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Summer 2003

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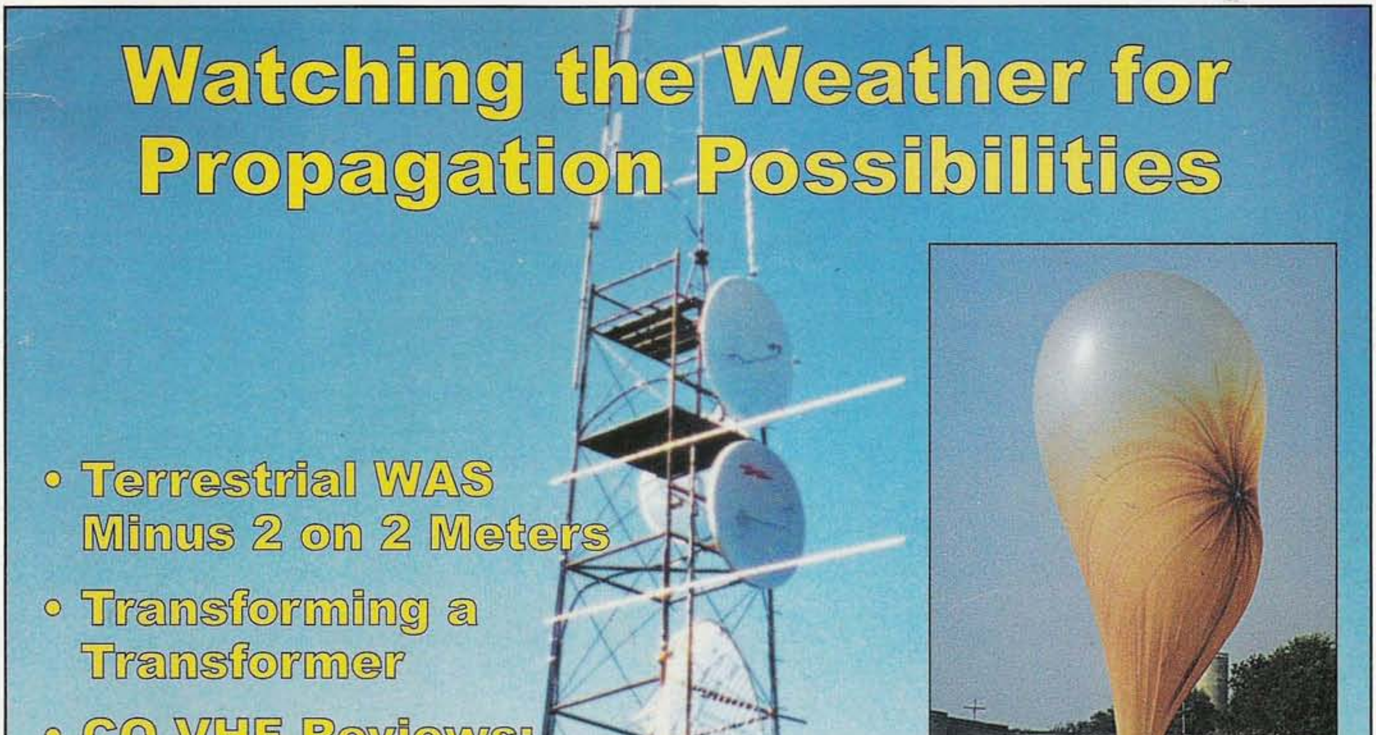

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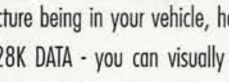
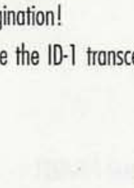


The wireless link supporting the RP-1, 1.2 GHz repeater, with a data rate of 10 mbps.



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These antennas are designed for use with the D-Star System.

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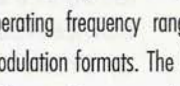
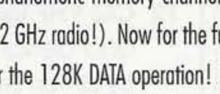


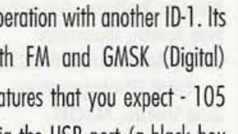
ID-RP1D 1.2 GHz Data Repeater



ID-RP1VS 1.2 GHz Voice Repeater

RC-24

Control Head



Included with ID-1, the control head shows all operating information.

The future begins here!

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FEATURES

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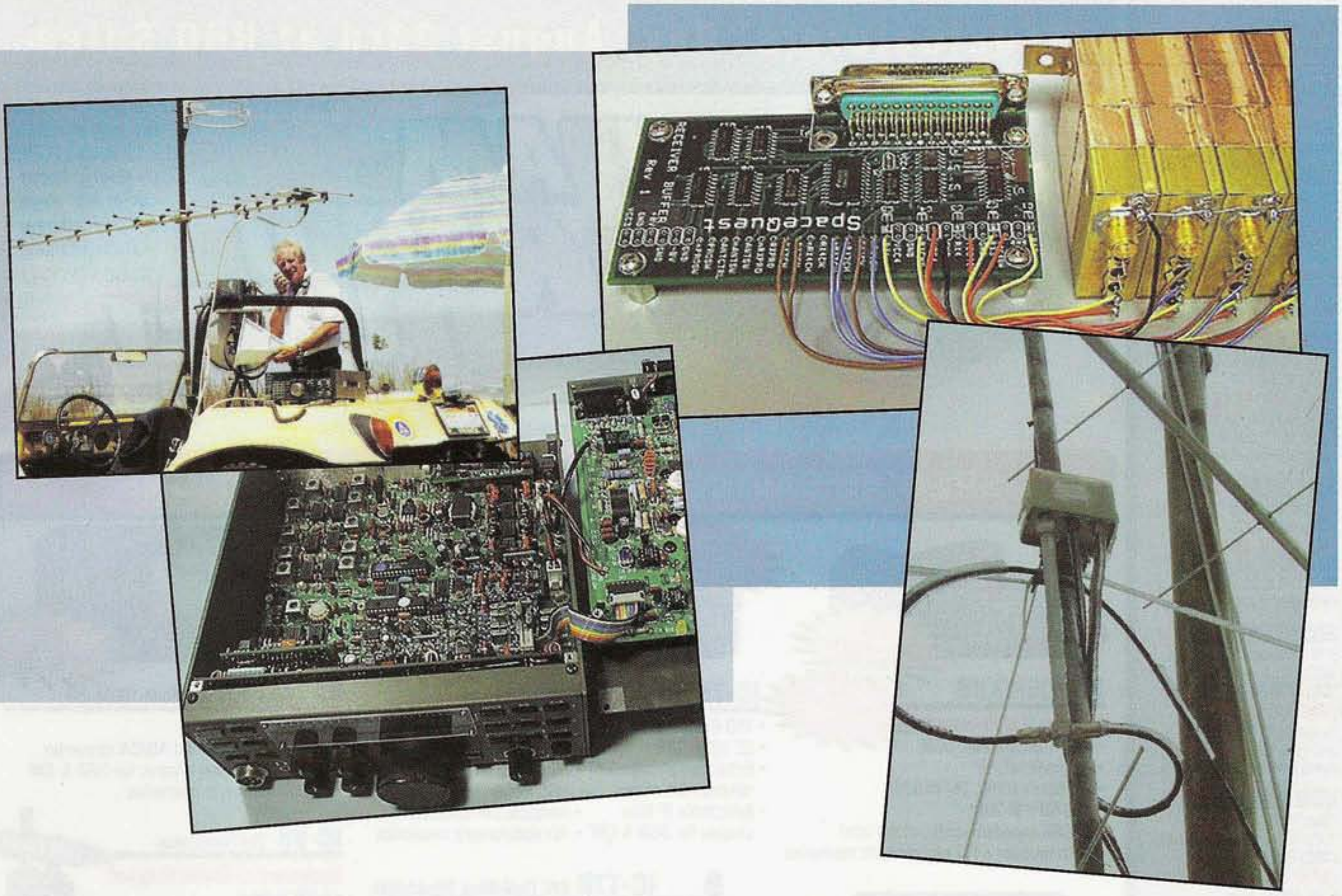


COLUMNS

DEPARTMENTS

ON THE COVER: More than 10,000 feet above sea level on the side of the Mauna Loa (Hawaii) volcano is this massive tower, the home of the antennas used by Paul Lieb, KH6HME, for the VHF-and-above beacons and for making contacts with the west coast of the U.S. when the band is open. From this site Paul has set many VHF and microwave records (see page 10). (Photo by Gordon West, WB6NOA)

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

The Growing Interest in VHF-and-Above QRP

About a year ago, my friend Tommy Henderson, WD5AGO, bought a new house. For a long time Tommy has been one of the better-known EMEers in the Tulsa area. However, at this point in his life, his family is getting bigger and he needed more room for them to grow. All things being considered, he found himself a nice home in Broken Arrow, a booming suburb of Tulsa, Oklahoma. I say *all things*—but the antenna consideration. You see, Tommy knowingly moved into a neighborhood with an antenna restriction.

Now Tommy is off the air—well, not exactly. He does have permission to use a TVRO dish in his back yard, and he did put up temporary antennas during last year's ARRL EME contest periods. Tommy is also on the air QRP.

When I learned that Tommy was operating QRP, I wondered if he had sold out to HF operations. He assured me that he had not left behind the VHF-and-above ham bands. By contrast, his interest in QRP has increased his interest in VHF-and-above operations. In fact, he has become a promoter of VHF-and-above QRP activities at gatherings of QRP enthusiasts, pointing out to the HF operators that weak-signal VHF-and-above operations have a lot to offer the serious QRP operator.

Operating QRP is a growing phenomenon. The commercial manufacturers are taking notice of this increased interest in QRP by developing radios ready to go QRP, with a few of them equipped to operate on some of the more popular VHF-and-above ham bands.

There is also a growing interest in kit radios equipped to operate on VHF. For example, Elecraft (see the extensive review of the K2 by Simon Lewis, GM4PLM, in this issue beginning on page 12) has developed three transverters for its K2 model. Surprisingly, one of the three is on 222 MHz, a not-so-popular VHF ham band. I wonder if Elecraft's contribution might bring about a bit of an upsurge in activity on that band.

Incidentally, because of its transverter-accommodating design, that K2 model is gaining increasing acceptance as an IF (intermediate-frequency) radio for EME operators. It doesn't hurt that one has to build the K2 from a kit, something else that appeals to those of us who are technically inclined. Speaking of building your own radio, take a look at the picture of Bob Friess, N6CM's 10-GHz transverter on page 68. Bob built that transverter for the K2 in an EC2 chassis.

Another entry into the put-it-together-and-tinker-with-it arena is Gerald Youngblood's SDR-1000 software-defined radio. With the SDR concept featured in the Summer 2002 issue of *CQ VHF* and a four-part series of articles appearing in successive 2002–2003 issues of *QEX* (beginning with the July/ August 2002 issue), Gerald's radio is now off and running. Also, like the K2, the low-power (one watt) feature of the SDR-1000 makes it ideal an IF radio for weak-signal VHF-and-above transverters. For more information on the SDR-1000 see <http://www.flex-radio.com>.

One neat characteristic of these cottage-industry manufacturers is their ability to quickly respond to needed or requested changes from the field. For example, both Elecraft and the SDR-1000 were ready to go when the 60-meter five channels became available in early July. (By contrast, of the bigger manufacturers only Ten-Tec, with its Orion model, was ready to go on the starting date.) In addition, in response to field-generated requests, Gerald is working on figuring out how he can incorporate 2 meters in the SDR-1000 despite 60-MHz upper-limit problems with the microprocessor he is using in the radio.

Recently, I received an e-mail from a northeast weak-signal operator who complained about all of the QRO operators in his area. While he made valid points about how these operators are hogging the calling frequencies, his solution for himself I find a bit too drastic. He said that as soon as he could get all of his equipment sold, he was off the air. By contrast, exploring the increasing interest in VHF-and-above QRP operating could be a very creative alternative to slugging it out on the lower VHF calling frequencies.

If you also are having the problem of front-end overload in your neighborhood, I urge you to take a look at the higher VHF-and-above frequencies using lower power. Getting back to Tommy, he has two 5760-MHz QRP transceivers ready to go for any ham in his neighborhood who wants to stop by and run with him.

How about you? With what are you willing to experiment? When you get it built, write it up and send it to us. *CQ VHF* can give your project ample coverage.

Contests and Propagation

Late summer and fall always have their contrasts in propagation. There are the dying embers of sporadic-*E* propagation that show up in early August. In the middle of the month is the *Perseids* meteor shower. This year the near full Moon will all but obliterate viewing the shower, so stay inside and operate rather than lying on the lawn and staring at the Moon. Also, for those of you on the west coast, there exists the possibility of transpacific tropo propagation. For more information on that mode, see Gordon West, WB6NOA's article "Watch the Weather," beginning on page 10. Then there are two microwave contests, the ARRL Microwave Contest and the first weekend of the ARRL 10 GHz and Above Cumulative Contest.

September brings a couple more contests, the second weekend of the ARRL 10 GHz and Above Cumulative Contest and the ARRL September VHF QSO Party, while October and November feature the annual ARRL International EME contest. Also in October and November are three more meteor showers—the *Draconids,* the *Orionids,* and the *Leonids.* November also may include a rare sporadic-*E* opening, as well as possible transequatorial propagation (TEP) for the 6-meter operator.

Each of these activities has its propagation peculiarities. Understanding them is part of the knowledge needed for successfully operating the VHF-and-above ham bands.

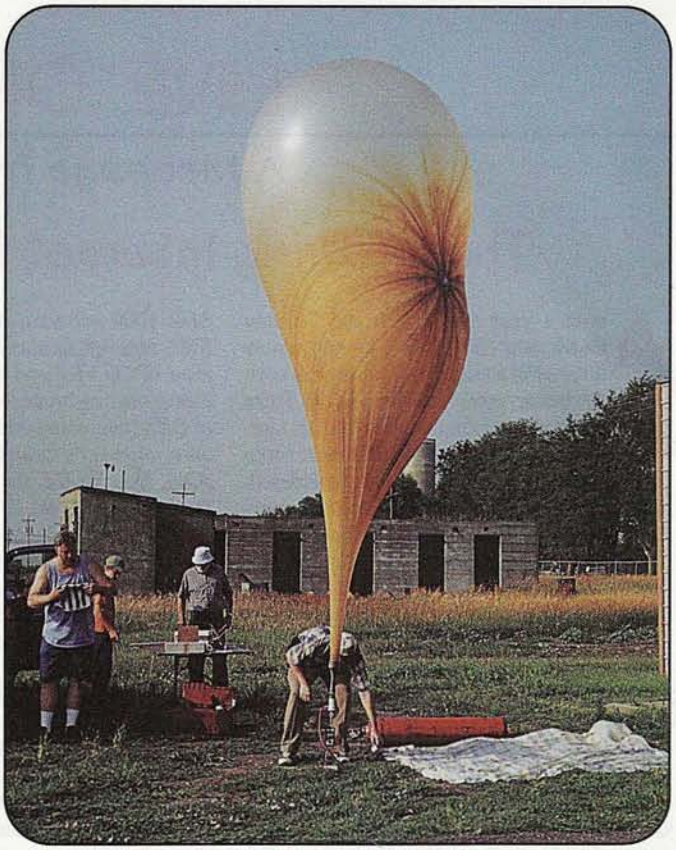
Due to our need for increased knowledge, we have added a new columnist beginning with this issue of *CQ VHF.* Tomas Hood, NW7US, who succeeded George Jacobs, W3ASK, as *CQ* magazine's propagation columnist and who also has taken up similar responsibilities for *Popular Communications,* our other sister publication, has agreed to come on board as our propagation columnist. His first column begins on page 60 in this issue. Tomas is the first to admit that he has a lot to learn about VHF propagation, so be patient with him and be his teacher as he increasingly becomes involved with us in the weak-signal VHF-and-above facet of our hobby.

Again, Thanks

In my travels to hamfests I am meeting more and more of subscribers and contributors to this magazine. In the short time that it has been back you have made it very successful by your acceptance of it as a venue for presenting more technically challenging articles for the weak-signal VHF-and-above operator. We of the staff of *CQ VHF* thank you for your support, and we will continue to work at earning your respect. Hopefully, in the near future we will see one of your ideas or projects in the pages of this magazine, which will make it even that much more of a quality publication. Until next issue…

73 de Joe, N6CL

Doug Eubanks, KAØO, filling one of the balloons with helium. (Photo by one of the crew)



Mike, KDØFW's balloon as it develops its aneurysm. Mike is on the far left, and Bill, WB8ELK, is at the balloon controlling the flow of helium. A few minutes later the balloon burst. (Photo by one of the crew)

The Great Plains Super Launch 2002

In 2002 this event set a new record with the launch and recovery of eight amateur radio high-altitude balloons carrying science and radio payloads to altitudes above 75,000 feet. Here is KD4STH's report on this exciting activity.

By L. Paul Verhage,* KD4STH

July 5 and 6, 2002 was more than just the 4th of July holiday weekend for about 25 people who share a common interest. On those two days the second annual Great Plains Super Launch (GPSL 2002) was held in Manhattan, Kansas. For those of you not familiar with GPSL, it is an opportunity for the amateur near-space community to simultaneously launch and track amateur radio high-altitude balloons. These balloons carry science and radio payloads to altitudes above 75,000 feet.

GPSL 2001 saw the launch of three balloons and was covered by *Weatherwise* magazine.[1] A record for the number of simultaneous launches was set that year. Seventeen people participated, representing Idaho, Kansas, and Nebraska. The near-space programs that launched balloons were HABITAT, NSBG, NSTAR, and TVNSP.[2]

The GPSL 2002 launch and recovery of eight balloons set a new record. Over 24 enthusiasts from 11 states attended.

*e-mail: <paul.verhage@boiseschools.org>

The balloons just after launch. Below them you can see the recovery parachutes and capsules. (Photo courtesy Marty, WAØGEH)

The states represented this time were Alabama, Arizona, Colorado, Idaho, Indiana, Iowa, Kansas, Missouri, Nebraska, Oklahoma, and Texas. The near-space programs that participated were ANSR, EOSS, HABITAT, NSTAR, Project Traveler, TVNSP, and Mike Bogard, KDØFW, of the Kansas City ATV Group.

Unlike 2001, GPSL 2002 hosted a symposium in conjunction with the launches. With representatives from over half of the active near-space programs attending, approximately one quarter of the entire amateur near-space community was present. They represented the entire history of amateur near-space exploration.

GPSL 2002 unofficially began on the evening of July 4, when about a dozen attendees got together for dinner. It was a great opportunity to meet old friends and make new ones. It also was an opportunity to meet the movers and shakers of amateur near-space, as I had only heard about them before.

The Symposium

The symposium was held in the Hemisphere Room of the Hale Library of Kansas State University. The library made available a networked PC, LCD projector, VCR, and overhead projector for the presentations. Ralph Wallio, WØRPK, was the emcee for the event.

The symposium began early in the morning, as many presentations and displays were planned. The displays included capsules and photographs from three programs. The morning session started with introductions, after which many attendees described the history or current status of their amateur radio high-altitude balloon programs and many interesting videos were shown. The first time there had been such a symposium was in 1993, and that event was hosted by EOSS. There had not been another since then, and the attendees of GPSL 2002 considered the nine-year span to be far too long. It is our hope that with more groups getting involved, such conferences will be held more frequently.

After the morning session, lunch at a nearby restaurant was the order of business. This was another opportunity to discuss near-space experiences in an informal setting.

The afternoon sessions consisted of a series of technical presentations on a diverse range of topics. Topics and presenters at GPSL 2002 were as folows: An Early High-Altitude Ballooning History, by Bill Brown, WB8ELK; Meteorology for High-Altitude Ballooning, by Mark Conner, N9XTN; ANSR Avionics, by Michael Gray, KD7LMO; EOSS Tracking and Recovery Procedures, by Marty Griffin, WAØGEH; The History of Windtrax, by Chuck Crist, W9IH; and TNVSP Airframes and Avionics, by the author of this article.

GPSL 2002 attendees headed out to dinner after the close of Friday's symposium. Bill, WB8ELK, was presented with a plaque declaring him the Father of Amateur Radio High-Altitude Ballooning. Bill began launching amateur radio balloons on August 15, 1987 and has launched over 200 balloons to date. His high-altitude ballooning article of August 1990[3] is probably the first piece on the topic. Bill's balloons have carried equipment from simple beacons to com-

(Continued on page 72)

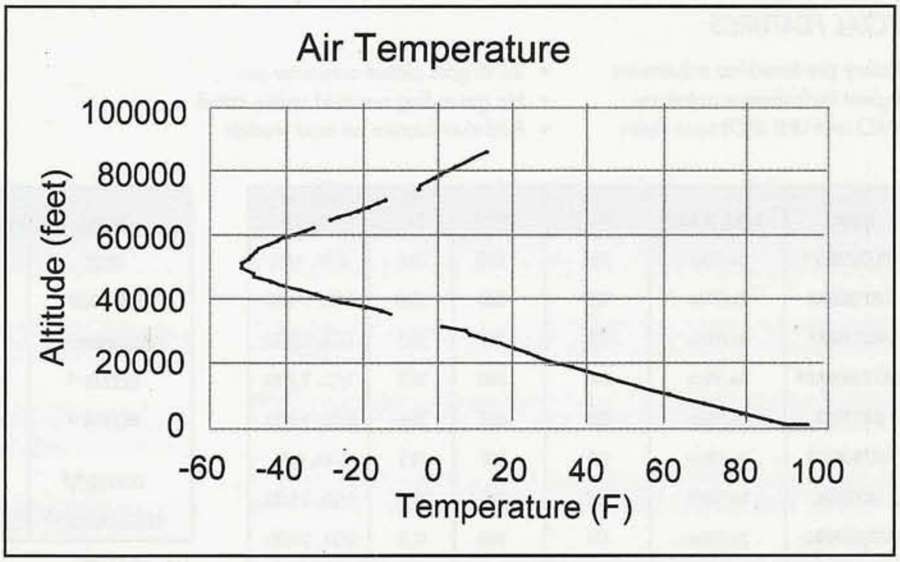


Figure 1. The external air-temperature readings were taken by an LM335 mounted outside the TVNSP capsule and shielded from direct exposure to the sun. The "knee" in the air-temperature line shows that the stratosphere begins at an altitude just above 50,000 feet, which is typical. We see the altitude of the stratosphere drop by 10,000 in the winter. (The author, using a Quattro Pro spreadsheet, generated figures 1–3)

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Features

- Wide frequency bandwidth
- Heavy duty fiberglass radome
- Stainless steel mounting hardware and radials
- Type–N Cable connection
- Compact size for easy mounting/ installation

Specifications:

Freq.: 2m: 144–148MHz
70cm: 440-450MHz
Power: 200 watts
Wind Rating: 135 MPH (no ice)
Height: 5.6 feet

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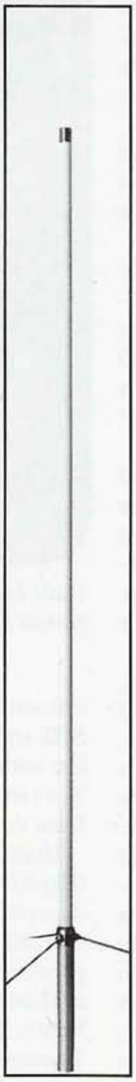
Diamond Antenna's best base station repeater antenna. Designed for strength and performance, the X500HNA is pretuned to achieve maximum gain in both the 2m and 70cm amateur bands.

Features

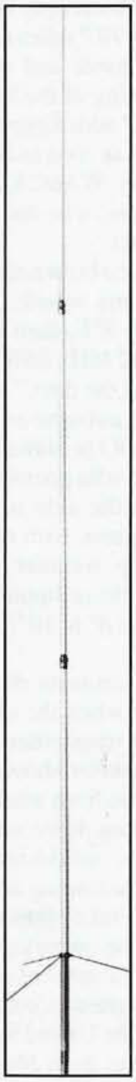
- Heavy duty fiberglass radome
- Overlapping outer shells for added strength
- Stainless steel mounting hardware and radials
- Strong–waterproof joint couplings
- Type–N Cable connection
- Wide band performance

Specifications:

Freq.: 2m: 144–148MHz
70cm: 440-450MHz
Power: 200 watts
Wind Rating: 90 MPH (no ice)
Height: 17.8 feet



X50NA



X500HNA

DIAMOND Mono-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
CP22E [1]	144	200	UHF	9.0	90
DPGH62 [1,6]	50	200	UHF	21.0	78
F22A	144	200	UHF	10.5	112
F23A	144	200	UHF	15.0	90
F718A [2]	440	250	N	15.0	90

DIAMOND Dual-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
X50A	144/440	200	UHF	5.6	135
X50NA	144/440	200	N	5.6	135
X200A	144/440	200	UHF	8.3	112
X510NA [3]	144/440	200	N	17.2	90
X510MA	144/440	200	UHF	17.2	90
X500HNA	144/440	200	N	17.8	90+
X700HNA	144/440	200	N	24.0	90
X2200A	144/222	150	UHF	11.5	112
U200	440/1240	100	N	5.9	135

DIAMOND Tri-Band Base/Repeater Antennas

MODEL	BAND (MHz)	WATTS	CONN.	HT. FT.	RATED WIND MPH (No. Ice)
U5000A	144/440/1240	100	N	5.9	135
V2000A [4,6]	52/144/440	150	UHF	8.3	110
X3200A [5]	146/222/440	100/200	UHF	10.5	112
X6000A	144/440/1240	100/60	N	10.5	112

1 Heavy duty aluminum construction.
2 F-718A: 440-450MHz., F718L: 420-430MHz.
3 X510NJ: 144-147/430-440MHz.
4 1/4λ rated in dBi.
5 2m: 146-148; 100 watts
6 52-54MHz. only; DPGH62 adjustable from 50-54MHz.

Most requirement: 1.4"-2.4".

BAND: 144=144-148MHz., 222=222-225MHz., 420=420-430MHz.,430=430-440MHz., 440=440 450MHz., 1240=1240-1300MHz.

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Watch the Weather for VHF/UHF DX!

Summer and fall bring tropo DX to its highest levels. Just imagine an FM and an ATV path completed over 2500 miles.

By Gordon West,* WB6NOA

Serious VHF and UHF weak-signal operators spend most of the winter gearing up for summertime tropospheric-ducting DX. New FM operators might be surprised when they answer a general call on their repeater from a base station located 1200 miles away. Imagine the surprise of the Long Island Amateur Radio Simplex operators on 147.510 MHz yakking FM when Frank, AA2DR, a well-seasoned VHF/UHF DXer, begins to hear faint signals from a mobile driving by the Kennedy Space Center.

Without fail, summer and fall bring tropospheric-ducting excitement. If you watch the weather patterns, you might be able to predict that the band will literally go "wide open" for tropo DX the day before it actually happens..

The term *tropospheric ducting* refers to the stratification of the air within our weather atmosphere, abruptly changing the normal refractive index. An abrupt change of refractive index from one medium to another is easily visualized by dropping a pencil into a glass of water that is half full. The pencil looks bent, doesn't it? Now you might imagine VHF and UHF radio signals that normally travel in a straight line becoming "bent" within the sharp edge of an approaching cold front or a long ridge of high pressure pushing down from a cell above.

"The formation of a duct is the result of the physics of the fluid. Any combination of fluid parameters which contribute to a sufficiently thick layer of super-refractivity may cause ducting," comments Bruce Eggers, WA9NEW. He points out that a "sufficiently thick" super-refractive layer may minimize signal losses through the top area of the duct and be sufficiently elevated so as to minimize losses on the bottom side of the duct. He indicates that this could cause field-strength attenuation nearly proportional to 1/R rather than 1/R squared.

"Under ideal ducting conditions, a signal from a transmitter 5000 miles away may have the same field strength as an identical transmitter only 70.7 miles away from common frontal layers and early morning radiational cooling of the lower layer of the atmosphere," adds Eggers.

"I can spot a tropo duct as soon as I take off," comments Bill Alber, WA6CAX, an avid airborne ham operator, who delights in working within the duct.

"I look for the suspended brown air, fly into the duct, and watch my outside temperature gauge jump by 8°F, then start working 2 meter and 432 MHz SSB 500 to 700 miles away along the duct," adds Alber, boasting his best airborne record of 2500 miles to KH6FOO in Hawaii.

Paul Lieb, KH6HME, who operates at the 8000-foot level on the side of the Mauna Loa volcano, agrees with tropo experts about watching weather patterns, looking for the cloud boundary layers and observing that 8° to 10°F rise in temperature.

"I worked over 350 contacts during three days one summer when the cloud layer was just below the transmitter site, and my outside thermometer showed a 10°F temperature increase from what the Hilo Airport was reporting down on the deck," comments Lieb, world-record holder of tropospheric ducting on multiple VHF/UHF bands. It takes him over two hours to drive up to the operating site on the side of an active volcano, but when he hooks into his Yagi antennas beamed toward the west coast of the United States 2500 miles away, he talks from Mexico to Washington state with ease.

VHF, UHF, and the microwave radio horizon are generally four-thirds the visual horizon. The slight bending, called refraction, of straight-line VHF/UHF/SHF signals is similar to the bending you see with the pencil in the glass of water. The refractive index of water is different from the refractive index of air.

Paul Lieb, KH6HME, and the first California to Hawaii multi-band transmitter.

Under "normal" weather conditions, the refractive index of air, represented by the symbol *N*, for normal, is slightly over 1 (1.000345 to 1.000290). Atmospheric pressure decreases with height in a logarithmic manner at about 1 mb (millibars) for every 10 miles in altitude. Temperature decreases 20°F for every 1 mile increase in altitude, up to approximately 9 miles.

Along with pressure decrease and temperature decrease as altitude increases,

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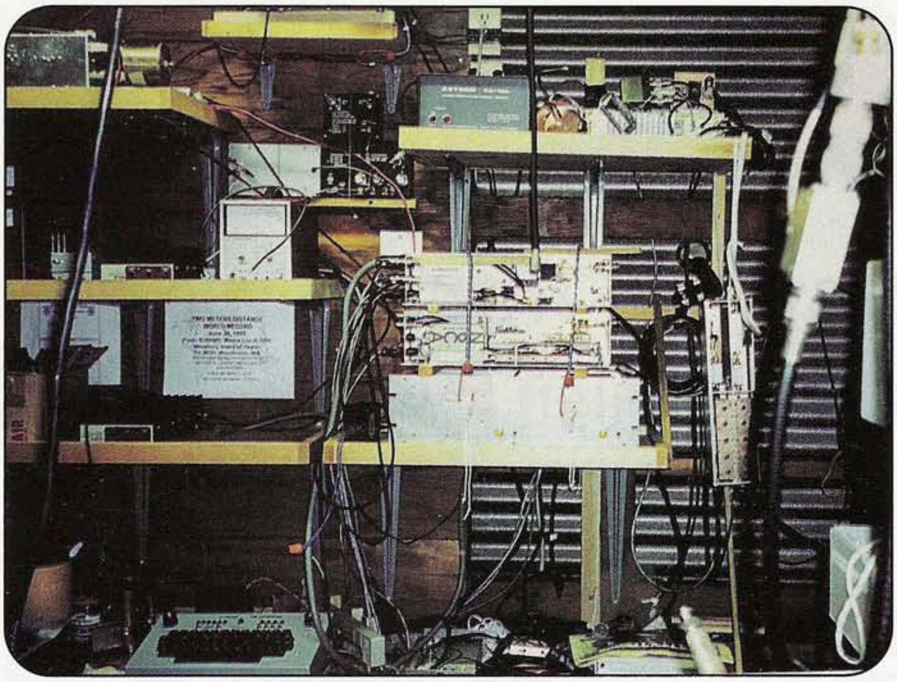


The many VHF/UHF beacons on the air 24 hours a day, all year, at the KH6HME beacon site.

water-vapor content also drops. You notice this when you fly cross-country and the dry air of the plane's cabin gives your curly hair a rather straight look!

On a normal spring day, the sky looks deep blue, with air pressure, air temperature, and suspended water vapor in the air decreasing with altitude. The spring weather is relatively cool, with plenty of fresh breezes, and thus your VHF/UHF radio setup at your QTH does its "normal" thing.

Now it is late summer, and the weather is just plain hot. There is very little breeze, and that normally blue sky has turned light brown; your eyes and lungs tell you that there are plenty of pollutants trapped in the air.

Are you trapped? These suspended smoke and smog particles are not dispersing up through the atmosphere because a slow-moving, high-pressure system spanning four states has just moved in and stalled out, leaving us another day of stagnant air. Go back inside immediately and get on the radio. More than likely, the VHF and UHF bands are wide open for tropo DX.

What has occurred in our weather layer of the atmosphere close to Earth is a cell of dry, warm air overlaying cool, moist air below. This high-pressure cell, packed with a concentration of air within the walls of the cell, contributing to a slightly heavier weight in mass, slowly descends. This is called *subsidence,* and since the air within this cell starts its gradual drop from as high as 30,000 feet, it is dry as a bone. As the air drops, it begins to compress with the higher air pressure near the surface, and with little wind down on the "deck," the high-pressure cell begins to stratify.

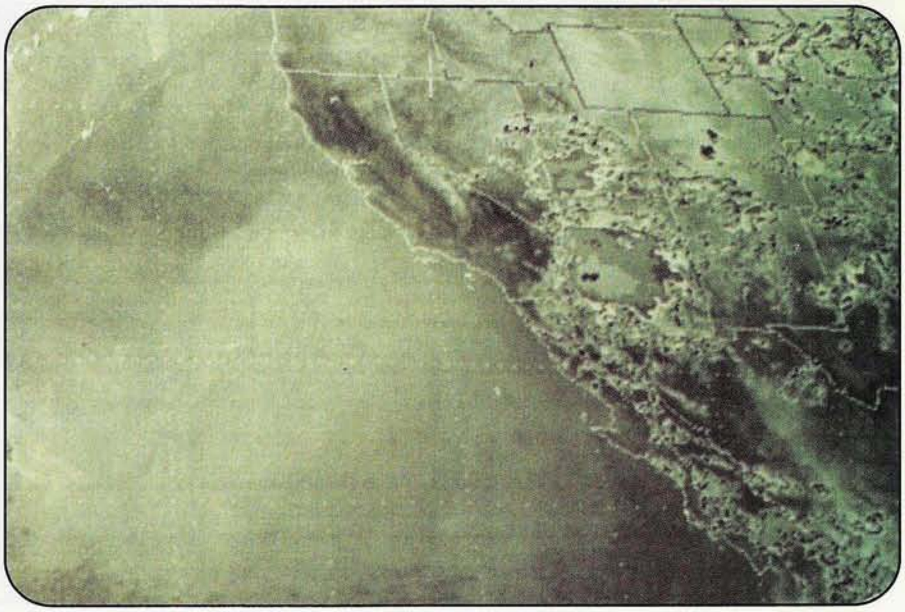
"The cool, moist air at the surface in late summer and early fall radiates heat energy and cools toward a radiational heat balance with the mean temperature of the integrated moisture content of the vertical structure of the atmosphere, becoming a cool, thin layer of air near the surface," adds Eggers.

A good analogy of this layering effect in the atmosphere just above ground level is what may be observed during an early morning walk by a lake that appears to be giving off steam. Water is a great reservoir of heat energy, and with no-wind conditions, sharp boundaries within our air begin to stratify.

Sea captains and port pilots who fly over oceans can tell you some amazing stories about what these air boundaries can do to objects on the horizon. Down in the W5 Gulf land, many times hams spot oil rigs up to 75 miles away—well beyond "normal" line of sight. More amazing is that the oil rigs are seen on the horizon as being upside down! Even more bizarre is the reversed sea mirage, when a skipper heading for port suddenly watches the distant coastal buildings and horizon disappear, as if swallowed by the ocean. As he sails closer to port, buildings began to reappear—inverted!

How many times have you been traveling down the road on a hot, windless day and seen shimmering water covering the roadway ahead? You know that this is simply a common mirage, and the blue shimmering water is actually a refraction

(Continued on page 77)



The light area shows good tropo between California and Hawaii. (National Weather Service photo)

CQ VHF Reviews

The Elecraft K2 Transceiver
A Build and Design System

By Simon Lewis,* GM4PLM

If you're anything like me, one of the main hurdles of building your equipment is making the finished item look good. Some of the recent articles in various UK magazines are a credit to their builders in that the finished item not only looked good enough for the shack bench, they also performed well. I could always get a piece of equipment working, but it was never the object of joy I wanted it to be because the finished item was never as good looking as a commercial item, which was a shame!

Those of you who remember the Heathkit days will recall the attention that was paid to the enclosures, which were supplied with the kits. They made that homebuilt equipment look good enough for the shack. Although many of these kits were built by amateurs a number of years ago, much of this equipment continues to sell well on the second-hand market.

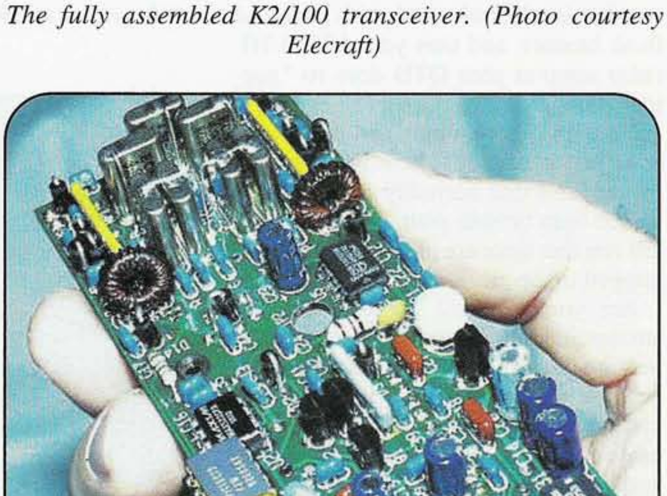
This memory sprang to mind some years ago when I first came across the web page of the Elecraft Company of America and one of its featured items, the K2 HF transceiver project. The company is run by Eric Swartz, WA6HHQ, and Wayne Burdick, N6KR, both very active amateur radio operators. Their flagship HF transceiver, the K2, is designed not only to compete, and indeed beat, the top HF radios on the market today in terms of performance and capabilities, but also to look as good as commercial radios while still being built at home as a kit by the average amateur. "Impossible!" I hear you say. Well, it's not impossible. Having built and operated one, I can assure you that it's every bit as good as the Elecraft web pages say it is!

What does the K2 have to do with VHF? For many years I have used one as a transverter driver for my VHF/UHF and microwave transverters, allowing me to have a VHF transceiver with all the excellent functionality found on a normal HF radio. Elecraft has risen to the challenge again, now offering a variety of high-performance transverters as part of their excellent line, which will be discussed later.

The K2 System

What's the K2 all about? Some years ago, Wayne and Eric decided that they wanted to design a kit transceiver along the lines of the old Heath designs, but they wanted it to perform better than modern-day radios. Still, they wanted the kit to be

The fully assembled K2/100 transceiver. (Photo courtesy Elecraft)



The adapter which allows the K2 to operate on SSB. (Photo by the author)

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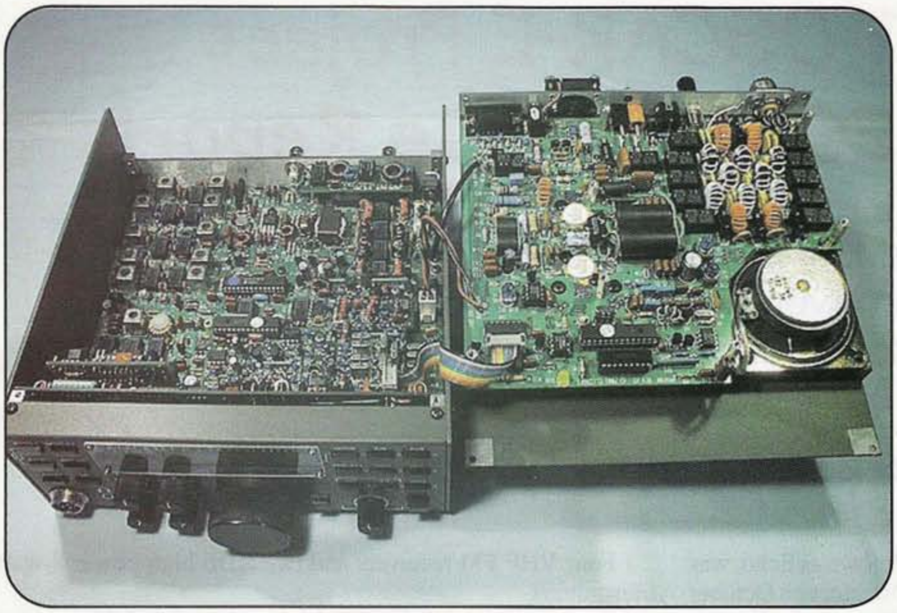

The K2/100 opened up to show the KPA100 option, with shield removed, on the right. (Photo courtesy Elecraft)

able to be built, aligned, and tested by using simple equipment in the shack at home. Slowly but surely they grew the K2 concept until its launch in 1999. Since then the K2 has continued to grow and develop. Along with its little sister, the K1, many hundreds of units have been sold around the globe. The K2's performance and capabilities put it among the highest performing radios available on the market today. This small box is a powerful little radio that packs a real punch. It gives the top-of-the-line HF radios such as the FT1000 a real run for their money, as I will demonstrate later.

