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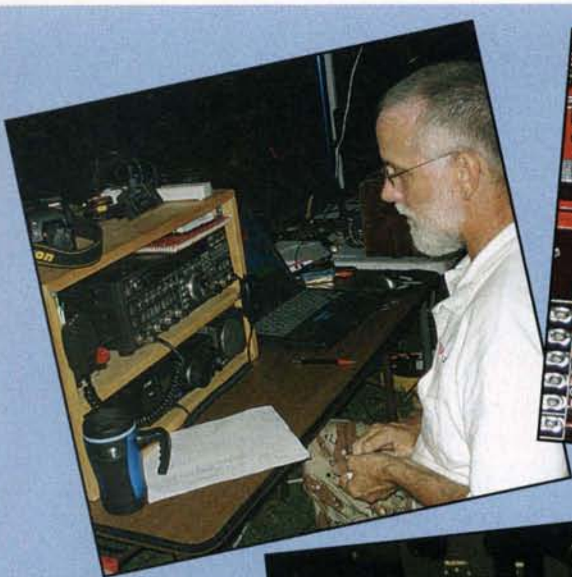
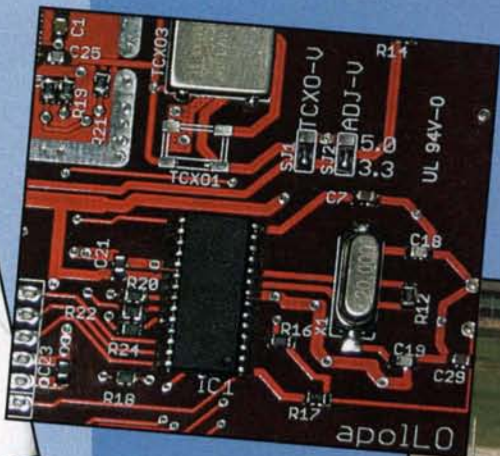
FEATURES





COLUMNS

DEPARTMENTS

On The Cover: The main cover photo shows an AMSAT satellite demonstration in the parking lot of this year's Dayton Hamvention®. For details see the "FM" column on p. 48 (photo by KØNR). Insets, left to right: The Holmdel horn antenna circa 1960; see "The Basement Laboratory Group" by WA2VVA on p. 31. A dual-band loop antenna; see "2500 Miles with Just a Loop?" by WB6NOA on p. 22 (photo by WB6NOA). A three-processor, two VHF radio system ready for a trip into space; see "The BIG BLUE Projects: One Student's Perspective," by KY1GDC on p. 40 (photo courtesy of KY1GDC).

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

TAPR/DCC Conference

This year's annual TAPR/DCC Conference will be held in Chicago, Illinois, September 26–28. According to TAPR (Tucson Amateur Packet Radio, Inc.) vice president Steve Bible, N7HPR, from its beginnings 27 years ago "it has grown to be the premier national digital conference covering digital voice and data technologies." Several years back the TAPR organization combined with the ARRL and its Digital Communications Conference to form the joint conference.

History

Digital communications experimentation has its roots with the Vancouver Amateur Digital Communications Group, which was experimenting with that mode as early as the late 1970s. The group's work caught the attention of Paul Rinaldo, W4RI, who through the League established the first computer networking conference in October 1981 in Gaithersburg, Maryland.

It was in that same month and year of 1981 that a group of hams who were members of the Tucson Chapter of the IEEE came together to discuss the possibility of developing an affordable packet terminal node controller (TNC). Pioneering work between Lyle Johnson, then WA7GXD and now KK7P, and Don Conners, KD2S, led to the development of a kit with the nomenclature TNC1. Their kit led to the second-generation development called TNC2, which became the basis for most packet networks today.

The following year TAPR was formed. Initially promoting packet radio, it now embraces almost any digital ham radio technology development. One of the most popular recent technological developments is software defined radio, or SDR. Growing out of the work of TAPR was Gerald Youngblood, K5SDR's development of the SDR 1000 and now its very well received successor, Flex Radio's SDR 5000.

Cooperation and Talent Mergers

Thanks to Bob McGwier, N4HY, who has common connections with Youngblood, TAPR, and AMSAT, at the 2006 AMSAT Symposium the AMSAT leadership was encouraged to use SDR technology in their forthcoming Eagle Project. This development has resulted in the merger of talent between AMSAT and TAPR. Evidence of this merger was made clear at the 2007 Dayton Hamvention®, where the linking of two SDR 1000 radios was demonstrated at the AMSAT booth and the first joint AMSAT/TAPR banquet was held at the Wright Patterson Air Force Base Museum.

Preceding the AMSAT–TAPR talent merger was another merger of sorts between the ARRL and TAPR. By 1993 the League's computer-networking conference had become the Digital Communications Conference (DCC). Realizing that the two organizations had much in common, the leadership of the organizations signed a memorandum of understanding (MOU) for the purpose of combining their annual meetings. Thus, in 1996 the first joint TAPR/DCC meeting was held in Seattle, Washington. Two years later it was held in Chicago. Now, 20 years later, the joint conference has returned to the "Windy City." For more information on this year's conference see the website:<http://www.tapr.org/dcc>.

My thanks go to TAPR president Dave Toth, VE3GYQ, TAPR vice-president Steve Bible, N7HPR, and TAPR/DCC co-chair Mark Thompson, WB9QZB, for supplying information for this section of my editorial.

Award for Design Achievement Winner

New in this issue of *CQ VHF* is the publication of the winner of Southeast VHF Society's annual Design Achievement Award. Awarded at the society's annual conference and jointly sponsored by the society, Downeast Microwave, and Mini-Circuits™, and this year joined by *CQ VHF* magazine, the winner receives a prize of either $1,000 cash or $2,500 in Mini-Circuits™ products, a gift certificate from Downeast Microwave, and this year we include a year's subscription to *CQ VHF* along with the publication of the project's paper in the magazine.

This year's winner is Steve Hicks, N5AC, who designed a USB programmable, highly stable local oscillator for microwave transverters. Steve illustrates the problem of instability in microwave transverters by way of his opening vignette of a fictitious QSO in which the operator with whom he is having a QSO is complaining that Steve's transmit frequency is not on the same frequency as it was the previous time the two of them made contact with one another. You can read his solution beginning on page 6.

The partnership between Mini-Circuits™ and the Southeast VHF Society has been ongoing for a number of years, resulting on several projects being designed using—and thus promoting the use of—Mini-Circuits™ components. It has become a win-win situation for all concerned. With *CQ VHF* magazine joining the sponsorship this year, it is hoped that national attention will be drawn to this very successful competition.

Along with the national attention, it is hoped that other organizations will become encouraged to also sponsor similar competitions. As the editor of this magazine, I can state that should any other organization wish to develop a similar competition, we will extend the offer of the same prize of publishing the project's paper and a free one-year subscription to *CQ VHF*.

Education Partnerships

Speaking of organizations, here is a suggestion for yours or for the company you work for: Become an education partner with a nearby public school. This summer is the right time to find a school and begin the partnership relationship with it.

If you do not know how to go about developing such a partnership, check with the board of education for your target school. Chances are that the board may have in place the wherewithal for your organization to become such a partner. If the board does not, then perhaps your area chamber of commerce may have a program in place for doing so. For an example of how the education partnership program is working for the Tulsa Public Schools and Tulsa Metro Chamber of Commerce, please see the website: <http://www.tulsaschools.org/sp/pie.shtm>.

The bilateral benefits for such a partnership are too numerous to articulate in this editorial. One, however, is the opportunity to become involved as a mentor very early in a child's process of choosing a life career. The child benefits by being given a possible direction for his or her future. The mentor has the satisfaction of knowing that he or she has made a significant, and potentially life-altering, difference in a child's life.

Should you become involved in an education partnership and have a story to tell that is related to our niche of the hobby, please let me know. I would like the opportunity to publish your story in a future issue of *CQ VHF* or via the "VHF Plus" column in *CQ* magazine.

Until next time . . 73, de Joe, N6CL

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A USB Programmable, High-Stability Local Oscillator for Microwave Transverters

A problem facing microwave operators, especially rovers, is frequency drift. Here N5AC provides a solution that can be programmed from your computer.

By Steve Hicks,* N5AC

The project described in this article received the 2008 Southeast VHF Society/Mini-Circuits™ Annual Award for Design Achievement. A similar version was previously published in the Society's 2008 conference Proceedings.

I picked up the mic and called again on 3456.1 MHz: "CQ CQ CQ Contest, N5AC, November Five Alpha Charlie, over."

"There you are," the voice came back, "but now you are about 3 kHz low."

"Weren't we about 3 kilohertz high this morning?" I asked.

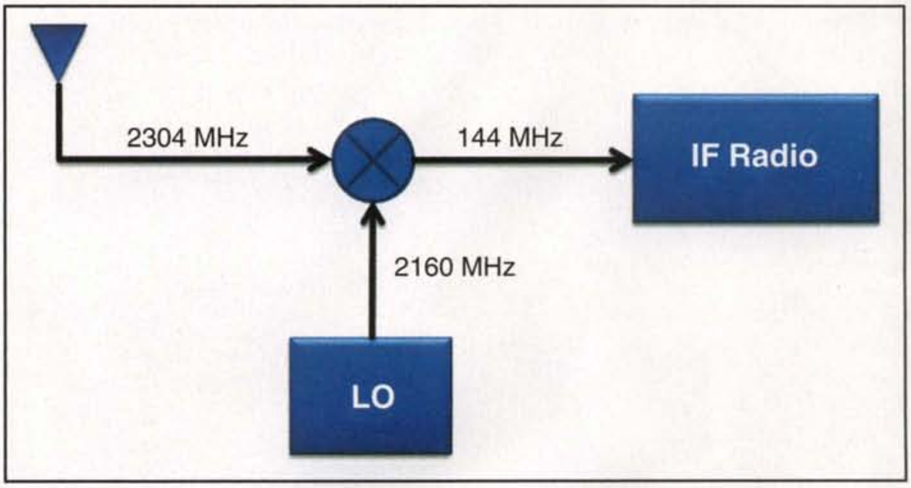

Figure 1. The 2304-MHz transverter (receiver) block diagram. (All artwork and photos by the author)

The Problem

The above on-the-air scenario is familiar to many microwave operators, especially rovers. The amount of frequency drift on the microwave bands varies with band of operation, equipment, and temperature. The cause of the drift is almost always the local oscillator in the transverter, which is primarily responsible for setting the operating frequency of the transverter. A typical 2304-MHz transverter block diagram, shown in figure 1, will explain why.

With a local oscillator (LO) frequency of 2160 MHz, the incoming RF at 2304 MHz will be downconverted to 144 MHz, assuming low-side injection (2304 – 2160 = 144). 2304.1 MHz will be heard on 144.1 MHz, and 2304.2 MHz will be heard on 144.2 MHz. If the LO drifts to 2160.005 MHz, though, 2304 MHz would be heard on the IF radio at 144.095 MHz, 5 kHz low. The IF radio's frequency stability is also important and can affect where signals appear, but with a lower frequency of operation (144 MHz for the IF radio in this case), the stability of the underlying oscillator has 15 times less impact than the microwave LO. Let's try to understand why this is so.

Oscillator stability is often rated in parts-per-million (ppm) across a temperature range. This figure is derived from the design and underlying physics of how the crystal is cut and mounted. A typical rating might be 1 ppm (10^{-6}) from 0–70° C. Parts-per-million indicates how many Hz a signal would move for every MHz of operating frequency. If this oscillator was the basis for a 144-MHz transceiver, the oscillator could move up to 144 Hz (ignoring for the moment mixing going on in the transceiver). That's not far. This same oscillator used on 10 GHz could drift up to 10 kHz over the operating temperature range ($10^{-6} \times 10^{10} = 10^4$)! This is much more significant. Combine with this the fact that many home-brew amateur projects do not achieve 1 ppm and it's evident where the drift comes from.

Therefore, by the time a 100-MHz crystal oscillator is multiplied up by a factor of close to a hundred, a small drift in the base oscillator becomes a massive movement in the microwave bands. Frequency stability on the microwave bands has been more of a luxury for amateurs. Few had it and the rest of us were always chasing everyone around the bands and trying to get on frequency. This problem is not unique to hams, though. Commercial enterprises, such as cellular phone carriers, have all of the same problems. They have to be able to hold a signal steady in the 1900-MHz band and demodulate a digital signal in a handheld transceiver, your cell phone. The solutions to these problems have opened up

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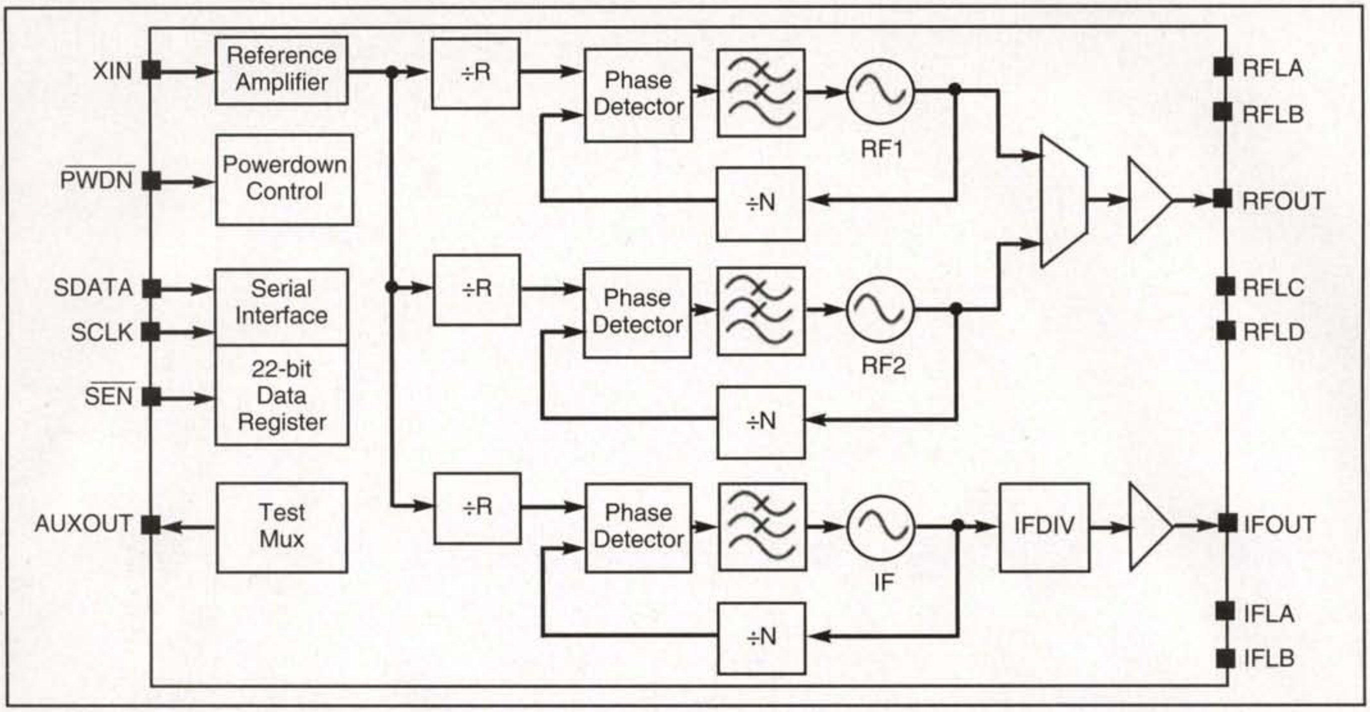


Figure 2. Si4133 synthesizer block diagram.

some new windows for hams to better control frequency stability.

