last quarter.
March 19	Moon apogee.
March 20	Spring equinox.
March 22	Poor EME conditions.
March 26	New Moon.
March 29	Moderate EME conditions.
April 2	Moon perigee.
April 2	Moon first quarter.
April 5	Excellent EME conditions.
April 9	Full Moon.
April 12	Poor EME conditions.
April 16	Moon apogee.
April 17	Moon last quarter.
April 19	Poor EME conditions.
April 21	*Lyrids* meteor shower.
April 25	New Moon.
April 26	Moderate EME conditions.
April 28	Moon perigee.
May 1	Moon first quarter.
May 3	Very good EME conditions.
May 5	Eta Aquarids meteor shower.
May 9	Full Moon.
May 10	Very poor EME conditions.
May 14	Moon apogee.
May 17	Moon last quarter. Poor EME conditions.
May 24	New Moon. Moderate EME conditions.
May 26	Moon perigee.
May 31	Moon first quarter. Good EME conditions.
June 7	Full Moon. Very poor EME conditions.
June 10	Moon apogee.
June 14	Moderate EME conditions.
June 15	Moon last quarter.
June 21	Summer solstice. Moderate EME conditions.
June 22	New Moon.
June 23	Moon perigee.
June 28	Good EME conditions.
June 29	Moon first quarter.

—EME conditions courtesy W5LUU.

For more information about the conference go to: <http:// www.svhfs.org>.

Central States VHF Society Conference: Technical papers are solicited for the 43rd annual Central States VHF Society Conference to be held in Chicago, Illinois on July 23–26. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. You do not need to attend the conference, nor present your paper, to have it published in the *Proceedings.* Posters will be displayed during the two days of the conference. Non-weak signal topics, such as FM, repeaters, packet radio, etc., generally not considered acceptable. However, there are always exceptions. Please contact the person below if you have any questions about the suitability of a topic. Strong editorial preference will be given to those papers that are written and formatted specifically for publication, rather than as visual presentation aids.

Deadline for submissions: For the *Proceedings,* June 1; for presentations delivered at the conference, June 29; and for notifying them that you will have a poster to be displayed at the conference, also June 29. Please bring your poster with you on July 23/24. Contact information: Kermit Carlson, W9XA, via e-mail: <w9xa@yahoo.com>, or snail mail: Kermit Carlson, W9XA, 1150 McKee St., Batavia IL 60510. Submissions may be made via the following: electronic formats (preferred); via e-mail; uploaded to a website for subsequent downloading; on media (3.5" floppy, CD, USB stick/thumb drive). For more informationgo to: <http:// www.csvhfs.org>.

Meteor Showers

The *α-Centaurids* meteor shower is expected to peak on Feb. 7 at 2300 UTC. The *γ-Normids* shower is expected to peak on Mar. 13. Other Feb. and Mar. minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids,* Feb. 1, 0900 UTC; and *χ-Capricornids,* Feb. 13, 1000 UTC.

The *Lyrids* meteor shower is active Apr. 16–25. It is predicted to peak around 1100 UTC on 22 Ap. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility up to 90 per hour.

A minor shower and its predicted peak is *π-Puppids* (peak on Ap. 23, at 1600 UTC). Other Apr., May, and June minor showers include the following and their possible radio peaks: Apr. *Piscids,* Apr. 20, 0900 UTC; *δ-Piscids,* Apr. 24, 0900 UTC; *ε-Arietids*. May 9, 0800 UTC; May *Arietids,* May 16, 0900 UTC; and *o-Cetids,* May 20, 0800 UTC. June *Arietids,* June 7, 1100 UTC; *zeta-Perseids,* June 9, 1100 UTC; and *β-Taurids,* June 28, 1000 UTC.

For more information on the above meteor shower predictions please see Tomas Hood, NW7US's "VHF Propagation" column beginning on page 58, as well as visit the International Meteor Organization's website: <http://www.imo.net>.

Advertisers' Index