The K2 system—and it really is a "system"—is based on the basic HF transceiver, which provides a fully functional, 80–10 meter amateur band, HF QRP CW transceiver. The system allows you to mix and match the functions and capabilities you need. Therefore, if you're interested in QRP CW only, the basic radio will suit you. The system also allows expansion of the radio by adding additional plug-in modules such as an SSB generator, 100-watt solid-state PA, noise blanker, audio and DSP filters, RS232 interfaces, internal gel-cell batteries for portable operation, and a range of internal and external automatic ATUs and transverter units. By selecting the units that you need, the radio can be tailored to your individual requirements.

The radio itself is designed to be built by the average amateur at home, with little or no test gear. It does not use surface-mount components, and Elecraft makes a big thing about building without using surface mount. They want to keep the radio construction open to anyone who can solder, handle a few simple hand tools, and follow a detailed set of instructions. The radio does not need any expensive or hard-to-obtain test gear to align it. It only requires a digital multimeter! It was designed with test gear built in, and the radio's microprocessor control system with its analogue-digital converters monitors all the important signals, providing feedback to the operator during alignment. These functions include a general-purpose HF frequency counter, voltmeter, and ammeter. The built-in test gear is capable of being used around the shack as well. The K2 also includes Built In Test Equipment (BITE). If any fault is detected it is displayed on the transceiver's main display using a three-digit code.

Controls and Functions

Let's look at the radio from a purely aesthetic and operational view first.

The K2 measures 3" × 8" × 10" (75 × 200 × 250 mm) and the basic unit weighs around 3½ lbs. (1.5 kg). The supplied multipart case is of a high standard and is painted an attractive olive-green color. In an effort to give a very pleasing and attractive finish, the screen is displayed in two colors. It is also very professional looking and quite durable, as I found over the time I have owned the radio. Matching control knobs and a large weighted VFO are supplied in the kit. The transceiver is powered from 12 VDC and consumes less than 100 mA on receive. At less than 2 amps consumption on a 10-watt transmit setting, it makes a perfect Field Day radio! A small bail arm is used to tilt the radio upward when it is in use on a bench.

The radio is based on no-wire construction and uses interconnecting PCBs, with a plug and socket arrangement. The connectors join three main panels which comprise the front panel, control panel, and main RF board. All have gold-plated contacts. Despite numerous connections and disconnections during build and subsequent updating, I have never had any problems. The chassis is built on six parts, which are joined with specially designed junctions. The main radio functions are accessed from a scrolling menu system similar to most modern commercial radios.

Transceiver operations are selected by multifunction keys with two additional programmable function keys to make menu items available instantly. This multifunction key system is described by Elecraft as "dab/hold." A quick dab of the key gets the top function on the key legend, and holding the key longer gets the bottom function. I was very impressed by this, and it's very easy to pick up. If you try to select a function that is associated with a missing module, then the message 'NOT INST' is displayed on the LCD. An LED S/Power meter is located at the top left of the front panel. Normally, I dislike this type of meter, but perhaps something has to go in order to make the radio this small! The meter can be altered between dot or bar graph modes. Also, you can switch it off completely if you're a real low-power portable fanatic!

Other buttons control band switching,

(Continued on page 64)

AMSAT OSCAR-E Project Summer 2003 Status Report

This status report about AMSAT OSCAR-E ("Echo") is a companion article to the presentation given at the Dayton Hamvention® in May and the two previous articles published in the *AMSAT Journal*[1,2] and *CQ VHF*[3,4].

By Richard M. Hambly,* W2GPS

The AMSAT OSCAR-E satellite, also known as Echo, was conceived by the AMSAT Board of Directors on October 8, 2001 when they initiated review of "a new small satellite project." Since that time an expanding team of AMSAT volunteers has been working in cooperation with our contractor, SpaceQuest, on the design, construction, and launch preparations for this new satellite.

Photo A. Original Microsat model (left) and Echo mechanical model (right)

Echo is a Microsat-class satellite that owes a great deal of its heritage to the original AMSAT Microsats—AO-16, DO-17, WO-18, and LO-19, which were launched in 1990—and to the AMRAD-sponsored Microsat AO-27, which was launched in 1993. As shown in photo A, Echo is a small cube about 9.5 inches (25 cm) on a side, like those first Microsats. It is fabricated from a stacked set of aluminum trays and covered on all sides by solar panels.

Summary of Features

Echo will offer capabilities that will appeal to users with a wide range of interests, from "EasySat" operations to scientific experiments. Here are the highlights:

• Mode V/U, L/S, and HF/U operation. Modes V/S, L/U, and HF/S are also possible.

• Analog operation, including FM voice.

• Digital modes. Store-and-forward operation is planned. Many speeds are possible, but 9.6, 38.4, 57.6, and 76.8 kbps are the most likely.

• PSK31 repeater mode using 10-meter SSB uplink and UHF FM downlink.

• Four VHF FM receivers and two UHF high-power 8-watt transmitters.

• Can be configured for simultaneous voice and data.

• Multi-band, multi-mode receiver.

• Can be configured with geographical personalities.

• Advanced power-management system.

• Digital voice recorder (DVR).

• Active magnetic attitude control.

Technical Overview

Echo's internal subsystems have been refined and modified since they were described in the previous articles. As you will see in the accompanying photographs and figures, significant progress has been made and Echo's hardware is taking shape.

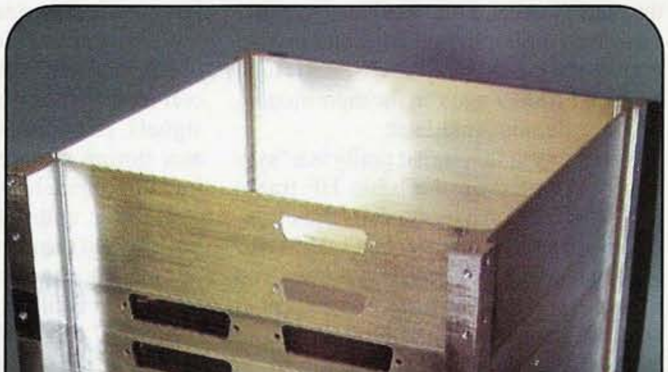

Photo B. The tray receivers of Echo.

**e-mail: <w2gps@amsat.org>*

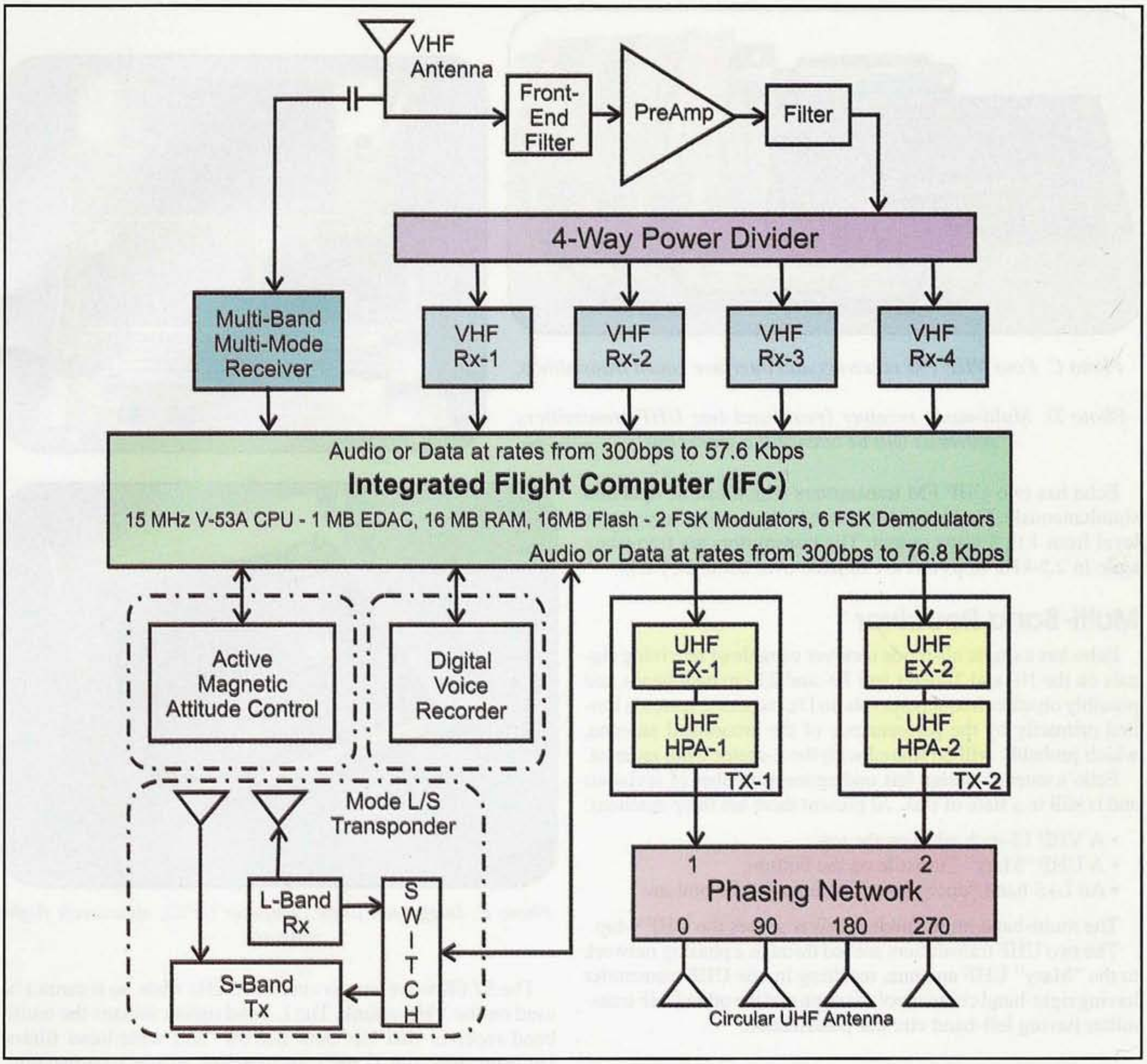

Figure 1. Block diagram of the Echo spacecraft.

As shown in figure 1, Echo is composed of a number of modules and subsystems, including:

- Four VHF FM receivers.
- A multi-band, multi-mode receiver.
- Two UHF transmitters.
- Six demodulators and two modulators.
- Integrated flight computer.
- Batteries, battery control regulator (BCR), regulators (not shown).
- Wiring harness, RF cabling.
- RF switching and phasing networks.
- 56 channels of telemetry.
- Magnetic attitude control.

Structure

As shown in photo B, Echo is fabricated from six trays, each made from solid blocks of 6061-T6 aluminum and stacked with stainless-steel sheer pins and four 4-40 tie-down rods. The tray dimensions are as follows:

- Receiver tray: 58-mm with 2-mm base.
- CPU tray: 24.8-mm with 2-mm base.
- Charger tray: 24.8-mm with 2-mm base.
- Battery tray: 38-mm with 2-mm base.
- Payload tray: 58-mm with 2-mm base.
- Transmitter tray: 39-mm with 9-mm base.

Thus, Echo has overall dimensions of approximately 9.5" × 9.5" × 9.5".

Echo has four miniature VHF FM receivers, each consuming less than 40 mW of power and weighing less than 40 gm each (photo C). Each receiver has two-channel capability, although it is not planned to use the second channel. The sensitivity of each receiver is –121 dBm for 12 dB SINAD.

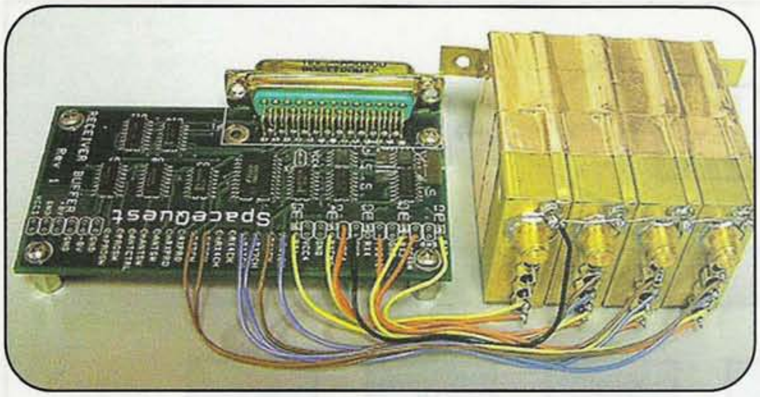

Photo C. Four VHF FM receivers and interface board transmitters.

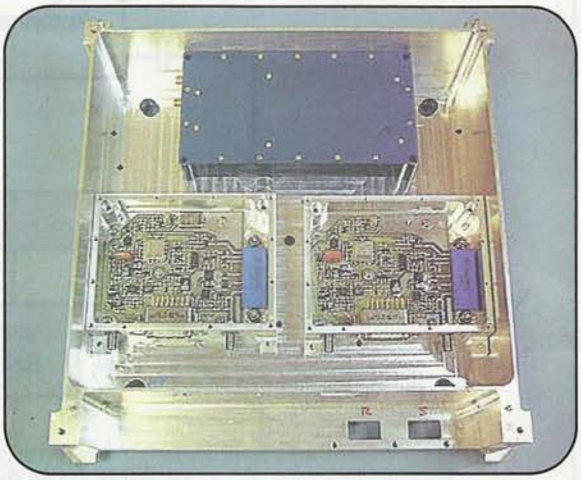

Photo D. Multi-mode receiver (rear) and two UHF transmitters. Antennas will be outside the spacecraft. →

Echo has two UHF FM transmitters which can be operated simultaneously. Each transmitter can be operated at any power level from 1 to 8 watts output. The transmitters are frequency agile in 2.5-kHz steps and are tunable over about 20 MHz.

Multi-Band Receiver

Echo has a single all-mode receiver capable of receiving signals on the 10- and 2-meter and 70- and 23-cm ham bands and possibly on other frequencies (photo D). Its performance is limited primarily by the performance of the broadband antenna, which probably will be shared with the 2-meter whip antenna.

Echo's antenna design has undergone a number of revisions and is still in a state of flux. At present there are three antennas:

- A VHF 18-inch whip on the top.
- A UHF "Mary" Turnstile on the bottom.
- An L+S band "open sleeve" antenna on the bottom.

The multi-band multi-mode receiver shares the VHF whip.

The two UHF transmitters are fed through a phasing network to the "Mary" UHF antenna, resulting in one UHF transmitter having right-hand circular polarization and the other UHF transmitter having left-hand circular polarization.

Link Budget Data

Echo's UHF transmitters are adjustable from 1 to 8 watts (figure 2). Maximum efficiency is achieved at 8 watts and that is the expected operating power level.

Antenna gain on the UHF is +2 dBic at ±45 degrees to –6 dBic at the backside of the spacecraft.

The VHF antenna feeds a low-noise amplifier (LNA) with 0.7 dB noise figure and 20 dB of gain. The LNA is followed by a bandpass filter with 1.5 dB of loss. The overall receiver performance is –125 dBm for 12 dB SINAD.

Data Modes

The modulation is either narrow-band FM voice or data using baseband-shaped raised-cosine-in-time FSK. Many data rates are possible, but 9.6, 38.4, 57.6, and 76.8 kbps are the most likely rates to see operational use. To be more specific, it is expected that 9.6 and 57.6 kbps will be used on uplinks and 9.6, 38.4, and 76.8 kbps on downlinks.

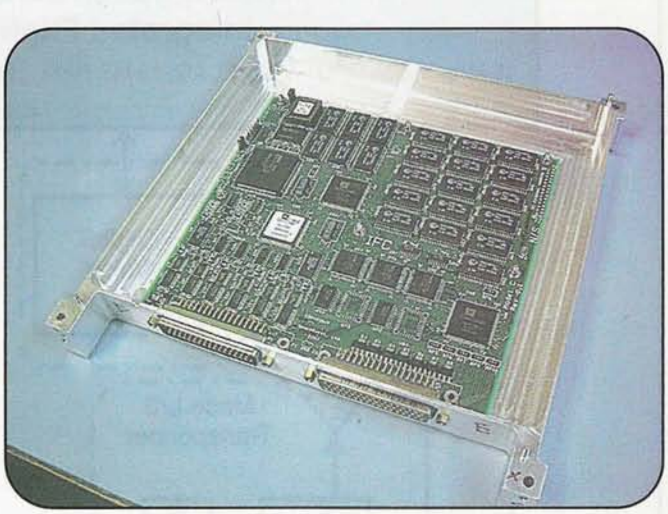

Photo E. Integrated flight computer (IFC), spacecraft flight software.

The 57.6K waveform is about 100 kHz wide, so it cannot be used on the VHF uplink. The L-band uplink utilizes the multiband receiver that has both narrow- and wide-band filters. Unfortunately, the 57.6K L-band uplink will be less than optimal, because the receiver's wideband FM-mode bandwidth is 150 kHz; it will take extra uplink power to overcome the additional noise from the mismatched filter bandwidth.

Downlinks will be 9.6 kbps on UHF (57.6 kbps is possible but not likely). Downlinks on S-band initially will be 9.6 kbps, with 38.4 and 76.8 kbps in use later. I expect that to test we will run S-band at 9.6 kbps in order to interest those with AO-40 stations. Then we will move to 38.4 and 76.8 kbps to get users excited about those faster speeds and gain experience on how they work with regard to Doppler.

We are looking forward to using 57.6 kbps. However, no ground equipment currently exists to support it, so operation of uplink or downlink at this speed will have to wait until some equipment becomes available.

Integrated Flight Computer

Lyle Johnson, KK7P, developed the Integrated Flight Computer (IFC). It is a flight-proven board with a power con-

(Continued on page 80)

Working the "Lower 48" on 2 Meters Without EME

In the central part of the continental U.S. there is an imaginary circle where there is the potential of working hams in all 48 of the contiguous states on 2 meters without EME. However, only a few have been successful. For the last two years the first-place winner in the Central States VHF Society States Above 50 MHz Contest has been KMØT. Here he tells the fascinating story of how he worked the Lower 48 on 2 meters in less than six months!

By Mike A. King,* KMØT

This is an incredible ham radio success story made possible through a lot of skill, advancing technology, a great deal of cooperation from fellow VHF+ operators, and a fair amount of luck. It all is still sinking in! First, however, some background is in order.

Some History

I was first licensed as KAØDXG in 1979. I obtained my Extra Class ticket in 1981, and along with it the call KMØT. I operated a lot in the early '80s during sunspot Cycle 21. I then graduated from high school in 1982, went to college, got a job, got married, bought a house, and Colleen and I had our first child, Patricia. I rarely operated after 1982–1983, until mid-November 1998, when the ham radio bug bit me again!

Changing jobs and ending up in Sioux Center, Iowa around 1999 brought ham radio back into the spotlight. Having a house and settling down seemed to trigger that inner voice. About then I started becoming interested in the VHF+ ham bands.

Prior to early 1999, I had limited my ham radio activity pretty much to HF and some FM on repeaters. However, during early 1999 I got on 2 meters and into weak-signal work. What got me all tweaked up about VHF was a hamfest I attended in St. Paul, where I listened to a talk about weak-signal communications by Jon, WØZQ, and Rich, NØHJZ. They explained the basics of VHF/UHF without FM. I was not only intrigued, I was also totally confused. Coming from an engineering background, I understood the concepts. Initially, all the new jargon to learn seemed somewhat overwhelming. To get myself going in the right direction, I knew I had to ask a few questions about propagation modes and operating procedures.

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e-mail: <km0t@arrl.net>

The author's wife Colleen and older daughter Patricia at the station. Now if only they would get their ham licenses!

At the end of the talk both Jon and Rich indicated that there was a club called the NLRS. The Northern Lights Radio Society is a group of weak-signal-type operators based mainly out of the larger portion of Minnesota and some parts of the surrounding states. They indicated that there was an e-mail reflector where anyone could post messages, as well as be on the receiving end of information. I knew that this was where I could ask my questions in order to get going.

Someone Let the Cat Out of the Bag!

As I began to post various technical questions to the NLRS reflector, I started learning about the types of coax available, their loss figures, etc. Also, items such as antennas, rotors, and rigs were good discussion points. Ed, WØOHU, responded to one of my questions. He indicated, in an informal fashion, "Ya know, you can work all 48 states from there without EME. There are a few others who have done it from your area."

"Hmmm," I thought. It seemed like a neat idea. I figured I had better get some antennas and radios going!

If Ed had never said anything, I probably would have just been destined and satisfied to chase grids, but working all states intrigued me. "Heck," I thought. "It can't be that tough. I think I can do it in a year." Now that I look back, how little did I know!

My First Aurora Contacts

At the beginning, February 1999, I was running a homebrew Quagi on 2 meters. It had an approximately 12-foot wood boom, and it was up around 65 feet. At the time I was using an FT-847 and 50 watts. At that point I had just a few 2-meter SSB QSOs under my belt.

On February 17, 1999 I fired up my rig and pointed the antenna at EN34. I called CQ and never thought anyone would come back to me. Well, I heard a weak station and finally found out where he was. It was Jerry, WBØAUS, in EN11, Nebraska. My jaw dropped in amazement as I realized I could work that far away on 2 meters. My state count was beginning with my first 2-meter QSO!

The only time I had heard aurora-type CW was back when I listened to a tape of raspy CW at the talk put on by WØZQ and NØHJZ. A few days after my first QSO, I remember leaving the rig on for the weekend, squelched, so I did not have to listen to the white noise. I came strolling by the ham shack on a Sunday afternoon and heard the raspy sounds. I excitedly ran to tell my wife Colleen about the aurora propagation, and to say I was going to give it a go. A "That's nice, honey" was all I needed to start chasing some real DX!

I worked a number of stations, although I was shaky and it was quite nerve racking. I could not figure out right away what 59A was (the "A" indicating that the tone received had the characteristic raspy auroral sound to it), as true to my HF habits, I was sending 599. That's how green I was. Also, getting down the grid exchange and sequences took a bit of getting used to. It was years since I had been on CW. All in all, though, I muddled through it and had my first real 2-meter DX under my belt!


Mike, KMØT, at the station console.

The rest of the winter and spring around the equinox held many aurora openings. I was getting the hang of how to predict and guess when to be on the air. Between the aurora openings and the weak winter tropo conditions, I had my first batch of states under my belt—the easy ones.

Now that I look back at my old logs of those first openings, I see the calls that I now have come to know and hear on a regular basis. I appreciate those guys working my shaky CW so that I could cut my teeth on aurora!

Getting Some DX on *E*-Skip

Springtime came, and along with that came some station improvements. I put up two M² 2M9SSB Yagis, stacked 9.5 feet apart. The top one was mounted at around 70 feet. Also, I had upgraded the power to a Teletec brick, good for about 175 watts.

I studied all the books and articles about how to predict sporadic-E propagation that I could find. The book *Beyond the Line of Sight*, edited by Emil Pocock, W3EP, and published by the ARRL, seemed to be the best one. Also, I learned about the "propagation loggers" and checked in regularly to see what was going on on the 2-meter band. The 144-MHz propagation logger sure is a good tool.

I recall reading how some folks monitored the FM broadcast band for *E*-skip conditions with hopes that the MUF (Maximum Usable Frequency) would make it to the 2-meter band. On Friday, June 18, 1999 I saw postings on the logger that said that Larry, NØLL, and others were receiving Los Angeles FM broadcast stations in the Kansas area. It was about quitting time at the office, so I ran home to see what was brewing.

I checked the geometry of Los Angeles to NØLL's QTH in EM09. I figured out a rough midpoint between the two locations and pointed the Yagis in that direction. It looked to me as if the path was to the southwest, just a bit north of Phoenix, Arizona. Within a few minutes I thought I was hearing a weak station calling CQ on SSB. I started calling CQ myself.

Within a few more minutes I realized that I was hearing a station with the call AA7A. "Wow!" I thought, "I think that this guy is in Arizona!" His signal was just above the noise, and I believe I got his attention a few times, but that was about it at the time.

Then I realized that the AA7A station, though still very weak, was chatting with someone else locally. All of a sudden the signals jumped to 59+20 and the two were still talking! I was so completely blown away by these two operators, who were clear as a bell, that I could hardly stand it! I recall their discussing that the band had died and it "looked like it was all over."

As soon as they let up on the microphone, I basically yelled in my excitement, "QRZ KMØT in EN13!"

Quite surprised, Ned, AA7A, replied and we worked right away. Then I worked his partner, Tom, W7RV. Continuing to call CQ a bunch, I raised a few other stations. It seemed that no one was there, but then all of a sudden a station would come back out of the blue 59++. I also heard plenty of SSB "bursts," which indicated that just brief moments of propagation were coming through.

I thought the band was dead, when a station in California (Rowan, K6DV) came through loud and clear. What can I say? It was a grand experience! Arizona and California on 2 meters. It just kept getting better! The really neat thing was that I worked Ned, AA7A, a few days later on 6 meters. We began talking about the opening, and I quizzed him on all he could tell me about 2-meter *E*-skip.

Just days later, on July 7, 1999, I managed to work some *E*-skip to the southeast. Howard, K4QI, among others, was worked to get a few states down there. To add to the excitement, on July 10, 1999 I was chatting with some guys to the east on 6 meters. The conditions were particularly weird, and I was hearing lots of weak signals from locations other than the main skip area. I discussed this phenomenon with Richard, AI3W, on 6 meters, and he told me that the "short skip" conditions may have been an indicator for 2 meters, and he was going up there to have a look around.

I took his advice and went to monitor 2 meters as well. I heard some strange bursts of noise on the calling frequency that I had never heard before. I figured it could be some audio just barely coming through on *E*-skip. Two quick CQs produced stations coming back to me 59++. Ed, W3EKT, Dave, K1RZ, and Russ, K2TXB, were quick to answer the calls. I also worked Rick, AI3W! I guess his advice paid off. Just like that, I had three more states!

My First Big Tropos!

Throughout July, between the exciting *E*-skip openings the local conditions were improving. I was discovering that I could work out quite a distance. I managed to get all the surrounding states and a lot farther to the east as well as to the southeast. Kentucky, Tennessee, and Ohio, states missed on aurora and passed over on *E*-skip, were easy pickings. These "Training Tropos," as I now call them, were great opportunities to learn how to get a feel for tropo conditions. I

The author giving his acceptance speech at the 2002 Central States VHF Society banquet after receiving the States Above 50 MHz Contest first-place plaque for the second year in a row. (N6CL photo)

worked the weak signals as far as the edge of the tropo openings were terminating. I managed to make a number of higher band contacts as well.

August, however, brought some tropo conditions that were pretty darn good. Many of the southern to southeastern tier states were worked. Among them were Texas, Oklahoma, Alabama, Mississippi, Louisiana, Georgia, and Arkansas. While I could see the state totals rise, these openings tired me out, because I had a hard time going to sleep with signals out of the southeast still 59++. These great tropo openings provided lots of opportunity to ragchew a bit, thus learning a lot from the experienced guys who were on the band.

Lost to Meteor Scatter

After making the several contacts on tropo, I took time out to count the states to date. I observed that I had some huge holes in certain parts of the country, mainly the New England states and the Pacific Northwest area. One evening while on 2 meters I came across Dick Hart, KØMQS. He laid it all out for me—the "ins and outs" of meteor-scatter propagation. I enjoyed listening, as he told me about how he did the lower 48, and I believe he was the first ever to do it! (No internet either, I might add!)

Dick explained some background information and got me up to speed on the data on the various meteor showers. He also explained the sequencing procedure, the importance of making schedules, the necessity of having accurate clocks, and the need for frequency control. I took in all of this and got very excited as he told amazing stories of the *Leonids* shower in 1963. He even mentioned that shortly after being on the air and working stations during the *Leonids* of 1963, he received an SWL card from the USSR. His signal was received on 144 MHz way over there during the shower. Dick indicated that he thought it was a fake, and he had never mentioned it to anyone. I told him that the story should at least be told because it might be true!

Having received all that information, the August *Perseids* meteor shower was at hand and I was going to see what all the hoopla was about. In addition, I was going with a great deal of information that Chris, NØUK, had explained to me on how to do High Speed Meteor Scatter (HSCW). I had just finished working on an HSCW interface, and I was going to give it a try. Then I completed an HSCW contact with Shelby, W8WN, to test the entire system.

During the shower between August 12 and 13, my wife heard all kinds of commotion from the ham shack—strange sounds of HSCW pings and blips along with 15-second spurts of my shouting "S2 S2 S2" and "Roger Roger Roger" over and over. She knew I was really hooked when I shouted out of the ham shack, "Hey, I just caught a huge 'blue whizzer' and worked DN13 on a 12-second monster burn!"

I finished the *Perseids* by having an SSB contact with WA1OUB (now K1SIX) for New Hampshire. Boy, was that some good 2-meter DX, which was random on 144.200 MHz as well!

More States via Long-Haul Aurora

More sunspots popped up in late September 1999, causing some good 6-meter conditions as well as 2-meter aurora. Del, K1UHF, came out of the noise with a 55A signal one afternoon for a new state. I also picked up more states to the west via aurora.

One evening I was treated to a VK opening on 6 meters. I know it's not related to working the lower 48, but it's a significant event that was aurora generated in conjunction with the solar-flare index and current state of the sunspot cycle.

Leonids 1999 The Big Show?

The 1999 *Leonids* was predicted to be the big show for meteor scatter and ping jockeys. I was told that the 1998 *Leonids* had been very good, and most were predicting that the 1999 event was to be the storm! This prediction was based on the 33-year period of the comet that causes the *Leonids* from 1966 to 1999. People were becoming very excited, eagerly awaiting the fireworks to begin!

The predictions were a bit oversold, and many operators said it was better in 1998. I really had nothing with which to compare it. I did not make very many contacts during the 1999 *Leonids*, but the ones I did make were awesome! Several of the five contacts I made were new states! In fact, one QSO on HSCW was made with Joe, K9KNW, in south Florida, which was the HSCW distance record for some time, until John, KØPW, squashed it a year later during the next *Leonids* shower. Oh, well!

Meteors to End the Year

The *Geminids* shower produced a new state for me. On December 14, 1999 I had an SSB meteor-scatter QSO with Dave, K1WHS, in Maine. Maine was the farthest away New England state I needed to work. A few weeks later the *Quads* meteor shower came in, and I managed to work both Steve, KØXP, in Massachusetts and Maarten, W1FIG, in Rhode Island on HSCW. Each of these great contacts, which took about an hour, were well worth the effort. They were the only hams I was aware of in these states who were doing this type of weak-signal work.

End of the First Year

As I ended my first year of weak-signal work on 2 meters, a bleak picture began to emerge. It appeared that I would not make my goal of working the lower 48 without EME in a year. Despite my efforts, it became apparent that with the minor showers, SSB was not the mode to use if a contact was desired. However, if operators in the states I was missing had been running HSCW, I would have completed my goal. I also noted that most of the showers seemed to favor more north-south paths, not the directions I needed the most.

My count at this time was at 40. I still had to work Delaware, Montana, New Mexico, Nevada, Oregon, Vermont, Virginia, and West Virginia.

The Next Six Months

By the middle of September 2000, a combination of tropo, aurora, and meteor scatter produced six more states, which seemed to fall into place fairly well. I picked up Virginia on long-haul aurora. I worked Shep, W7HAH, on some fairly rare aurora to the west. Meteors accounted for New Mexico on SSB with David, N5JHV, and Oregon on HSCW with Barry, KA7V. West Virginia came in on some late season tropo. I picked up Nevada on HSCW during the June VHF QSO Party. However, there still were the elusive two—Vermont and Delaware. I had been running schedules with K1LPS for Vermont to no avail. Furthermore, I could not find any operators in Delaware who were willing to run.

Depression Sets In

At the end of a year and a half I was at 46 states. The next year-plus brought many schedules to Vermont with K1LPS. Larry and I tried a number of times during different showers, but we only heard each other a few times here and there on SSB.

Twilight view of the VHF+ antenna array.

I still had no luck with Delaware, as folks there on 2 meters were pretty scarce. I was beginning to wonder if getting the last two states would ever happen. There was very little activity in these regions, and no HSCW.

Ah . . . WSJT!

Thanks to Joe Taylor, K1JT, the software program WSJT premiered, producing some new life and activity in meteor scatter. Virtually overnight, HSCW became a forgotten mode. I discussed WSJT with Larry, K1LPS, who was working on his setup, which was taking some time. He mentioned that he had a friend who might be getting on using WSJT, and he said would let me know.

States Above 50 MHz for CSVHFS

Gradually other goals took precedence, because it seemed that contacts with Vermont and Delaware would never happen. I began to get into the Central States VHF Society "States above 50 MHz" operating event, and I submitted scores for the 2000–2001 event. In that year from, July 1, 2000 to June 30, 2001, I posted a 144-MHz state count of 34, all without EME.

Having a very good outcome for the operating event that year, I decided to really go after it again for the 2001–2002 event. With July 1, 2001 marking the states count going back down to zero, and thus starting over again, good tropo conditions in July started the 2-meter count increasing quite rapidly, all the while thinking about how I was going to get Vermont and Delaware.

Perseids 2001

By the time the *Perseids* rolled around on August 10, 2001, my state count was at 15 on 144 MHz. All were on tropo except one, a fantastic sporadic-*E* contact to Florida. With WSJT taking hold of many folks and creating new activity, I jumped head on into the *Perseids* with full force.

By the end of the *Perseids* I had 30 more QSOs on meteor scatter and the state count was now at 33! Eleven states were picked up on WSJT, one on HSCW, and three on traditional SSB. The *Perseids* proved to be the shower that really favored WSJT.

The next few months brought in seven more states via tropo and aurora. By the time the *Leonids* rolled around, I was sitting at 40 states for the year. However, I was still looking for Delaware and Vermont for the overall 48.

Leonids 2001 Fireworks

Lots of talk had been traversing the internet, as well as the airways, all about whether this was the year the *Leonids* would be the "storm." Certain astronomy figures were good predictions for the U.S. mainland. Going on that information, I began a steady attempt to get Vermont and Delaware on the air. The state count for the CSVHFS award was "good enough," and I was going to concentrate on looking for the two states I needed for the lower 48.

The previous couple of months had been spent on e-mail with K1LPS about his coming on board with WSJT. He did not think he was going to be ready, but he indicated that his neighbor, Mike, N1JEZ, was going to be getting on WSJT. With that, Mike and I corresponded and set up skeds for the *Leonids*. He had a few 6-meter QSOs on WSJT, but to my knowledge, he didn't have any on 2 meters.

In addition, right before the *Leonids* I got a flurry of e-mails from operators in Delaware who just were not going to be on the air. That really took me down a notch. However, I thought I would take a chance and bug "Brian the Rover," ND3F, to see if he would make a little trip to Delaware. Brian and I had e-mailed over the last year, but with schedules and equipment/car problems he was never able to make the trip for me. Well, as luck would finally have it, he e-mailed back and said he would take a little trip "just across the state line" for me!

Mike, N1JEZ, and I decided to run early Saturday morning. At 1145 UTC, November 17 on WSJT we completed the contact with little effort because the pre-*Leonids* rocks were fairly good. Wow! What a deal that was! I had finally nailed Vermont for state #47 overall and #41 for the year! It was neat running with him early; that way I could concentrate on "Brian the Rover" and his stacked Yagis. I could just imagine Brian cruising with the rover, seeing the state line, and finding a spot where he could swing the Yagis to the east!

After that things got better. I had some time to kill until my SSB schedule with Brian, so I hung out at the radio most of the day just to monitor the action. Six meters was buzzing that day as well, and I worked a bunch of DX, including JA, KH2, and V73, so it was a good day to be around the shack.

At one point toward the evening of the 18th, I was listening on 144.200 MHz, just minding my own business, when at 0645 UTC, Charlie, KK4TE, in Alabama came barreling through on a good long burn. I jumped on the microphone quickly, and we completed without any trouble. We even had time to say "Nice to work you again!" Charlie and I had worked on a sporadic-*E* opening the year before on 2 meters. I was using a single HO loop and 25 watts from the truck mobile that day, so it was a pretty special contact.

Anyway, this second contact put me at #42 for the year. After that I began to pay a bit more attention, as the calling frequency started to buzz with action.

Finally Brian arrived in Delaware, and our schedule was successful. He was weaker than some of the other stations I had been hearing, but I was not complaining! It was a 15-minute sked that we had set up, and we finished right at the end of that time period.

What a feeling to have it all finally come together! I had worked all 48 states without EME on 2 meters. It took longer than I predicted, but I certainly did not know what I was talking about two years and nine months earlier!

A Few More?

I leaned back in my chair and thought for a minute. Now what? With Brian's contact I was sitting at 43 states for the year. Could this get any better?" I thought I might as well chase a few more states to see if I could get just a few more for the year. I scrambled back to the calling frequency on 2 meters, and I could tell that things really were starting to pick up.

At this point I had no idea what was about to happen. "Lady Luck" was apparently in the house that night, and my wife was not kicking her out! Things just started to fall into place.

The calling frequency became a madhouse at around 0900 UTC, and the rocks appeared to be very intense to the south-

Station Setup

During the time frame of about three years I made a number of station modifications. Initially, I started with a Yaesu FT-847 and ran barefoot with a homebrew Quagi.

As mentioned in the main article, approximately six months later I upgraded to a Teletec Brick, which gave me about 175 watts, and changed the antennas to two stacked M^2 2M9SSB antennas. The vertical stacking distance was 9.5 feet, with the top antenna at around 70 feet. These antennas, which work really well, give good gain for their boom length. The pattern is not too sharp either, and it has aided in meteor-scatter work, tropo, and contests. I am able to hear signals off the side, so I can contact those who are not right on the beam path. Also, I ran a mast-mounted preamp from SSB Electronics for some time.

Note that these antennas are spaced relatively close together, with 222 MHz and 6-meter Yagis between them. Even so, they still play very well in this non-optimal configuration. If you are interested in replicating this setup, you might work with the mast length you have. Fortunately, I was lucky to find a configuration that works.

Approximately six months after the antenna upgrade I switched to a Yaesu FT-1000MP as the IF rig and a Downeast Microwave transverter. I ran that equipment for a while. Then I came across an SSB Electronics LT2S transverter. When I switched to the LT2S, I eliminated the mast preamp (I found I did not need it.) and upgraded my power to 300 watts with a TE Systems amplifier, which has been the station configuration for a year or so. The feed line is LMR-600, with LMR-400 up the mast and for the phasing harness. Topping off my 2-meter configuration is the HSCW/WSJT interface, which is a Rig Blaster from West Mountain Radio.

For other station equipment on the rest of the VHF+ ham bands, 50 MHz and up through 10 GHz, see my website: <http://www.qsl.net/km0t>.

west. I pointed that way and tried to make a few contacts, but the QRM was pretty bad. Consequently, I jumped down a few kHz and started calling "CQ Scatter." Much to my surprise, at 0947 UTC Jim, NW7O, came in clear as a bell! *Viva Las Vegas,* and Nevada for number #44!

I called a bit more where I was, with no takers. I moved up to 144.200 MHz, where I decided to slug it out for a bit. Through the QRM, at 1030 UTC, I managed to work Pat, N6RMJ, in California for #45! Completing with Pat, I exclaimed to myself, "Holy smokes! All the states to the west are done for the year!"

I was starting to wonder, "Would it be possible to work all 48 in a year for the CSVHFS States above 50 MHz Contest?" I shrugged it off and continued pursuing the bands. Chances were pretty slim, I figured, with Massachusetts, Tennessee, and South Carolina left to work. I figured that Tennessee would be possible, but the others would be a long shot.

When You're Hot, You're Hot!

Well, as luck would have it, at 1045 UTC I saw a posting by Ivan, K1MS, in Massachusetts, stating that he was calling on 144.125 MHz. I quickly swung the antennas around and spun the dial. Almost immediately I heard him on a solid burn. I put out my call and grid, and we completed without any effort! I thought I would never work that state again on 2 meters!

Because the band was still filled with signals, I worked a few more stations, and Gary, KE8FD, popped up on the propagation logger. He posted that he wanted to meet on 144.220. "It would be nice to work Gary again," I thought, because I knew he recently had moved, and he had not been on the air very much lately.

I decided to look up where he was located, and believe it or not, he was in South Carolina! I had not realized nor remembered that that was where he had moved. Again, I repositioned the antennas and heard him right away. Within a few minutes we completed at 1112 UTC on SSB with little effort.

Knowing that I only needed Tennessee, I posted to the logger that I was looking for stations there. Right away, Bill, W4HP, came back, and we met on 144.225. We managed to work with a bit more difficulty at 1116 UTC. The reflections were quite weak at the shorter distance, sounding mostly like backscatter from the meteor burns.

Completely amazed at the round of luck that had just transpired, I just sat there. I had worked the lower 48 states on 2 meters without EME from July 1 to November 18th, less than 6 months, for the CSVHFS event!