Finding a Solution

By now you may have figured out that I am talking about synthesizers, VCO and PLL integrated circuits, and high-stability underlying oscillators. Many solutions in each of these product categories have emerged as the demand for quality cellular and other handheld communications has increased. More and more of this functionality is also being placed on a single chip to reduce size. It used to be that you would purchase a VCO and a PLL chip and be responsible for your own loop filter, but now many of the parts are incorporating all of the pieces inside them.

I recently stumbled upon the Si4133 family from Silicon Labs in Austin, Texas.[1] This device has two on-board RF synthesizers that can operate in a selected range inside of the 750–1700 MHz range and an IF synthesizer that can go from 62.5–1000 MHz. The output from both of the RF synthesizers is not on at once. The part is designed to be able to jump from one to the other as you would in a multi-band handheld radio (phone) so they are multiplexed to a single output on the part. The last one programmed is sent out of the part through the multiplexer. The Si4133 family requires only an external inductor for each of the synthesizers for tuning and all the rest of the VCO, PLL, loop filter, etc., is all within the IC itself. The part also requires a reference frequency input that is used as the base oscillator for the PLL. A block diagram of the Si4133 is shown in figure 2.

When I saw this part, I started thinking about ways to use something like this for the microwave bands. If I could get the base oscillator provided to the XIN pin stable and could I program this, I could get a very stable base oscillator in the 1-GHz range that I could multiply up for a microwave LO. Coincidentally, the largest producer of microwave transverters in the United States, Downeast Microwave[2], is using a self-contained, roughly 1-GHz base oscillator as the starting point in all of its 2-GHz and up microwave transverters (of which I owned four, one for each of the ham bands between 2–10 GHz). The idea was really starting to take shape, but I had some more work to do.

Unfortunately, since the Silicon Labs synthesizers are designed to go into cellular phones and the like, there is an expectation that their frequency will be programmed by a microprocessor in the phone. In fact, the part has no non-volatile memory and powers up "dumb" and needs something to tell it what to do. I figured programming a microprocessor to load the synthesizer would be simple, though. My idea for a programmable oscillator is not entirely unique and there are a few oscillators that have capabilities like this floating around in the ham community today [3], but the predominant implementation stores the frequencies inside the micro and uses a dip switch to select among a few different common frequencies or is built for a single frequency. I wanted to be able to tune anywhere in the available range easily so I could use it for any microwave project.

Traditionally, I've done all of my micro programming like this using a serial port. I'd write a PC program to program the microcontroller using RS-232. However, RS-232 is falling out of favor in most circles, if not the amateur community, in favor of USB. I figured USB can't be *that* hard, right? I looked at some of the specifications and found that there is a lot of hidden complexity in USB. It allows a single hardware device to have a number of on-board virtual devices. For example, a single hardware device could have multiple serial ports or a single serial port and some sort of control interface, etc. With limited hobby time, I needed a way to cut through all of this complexity and quickly build a prototype that would get me what I needed. In the end, I wanted a PCB with a synthesizer that had a USB connector to program the microprocessor with virtually any frequency.

There are a few chips on the market that perform serial to USB, such as the FTDI

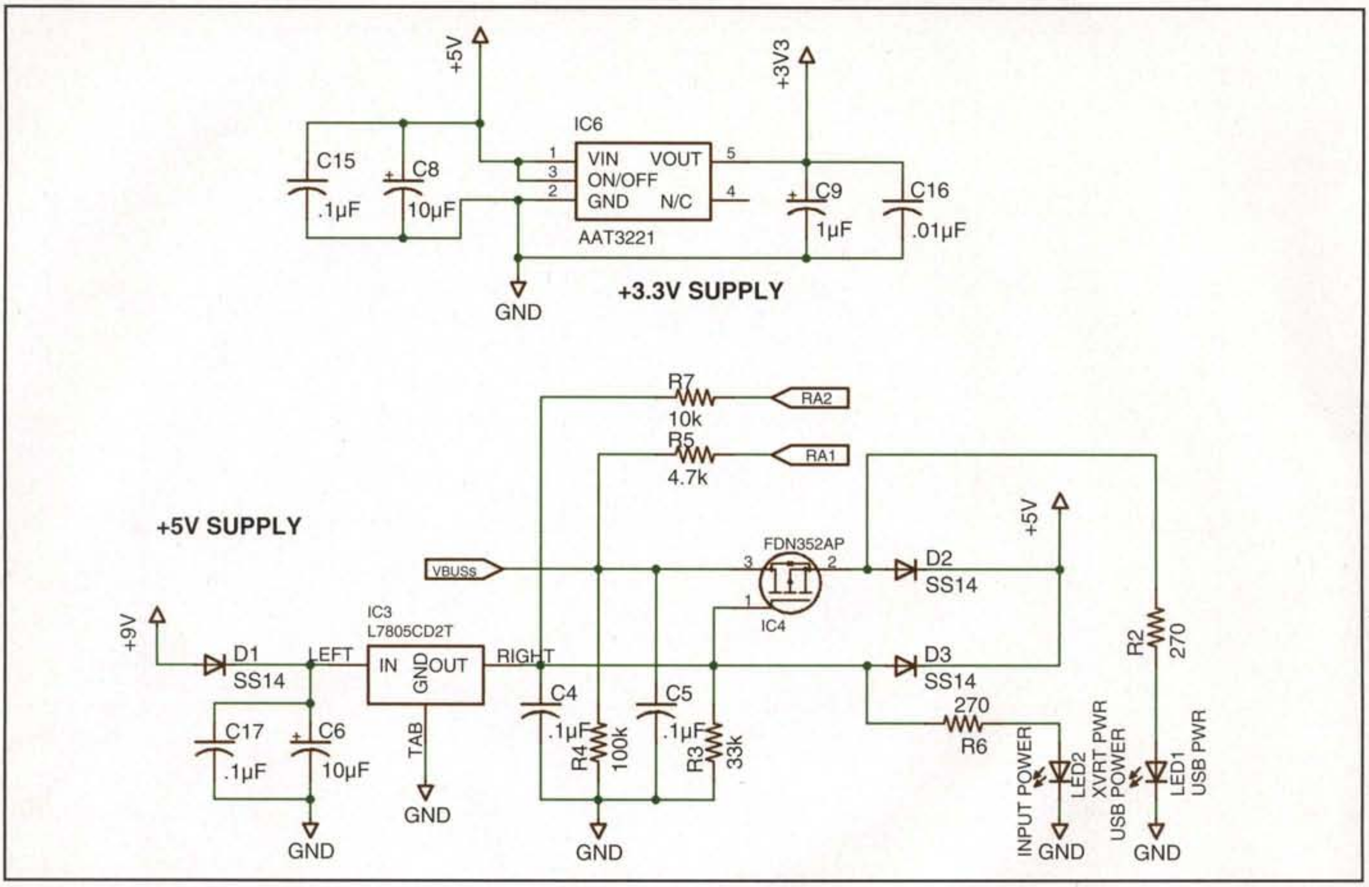


Figure 3. The apolLO I power-supply schematic.

chip [4], which hide the mechanics of talking to USB, and this was certainly one option. I was trying to keep the part count and the cost down, though, and I found that Microchip makes a small family of four parts that have on-board USB and require no additional external hardware (save the connector) to support USB[5]! What a windfall! I basically could hook a microprocessor to a synthesizer, add an inductor, some bypassing, and a USB connector and I would be in business! Well, it's never that simple, but it wasn't that far off.

The Final Design

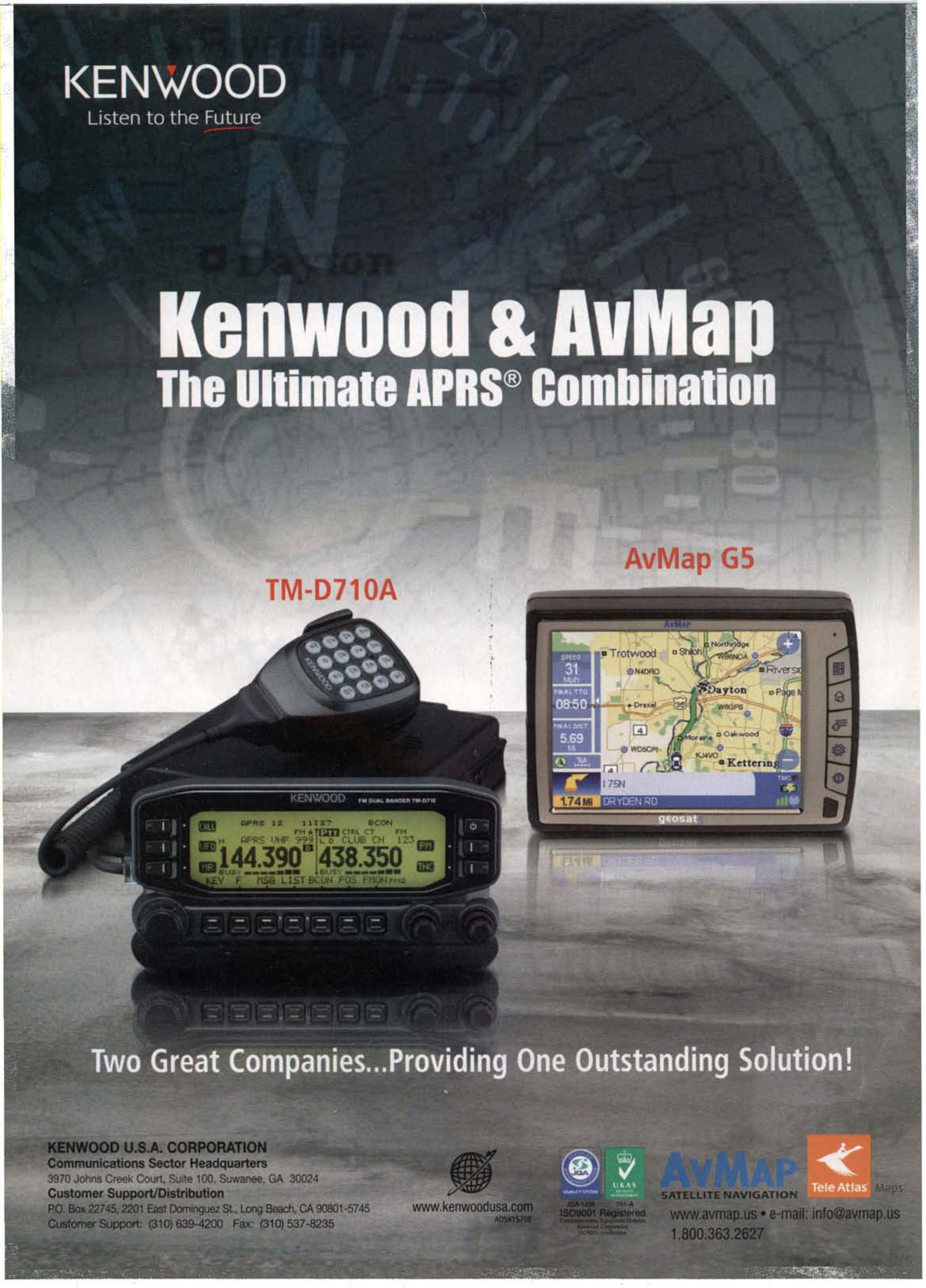
The end design is very simple from a hardware standpoint and was almost more of an exercise in systems engineering, or putting the pieces together, rather than traditional electrical engineering. The power supply shown in figure 3 is mostly from a reference design provided by Microchip and generates a stable +4.5V supply from either the USB port (which has power) or from power input to the board. The +5V section has two main inputs—VBUS, which is the power from the USB port at 5V, and the input labeled +9V, which is intended to accept power from a transverter. The MOSFET shown as IC4 is designed to require current to be drawn from the power input pins rather than the USB in the case where power is applied to both inputs. To this I added a +3.3V supply for the synthesizer power.

Diodes D2 and D3 keep the power inputs separated. The outputs marked RA1 and RA2 provide information to the microprocessor so that it can tell the PC if it is drawing power from the PC or from an external source. This is done by the software in the PIC microprocessor. The 3.3V supply generates a low-current 3.3V source for use by the Si4133 synthesizer. Two LEDs are provided from the power supply and show when the board is powered by the USB port or by the external power input.

The synthesizer and the microprocessor are connected together through a set of data and clock lines that are used to load the synthesizer with configuration data. The bus line visible between the processor and the synthesizer has level-shifting resistors, since the processor is a 5V part and the synthesizer is a 3V part. Inductors external to the synthesizer control the range of the VCO internal to the synthesizer, which ultimately controls the synthesizer range. Although the VCO is capable of operating in a wide range of frequencies, 750–1700 MHz, only a narrow portion of this range can be tuned in any one implementation and the specific range is controlled by the external inductor.

The final input to the synthesizer is an external reference oscillator. This oscillator is used as a reference for phase locking inside of the synthesizer and should be in the range of 2–26 MHz. This reference sets the baseline for stability, accuracy, and phase noise of the final oscillator (see sidebar for details on these terms). While it might seem that we're back to the original problem of a stable oscillator—this time for our reference—there is a key difference: This oscillator can be on an arbitrary frequency. In other words, it does not need to be a direct multiple of our final oscillator frequency. Since there are many of stable 10-MHz reference oscillators available in the surplus market, this becomes a much easier problem.

A couple of examples of 10-MHz references are shown in figure 4. On the left is an Isotemp OCXO 134-10 with a stability of 0.01 ppm obtained for about $50 surplus, and on the right is a GPS disci-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Oscillator Characteristics

Stability refers to the ability of an oscillator to stay on the same frequency given changes in temperature, voltage or other environmental conditions. A stability of 1 ppm (one part-per-million, or 10-6) indicates that the oscillator will not move more than 1 Hz for each MHz of operating frequency over the specified temperature range. If an oscillator is multiplied in frequency for a higher operating frequency, the stability translates to a larger drift. For example, a 1-MHz oscillator with a stability of 1 ppm multiplied to 10 GHz could move up to 10 kHz across the specified temperature range. This is why oscillator stability becomes more important for higher operating frequencies. An oscillator that works well on HF may perform very poorly in the microwave frequencies.

Oscillators are also specified with a long-term stability value, sometimes known as **accuracy**. This aging number is expressed in ppm change over a period of time, such as 0.1 ppm/year. This number refers to the long-term drift that will occur as a natural part of crystal aging. The two main ways to combat this are to periodically net the oscillator back on frequency by comparing it against a standard and manually adjusting the frequency, or disciplining the oscillator to a more accurate reference such as GPS.

Phase noise is additional power in an oscillator output that is not on the fundamental frequency. All real oscillators have some phase noise, also called *noise sidebands,* which are a result of the design. For example, a synthesizer with a 1-MHz phase-detector update rate would have a noticeably higher noise level right at the carrier plus 1 MHz than would an oscillator with a 100-kHz phase detector update rate. PLL-based synthesizers have noise near the carrier as a result of the minor adjustments made to keep the carrier locked. Phase noise is expressed in dBc/Hz, or the number of dB down from the carrier the noise is, given a specific frequency away from the carrier. Thus, a phase noise of –70 dBc/Hz at 10 Hz means that there is noise that is 10 Hz away from the carrier and 70 dB below the carrier's power. The problem comes in when the oscillator is multiplied, because the noise gets multiplied at a rate of 20logN, where N is the multiplication ratio. Therefore, if we have a 1-GHz oscillator that is multiplied for a 10-GHz LO, the phase noise will increase by 20 times (20log10 = 20). Thus, the higher in frequency we go, the more noise we will have. This places a practical limit on how high in frequency we could use any given oscillator.

plined HP 58540A 10-MHz reference obtained for around $150. Additional options include surplus rubidium oscillators, other OCXOs, reference modules from cellular base stations such as the HP Z3801A, and others. The phase-noise and stability characteristics of these will vary, but most will be suitable for amateur operation up to 10 GHz or higher.