Reflections

Now that I look back, it seems as if technology really had the upper hand in all this. There are many factors that contribute to making things much easier than they had been in the past.

The internet is a wonderful tool for coordinating schedules on the fly, and e-mail makes it very easy to set up things in advance. In addition, the information available on tropo propagation events, meteor predictions, aurora openings, and sporadic-*E* indicators is right at your fingertips if you wish to use it. Also, callsign lookups of station QTHs on the fly via the call book servers is a necessary tool. The internet combined with amateur radio surely makes the world a smaller place, all at the touch of a button or the spin of a VFO. They work well together!

Two-meter CW/SSB hardware is quite readily available now with HF/VHF multimode rigs, making the number of operators greater and the chances of contacting someone much better. Brick amplifiers are also affordable; you don't need a KW if you work at it.

Software such as MSDSP for HSCW and WSJT makes it possible to take advantage of meteor-scatter propagation almost any time of the year. New modes such as JT44 will make this even better for tropo-type propagation and JT44 is already making big headlines.

All these factors, combined with being at the right place at the right time, make it possible to do things that were much more difficult to accomplish in the past. I give credit to those who did it the hard way and paved the way in the first place. I also want to give credit to all the operators I worked who took the time out to find me and put up with my schedules.

I also thank my wife Colleen, who put up with my ranting and raving about all of this. She is a true hero, and a staunch supporter of my hobby! ■

How to Transform a Transformer

If the transformers in your junkbox never seem to be exactly what you need for a project, VE3ERP has a solution–wind your own–and a computer program to do all the math.

By George Murphy,* VE3ERP

Did you ever have the urge to get the exact power transformer needed for a project by rewinding an old transformer from your junk box? There are several methods of selecting a transformer to rewind for a particular application. Most of them, at least in my experience, result in my trying them all and finally using the one that blows the fewest fuses.

Recently, I had occasion to design a multi-voltage DC output power supply to replace the multitude of wall-wart DC "power supplies" cluttering up every wall outlet and power bar in a friend's entertainment and computer center. The design was no problem; it was just an enlarged version of the SUPER ACADAPT[1] I have in my hamshack, but I needed a larger transformer to run it. Rather than use my usual pragmatic FUD (Fumble Until Done) technique, I decided to do it right.

What it boils down to is this: The best way to transform a transformer is to design what you want from scratch the way engineers do, look for a transformer in your junk box with a core size close to what is needed, and transform it!

A Few Definitions

I will try to spare you one of my personal pet peeves. Often when delving into an intriguing article, I am frustrated by the author using esoteric terminology I do not understand, on the assumption I am already an expert on the subject. Thus, if you are unfamiliar with "transformerspeak," here are a couple of terms you should be aware of:

Current Density (measured in circular mils [C_M] per ampere): This defines the current carrying capacity of a conductor. The higher the current density, the more current can be carried. In a power transformer this means that for a given current, high-current-density wiring will run cooler but takes up more space and requires a larger and heavier core than low-current-density wiring. It is good practice to design for the lowest current density that will do the job. Some typical densities commonly used for small power transformers are:

500 C_M/amp—intermittent light-duty service (e.g., small appliances)

700 C_M/amp—continuous-duty commercial service (e.g., communications equipment, computers)

1000 C_M/amp—continuous heavy-duty service (e.g., industrial generators, military equipment)

Core Flux Density (measured in gauss): The number of magnetic force lines per unit area. The flux density employed depends on the application, the power rating, the core material, and the frequency. Designing for a flux density higher than actually required results in larger cores and heavier wires than necessary. For small transformers (up to about 50 volt-amperes, or VA) flux densities of about 14,000 gauss are commonly used.

Selecting inappropriate values of current density and core flux density may result in excessive size, inefficiency, and/or possible overheating of the transformer.

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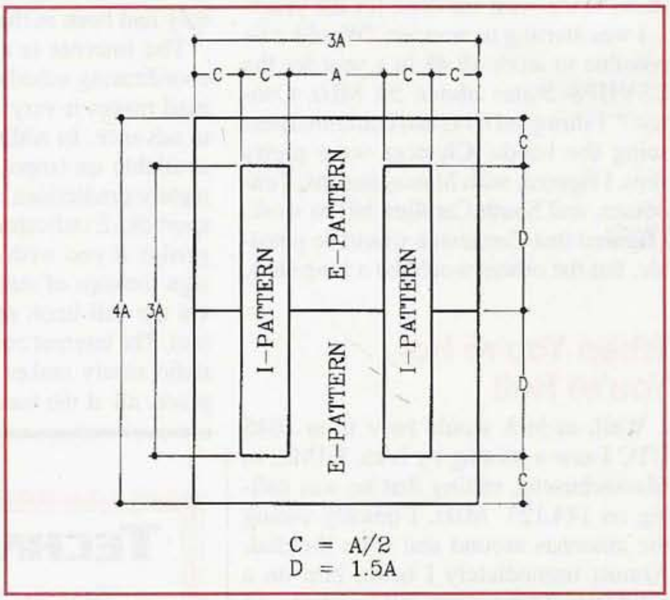

Figure 1. "EI" lamination blank for cutting transformer cores. There is no waste in this process. Figure 2 shows how the cut pieces go together.

Typical Standard Lamination Dimensions
(all dimensions in inches)

Type	Blank Size	A	C	D
75 EI	2.250 × 3.000	.750	.375	1.125
87 EI	2.625 × 3.500	.875	.4375	1.3125
125 EI	3.750 × 5.000	1.250	.625	1.875
150 EI	4.500 × 6.000	1.500	.750	2.250

Table A. The typical standard lamination dimensions.

The Anatomy of a Power Transformer

The most common core form for small power transformers is the *EI* configuration, so named because the shapes of the segments resemble the letters *E* and *I*. Figure 1 shows how these segments are stamped from rectangles of sheet-iron alloy with no waste whatsoever. The two shapes are interleaved through a coil as shown in figures 2 and 3 to form the transformer core.

It is interesting to note how dimensions C and D are related to dimension A (C = A/2; D = 1.5A). When assembled, this forms two rectangular C wide paths for the magnetic lines of force, joined along their long sides where they become a single tongue A (2 × C) wide. Thus, it is only necessary to establish dimensions A and B to design the entire core. Once you have these dimensions, you can rummage in your junk box for a transformer with a similar-size core and carry on with the design process to determine the specifications for the new windings.

Design Philosophy

The design goal is to find the smallest possible standard core that meets your specifications with windings filling the core "windows" to maximum possible capacity. The inevitable inherent air gaps between the windings and the frame (shown exaggerated in figure 3) should be kept as small as possible. To do all this it is only necessary to decide the following:

a) Power mains voltage, and frequency in Hz.
b) Desired output voltage.
c) Desired output current in amperes.
d) Your choice of current density, in circular mils per ampere.
e) Your choice of core flux density, in gauss.

Using the Equations

If you're a math-sensitive type, you've probably noticed with fear and trepidation that this article includes 30 different equations. Fear not. I have a computer program that will do the math for you. For those who really want to understand how all this works, though, I'm going to walk you through using each of the equations.

Let's use a textbook example[2] to design a transformer with the following specifications:

a) Input 110 VAC at 60 Hz
b) Output 50 VAC
c) Output current 2 amperes
d) Current density 1000 circular mils per ampere
e) Core flux density 13,000 gauss
f) Estimated efficiency 0.90 (90%)

Plug these values into the equations shown in Table B and Table C as follows:

1) Eq. 1: Volt-Ampere Rating
$V_A = 50 \times 2 = 100$ VA

2) Eq. 2: Wa Product
$W_A = (17.26 \times 1000 \times 100) \div (60 \times 13000) = 2.2128$

3) Eq. 3: Optimum A Dimension
$A_{OPT} = (2.2128 \div .75)^{(1/4)} = 1.3106$ inches

4) From your junk box you select a transformer with the following core dimensions: A = 1.25", B = 2.0", C = 0.625", D = 1.875". You decide to use these dimensions in your calculations.

5) Eq. 4: Optimum B Dimension
$B_{OPT} = 2.2128 \div (1.25 \times .625 \times 1.875) = 1.5106$ inches

6) By removing some of the laminations you will be able to reduce B to 1.500 inches, so you decide to use 1.5 inches as dimension B in your calculations.

7) Eq. 5: Input Power
$P = 100 \div .9 = 111.11$ watts

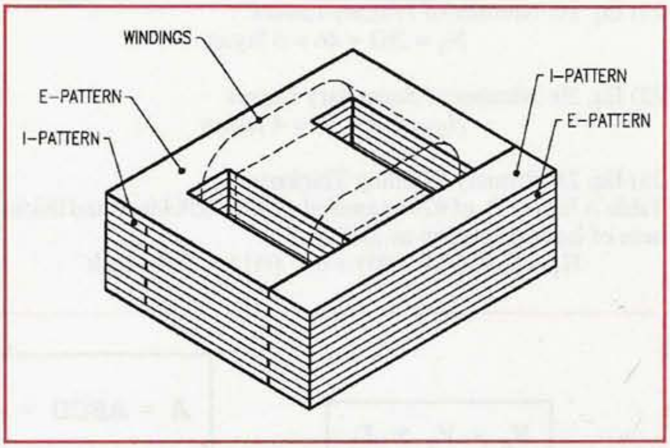

Figure 2. Transformer core stack assembly, using the "E" and "I" shaped metal pieces cut from the blanks shown in figure 1.

8) Eq. 6: Input Current
$I_1 = 111.11 \div 110 = 1.010$ amperes

9) Eq. 7: Output Current
$I_2 = 100 \div 50 = 2.000$ amperes

10) Eq. 8: Number of Primary Turns
$T_1 = (110 \times 10^8) \div (28.64 \times 60 \times 1.25 \times 13{,}000 \times 1.50)$
$= 263$ turns

11) Eq. 9: Number of Secondary Turns
$T_2 = 263 \times (50 \div 110) = 119$ turns

12) Eq. 10: Primary Wire Diameter (circular mils)
$A_1 = 1000 \times 1.010 = 1010\ C_M$

13) Eq. 11: Primary Wire Diameter (inches and AWG)
$W_1 = 31.7805 \div 1000 = .0318$ inch
Table A shows the nearest AWG size to be #20

14) Eq. 12: Secondary Wire Diameter (circular mils)
$A_2 = 1000 \times 2.0 = 2000$ circular mils

15) Eq. 13: Secondary Wire Diameter (inches and AWG)
$W_2 = 44.7213 \div 1000 = .0447$ inch
Table A shows the nearest AWG size to be #17

16) Eq. 14: Window Space Available for Coil (figure 3)
$H = .625 - .092 - .02 = .513$ inch

17) Eq. 15: Width of Primary Winding (figure 3)
$L_1 = 1.875 - (2 \times .125) = 1.625$ inches

18) Eq. 16: Width of Secondary Winding (figure 3)
$L_2 = 1.875 - (2 \times .188) = 1.499$ inches

19) Eq. 17: Number of Primary Turns per Layer
Table A lists 28.4 turns per inch for #20 enameled wire.
$N_{L1} = 1.625 \times 28.4 = 46$ turns

20) Eq. 18: Number of Secondary Turns per Layer
Table A lists 20.1 turns per inch for #17 enameled wire.
$N_{L2} = 1.499 \times 20.1 = 30$ turns

21) Eq. 19: Number of Primary Layers

$$N_1 = 263 \div 46 = 6 \text{ layers}$$

22) Eq. 20: Number of Secondary Layers

$$N_2 = 119 \div 30 = 4 \text{ layers}$$

23) Eq. 21: Primary Winding Thickness
Table A lists O.D. of #20 enameled wire as .0364 inch and thickness of layer insulation as .005 inch.

$$H_1 = 6(.0364 + .005) = 6 \times .0414 = .2484 \text{ inch}$$

24) Eq. 22: Secondary Winding Thickness
Table A lists O.D. of #17 enameled wire as .0506 inch and thickness of layer insulation as .01 inch.

$$H_2 = 6(.0506 + .01) = 4 \times .0606 = .2424 \text{ inch}$$

25) Eq. 23: Total Coil Build-up (figure 3)

$$H_3 = .2484 + .2424 = .4902 \text{ inch}$$

26) Maximum efficiency is attained when the coil completely fills space H. At this point compare H_3 (.4902 inch) with H (.513

$$V_A = V_2 \times I_2$$
Eq. 1

$$A = ABCD = \frac{17.26\,SV_A}{fG}$$
Eq. 2

$$A_{OPT} = \left[\frac{W_A}{0.75}\right]^{\left(\frac{1}{4}\right)}$$
Eq. 3

$$B_{OPT} = \frac{W_A}{0.75A^3}$$
Eq. 4

$$P = \frac{V_A}{E_{EST}}$$
Eq. 5

$$I_1 = \frac{P}{V_1}$$
Eq. 6

$$I_2 = \frac{V_A}{V_2}$$
Eq. 7

$$T_1 = \frac{V_1 \times 10^8}{28.64fAGB}$$
Eq. 8

$$T_2 = T_1\frac{V_2}{V_1}$$
Eq. 9

$$A_1 = SI_1$$
Eq. 10

$$W_1 = \frac{\sqrt{A_1}}{10^3}$$
Eq. 11

$$A_2 = SI_2$$
Eq. 12

$$W_2 = \frac{\sqrt{A_2}}{10^3}$$
Eq. 13

$$H = C - B_T - C_T$$
Eq. 14

$$L_1 = D - 2M_1$$
Eq. 15

$$L_2 = D - 2M_2$$
Eq. 16

$$N_{L1} = L_1 \times T_{L1}$$
Eq. 17

$$N_{L2} = L_2 \times T_{L2}$$
Eq. 18

$$N_1 = \frac{T_1}{N_{L1}}$$
Eq. 19

$$N_2 = \frac{T_2}{N_{L2}}$$
Eq. 20

$$H_1 = N_1(E_1 + P_1)$$
Eq. 21

$$H_2 = N_2(E_2 + P_2)$$
Eq. 22

$$H_3 = H_1 + H_2$$
Eq. 23

$$F_1 = T_1\frac{2(A+B+4B_T) + \frac{2\pi H_1}{2}}{12}$$
Eq. 24

$$F_2 = T_2\frac{2(A+B+4B_T) + \frac{2\pi(H_1+H_2)}{2}}{12}$$
Eq. 25

$$C_1 = R_1 \times I_1^2$$
Eq. 26

$$C_2 = R_2 \times I_2^2$$
Eq. 27

$$W_T = 0.27(6BA^2)$$
Eq. 28

$$C_o = 1.1(C_1+C_2)$$
Eq. 29

$$E_{CAL} = \frac{100V_A}{V_a + C_1 + C_2 + C_o}$$
Eq. 30

Table B. Power transformer equations.

A_1 = Primary wire diameter in C_M	E_{CAL} = Calculated efficiency	N_{L2} = No. of secondary turns per layer
A_2 = Secondary wire diameter in C_M	f = Mains frequency (Hz)	P = Input power (watts)
A = Tongue width (in.)	F_1 = Length of primary wire (feet)	P_1 = Pri. layer insulation (Table A)
A_{opt} = Optimum tongue width (in.)	F_2 = Length of secondary wire (feet)	P_2 = Sec. layer insulayion (Table A)
B_{opt} = Optimum stack height (in.)	G = Core flux density (gauss)	R_1 = Resistance of pri. wire @ 50°C
B_T = Bobbin allowance (.092 in.)	H = Available space for coil (fig. 3)	R_2 = Resistance of sec. wire @ 50°C
B = Stack thickness (in.)	H_1 = Primary winding thickness	S = Current density (C_M per amp)
C = Window width (in.)	H_2 = Secondary winding thickness	T_1 = Number of primary turns
C_M = Circular mils = (wire diameter in inches × 1000)^2	H_3 = Total coil build-up (fig. 3)	T_2 = Number of secondary turns
	I_1 = Input current (amps)	T_{L1} = Pri. turns per inch (Table C)
C_T = Cover allowance (.02 in.)	I_2 = Output current (amps)	T_{L2} = Sec. turns per inch (Table C)
C_O = Estimated core loss (ohms)	L_1 = Width of pri. windings (fig. 3)	V_1 = Input voltage
C_1 = Pri. wire copper loss (ohms)	L_2 = Width of sec. windings (fig. 3)	V_2 = Output voltage
C_2 = Sec. wire copper loss (ohms)	M_1 = Margin, pri. (fig. 3 & Table A)	VA = Volt-Ampere rating
D = Window length (in.)	M_2 = Margin, sec. (fig. 3 & Table A)	W_1 = Primary wire diameter (in.)
E_1 = Pri. wire enamel O.D. (Table A)	N_1 = No. of primary layers	W_2 = Secondary wire diameter (in.)
E_2 = Sec. wire enamel O.D. (Table A)	N_2 = No. of secondary layers	W_A = Product of A × B × C × D
E_{EST} = Estimated efficiency (decimal)	N_{L1} = No. of primary turns per layer	W_T = Estimated core weight (lbs.)

Table C. Variables used in the equations.

inch) calculated by Eq. 14 in step 16 above. This indicates a clearance of about .023 inch between the coil stack and the core, which is quite acceptable.

If H_3 is greater than H, you can decrease it by reducing the wire size and/or number of turns by any, or a combination of any, of the following options:

a) Increase core lamination dimension B (reduces turns, increases weight).

b) Reduce current density (reduces wire sizes, increases temperature rise).

c) Reduce output current (reduces wire sizes, lowers VA rating).

Or, if H_3 is considerably less than H, do the opposite. In either case it will require going through the entire procedure again. For those of us with computers, there is a quick and easy way of doing the whole design from the start by using *HAMCALC*'s "Power Transformer Design" program.[3] A *HAMCALC* printout of the example we are working on is shown in figure 4.

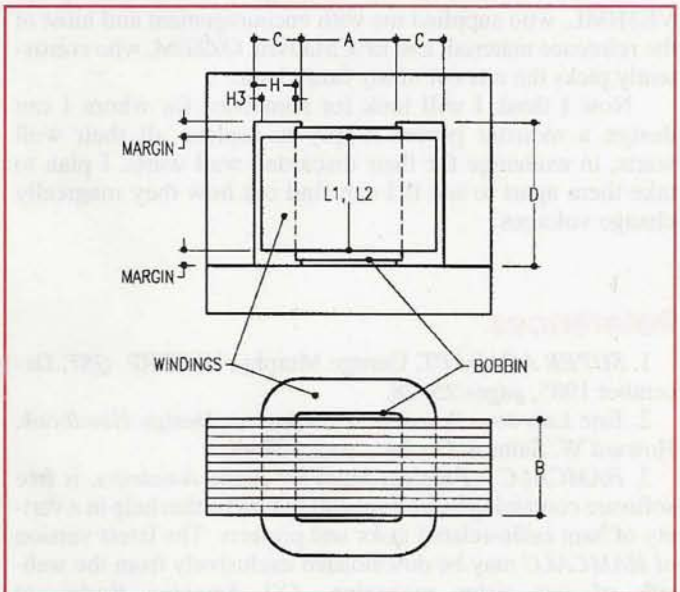

Figure 3. Final form of a transformer, with windings added. Dimension B is optimum when it is approximately equal to dimension A.

27) Eq. 24: Length of Primary Wire

$$F_1 = 263(2 \times 3.118 + [2 \times 3.141593 \times .2485 \div 2]) \div 12$$
$$= 263(6.236 + .7807) \div 12 = 153.78 \text{ feet}$$

Design for a 60 Hz, 100 VA Power Transformer			
Current density	1000.0 C_M/amp		
Core flux density (silicon core)	13.0 kilogauss		
Selected lamination dimension A	1.250 in.		
Selected lamination dimension C	0.625 in.		
Selected lamination dimension D	1.875 in.		
Selected lamination dimension B	1.500 in.		
Input power @ 90% estimated efficiency	111.1 watts		
	Primary	**Secondary**	
Voltage	110.000 V	50.000 V	
Number of turns	263	119	
Current	1.010 amp	2.000 amp	
Minimum wire diameter	0.032 in.	0.045 in.	
Selected wire diameter	0.032 in.	0.045 in.	
Selected wire gauge number	20 AWG	17 AWG	
Turns per layer	46	30	
Number of layers	6	4	
Length of wire	153.78 ft.	77.13 ft.	
Resistance of wire @ 50°C	1.75 Ω	0.44 Ω	
Copper loss @ 50°C	1.78 Ω	1.75 Ω	(total loss = 3.53 Ω)
Total layer thickness	0.603 in. (to fit 0.625 window dim. C)		
Approximate weight of core	3.8 lb. (estimated core loss 3.89 Ω)		
Approximate actual efficiency	93.1%		

Core Dimensions

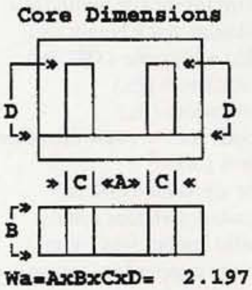

Figure 4. Power transformer design program results after plugging in the values specified in the text.

28) Eq. 25: Length of Secondary Wire

$F_2 = 119(2 \times 3.118 + [2 \times 3.141593 \times \{.2485 + .2424\} \div 2]) \div 12$
$= 119(6.236 + 1.5422) \div 12 = 77.13$ feet

29) Eq. 26: Primary Wire Copper Loss

Table A lists resistance of #20 wire at 50°C as 13.37 ohms per 1000 feet; therefore:

$$R_1 = 153.78 \div 1000 \times 11.37 = 1.7485 \text{ ohms}$$
$$C_1 = 1.7485 \times 1.0201 = 1.78 \text{ ohms}$$

30) Eq. 27: Secondary Wire Copper Loss

Table A lists resistance of #17 wire at 50°C as 5.67 ohms per 1000 feet; therefore:

$$R_2 = 77.13 \div 1000 \times 5.67 = .4373 \text{ ohms}$$
$$C_2 = 0.4375 \times 4.0000 = 1.75 \text{ ohms}$$

31) Eq. 28: Estimated Core Weight

$$W_T = 0.27 \times 6 \times 1.5 \times 1.5625 = 3.8 \text{ lb.}$$

32) Eq. 29: Estimated Core Loss

Assuming core loss is 110% of copper loss, then

$$C_O = 1.1 \times (1.78 + 1.75) = 3.883 \text{ ohms core loss}$$

33) Eq. 30: Calculated Efficiency

$$E_{CAL} = (100 \times 100) \div (100 + 1.78 + 1.75 + 3.883)$$
$$= 10{,}000 \div 107.413 = 93.1\%$$

This completes all the nasty math.

Conclusion

Using the basic design values derived from these equations you can proceed with removing the windings from your junk-box transformer and rewinding it to suit your needs. This basic design is probably all that is needed for most amateur radio applications, and it is the starting point for further detailed design aimed primarily at reducing weight, cost, and amount of copper; increasing efficiency; and other mass-production matters so dear to the hearts of transformer manufacturers. If you want to know more about these matters, read Eric Lowdon's *Practical Transformer Design Handbook* (see footnotes). It has 16 chapters and over 250 pages devoted to them!

Much of the credit for this article goes to Curt Thompson, VE3HML, who supplied me with encouragement and most of the reference material, and Erik Madsen, OZ8EM, who consistently picks the nits out of my fuzzy logic.

Now I think I will look for someone for whom I can design a monster power supply to replace all their wall warts, in exchange for their discarded wall warts. I plan to take them apart to see if I can find out how they magically change voltages.

References

1. *SUPER ACADAPT,* George Murphy, VE3ERP, *QST,* December 1985, pages 25–28.

2. Eric Lowdon, *Practical Transformer Design Handbook,* Howard W. Sams & Co. Inc., pages 39–40.

3. *HAMCALC – Painless Math for Radio Amateurs,* is free software containing more than 200 programs that help in a variety of ham radio-related tasks and projects. The latest version of *HAMCALC* may be downloaded exclusively from the website of our sister magazine, *CQ Amateur Radio*, at <http://www.cq-amateur-radio.com>. Look for the "Download *HAMCALC*" prompt. The Power Transformer Design program is included on Version 43 or later of HAMCALC. At press time, the most current version was 66. ■

QUARTERLY CALENDAR OF EVENTS

Conferences

August: This year's **Eastern VHF-UHF Conference** will be held in Enfield, Connecticut, from August 22–24. For more information see their website at <http://www.newsvhf.com/>.

September: The **22nd Annual ARRL and TAPR Digital Communications Conference** will be held September 19–21 in Hartford, Connecticut. For more information, see their website at <http://www.tapr.org/tapr/dcc/index.html>. This year's **Microwave Update** will be held in Everett (Seattle), Washington September 25–28 in cooperation with the Pacific Northwest VHF Society. For more information see the Microwave Update website at <http://www.microwaveupdate.org/>.

Calls for Papers

22nd Annual ARRL and TAPR Digital Communications Conference, September 19–21: Contact Maty Weinberg, at <maty@arrl.org>. The deadline for submitting papers is August 5, 2003.

Contests

August: There are two important contests this month. The **ARRL UHF and Above Contest** is scheduled for 2–3 August. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is scheduled for August 16–17.

September: The September **ARRL VHF QSO Party** will be held the 13–15. The **144 MHz Fall Sprint** is September 15. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 20–21. The **222 MHz Fall Sprint** is September 23.

October: The **432 MHz Fall Sprint** is October 1. The **Microwave (902 MHz and above) Sprint** is October 11. The **50 MHz Fall Sprint** is October 18. The first weekend of the **ARRL International EME Competition** is October 18–19.

November: The second weekend of the **ARRL International EME Competition** is November 15–16.

Complete rules for the ARRL contests can be found in the issue of *QST* the month prior to the contest or the month prior to the first weekend of contests extending over two months, or on the League's website, <http://www.arrl.org>. Complete rules for the Fall Sprints can be found at the Southeastern VHF Society (the sponsor) website: <http://www.svhfs.org>. Please note that the dates for the Fall Sprints are unofficial, as the official dates were not available at press time.

Meteor Showers

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the ***Perseids*** meteor shower. Its predicted peak is around 0440 UTC August 13. Visually, this year's shower will be blocked by a near full Moon.

October: The ***Draconids*** is predicted to peak somewhere between 0930–1240 UTC on October 9. Additional times and dates to watch for are 2000 UTC on October 8 and 0400 UTC on October 9. The ***Orionids*** is predicted to peak at 2100 UTC on October 21.

Quarterly Calendar

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

August 3	Moderate EME conditions
August 5	First quarter Moon
August 6	Moon perigee
August 9	Lowest Moon declination
August 10	Very poor EME conditions
August 11	Full Moon
August 17	Moderate EME conditions
August 19	Last quarter Moon and Moon apogee
August 23	Highest Moon declination
August 24	Poor EME conditions
August 27	New Moon
August 31	Moon perigee. Moderate EME conditions
September 3	First quarter Moon
September 5	Lowest Moon declination
September 7	Moderate EME conditions
September 11	Full Moon
September 14	Poor EME conditions
September 16	Moon apogee
September 18	Last quarter Moon
September 19	Highest Moon declination
September 21	Moderate EME conditions
September 26	New Moon
September 28	Moon perigee. Moderate EME conditions
October 2	First quarter Moon and lowest Moon declination
October 5	Moderate EME conditions
October 10	Full Moon
October 12	Poor EME conditions
October 14	Moon apogee
October 17	Highest Moon declination
October 18	Last quarter Moon
October 19	Good EME conditions
October 25	New Moon
October 26	Moon perigee. Moderate EME conditions
October 29	Lowest Moon declination
October 31	First quarter Moon
November 2	Moderate EME conditions
November 9	Full Moon. Poor EME conditions
November 10	Moon apogee
November 13	Highest Moon declination
November 16	Last quarter Moon. Good EME conditions
November 23	Moon perigee. Moderate EME conditions
November 24	New Moon
November 26	Lowest Moon declination
November 30	First quarter Moon. Moderate EME conditions

—EME conditions courtesy W5LUU.

November: While another peak in ***Leonids*** activity is two years away, it is still important to pay attention to this shower, as it may produce a ZHR in excess of 100 at its peak. It is predicted to peak at 0230 UTC on November 18.

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

Go Simplex

Often neglected on our handheld's dial are the simplex frequencies, and author WB6NOA urges us to check them out. Who knows? We might find new friends and new ways of communicating on the 2-meter and 70-cm ham bands.

By Gordon West,* WB6NOA

If your local repeater seems to be lacking some ham radio excitement, try simplex! You might be surprised by how far 2-meter and 446-MHz simplex will travel using a regular FM transceiver. Getting your club off the repeater and on simplex will also hone operating skills, quickly showing who has the best antenna system.

How many times have you tuned into a repeater only to hear one mobile operator telling the other ahead of him on the road that he has a burned-out brake light? If the two operators are mobiling within such close proximity, why are they tying up a repeater unnecessarily? Also, who needs a repeater if you are running around town mobile and want to stay in touch with your wife-ham on the air? Any decent 2-meter, 440-MHz, or dual-band 144/440-MHz antenna on top of your house might reach 10 or 15 miles simplex rather easily.

Also, house to house with a white fiberglass single- or dual-band base antenna might yield 20- or 30-mile distance contacts. When the weather conditions are just right, you might even reach out over 100 miles on 2-meter or 446-MHz simplex FM.

In southern California hundreds of hams meet regularly on simplex frequencies or on evening nets. The net control station is usually a well-equipped home station with an excellent single-band or dual-band collinear array antenna fed by low-loss coax such as Belden 9913 or Times LMR 400.

The net control station needs to be able to more carefully judge incoming simplex signal strengths than the little color light-emitting diodes on the base transceiver indicate, or the relatively small S-meter, which usually pegs on an extremely strong signal, can tell you. There is an answer!

An External Relative Signal Strength Meter

If the mobile or base transceiver has a conventional D'Arsonaval S-meter, you are set for an easy additional signal-strength-meter hookup. Most conventional needle-movement S-meters are driven by the automatic gain control (AGC) stage of the transceiver, and the meter is normally a 0–100 microamp movement. The meter already built into your mobile or base 2-meter or 446-MHz FM transceiver or multi-mode transceiver won't load down the AGC circuit, yet it will read a reliable signal strength. The little meter, however, is usually so small that it makes is difficult to judge the difference between two simplex stations that are relatively close in signal strength.

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Frank, AA2DR, "Dr. Radio," runs a radio museum where there are more operational radios than simplex control operators to work over the airwaves.

The answer is an external 0–50 or 0–100 microvolt meter found at most ham radio swap meets. Even if you can't read whether it is a microvolt meter, you can always tell simply by rocking the meter back and forth and watching the needle. If the needle slowly floats up and *slowly* floats back down, this is indeed a microvolt meter that will make a dandy additional S-meter. However, if the needle abruptly goes up and down when you wiggle the movement, this is probably a milliamp meter, which would not be usable. It must be the "floating" needle microamp meter movement.

You probably would disregard how the microamp movement is calibrated. For example, if it came out of an automotive-engine tester, it might be calibrated in revolutions per minute or distributor timing. Maybe the microamp meter movement is calibrated in gallons per hour or inches of mercury. Who cares?! What you are looking for is a giant display that will easily show the difference between various incoming signal strengths.

Here is how to install your new microamp meter: Wire it to your present S-meter D'Arsonval movement in parallel. With just background noise, you should see a slight deflection in the needle movement. When a signal comes in, chances are that it will deflect all the way to the right. This is what you want, but you'll need to go into your transceiver's AGC action and calibrate the S-meter pot to bring a very strong signal down to the extreme right edge of your new meter movement. You might do this standing in your driveway with a handie-talkie and talking on a simplex frequency.

Now get out there, tune around the different repeaters, and make sure that none of the repeaters is stronger than the needle movement all the way to the right (or full scale). Once you make sure that you're properly calibrated for an enormous signal, then it's time to start looking at repeater inputs or simplex frequencies for less signal strength. A relatively strong signal should give you about three-quarter swing of the needle, and a signal almost in the noise should give you about one-third movement.

Hopefully, this new, large microamp meter is calibrated with tiny markings so you can easily tell the difference between two incoming signal strengths. If so, you are all set. Now the fun begins!

Assuming that you are the net control station, you will write down everyone's "new" signal strength as seen on the new meter movement, all on simplex. Each new net will easily show such changes in station setups, such as when a ham has changed from small coax to large coax, by a relatively big change in the incoming signal strength. You can then run some competition to see who can make the greatest improvement to his or her simplex signal.

Friendly Competition

"We have a simplex net called the Long Island Amateur Radio Simplex Club—'LIARS' for short," comments Frank, KB2WQU. Net control is usually Frank, AA2DR, "Dr. Radio," who runs a radio museum where he has more operational radios than simplex control operators to work over the airwaves. Frank has adapted many of his needle-movement transceivers for a variety of 0–50 huge microamp meters.

"Our LIARS simplex net on 147.575 MHz encourages everyone on Long Island to continuously upgrade their home and mobile antenna systems," adds AA2DR. "It also creates some fun competition to see who can drive 80 miles away and still get back to my base station with a big calibrated S-meter." Frank also points out that some of the new hams checking into the simplex net were surprised to find out how poor their signals were coming in from only a few miles away. After a little investigation, they discovered water in the coax, or other problems with their antenna system on top of the house or on their mobile. They didn't realize they had problems going through the local repeater, but simplex is a fast way to tell who has a good antenna system, and these hams are motivated to work over the weekend to make slight improvements to an already great signal.

Here in southern California, hams who regularly check into several simplex nets will quickly find out what their signal strengths are compared to other hams living in their neighborhood. This again creates some friendly competition to get the antenna up higher, or use better coax, or maybe even switch over to a beam. Believe it or not, simplex signal-strength competition usually does *not* promote the purchase of power amplifiers. Many hams learn that it's much easier and less expensive to improve on an antenna system rather than go out and spend a couple of hundred dollars on a 25- or 100-watt amplifier. While it may improve the purchaser's signal, that new amp will do nothing to improve reception of the original antenna system. Only the less-expensive change in the antenna or coax system will make that improvement.

"In just three months we have seen many of our hams completely redo their home antenna system and double their signal strength," adds Frank. "Our nets carry on great discussions about coax cable, dB gain of collinear array antennas, antenna height above ground, and that great competition for two hams in the distant city to try to outdo each other the next week during check-in."

Most important, it gets many hams out of the "routine" of just making an easy contact on a repeater. Going simplex adds some excitement and competition to improving your antenna system and figuring out ways to get a better signal to that distant net control station who has hooked the tiny hard-to-read S-meter into a whopping, 0–50 microamp meter for a very visual relative-signal-strength readout. ■

Meteoric Transatlantic Attempt Falls Short

In November 2002 hams in Newfoundland and Ireland attempted to make an award-winning transatlantic contact on 2 meters. Although they were not successful, there were encouraging moments and valuable lessons were learned.

By Paul Piercey,* VO1HE

They've become the brass rings of VHF communications—the glass goblets known as the Brendan Trophies of the Irish Radio Transmitting Society. The trophies are to be awarded to each of the operators of the two amateur radio stations that first establish (unaided terrestrial) two-way communication between the continents of Europe and America (North or South) on 2 meters. Several attempts have been made, but to date none have succeeded in making the contact.

Paul Piercey, VO1HE, has been on the North American side on more than one occasion. His first attempt was in July 1999, and his most recent was November 2002 during the much-publicized Leonids *meteor shower. What follows, courtesy of VO1HE, is documentation of this latest attempt at being awarded the glass goblets. The account originally appeared in the "SONRA Newsletter" and was reprinted in part in the June 24, 2003* ARRL Letter. *—N6CL*

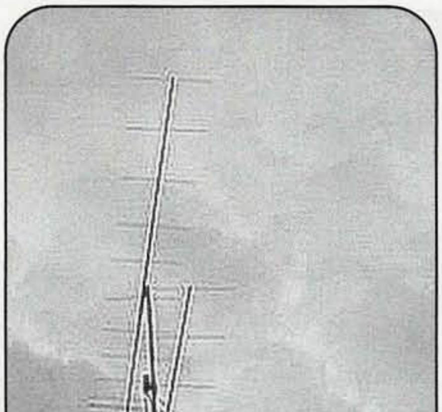
It began with a simple question and turned into quite an adventure. On August 22, 2002 I received an e-mail from Nico Exner, DK5DQ, of the VHF-DX-Gruppe, wondering if there was any chance we would be interested in trying an experiment. The idea was to set up a station on this side of the Atlantic Ocean. Newfoundland, being ideal due to its proximity to Ireland, was the choice for the QTH to be used to attempt to make contact with a station to be set up on the western coast of Ireland by Nico and his group using the FSK441 digital mode. This attempt was to coincide with the November 19, 2002 *Leonids* meteor shower, because it was predicted that this shower was to offer the most meteors per hour for the next 97 years.

The North American crew sets up (the first time) to try a 2-meter transatlantic meteor-scatter QSO from Admiralty House, St. John's, Newfoundland. Left to right: Alasdair, VO1LIN; Wayne, VO1TA; Harry, DL2DAO; Graham, VO1DZA; and Rick, VO1ZX. (Photos courtesy the author)

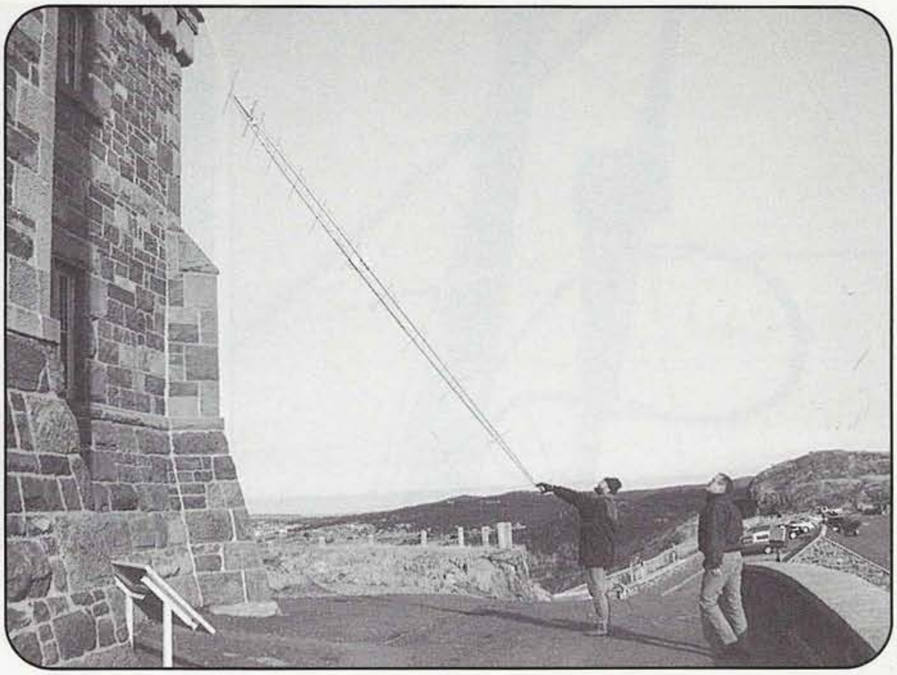
After a quick round-table discussion at the Society of Newfoundland Radio Amateur's (SONRA) executive level, we decided to make the leap. I relayed this message to Nico and within days received a phone call to discuss the arrangements. I explained that we didn't have much in the way of high-powered VHF equipment. We had an estimated output power of 160 watts at hand, and we would have to acquire the antennas, as the one we had used during our previous attempt in 2000 had been destroyed. We had a Yaesu FT-736R VHF/UHF rig to drive the amplifier, so our station could be assembled with a little effort. Nico took this information back to his group for discussion while I awaited further news.

News wasn't long in coming. The next day I received a phone call from Nico

**66 Rumboldt Pl., St. John's, NL, A1A 5K9, Canada*
e-mail: <vo1he@rac.ca>



Paul, VO1HC, and Wayne, VO1TA, scale to dizzying heights to install the 2-meter Yagis.



After it was learned that Admiralty House was unusable for the experiment, the crew relocated to Cabot Tower on Signal Hill, the original venue for the test. VO1LIN and VO1TA helped guide the antennas up to the roof tower.

explaining that the plans had changed. They were concerned that we didn't have sufficient output power and antenna gain to complement their planned station in Ireland. That went without saying, but we were ready to do what we could. Nonetheless, the plan became an offer for one of their group to travel to St. John's, Newfoundland and bring a high-power amplifier, transverter, and some antennas to augment a Kenwood TS-850 station available in Canada. Another executive discussion ensued, and this new plan was given the green light. With that decision made, both sides went forward with their respective preparations with this new scheme in mind.

We were asked to provide a 12-volt power supply, and we had plenty of those. Furthermore, the antennas weren't readily available in Germany, so they were purchased in the U.S. and shipped to me, along with some high-power, low-loss cable.

Harry Schleichert, DL2DAO, would travel to St. John's. Paul Webster, VO1HC, offered to billet him for his stay. Nico and Volker Muchlhaus, DL5DAW, were set to travel to Ireland to meet up with Tony Baldwin, EI8JK, and Tony Moore, EI7BMB.