The final PC board, shown in figures 5 and 6, is designed as a drop-in replacement for the DEMI MICROLO local oscillator board. The MICROLO is the local oscillator used in the Downeast Microwave 2304-, 3456-, 5760-, and 10368-MHz transverters. There are a large number of these transverters in the field, and my personal interest was in adding a phase-locked oscillator to my DEMI transverters, so I designed the board to fit in the same space. This does not preclude using the board for other projects, of course.

Section 1 in figure 6 has the power supply mentioned earlier and the USB connection (on the left near the edge of the board). When powered via a transverter or other external power source, the green LED on the reverse of the board will be lit (LED2).

The second major section of the board is the microprocessor (µP); Section 2. The microprocessor's main purpose is to interface to the PC to collect information on how to program the synthesizer (frequency, reference frequency, PLL settings, etc.) and to program the synthesizer with this information. As mentioned earlier, the PIC 18F2550 was chosen because of its ability to interface directly to USB without other components and because of its low cost. The µP uses a 20-MHz clock which is used to derive the internal clock for the µP (48 MHz) and the USB clock (also 48 MHz for full USB 2.0 speed). While I could have derived the microprocessor clock from the reference input, I wanted to keep the two circuits completely separate to avoid any additional noise in the RF section. Also, I wanted to run the processor even when the reference failed or was removed. The 20-MHz CPU crystal allows the circuit to use full-speed USB 2.0 when communicating with the PC.

The PC software can query the board for configuration information as well as write configuration information to the RAM or EEPROM (non-volatile) in the microprocessor. On power-up, the microprocessor reads the local EEPROM containing the synthesizer configuration and writes this to the synthesizer. The synthesizer itself has no non-volatile memory for configurations.

The TCXO section (Section 3 in figure 6) accommodates one of three different TCXO pin-outs, or an external reference can be fed to the board. Most will want to use an external reference for two reasons: First, if you are going to run several transverters, it would be better to have a single external reference so only one frequency has to be adjusted. Second, the qualities of the larger OCXOs that are available surplus far surpass what you can get in a 5mm × 7mm TCXO. However, there may be situations, such

Figure 4. Two high-stability 10-MHz reference oscillators.

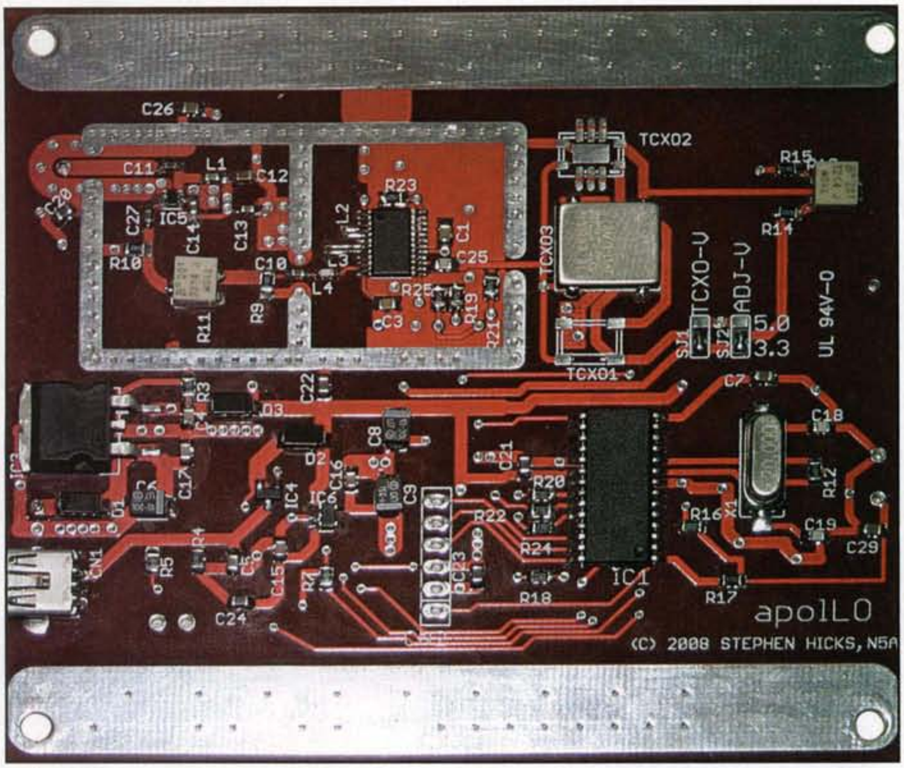

Figure 5. The final apolLO I fabricated PC board.

as a tripod-mounted 10-GHz transverter, in which some would prefer a TCXO in the transverter. There are also two sets of pads to select the TCXO voltage, and in the case of a VCTCXO, to select the voltage that is used to set the frequency. The external reference needs to provide a 0.5V to 3.6V peak-to-peak of reference signal (+7 dBm to +24 dBm). The Si4133 seems fairly forgiving, though, and I've run the board down to –10 dBm and it seems to perform well there also.

The Si4133 synthesizer is located in Section 4 of figure 6. Since the output of the Si4133, as low as –5 dBm, is low for use as an LO amplifier, I added an amplifier that can be seen in Section 5 of figure 6. The amplifier raises the signal level to +10 dBm or more. A pot is located in between the synthesizer and the amplifier to enable adjustment of the output power from the board.

Detecting a Lock

The Si4133 synthesizer has an AUXOUT pin that can be used as a lock detect function. This is useful for determining if the frequency that has been programmed in the synthesizer is out of the VCO tuning range. When I first started working with the software, my expectations were that if my frequency was "good" and the synthesizer locked, I would get one voltage (+3V) on the pin, and if the frequency would not lock, I would get the other voltage (GND). The reality is a little different, though. As the synthesizer begins to have trouble locking, it loses lock for a short period then regains it, and this repeats over and over, generating all kinds of spurs and noise. If the AUXOUT line were simply connected to an LED, it might dim a bit when the synthesizer was losing lock, but this would likely be almost imperceptible. This was not a good solution.

What I decided to do instead was to sample the line 1000 times (this took less than 1 ms) and then look at the percentage of times when the synthesizer was reporting that it was locked. What I found was when it was in the operating region, the lock detect signal would be on 100% of the time. As the synthesizer lost lock, it would gradually go down to around 90% and then would fall fairly quickly down to around the 10% or less region. I decided to translate this into four states shown below:

State	Lock detect line % on	Lock LED
Locked	100%	Solid
Weak Lock	> 90%	Fast blink
Poor Lock	< 90%	Slow blink
Unlocked	0%	Off

I then translated this into an LED visible on the board as shown above. You generally would not want to run the synthesizer in any mode except when it is locked, but the LED can help in troubleshooting. When there is a weak lock, there is a carrier on the programmed frequency, but it will be discontinuous for up to 10% of the time, and outside of this time the synthesizer will be generating noise near the carrier.

Performance and Phase Noise

No discussion of a microwave oscillator would be complete without some basic

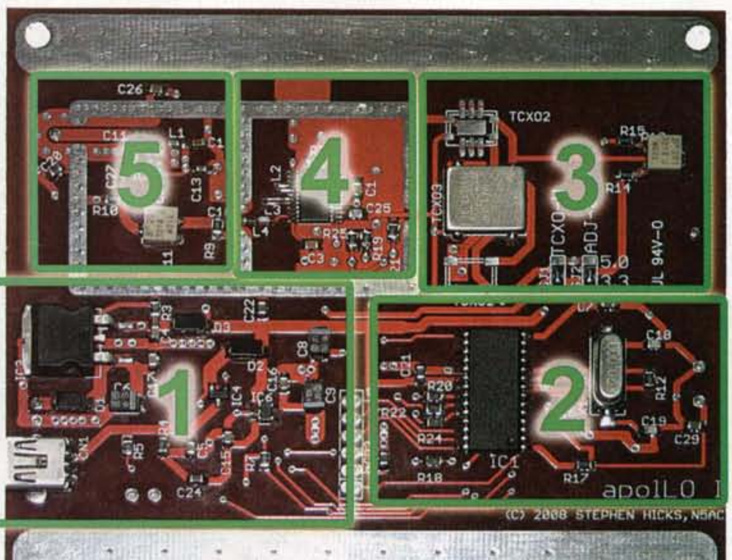

Figure 6. Major sections of the apolLO I PC board (annotated in text).

phase-noise discussion. A phased lock loop will always have some noise close in to the carrier, and this is the noise we are most concerned about for amateur radio use. Why? This noise can be audible when heard in the receiver if it is significant, and it can also create wideband noise near the carrier when we transmit. For example, if we are transmitting 200 watts on 2304.1 and the phase noise of our final LO is –50 dBc/Hz in the area of 1–10 kHz, this means that at 2304.105 MHz we will be creating noise that is 50 dB below our carrier (200 watts). This power level would be 200×10^{-5}, or 2 mW. This doesn't sound like a lot, but if your friend 10 miles across town is listening for a signal in the noise, your more local 2-mW signal is likely to be much more significant. Also, because it is noise, you would have just raised his noise floor significantly!

Since the multiplication of the oscillator increases the phase noise, there is a practical limit of how high in frequency any given oscillator should be used. What the real limit is depends on your situation. From a receive perspective, the question is: Can you hear a difference? In other words, does the phase noise raise your noise floor and make your operating difficult. From a transmit perspective, the question is about how clean your signal is. This equates to how many percent of your power you are transmitting on-channel versus how much is being generated as noise. If you are in an isolated area or are a mobile station, you probably can get away with a little noisier signal. On the other hand, if you are in a populated area and you are receiving complaints about QRM, you most likely have gone too far with your oscillator.

With all this talk about phase noise, the question of how much is too much arises. I don't have a really good answer for you, primarily because I have yet to use an oscillator for amateur radio that I felt was really objectionable. Most oscillators of the type we are talking about should be fine for use up to around the 24- or maybe even 47-GHz ham band. The phase-noise plot of the apolLO I board using an external surplus Datum 10 MHz reference is shown in figure 7.

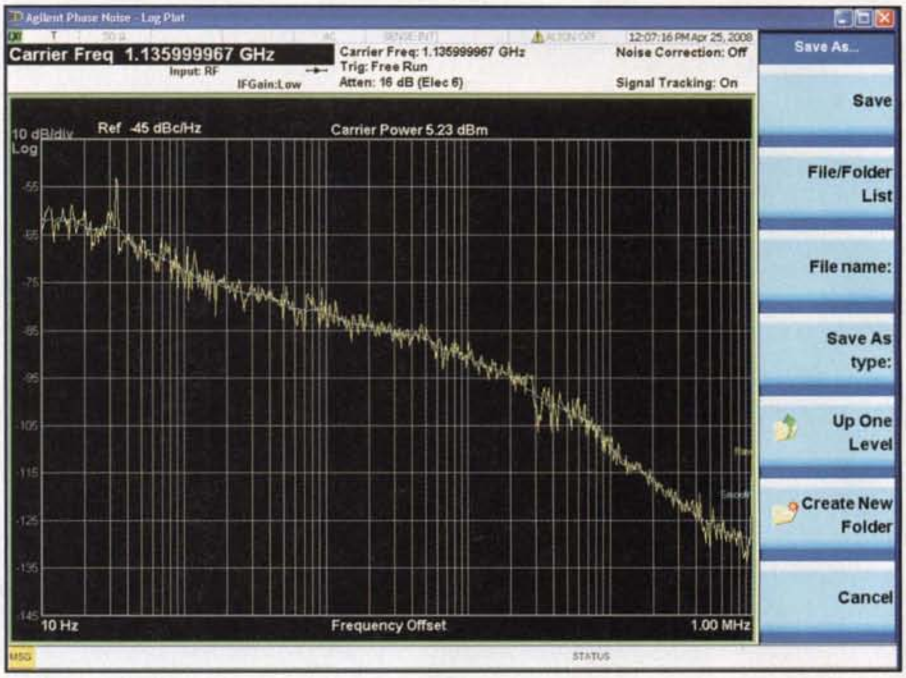

Figure 7. Phase noise of apolLO I at 1136 MHz with external 10-MHz reference.

Programming the LO

One of the unique features of the apolLO is the ability to program it. This makes it useful not only as a LO. but also as a good piece of test equipment. If you need an inexpensive signal source you can program and don't have a high-dollar signal generator, it might be a useful addition to your toolbox. The initial utility I created to program the apolLO is a Microsoft .NET application and will run on Microsoft Windows®. The utility, shown in figure 8, retrieves all of the typical model number and firmware version information from the LO as well as the current frequency of operation. It also allows direct access to registers inside the synthesizer to program the PLL divider values and set the PLL loop gain and which synthesizer is currently in operation (remember, there are two RF synthesizers inside the Si4133). This is, however, only one way to accomplish the programming.

Since many may not want to think about the calculations required to come up with the correct divider values to make the PLL function, I created a programming wizard that steps the user through the same process that you might go through if you were making the calculations yourself; instead the wizard makes them for you. The key pieces of information that the wizard needs to know to assist in the process are:

1. The frequency of your reference (generally 10 MHz).
2. The frequency of operation of your transverter (10368.1 MHz, for example).
3. The frequency of your IF radio (144.1 MHz, for example).
4. Whether you are using low- or high-side injection (typically, amateurs use low-side injection where the LO is below the operating frequency, but sometimes you might want to use high-side injection).
5. The multiplication factor to get you from a roughly 1-GHz intermediate LO up to your final LO (in the case of 10 GHz, often a factor of 9 is used so the final LO would be on 10,224 MHz, but our intermediate LO would be on 1152 MHz)

One of the wizard panels where custom transverter settings are entered is

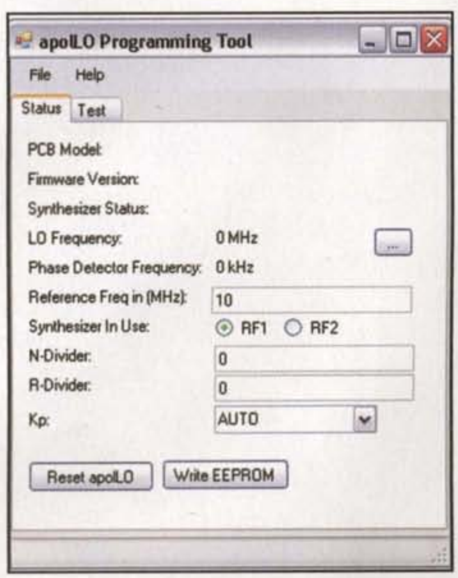

Figure 8. The apolLO programming utility for Microsoft Windows®.

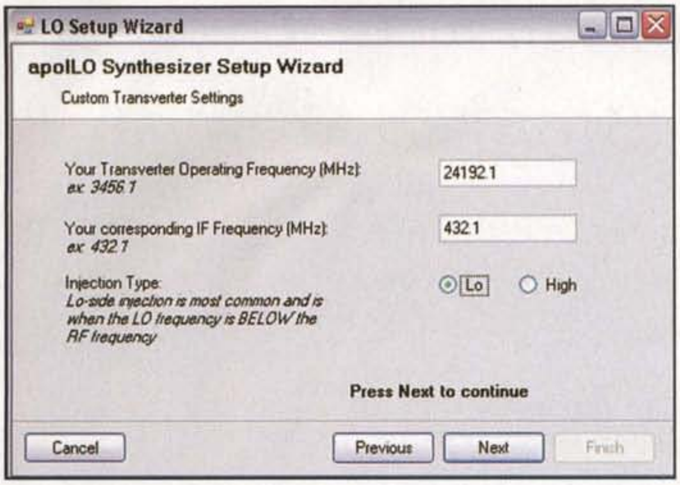

Figure 9. One of several panels in the apolLO programming wizard.

shown in figure 9. Here the user has entered 24,192.1 MHz for his transverter operation frequency (the 24-GHz ham band calling frequency) and 432.1 MHz for his transverter frequency and low-side injection. All of this ultimately ends in calculations that are shown in figure 10. Here you can see that a ×20 multiplier is selected and that the final LO frequency is 23,760 MHz. This will place the apolLO on 1188 MHz. When "Finish" is pressed on the wizard,the parameters are loaded into the LO and can then be written to EEPROM as a permanent change.

This provides a lot of flexibility so that several configurations can be tried in the shack to see what selection of parts, filters, etc., produce the best performance, all without building a new LO just to try the different configurations. It also gives rise to the possibility of keeping a "spare" LO on hand. If an LO in any transverter fails during a contest, it is a simple matter to program another one and plug it into the transverter.

Conclusions

From a functional standpoint, the apolLO was an easy project to build. The block diagram and conceptualization of the project was simple. As with any highly integrated design, though, there are a lot of details that have to be considered. The synthesizer itself has several parameters that can be tweaked, and software had to be written on both the PIC and the PC to make the whole package come together. The apolLO I has been a good project to experiment with oscillators, and it serves its function of replacing the aging MICROLO. The variable output, PC programmability, and ability to move the oscillator to a wide range of frequencies gives the design a lot of flexibility to be used in a number of different projects, not just as a replacement for the MICROLO.

I have just finished work on the second revision of the board, which includes the ability to shift to several different LO frequencies. My expectation is that this will help EME operators who need to operate on a number of different frequencies due to the range of allocations on the bands in each country. With this capability, the transverter could be moved from 2304 MHz to 2320 MHz to 2400 MHz with the flick of a switch. Since no additional components (crystals) are required, this is a very economical way to build a multi-frequency LO.

Kits, assembled, and bare apolLO I boards are available at: <http://store.n5ac.com>.

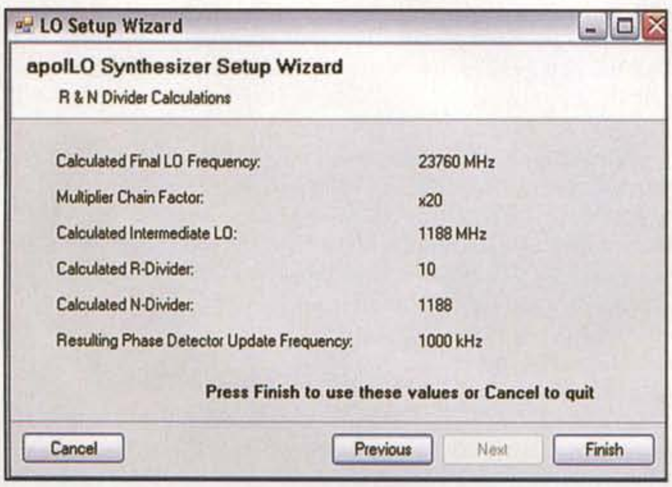

Figure 10. Final panel of the programming wizard setting apolLO parameters.

Notes

1. Silicon Labs, Austin, Texas: <http://www.silabs.com>.
2. Downeast Microwave: <http://www.downeastmicrowave.com>.
3. AD6IW microwave oscillator: <http://www.ad6iw.com/pll3.html>; and JWM Engineering: <http://www.jwmeng.com>.
4. FTDI Serial to USB chip: <http://www.ftdichip.com>.
5. Microchip 18F4550 family of microprocessors: <http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1335&dDocName=en010300>.

Low-Noise Pre-amplifiers for the 1.3, 2.3, and 3.4 GHz Amateur Bands

A goal for the microwave operator is to reduce the noise introduced by pre-amps. In this article G4DDK describes low-noise pre-amps for three of the popular microwave amateur bands.

By Sam Jewell,* G4DDK

Invariably, 1296-MHz moon-bounce (EME) requires the use of a very-low-noise pre-amplifier (LNA) to receive the weak signals that are often encountered. This is especially true when only a small TVRO dish can be used as the antenna. I have successfully used a 7.5-foot KTI TVRO dish for both 1.3- and 2.3-GHz EME using the pre-amplifier designs in this article.

My initial EME activity was with the well-known 1.3-GHz LNA design published by Tommy Henderson, WD5AGO[1], whilst the 2.3-GHz LNA was a modification of a design by Al Ward, W5LUA[2].

Following requests for help and information. I made a number of PC boards for radio amateurs in Europe. In general these worked well, which is a testament to the solid designs from Tommy and Al.

Because of ongoing demand and difficulties obtaining new ATF10135 MESFETs (metal epitaxial semiconductor field effect transistors) for use in the second stage of the 1.3-GHz pre-amplifier, I decided to investigate an alternative second-stage device. I also decided to house the pre-amplifier in a readily available tin-plate box. The new design achieves a lower 1.3-GHz noise figure, and higher gain than the original pre-amplifier design.

Noise-figure and gain measurements at various microwave events in the UK, The Netherlands, Germany, as well as at Central States VHF Conference 2007 have shown that a stable, repeatable, noise figure of around 0.25–0.27 dB, with an insertion gain of 36 dB, is achievable with the 1296-MHz version.

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This is an update of the paper presented at the Florence 2008 EME Conference.

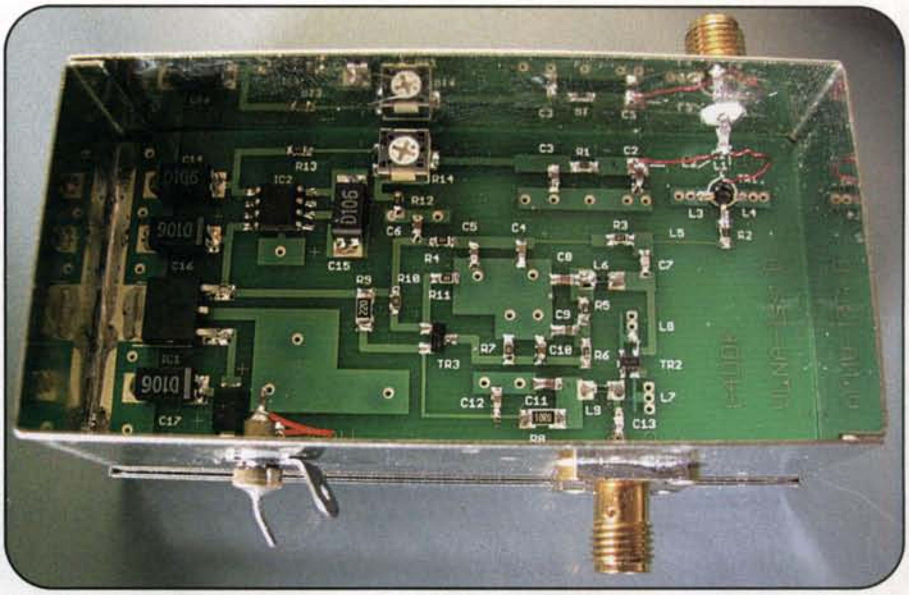

Photo A. The completed 2.3-GHz version of the LNA.

It was apparent that the same pre-amplifier board also had the potential to work at 2.3 GHz, especially with the air-supported input components as used in Al's design. This necessitated some component-value changes to optimize performance at the higher frequency. After installing components with the calculated values (and some inspired empirical substitution!), the result was a noise figure of around 0.35 dB and an insertion gain of about 26 dB. The reason for lower gain at 2.3 GHz is partly due to the second-stage device and the use of a non-optimum microstrip line, which is part of the 1.3-GHz design. However, for EME work, even an insertion gain of 26 dB may be enough to eliminate the usual second pre-amplifier unit.

Further work showed that the pre-amplifier would also produce an acceptable noise figure and gain in the 3.4-GHz amateur band. A 3.4-GHz noise figure of between 0.5 and 0.55 dB with an insertion gain of around 28 dB is easily achieved.

Versions of the pre-amplifier have been successfully tuned for use at 1090 MHz, 1240–1296 MHz, 1420 MHz, 2200–2290 MHz, and 2302–2320 MHz, all with excellent results. Work has commenced on a 432-MHz version of the pre-amplifier.

Circuit Description

The circuit schematic is shown in figure 1.This is the same for all three versions of the pre-amplifier. Component values are shown in Table 1. Where component values are different for each of the various bands, these are shown in Table 2.

Two different low-noise GaAs FETs have been specified for use in the 1.3-GHz pre-amplifier. The NE32584C gives the lowest noise figure, but these are no longer available from NEC. However, there are still large stocks of the NE32584C and other package variants available as surplus stock in the U.S. and Europe.

The Avago ATF36077 has been shown to work extremely well in the TR1 position, but it has a marginally higher noise figure at 1.3 GHz compared to the NE32584. The NE32584 is therefore the preferred device for 1296-MHz EME. The second-stage device is an Avago ATF54143 in all cases. I have been unable to get the newer NE3210 HEMT to work well in the first stage at these frequencies.

The input circuit consists of a "T" match with suitable low-loss capacitors and inductors. These components are air supported, rather than soldered to PC board pads, in order to keep losses due to parasitic strays to a minimum.

Low-noise matching is achieved by careful adjustment of the spacing of the turns of L1. Adjustment is critical in order to achieve the very lowest noise figure. This will not coincide with maximum gain. In these designs lowest noise always occurs on the high-frequency side of the maximum-gain frequency.

Input impedance match is improved by the use of first stage GaAs FET source series inductance. This is already designed into the PC board, and results from the inductance of the leads of TR1, so you don't need to worry about tuning this parameter. Since the source leads of the ATF36077 are broader than those on the NE32584, the inductance is lower and consequently the feedback is less. This results in a slightly worse input return loss. When tuned for lowest noise figure with a 50R source, the input return loss of the pre-amplifier will not affect the achievable system noise figure as long as the antenna is also a good 50R source. However, poor input return loss does lead to a greater uncertainty of the actual noise figure when measurements are made. This is often the reason for some very disappointing and even optimistic results when using otherwise excellent pre-amplifier designs.

Negative bias for TR1 is provided by an ICL7660 DC-DC converter. R14 allows a range of adjustment of gate bias voltage which will lead to a consequent change in drain current.

Active bias was chosen for TR2, as the drain current is set at 65 mA to achieve a good dynamic range. At this elevated current I felt that active bias would help to maintain circuit performance.

The pre-amplifier uses a 5-volt, 500-mA regulator that uses a surface-mount 78M05 regulator soldered to the PC board ground-plane heat sink. A TO92 packaged 78L05 will not supply enough current without over-dissipating.

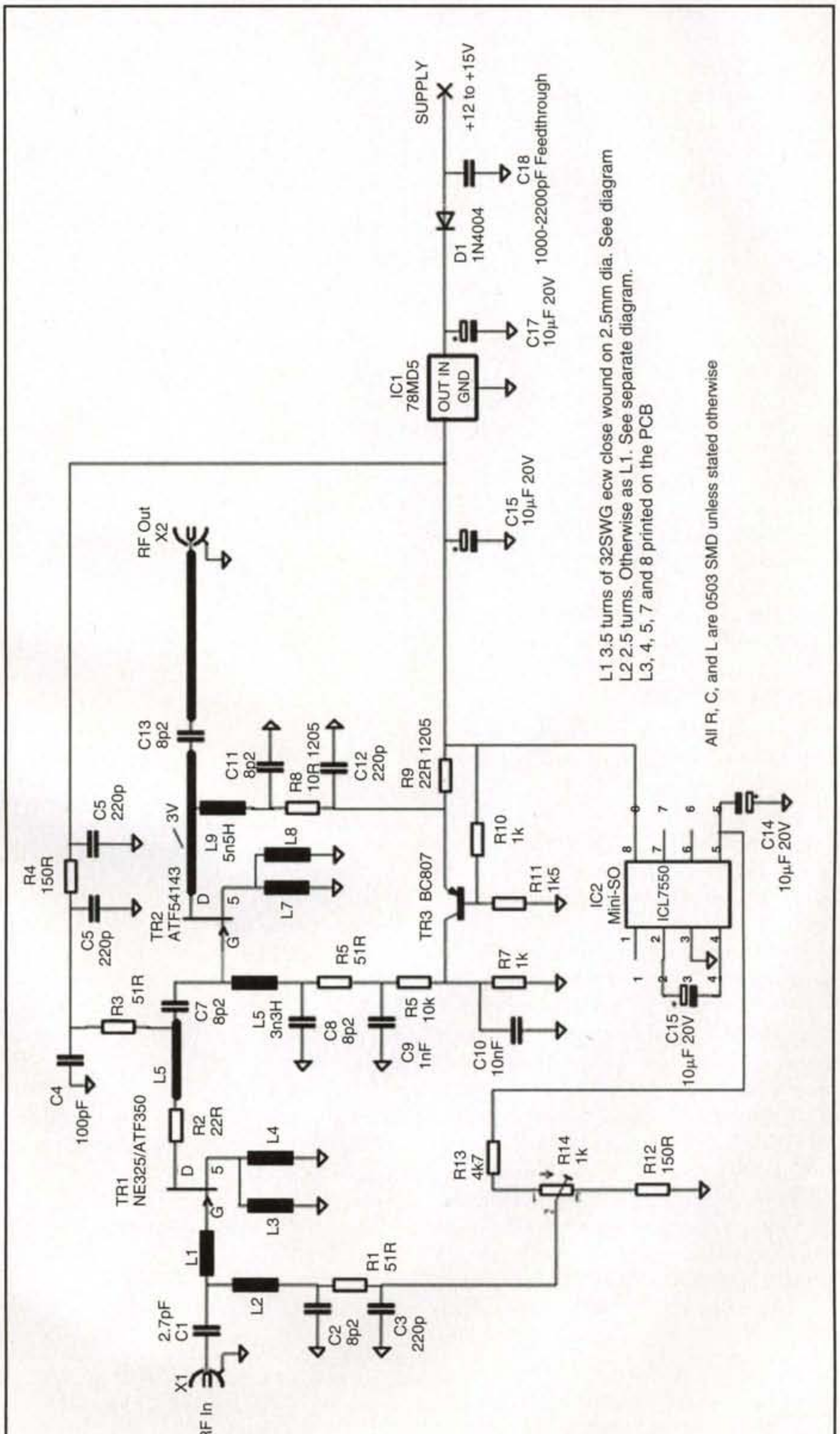

Figure 1. Circuit schematic of the 1.3-GHz LNA. Values for the 2.3- and 3.4-GHz versions are given in Tables 1 and 2.

D1 is there to ensure that an accidental reversal of the supply doesn't destroy the pre-amplifier.

Noise and gain matching of the 2.3-GHz and 3.4-GHz version of the pre-amplifier necessitates a change of C1, L1 and L2 inductors at the input, L9 in the drain of TR2, and the coupling capacitors C7 and C13. It also uses the ATF36077, and not the NE32584, in the first stage, although an ATF54143 is still used in the second-stage position.