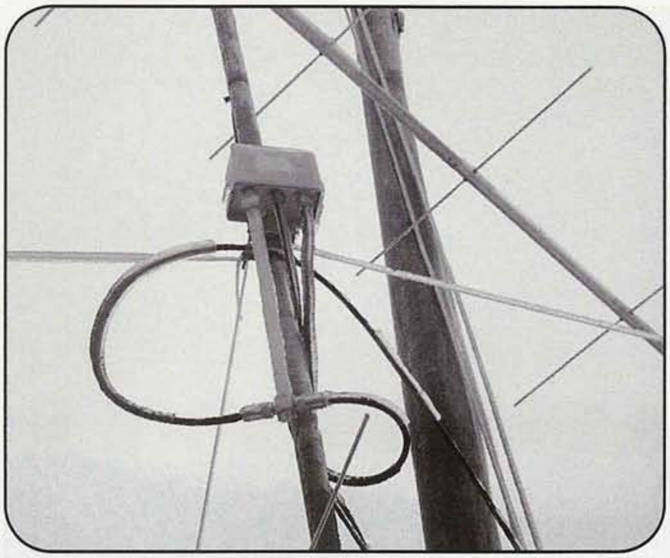
We had offered our club station, VO1AA, located at Signal Hill National Historic Site, to serve as the western base for the experiment. It was only fitting that the site where the first transatlantic wireless signal had been received over 100 years earlier serve as the site for this attempt. The main requirements were that there be a clear shot to the east/northeast for the antennas and 220 volts AC power for the amplifier. Having used 220 volts during the visit by HRH Queen Elizabeth in 1997 for the Cabot Celebration, and having requested a 220-volt outlet at our station during renovations in 1991, we were fairly confident that these criteria could be satisfied. Meanwhile, preparations continued on both sides of the Atlantic, and we arranged the necessary permission with Parks Canada, our partners at Cabot Tower, to conduct the experiment from their site.

Unfortunately, with only days to go before Harry was to arrive, we couldn't find that 220-volt outlet. We could have gotten a cable installed from the main service panel to the station, but it would have cost us a lot of money and might not have been done in time. This, coupled with some other concerns that came up during our site assessment, caused several frantic phone calls among Graham Dillabough, VO1DZA, Dave Taylor of Parks Canada, and me. It was then decided that an alternate site should be chosen and that our other club station, VO1BZM, located at Admiralty House in Mount Pearl, would be the best choice as it had full access, 220-volt power, and other creature comforts. With that decision behind us, we breathed a bit easier.

Day 1: November 16, 2002

Harry, DL2DAO, arrived at 2 AM on November 16 and was met at the airport by Paul, VO1HC, Brad Sheppard, VO1XA, and me. Thankfully, Harry's luggage and equipment case were the first off the plane, so we loaded up Paul's van and were on our way in short order to get some much-needed rest, as it looked as if we might not get much over the next few days.

Many local amateurs get together for breakfast at a local shopping mall each Saturday, and this Saturday was no exception. We used this particular occasion to discuss the equipment setup. Once we



As if their troubles had been few, the VO1AA team arrived at Cabot Tower on the windy third day of the experiment to find antennas and feedlines coated with ice.

The failure of the large amplifier was a big blow to the experiment, leaving Harry, DL2DAO, to forge ahead with the attempt using the smaller reserve amplifier.

were awake and fed, we headed out for Admiralty House to set up the equipment. With Wayne Smith, VO1TA, and Paul, VO1HC, doing the tower climbing, Graham, VO1DZA; Alasdair Black, VO1LIN; Rick Turner, VO1ZX; Doug Tilly, VO1CN; Craig Tucker, VO1LCT; Harry, DL2DAO; and I went about setting up the station.

The British Admiralty had set up Admiralty House during World War I as a relay station and listening post to monitor radio traffic in the North Atlantic. The site was chosen for two reasons which played a role in our little adventure. First, it is well above sea level, giving good range for the station. Second, it is invisible to the ocean so as to protect it from bombardment. Keep this in mind as you read on.

After about six hours of setting up, we were ready to test the equipment. The antennas were in place thanks to the tower-climbing skills of Wayne and Paul, and the gear was plugged in and operational. Harry fired up the station and made sure all the equipment was working properly and tried some calls to the west to see how the propagation was to the rest of North America. After a little while we called it a night.

I headed back to join in the ARRL Sweepstakes Phone contest. Operating as VO1AA, I was getting into the groove when I received a phone call. It was Ken Whalen, VO1ST, who was looking for Paul to advise him that a change in venue was required! While talking to Nico earlier, Harry learned that the station needed to see the horizon in the direction of Ireland, approximately 65° to the east. In order for our signal to hit the meteor trails at the proper angle, no more than a 2° elevation of the antennas from the horizontal could be tolerated. This wasn't possible at the Admiralty House location. Remember that the site had been chosen for its invisibility from the sea!

We were on the move. Ken and Dave had taken a trip to Cabot Tower, the original site, and found the 220-volt power line hidden behind a panel in the wall. It needed an outlet but was usable. I called the other members of the team and we arranged to go to Admiralty House the next morning for the disassembly and move. Sweepstakes was over for me.

Day 2

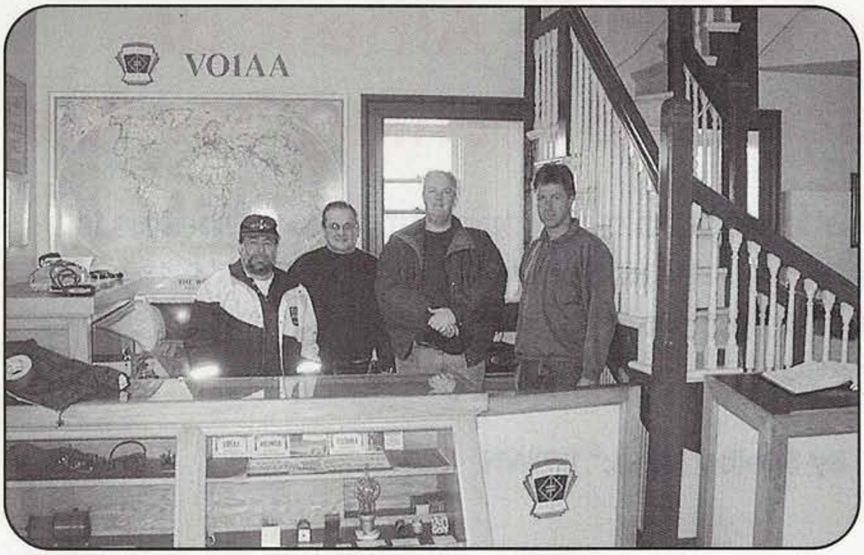
I arrived at Admiralty House at 8 AM on the 17th, after being awakened from my slumber by an incessantly ringing telephone at 7:30. It was Paul, who was making sure I was awake! The day was crisp but fair. The sun was out and there was no wind. Wayne, Paul, Harry, and Graham were already there and the dismantling began. After an hour we were packed up and ready to go. We stopped at a local coffee shop to take a break and then headed up to Cabot Tower to set up the gear. It went rather swiftly, and the only thing we were missing was the 220-volt power outlet. After the necessary arrangements were made to get the outlet installed the next morning, I dropped off Harry at Brad's place for the evening meal.

Day 3

Weather anywhere is a funny thing, and our QTH was no exception. After setting up the equipment in relative comfort the day before, we awoke on November 18th to find a couple of inches of snow on the ground. There was freezing rain, ice pellets were falling, and the wind gusted to about 50 kph and was predicted to go to 80 kph. Paul had to work, so I picked up Harry and we made our way up to Signal Hill.

When we arrived, we knew it wasn't going to be good. The antennas were no longer aligned and the wind was at least 10 kph stronger. There was about 2 inches of ice on everything. A typical autumn day in St. John's! Undeterred, we went into the station and awaited the electrician who would hook up the outlet. Once that was done, we started testing the gear. The antennas seemed okay, but they were pointed in the wrong direction. After a couple of hours of testing and discussion, it was decided that we had to try to realign the Yagis. After Wayne and Graham arrived, we made the decision to take the antennas down to work on them.

The temperature had risen and the ice was melting, but not quickly enough to save our HF doublet, half of which couldn't stand the weight of the ice. The wind was no weaker though. We managed to get the antennas down without any dam-



Part of the VO1AA team that attempted to span the Atlantic (left to right): Paul, VO1HC; Wayne, VO1TA; the author, VO1HE; and Harry, DL2DAO. Although they did not complete a QSO across the pond, a number of pings were heard and recorded, giving the team new hope that the challenge can be met.

age and made the choice to make the attempt with only one. Once all the ice had melted, we managed to get the antenna up and in the right direction. Some further testing showed we were ready to go.

Over the span of four hours, from 7 to 11 PM, many of the gang showed up to see what was happening. The sky was partly overcast, and it was cold and very windy (estimated at 90 kph or more). The antenna was still in place, although it was moving laterally about 10°. Graham's wife Joy brought the team some very welcomed soup and sandwiches. Cal Tucker, VO1CLT, showed up later with a pizza. At this point, things were running smoothly and everyone was sated. Harry set up the computer to call CQ until the time of our sked with Nico.

The first meteor peak was predicted to be at 11:30 PM or so. We started calling Nico, who had been granted the use of EI2TAA (transatlantic attempt) and 750 watts output. For several hours we continued the 30-seconds-transmit, 30-seconds-listen pattern, but heard nothing. Harry set it up to call CQ until the next scheduled contact time, which was at 7 AM.

Then, at around 3:15 AM, we got a few consistent pings! No callsign was decoded, but the signals were audible. A quick phone call to Nico was made to arrange a new sked, and we prepared to try the contact again, hoping this development was the mark of improved conditions. At 3:30 AM we started our transmit-receive pattern again. We continued for about a half hour when we noticed the amplifier wasn't operating. We investigated to find that the fuse had blown. Not having an exact replacement, we tried a close approximation, only to have that one blow immediately. We tried another, but it was no use. The amplifier gave off some smoke with that last attempt, and we knew it was done. We made a hasty decision to retrieve the 160-watt amp from Admiralty House. Graham and I drove to Torbay to get the key and then to Mount Pearl for the amp. It took us an hour to get back, and after a few minutes we were back on the air, albeit at a substantially reduced effective radiated power.

The next meteor peak was due for 7 AM, so we began our transmit-receive pattern at around 6:30. Another phone call was made to Nico. and in the ensuing conversation we made the decision to shut down at 7:30. Given the loss of the amplifier, we knew it wasn't going to happen this time around. It also meant that testing to mainland North America was not going to be viable. By 9:30 AM we had dismantled the station and were on our way home.

The next day, the 19th, was a quiet day for everyone. Harry took a sightseeing tour of the area with Ken and later went to Graham's QTH for the evening meal. The rest of Harry's stay would prove to be less stressful.

Epilogue

Even though we did not make the award-winning contact, there were some encouraging moments. Those few early-morning pings meant we were hearing something off the meteors. Harry took the data home for further analysis. Hopefully he will find a callsign in there somewhere and we'll know what we heard.

In the end the experience was well worth it. We made some new friends and learned some valuable lessons. One of the lessons learned was that the summer is a much better time to make an attempt. It's certainly a lot warmer that time of year. Keeping this in mind, we also thought that perhaps the *Perseids* meteor shower could be the source for a future attempt at some meteor-shower propagation contact.

I just thank God that unlike our predecessors at transatlantic communications, we didn't have to fly a kite!

Special thanks to Dave Taylor and Parks Canada for the use of the site and the help getting it prepared. Thanks also to all the local amateurs who came out to assist with setting up and dismantling of the station.

Experimental North American 144-MHz Sporadic-*E* Alerting Service

Due to the increased interest in sporadic-*E* propagation on 2 meters in North America, a DX robot has been developed by Allard Munters, PE1NWL. DXRobot, Gouda, The Netherlands is described in the following article extracted from the website of W8WN.[1]

By Shelby Ennis,* W8WN

Europeans seem to get many more 144-MHz sporadic-*E* openings than those of us in North America. It appears that while they really do get more, much of the difference is in the fact that there are many more active VHF DX operators in Europe and they have better alerting systems. Thanks to Allard Munters, PE1NWL,[2] we now have an experimental 144-MHz alerting service set up for us in North America. Note that this is still experimental, and changes in the way it works are being made. If you like the idea, please subscribe and use it properly.

How to Subscribe to The NA Alerting Service

You can subscribe/unsubscribe to the North American 144-MHz alerting service at <http://gooddx.xs4all.nl/cgi-bin/gooddxvisitors>. The list's name is "eskip-na." You can also subscribe to some of the European services if you're interesting in seeing what happens over there.

Enter your e-mail address in the box indicated, go to the next page with the different alerts, and check the "eskipna" box (plus any others in which you're interested). You also might want to subscribe to the daily European E_s summary. It's fascinating to see what they have worked!

The information can also be sent to your pager, so you might want to consider getting alerts by that method. At least you would know what you missed while you were not available. When a report that contains a "key word" concerning sporadic-*E* is uploaded, the DXRobot will send out an alert to those who subscribe to the service.

If you log on to <http://gooddx.xs4all.nl/eskipNA>, you can get a listing of the loggings that were harvested by the NA DXRobot. Each of them would have caused the DXRobot to generate an E_s alert. This North American summary is not sent out automatically each day. You must manually go on the web and read it, so you may wish to bookmark this page.

Where do Alerts Come From?

Remember that the alerting system works only if you report your sporadic-*E* observations. These reports must be made to the 144-MHz Propagation Page (<http://dxworld.com/144prop.html>; bookmark this page). When you report, you must use Es, es, e's, eskip, Eskip, or e-skip in the post, along with the location of each end of the propagation (if known).

Caution: When entering a sporadic-*E* report on the 144-MHz Prop page, use the text box at the top of the page and include your callsign and grid! Do not use the box at the bottom for your call, because the DXRobot strips this off.

Please do not abuse this service! Don't report or comment on sporadic-*E* on the 144-MHz Prop page when there is none! The DXRobot can be set to disregard anyone who continually misuses the service. However, remember that the page is for reporting all types of propagation. Simply specify what you are reporting. The DXRobot ignores any posts that do not include one of the sporadic-*E* key words.

Does it work? The North American service has been available only for a short time. Even so, those who subscribed have already received immediate notices for several small sporadic-*E* openings. However, how well it works will depend on the reports available to the DXRobot on the 144-MHz Propagation web page.

How It Works

The following explanation is by PE1NWL:

Every 5 minutes the robot checks the reports on the 144-MHz Propagation page at <http://dxworld.com/144prop.html>. The robot then filters the newly received reports based on certain criteria. If the criteria for E_s are met, then the robot sends out alerting messages to its mail list.

Once an alert has been sent, the robot then "locks out" for a period of time (currently set at one hour) and does not send any more alerts until that time period has elapsed and another post is made. This is to keep from flooding your mailbox if a number of reports quickly follow the initial report.

It is set so that "European" or similar words will cause it to bypass that message; otherwise, comments on a huge European opening would trigger it, causing false alarms. (There are a number of other words that will inhibit an alert. Therefore, when making a report, make it short, simple, but complete. Nothing extra. If you need to put in further information, put it on a separate posting to the Prop page).

The DXRobot has its own mail server so that all of the e-mails can be sent out rapidly.

**e-mail: <w8wn@amsat.org>*

[1]To access the links in this article, go to <http://www.qsl.net/w8wn/hscw/papers/esalerts.html>

[2]e-mail: <pe1nwl@gooddx.xs4all.nl>

The robot does not make forecasts, and the alerts also are not generated based on any prediction or forecast. It simply "detects" that there is an opening based on the band activity as reported on the web page.

Some Extra Notes

Remember, all you will get via e-mail is a single alert. This will not really tell you anything except that you need to start checking.

1. Go immediately to the 144-MHz Prop page and read any other postings. Then check that page occasionally after that.

2. Turn on your 2-meter rig, point your antenna in the most likely direction, as indicated by the loggings.

3. Turn on your 6-meter rig, TV or FM BC receiver, or whatever you have to check the lower frequencies.

4. You may want to download the simple E_s MUF Calculator by G7RAU. (Put in the grids at each end of the path, along with your grid and the reported frequency, and it gives you some general idea of the MUF, a possible direction in which to head, etc.) Go to <http://www.g7rau.co.uk/soft/default.asp> and download RAUMUF.ZIP at the bottom of the page. (The live_muf.zip program at the top of the page works only for Europe at this time, so that is not the one you want).

5. If there is no usable sporadic-E in your area, continue to check occasionally. It can build to a high MUF in only a few minutes!

6. If you do hear something of interest, report it on the 144-MHz Prop page.

7. The next day get a summary of all the loggings from the DXRobot.

8. Remember that this alerting service is experimental. There will be changes as it is fine-tuned to meet our needs. Check <http://www.qsl.net/w8wn/hscw/papers/esalerts.html>) or the Hot News page <http://www.qsl.net/w8wn/hscw/papers/hot_news.html> occasionally. If this service is of no interest or is misused, it will be discontinued. Therefore, please let us know what you think of it.

The Experimental Stage

The North American service was set up in the middle of June, and a number of changes have already been made to improve its operation and better meet our particular needs (which are not exactly the same as the needs of Europeans). More changes will be made, so if you see a way to improve its operation, please send your suggestion to PE1NWL or W8WN.

Here are some things to consider: How long should the lockout period be? Two hours? One hour? Thirty minutes? Something else? Are other key words needed, or is the above list sufficient? Can you think of other words that should cause it to bypass posts that also contain a trigger word?

A "quiet time" can be put in so that your pager will not go off in the middle of the night. Because the U.S. covers four time zones and E_s can occur late at night, what should these quiet hours be, or should we have any at all? Will the above exclusion feature be sufficient?

What about an aurora alerting feature like the Europeans have? Allard does not want to attempt to enable this feature until we know if the E_s alert generates any interest.

If you want a general space-weather-type (not propagation report) auroral alerting system, go to <http://www.ips.gov.au/mailman/listinfo/ips-aurora-alert> and subscribe to this service. It works quite well.

The European DX Robot

The following information is provided by Allard so that you can see how the European version of this robot works, which is somewhat different from our system. It might give you ideas for further enhancements.

Every 5 minutes the robot receives the DXcluster spots from the DXsummit website at <http://oh2aq.kolumbus.com>. (The DXsummit is just a gateway between the packet-radio DXcluster and the internet, so anything that's posted to the worldwide packet cluster will also appear on the DXsummit web pages. The robot then filters the newly received DX spots based on certain criteria. If the criteria for E_s or AU are met, then the robot will send alert messages out to a mailing list (currently over 1000 users worldwide; subscribe at <http://gooddx.xs4all.nl/cgi-bin/ gooddxvisitors>). Again, the DXRobot has its own mail server so that all of the e-mails can be sent out rapidly. Approximately 1000 e-mails and SMS messages are sent out within 4 minutes. In addition, the propagation monitor status is updated so that other VHF websites that have links to gooddx.net are also updated instantaneously. Because of the many links from other websites to the monitor, I get a lot of traffic on the monitor web page. Recent logs show that the monitor has over 12,000 hits per day.

By the way, you can view some fantastic maps of this year's European E_s openings and other VHF propagation information at <http://www.vhfdx.de/>.

Conclusion

If you're interested in 144-MHz (or 222-MHz) DX, try Allard's North American sporadic-E alerting service. I think you'll like it! If you don't, just unsubscribe. Be sure to bookmark the 144-MHz Propagation Page at <http://dxworld.com/144prop.html> and immediately report any E_s. If you have suggestions for enhancements, let us know, since this is still experimental. Watch for notes on updates, changes, and additions to the service on the Hot News Page.

By John Champa,* K8OCL

OP ED

One Reader's Opinion

Alternative Options for Resolving HSMM Interference Issues

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

Writing for myself, and not the ARRL High Speed Multimedia (HSMM) Working Group, I wish to respond to "Op Ed" in the Spring 2003 issue of *CQ VHF* regarding the 2.4-GHz band and the negative slant the piece gave to amateur radio spread-spectrum experiments on that band.

One of the flaws in the spring "Op Ed" was the author's omission of the fact that in the U.S. the unlicensed FCC Part 15 IEEE 802.11b devices have access to channel 1 through channel 11. However, the U.S. amateur radio 2.4-GHz band shares only channels 1 through 6 of that Part 15 service. Therefore, any Part 15 wireless local area network, or WLAN, station experiencing interference from an amateur station of any type needs merely to change its operating channel to one of those *outside* the amateur band.

On the other hand, it must be noted that FCC regulations clearly require that any Part 15 user who is causing harmful interference to an amateur station must either cease operations, or correct the interference problem no matter how prestigious or wealthy the manufacturer of his or her equipment might be. That is the law.

Recently, current FCC rulings confirmed this requirement when two unlicensed Part 15 cordless-phone-device, not WLAN, users were directed by the FCC to either cease operating or eliminate the sources of the interference to a licensed amateur radio station using the AMSAT-OSCAR 40 satellite downlink. At last report, the unlicensed Part 15 equipment owners had a friendly relationship with the amateur radio operator, and the Part 15 owners were working with the equipment manufacturer to correct the interference problem. Again, that is the law and that is the way it is being enforced.

In like manner, any unlicensed WLAN Part 15 station experiencing interference from a licensed amateur high-speed multi-

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On the left is the Logitech USB 1.1 Notebook Pro camera and its carrying case (for information see <http://www.logitech.com>. The large golf-ball camera on the right is the Orange Micro iBOT2, a USB 2.0 version of Logitech's iBOT firewire camera (for details see <http://www.orangemicro.com>). (Photo courtesy AH7R) media (HSMM) station must accept such interference. It should be pointed out, however, that to date there has not been a single such report, so let's get real. Even if every active amateur radio station in the U.S. were equipped with HSMM, it is doubtful there are sufficient numbers of us licensed amateurs to cause any problem for the millions of Part 15 WLAN users.

Probably the most obvious reason for this lack of QRM is that the vast majority (but not all) of the unlicensed Part 15 users, both commercial and home-office WLAN, are located indoors and are using low, vertically polarized rubber-duck antennas. On the other hand, all amateur HSMM station antennas are outdoors and most use horizontally polarized, usually highly directional antennas up relatively high. These are much different RF environments.

Nonetheless, once again, the unlicensed Part 15 station has a simple solution if the amateur next door is using HSMM. Go to one of the channels outside the amateur band!

Let's look at a rundown of all the unlicensed WLAN channels. Keep in mind these are 5-MHz-wide channels, and the primary signal of an IEEE 802.11b device is 22 MHz wide, so there is overlap, and again, only channels 1 through 6 are within the U.S. amateur radio 2.4-GHz band.

1. Channel 1: All stations, both Part 15 and Part 97, have always been asked by the ARRL HSMM Working Group to avoid operating on channel 1. Operating here may cause harmful interference to the licensed users of the AMSAT-OSCAR 40 satellite downlink. Many unlicensed Part 15 owners, including a number of wireless internet service providers (WISP), have honored this request, so there is a growing consensus to totally avoid the use of channel 1.

2. Channels 2–5: Amateurs are experimenting (albeit on a relatively small scale at present) on channels 2 through 5, so this probably is not the best RF terrain on which to park your office or home unlicensed Part 15 WLAN equipment either. You just might cause a problem to a licensed Part 97 user of the band. It's not a likely situation, but prudent practice is to avoid the possibility if you are an unlicensed Part 15 equipment owner.

3. Channel 6: Both home users and commercial WLAN users are starting to see the advantage of keeping their wireless equipment low-profile for security reasons. Thus, it would be wise to completely avoid the most common WLAN default, *right-out-of-the-box channel 6.* Amateurs are encouraged to avoid this channel, too, because that is where the bulk (70%?) of all Part 15 traffic is located, according to several aerial RF surveys. Therefore, avoid the QRM and stay off channel 6, even though it is legal for amateurs to operate there. Finally, what knowledgeable WLAN owner would want to set up his or her home or commercial office WLAN on that default channel 6 anyway? It would be similar to expecting privacy while playing checkers next to the freeway (hi).

4. Channels 7–11: The choice is obvious and simple for the owner of unlicensed 2.4-GHz equipment. Put the unlicensed Part 15 devices on one of the channels from 7 through 11, which have center frequencies totally outside the amateur band. Commercial WLAN users are starting to see the advantage of this approach. At least one major WiFi vendor is now recommending to all their customers to stay completely off channels 1–6 for all the reasons stated above. Also, they recommend they keep their unlicensed WLAN equipment, antennas, and coverage specific, modest, and low profile for the best security. They further recommend to all their customers that WLAN access points or hubs be linked together using a wired virtual LAN (VLAN). This, we are told, is a more secure configuration than the earlier methods of using commercial WLAN cells with adjacent non-overlapping channels that take up the entire Part 15 band by spreading out the WLAN channels over 1, 6, and 11, as was previously the customary practice. This is now considered a risky and outdated configuration for reasons of business security, we are told.

Finally, and as the ARRL has preached for decades, just because an amateur station has the legal right to run high power does not mean that it should run high power. Sound operating practice clearly indicates, and always has, that all stations use only the minimum power output necessary to maintain the communications link. This has always been the rule, regardless of whether it is an FM repeater or an HSMM access point. To suggest that anything other than this is being proposed is simply in error and a misreading. The intent of the HSMM materials has always been to encourage amateurs to experiment with spread spectrum, and to provide Part 15 equipment experimenters with a friendly welcome to the ranks of the licensed Amateur Service and/or membership in the League.

Yes, amateurs of all license classes are encouraged to get on the air; to get in on the fun and easy low-cost, spread-spectrum experimentation, and join the HSMM activity on the 2.4-GHz band. It's as simple as 1, 2, 3:

1. Go to your local Radio Shack®, Best Buy®, or other consumer electronics outlet and purchase some economical and readily available WLAN, also called WiFi, equipment. Just make certain it states that it complies with IEEE 802.11b. This is normally the cheapest choice anyway, because it is slowly being replaced by the newer 802.11g equipment. If you use a laptop in your station, get the PCMCIA card style. If you have a PC, get the WLAN-adapter type that plugs into the USB port. This is the heart of your new station. It is a computer-operated HSMM 2.4-GHz transceiver, and it probably will set you back about $60 to $80.

2. Make certain the antenna(s) are removable and/or there is an external antenna port. If the device comes with a rubber-duck, or other little detachable antenna, remove it and throw it in the junk box. You won't need that.

3. Go to any issue of *CQ* magazine and look up Nemal Electronics®, CableXperts®, or other cable source and order an 18–24-inch strain-relief cable, also called a pigtail, of the type needed for your WLAN card or device. It will probably cost less than $20. It will have a strange-looking Part 15 type antenna connector at one end and a normal N-series connector at the other. Load the software on your PC and set it to any channel between 2 and 5 (they're in the amateur band). Hook up any external 2.4-GHz antenna (homebrew half-wave dipoles built on an N-connector are really cute…hi), or you can buy an Andrews 24-dBi dish antenna for as little as $95. Shop around where the AMSAT-OSCAR 40 guys buy their Mode-S antennas. The antenna coaxial cable will likely be the most expensive part of the entire station, as you will want to use the lowest loss type you can handle. That's all there is to it. You may not have spent more than $100 so far, depending on what antenna hardware you have around.

For operating software, most amateurs are using Microsoft® NetMeeting collaborative software, also called groupware, which comes free with the Microsoft Windows® operating system. They first go into chat mode much as in packet radio. Later they will add a headset to their sound card and start using streaming audio for normal voice contacts. Still others will add small, inexpensive web cams and operate another new multimedia mode, amateur digital video (ADV). This video is currently of somewhat less quality than amateur television (ATV), but it does provide acceptable full-motion color video suitable for two-way amateur communications (see photo).

Depending on how close your ham buddy is to your location, how high and clear your antennas are, the quality of the coaxial cable you are using, and a zillion other factors, you should be able to get several miles range. Remember, these HSMM devices are truly QRP and run only about 30–100 mw of RF output, so be resourceful and experiment often with different antennas, etc.

If your signals are not covering the path between you and the nearest other HSMM station, then open a copy of any edition of the *ARRL Handbook* and read the sections on antennas, transmission lines, and UHF propagation. Consider putting the antennas up higher, getting or building higher gain antennas, using lower-loss coaxial cable, etc., until the link is achieved. You may also find a way to mount your gear at the antenna and avoid the expense and loss of coaxial cable.

Running higher power is an expensive last resort, but all amateurs should already know that, right? It's the sound operating practice, preached by the ARRL for decades, of running the minimum power needed to maintain communications, and it also is just good, old-fashioned common sense. Moreover, running the lowest possible power is glaringly obvious in the case of HSMM gear, because the RF power amplifiers (called BDAs, for bi-directional amplifiers) are relatively expensive. A good 1-watt BDA for IEEE 802.11b can cost as much as $500, which is perhaps quadruple what you just paid for simple steps 1, 2, and 3 above.

IEEE 802.11b RF is spread spectrum, which means amateurs can operate using up to 100 watts of power. The FCC regulations provide that higher power limit because the government expects licensed amateurs to explore the full capabilities of this mode, not just set up little wireless household devices or appliances connected to a PC and a printer a few feet away. Again, just because you can run that much power on HSMM, doesn't mean you should. Be considerate of others who may be using the band, both amateur and non-amateur. Use only the power needed for the link. Got that?

We also need to consider several acceptable methods for separating Part 15 from Part 97 traffic on 2.4 GHz. It should be noted, however, that at least so far we have not encountered Part 15 traffic mixing or even QRMing our test HSMM networks, nor us QRMing them, to the best of our knowledge. This is despite the fact that our main HSMM test network ("The Hinternet") in Livingston County, Michigan resides directly in the middle of a major commercial wireless internet service provider (WISP) operation (MediaNet, Inc.). Oh well. So much for the "New CB Band Theory" (hi).

Please note that cooperation, coordination, and knowledge sharing (and even amateur radio and League membership recruiting...hi) are encouraged when you encounter the wireless LAN community organizations and the WISPs that may be in your area. Although we are licensed and they are not, they outnumber us many times over, so we should practice a live and let live in good harmony approach. Because of the content restrictions of the Amateur Service (no pornograhy, no commercial activity, etc.), they may not wish to join us, but that doesn't mean we can't get along.

A traffic separation technique that is considered acceptable involves the use of WEP (wired equivalent protection)...not for encryption, as that may be inappropriate in the Amateur Radio Service, but for authentication. If you use this approach under Part 97, therefore, you should ask that the WEP key be published on the HSMM webpage, <www. arrl.org/hsmm/>. As an alternative, you could use your local radio club webpage to publish the key. Again, the WEP is used to avoid the accidental mixing of Part 15 and Part 97 traffic. Another approach gaining in popularity with many HSMM stations is the use of 44 domain IP addresses which are only available to the Amateur Radio Service.

This is all just the beginning. Did the previous "Op Ed" writer think that the only thing amateurs would be doing with this technology is the same as some WISP have done—i.e., just replace rubber ducks with outside antennas, thus changing the RF footprint from a WLAN to a wireless wide-area network? Amateurs are much more innovative and creative than that. No, these are just our first few baby steps into this spread-spectrum domain pioneered many years ago by the Tucson Amateur Packet Radio (TAPR) group. It's just that now we have access to cheap, off-the-shelf gear that can be modified for the Amateur Service so we can learn, experiment, grow, and change.

Here is some of both my short- and long-range vision for HSMM:

The previous "Op-Ed" writer may not be aware of HSMM Working Group collaboration with TAPR to develop transverters suitable for use with 802.11b gear. These transverters would take the 2.4 – 2.5-GHz frequencies to the 3.3–3.5-GHz amateur band where there isn't Part 15 traffic at all, but the propagation is similar to that for 2.4 GHz. Also, HSMM is cooperating with AMSAT-NA and its proposal to experiment with ground-based 5-GHz in-band transponders.

There are other avenues of investigation that may also yield positive results in terms of the eventual development of an HSMM Backbone Network, or "Hinternet," for the amateur service—the use of HF and VHF (50.6–50.8 MHz) frequencies!

Accordingly, the HSMM Working Group is kicking-off a major research project called The HSMM-HF Project. Neil Sablatzky, K8IT (<k8it@arrl. net>), has enthusiastically agreed to lead this new HSMM project. Neil was part of the original Hinternet Team. He built the first very large 2.4-GHz slot antennas for use in early amateur radio 802.11b experiments *(see the "HSMM" column in this issue of* CQ VHF *for more details on simple, inexpensive 2.4-GHz horizontally polarized slot antennas—ed.).*

Some of this new HSMM-HF Project is based on what we have learned about propagation using IEEE 802.11g. This "g" version is also on 2.4 GHz, but uses a non-spread-spectrum approach which is predominately orthogonal frequency division multiplexing. This is a modulation scheme.... Think of it as large string of PSK-31 signals. The HSMM Working Group has found that OFDM is more resistant to the adverse effects of multipath fading than spread spectrum. The plan is to use Gerry Youngblood's software-defined radios, Model SDR-1000, as the test platform for this project. See <www.flex-radio.com> for details.

Just because the "rest of the world" is using some off-the-shelf wireless gear for WLAN, and amateurs are adapting this same gear to their style of operating, does not mean by any stretch that this is what amateurs are always and forever going to be doing. We are just getting started with our explorations!

Vy 73, John, K8OCL

By Neil Sablatzky,* K8IT

HSMM

Communicating High-Speed Multi-Media via Amateur Radio

A Horizontally Polarized Omni-Directional Antenna You Can Build

As mentioned in the Spring 2003 column, most HSMM communication will be horizontally polarized to minimize interference to ISM Part 15 users, who predominately use vertical polarization. This month we will discuss how to build a very low-cost Alford Slot antenna suitable for HSMM Part 97 stations.

As shown in figure 1A, an Alford Slot antenna is based on a one-half-wave-length vertical slot. By machining a slot into a cylinder (figure 1B), the impedance of the circumference becomes lower than the vertical-slot impedance, which allows current to flow and a set of infinite stack loops to radiate. If the diameter of the cylinder is about one eighth the desired wavelength, the slotted length is adjusted to 0.75 of a wavelength, and the slot width is maintained at 0.02 wavelength, a useful 7–8 dBi horizontally polarized omni-directional pattern results. Figures 2A and 2B illustrate the difference in radiation patterns between the slotted sheet and the cylinder. Empirical testing of several prototypes reveals a stable design.

The antenna consists of a length of slotted tubing as shown in figures 3A and 3B. The width and length of the slot, the wall thickness, and the diameter of tubing are all related and will vary slightly.

For HSMM use, I decided to use 1/2-inch copper water pipe, which has a nominal OD of 0.625 inch. The slot was cut to be 2.5 mm wide and 88 mm long. The slot was centered in a length of 1/2-inch copper water pipe with an overall length of 188 mm.

The slot in the tubing can be cut with a small jeweler's file. You first will need to drill a hole at either end of the vertical slot. Use a 3/32-inch drill bit.

The length of the copper tube above and below the slot is not critical, and the copper tube can be used as a support device. However, you must provide a copper shoprting disk for both the top and bottom end of the vertical slot. Slipping a copper disk in from each end and soldering from the open side around the disk works great.

The feed-point impedance of this antenna is approximately 200 ohms. A convenient method of feeding it from 50-ohm coax is to build a 4:1 balun, which consists of a piece of 0.141-inch (UT141) semi-rigid coax with two slits cut along opposite sides of the outer shield. These slits are 29.3 mm long.

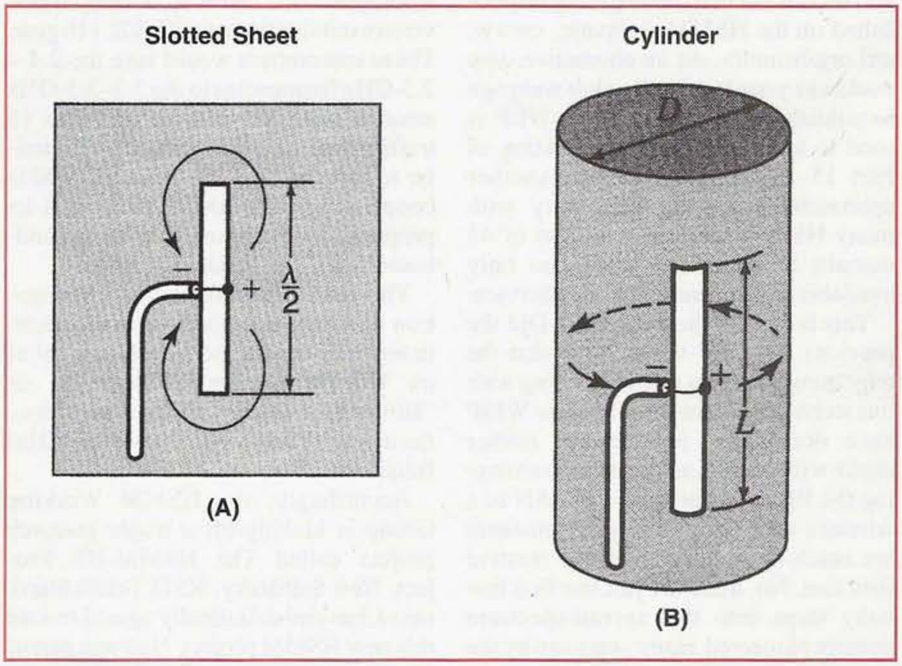

Figure 1. (A) A one-half-wave vertical slot antenna. (B) Vertical slot antenna formed into a cylinder.

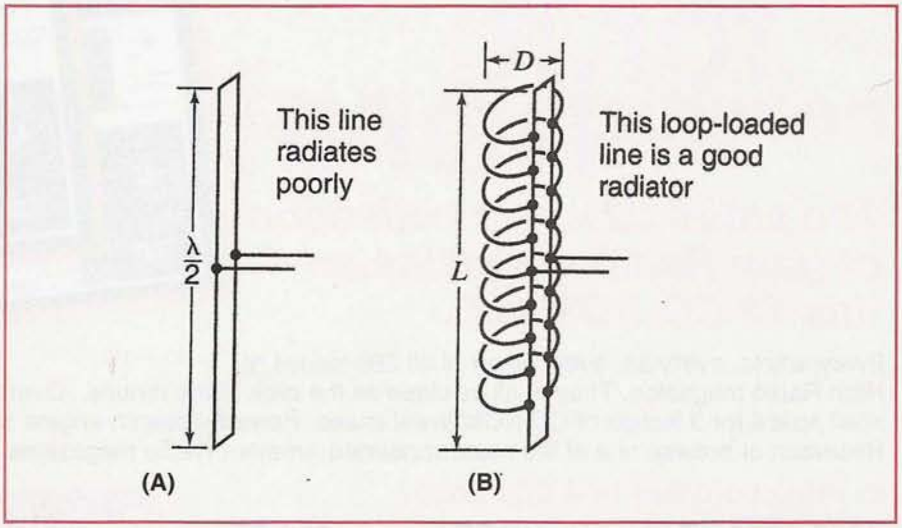

Figure 2. (A) The radiation pattern of a vertical slot antenna. (B) Radiation pattern of a vertical slot antenna formed into a cylinder

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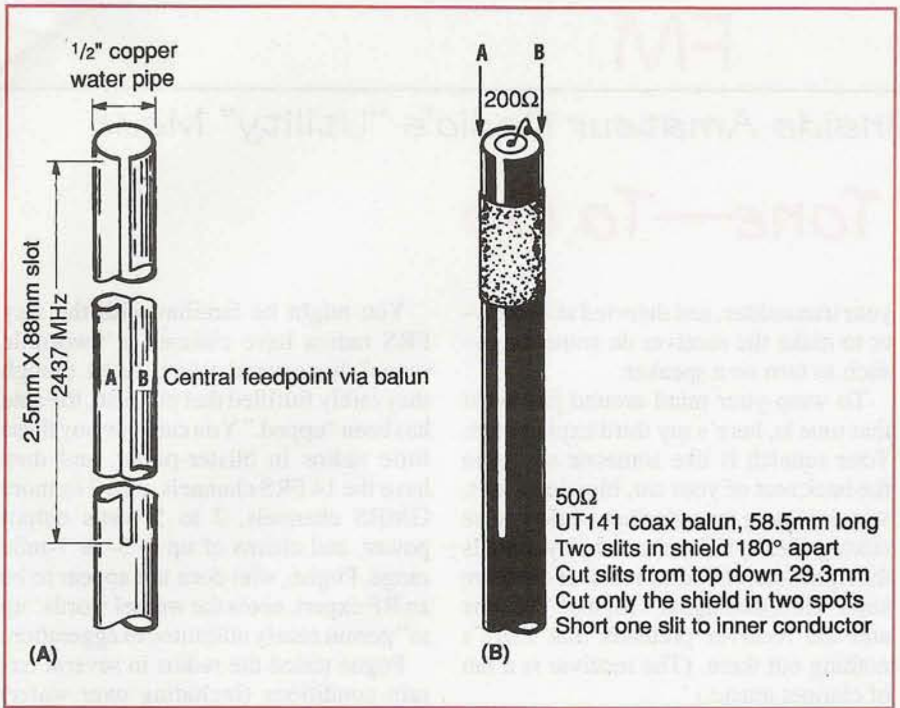

Figure 3. (A) The slits made in the copper-pipe tubing for the creation of the slot antenna. (B) The 4:1 balun needed to match the 200-ohm impedance of the antenna to the 50-ohm impedance of the feedline.