With the very high gain that is achieved in the 1.3-GHz version of the pre-amplifier stability can be a problem due to the compact construction that has been used. A range of RF absorber materials was tried by gluing several different types to the lid of the tin-plate box, in turn, and noting the results. Eventually ARC DD-10017 (2 mm thick) silicone magnetic absorber tile material was selected for use in the 1.3-GHz and 2.3-GHz pre-amplifiers, where it has proven to be very effective at suppressing unwanted coupling and aiding stability. At 3.4 GHz it has been found necessary to use ARC LS-10055 Urethane foam (3.2 mm thick), since the coupling mechanisms change considerably from 1.3 GHz to 3.4 GHz.

Part	Value	Package
C1 – 1.3 GHz	See table 2	SMD0805
C1 – 2.3 GHz	See table 2	SMD0805
C1 – 3.4 GHz	See table 2	SMD0805
C2, C8, C11,	See table 2	SMD0603
C7, C13 - 1.3 GHz	See table 2	SMD0603
C7 , C13 - 2.3 GHz	See table 2	SMD0603
C7 , C13 – 3.4 GHz	See table 2	SMD0603
C3, C5, C6, C12	220 pF	SMD0603
C4	100 pF	SMD0603
C9	1 nF	SMD0603
C10	10 pF	SMD0603
C14, C15, C16, 17	10 µF 20V	Tantalum
R1, R3, R5	51R	SMD0603
R2	22R	SMD0603
R4, R12	150R	SMD0603
R6	10k	SMD0603
R7, R10	1k	SMD0603
R11	1k5	SMD0603
R14	1k	SMD trim resistor
R8	10R	SMD1206
R9	22R	SMD1206
R13	4k7	SMD0603
TR1	See table 2	—
TR2	ATF54143	SOT343
TR3	BC807	SOT23
IC1	78M05	D-Pak
IC2	ICL7660	SOIC-8
D1	1N4001	SMD
L1/l2	0.28-mm dia. enamel-covered copper wire	See diagrams
L3, L4, L5, L7, L8	Printed on PCB	—
L6	3n3	SMD0603
L9 – 1.3 GHz	See table 2	SMD0603
L9 – 2.3 GHz	See table 2	SMD0603
L9 – 3.4 GHz	See table 2	SMD0603
Box	4 piece tinplate	74 mm × 37 mm × 30 mm
Absorber – 1.3 and 2.3 GHz	See table 2	30 mm × 50 mm
Absorber – 3.4 GHz	See table 2	30 mm × 50 mm
PCB	VLNA Issue B	72 mm × 34 mm

Table 1. Component list for the 1.3, 2.3, and 3.4 GHz LNA.

Construction

Full construction details, alignment, and tips are shown on my web page at <www.g4ddk.com>.

The preamplifier is built on a double-sided 1.6-mm thick, FR4 printed circuit board. The PC board artwork is shown in figure 2. Component layout is shown in figure 3.

The PC board is seam-soldered into the tin-plate box. The same board is used for the 1.3-, 2.3-, and 3.4-GHz pre-amplifier variants. The only components that need to be changed when optimizing the band of operation are TR1, L1, L2, L9, C1, C7, and C13 (and the absorber tile material for the 3.4-GHz version). See the component list for details.

Except where indicated, 0603-size surface-mount components are used on the board in order to minimize component parasitics. This has proven most successful, and it is a very good reason to move towards using 0603- or even 0402-size parts in all designs above 1 GHz.

Input and output RF connectors are both SMA. EME operators may prefer to use an "N" type for the input. As long as this has the smaller size flange, it can be fitted within the 30-mm height of the box. The connectors can be fixed to the box by drilling holes and using small screws with nuts, or by soldering the connector flange to the tin box.

The input connector is mounted 10 mm above the track side of the PC board and in-line with the gate of TR1. The output connector is mounted with its spill soldered direct to the pre-amplifier RF output track.

The tin-plate box needs to be marked as indicated on my web page with holes drilled to accept the input and output sockets as well as the feed-through capacitor.

It is advisable to solder the four 10-µF tantalum capacitors and the 78M05 voltage regulator onto the board before this is soldered into the tin-plate box, as the capacitors near the 78M05 voltage regulator will be found difficult to solder afterwards due to their proximity to the sides of the box. Take care to observe the correct polarity of the tantalum capacitors.

Band	L1	L2	C1	C7, C13	L9	TR1	Absorber
1.3 GHz	3.5 turns	2.5 turns	2.7 pF	8.2 pF	5.6 nH	NE32584/ATF36077	ARC DS10017
2.3 GHz	12-mm hairpin	11-mm straight	3.3 pF	4.7 pF	3.3 nH	ATF36077	ARC DS10017
3.4 GHz	9-mm hairpin	11-mm straight	1 pF	4.7 pF	3.3 nH	ATF36077	ARC LS10055

Table 2. Component changes for the three amateur band versions of the LNA. All other values are the same for the three amateur band versions of the pre-amplifier.

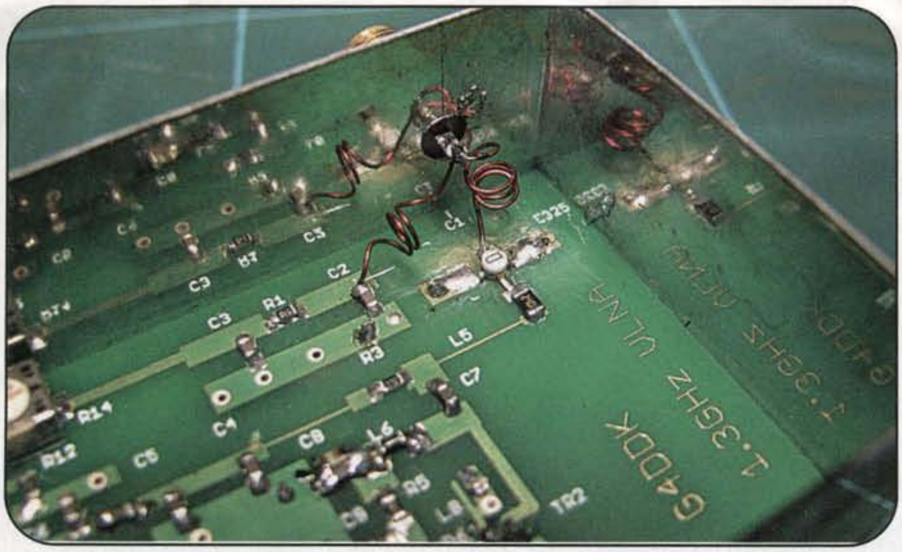

Photo B. Input coil details of L1 and L2 for the 1.3-GHz version.

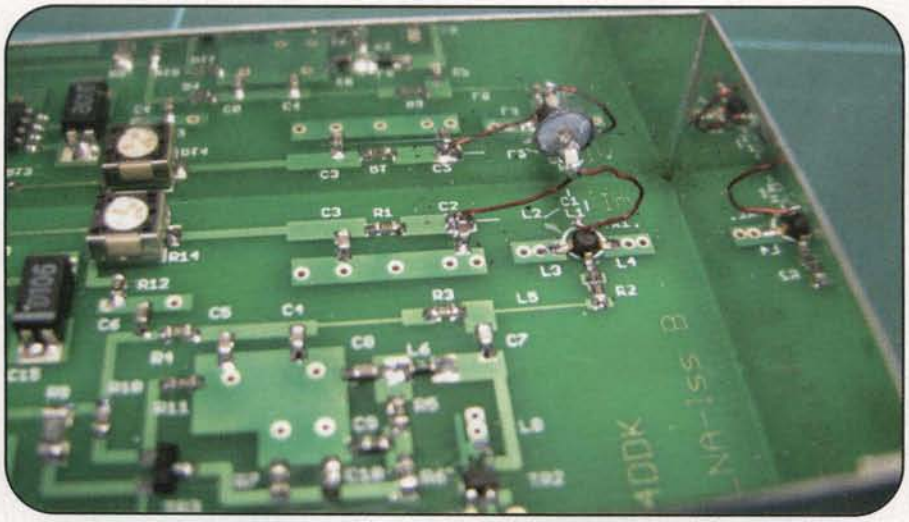

Photo C. The 2.3-GHz VLNA L1 and L2 hairpin loop details.

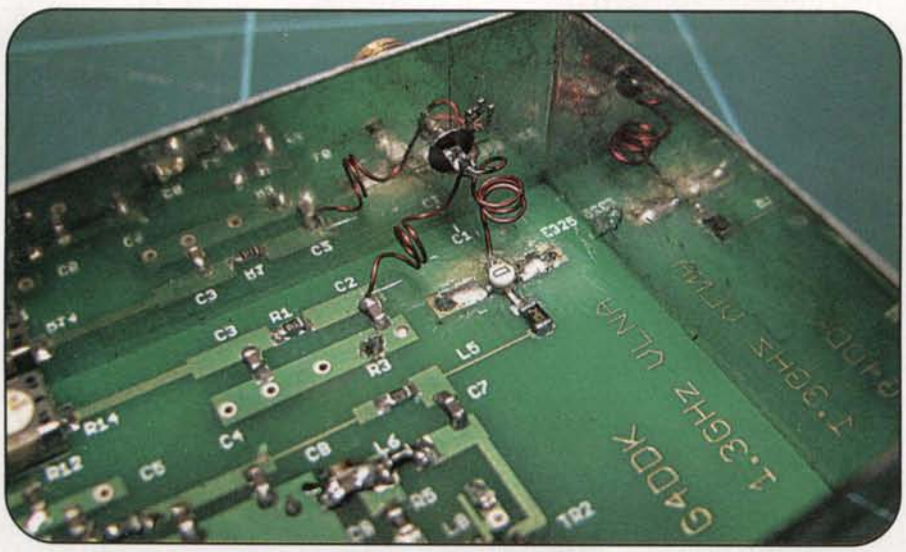

Photo D. The 3.4-GHz LNA L1 and L2 input hairpin loop details.

Use only small-gauge solder (U.S. 30-gauge size; nothing larger) and a fine-pointed, small soldering iron to solder all the components onto the board. *Regular 24-gauge solder is guaranteed to make a mess of the board!*

Solder C1 onto the spill of the input connector, being careful not to overheat the capacitor, as it could crack and this is not always obvious. Solder L2 so that one end is on the track pad, as shown, and the other end is carefully soldered to the free end of C1. Solder L1 so that the lower end lead is free to be soldered to TR1 gate. Winding details for L1 and L2 are shown on the schematic diagram and orientation of L1 and L2 can be seen in photo B.

Solder in the two GaAs FETs *after* the initial setting up.

Initial Setting Up

Check that there is +5V at the output of IC1 and that there is –5V at the output of IC2. Solder in TR1 and TR2 when you are happy that the supply voltages are correct. Disconnect the supply first, of course!

Alignment

Adjust R14 for 2V on the drain of TR1.

1.3 GHz details. With L1 still close wound, measure the noise figure. Now carefully bend the top turn up and away from the remaining turns. The turns should be spaced as shown in figure 2. Re-measure the noise figure. It should be very low. Now *carefully* adjust the spacing of these coil turns for the lowest noise figure. Care here will be rewarded. There *may* also be some advantage in *slightly* re-adjusting L2 coil spacing. Use only the recommended wire size. Larger gauge wire may crack C1 whilst L1 is being adjusted. Be warned!

Put the RF absorbent material inside the lid of the tin-plate box. Putting the lid in place should not result in any increase in noise figure or loss of gain.

Slight readjustment of TR1 bias, with R14, may produce a slightly lower noise figure.

2.3 and 3.4 GHz details. There should be no need to adjust L1 or L2 in the 2.3- or 3.4-GHz version of the pre-amplifier. As long as L1 is the correct length and oriented as shown, it should be as good as it gets. Adjustment of the drain current with R14 is the only variable left.

Photos C and D show the input coil/hairpin positions.

Always check <http://www.g4ddk.com> for the latest building instructions for the LNA before commencing construction of the pre-amplifier.

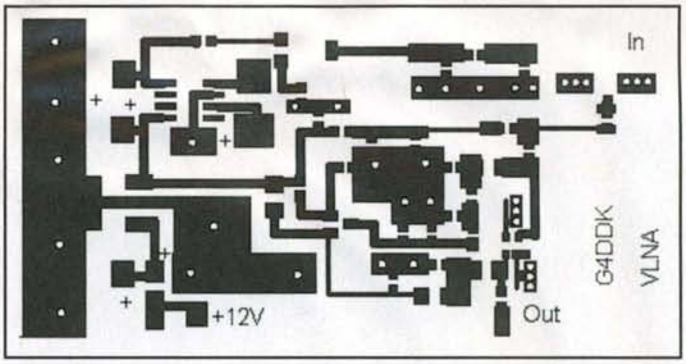

Figure 2. VLNA PCB. 74×37×1.6 mm FR4 double-sided.

Results

A number of the pre-amplifiers are now in regular use on EME. In particular, the 1.3-GHz pre-amplifier has been popular with small-dish EME operators. The 2.3-GHz pre-amplifier has proven to be competitive with other designs in use in both EME and terrestrial operation. Few 3.4-GHz pre-amplifiers have been built. Could this could be a result of the lesser activity on this band?

Initial concerns about using 0603-size SMD parts have not been realized. The biggest problem seems to have been losing the small parts on the typical radio amateurs work bench! 0603-size parts are currently the most economic SMD size parts to purchase from component suppliers (at least in the UK) and an extremely wide range of parts is available.

A couple of incidents of poor noise figure have been reported. This tends to manifest itself as a noise figure (on 1.3 GHz) of about 1–1.5 dB and a gain in the low 20-dB range. When this has been investigated, it usually was found to be due to instability, with an oscillation around 15 GHz. The reason for this has not been finally resolved, but is easily cured by cutting a small (2 mm × 3 mm) piece from the absorption tile and gluing this over the 22R (R2) resistor in the drain of TR1.

Future Work

The existing PC board is well-suited to be used in the 430-MHz band. However, simulations with Microwave Office have shown that instability may be a problem. A suitable solution is currently being investigated and the results will appear on my web page in due course.

It seems unlikely that the present PC board and circuit will be usable at 5.7 GHz and above, although this is not ruled out with a change of TR2 and a few other small circuit modifications.

References

1. "Low noise two-stage amplifier for 23 cm," WD5AGO design presented in the *Proceedings* of the 1999. Microwave Update, Plano, Texas.

2. "Low noise amplifier for 2404 MHz using the HP PHEMT device ATF36077" WB5LUA (now W5LUA) design presented in the *Proceedings* of the 1994 Microwave Update, Estes Park, Colorado.

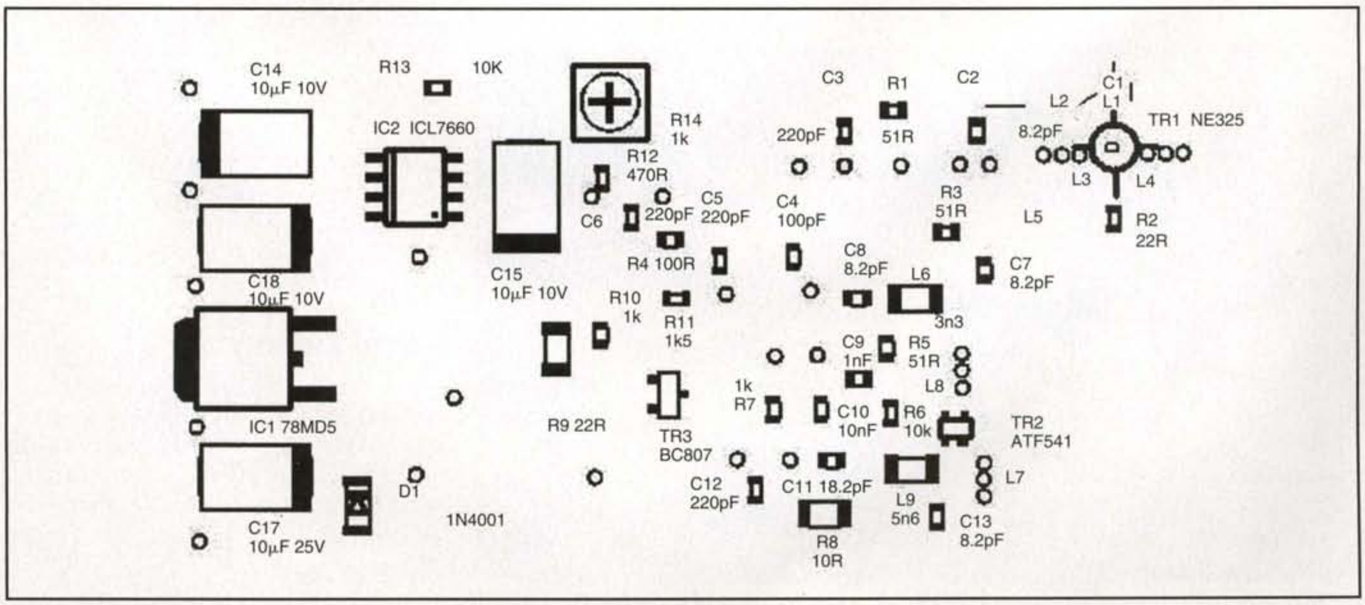

Figure 3. Component overlay for the LNA.

Predicting 6-meter *F2* Propagation

K9LA introduces a method for predicting 6-meter *F2* propagation for any path, any phase of a solar cycle, any month, and any time of day.

By Carl Luetzelschwab,* K9LA

In his article "Predicting Transatlantic 50-MHz F-Layer Propagation" in the March 1993 issue of *QST*, Emil Pocock, W3EP, derived a statistical plot that forecasted transatlantic 6-meter propagation from New England to Europe via the *F2* region. The plot was based on data for the months of November, December, January, and February around solar maximum at the optimum times of day.

The purpose of this article is to introduce a method to predict 6-meter *F2* propagation for any path, for any phase of a solar cycle, for any month, and for any time of day. If you're a seasoned 6-meter operator, more than likely you won't need any help with predicting 6-meter *F2* propagation. However, if you're new to 6 meters or in an unfamiliar location, you may find this method useful.

The method will use one of our HF propagation prediction programs, specifically VOACAP (Voice of America Coverage Analysis Program), which is the Voice of America version of the well-respected IONCAP (Ionospheric Communications and Analysis Prediction) program. For a brief tutorial of VOACAP, including download instructions, visit <http://mysite.verizon.net/k9la/id9.html> and read the file "Downloading and Using VOACAP."

An Initial Run with VOACAP

Since VOACAP is an HF prediction program (2–30 MHz), we suspect it won't do very well on 6-meter paths. We can verify this by running a prediction from North America to Europe during the good days of November 2001. Then from observations during this period in "The World Above 50 MHZ" column by W3EP in the February 2002 issue of *QST*, we can evaluate VOACAP's 6-meter performance. Figure 1 shows the path under analysis.

We'll use Method 30 in VOACAP at 1600 UTC for a path from western Pennsylvania to Germany. Because our propagation prediction programs were developed based on the correlation between a smoothed solar index (either smoothed solar flux or smoothed sunspot number) and monthly median ionospheric parameters, we'll run the prediction using the November 2001 smoothed solar flux of 194 (from the plot "ISES Solar Cycle F10.7cm Radio Flux Progression" at <http://www.swpc.noaa.gov/SolarCycle/>.

Figure 1. The western W3 to DL path.

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VOACAP predicts the monthly median MUF (maximum usable frequency) for our W3-to-DL path to be 37.2 MHz (this is the value given in the left-most column of the results). We can determine the distribution about the median MUF by using the tables of MUF variability in our ionospheric literature (for example, in the booklet "Predicting Statistical Performance Indexes for High Frequency Ionospheric Telecommunications Systems," Technical Report 1-ITSA 1, 1966).

From this we see that on 10 percent of the days of November 2001 (three days) the actual MUF is predicted to be as high as 41.3 MHz. This also says the probability of the MUF being high enough for 50.1 MHz is zero. However, there was 6-meter *F2* propagation in November 2001, as noted in the aforementioned "The World Above 50 MHZ" column, and thus our initial suspicion that VOACAP doesn't do well on 6 meters is confirmed.

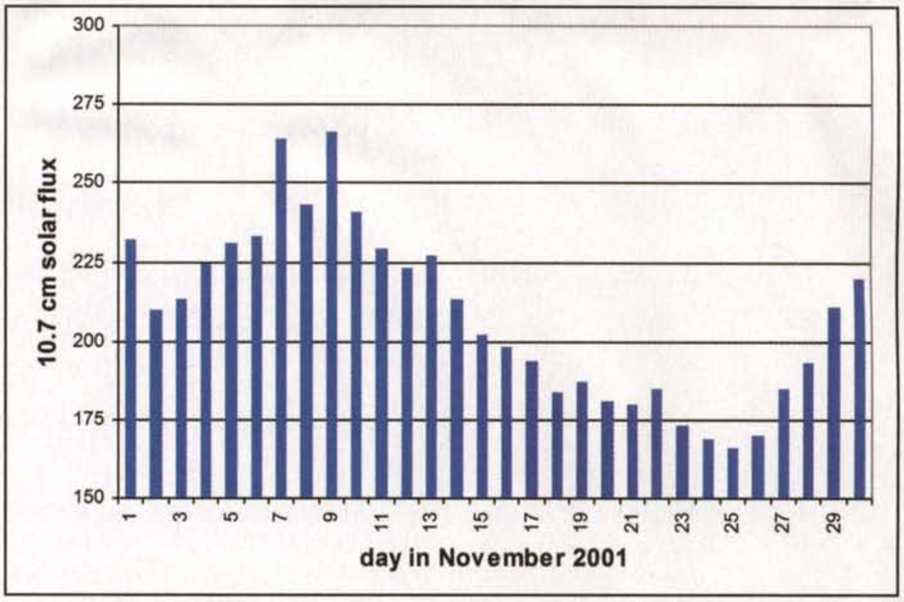


Figure 2. Daily solar flux for November 2001.

A Solar Index Issue

One problem with VOACAP for 6-meter predictions (and with any of our other HF prediction programs, for that matter) is tied to the solar index used. The use of the heavily-averaged smoothed solar flux value of 194 for our prediction belies the fact that the solar flux was significantly higher right before November 11 through November 19, the period when most of the 6-meter openings occurred. Figure 2 plots the daily solar flux for November 2001.

Thus, it appears that we need a shorter-term solar flux measurement for input to VOACAP. We could use daily solar flux, but unfortunately the state of the ionosphere does not correlate well with daily solar flux. Figure 3 shows this by plotting the daily MUF over the Goose Bay, Labrador ionosonde (which is along the path from western Pennsylvania to Germany) and the corresponding daily solar flux for November 2001.

The R^2 value in the upper right-hand corner of figure 3 tells us how well the two parameters (daily MUF and daily solar flux) are correlated. An R^2 value of 0.00 indicates no correlation, and the data points would be widely scattered about the red regression line (as they are in figure 3). An R^2 value of 1.00 indicates perfect correlation, and all the data points would fall right on the red regression line. With an R^2 value of 0.2679, we confirm that there is little correlation between MUF and solar flux on a daily basis. For example, a solar flux of around 195 resulted in a MUF as low as 40 MHz on one day and as high as 46 MHz on another day.

The result of figure 3 is typical of results using data from other months and other years. Even bringing geomagnetic field activity into the picture (through a *K* or *A* index) doesn't improve the correlation to any significant degree on a daily basis.

What this tells us is that there are other processes that ultimately determine the amount of *F2* region ionization in the ionosphere. Solar flux is certainly the instigator (strictly speaking, solar flux at a wavelength of 10.7 cm is a proxy for the true ionizing radiation at wavelengths between 10–100 nm), but geomagnetic field activity on a longer term basis and events in the lower atmosphere coupling up to the ionosphere also play important roles. This is why our propagation prediction programs were developed as monthly median models using a smoothed solar index. The developers never meant them to be used for daily predictions, as they well understood the scatter seen in figure 3.

Path Geometry Issues

The other problem with VOACAP for 6-meter predictions (and again with any of our other HF prediction programs) is

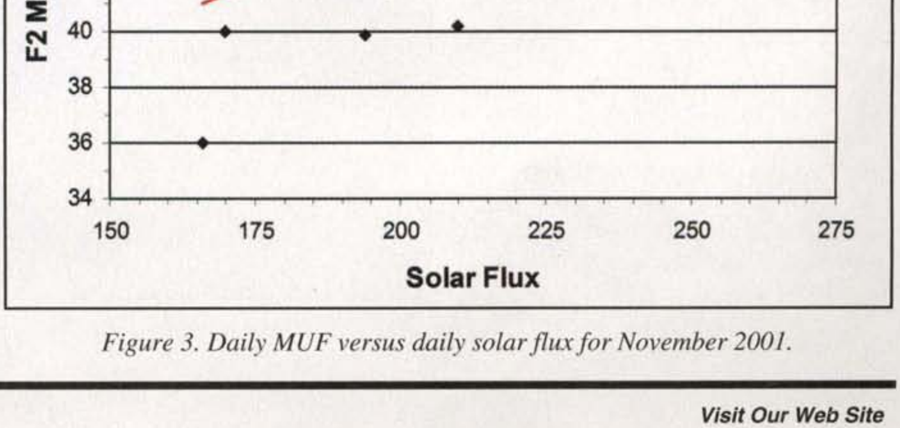


Figure 3. Daily MUF versus daily solar flux for November 2001.

path geometry issues. There are three fundamental assumptions under suspicion for 6-meter propagation.

The first assumption is that hop lengths are 3000 km. That value is a good compromise for the 3–30 MHz HF range, with shorter distances at the lower frequency end (because there's more refraction at the lower frequencies, giving shorter hops) and longer distances at the higher frequency end up to the generally accepted HF limit of 4000 km. We therefore would expect that 6-meter propagation could have hops greater than 4000 km, with resulting higher MUFs, since the electromagnetic wave would graze the ionosphere at an even lower angle of incidence (W3EP cited two papers discussing propagation above 30 MHz with hops significantly greater than 4000 km in his March 1993 *QST* article). There's also evidence from other QSOs suggesting that propagation on 6 meters at times can involve ionosphere-ionosphere modes (chordal hops or ducting), which also results in higher MUFs.

The second assumption is that an electromagnetic wave follows a great circle path. This ignores the fact that some deviation from the great circle path can occur, which is due to an encounter with the ionosphere where MUFs are higher (generally at a more southerly latitude).

The third assumption is that pure refraction occurs. This ignores scatter-type paths (VOACAP does have an over-the-MUF algorithm that assumes scatter, but it doesn't help our efforts, since VOACAP only goes to 30 MHz). Although scatter-type paths incur additional losses, the amount of *D* region absorption on 6 meters is minimal. Thus, 6 meters is more forgiving than the HF bands, and it can tolerate more loss due to a scatter mechanism.

Forcing VOACAP to Agree with 6-meter Observations

We know that the "stock" VOACAP does not do too well with 6-meter predictions, and we also know the issues that appear to cause this – the use of the heavily averaged smoothed solar index and assuming only refraction over 3000-km hops along the great circle path.

For the solar index issue, we'll use a 7-day average of solar flux. That better represents what the ionosphere is doing short term (it's not perfect, but it is better than the use of daily solar flux). For the path geometry issues, we'll apply a multiplying factor (derived from W3EP's 1993 *QST* article and from observations in W3EP's February 2002 column) to the *F2* region through the "foF2 Fprob" option in VOACAP's setup menu. Using a 7-day average of solar flux certainly gets VOACAP closer to 6-meter reality, but the multiplying factor is still needed to account for "non-HF" modes on 6 meters.

The Method to Predict 6-meter Propagation

The development of the method is mostly based on sound physical principles, but I readily admit some of it is akin to "arm waving," since our understanding of propagation in the ionosphere is statistical in nature; it is not deterministic. The method can be summarized in four steps:

Step 1: Determine the short-term solar flux by taking the 7-day average prior to the desired period.

Step 2: Change the multiplier in the "foF2 Fprob" option in VOACAP from 1.00 to 1.20.

Step 3: Run Method 30 in VOACAP using an operating frequency of 30 MHz (VOACAP defaults to 30 MHz if you try to input 50 MHz, but that's OK, as we're really not concerned with any operating frequency we input). Note the MUF in the *first* column of data (ignore the data in the 30 MHz column).

Step 4: If the MUF in the *first* column is around 45 MHz, you should start looking for 6-meter *F2* propagation. The higher the MUF with this method, the higher the probability will be for 6-meter *F2* propagation.

Geomagnetic Field Activity

Along with extremely high solar flux comes the likelihood of geomagnetic-field activity. In general, the *F2* region will be depleted when this occurs, so high solar flux values will not necessarily always imply 6-meter propagation. In essence, this method will work best when the geomagnetic-field activity is either low to start with or returns to quiet conditions.

Acknowledgements

I would like to thank Emil Pocock, W3EP, for his review of and comments on this article. ■

2500 Miles with JUST a Loop?

Although the lowly VHF/UHF loop antenna offers zero gain in all directions, it is the hot ticket on SSB and CW!

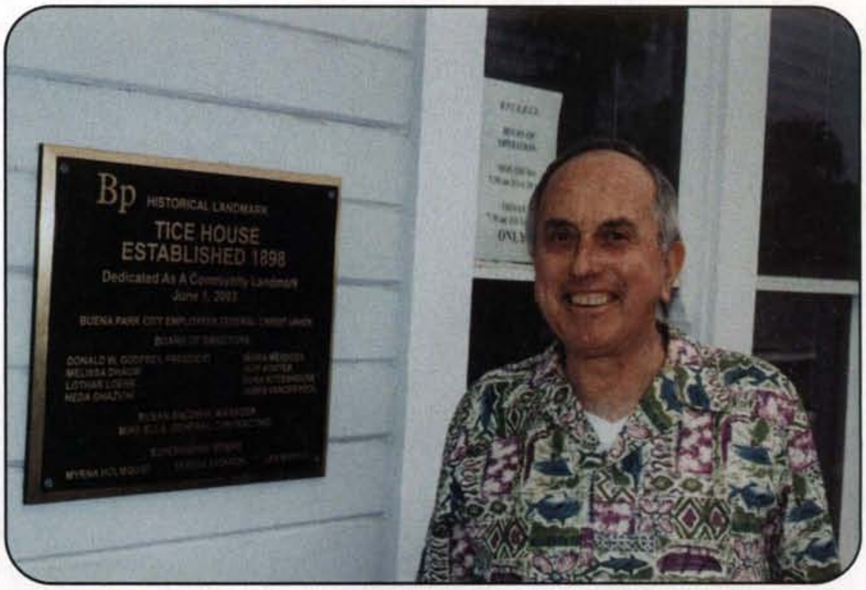
By Gordon West,* WB6NOA

Count the horizontal omnidirectional loop antenna *in* for your VHF/ UHF mobile/portable station. The tiny loop might also bridge the Pacific (or Gulf, Midwest, or East Coast) from a hidden attic installation.

"Every July, like Pacific Coast clockwork, a Pacific high builds in between California and Hawaii," comments Julian Frost, N3JF. "Our first California-Hawaii opening this year developed on June 18th, and signals were so strong that I could easily hear the KH6HME beacon coming in on my attic loop, spanning 2500 miles!"