Next short one of the outer shield sides to the inner conductor at the top of one slit and then solder both outer shields to the mid-point of the copper water pipe vertical slot on opposite sides of the copper water pipe vertical slot.

Now route the UT141 coax inside and down the tube along the inside wall opposite the vertical slot. By drilling a small hole in the bottom disk, you can route the coax out the bottom of the length of copper pipe. Finally, terminate the UT141 coax with your favorite UHF RF antenna connector.

Dayton 2003 Highlights

The Dayton Hamvention® included many companies offering HSMM equipment. New products from ICOM, WI-SYS, and RFLYNX were on display.

The ARRL's HSMM Working Group presentation, which was part of the ARRL's Technology Task Force Forum, was well attended by both amateurs and Part 15 users. Favorable feedback was given by several WISP (Wireless Internet Service Provider) owners for the approach the HSMM WG suggested to amateurs with respect to minimizing interference to Part 15 users. The HSMM WG suggests that amateurs first contact their local WISPs to ensure that any operation on their part will not interfere with the local WISP operation.

The HSMM WG also announced plans to develop High Frequency High Speed Multi-Media Network Links on frequencies below 30 MHz. No details were available, except that the development is going to be based on Gerald Youngblood, AC5OG's software-defined radio, the SDR-1000, which is a complete software DSP radio platform. More information on Youngblood's radio can be found at his website: <http://www.flex-radio.com>.

Correspondence

The following was sent to me by John Champa, K8OCL, ARRL Chairman, HSMM Working Group *(also see this issue's "Op Ed" by John—ed.).*

Dear Neil,

The ARRL Technology Task Force High Speed Multimedia (HSMM) Working Group has been encouraging the development of HSMM experimental networks around the United States. Given the relatively low population density of amateur radio stations in some areas of the country, our path analyses sometimes indicated that higher gain antennas, lower noise receive systems, and slightly higher transmit powers are warranted to provide successful links between stations.

Although some off-the-shelf Part 15 equipment in the form of bi-directional amplifiers (BDA) is available, these items tend to be extremely expensive in terms of the typical amateur radio equipment budget. For example, a typical 1-watt BDA can cost as much as $500.

Accordingly, encouraging your more technically oriented readers with home construction capabilities to develop more economical homebrew solutions to this occasional need for the BDA would be appreciated. Simply put, we need construction articles for 4–10 watt bi-directional amplifiers for 2.4 to 2.5 GHz to amplify 13-22 dB IEEE 802.11b/g signals to an output between 4-10 watts. We need receive pre-amplifiers that have 10–20 dB amplification with a noise figure of less than 4.5 dB.

Standard input levels of 10, 17, 25, 50, 100, and 200 mw would be helpful.

The amplifier will be connected to an 802.11b/g WLAN device, so T/R switching done by RF sensing with speeds required to support IEEE 802.11b/g operation would be needed.

Submitted homebrew BDA construction articles could be published in your venue (this column) or on our webpage, <http://www.arrl.org/hsmm>.

Thank you in advance for your support of amateur radio HSMM experimental efforts. —*Very 73, John, K8OCL*

I encourage all readers to send me e-mail with your questions. I will try my best to answer all of them. My e-mail address is <k8it@arrl.net>. I would also like to receive digital photos of HSMM applications. Please identify any people in your photos with names and callsigns and provide a short description of the subject.

73, de Neil, K8IT

HSMM Trivia

Submitted by Darryl Smith, VK2TDS:

There is an antenna that performed the worst in our tests. What is the name of that antenna and what company made the chips for it? (The answer will appear in the next column.)

By Gary Pearce,* KN4AQ

FM

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

Tone—To Go

It's summer vacation season. Hams are on the road, taking their VHF/UHF FM radios with them. As they travel, to their dismay they discover that they can't use many of the repeaters they pass on the road—even repeaters they hear on the air that are being used by local hams. The reason is because the repeaters are tone-guarded, and the mobile ham doesn't know the tone.

Does the FM guru have a solution? Maybe, but first I think I'd better do the tone primer that all FM columnists must do at least once. I've been holding off, waiting to let the *CQ VHF* subscription base increase. We're up, so it's time. After this quarter's column, I'll try to let the subject go for a long time and look at other stuff.

What is "Tone"?

You're reading *CQ VHF,* so there's a pretty good chance that you are very familiar with tone squelch. However, I remember how baffled I was when I first encountered it in the early 1970s. What was this mysterious technology that allowed the signals of only certain select hams into a repeater? I wasn't the only one in the dark. Lots of hams use tone squelch today without understanding it. Many operators haven't figured out how to make it work and they are stuck on carrier-access repeaters. Therefore, here's the tone primer.

First, the very simple explanation: Tone is a system that lets a receiver accept certain radio signals on a channel, rejecting other signals on that same channel.

Now I'll get slightly more complex: Tone squelch is based on a low-frequency, low-volume pure sine-wave tone that is added to your voice, which is sent from your transmitter, and detected at a receiver to make the receiver do something—such as turn on a speaker.

To wrap your mind around just what that tone is, here's my third explanation: Tone squelch is like someone sitting in the back seat of your car, blowing a soft, very low note on a clarinet while you're talking. Really! The clarinet player holds the right note, and some receiver out there says, "Hey, that signal's for me!" No tone and the receiver pretends that there's nothing out there. (The receiver is a fan of clarinet music.)

This rose goes by many names. The generic name is Continuously Tone Coded Squelch System, or CTCSS for (not very) short. The name and the initials are both awkward mouthfuls, so I just call it *tone* (or *tone squelch* when I'm feeling formal). It is probably best known as PL, the initials of the Motorola trade name Private Line. Almost all the old-timers call it PL, although there are a few holdouts for the name applied by other companies, such as GE's Channel Guard (CG). If I were a *really* old timer, I could tell you the name used by RCA, E.F. Johnson, and a handful of other legendary brands of commercial FM radios. Write to me if you feel the need to remind me. It is also sometimes called *sub-audible tone,* or *sub-tone.*

Okay, now that we're on a first-name basis, just what is tone squelch? How does it work? What can it do for you, and what can't it do?

Range War

Wait. I can't get into instruction without wasting some time first. That's my trademark. I'm looking at an explanation of tone squelch in a *New York Times* article by David Pogue[1] that was reprinted in the May 21, 2003 issue of the *Raleigh News & Observer.* In his article Pogue takes radio makers to task for their exaggerated claims of 5- and 7-mile range for their new GMRS handheld radios. That is the tangent I'll follow for a while before getting back to tone.

You might be familiar with the way FRS radios have claimed a "two-mile range" for several years. Even though they rarely fulfilled that promise, the ante has been "upped." You can now buy these little radios in blister-packs, and they have the 14 FRS channels, plus 7 or more GMRS channels, 2 to 5 watts output power, and claims of up to 5- or 7-mile range. Pogue, who does not appear to be an RF expert, notes the weasel words "up to" permit nearly unlimited exaggeration.

Pogue tested the radios in several terrain conditions (including over water) and squeaked out 3.3 miles at absolutely best case, and less than 2 miles in all overland tests. Hams who have played with UHF handhelds on simplex might expect to do a little better, especially over water, but I think most of us would admit that 5 miles between rubber-duck-equipped handhelds on level ground in a rural area is not likely. Hit a hot spot just right, and you might be able to talk at that distance, but routine communications? No way.

Pogue challenged the manufacturers on their claims, saying that they "call these freakishly poor results," chalking them up to "environmental factors that can affect range—humidity, wires, vegetation, buildings, clouds, hills, airplanes, and even sunspots." He adds, "Now there's a high-tech corporate excuse you don't hear every day." How much do you want bet that the guy he was talking to was a ham? Sunspots? Affecting UHF handhelds? Not likely!

A few years ago I ran a test between a pair of "2-mile range" Motorola FRS radios and ICOM W32s (running 1/2 watt to match the FRS power). However, in preparing for the test, I didn't check the sunspot count.

On a flat, straight road lined with wood-frame beach houses and no overhead power or phone lines, both radios worked well to just under a mile. They got pretty noisy after that. At the claimed 2-mile limit I could communicate over the FRS radios only when they were carefully aligned in "hot spots." Civilians would not recognize that as communications.

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1 *Pogue, David, "For Two-Way Radios, a Mileage Test," Circuits: State of the Art,* New York Times, *May 8, 2003, Late Edition: Final, Section G, Page 1, Column 1.*

The W32s beat the FRS radios by a hair at 1/2 watt.

One other thing, as long as I'm not even pretending to be on-topic—licensing. The GMRS radios are supposed to require a license, complete with callsign. The 10-year tab is a steep $75. Pogue says, "radio makers acknowledge . . . that this requirement may be the most universally ignored regulation since the invention of jaywalking." He hasn't spent much time on CB.

What Did You Say "Tone" Was Again?

Now back to our column. In his article Pogue attempts to explain tone, which has now picked up some new names, such as privacy code, sub-channel, and subcode. Here's what he says about tone in the FRS/GMRS radios: "Each radio also offers subcodes: thin frequency slices of each channel that help prevent crosstalk from other radio owners in the area."

I think that about sums it up. Thin frequency slices of each channel. Why didn't I think of that? Well, Mr. Pogue did such a nice job of skewering the big radio guys on their inflated range claims that I think we should give him a free pass for spouting utter gibberish on a technical subject that nobody really cares to understand anyway—nobody but hams and radio techs, that is.

Now here's the bottom line: As I said up front, CTCSS is a low-frequency, low-volume pure sine-wave tone that is added to your voice and sent from your transmitter. There are about 38 separate audio frequencies used for the tone, from 67 Hz to 250.3 Hz, although most radios include a few extra "non-standard" tone frequencies. This tone is called *sub-audible* because ham and commercial radios are supposed to filter out audio below 300 Hz and not let it get to the speaker. Humans, of course, can hear those frequencies just fine if a speaker can reproduce them. If you turn up the volume with someone sending one of the higher frequency tones, you will hear it, or harmonics of it, in your speaker. In a narrowband FM radio with 5 kHz deviation, the tone should have about 700 Hz deviation. Because it's added to the voice, the voice volume has to be reduced a bit to avoid over-deviation by the combined voice-plus-tone audio signal.

The tones are generated by a circuit called an *encoder*. In the 1980s tone encoders were separate, optional plug-in circuit boards. Older radios didn't have provisions for encoders at all, but you could buy an add-on aftermarket board and try to stuff it into your radio. Today they are part of the radio's circuitry and controlled from the front panel.

Tone becomes useful only at the receiver end of things. There, a circuit called a *decoder* listens for the tone. When the decoder hears the tone, it can do several things. The most common thing it does for hams is turn on a repeater transmitter. On a "tone-guarded" repeater you have to send the correct tone or the repeater stays off the air, which was our mobile ham's problem: What tone should he send to activate the repeater?

There also is a digital version of tone that has begun showing up in amateur radios over the past few years. Probably it shouldn't be called *tone,* because it isn't. It's a data "word" sent at a low rate, using low-frequency audio energy mixed with the voice just like the CTCSS tone. It is kind of like sending a packet word over and over. The generic name is Digital Coded Squelch, or DCS, and some of the manufacturers even use that name instead of making up a new one. However, you will find DPL (for Digital Private Line) and DCG (for Digital Channel Guard, which is a General Electric trademark term) in use by some big radio manufacturers. The goal is the same as tone—turn on a speaker or a repeater.

There may be some ham repeaters out there that require you to send DCS. Today these would have to be fairly exclusive or "closed" repeaters, because most radios don't have DCS encoders and it's not something you can tack on easily (although there are "outboard" DCS boards on the market).

Our mobile ham probably doesn't have to worry about DCS for at least a few years. The repeater he can't kerchunk is probably not using DCS. It's probably just plain old tone. Again, however, what tone?

Why Tone?

I'll get to the "what tone" in a minute. First, let's look at the "why" question.

Engineers (probably hams) invented tone to solve the problem of channel congestion in the early days of commercial two-way radio. Bob's Towing Service and Mary's Taxi Company didn't want to listen to each other's transmissions. However, there weren't enough separate RF radio channels available to let every business have a private, quiet channel, so they had to share one. To keep Bob's speaker quiet when Mary was dispatching and vice-versa, they both used tone squelch. Bob's radios used the tone frequency of 107.2 Hz. Mary used 156.7 Hz. In addition, several other users on the channel used other tone frequencies (nice, quiet radios). Problem solved.

However, as you know from physics, for every solution there is at least one new problem. In this case, Bob was giving directions to his tow-truck driver one day just as Mary received an order for a taxi ride. Her tone decoder prevented her from hearing that Bob was on the air, so she keyed the mic and called one of her cabs while Bob was still transmitting.

Bob's driver heard something like this from his speaker: "Go pick up a stalled Chevy at 245 WashingtSQUEEEP——————." Meanwhile, Mary's cab driver heard nothing at all—not even the squeeep.

What happened? This being the old days, Bob and Mary were using simplex. Bob's tow truck was near Mary's office, so when Mary started transmitting, her signal was a little stronger than Bob's. She captured the tow-truck driver's receiver. The "squeeep" sound was a bit of heterodyne. Then, the tow-truck receiver couldn't hear the tone from Bob's transmitter any more, so it turned off the speaker, even though Bob was still transmitting. Mary's taxi happened to be sitting at the gas pump in Bob's filling station, about 50 feet from Bob's antenna, after filling up with 28 cents per gallon ethyl. The driver didn't hear Bob at all, of course, because his radio was set for a different tone. With Bob's transmitter on, he didn't hear Mary either.

The radio manufacturers tried several solutions to this problem: light a pilot light when the channel was busy (your radio may still do that); lock a transmitter out when it was receiving a signal; turn off the decoder when the mic was lifted from the hang-up bracket so the radio operator could hear the other traffic on the channel. Ingenious people found a way to defeat them all.

Tone and Ham Radio

Public-safety radio users—police, fire, medical—typically didn't have to share channels within their community. However, they did have to share them with other users 50 to 100 miles away. These other stations were close enough so that they could hear each other during band openings. (Yes, the commercial radio services get the same band openings we hams do, but they don't enjoy them as much.) Therefore, they use tone to keep their radios from hearing their neighbors down the pike.

That's one of the main reasons ham repeaters use tone. Ham repeaters are typically located about 100 miles apart—sometimes more, but rarely less. Most of the time that's far enough apart to avoid serious interference. Too often, however, a ham using one repeater will put a weak signal into the neighboring repeater, especially if that ham is near the half-way point, running a bit of power from a good location. Better operating procedure, such as running less power or a directional antenna, might solve some of those problems, but not all of them. Band openings, which we otherwise enjoy, can make the repeater problem worse. Therefore, the repeater owner adds a tone decoder to the repeater to kill the signals from hams using the neighboring repeater.

A second problem that makes repeater owners "go tone" is noise at the repeater site. Repeaters are often located at busy RF sites. Everyone wants to be on the building, hill, or tower that provides high elevation, so the ham repeater has a lot of commercial neighbors with antennas only a few feet away. A carrier squelch repeater could be keyed up a lot with bleeps and squawks from intermodulaton (intermod) and other RF gremlins. These can be hard to track down, and expensive to eliminate even if they can be found. It is easier to add tone decode and keep the repeater quiet, even though you're not really eliminating the offending signal from the receiver.

Therefore, the repeater owner elects to trade problems (he might use the word *solve,* but just wait). He adds tone to the repeater and quickly discovers two new problems.

One is the slings and arrows from the local hams who can't use the repeater any more, possibly because they have relic radios that don't have tone (or have just one tone frequency), or possibly because they have very modern radios with an inch-thick manual and the tone is buried seven layers deep in a "set and forget" menu of some kind. Either way, user education is one of the problems the repeater owner finds that he has traded. He has to let everyone know what the tone frequency is and help some people get their radios working with the tone. Those of you who have never been through "user education" may scoff, but just try it.

The second problem is that he has just masked his RF problems. He hasn't solved them. If a moderately strong signal appears on the repeater input without tone, it will still interfere with users. It just won't key up the repeater. If the interference is strong enough, it will make a weaker user signal "go away." Most repeater users get very confused when this phenomenon happens.

Masking the problem may be the best you can do with the time and financial resources you have, but you should understand the compromise and educate your users about it.

Back on the Road

Okay, let's get back on the road with our vacationing ham. He's passing your tone-guarded repeater, and he'd like to talk or maybe he even has an emergency to report, but he doesn't know your tone. His options are limited, and he has no perfect option. Here's my list. You can probably think of a few things I'll miss.

1. Look it up. If he has a repeater directory, he can attempt to look up the repeater and see if the tone is listed. I don't recommend this for a solo driver, though, unless you enjoy bouncing off bridge abutments. This is something that's accomplished more effectively in advance, marked on a map in BIG letters and numbers, and programmed into memory. (Finally, a use for those memory channels above number 11!) Do that and you'll improve your odds of getting into repeaters along the route. Repeater directories are not flawless, however, and the tone listings are error-prone. It's not the directory editor's fault. Getting up-to-date information from some repeater owners is impossible. They are neither belligerent nor deliberately uncooperative; it's just not a high priority in their busy lives.

2. Scan for the tone. If the repeater is currently transmitting, if the repeater sends its tone, (many suppress it on the output) and if the ham has tone scanning in the radio, he can scan for the tone. This won't help when the repeater isn't on the air, of course. Newer radios include tone scanning that isn't too hard to find, but it still may require dangerous multi-button manipulation by a solo driver. It would be nice if tone scanning could be a one-button feature, but buttons are a limited resource on shrinking front-panels. Which one do you want to trade?

3. If the radio doesn't have tone scanning, he can do it manually by turning on the tone decode and clicking through the tones until the speaker opens. Again, this is not recommended for a solo driver.

4. If the repeater is not on the air, then he could select a tone, kerchunk, change the tone, kerchunk again across the tone spectrum until the repeater keys up. I've done this a few times when it was the only way to find a tone.

Repeater owners could help some by having the repeater announce the tone frequency on the ID if you have a voice ID. Many repeaters do it that way as a courtesy to traveling hams, or as part of the local ham education campaign.

There are some "blue sky" solutions, too. Repeater controller manufacturers could agree on a standard "bypass" for tone guard. It could be a long touch-tone zero (LTZ) or other digit that would cause the repeater to announce its tone, or allow carrier access for a few minutes (an idea suggested in mail from Mike Urich, KA5CVH). I've seen some limited attempts at a "universal" second tone to which all repeaters would respond—say, 100 Hz. Could you keep all the users from just plugging in 100 Hz and avoiding the hassle of learning the primary code? Furthermore, I've seen "regional" tones where most repeaters in a defined geographic area use the same tone, so if you find one, you've found them all. I don't expect to see any of these implemented widely, but again, if we talk about it enough we might get a following.

In the meantime, however, none of the current options is perfect. Repeater owners choose tone access as a convenience or as a necessity for local operators at the expense of travelers. That's just the way it is. If you want to minimize the impact, keep your repeater information up to date with your local repeater council and announce your tone on your ID.

146.52 MHz Revisited

It looks as if 146.52 MHz will become a regular feature of this column. It has drawn a lot of interest. If you'll recall from the Spring 2003 issue of *CQ VHF,* Leonard Umina, K1LU, suggested several different tones for a variety of uses of 146.52 MHz: 100 Hz for emergencies, 67 Hz for general calling, no tone for ragchewing, and 254.1 Hz to let people know you're at Disney World with them.

Bob Witte, KØNR (who wrote the article on VHF QRP in the Spring 2003 issue), wrote to point out that the plan might work if it were simplified. Anyone listening for general calls (67 Hz) would certainly also want to hear emergency calls. However, our radios typically don't permit listening for two tones simultaneously. Therefore, he suggests lumping general calling and emergencies under the same tone, which should work, assuming people "don't ragchew using the calling tone" (see the "FM" column in the Fall 2002 issue).

Most radios let you program the same frequency with different tones, into different memories, so you can scan for different tones by scanning memories. However, I agree with Bob—the practice gets too complex to expect people to do it. I still don't think we'll get hams in general to do more than they're doing now. Even so, I'm also still willing to be wrong!

Mike, KA5CVH, also commented on 146.52-MHz ragchewing. He says that finding simplex contacts is difficult enough without spreading them around the band, so "leave ragchewing on 146.52 MHz alone. I'm not naive enough to believe that this isn't a problem in the eyes (or ears) of some hams, but I don't see it as a significant enforcement issue."

Well, this is like a slow-motion version of an eham.net debate, yet it shows you're reading the column, so I welcome your comments.

Dayton

I was lucky enough to get to the Hamvention® this year (the "Dayton" has been dropped from the official name, but, at least, so far, it's still at the good old Hara Arena). This was not a banner year for new FM equipment, but there were some models introduced.

Alinco showed the DR-620T. It is a dual-band mobile capable of TWOBAAT receive (that's my acronym for simultaneous two-band receive, which means Two Bands At A Time). The '620 will hear two VHF or two UHF channels at once, too. Its special features include broadcast-band FM with wideband receive and digital voice communications with optional EJ-47U unit.

Yaesu is planning a dual-band version of its four-band FT-8900. The 8900 is an FM rig that covers 10, 6, and 2 meters, as well as 70 cm. The new radio, the FT-8800, will be just 2 meters and 70 cm. It looks just like the '8900.

ICOM is on the verge of releasing its D-STAR system. That's a combination 1.2/10-GHz FM/digital system that will combine analog FM with narrow and broadband digital on 1200 MHz and a 10-GHz digital linking system. This is a bold attempt at moving amateur radio into the future. Even ICOM doesn't know exactly how hams will use it, or even if hams will use it. There's a very limited amount of FM operation at 1200 MHz in the U.S. (I'm told it's big in Japan, where the D-STAR system has already been deployed.) We'll be watching D-STAR carefully. If you buy one, drop me a line!

The National Frequency Coordinating Committee meeting was smaller than I expected. Two years ago there was a big audience. This year they had a short time slot on Friday afternoon, which may have held participation down, as hams combed the flea market for bargains.

NFCC President Nels Harvey, WA9JOB, announced that he and VP Ken Chilton, KA1TIH, would be retiring at the end of their terms. He also discussed the efforts of the new coordination group in the New York City area, MetroCor, to become an NFCC member.

Frequency coordination is a very behind-the-scenes activity for FM and repeaters. It's a big deal to a repeater owner who's attempting to obtain coordination and a very big deal to one who has been denied coordination (holding a letter from Riley with an interference complaint). For most hams, however, it's an invisible area of the Utility Mode. I'm planning to shed some light on it in an upcoming column. If you have something to say about coordination, I'd like to hear from you.

FM operation at Dayton has always been interesting. DARA's talk-in repeater on 146.94 MHz is always entertaining. The talk-in operators do a pretty good job of answering a question, waiting 10 seconds, and then having someone ask the same question so they can answer it again. They could be supplied with a little more information on activities in advance. It seems as if there is a lot going on that they don't know anything about.

Of course, the repeater is a target for some of our maladjusted brethren. It has been that way at least since the early 1970s when I first started attending the hamfest. I wonder if they are a local phenomenon or part of the swarm from out of town (probably some of both). The talk-in guys are cool, though. It doesn't bother them.

The other Dayton repeaters also seemed hyperactive during the weekend. It's the level of activity on 6 and 2 meters, and 125 and 70 cm, that we might wish all areas had all the time. This year there were several IRLP and Echolink connected repeaters, and visitors used them to phone home. I scanned the bands while walking through the flea market and discovered lots of groups hiding out on various frequencies across 2 meters and 70 cm. Some groups talk on their home repeater's output frequency if there isn't a local machine on that channel.

The arena was crowded, but it didn't seem as incredibly dense as it has been in other years. However, even if the crowd is thousands fewer than it was at its peak, Dayton—excuse me—Hamvention® is still an incredible experience. If it's made for, or done with, ham radio, you'll find it at Dayton. Make your motel reservations now, and I'll see you there next year.

That's it until the fall issue. Have a great summer! ■

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Multi-Band Dish Feeds

Multi-band dish feeds grew out of the need for something easier to haul around for my antenna range. These dish feeds have given me 12 years of service. Every July the Central States VHF Society holds an antenna contest, which gives the members a chance to compare designs on a one-on-one basis, try out their new designs, and tweak their current antennas. Marc Thorson, WBØTEM, measures 50–432 MHz antennas and I handle the higher bands up to 24 GHz (I'm working on 47 GHz). It's not uncommon for us to measure 125 antennas during a morning. Hauling equipment around for my eight bands is a challenge, to say the least. Being able to combine antennas is a great help—a great help for me, and a great help if you're a contest Rover station, or if you just want to combine several bands in one dish feed.

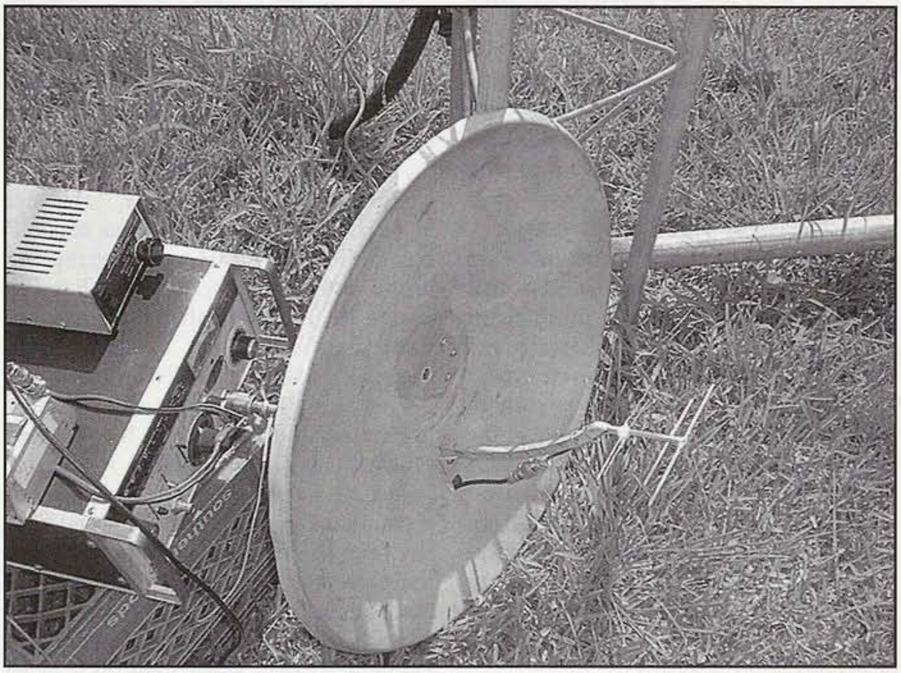
Photo A. The 902–1296 MHz feed in use on the antenna range.

The dish was used as the signal source during a recent North Texas Microwave Society Antenna technical party. Yes, it was right on the ground. Putting the source antenna on the ground makes the ground part of the antenna. Basically, it gets rid of ground bounce and gives me a cleaner down-range signal.

You don't have to use these feeds on two bands, because they work just fine as a 902 MHz, 915 MHz, 1260 MHz, 1296 MHz, 2304 MHz, 3456 MHz, WeSAT, ATV, AMSAT Mode L, AMSAT Mode S, or even 802.11 dish feed.

Electrically you should recognize this design as just a multi-band dipole like one you might use on 20 and 15 meters with two reflector elements tuned for the same bands as the driven element. It is just a very small version of many HF two-band, two-element beams.

Performance has been pretty good. Built carefully to the dimensions (see Table I), the SWR is less than 2:1 on both 902 and 1296 MHz. If you have test equipment, it's easy to get better than –20 dB return loss (less than 1.1:1 SWR).

Construction

The driven element is made of bare No. 12 copper (2-mm) wire. I don't suggest a different diameter wire unless you have the test equipment to measure SWR on 902 and 1296 MHz. Changing the wire diameter will change the tuning. The reflector elements are made from 1/8-inch (3-mm) copper or brass hobby tubing. No. 10 and No. 12 copper wire have also been used to make the reflectors. I formed the driven elements by bending the wire around the shank of a screwdriver. You want the elements parallel and 1/4 inch (6.5

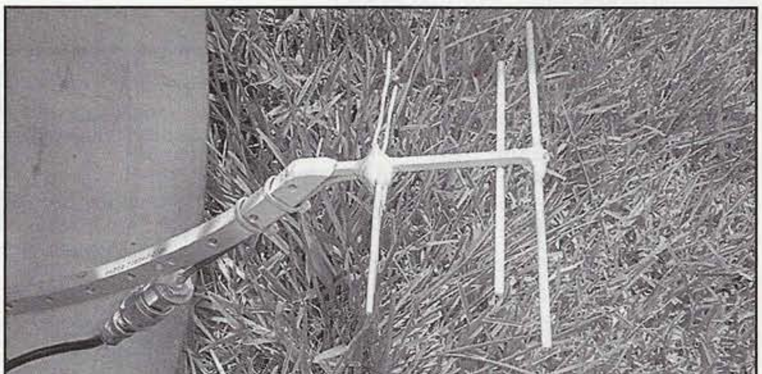
Photo B. The 902–1206 MHz dish feed.

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

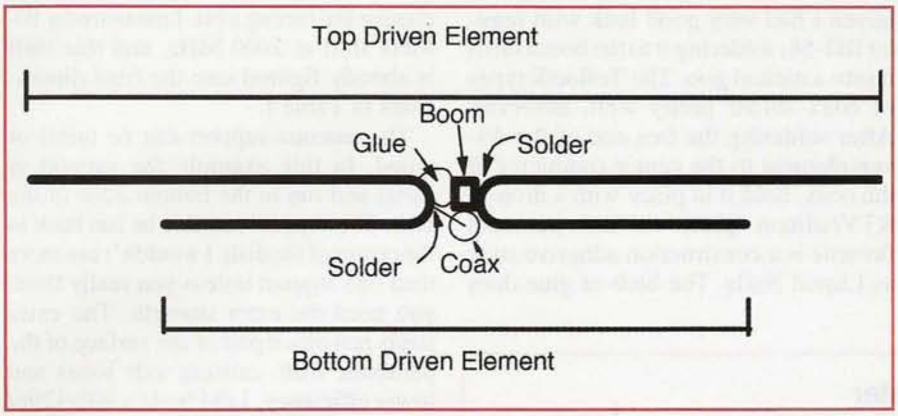

Figure 1. The length and position of the two driven elements of the two-band feed antenna.

Band MHz (MHz)	Top Driven Element	Bottom Driven Element	DE-R1	DE-R2	R1	R2
902/1295	5.9	4.5	1.9	2.4	4.8	6.8
1296/2304	4.2	2.5	1.25	2.25	2.8	4.8
1269/2402	4.3	2.4	1.2	2.3	2.7	4.9
1296/1691	4.2	3.4	1.75	2.25	3.7	4.8
2304/3456	2.5	1.75	.80	1.25	1.9	2.6

All dimensions are in inches unless otherwise noted.
DE-R1/DE-R: Distance between the driven element and the reflector element.
R1, R2: Length of the reflector elements.

Table 1. Dimensions of the dish feeds.

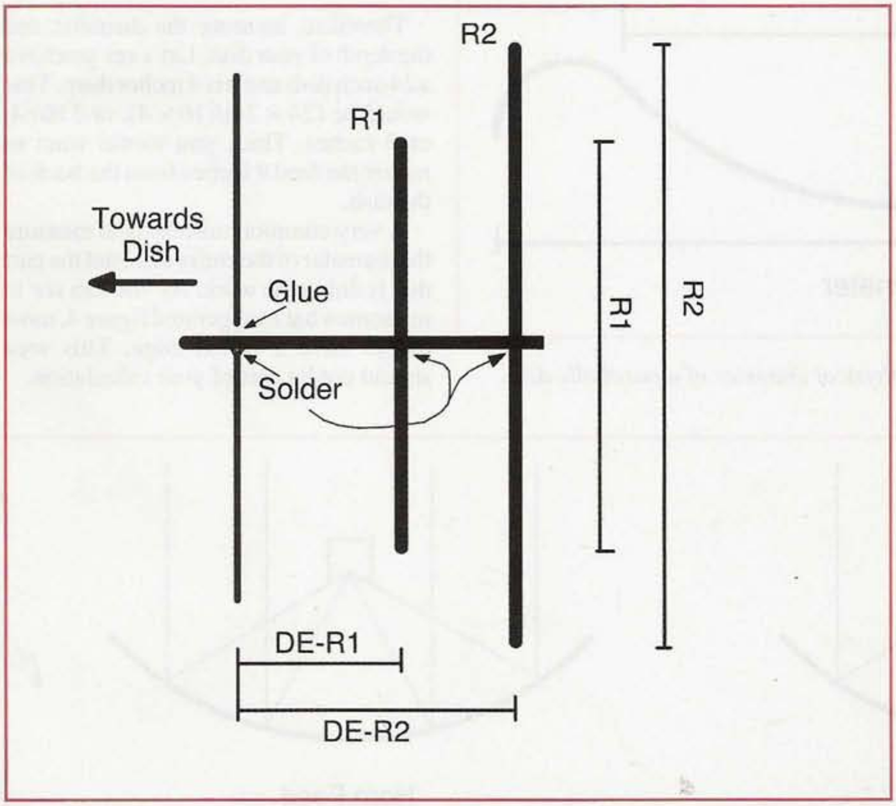

Figure 2. The relative size and position of the various elements of the two-band feed antenna.

mm) apart, measured from the center lines. For the boom I used 1/8-inch hobby tubing, which is the same as the reflector elements, but the 1/8-inch square hobby tubing is easier to work with.

The reflector elements are soldered to the boom and then soldered on one side of the driven element. Semi-rigid coax such as .141 works great, but Teflon® versions of RG-58 can also be used. I haven't had very good luck with regular RG-58; soldering it to the boom turns it into a melted goo. The Teflon® types of coax solder pretty well, however. After soldering the free end of the driven element to the center conductor of the coax, hold it in place with a drop of RTV/silicon glue, or my personal favorite is a construction adhesive such as Liquid Nails. The blob of glue does change the tuning a bit. I measured a 10-MHz shift at 2400 MHz, and this shift is already figured into the final dimensions in Table I.

The antenna support can be metal or wood. In this example the support is metal and run to the bottom edge of the dish. The support can also be run back to the center of the dish. I wouldn't use more than one support unless you really think you need the extra strength. The extra struts just block part of the surface of the parabolic dish, causing side lobes and lower efficiency. I did build a 902/1296/2304-MHz tribander, but it needed a stack of test equipment to tune it. I ultimately just built a log periodic antenna and used it as a feed.

My thanks to W5ETG for the beta test site, proving the feeds were reproducible.

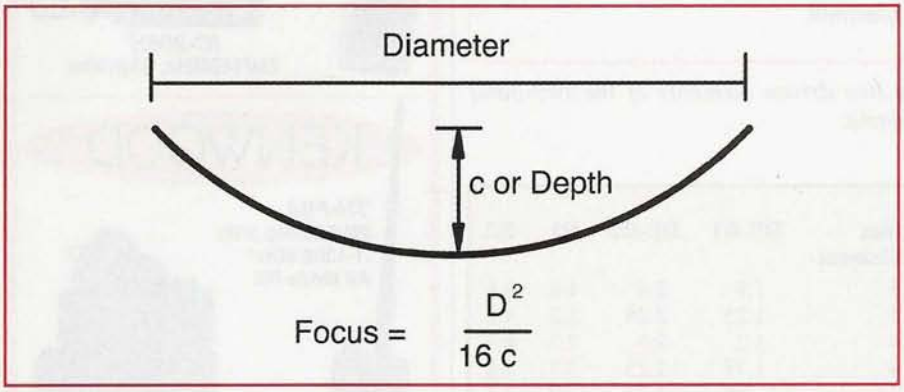

Figure 3. The positioning of the feed antenna for the parabolic dish in relation to the distance from the surface of the dish (see text for the formula for calculating the correct position).

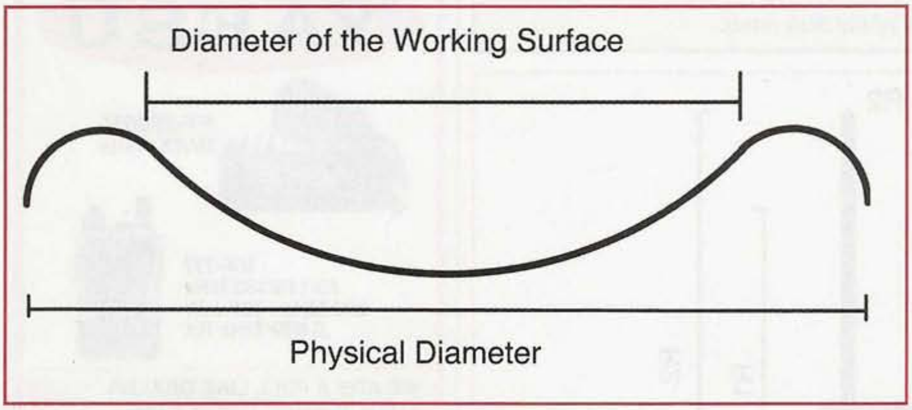

Figure 4. The working surface vs. the physical diameter of a parabolic dish.

The Focus of a Dish and Focus vs. Diameter

The focus of a dish is calculated by the formula:

$$\text{Focus} = (\text{Diameter}^2/16c)$$

where c is the depth of the dish.

Therefore, measure the diameter and the depth of your dish. Let's say you have a 24-inch dish and it is 4 inches deep. That would be $(24 \times 24)/(16 \times 4)$, or 576/64, or 9 inches. Thus, you would want to mount the feed 9 inches from the back of the dish.

A very common mistake is to measure the diameter of the entire dish, not the part that is doing the work. As you can see in my somewhat exaggerated figure 4, most dishes have a rolled edge. This area should not be part of your calculation.

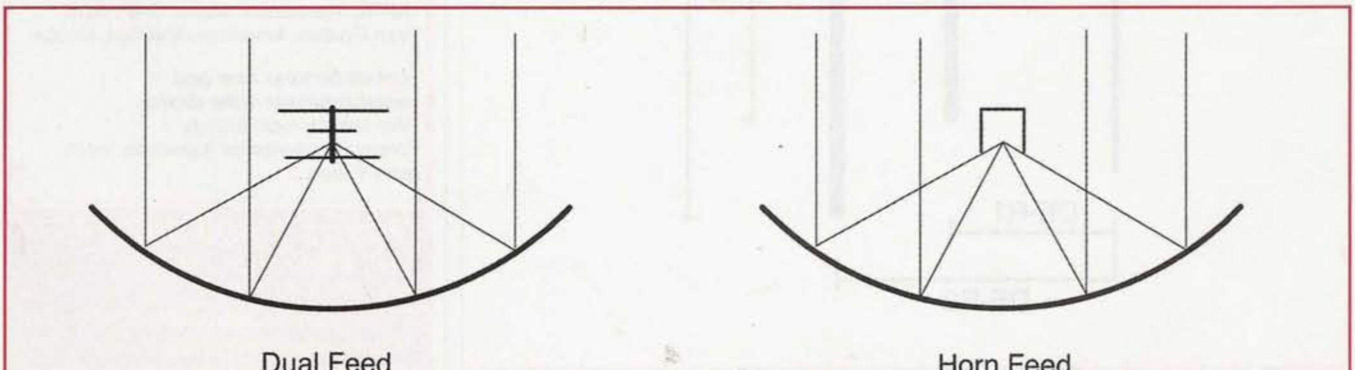

Figure 5. Feeds, focus, and feed phase center.

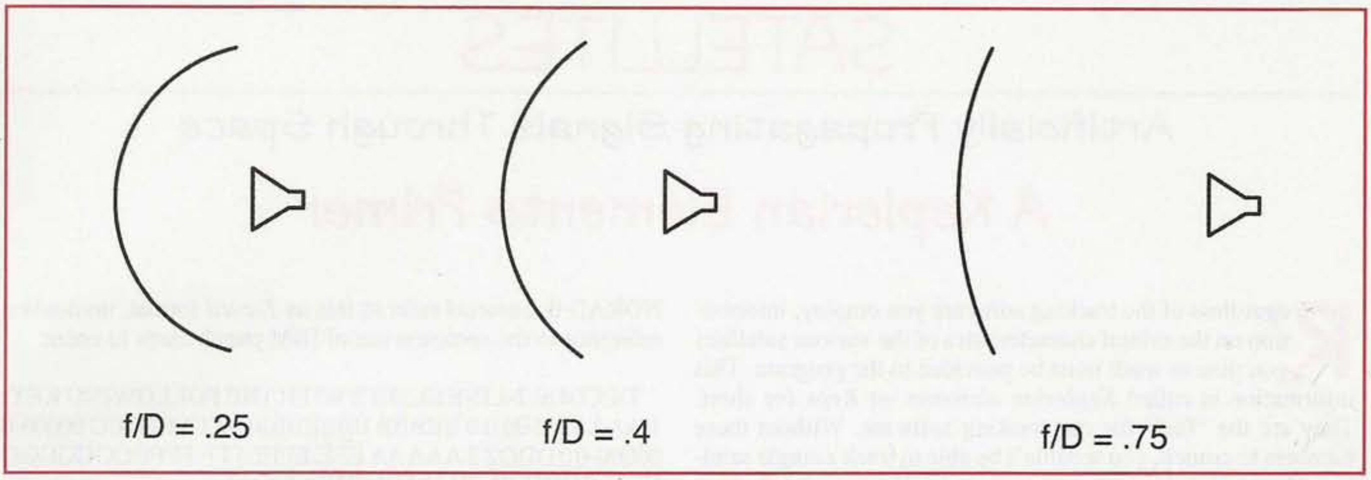

Figure 6. The f/D (focus vs. diameter) of a parabolic dish antenna.