Often homeowner associations ban any sort of visible outside ham antenna, but a single loop might double as an over-the-air outside digital TV antenna, and can easily hide inside an attic for some exciting horizontally-polarized VHF/ UHF contacts:

50.125 MHz calling SSB
144.200 MHz calling SSB
432.100 MHz calling SSB
1296.100 MHz calling SSB



Paul Lieb, KH6HME, the tropo voice of Hawaii. (All photos by the author)

Loops Plus Weather Equals Success

Tropospheric ducting is a weather phenomenon. Loop antennas, horizontally polarized, eliminate 10- to 20-dB cross-polarization loss if you are trying to work VHF/UHF SSB and CW from a monster collinear vertical or that big vertically polarized beam.

When weather conditions associated with a stationary high-pressure system form, "tropo" signal enhancement can be so pronounced that a 0-dB gain horizontally-polarized loop can span over the water to a distance greater than 2500 miles!

The Loop

The horizontal loop antenna is a half-wave dipole formed in a circle to offer no-null performance in all directions. There are multiple commercial manufacturers of single-band VHF/UHF loops (see References), including one unique loop that offers 2-meter *and* 432-MHz performance—one loop, two bands. This is handy when operating multi-band HF equipment that outputs 2 meters and 440 MHz to a single antenna connector. This dual-band loop allows you to jump from 2 meters to 70 cm without any coax switching.

The popular single-band 2-meter horizontal loop may incorporate a capacitive end-element termination, compensating for its relatively small size, for compact, sturdy mobile operation. The feedpoint may include a gamma match and/or series capacitance, usually encased within a protective cover. The loop antenna offers high-Q performance with an extremely sharp SWR drop at the bottom of the 2-meter band. Rain or icing may dramatically de-tune these small loops, so each manufacturer has developed its own unique capacitive end-loading scheme—some using a gap in the loop, and others terminating to a solid insulator at the loop ends.

Of great importance to the construction of these loop antennas, including home-brew, is zero vibration of loop elements where they join capacitive matching assemblies. During the 20 years of testing very-high-frequency loops, noted VHF/UHF SSB DXer Frank, AA2DR, concluded that only the most rigid loop element structures will withstand typical mobile operation. And when ice storms hit Long Island, Frank reports the immediate demise of both mobile loops as well as mobile loop performance over the air.

There are several manufacturers of horizontal loops, and during the many tests in which we participate at the seashore in our mobile communications van, loop reception and loop trans-

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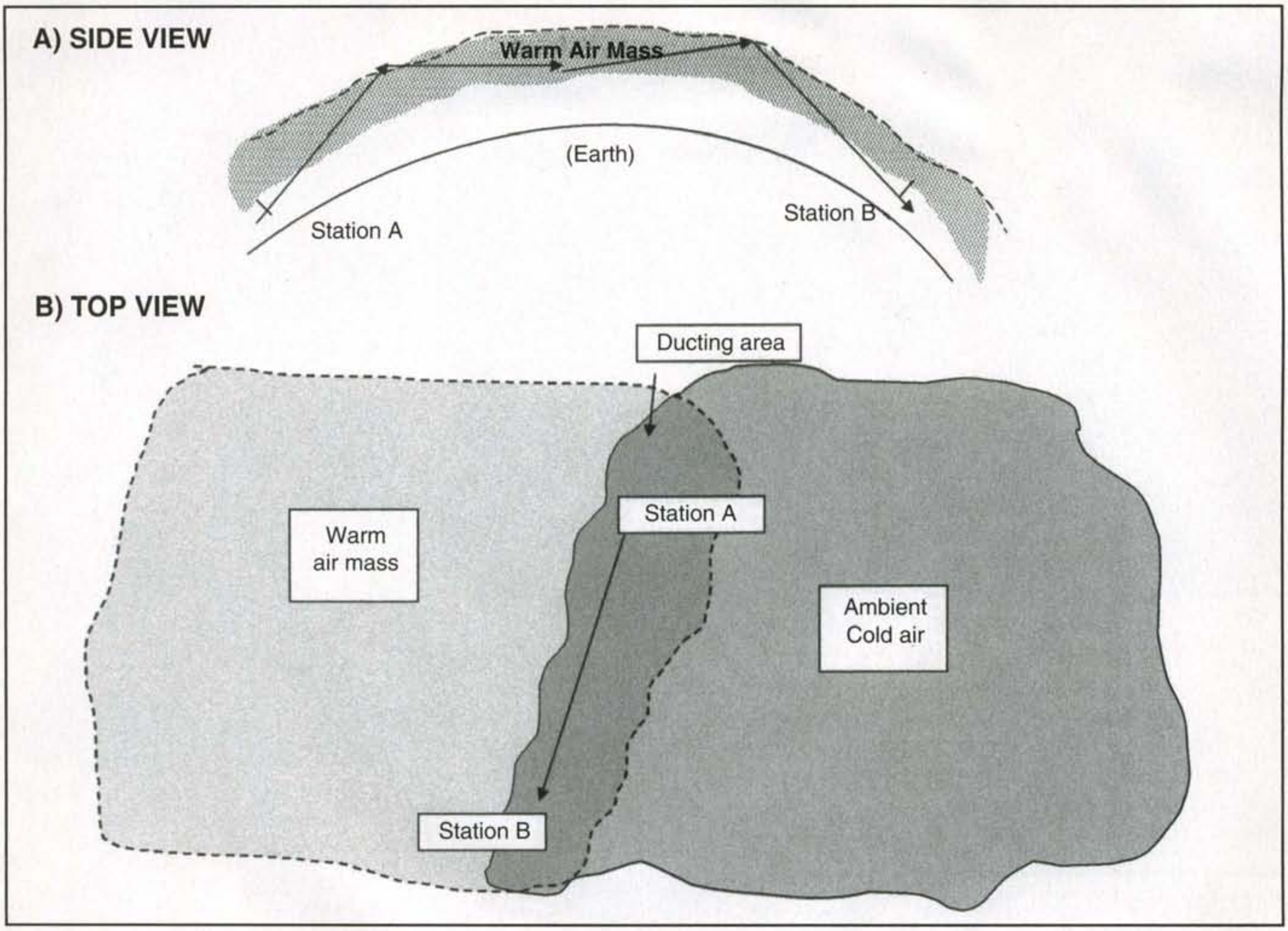


Figure 1. Tropospheric ducting. Note that tropo ducting can occur at different times on all of the VHF bands.

mit capabilities were nearly identical among manufacturers' products. Larger size loops, such as the Big Wheel design from W1FVY and W1IJD, have an edge in performance, mainly due to their larger size of three one-wavelength elements, all connected in parallel, using stub feedpoint matching to raise the feedpoint to 50 ohms. Although the Big Wheel design may flap in the breeze at 60 miles an hour, the broad-band design does not de-tune, as long as the stub matching network remains absolutely solid.

We also tested signal reception and transmit enhancement by stacking loops (2 meter) 48 inches apart (5/8 wavelength) using a T-connector with a bottom on 1/4 wavelength of RG-59 and the top loop with 3/4 wavelength coaxial cable, following the explicit directions on how each coax cable connector should be facing. Misalignment of loop feedpoints is a common problem with stacking antennas, and you must follow the antenna manufacturer's instructions to the letter in order to achieve the desired gain of 3 dB. Typically in our mobile tests we never saw a huge difference in picking up the Hawaii beacon with a single loop versus a pair of stacked loops. However, on an antenna test range or in the attic of your condo, stacking loop antennas may have 2 dB gain merit.

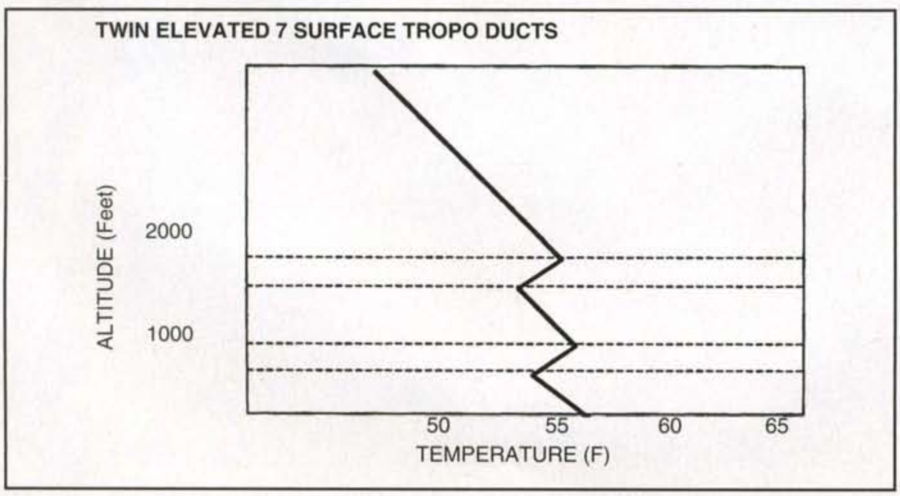
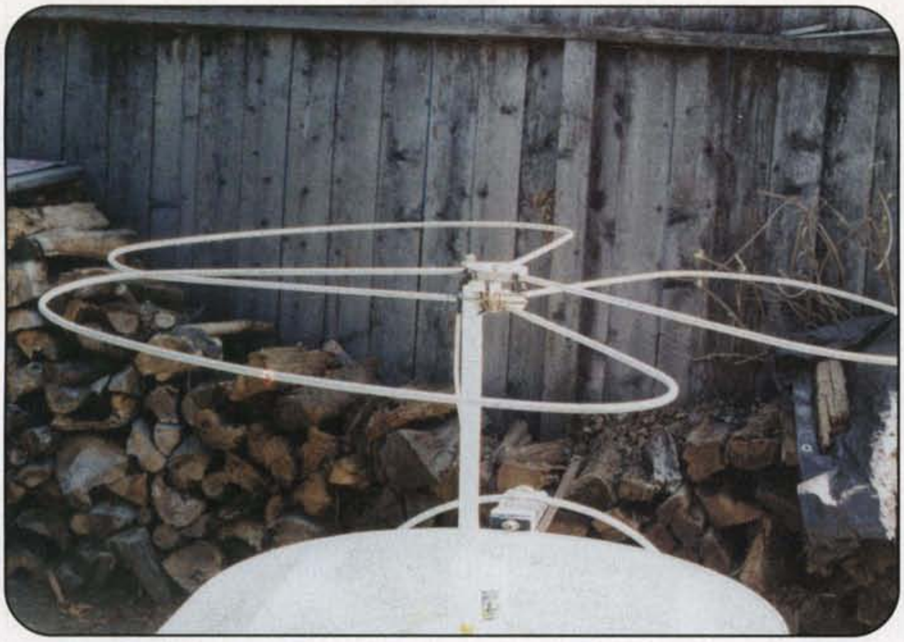


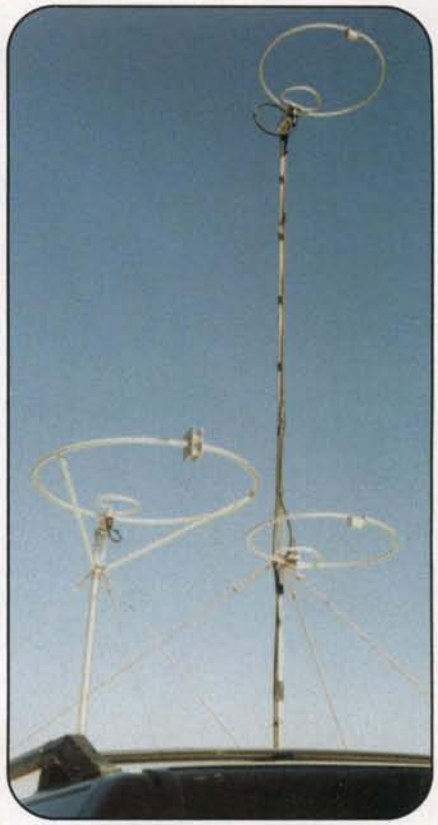
Figure 2. Evening double tropo enhancement due to heat rising from land.

The Weather

The largest contributor to an increase in signal strength is favorable weather conditions to create the long-haul tropospheric duct. Between California and



Classic "big wheel" 2-meter horizontal antenna.

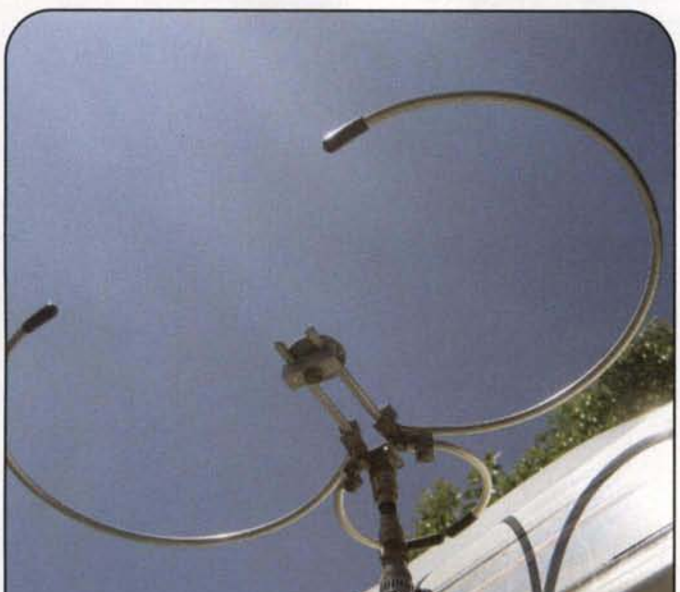


Two-meter stacked loops with a single 6-meter loop on the left.

Hawaii, or Denver to Chicago, or Chicago to Texas, or Texas to Miami, the path depends on a stationary high-pressure system to create an inversion layer with a refractive index greater than the air below. Temperature inversions from stratified sinking air, within a high-pressure cell, that approach delta 10 degrees Fahrenheit increase will likely trigger the waveguide effect of the tropospheric duct. If this undisturbed inversion stratification remains intact for over 1000 miles, that may be how far your loop will talk and listen! Summertime high-pressure cells develop all over our Northern Hemisphere, and if you carefully monitor "tropo" forecasts, your little loop will most likely work the circuit when band conditions build.

No loop will ever achieve the results of a horizontally polarized beam. However, beams on a mobile (in motion) are generally rare, but horizontal loops are common.

Close-up of the M^2 loop ready for the mounting bracket.



A dual-band KU4AB.com loop with solid-rod construction on WB6NOA's communications van, 144.2 and 432.1 MHz with one feedpoint!

Now that most manufacturers are including VHF/UHF multimode capabilities in their relatively small HF transceivers, the popularity of the compact loop for *portable* operation is increasing. Last year during an intense 2500-mile opening between the West Coast and Hawaii, my wife Suzy did more than sell seashells at the seashore; she worked 2-meter SSB into a loop for some unbelievable DX! I run loops on my dune-buggy for 2-meter and 70-cm "tropo" elevation surveys and the 2-meter/70-cm loops were my companions at Catalina Island '08 Field Day activities, easily working mainland hams on SSB and CW. Also, five years ago, we worked Paul, KH6HME, using a West Coast single loop antenna over the long ocean path to Hilo, Hawaii.

When a tropospheric duct opens up communications between two distant stations, signal strengths at modest power levels may peak well above S-9. This is more than enough latitude to open communication possibilities between a distant station using a beam and the other end of the circuit with "just" a loop!