If the dish has a fairly polished surface, a quick reality check can be made by pointing the dish at the sun. If there is a bright spot in the middle of the feed, you're pretty close to the focus, which is a quick measurement unless you like your feeds well done. For that last fraction of a dB you really need to find the focal point by moving the feed in and out on an antenna range, but these calculations will get you pretty close. You want the "phase center" of the feed to be at the focus of the dish, not just the edge of the feed. For the multi-band feed (this is about the center of the antenna) for horn-type feeds, the phase center is just inside the opening of the feed.

Now you have the numbers to look at the f/D (focus vs. diameter) of your dish. This value is very important in deciding what feed to use and the ultimate efficiency of your parabolic dish antenna. In the last example, the f/D would be 9/24, for a .375 f/D.

This feed works best with deep dishes having a f/D of .3 to .35, but it will give good results with dishes having a f/D from .25 to .4. As a side note, the satellite TV dishes have the feed *way* out in front. Their typical f/D is .7. Why you would want a .7 vs. a .25 f/D can be the subject of many future columns.

The feed is a little more fragile than I would like. If you are mounting the antenna outside for the long term, I would suggest some kind of cover or radome for it. The reflector elements seem to be the most likely to break off. Successful field repairs have been made with duct tape, twist ties, super-glue type adhesive, cable ties, and even chewing gum. ■

mhz mHz MHz . . . ghz gHz GHz

Now for one of my pet peeves: About 35 years ago, to honor Dr. Hertz for his work confirming the existence of electromagnetic waves (radio waves), cycles per second were renamed Hertz. Because it is customary to capitalize a person's proper name, the correct abbreviation is Hz. Let's drop using mhz and ghz, as they do not have any meaning in electronics.

The accompanying photo is of a 7-mHz transmitter. Just connect the clip leads to the coax connector, and every 71 seconds reverse the leads! What? mHz is the abbreviation for milli Hertz, so we are talking about 7/1000 Hz. Some friend sends you an e-mail and asks you to get on 146 mHz. Tell him or her that you're still collecting wire for your 1/2-wave dipole antenna. You need about 636,000 miles of wire to build a dipole antenna for 146 mHz! It's MHz and GHz, guys!

Keep those questions and e-mails coming. Your questions give me some of my best ideas for projects and articles.

The 7-mHz transmitter.

By Tom Webb,* WA9AFM

SATELLITES

Artificially Propagating Signals Through Space

A Keplerian Elements Primer

Regardless of the tracking software you employ, information on the orbital characteristics of the various satellites you plan to work must be provided to the program. This information is called *Keplerian elements,* or *Keps* for short. They are the "fuel" for our tracking software. Without these numbers to crunch, you wouldn't be able to track a single satellite. Keplerian elements were named in honor of Johannes Kepler, a 17th century physicist and mathematician who developed Kepler's Three Laws of Planetary Motion.

Keps are, in a very real sense, a snapshot of a satellite's orbital parameters. They tell the software the exact position of the satellite at a specific time and date. From that information the software can predict future positions of the satellite.

Our two examples of the most commonly used formats, AMSAT and NASA, are for AO-7 from elements distributed on 29 May 2003.

Back in the "bad old days," to load Keps automatically any nonessential information had to be removed from the Kep files, because the older DOS-based software was unable to distinguish nonessential data from required data.

The AMSAT Format (see below) was devised to allow simplified manual entry, thus being more "human friendly." Each element was identified to assure that the right numbers got in the right places.

Satellite: AO-07
Catalog number: 07530
Epoch time: 03149.21046743
Element set: 173
Inclination: 101.7417 deg
RA of node: 195.9888 deg
Eccentricity: 0.0011868
Argument of perigee: 247.9033 deg
Mean anomaly: 112.0780 deg
Mean motion: 12.53565389 rev/day
Decay rate: –2.9e-07 rev/day^2
Epoch rev: 30567
Checksum: 308

As tracking software became more sophisticated, the ability to load Keps automatically became a common feature. Now virtually all the current software will automatically update their Keps without having to edit extraneous material. The NORAD 2-Line Format contains "just the facts" data—no identifying labels, just the necessary element values to project the satellite's position. Both NASA and NORAD use this format for tracking predictions. When NORAD began its space-tracking mission, the tracking programs were written in Fortran. Early NORAD documents refer to this as *T-card* format, no doubt a reference to the common use of IBM punch cards to enter:

DECODE 2-LINE ELSETS WITH THE FOLLOWING KEY:
1 AAAAAU 00 0 0 BBBBB.BBBBBBBB .CCCCCCCC 00000-0 00000-0 0 DDDZ 2 AAAAA EEE.EEEE FFF.FFFF GGGGGGG HHH.HHHH III.IIII JJ.JJJJJJJJKKKKKZ

KEY: A-CATALOGNUM B-EPOCHTIME C-DECAY D-ELSETNUM E-INCLINATION F-RAAN G-ECCENTRICITY H-ARGPERIGEE I-MNANOM J-MNMOTION K-ORBITNUM Z-CHECKSUM

AO-07 1 07530U 74089B 03149.21046743 -.00000029 00000-0 10000-3 0 1737 2 07530 101.7417 195.9888 0011868 247.9033 112.0780 12.53565389305675

There is a third format called *One Line Element (OLE),* or *Charlie Format,* which is used almost exclusively by the U.S. Navy. All the Keplerian-element information is contained on one line. The Charlie Keps for AO-7 would look something like this:

07530031492104670000291017411959880011862479031 1207812535653

Columns 1–5 are the NORAD catalog number; columns 6 and 7, the year; column 8–10, the Julian Day number; columns 11–16, fraction of the day; columns 17–22, drag; columns 23–28, inclination; columns 29–34, right ascension of ascending node; columns 35–40, eccentricity; columns 41–46, argument of perigee; columns, 47–52, mean anomaly; and columns 53–60, mean motion.

As you quickly can see, this particular format may be the height of brevity, but it certainly isn't user friendly.

Let's take a look at each of the elements and what each is telling us. Let me warn you, though, that the explanation of some of the elements may be a bit over the head of the "mathematically challenged" (such as your learned author). Do not worry, however, because we are only going to explore the very basic concepts behind each one. The intent is to give you grounding in what you are seeing and in what it's telling you. The explanations are based on the AMSAT format, so let's begin.

The Elements

Satellite (AO-7): Quite simply, the name of the spacecraft. As in our AMSAT format, the name shown is AO-7, the name assigned by AMSAT. However, if you decide to change the name in your tracking software to, say, OSCAR-7, when you do an automatic update of your Keps, only AO-7 will get updated, not your new name. Your best bet is to go with the name the Keps use.

Catalog Number (07530): Although not a function in tracking calculations, NASA assigns a number to each object orbit-

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e-mail: <tmwebb@ionet.net>*

ing the Earth. In this case, what the amateur radio community calls AO-7 is identified as Object 07530 by NASA and NORAD. They have their agenda; we have ours.

Epoch Time (03149.21046743): Because we equate Keps with a snapshot of the spacecraft's position, the epoch time essentially is when the picture was taken, which is kind of like that pesky little date/time stamp in the lower corner of your vacation photos—only a lot more precise. The first two numbers, 03, indicate the year—i.e., 2003. The next three numbers, 149, are the day of the year (many of you know this as the Julian Day). The last eight numbers are the time of day expressed as a decimal number versus hours and minutes. This tells your tracking software exactly when the remaining elements were measured—i.e., the starting point for all tracking computations.

Element Set (173): This tells you how many sets of Keps have been measured on the spacecraft. In this case, this is the 173rd set of Keps reported on AO-7. Although not used in tracking calculations, it gives you a clue as to the age of the Keps you are getting ready to load.

Inclination (101.7417): This number, expressed in degrees, is the angle at which the spacecraft crosses the "equatorial plane" of the Earth—i.e., the equator in the ascending (going from south to north) portion of its orbit. The point where the orbital and equatorial planes cross is called the *line of nodes.* Remember that term, because we'll return to it later. Some quick examples are as follows:

If the satellite is in a polar orbit, it crosses the equatorial plane at an inclination of 90 degrees; if the satellite is in an equatorial orbit, the inclination is 0 degrees. Although the inclination value is typically between 0 and 90 degrees, some satellites have an inclination of up to 180 degrees in what are called *retrograde* orbits. The inclination will give you a clue as to the maximum latitude to which the sub-satellite point will go. In the case of AO-7, it is a retrograde orbit, and its sub-satellite point will go a maximum of 79 degrees north/south. Conversely, a geostationary satellite is in an equatorial orbit, having an inclination of 0 degrees.

Right Ascension of Ascending Node (195.9888): The right ascension of ascending node—or RAAN, as it is more simply called—is the second element used to fix the position of the satellite in space. This is a rather tough one to explain to the layman, so brace yourself. Remember that we're working in three dimensions when tracking satellites. Therefore, we have to rely on an astronomical coordinate, which is better known in the scientific world as the right ascension/declination coordinate system. Inclination is one part of the system; RAAN is the other. RAAN is measuring, to quote *The Radio Amateur's Satellite Handbook,* "an angle that specifies the orientation of a satellite's orbital plane with respect to the fixed stars." The "fixed star" is the position of the Sun when it crosses the equatorial plane, south to north, on the first day of spring, a.k.a. the vernal equinox. The RAAN is the angle formed from the center of the Earth to the vernal equinox and the point the satellite crosses the equator on an ascending orbit. Now if you still don't understand exactly what RAAN is, just accept it. It lets you track satellites and we'll leave it at that.

Eccentricity (0.0011868): Contrary to popular belief, and according to Kepler's Law, satellite orbits are not perfect circles. Kepler's first law states: "The orbit of each planet (satellite) is an ellipse with the Sun (Earth, Moon, Mars, wherever) at one focus." As my high school math teacher put it, "An ellipse is a 'squashed circle.'" This isn't a mathematically accurate statement, but it's colorful. With a circle you have a center. As you flatten the circle, the center point separates into two points—the *foci,* and according to Kepler, the celestial body around which the satellite orbits will be at one of these foci. This number gives you an indication of the shape of the orbit. Zero indicates a perfect circle (you won't see an orbit that is a perfect circle, but some will come close). As the eccentricity approaches 1, the orbit will be more elongated, with 1 effectively being a straight line. For tracking amateur satellites, eccentricity expressed in Keps will be between 0 and 1.

Argument of Perigee (247.9033): The argument (angle) of perigee (ARGP) is another element that may be a bit tricky to explain, but it's a very critical one. Picture it: We draw a line from perigee, the closest point to Earth of the satellite's orbit, to apogee, the farther point of the orbit. This line is known as the major axis, which passes through the Earth's center. The angle created from the center of the Earth between the line of nodes—i.e., where the satellite crosses the equatorial plane on the ascending node—around to perigee on the major axis is the ARGP. In the case of our example, it is 247.9033 degrees. This element allows the tracking software to place the perigee in the orbital plane. Remember that perigee is where most tracking functions begin or end. The raw ARGP data can tell us if the satellite's perigee is in the Northern (0–180 degrees) or the Southern (180–360 degrees) Hemisphere . The argument of perigee will be between 0 and 360 degrees. Therefore, if you get Keps with the ARGP greater than 360, you have a problem.

Mean Anomaly (112.0780): Once you have crunched the numbers to determine the satellite's orbital characteristics, you need to be able to track it along the orbital ellipse or path. Mean anomaly, or MA, expressed in degrees, is the angle from the center of the Earth created by the satellite's current position and last perigee. (In the case of our example, an angle of 112.078 degrees) at epoch time. Because MA places the satellite along the orbit, it also comes in handy for scheduling purposes. The units from 0 to 256 typically express MA, which is also called *phase* by some tracking software. Satellite controllers will schedule operational events with reference to MA—i.e., the satellite will be off from MA 0 (perigee) to 99, in a particular mode between 100 and 150, off between 151 and 200, and beacon only from 201 to 256. Besides the scheduling function, if you get an MA greater than 256, you know something is wrong with your Keps.

Mean Motion (12.53565389): This element gives us an indication of how many orbits the satellite will make in one 24-hour period, which in this case is roughly 12.5 orbits or periods. The element is related to Kepler's Third Law: The square of the period of revolution of a planet (satellite) about the Sun (Earth) is proportional to the cube of the semi-major axis of the planet's (satellite's) elliptical orbit.

Now if that didn't clear things up for you, let's put it in layman's terms. A satellite goes faster when it is close to the Earth (perigee) and slower when it is farther from the Earth (apogee). The minimum period of a satellite is one per day—i.e., a geostationary satellite—but some low Earth orbit (LEO) satellites can have up to 15–16 orbits in a day. Each orbit begins and ends at perigee, the closest point to the Earth of a satellite's orbit.

Decay Rate (–2.9e-07): From the moment a satellite achieves orbit, a variety of forces are trying to slow it down. If a satellite's velocity drops below a minimum speed, the satellite will fall from orbit. Decay rate (sometimes known as *drag*) can come from several sources: the Earth's atmosphere (yes, the satellite is in what we consider "outer space," but the Earth's atmosphere, as thin as it might be, can affect a satellite's orbit several hundred miles out), space dust, and gravitational effects from the Earth, Moon, and Sun. Drag is expressed in a very small number (normally a positive number). Drag can also be expressed as a negative number, which would make you think the satellite is actually being lifted. However, negative drag is actually a method of mathematically adjusting for changes in actual drag that were overestimated, or when gravitational effects are affecting the satellite by small amounts. If you are ever in doubt of the decay-rate number you get in your Keps, you can enter zero and still have an accurate orbital prediction.

Epoch Revolution (30567): Epoch revs are not a factor in calculating a satellite's orbit. Their main function is presenting the number of orbits the satellite has made. Many folks in the satellite community like to note in their log or on their QSL card the orbit in which the contact was made. In this case, AO-7 was in Orbit #30,567—well, maybe. In many cases, the epoch rev number in the Keps you receive may be incorrect, but again, its main value is personal recordkeeping.

Checksum (308): Although the checksum is also not a factor in calculating the satellite's position, it will assure you that you are getting an accurate set of Keps. The checksum number is devised by the transmitting station and utilized by the receiving station to examine the data for transmission errors. In this case, 308 was devised by the source of the Keps, and the receiving party's software should arrive at the same number—i.e., 308.

Summary

Regular and frequent updates of your Keplerian elements are always a good idea, but don't be concerned if you go a couple of weeks without an update. Keps for every object in the Earth orbit are determined by the North American Aerospace Defense Command (NORAD) based on observations by various space surveillance radars.

NORAD provides this information not only to NASA and other government agencies, but also to the general public. There are several sources of Keps, one being the AMSAT website (http://www.amsat/keps/menu.html). On the AMSAT website you also can subscribe to regular delivery of Keps via e-mail.

If you are really seriously into higher math, *Models for Propagation of NORAD Element Sets* by Felix Hoots and Ronald Roehrich is suggested reading. Written in 1987, it is an in-depth discussion of how the various elements are derived mathematically. It can also be found at the website mentioned in the preceding paragraph.

A question I'm often asked is "Where can I get Keps on the Moon?" Well, to be honest, I'm not really sure, but I usually answer by telling folks to go outside and look. If you're interested in Earth-Moon-Earth (EME) or moonbounce communication, the following publication deserves consideration:

Lunar tables and programs from 4000 BC to AD 8000, by Michelle Chapront-Touz and Jean Chapront (ISBN 0-943396-33-6) is published by Willman-Bell, Inc., P.O. Box 35025, Richmond, Virginia 23235. Although the authors are French astronomers, the book is written exclusively in English. Note the spelling of the publisher's name; it is *Willman,* not William!

There you have it, a brief discussion of Keplerian elements, the fuel that runs amateur satellite tracking programs. The intent was not to make the reader a mathematical expert, but rather to provide a good explanation of Keplerian elements, assuring the user of getting the most accurate information available. If you want to get into Keps in greater depth, you might want to check two sources. First, chapters 7 and 12 of *The Radio Amateur's Satellite Handbook* have excellent discussions on Keplerian elements. Also, the "Help" file on Keplerian elements from InstantTrack, authored by Franklin Antonio, N6NKF, has a straightforward tutorial on Keps. ■

In Memoriam: Jerry Schmitt, KK5YY

As many of you may already know, on May 23rd the satellite community lost one of its shining stars, Jerry Schmitt, KK5YY. He and his wife Barbara, KD5CGU, were preparing to celebrate Jerry's impending retirement from Los Alamos National Laboratory and planning their move to Alaska.

I met Jerry in person only once, at HamComm in Dallas, Texas a few years ago. He was getting ready to conduct an AO-27 demonstration in the parking lot just outside the convention center. I tagged along to observe, but I discovered quickly that one didn't "just observe" around Jerry. When he realized that I had "been there, done that" with AO-27, he quickly put me to work. A Kenwood VC-H1 SSTV camera and an HT were shoved into my hands with the instructions to "take shots and transmit them back into the building." I immediately confessed that I had no idea how to operate the VC-H1. Ever the mentor, Jerry gave me about 15 seconds of clear, rapid instructions (point there, press this, then transmit—simple—got it?). As the demonstration began, Jerry kept a constant patter of information flowing while working the satellite, and I accomplished my duties as an "unofficial" SSTV photographer. (I never did find out where those photos were being sent, but I was determined to follow Jerry's instructions.) Each action and procedure during the satellite pass was explained with rapid-fire accuracy; you couldn't help but learn around Jerry.

With the pass completed, Jerry continued to expound in great detail on portable satellite antennas. Although much of his presentation was factual, he wasn't afraid to express a "candid" opinion about one antenna or another, even if the owner of one was standing there with antenna in hand. His favorite was the Arrow Antenna, which he helped develop, and he had no reservations about pointing out the ones that he liked and didn't like . . . and why. He expressed his opinions with empirical accuracy and detail; you knew his thoughts were based on careful study, not baseless opinion. In that 20-minute period I learned more about portable satellite antennas and operation than I could ever have read.

I never saw Jerry again. I talked with him briefly on several of the LEO birds and corresponded via e-mail about a cruise I was taking to his beloved Alaska.

Jerry's influence in the amateur radio community went beyond satellites. He was deeply involved in the development of several pieces of popular amateur radio gear, including the ICOM IC-706MKIIG, the Kenwood TH-D7A, and the Yaesu FT-100.

I don't think of Jerry as a Silent Key. I simply feel that he has signed the log for the last time. Jerry Schmitt silent? Not too likely!

—WA9AFM

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Trends, Reflections, and an Outlook

HF radio enthusiasts can hook up a light bulb and communicate with the world when propagation conditions are "just right." Toss up some wire, tune up the rig, and talk around the world. Rumor has it that operators on VHF and higher frequencies work "real radio." They cook their meals in front of their portable parabolic dish antenna. They bounce signals off the moon or meteor trails. Their DX is a raspy-sounding Morse Code signal propagated off aurora. You need to have more than a wet noodle, or the loss will make the coax nothing more than a dummy load.

Propagation on VHF and above is not quite the same as it is on HF. Sure, *F*-layer refraction takes place at times on 6 meters and a bit higher. It is true that sporadic-*E* works on HF, but there is a whole different and exciting set of modes and techniques that are unique to VHF and above. This column focuses on propagation on very-high and ultra-high frequencies. What's happening in the real world? What are the theory and science of radio-wave propagation at such high frequencies? What new aspects of propagation research are you, the reader, exploring in your daily amateur radio operations? What propagation discoveries are being made in the commercial VHF and UHF domain, and how can they be applied to our hobby?

When *CQ VHF* Editor Joe Lynch, N6CL, wrote and asked me if I might be interested in writing this column, I hesitated. I am a student of propagation, and there is so much to learn. Also, there is so much to explore. The unique field of VHF/UHF propagation is one I have not explored in depth as much as I have explored the HF side of our hobby. However, I love to dive into new areas of knowledge, and while doing so, I enjoy sharing my discoveries as well as my experiences with fellow hobbyists. I cannot do this alone, though. Many of you have dedicated your entire radio hobby to VHF and higher frequencies, modes, and techniques. Please write to me and send me your observations, your corrections, your insights, your questions, and your suggestions. I would like to make this column one of community cooperation. I will list significant observations and events that you send to me, as they relate to propagation. I'll research answers to your questions. I'll editorialize, theorize, and summarize. I hope you will enjoy this effort, and I hope the column will prove useful to you. Write to me and let me know your thoughts.

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Sporadic-*E* Season Alive and Well

In the Northern Hemisphere the 2003 sporadic-*E* season took off with a bang early in the year. Watching the DX Spot Reflectors (i.e., the DX Summit by OH2AQ <http://oh2aq.kolumbus.com/dxs/>) revealed activity starting as early as February. Propagation really got hot after April and in full swing by June. FM and TV DXers reported signals on the low TV frequencies between locations such as Manitoba (Canada), Idaho, Colorado, Arizona, New Mexico, and as far south as Mexico (XHFA-TV). (See the FM DX page at <http://www.amfmdx.net/fmdx/> for more on FM DX.) One amateur radio operator reported openings during June on 220 MHz between Idaho and Nevada, as well as 2-meter skip between Idaho and New Mexico, Mexico, Arizona, Texas, and Nevada. From Kansas came reports of FM and TV DX from Texas, Florida, and Ontario (Canada), as well as from Nevada, Utah, and New York. The cluster activity shows a good amount of two-way activity in North America as well as in Europe. I'd like to hear your reports, especially any surprising and unusual openings you experienced.

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

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

There are a handful of theories regarding how sporadic-*E* occurs and how it works. One theory suggests that weather, including the influence of ionospheric wind shear, plays a key role. Others suggest that meteors may trigger sporadic-*E*. What keeps scientists and amateurs digging through the evidence from on-the-air, sporadic-*E*-mode, two-way contacts is that none of the directly measurable theories has accurately held true in every observed opening. This leads us to believe that sporadic-*E* is complex and created by various unrelated conditions and phenomena.

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

As we move away from the sporadic-*E* seasonal maximum, what can we expect from sporadic-*E*? August still holds a fair possibility for continued sporadic-*E* activity, but September and October are months when sporadic-*E* is pretty rare. These are the months when we start looking at other modes of propagation.

Troposcatter Propagation

Watch for troposcatter-mode propagation in the early morning and early evening. Occasional long-distance openings may occur during August. During September—when high-pressure centers may stall; or cool, wet air masses develop in the Midwest—you may find good, steady openings, some of which might last for several days. The first part of October still holds promise of troposcatter, but favorable conditions become less frequent later, as we move closer to winter. Watch for unusual weather, however, such as tropical storms moving north, or a sudden cold snap moving south. William Hepburn has developed an excellent, but experimental, VHF/ UHF Tropospheric Ducting Forecast page. The Main Index, at <http://www.iprimus.ca/~hepburnw/tropo_xxx.html>, has a menu containing maps for the eastern and western USA, the Gulf and Caribbean, the eastern South Pacific, and the eastern north Pacific.

Meteor Scatter

Meteor-scatter propagation becomes exciting again in August, with the *Perseids* shower on August 9–14. Speculation varies, but I expect enough activity to make it worthwhile for you to set up your station for this one. The shower peaks on August 12.

There's not much happening in September, but the *Orionids* will start on October 19 and stay active until October 24. I've worked meteor scatter with just a mobile vertical antenna and 100 watts. If I can do it, so can you. For a good resource on meteor-shower events and forecasts, see <http://www.amsmeteors.org/>. Specifically, look at the Radio Observation of Meteors at <http://www.amsmeteors.org/radmet.html>.

The Solar Cycle Pulse

We are clearly past Solar Cycle 23's peak. As we move away from the April 2000 peak (a smoothed sunspot number of 120.8; yes, there was a second peak on November 2001, with a smoothed number of 115.5), we are undergoing the usual after-peak climb in geomagnetic activity.

It has been discovered that in every solar cycle since Cycle 11 there have been two peaks in geomagnetic activity. A first, weaker peak occurs somewhat before the sunspot maximum. Then a more intense peak occurs a year or so after the sunspot maximum. So far 2003 has seen a steady increase in geomagnetic activity due to the weakening Sun and the breakdown of complex solar structures. Coronal-hole-mass ejections are occurring more often, releasing plasma out into the solar stream through which the Earth moves.

The smoothed planetary *A*-index from November 2001 through November 2002 reads as follows: 12, 12.2, 12.4, 12.8, 13, 13.2, 13.3, 13.5, 13.9, 14.3, 14.9, 15.5, and 16.1. The monthly readings from December 2002 through May 2003 are 13, 13, 15, 19, 20, and 24. June's smoothed planetary *A*-index will be even higher. This gives rise to quite a number of disturbed days when the geomagnetic field is active and stormy. Aurora activity, while not as common as during the last few years, was moderate throughout the beginning of the year, giving plenty of opportunity for aurora-mode VHF communications.

The observed smoothed sunspot numbers from January through May 2003 are 79.5, 46.2, 61.5, 60, and 55.2. The smoothed monthly 10.7-cm solar-flux numbers are 144.6, 124.6, 132.3, 126.5, and 116.2. These numbers reflect the steady decline in Solar Cycle 23, and *F*-layer openings are becoming extremely rare. The smoothed monthly sunspot numbers forecast for August through October are 50.4, 49.1, and 47, while the smoothed monthly 10.7-cm solar flux is predicted to be 106.8, 103.8, and 100.5 for August through October 2003.

Future Columns

I am planning on exploring some of the software aids available to the VHF/UHF operator, such as K9SE's VHF Propagation Analysis Software and Sporadic-*E* Propagation Assessment for the VHF Operator <http://home.netcom.com/~wb9qiu/>. I would like to delve deeper into a discussion of troposcatter and sporadic-*E* propagation, as well as other propagation modes. What would you like to see covered? What propagation information would be helpful to you in your daily VHF/UHF activities? Be sure to drop me an e-mail or write me a letter using the addresses at the beginning of this column.

I have a website dedicated to propagation, and I am adding additional VHF resources. Visit: <http://prop.hfradio.org>. I also provide a version for WAP devices (cell phones that can read WML web pages) at <http://wap.hfradio.org>.

Until the next issue, happy DXing! I look forward to your correspondence. 73, Tomas, NW7US

CQ's 6 Meter and Satellite WAZ Awards

(As of June 15, 2003)

By Paul Blumhardt,* K5RT, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones Needed
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	16,17,18,19,20,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26.31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,7,10,12,18,19,23,24,26,29,31,32
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

Satellite Worked All Zones

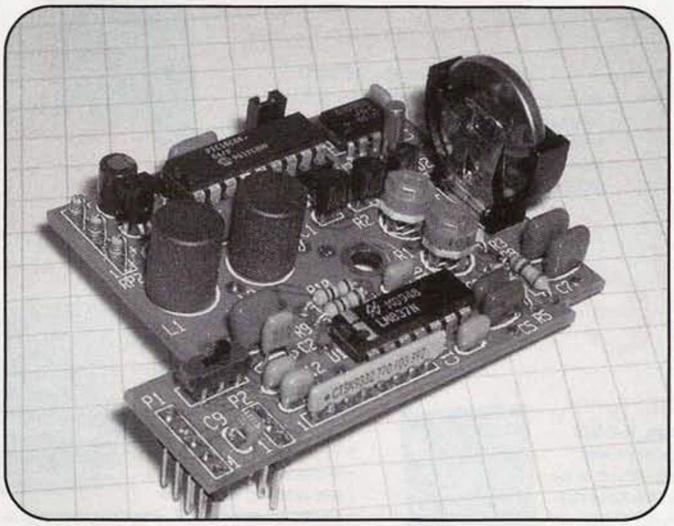
No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
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

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. Last year 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: WAZ Award Manager, Paul Blumhardt, K5RT, 2805 Toler Road, Rowlett, TX 75089. 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 Paul Blumhardt. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. K5RT may also be reached via e-mail: <k5rt@cq-amateur-radio.com>.

**CQ WAZ Award Manager, 2805 Toler Road, Rowlett, TX 75089; e-mail: <k5rt@cq-amateur-radio.com>*



The Low Noise Audio Filter/Real-Time Clock option board. (Photo by the author)

display, and S-meter and noise-blanker functions. Controls for keyer speed, RF power output, AF, and RF gain are situated immediately to the left side of the front panel, as is a standard 8-pin type microphone socket which can be internally configured for Yaesu, ICOM, or Kenwood standards. There is even a matching Heil microphone available for the K2, eliminating the need to rewire the microphone to suit your new radio! Power output can be varied from 100 mw to 12 watts on the basic model. The speech processor and VOX functions are also controlled from front-panel buttons. A 3.5-mm headphone socket is also fitted to the front panel. Above the main VFO knob is a large backlit LCD display, which is not only used to display frequency information, but also to display mode selection and functional state of the radio's modules. In addition, the LCD is used to display messages about firmware and hardware during power-up BITE checks and during the alignment sections of the construction. The LCD backlight intensity can be altered, depending on light conditions and power-saving requirements. For maximum power saving, the LCD backlight intensity and the S-meter can be switched off completely. RIT and XIT are controlled from a small sub-VFO knob, which is activated by a small button to the lower right of the front panel, allowing the selected function to be varied over 1.2 kHz in 10-Hz steps. The back panel also has a variety of connectors covering connections for antennas, transverters, external speakers, DC input, and a stereo 3.5-mm key socket that can be configured for both straight and iambic keys. A large speaker is mounted in the top cover.

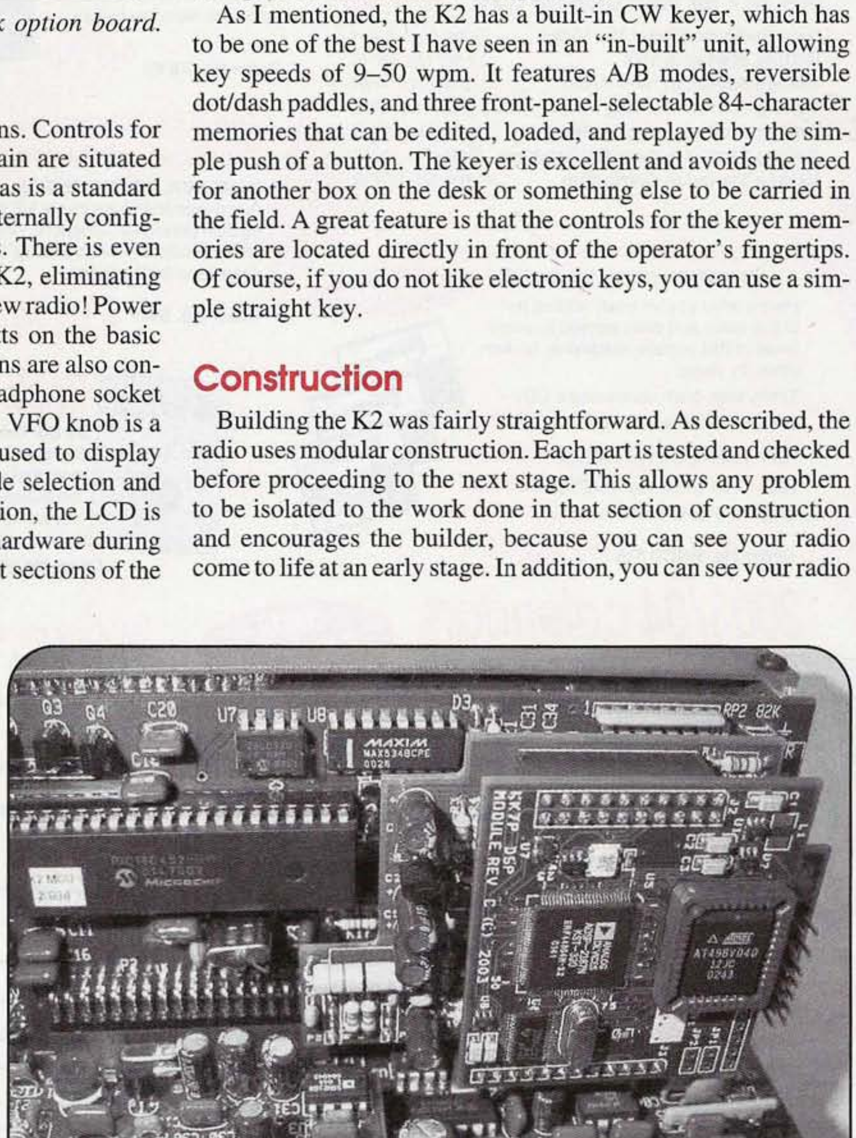
As you would expect, the transceiver is microprocessor driven, making it relatively simple to add additional options and functionality. The radio firmware supports twin VFOs; split operation; and 50 memory channels, each capable of storing mode, VFO A/B/Split, filter, AGC, and NB setting information.

Wayne and Eric have paid particular attention to RF performance, and the radio really does perform. The receiver is a single conversion design using an unusual IF frequency of 4.915 MHz. It has three switchable IF crystal filters and full IF-derived AGC. The transceiver is not general coverage, and for good reason, but it uses individually switched bandpass filters for each amateur band for best performance. A built-in preamp and attenuator can also be selected. For basic CW operation the radio has its own adjustable IF bandwidth controls supplied as standard, and these can be varied over a 200–1500-Hz range using the 5-pole filter fitted. A fixed filter mounted on the upgrade module is used for SSB. Sideband selection can be selected for dodging annoying interference on CW, and the sidetone pitch can be adjusted with the transmit sidetone tracking it. The K2 can tune in 10-, 50-, and 100-Hz steps, selected from the front panel. Full or semi break-in is available and silent, thanks to the pin-diode transmit-receive changeover system. One unusual feature is the inclusion of a spot function, which places a sidetone over the received station, allowing the operator to net the receiver perfectly.

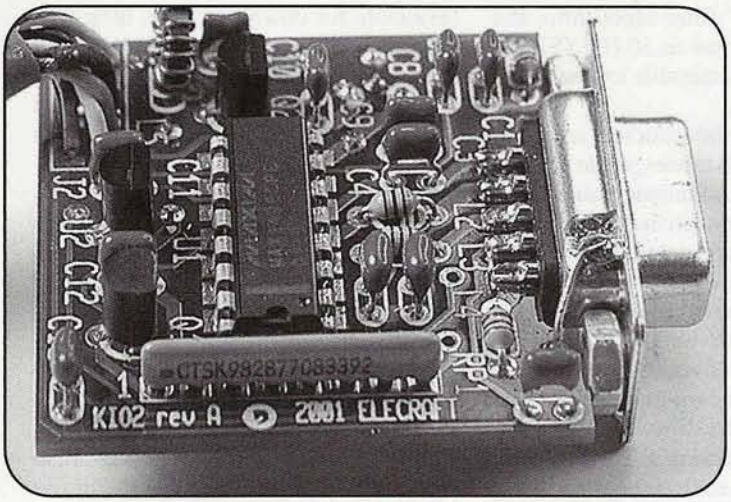
As I mentioned, the K2 has a built-in CW keyer, which has to be one of the best I have seen in an "in-built" unit, allowing key speeds of 9–50 wpm. It features A/B modes, reversible dot/dash paddles, and three front-panel-selectable 84-character memories that can be edited, loaded, and replayed by the simple push of a button. The keyer is excellent and avoids the need for another box on the desk or something else to be carried in the field. A great feature is that the controls for the keyer memories are located directly in front of the operator's fingertips. Of course, if you do not like electronic keys, you can use a simple straight key.

Construction

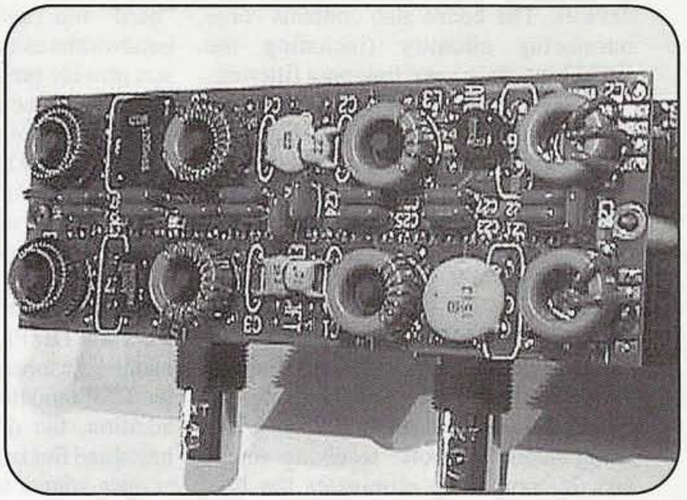
Building the K2 was fairly straightforward. As described, the radio uses modular construction. Each part is tested and checked before proceeding to the next stage. This allows any problem to be isolated to the work done in that section of construction and encourages the builder, because you can see your radio come to life at an early stage. In addition, you can see your radio



The KDSP2 DSP module installed. (Photo by the author)



The RS232 board, which allows the K2 to communicate with a computer. (Photo by the author)



The QRP auto antenna tuning unit (ATU). (Photo by the author)

develop. As I said, no surface-mount components are used. It has simple, discrete, normal-size components and a few normal-size ICs, which are the norm throughout Elecraft's kits. There is nothing really fiddly here. A regular-size soldering iron and fine-gauge solder is all that is needed, plus a few hand tools, such as a good pair of small-nose pliers, a good pair of sharp sidecutters, and a selection of small screwdrivers. Oh yes . . . there are a lot of components in this kit!

Construction of the basic K2 took me approximately 40 hours spread over a couple of weeks of sick leave (Yes, I was actually sick!). I took my time with it, but I did have a lot of dedicated build time. I had previously built lots of kits, which was helpful. The average amateur should be able to complete the K2 in approximately 50-60 hours, taking into account normal disruptions and breaks. I only had one problem building the radio because of a missing component that had been overlooked during construction, which managed to stop RF getting to the correctly constructed RF driver stages! Once that component was added, my transceiver was completed without any further problems, and later when it was tested using commercial test equipment, the radio performed to the exact specifications.

The kit is very comprehensive, and apart from solder and tools, there is not much else required to complete it except patience. The manual supplied with each kit is well worth mentioning. For the main K2 radio, it's simply huge! The entire manual runs over 100 pages, with 70 of them dedicated to construction. The construction sections detail what is being worked on, identify the components needed, and show you where the components are positioned on the board. Each component has a tick off to show its completion, and you simply progress through each component, soldering and ticking off as you go. At the end of some sections there are test plans to be completed to ensure the work's completion is 100% before you proceed to the next level. There are also four appendices to the manual which cover a full component inventory, full circuit and interconnection diagrams, additional diagrams and construction, as well as PCB overlays. The standard of the manual is beyond reproach. It is a self-confessed "labor of love" according to Wayne and Eric. It's certainly refreshing to be able to see that you could repair this radio if anything went wrong.

As I mentioned, the radio is built around a set of microprocessors, and the firmware for this is upgradable. This means that new features can be added simply by replacing the memory chip holding the software. No more trading in to get the latest model here! The use of this microprocessor and firmware also means that the radio carries many unusual functions, such as the inclusion of built-in test equipment and the versatile memory keyer already mentioned. Firmware upgrades are available at low cost as the updates are made available, which is a great idea that many manufacturers have not yet caught on to.

The radio's main architecture is modular and controlled by a one-wire interface called AUXBUS. This allows commands to be sent to the various modules to achieve certain tasks, such as changing bands, for example. This distributed command system also means that any future modifications or changes to the radio can be made without changing the transceiver itself. Commands are only sent over the wire when needed. Otherwise, the processors sleep, reducing RFI. To reduce interference, the receiver is also muted when changing bands, for example. The main processor is an 8K PIC16C77 micro controller. It is self-contained and draws very little current. It also has a built- in 2K of non-volatile EEPROM storage, which contains the memory information, VCO and VFO lookups, filter calibration, and CW message information.

Expanding the Radio

If, like me, you want the radio to do everything, then you may want to buy additional features when you purchase the radio or add them once you have the basic unit working. Some of these add-ons are as exciting to build as the main radio. I will describe what is currently available at the time of this writing.

SSB Adapter (KSB2): This add-on board allows you to include SSB in the basic CW radio. The board is again a simple build and plug-in module. An optimized 7-pole 2.2-kHz SSB filter is included in the board, as is a speech processor and VOX facility.

100-watt Solid-State PA Unit (KPA100): The 100-watt PA unit turns the K2 into a full-feature 100-watt HF transceiver. The unit fits in the K2 case and is designed around 2 x 2SC2879 devices. The board also contains some interfacing circuitry (including the RS232 interface) and low-pass filtering.

Low Noise Audio Filter/Real-Time Clock (KAF2): The audio-filter board supplements the K2's crystal filters with an effective, low-noise audio filter. It also adds a real-time clock, allowing you to check the time or date with a tap of the K2's DISPLAY button. The KAF2 includes a passive, balanced low-pass filter (LPF), which significantly attenuates splatter, carriers, and wideband IF noise above 3 kHz. It's especially useful on quiet bands, with the preamp off, or when using small, low-noise receiving antennas. It completely eliminates the hiss sometimes heard when using high-fidelity headphones. The passband has very low ripple, so the filter has no impact on speech or data signals. Also included is an active, two-stage, narrow band-pass filter for CW or data use. It can be used in conjunction with the K2's variable-bandwidth CW filter, providing a significant improvement in skirt selectivity and noise reduction. The center frequency is tunable over the K2's entire 400–800-Hz CW offset/sidetone range. The –3-dB bandwidth of the cascaded filter sections is about 80 Hz, ideal for digging weak signals out of QRN or QRM, and the Q of both stages is low enough to avoid excessive ringing. The AFIL switch on the K2 front panel turns the band-pass filter on or off.

The real-time clock displays 24-hour time, as well as both MM-DD-YY and DD-MM-YY date formats. Time and date can be set easily using the BAND+ and BAND– switches. The RTC is very convenient for field operation because it eliminates the need to bring a separate clock. The on-board lithium backup battery will power the clock for up to several years, and it can be replaced by removing either the K2's top cover or left side panel.

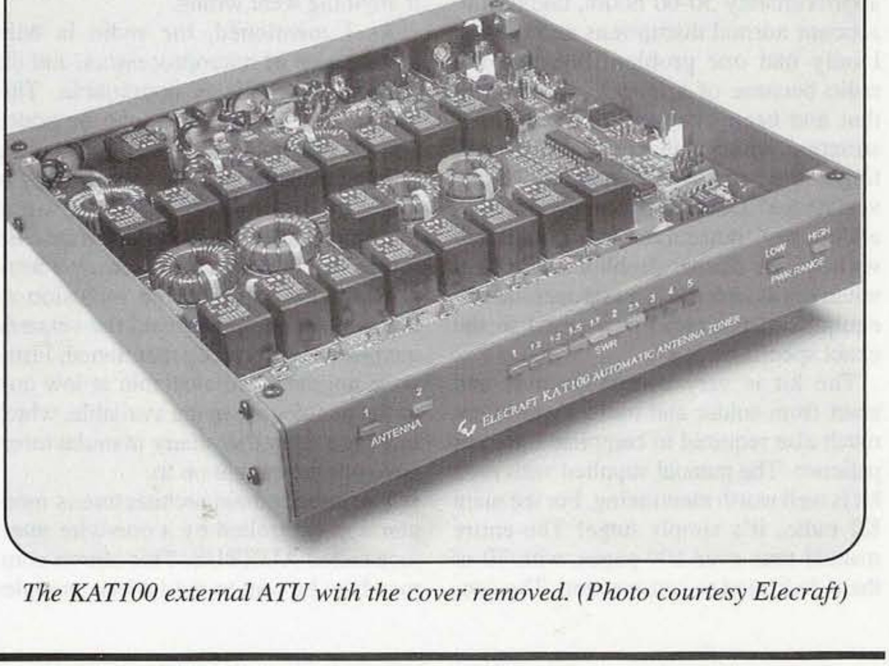
KDSP2 DSP Module: This module brings versatile, high-performance digital signal processing (DSP) technology to the K2 and K2/100 transceivers. The KDSP2 unit, which is fully integrated with the K2, plugs directly into the control board. The DSP IC and related parts are pre-installed on a small plug-in module, so there are no surface-mount components to install. The KDSP2 provides up to four user-configurable filters in each mode (CW/SSB/data), complementing the K2's variable-bandwidth crystal filter. CW filter settings include center frequency and bandwidth, with "hard" and "soft" filter algorithms and bandwidths as narrow as 50 Hz. SSB filters provide programmable low and high cutoff frequencies.

Four levels of noise reduction are available in CW and SSB modes, while the SSB mode includes an automatic notch filter. The KDSP2 is unique in that noise reduction and auto notch parameters can be modified to suit the operator. Filter modes and features can be accessed quickly via the K2's DISPLAY button, while parameter adjustment is accomplished using the DSP module's own menu system. In addition, the unit's firmware is flash-based and field upgradable. The DSP code is open-source to encourage community involvement and education, which can be downloaded for personal use. Like the analog filter module, the KDSP2 includes a real-time clock/calendar with its own backup battery. This feature is especially useful during field operation, eliminating the need for a separate clock for logging or contest use. Current drain of the KDSP2 can be reduced to approximately 10 mA by placing the audio-filter subsystem in bypass mode.

RS232 Interface (KIO2): This board is the CAT port of the radio and allows a PC to be connected to the radio. Virtually any home or laptop computer with a serial (RS-232) port can be used with the KIO2. It will also work with most popular software applications, including Elecraft's own K2 remote control and voice utilities, K2 remote, and K2 Voice (available for download from their web page, as is a Mac version). You can even write your own K2 control programs. Simple commands for front-panel switch and display emulation are provided, in addition to more conventional parameter-based commands. Many transceivers with serial interfaces provide only logic-level (TTL) signals; connecting them to a computer requires an external RS-232 converter. In contrast, the KIO2 provides true RS-232 signal levels without compromising receiver performance. It also has very low current drain. In addition to the serial interface, the KIO2 includes an AuxBus output, +12 V to power small external accessories, and signals for use with external power amplifiers. All signals are RF-filtered.

QRP Auto ATU (KAT2): The QRP auto ATU allows you to connect nearly any antenna directly to the K2 and use it on all bands (160–10 meters). Two antenna jacks are provided; instantly A/B test both antennas on any signal using the ANT 1/2 switch. All latching relays are used, so current drain is zero except when tuning, making it perfect for low-power field operations.

High Power External Auto ATU (KAT100): The high-power version of the auto ATU is a matching external auto ATU for the high-power version of the transceiver. This unit is low-profile, measuring only $1^1/2$ inches (35 mm) high, and has the same design and footprint as the K2. The L/C settings are



The KAT100 external ATU with the cover removed. (Photo courtesy Elecraft) stored in EEPROM and allow for instant recall on band or antenna change. It will match 10:1 SWR loads and automatically reduces output from the K2 when TUNE is pressed. A dual-range bridge allows tune-up with as little as 0.2 watts, and a direct display of power, SWR, and other data is shown on the K2's LCD. It interfaces directly with the K2 via the AUX port (DB9 + "Y" cable on the KPA100 or KIO2). It has the same K2 control and menu features as the KAT2 QRP tuner. There are two versions of this unit. The low-profile KAT100-1 can be placed beneath the K2, while the full-height KAT100-2 is intended for side-by-side arrangement with the K2 and mounts inside the EC-2 project enclosure available from Elecraft.

Internal Gel Cell Battery (KBT2): With the battery installed, the K2 becomes the ultimate all-band field radio with its own power supply. Rated at 2.9 AH, the gel-cel battery is extremely safe and can be continuously recharged inside the K2 from the same DC supply used to power the rig at home.

High-Performance Noise Blanker (KNB2): The KNB2 eliminates most pulse-type noise, including that from power lines.

160M and Second Antenna Module (K160M): This adds 160 meters TX/RX and a second RX antenna input (usable for all bands). Also, it supports transverters that need split TX/RX paths.

Transverters: Elecraft has now released a range of matching external transverters for the K2 system. This will allow the K2 to stand as an excellent prime mover for other microwave transverters or as a prime mover for a high-power VHF amplifier. Several members of the 144-MHz EME (earth-moon-earth) community are getting rid of their high-priced HF transceivers and investing in K2s. The word is out!

These three state-of-the-art XV Series transverters are available for 6 meters, 2 meters, and 135 cm. The transverters can actually be used with nearly any transceiver that covers the 28–30-MHz frequency range, including Elecraft's K2 and K2/100. They interface directly to the K2, and that is where you can obtain the most benefit from them! The XV Series provides important benefits for the operator in both receive and transmit modes. On receive, the transverters combine a low receive noise figure (typically 0.8 dB) with a high dynamic-range front end (+17-dBm mixer), ensuring exceptional weak-signal performance even in large-signal environments.

Reliable overload detection is included at the IF port to protect the mixer. On transmit, the XV's 20–25 watts output will drive most high-power linear amplifiers. A sequenced keying output is provided for external amplifiers, and a built-in wattmeter using a 10-segment LED bar graph provides fast power- output monitoring. Provision is also made for an optional crystal oven to enhance frequency stability.

Single-port and dual-port IF connections allow use with almost any transceiver. IF transmit levels from –20 dBm to +39 dBm (.01 milliwatt to 8 watts) can be accommodated, with a constant-impedance IF termination for consistent performance. Multiple transverters can easily be daisy-chained to a K2 transceiver, providing multi-band operation without cable rearrangement. A brightly illuminated label clearly identifies which transverter is selected and allows switching directly from the front panel.

There is also an auxiliary BNC connector on the rear panel that can be wired for RX-only path at the VHF output for split TX/RX paths.

The XV Series transverters are packaged in attractive, low-profile enclosures measuring only 1.2 inches (3 cm) high, with styling that matches the Elecraft K2. The transverters are also electrically well integrated with the K2, providing automatic band selection; independent, calibrated display of each transverter's operating frequency to 10 Hz; and front-panel power-level control. Like Elecraft's transceivers, the XV transverters are completely modular, simplifying construction and alignment. Again, the kits are easy to assemble, featuring "no-wires" construction, and all the surface-mount parts used in the kit (15 total) are pre-installed at the factory, requiring no surface-mount component experience. *Note:* The KIO2 AUX I/O option or the KPA100 (which includes KIO2 functionality) must also be installed in the K2 to provide the external control signals for the XV transverters.

K2 Remote and K2 Voice Software: The K2 Remote is a new freeware remote-control program available from Elecraft and designed for the K2. It runs under Windows® (95, 98, 2000, and ME). It requires the KIO2 RS-232 control option for the K2 to operate. New versions will be available for download at no additional charge as they add features to K2 Remote. The soft-

The K2 with the XV50, XV144, and XV222 transverters stacked at the right. (Photo courtesy Elecraft)

ware operates in one of two modes: direct control of the K2 from a local PC via RS-232, and remote control using two PCs—one at the radio running a small server program (K2 Server, which comes with K2 remote) and a remote PC (laptop, etc.) running K2 remote and communicating with the K2 server program via TCP/IP protocol. This allows full remote control of the K2 via a local home network or even via the Internet. (WA6HHQ runs K2 remote via his wireless 802.11 home network—working DX while eating breakfast!). Audio to/from the K2 can be routed over the TCP/IP network using any of several widely available programs, including Microsoft's Netmeeting program (included with newer Windows® systems.

K2 Voice is a complete voice feedback program for the K2. It runs under Windows® (again, 95, 98, 2000, and ME) and requires the KIO2 RS-232 control option for the K2 to operate. K2 Voice is designed to make the K2 fully operational for hams who are unable to see the normal K2 controls and displays. It will report just about everything that happens on the K2 using the sound card in your PC. It reports the K2's frequency, mode, filter selections, split, VFO A/B, etc. K2 Voice operates in one of three modes:

Fully Automatic—All button presses and frequency changes made on the K2 are automatically reported within one second of completion. VFO frequency changes are reported after tuning has stopped for one second.

Semi Automatic—Same as above except the VFO is not automatically reported. Press a key to get the current VFO frequency.

Manual—Press a key for each function to be reported. For example, press ALT- F to get the current frequency, ALT-M to get the current mode, etc.

Conclusion

I find the K2 to be an excellent little radio. It is small only in size, certainly not in features or performance. The accompanying photos, some taken from the Elecraft web page, certainly show the company has done its homework, and in tests the little K2 keeps up with the best.

This is a radio that can be built at home using simple tools and little in the way of test gear. Interfacing to the outside world is easy. The ability to mix and match modules and features to suit your operating needs is a refreshing change. Indeed, you can build the K2 to act as your main base radio, as a fully-fledged 100-watt unit, but then have the ability to remove the PA quickly and easily, fitting the small automatic ATU and battery for portable Field Day use. The ability to build the basic unit and then add modules as required is a very good feature, especially for those on a budget. It's easy and fun to construct and brings back the ability to homebrew a radio that not only looks professional-grade, it also performs like the top radios on the market. The support and assistance offered by Wayne and Eric at Elecraft is fantastic as well. The second-hand price of the K2 certainly reflects its popularity—that is, if you can find one!

On the air I found the K2 to be a little gem. The radio's performance is as good as (if not better than) some of the top-of-the-line transceivers I have used in my years on the air. The receiver background noise is quiet, and signals, even weak ones, leap out and sound clear and sharp. The receiver remains sharp even under heavy band conditions and even sounded clear on 40 meters using a full-size antenna at night. I also ran the radio for some time driving a 70-MHz transverter during one of the VHF contests. The K2 performed beautifully. It's certainly nice to have all those functions that are not normally available on the average VHF multimode rig. The great RF performance of the K2 certainly bodes well on the VHF bands, too, and allowed the K2 and transverter pair to give me a good setup on VHF.

Bob Friess, N6CM, built a 10-GHz transverter for the K2 in an EC2 chassis. (Photo courtesy N6CM)

If you're looking for a new spark in the hobby and fancy a go at building a superb HF kit that really is well thought out, then look no further than the K2. It's great fun building something that looks so superb on the shack bench. Mine was certainly a conversation piece when I completed it and showed it off at the local radio club! Now that you can add VHF transverters to the basic unit, there's even less of an excuse not to have a go at homebrew!

Contact Elecraft, P.O. Box 69, Aptos, CA 95001-0069; telephone 831-662-8345; e-mail: <sales@elecraft.com>; on the web: <www.elecraft.com>. ■

The VHF Bands Are Still Alive!

Solar-flare activity creates major openings on 6 and 2 meters!

By Ken Neubeck,* WB2AMU

Just when many VHF operators folded their logbooks on *F2* activity for 6 meters, it appears that there is still some life left in solar Cycle 23! The supporting evidence for this occurred when a significant geomagnetic event took place on May 29 and 30, resulting in a number of different propagation modes that appeared on 6 and 2 meters; aurora, auroral-*E*, and *F2* were observed. There were periods of strong aurora propagation. As a result, great excitement ensued, with some major observations being made with regard to the behavior of these propagation modes.

Prior to this there had been some significant geomagnetic events that occurred during the current solar cycle which resulted in some major aurora openings on 6 and 2 meters, followed by *F2* openings on 6. These were on April 6, 2000; March 30 and 31, 2001; and April 11, 2001. The *K*-index values on these dates reached 8.

Spring 2003 Activity

During spring 2003 VHF operators were still checking out the bands and spotting the network daily to see if there were some signs of life for Cycle 23 in the form of geomagnetic activity. Some minor aurora events on 6 meters were observed in the northern U.S. and in Europe at the end of March. During April, however, there was very little geomagnetic activity. Very few aurora or *F2* openings were observed, but some TEP activity was still being spotted by hams located near the equatorial zones.

On May 28 the sunspot group designated S169 (photo A) emitted a major X flare on the order of X3.1 (photo B). Since this group was near the equator of the Sun and the flare went straight out from the Sun, it was geo-effective. There was a reasonable expectation that the Earth would be impacted within the following two days.

As early as 3:00 PM local time in the east Lefty, K1TOL, in Maine, was hearing aurora signals. I was able to make a short QSO with him from my work QTH on Long Island by pointing my beam north. There was the feeling that this was going to be a significant event.

When I arrived home, I worked a few stations on 6 meters, beginning with John, K1GUN, in Maine. The distinctive auroral tones on signals were present. Next I set up a portable 2-meter station in my driveway with my 3-element Yagi on a 10-foot mast directed toward the north. I made a CW QSO with K4QI in grid FM06 in North Carolina and then with K1ZC, grid FN43, in New Hampshire. I managed one new grid on this band with Mark, W3MRG, in grid FN10.

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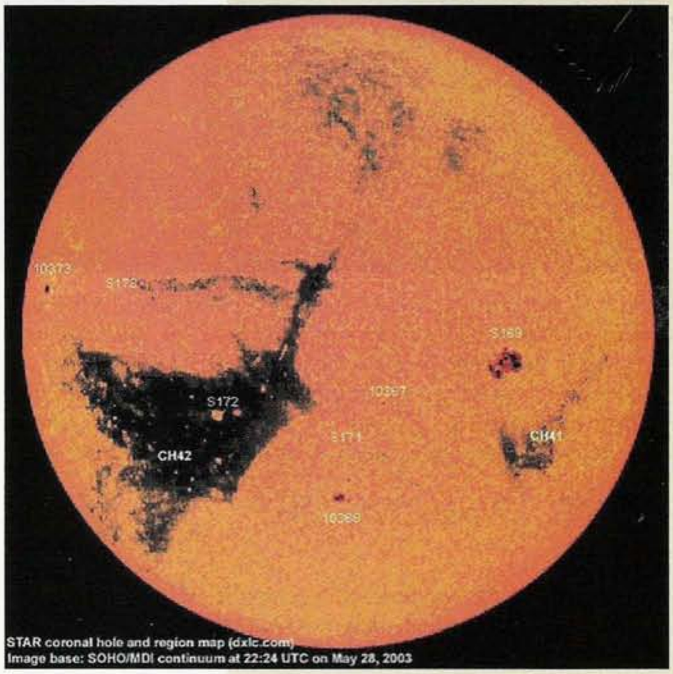


Photo A. Taken late in the day on May 28th, sunspot group S169, located on the equator of the Sun, is seen just hours after the emission of a major X-level flare. S169 is in a good geo-effective position for Earth by being located near the equator of the Sun. (Photo courtesy NOAA)

The activity I observed on 2 meters was fairly significant. I copied as many as five or six different stations that could be heard at any one time; of course, they were all on CW. I went back to 6 meters and found virtually the same number of stations. I then made some QRP contacts with stations in the New Jersey area. The *K*-index value reached a high of 8 at the peak of the aurora event in the early evening.

Stations in the northern part of the U.S., such as Greg, N8CJK, seemed to do particularly well. Another station in Michigan (Tom, K9VBL) heard as many as nine different beacons within five to eight grid squares away via aurora. Among the stations he heard were KØKP, N9PUM, and WR9L. Many of these beacons run less than 10 watts, giving you an idea of the aurora's strength.

When the aurora subsided, *F2* activity developed over the next two hours, with HK3PJ coming in about 5-by-5 signal strength into the northeast. A number of stations in the Midwest also heard a beacon from Argentina coming in on an apparent double-hop *F2* skip. The formula of a strong aurora opening

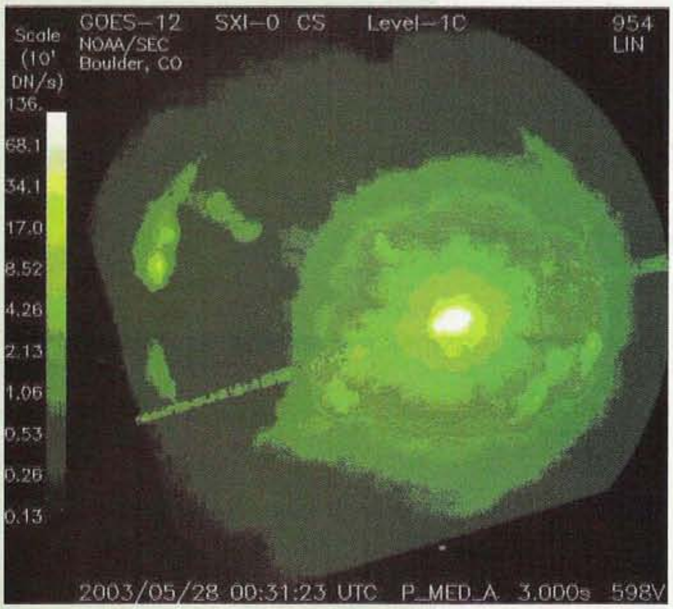


Photo B. In this shot, the sunspot group designated S169 has emitted a major X-level flare early on May 28th. The level was very high, with peak measurement at the X3.1. There was an approximate two-day wait for this geo-effective flare to collide with the geomagnetic field of the Earth, resulting in aurora activity on the VHF bands. (Photo courtesy NOAA)

resulting in an *F2* opening still seemed to hold true, even at reduced solar-flux values, below 150 at this time.

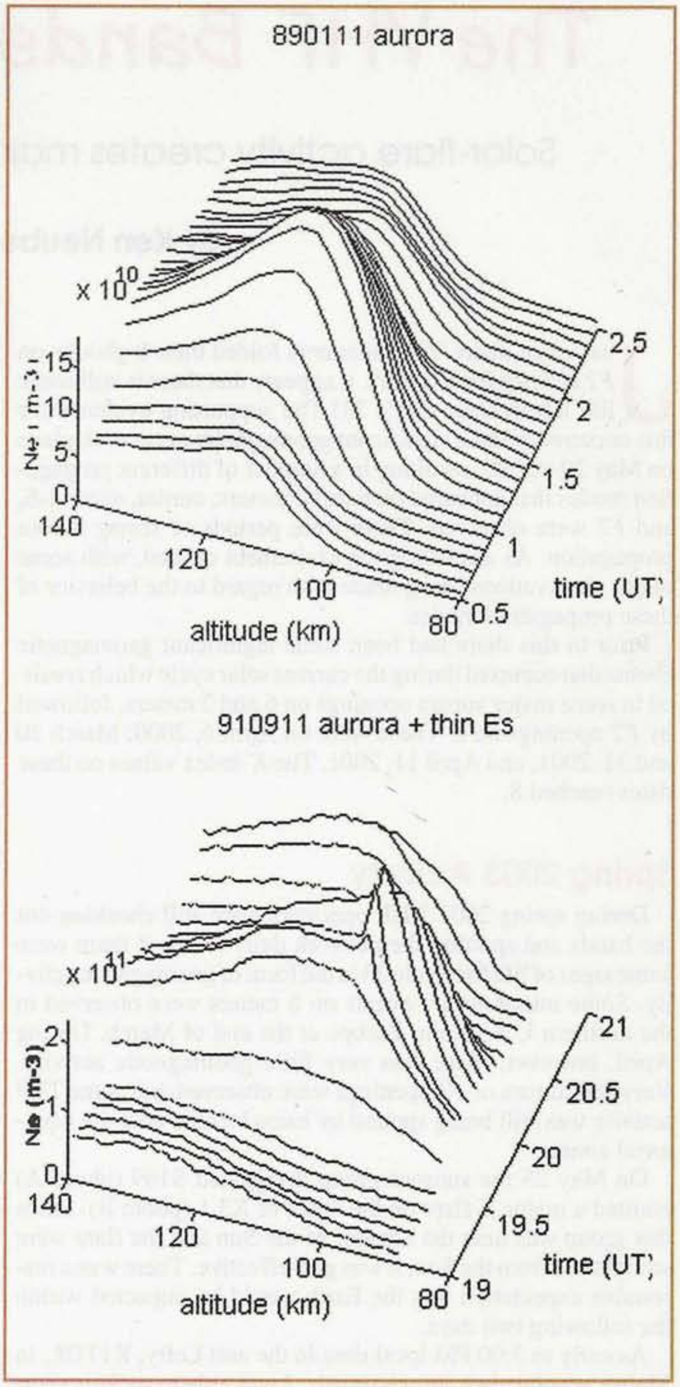
The effects of the aurora were felt as far south as Florida and other southern states! Terry, K4RX, worked stations in the Midwest, including W9SE, N9TH, and WB8XX. Then he worked W1JJ and N2DB in the northeast. Terry was also able to work two stations in Colombia—HK3JRL and HK3PJ—when the aurora subsided.

Stations in southern California (WB6NOA, for one) were able to take advantage of aurora openings that initially allowed contacts on 6 meters into British Columbia, Canada. Eventually, the aurora changed into auroral-*E* conditions and stations in British Columbia and U.S. stations in the Pacific Northwest were worked!

The aurora and *F2* events were not all that was observed on the VHF bands! A full-fledged auroral-*E* opening occurred during the early morning hours of May 29! This opening was so strong that it resembled sporadic-*E* with some additional audio qualities. For example, at 1:30 AM I awoke and heard Emil, W3EP, talking with David, ZF1DC, in the Cayman Islands on 6 meters. The signals sounded like sporadic-*E*, but there was a distinct tinny quality to the audio.

I went back to bed and awoke again at 5:30 AM to hear the sounds of several beacons from the Midwest coming in via auroral-*E* at 579 signal strength or higher! Among the stations I heard were KØKP, N8PUM, and WR9L, to name a few. Unfortunately, there were no "live" stations at that time.

I was pointing my beam west, directly at these stations, getting the impact of a sporadic-*E* opening. This leads to the following question: At what point in time does an auroral-*E* opening become a *true* sporadic-*E* opening?



Figures 1 & 2. Plots of past auroras made by EISCAT radar in northern Europe. The first plot shows a typical aurora pattern that is broad in nature. In the second plot, a sporadic-E layer is embedded inside the aurora itself. This is probably what is happening during an auroral-E opening when a sporadic-E layer is emerging, and eventually when the aurora subsides, the sporadic-E layer is all that remains. (Figures courtesy Dr. Sheila Kirkwood)

Lefty, K1TOL, who has frequently seen this over the years at his Maine QTH, observed that when one turns the beam northward, away from the direct path, the auroral tones increase. I believe that what I observed at 5:30 AM on the 29th was the retreating of the aurora formations toward the north, leaving behind a sporadic-*E* opening with some enhancements. Figures 1 and 2 show some historic plots of aurora and auroral-*E* events that were captured by EISCAT radar in northern Europe.

Indeed, the plots in figure 2 suggest what many hams have observed on 6 meters: A strong aurora formation seems to swallow or dominate a sporadic-*E* formation. It is only when the aurora itself subsides that the sporadic-*E* formation is detected. During the retreating of the aurora, the sporadic-*E* formation has some of the characteristics of the aurora that can be detected in the signals. Having a band such as 6 meters, where this phenomenon can be observed with no impediments, is a very useful tool in understanding this aspect of radio propagation.

Finally, by 6:30 AM I was working a number of stations from my QTH, beginning with Greg, N8CJK, in Michigan. All the signals were strong and could be worked with moderate power and a directional antenna. This sporadic-*E* opening lasted for several hours, until noontime locally, with the opening eventually developing toward the south.

Summary

It seems apparent that during a particular sunspot cycle *F2* activity is never truly finished until geomagnetic activity is significantly diminished. While the main crux of *F2* activity goes down with lower solar-flux values, a major geomagnetic event such as this one is capable of stimulating *F2* activity along north-south paths.

Therefore, from this event a lot of important observational information was gleaned which aids in our understanding of the propagation modes we see on 6 and 2 meters. It does not appear that all is finished yet for this particular cycle. A few weeks later, on June 16th, there was more solar activity that resulted in the *K*-index reaching 6, and many aurora contacts were made in the upper part of the U.S. on 6 meters. I made contacts with Greg, N8CJK, grid EN84, in Michigan, and two others in Maine. This relatively modest opening, compared to the event that occurred on May 29, apparently was not strong enough to create subsequent *F2* activity. However, this may be a sign of things to come for this cycle during the next several months. It would behoove VHF operators to keep an eye on the various internet spotting sites as well as an ear on the VHF bands.

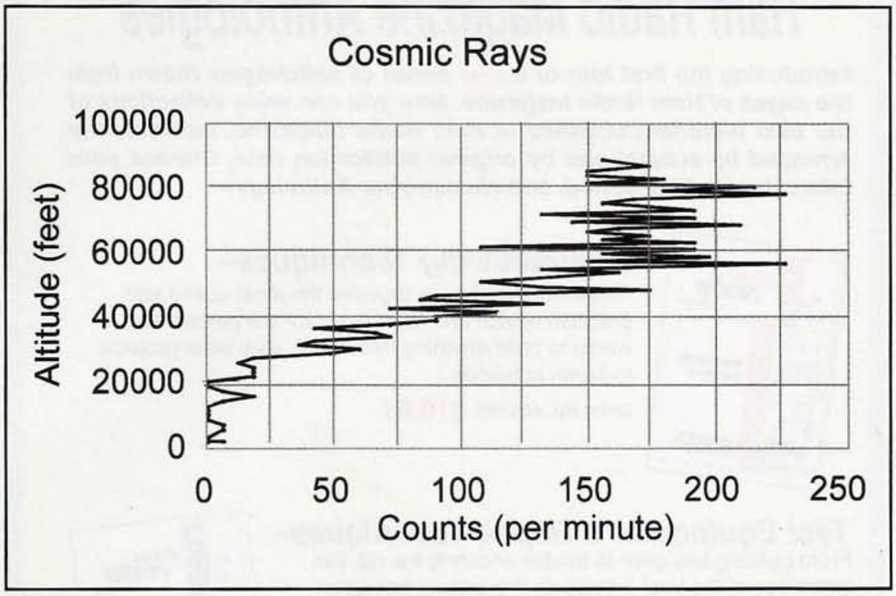


Figure 2. The cosmic-ray count was determined by counting the pulses from an Aware Electronics RM-60 Geiger counter. The counter is sensitive to alphas, betas, and gammas, along with x-rays, gamma rays, and energetic protons. Cosmic rays are predominately high-energy protons. The proton flux above the Earth's atmosphere during launch time was just over three protons per cubic centimeter (very quiet). Past flights have seen counts four times higher at 62,000 feet. The current proton density in space can be found at <http://www.spaceweather.com>.

plete APRS stations and ATV. He has helped launch *rockoons* (a rocket carried on and launched from a balloon platform) and cameras to record meteor showers from 100,000 feet. Very interesting is the fact that his meteor-shower flights were made in conjunction with the Marshall Space Flight Center (MSFC).

The Launch

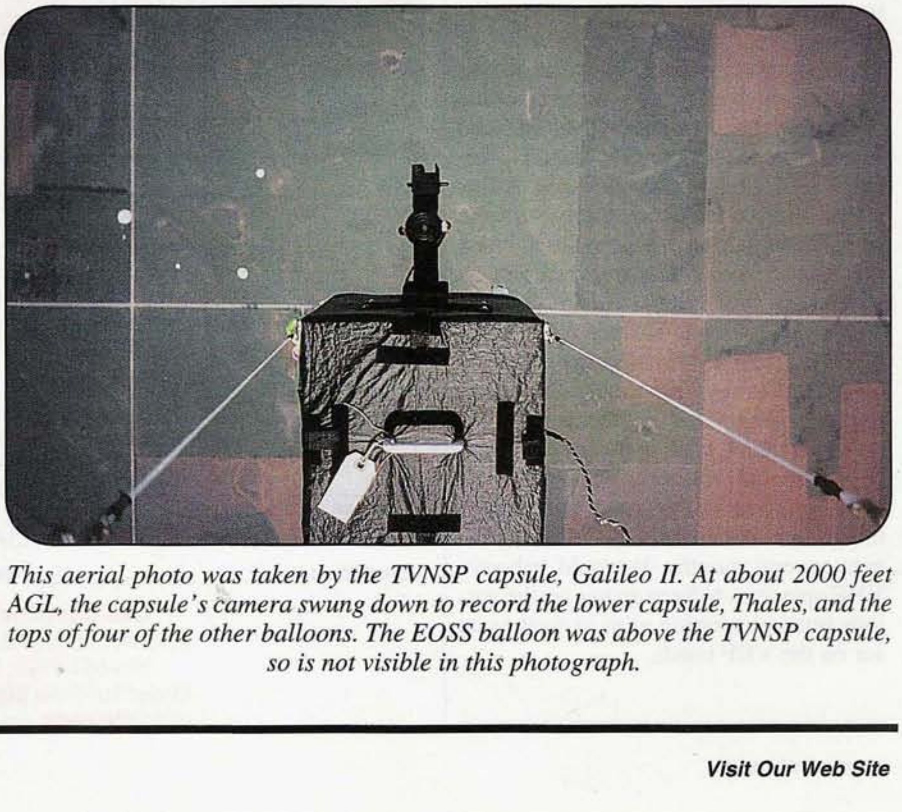
The speed and direction of the winds aloft at the Johnson Near Space Center made it necessary that the GPSL 2002 launches take place from the municipal airport in Herington, Kansas, a converted World War II B-29 bomber training base. Launch crews began arriving at the airport shortly before 7 AM, followed soon thereafter by a reporter from the Herington newspaper.

Due to the large number of balloons being filled and the limited ceiling height of the airplane hangar, the balloons were filled outdoors. Fortunately, the surface winds were very light all morning, although I did worry that the winds might strengthen as the morning progressed. The highlight was the 20-year-old balloon of Mike Bogard, KDØFW, which, darkened with age, initially began to fill without incident. However, it wasn't long before a thin patch of latex in the skin stretched to the point where it looked as if the balloon was developing an aneurysm. The balloon eventually burst with an audible pop, while Bill, WB8ELK, was holding the neck of it.

Amateurs in the near-space hobby are accustomed to just this sort of disaster, so Mike was able to get a second balloon (this one less than a year old) from Zack Clobes, WØZC. Unfortunately, Zack couldn't be with us for the symposium, but he was able to be at the Saturday launch, adding Project Traveler to the list of near-space programs in attendance.

By about 9 AM all of the balloons had been filled and sealed. After conferring with the program managers, it was determined that everyone was ready for launch. Payload lines and lanyards were securely attached before crews began moving their balloons away from the hangar and into a grassy field near the tarmac. There was a total of eight balloons: five near-space stacks with one balloon each, a sixth stack with two balloons, and a red piball for tracking surface winds at launch. Don Pfister, KAØJLF, of HABITAT, used a second balloon on his stack, while Mike Manes, W5VSI, Rick Von Glahn, NØKKZ, and Marty Griffin, WAØGEH, all of EOSS, launched the red piball along with their balloon.

The groups/balloons included EOSS 1200 and 100 grams; HABITAT 300- and 600-gram combination; KDØFW 1200 grams; NSTAR 800 grams; Project Traveler 600 grams; and TVNSP 1200 grams. The positioned balloons and their crews formed a line 200 feet long, making communication difficult. (The crews were too busy handling the very large balloons to use HTs.)



This aerial photo was taken by the TVNSP capsule, Galileo II. At about 2000 feet AGL, the capsule's camera swung down to record the lower capsule, Thales, and the tops of four of the other balloons. The EOSS balloon was above the TVNSP capsule, so is not visible in this photograph.

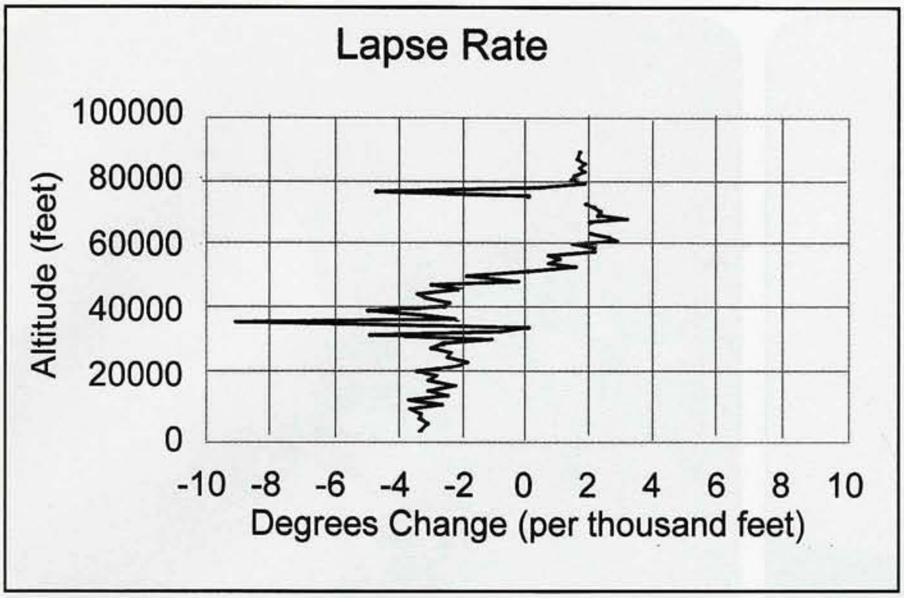
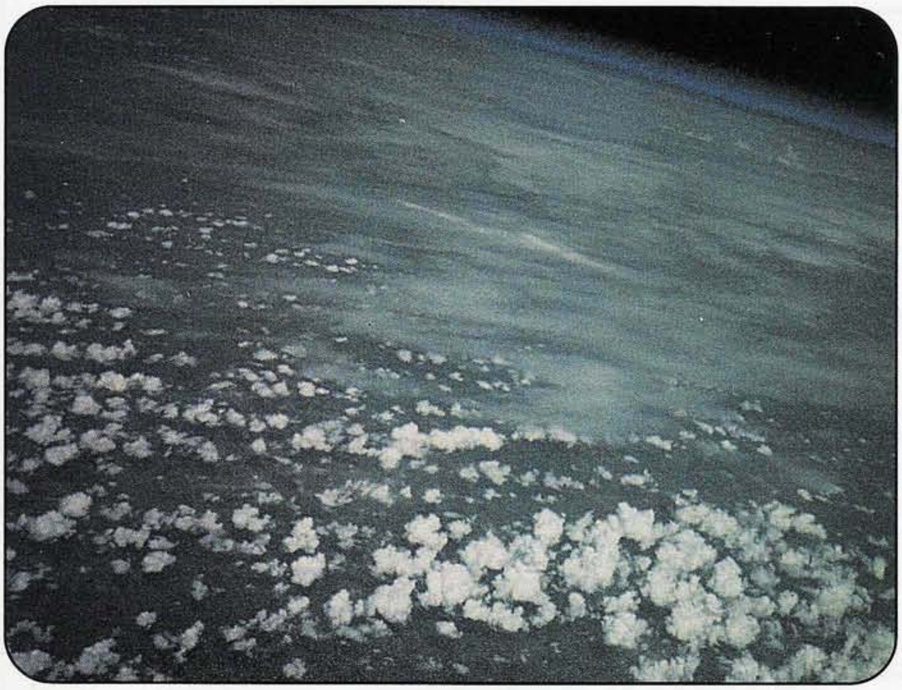


Figure 3. The lapse rate is a measure of how fast the atmosphere cools with increasing altitude and was determined by dividing the change in air temperature by the change in altitude. The lapse rate in the first 8000 feet of the atmosphere is higher than –5.4°F per 1000 feet, indicating a stable atmosphere for the first 8000 feet. Above 8000 feet the air had cooled below its dew point of 65°F and the lapse rate averaged –3°F per 1000 feet, indicating the atmosphere is close to unstable at these higher altitudes. Above an altitude of 50,000 feet the lapse rate is positive, because the stratosphere is warmed by sunlight. In the troposphere the lapse rate is negative, because the air is warmed by its contact with the ground.



Taken at an altitude of about 86,000 feet, this photo shows the curvature of the Earth and the inky black of space in the upper righthand corner. At this altitude the air pressure is just over 3% of sea-level pressure, far too low for the air to scatter blue light from the sun, leaving the skies black. The air temperature at this altitude is 9°F. The distance to the horizon in this photograph is 390 miles. The view looks toward the northwest.

Half of the balloons were controlled by lanyards, with the lanyards passing through rings located at the neck of the balloons. This allowed the crews to raise the balloons and their payloads above the ground before lift-off. (To launch the balloons, crews release the lanyards, letting them slip through the balloon's ring. Some crews use a single lanyard, while others use two.) The remaining three balloon crews held their stacks in their hands and released the entire stack when it was time to launch.

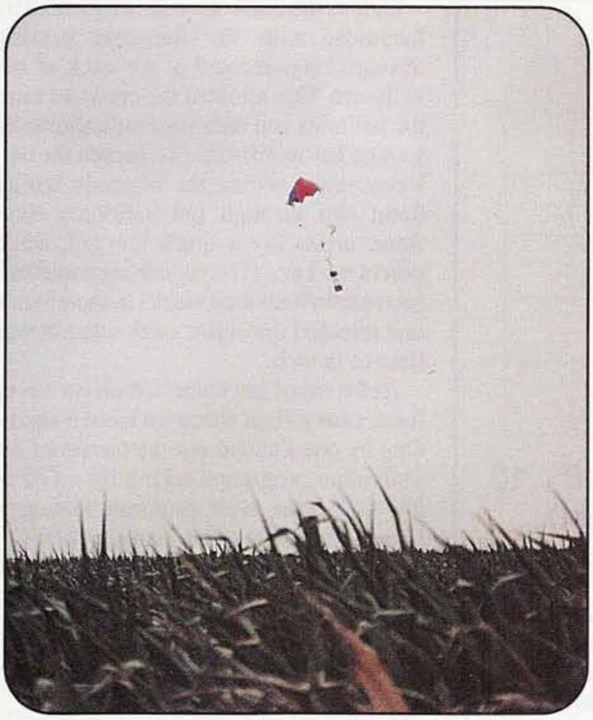
At the top of my voice, which isn't very loud, I ran a final check on launch status. One by one I called out the names of the individual programs, asking for a GO or NO-GO from each program manager. One by one the answers came back "GO." The balloons on lanyards were raised to their full height. Then the ones with two sets of lanyards were released from the first lanyard. Now each balloon was prevented from lifting off by one person. Starting at five, I counted down to zero, and at zero all the balloons were released simultaneously. A quick check of our watches indicated it was 9:43 AM CDT, and it had been a successful and spectacular launch.

Flight

None of us had ever seen eight balloons of this size and proximity take to the air all at once. Many of us think that two of the balloons bumped into one another early in their ascents. However, if this did happen, it did not cause any problems. The balloons climbed at a rate of about 1000 feet per minute and quickly appeared to be only tiny dots, eventually getting lost in the haze-filled skies. Before they disappeared, though, the balloons took on the appearance of a sentence, with Don's double balloon forming a colon at the end of it.

Five of the balloons carried APRS trackers and were monitored live on laptops. KDØFW's balloon had ATV and a repeater. Fox-hunting techniques were used to track and recover his balloon. This just goes to show that you don't need to have the latest in APRS to successfully launch, track, and recover an amateur radio high-altitude balloon.

The winds aloft were very light, so the balloons drifted very slowly and we were in no hurry to begin chasing them. We took this time to take photographs of all the crews and then go to town for some refreshments while we waited for the bal-



One of the capsules coming down via its parachute. (Photo courtesy Doug, KAØO)

A very happy author after having recovered his capsule in a cut-wheat field. The burst balloon is visible behind the author. The line connecting the balloon to the parachute was not cut during the descent, so the burst balloon came down with the parachute and capsules. (Photo courtesy Don, KAØJLF)

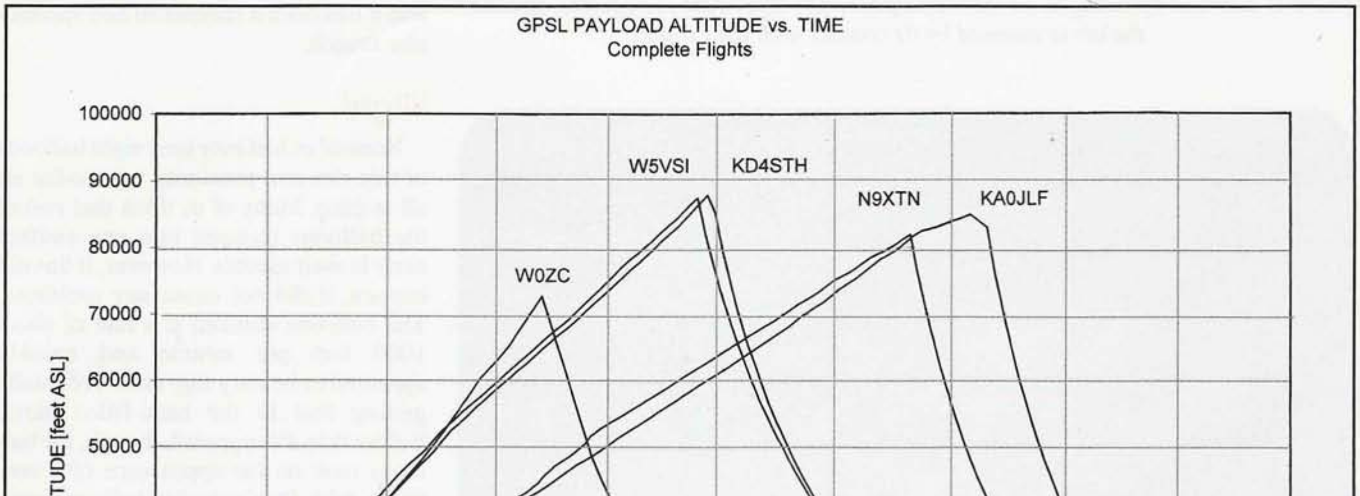


Figure 4. Using an Excel spreadsheet, Ralph, WØRPK, generated this graph, which displays the altitudes of the five APRS-tracked capsules throughout their flight. Note that the EOSS (W5VSI) and TVNSP (KD4STH) flights had almost identical ascent rates. This explains why they landed so close together. The highest altitudes reached in GPSL 2002 were those of EOSS and TVNSP at about 88,000 feet.

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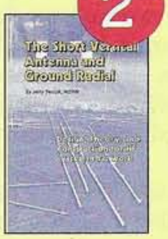

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loons to burst and begin their descents. The Herington Dairy Queen was soon swamped with out-of-state visitors carrying outlandish tracking equipment. We managed to turn a few heads in this small Midwest town.

While we were enjoying our refreshments, word came over the APRS that the first balloon had burst and was on its way down. Zack's balloon had reached an altitude of more than 72,000 feet. The chase was on, as we raced to recover the balloon. However, before we could recover Zack's balloon, the remaining balloons began to burst. Near-space capsules began to drop out of the Kansas skies like flies. The two balloons that landed the closest together, less than a mile apart, belonged to EOSS and TVNSP. Except for Zack's balloon, all of them landed between 12 and 1 PM and about 22 miles due west from the launch site. With roads every mile and arranged on a grid, recovery was fairly straightforward.

Doug Eubanks, KAØO, of the NSTAR group, probably had the best view of the recovery effort. He was able to photograph three of the capsules on their parachutes. After recovering their capsules, the NSTAR and TVNSP chase crews headed back to the Herington airport to load the nine helium tanks into our cars. Then it was off to get the film processed.

At about the same time, the recovery location of Mike's payload was being determined by listening for its ATV carrier. Direction-finding techniques picked up the ATV carrier by 2:20 PM, and Mike, KDØFW, his wife Jackie, and Bill, WB8ELK, recovered the payload by 3 PM.

Summary

GPSL 2002 was the most successful event of its kind. I hope you enjoyed reading about it and seeing the photographs as much as I enjoyed participating in it.

On-line photos can be found at <http://www.eoss.org/ansrecap/thirtyone_to_sixty/recap58.htm> and at <http://members.cox.net/mconner1/nstar.html>. Both sites have maps of the balloon tracks. A group photo taken on the Hale Library's Grand Staircase can be seen at <http://www.crosspaths.net/~wallio/gpsl2002.html>.

Perhaps you will decide to become a part of amateur near-space exploration, either by starting your own program or joining an established group. In the accompanying sidebar I've included the web pages of those involved with GPSL 2002. We are happy to help individuals who are new to the amateur near-space community. Amateur near-space in general and GPSL in particular are great opportunities to use amateur radio in an exciting activity.

I'd like to thank my mother for arranging for the use of the Hemisphere Room for GPSL 2002. I also owe a thank you to the HABITAT and NSTAR teams for helping me move the helium tanks. Each tank weighed 120 pounds, and we had nine of them. Thank you, too, to Linweld for giving GPSL 2002 participants a discount price for the tanks. Finally, without the help of Mark, N9XTN, and Ralph, WØRPK, I could not have made GPSL 2002 work. Thanks, guys.

For those who missed GPSL 2002, proceedings and T-shirts are being made available. For prices, please contact me via my e-mail address, listed at the beginning of this article. ■

Notes

1. Near-Space Race, *Weatherwise,* December 2001, pp. 14–23.

2. Amateur radio high-altitude balloon programs: ANSR, Arizona Near Space Research; EOSS, Edge Of Space Science; HABITAT, High Altitude Balloon Investigation, Testing And Tracking; NSBG, Near Space Balloon Group; NSTAR, Nebraska STratospheric Amateur Radio; TVNSP, Treasure Valley Near Space Program.

3. "High Altitude Ballooning," *73 Amateur Radio,* August 1990, pp. 30–37.

Amateur Near-Space Websites

ANSR: <http://www.ansr.org>
Mike Bogard, KDØFW: <http://www.qsl.net/kd0fw>
Bill Brown, WB8ELK: <http://www.wb8elk.com>
EOS: <http://www.eoss.org>
HABITAT: <http://habitat.netlab.org/index.shtml>
NSTAR: <http://members.cox.net/mconner1/nstar.html>
Project Traveler: <http://www.rckara.org/project_traveler/>
TVNSP: <http://www.the-one.com/tvnsp>
Ralph Wallio, WØRPK: <http://users.crosspaths.net/~wallio/gpsl2002.html>

of the blue sky appearing to hover just above the asphalt ahead. A very hot air boundary just above the roadway creates this optical illusion. For years microwave operators at 10 GHz have used this common phenomenon to bounce signals off sharp hot-air boundaries.

Tropospheric ducting is a summer- and fall-anticipated path in the following locations:

- Hawaii to the U.S.West Coast
- San Francisco to Los Angeles
- Denver to Dallas
- Texas to Florida
- Great Lakes to the eastern seaboard
- Great Lakes to Texas
- Nova Scotia to Miami
- Midwest to Southeast

These are common VHF/UHF communication paths when a high-pressure cell settles in and becomes a stationary nuisance for good, clean air. Many times you literally can see the tropo boundary—smoke ascending to about 800 feet and abruptly going horizontal. A quick check of your local weather station will probably show a giant "H" sitting overhead, and that means a high probability for extended-range contacts from 6 meters on up.

"The whole physical process takes place over vast areas of the weather chart," comments Jim Bacon, G3YLA, in an article in *Practical Wireless,* October 1990.

"Highs are among the largest of the weather systems when it comes to horizontal dimensions. This, in turn, determines the geographical scale of any radio-path enhancement produced by highs," adds Bacon. He confirms the atmospheric horizontal layering, which creates subsidence inversions at about the 1000-foot level.

"The important point to remember about highs and the inversions they produce is that the lower atmosphere becomes horizontally layered over large distances with cool, sometimes moist air near the surface and dry, warm air above the inversion. This makes quite an abrupt boundary between these two different air masses," confirms Bacon.

The most common "parking space" for high-pressure systems is between 30 and 45 degrees latitude above and below the equator. The majority of the United States, plus the regular summertime Pacific high and the regular summertime Atlantic high, favor tropospheric ducting

The path from California to Hawaii is easily seen in the bronze inversion layer.

from subsidence inversions right in our own backyard. If your weather-forecast map shows mean-sea-level atmospheric pressure in millibars, look for hot band conditions when your stalled high-pressure cell reaches 1025 millibars over the path you may believe is open on VHF, UHF, and microwaves.

Research clearly shows, however, that a high-pressure cell alone may not open the 2-meter band for long-range tropo. What is necessary is for the high-pressure cell to develop *over* moist air. This explains why many world-record VHF, UHF, and microwave tropo records have been set between California and Hawaii; there is an inexhaustible supply of cool, moist air hugging the ocean, undisturbed, for 2500 miles.

Advanced visual and infrared weather charts clearly show the undisturbed low clouds between the West Coast and Hawaii—and sometimes farther—during periods of intense subsidence-inversion band openings. Many times this same condition exists between the East Coast and Europe, and VHF and UHF weak-signal operators may ultimately bridge this path, too. There's a handsome trophy just waiting for the first USA and European team to successfully span this 6000 km distance.

Ham operators in southern California, Texas, and Florida all seem to agree on one additional weather phenomenon that may help trigger an extremely strong tropospheric duct over the ocean—*hurricanes!* As a hurricane slowly approaches the higher latitudes, counterclockwise bands of moisture spin out from the center of the storm and mix with cool, moist ocean air capped by the already-in-place high-pressure cell. Hams along the periphery of the incoming bands of "hurricane" weather report that they can literally smell this very moist tropical air coming up from the south. This dramatically increases the water content of the surface air, resulting in even a more abrupt change of the dry air temperature inversion above associated with subsidence. If the winds are gentle, additional layering of these two different air masses seems to induce even higher operating frequency DX.

On July 30, 1982 Chip Angle, N6CA, went mobiling in his 1976 Chevy van with a homebrew 1296-MHz transceiver homebrew system with a .5 dB noise figure and successfully completed a two-way exchange with 30 watts from a 7289 driver tube. This output drives a 180-degree ring hybrid homebrew setup that splits the signal into two 15-watt levels. These two signals drive two individual 7289 amplifiers in parallel for a maximum power output of 500 watts. Antennas were loop Yagis with 20-dBi gain developed by Chip. Boom length was 12 feet. Signal reports were 59 from California to Hawaii, and then Hawaii to California, over a path of 2500 miles. The record didn't end there.

In 1991 and 1994 Chip and Paul, KH6HME, completed two-way contacts on 2304 MHz, 3456 MHz, and finally 5760 MHz over the 2500 mile path! Each contact was completed with a very large hurricane spinning to the south, introducing large amounts of moist air into the already strong atmospheric layering that was taking place.

"On some very special occasions with a hurricane to the south and an intense high-pressure system in place, I can fly into specific atmospheric layers and literally see, smell, and temperature-sense radio paths," adds Bill, WA6CAX. He reports that the more narrow the layer, the greater the signal strength on 432 and 1296 MHz to distant beacons. This makes sense; much like a waveguide, the higher the frequencies, the smaller the waveguide.

Suzy West, N6GLF, worked Hawaii on 2 meters at a distance of 2500 miles with just 2 watts.

You don't necessarily need to live next to a great body of water to cash in on this summer's tropo-ducting experience. North American distance records compiled by Al Ward, WB5LUA, show some interesting paths for some very-long-range VHF and UHF contacts:

- 2700 km from Key West to Nova Scotia on 144 MHz
- 2000 km Midwest to Northeast on 222 MHz
- 2200 km Key West to Northeast on 432 MHz
- 1700 km Texas to Florida on 903 MHz
- 2000 kilometers Texas to Northeast on 1296 MHz
- 1500 km Texas to Great Lakes on 2304 MHz
- 1200 km Texas to near Chicago on 5760 MHz
- 1100 km west coast of Mexico to San Francisco area on 10,000 MHz
- 256 km West Coast Bay Area into Oregon on 24,000 MHz

Many of these long-range, record-breaking contacts occurred *not* as a result of a subsidence inversion, but rather as a result of tropo from approaching storm fronts. No great body of water is necessary! Look for incoming cold, bad weather that will collide with that nice fall, warm weather which has been hanging around since summer. As cold arctic air lines up and gradually develops a wall along the prevailing jet stream, sharp temperature and moisture gradients begin to form. The path is usually south to northeast, skirting along the approaching slow-moving cold front. When the approaching cold front is about a day away, get set for some exciting band conditions. When you begin to see bands of high cirrus clouds, conditions along the front might carry VHF and UHF signals well over 1000 miles.

The Tropo Experience

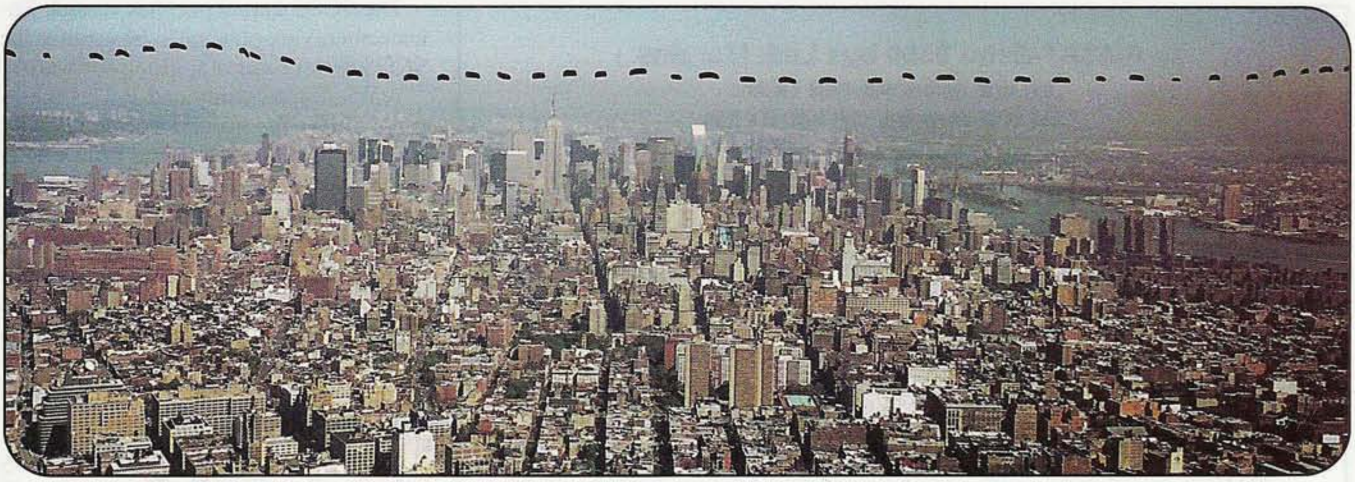
The most popular mode of working weak-signal tropospheric ducting is on single sideband at the bottom of 50, 144, 222, 432, and 1296 MHz. Most CW and SSB tropo operators work horizontal polarization. A relatively small, inexpensive 11-element beam, turned on its side, should be aimed at the expected path of the tropo-duct opening. A rotator certainly helps, but it is not absolutely necessary if you live in the southern extremes of the U.S.

Begin your tropo experience by first tuning into the continuous 24-hour beacon sub-bands: 50.060–50.080, 144.275–144.300, 222.050–222.060, 432.300–432.400, 902.100, and 1296.070–1296.080 MHz. If you don't hear any beacons coming in, try the weak-signal CW and SSB calling frequencies. Double check that your SSB operation is always upper sideband: 50.125, 144.200, 222.100, 432.100, 902.100, and 1296.100 MHz.

Make some noise! Aim your horizontal beam in the likely direction of the subsidence inversion or parallel to the approaching cold front. Give your callsign, and *be sure* to give your general location. This is especially true if you have a number in your callsign that is not indicative of where you are located. If you simply announce "WZ9ZZZ," you will have all your local Texas stations calling you in a pile-up, not realizing you are a transplant from Chicago who is now operating in Houston. Always give your location when you're operating tropo DX.

You don't necessarily need a lot of SSB or CW power to work the duct. Once the tropospheric duct builds in, 100 watts or less is common into a minimum of a short-boom, 11-element beam. A better antenna would be a horizontal, long-boom Yagi, available from antenna manufacturers with an interchangeable mounting bracket for either vertical or horizontal polarization. Always run tropo horizontal. You don't need a kilowatt amplifier. If you want to double your effective radiated power, simply swap your tired RG8 coax for brand-new LMR-400 coax cable that takes the same PL-259, and you're set. If your radio takes a type-N connector and if you are worried about trying to do soldering, go for a PL-259; then get the adapter. Up to 1296 MHz, a PL-to-N adapter is barely a bump in the line.

If you don't have a multimode SSB 50, 144, 432, or 1296 MHz transceiver, there



A rare photograph of the New York City skyline taken from the roof of one of the towers of the World Trade Center. The tropo duct can be seen low on the horizon. (Photo by Drew, N2RFA)

are still great opportunities for you to work tropo. Do it on FM, vertically polarized. Begin monitoring the FM national simplex frequencies for vertically polarized signals coming in hundreds of miles away along the expected tropospheric duct: 52.525, 146.520, 223.500, 446.000, and 1294.5 MHz.

Almost any quality VHF or UHF base-station vertical antenna may yield some outstanding tropo results. Brand-new LMR-400 type coax is absolutely necessary to minimize any loss of a weak FM tropo signal coming into the antenna and making it down to your radio room's FM transceiver. You could even do tropo on a handheld tied into big coax and a high-gain collinear base antenna.

If your FM radio will tune up to the 162 MHz weather band, see what weather channels you can hear and listen carefully for their identifier and location. When tropo sets in over your region, you might be hearing a weather station 800 miles away! This is a sure sign that you will have tropo activity down on 146 MHz.

You can easily work distant repeaters via tropo as well. Always give your location so others on the distant repeater will realize what may be happening. Expect some raised eyebrows at first when you tell them you are coming in 800 miles away! When the tropo duct opened between Hawaii and the southern California Catalina Island repeater, there were a couple of minutes of conversation that stated the disbelief that a ham in Hawaii driving his car with a 50-watt mobile was actually spanning the 2500-mile path!

When the tropo duct builds in, subsidence inversion associated with a high-pressure system may keep the VHF and UHF bands wide open for several days. You will be amazed to hear how signal levels stay relatively stable during the ducting experience, as opposed to wide swings from strong to non-existent in the span of 30 seconds from a sporadic-*E* contact. The builds and fades of tropo signals indeed will change over the course of an hour, but they will not race up and down within 30 seconds as you would hear with a brief ionospheric-skip occurrence.

The incoming tropo signal will behave much like the garden hose that slowly swishes back and forth when it is left unattended on the lawn. You may be tuned into a distant repeater 1200 miles away and hear it clearly for about a half hour, and then it slowly sinks into the noise on your FM receiver. Your friends across town, who in the first place didn't believe you heard anything beyond 30 miles away, now begin to hear that same repeater clearly. Tropospheric ducting can be so selective that two hams in the same city may alternately hear the same station, one at a time, but that station sometimes blanket an area such that the entire city simultaneously hears the signal, and then loses it an hour later, only to have it reappear later on in the afternoon. Your local weather patterns on a hot windless day should truly bring in good tropospheric conditions.

Tropo forecast maps from William Hepburn are available at <http://www.iprimus.ca/~hepburnw/tropo.html>. You should also join some of your regional weak-signal VHF/UHF groups (see sidebar).

My "personal best" tropo DX was an experiment using FM on 70 cm (440 MHz), running 3 watts from a Yaesu FT-817 into a KB6KQ horizontal loop at the beach, completing a path 2500 miles away to Hawaii. We repeated this feat moments later on 2 meters FM, too. Don't let anyone tell you that weak-signal VHF/UHF tropospheric ducting is only available to hams with more elaborate single-sideband radios and monster long boomers. When conditions are right, FM can get you started. Good DX to you this summer and fall! ■

Some Regional Weak-Signal VHF/UHF Groups

Central States VHF Society: <http://www.csvhfs.org>
Midwest: <http://www.ceitron.com/mvus>
North Texas Microwave Society: <http://www.ntms.org>
Northeast Weak Signal Group: <http://www.newsvhf.com>
Pacific Northwest: <http://www.pnwvhfs.org>
Rocky Mountains: <http://www.qsl.net/rmvhf>
Southern California Microwave: <http://www.ham-radio.com/sbms>
6 meters: <http://www.6mt.com>
Six Meters International Radio Klub: <http://www.smirk.org>
Southeastern VHF Society: <http://www.svhs.org>
West Coast Weak Signal Society: <http://www.wswss.org>

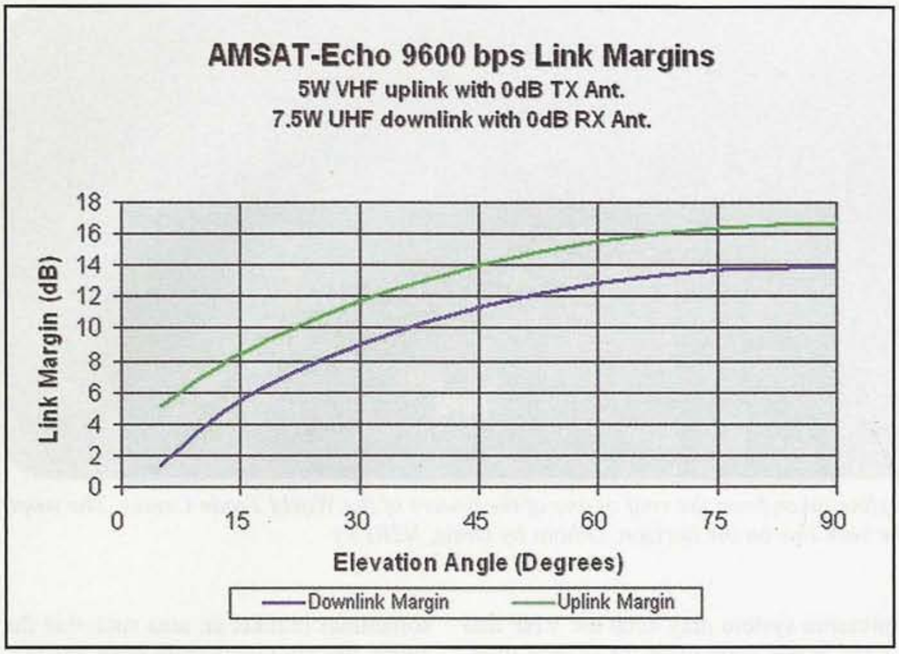


Figure 2. Mode V/U link margin graph.

sumption of less than 300 mW. The IFC includes advanced features, including six receive and six transmit serial communication channels, 1 MB of error-detecting and correcting (EDAC) memory, 16 MB RAM, and 16 MB flash memory for mass storage.

The IDC also has six agile demodulators and two agile modulators to support data communications.

Echo's software consists of a boot loader, kernel, operating system, and applications (photo E). Echo will use the Spacecraft Operating System (SCOS), which has been used on all of the amateur radio Microsat projects to date. Harold Price, NK6K, should be thanked for allowing AMSAT to use SCOS.

The software development team consists of Bob Diersing, N5AHD; Jim White, WDØE; Harold Price, NK6K; Lyle Johnson, KK7P; and Skip Hansen, WB6YMH.

Bob Diersing, N5AHD, has agreed to update the boot loader. A test version of boot loader is now complete. This is the first step to enable the rest of the software effort.

The SCOS kernel port has started. Enhancements are planned to be made to the SCOS drivers and supporting software.

A Windows® command and telemetry program for the ground station is about 50 percent complete at the time this is being written. A Windows®-based bootloader prototype for the ground station is done. The housekeeping task has been created and will soon be tested.

The communication protocol for the digital voice recorder (DVR) interface is documented.

Solar Panels

Echo will have six high-efficiency solar panels (photo F). The panels will use triple-junction MCORE GaAs cells that are nearly 27 percent efficient. This results in about 20 watts of power generation capacity when not in eclipse (12–14 watts per side).

Power Distribution

Echo is equipped with a matched set of six NiCd cells that have a capacity of 4.4 amp-hours each (photo G). The output of the battery subsystem is nominally 8 volts DC.

The interface between the solar panels and the batteries is through the battery control regulator (BCR, photo H). This critical subsystem is designed to be autonomous and fail-safe so that the batteries are protected above all else.

The BCR operates at 50 kHz with 89 percent efficiency. It charges the battery using only solar-panel power, so it is capable of charging a dead battery. The

Photo F. Mark Kanawati, N4TPY, preparing to bond solar cells to the panels.

Photo G. Battery tray.

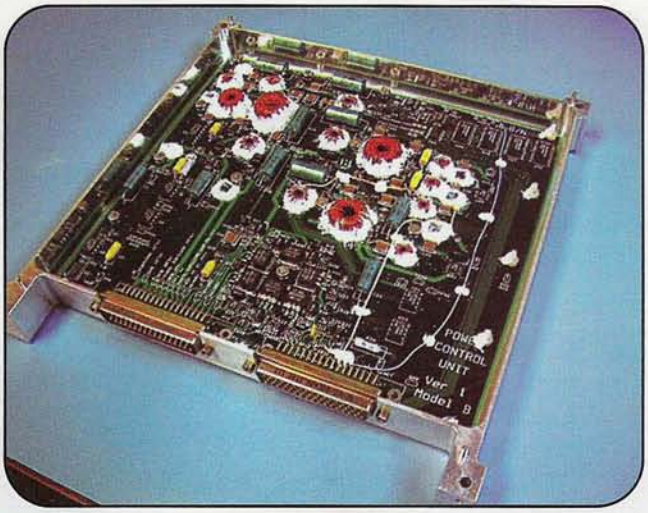


Photo H. Battery control regulator (BCR).

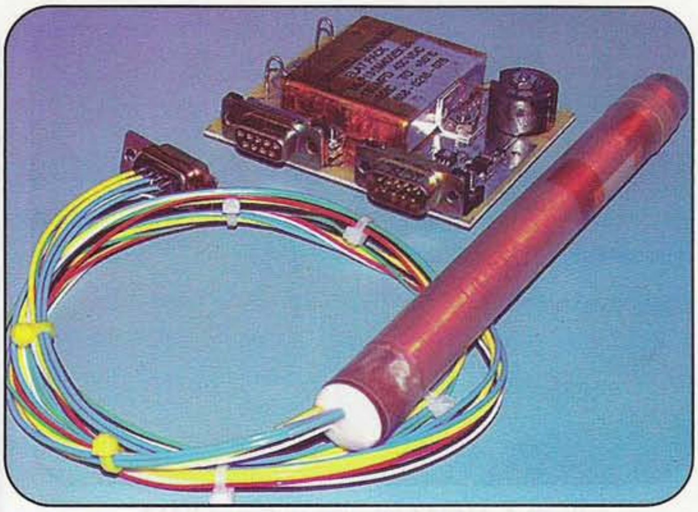


Photo I. Active magnetic attitude control.

BCR prevents the battery from overcharging or depleting completely at any temperature and provides the necessary voltages and telemetry.

Attitude Control

A new experimental active magnetic attitude control (photo I) has replaced the passive system used on previous Microsats. This design, by Doug Sinclair, VA3DNS, consists of a torquer rod and a charging module.

The torquer rod is a semi-permanent magnetic rod the strength and polarity of which are adjustable by applying a charging current over a period of up to 15 seconds, where 15 seconds imparts a maximum charge. This charging current application allows some control over the satellite's attitude relative to the Earth's magnetic field. It also permits us to turn the satellite upside down.

Digital Voice Recorder

Echo will be equipped with a multichannel digital voice recorder (DVR). This recorder can sample audio from a selected receiver output with 16 bits resolution at a rate of 48K samples/second. Recordings can be played back on any of Echo's downlink channels.

The DVR is based on the same ARM7 processor planned for use in the IHU3 for upcoming high-orbit missions. It has up to 64 MB of RAM disk storage, providing almost 12 minutes recording time.

Integration Lab

Thanks to the efforts of Ron Parise, WA4SIR, NASA Goddard Space Flight Center has returned the AMSAT Integration Lab (photo J) to us. NASA and a group of hams led by Jan King, W3GEY, and Tom Clark, W3IWI, constructed this building on the grounds of what is now the NASA Visitor's Center in the spring of 1978. The Integration Lab was used between 1978 and 1988. It was instrumental in the construction of the Phase 3A satellite and OSCAR-10.

The Goddard Amateur Radio Club has helped to clear the building of the materials stored there by the Visitor's Center. We are now waiting for NASA's facility department to repair the roof and floor. Once these repairs are completed, we will

Photo J. AMSAT Integration Lab at NASA.

bring in furniture and test equipment, much of which will be provided by NASA and the Goddard Amateur Radio Club. We are also assembling a satellite command and test station for this facility. Fortunately, our satellite antenna tower is still standing and is in good condition.

Launch

Echo's launch is now planned for May 2004. The launch will be on a Dnepr LV (SS-18) rocket from the Baikonur Cosmodrome in Kazakhstan (photo K).

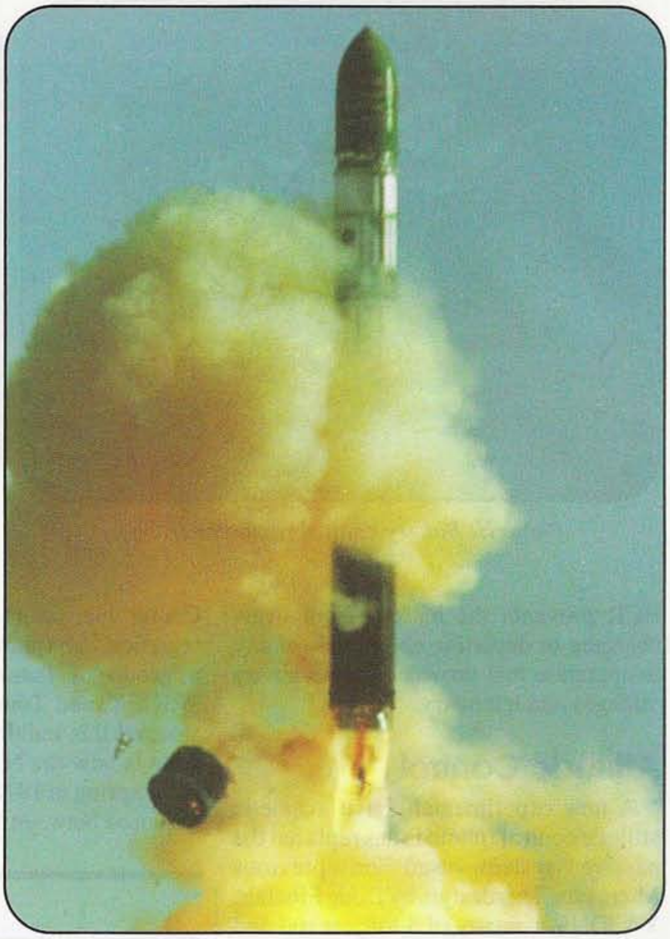


Photo K. Dnepr LV (SS-18) launch from Baikonur Cosmodrome in Kazakhstan, December 2002.

Conclusion

AMSAT OSCAR-E ("Echo") has evolved and matured since its inception in late 2001. Many of its modules are now built and undergoing preliminary testing. Software is beginning to come together. Soon we will begin the system integration, where the various subsystems will be tested in functional groupings. Then we will proceed with full satellite integration and testing.

By this time next year the Echo satellite should be in orbit, providing communications services to the amateur radio community for many years to come.

Notes

1. Rick Hambly, W2GPS, "AMSAT OSCAR E, A New LEO Satellite from AMSAT-NA," *AMSAT Journal,* May/June 2002, pp. 5–11.

2. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Status Update, A New LEO Satellite from AMSAT-NA," *AMSAT Journal,* November/December 2002, pp. 14–17.

3. Rick Hambly, W2GPS, "AMSAT OSCAR E, A New LEO Satellite from AMSAT-NA," *CQ VHF,* Summer 2002, pp. 13–20.

4. Richard M. Hambly, W2GPS, "AMSAT OSCAR-E Project Status Update, A New LEO Satellite from AMSAT-NA," *CQ VHF,* Winter 2003, pp. 12–13, 72–74. ■

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Searching For The Ultimate DX

Testing the Null Hypothesis

What exactly would constitute incontrovertible proof of extra-terrestrial contact? When SETI was the exclusive province of professional radio astronomers, scientific rigor set high standards of proof. The question is now complicated by the privatization of SETI, which has opened up this exciting field of research to laymen. The public may make only a vague distinction between proof and faith. The spectrum of human skepticism versus gullibility encompasses a wide range of extremes, characterized by diverse viewpoints ranging from "of course they exist; we couldn't possibly be alone!" to "I'll believe in the existence of intelligent extra-terrestrials only when one walks up and shakes my hand." We must take pains to prevent such declarations of faith from clouding the judgment of our SETIzens.

As radio amateurs striving to embrace scientific professionalism, we start by acknowledging that one can never conclusively prove the negative, but that it takes only one counter-example to disprove it. Conservative experimental design demands that we frame our research hypothesis in the null form: "resolved that there are no civilizations in the cosmos which could be recognized by their radio emissions." Now a single, unambiguous radio signal is all it takes to disprove the null hypothesis and negate the notion of humankind's uniqueness.

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What constitutes an unambiguous signal? A popular definition holds it to be one which could not have been produced by any naturally occurring mechanism that we know and understand. This is an insufficient condition. The first pulsars, after all, fit that definition. They were first labeled "LGM," for Little Green Men, and their intelligent extra-terrestrial origin was seriously considered for several months, until our knowledge of the mechanics of rapidly rotating, dense neutron stars became more complete. There is the risk that any signal that cannot be produced by any known natural mechanism could well have been generated by an astrophysical phenomenon which we have yet to discover. Therefore, we need an additional metric.

Here are several of the hallmarks of artificiality, which we can expect an electromagnetic emission of intelligent origin to exhibit:

- spatial/temporal characteristics consistent with sidereal motion
- coherence not achievable by known natural emission mechanisms
- Doppler signatures indicative of planetary motion
- frequency selection that exhibits a knowledge of one or more universal constants
- information content suggestive of a mathematically based culture

The common denominator of all these characteristics—in fact, of all human (and we anticipate, alien) existence—is that they are anentropic. Any emission that appears (at least at the outset) to defy entropy is a likely candidate for an intelligently generated artifact. In that regard, periodicity is a necessary, although not a sufficient, condition for artificiality (remembering, once again, the pulsar).

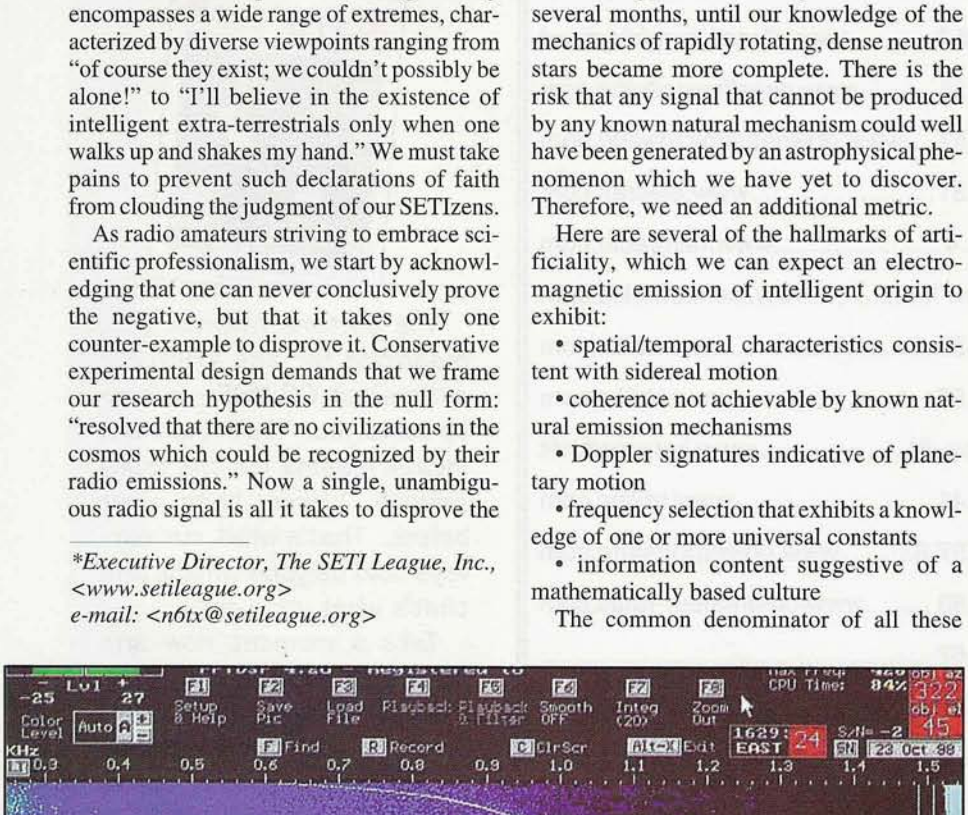
Unless we are blessed with communication rich in information content, signals that convey otherwise unknown information about the culture that generated them, we are unlikely to ever achieve absolute certainty that what we have received is indeed the proof of existence we seek. Multiple independent observations, however, can do much to dispel the obvious alternative hypotheses of equipment malfunction, statistical anomaly, human-made interference, and deliberate hoax. In that respect, the development of well-coordinated signal-verification protocols can do much to narrow our search in space. Once again, in signal-verification activities it is the null hypothesis we should be attempting to verify. We thus expect that we ultimately will rule out most candidate signals. However, there eventually may come a signal that simply cannot be explained away.

"Once you have eliminated the impossible," Arthur Conan Doyle wrote in the voice of Sherlock Holmes, "whatever remains, no matter how improbable, must be the truth." Above all else, this truth must pass the interocular trauma test: When the proof we seek is so powerful as to hit us between the eyes, we can no longer deny it.

No government pronouncement is likely to pass this demanding test, as far as a skeptical public is concerned. However, if a diverse, international group of laymen, working independently, can produce multiple, internally consistent observations, backed by the corroboration of our professional counterparts, then the world is most likely to accept that group's interpretation as reasonable.

SETI continues to seek clear, unambiguous evidence, without even knowing for certain what form that evidence will take. We hope to stumble across the inescapable. Until then, as responsible radio amateurs we will continue to test the null hypothesis.

(Errata: In Dr. Shuch's article "SETI Horn of Plenty" in the Spring 2003 issue, figures 2 and 3 [pages 8 and 9] are reversed. This results in the performance figures of the N6TX horn being attributed to the Ewen horn and vice-versa. We regret any confusion this may have caused readers.—ed.)



This allegedly captured signal, supposed proof of extra-terrestrial contact, was anonymously hacked into a closed SETI League e-mail in October 1998. It proved to be a blatant hoax. SETI requires standards of proof which guard against such fraudulent claims.

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