Resources

<www.KU4AB.com>: dualband loop
PAR Electronics (561-586-8278): Omniangle
<KB6KQ.com> (new owner): loops
M² (www.m2inc.com): HO loop
Olde Antenna Lab (303-841-1735): Big Wheels
<HamUniverse.com>: loops
<ErikBurrows.com>: loops
K1RST: loops
<dxinfocentre.com>: Hepburn Tropo Maps

Observing the Double-Hop Sporadic-E Phenomenon on 6 Meters

During the sunspot cycle low, North American 6-meter operators find it difficult to work many countries. WB2AMU suggests a possible solution to this dilemma.

By Ken Neubeck,* WB2AMU

In Europe and other parts of the world, countries are located close enough to one another such that they can be worked on 6 meters via single-hop sporadic-*E* (E_s). This is also true for 6-meter stations located in the southern U.S., where they are within single-hop range of many Caribbean and Central American countries. However, for many 6-meter stations that are located in the northern portion of the U.S. and much of Canada, there are not a heck of lot of DXCC countries that can be worked via single-hop sporadic-*E* skip. This would normally be a bleak situation for these operators in their pursuit of DX on 6 meters when *F2* is not a factor. On the other hand, the occasional presence of simultaneous multiple sporadic-*E* formations can help in working long-range DX on 6 meters.

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Observations

One thing that I have observed over the years with regard to double-hop sporadic-*E* events (see figure 1) is the fact that they are very rare during the months not in the summer sporadic-*E* season (May through August for the Northern Hemisphere). Indeed, even though there is a minor winter window for sporadic-*E* activity, and there have been rare events over the years during the equinox period, I can only recall a very small number of double-hop sporadic-*E* events that I have observed during the non-summer months over the past 15 years. I recall a special occasion when I observed a double-hop event one evening in the middle of March 1996, when stations in Arizona were being heard on Long Island, along with single-hop skip stations from the Midwest. Otherwise, I have not recorded any multiple-hop sporadic-*E* events during any of the winter months (October through February) in over 15 years of personal observations.

The significant reduction of double-hop sporadic-*E* events during the non-summer months is a general, not statistically based indicator of the overall reduction of sporadic-*E* activity when comparing the two time periods. If we use the observed summer season data that I have collected on 6 meters over the years (see Table 1) and compare it with no days of E_s during the other months, this could almost be summed up as roughly a ratio of 100 to 1 for my particular location. While this clearly is not meant to be a scientifically accurate calculation, it gives a

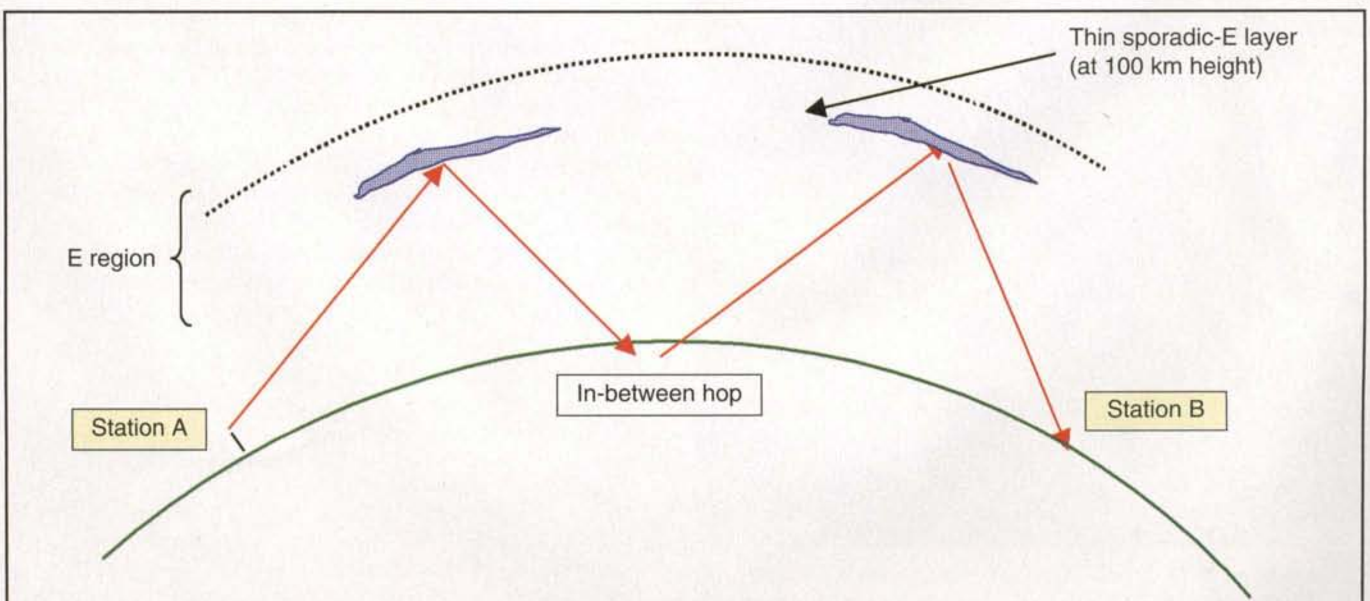

Figure 1. Double-hop sporadic-E pictorial description.

rough order of magnitude as to how intense the summertime sporadic-E season is compared with the winter season.

Perhaps the thing that is most important to note is that observations of double-hop sporadic-E events is location dependent, as some locations such as the New England area can experience many more such openings into Europe during the summer months. My location on Long Island is not in that "magic spot" for observing Europe as is, say, K1TOL in Maine, who is geographically favored as well as geometrically favored in terms of the distance for the two hops.

The earliest that I have ever observed double-hop sporadic-E during any year was on May 9th, and the latest that I have observed it is August 17th, roughly a 90- to 100-day window of opportunity for my location. It is most likely that this window of opportunity is somewhat larger for areas such as New England into Europe, and the southeast U.S. into the Caribbean. It could loosely be argued that the peak months for double-hop sporadic-E are June and July. This would not be based on just my observations, but also on the observations of stations in New England. It is also noted that in most cases, the double-hop sporadic-E activity begins almost as soon as the sporadic-E season begins in May and lasts into August.

Also under consideration in this analysis is the fact that there are situations in which the observing station is hearing signals from two opposite directions. This scenario, while not technically called a double-hop sporadic-E event for the observing station, is truly a dual-formation sporadic-E event. These events are also reflected in Table 1 as recorded in the notes that I have collected over the years. I have not recorded any such events in all of my years on 6 meters during the wintertime sporadic-E season. They are a challenge to record, as they are not always obvious, particularly if the beam is pointed in the direction of one of the sporadic-E formations, reducing the strength of the signals from the direction where the other formation is. It is important to note that this case is distinct and not to be confused with strong sporadic-E events that create backscatter conditions in the opposite direction (the backscatter signals typically are not as strong).

As discussed in previous *CQ VHF* articles, there are variations in individual sporadic-E openings in terms of signal strength (uniformity of the formation), density (the highest frequency reflected), and duration (time). Thus, one can imagine the extreme number of variations involved when dealing with two sporadic-E formations occurring at once! Sometimes the stations at the end points of the two hops can hear one another for only a few minutes, or sometimes for several hours. Sometimes stations in between the two stations on either end of the QSO are very strong, and this can lead to difficulty in the double-hop stations being able to hear one another underneath much stronger signals.

In some rare cases, the in-between hops may be in an area where there are few stations, making it easier for the stations on the end of the two hops to be able to work one another with less interference. I found this to be the case during a 6-meter opening from my QTH on Long Island into the Arizona and southern California area on the evening of June 4, 2008. I was able to work a decent number of western stations over a three-hour period without hearing many in-between stations. I heard a few W4s and W9 stations in

Kentucky and Indiana, but they were not excessively strong and did not cause a problem for me (see Table 2). It can sometimes be a roll of the dice as to how easy it is to work stations via double-hop, because where the in-between hop falls can dictate the amount of interference that will have to be dealt with!

Another interesting thing is figuring out which of the two sporadic-*E* formations is stronger. In the past, when I heard strong signals on a single-hop opening I sometimes heard some double-hop signals come in later with weaker signal strength. This suggests that the initial formation was probably the "stronger" of the two. Stronger is a relative term when discussing a formation, and a better term may be the *uniformity* of the formation where there is minimal fading. I suspect that the opening that I listed in Table 2 had a stronger second formation (the sporadic-*E* formation that was closer to the western stations), because I did not hear very strong signals with the first formation (the one closest to me).

Table 1 also shows that there is variability in the number of double-hop events on a year to year basis for any particular location. For example, 2004 was a poor year, while 2006 was an exceptional year. I suspect that there are multiple formations that can appear at the same time but may not be in a favorable position where they can be linked. When this situation occurs, it most likely is a function of the density and the distance between the two formations as shown in figure 2. The density of one formation

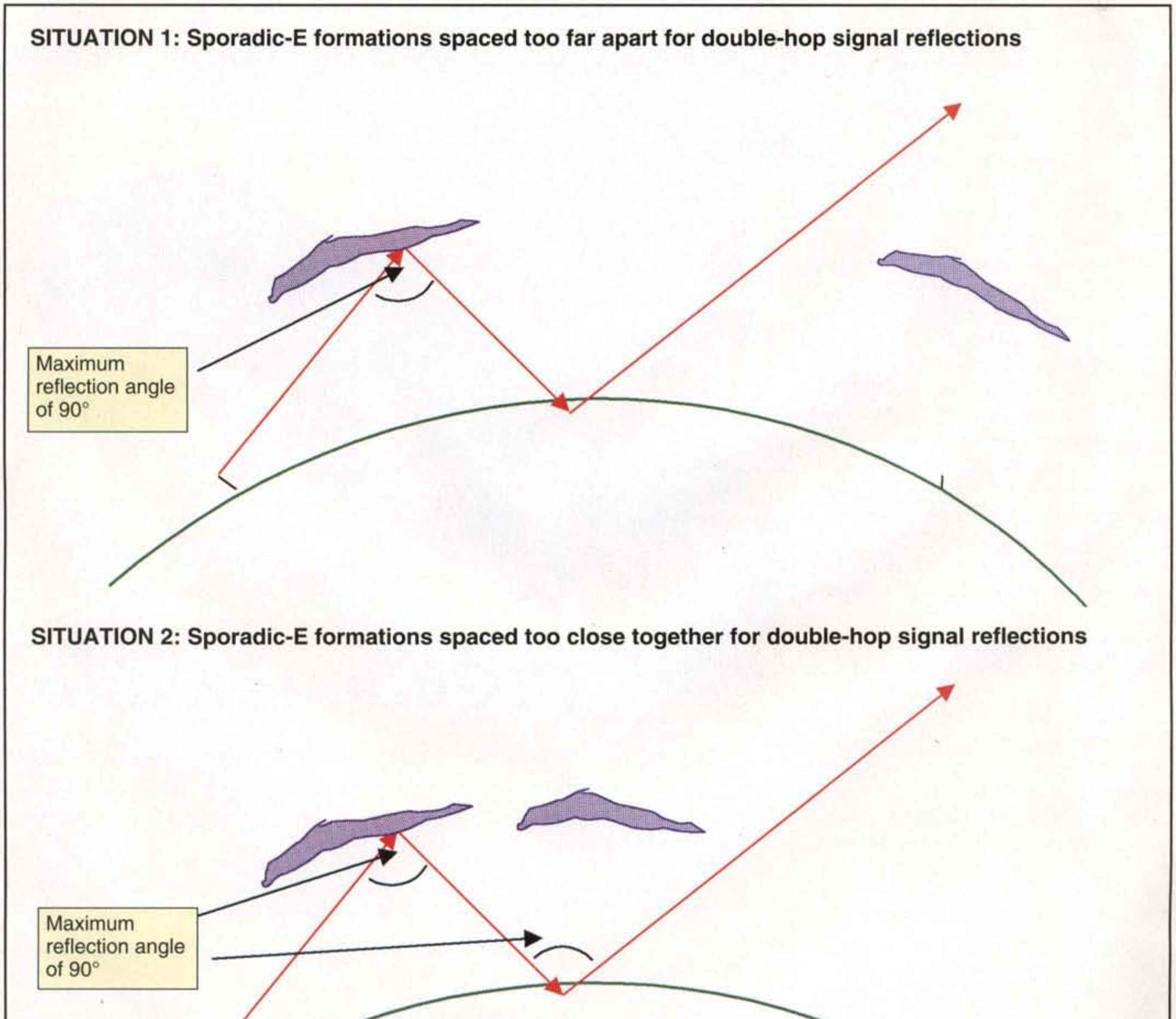

Figure 2. Near-misses for double-hop sporadic-E events.

Year	May		June		July		August		%	Earliest & Latest
	E_s	$2\times E_s$	E_s	$2\times E_s$	E_s	$2\times E_s$	E_s	$2\times E_s$	$E_s/2\times E_s$	Day for $2\times E_s$ Event
2000	13	2	19	5	23	7	9	1	23.4%	May 26, August 4
2001	18	1	21	5	21	11	12	2	26.4%	May 31, August 17
2002	7	0	20	1	11	0	9	1	4.3%	June 11, August 4
2003	16	1	14	4	26	6	8	0	17,2%	May 24, July 29
2004	12	0	12	1	14	2	8	1	8.7 %	June 20, August 4
2005	14	3	10	1	14	2	11	1	14.3 %	May 20, August 9
2006	16	6	17	3	20	10	3	1	35.7%	May 21, August 3
2007	5	1	16	8	20	7	2	0	23.2%	May 9, July 29
Total	**101**	**14**	**129**	**28**	**149**	**45**	**62**	**6**	**21.1%**	**(93 days /441 days)**

Note: The total for double-hop sporadic-E events also includes events where I heard skip in two opposite directions.

Table 1. Number of days of double-hop sporadic-E events observed at WB2AMU (FN30).

may be poor and it may be too close to (or too far from) the other formation, where it could not possibly link 6-meter signals. This certainly could account for some of the variability in the total number of double-hop sporadic-*E* events that are recorded during any summer season.

Generally, it is recommended that directional antennas be used to be able to work double-hop sporadic-*E*. However, that does not mean that lesser antennas will not work. On May 22, 2008 I was at my work QTH located in the middle of Long Island. I was listening with just my mag-mount vertical antenna on my car when I heard a moderately strong CW signal on 50.098 MHz. It turned out to be CU2JT from the Azores! I started my car and pumped the power to 70 watts on my FT-100, and I was able to work him after he finished a QSO with another Long Island station. This was a better-than-average type of double-hop situation. However, directional antennas are generally better because of fading conditions that can occur during two-hop situations.

Over the years, there have been days when sporadic-*E* formations seemed to be everywhere. When such events occur during a major contest such as the ARRL VHF QSO Party, the CQ WW VHF Contest, or ARRL Field Day, it becomes easier to track the number of formations present. One such event that I observed was Field Day 1994, when major openings were occurring everywhere on 6 meters during the first two hours of the event. From my location on Long Island, not only were we hearing stations from the Midwest, but eventually also weak signals from Europe in the other direction! I found out later that stations in Florida (such as Damon Morrison, KJ4E) had a prolonged opening into much of Europe (he worked 120 stations in 21 countries!). I also collected other reports from Field Day stations around the country. The West Coast was working the East Coast, and stations in southern California were working stations in the Pacific Northwest! During the first two hours of that particular Field Day, I estimated that there were at least six, possibly even seven, sporadic-*E* formations present at the same time. I would guess that during each summer there are days when four or five sporadic-*E* formations occur at roughly the same time but are not always fully captured unless a contest or similar event is going on.

A problem that is specific to coastal area such as the East Coast and West Coast of the U.S. is the sporadic-*E* paths that land in water, including double-hops. For me, one eastern path falls around the area of the Azores Island. Usually I can work into that area or coastal Portugal about once or twice each year during the summer. However, I can only imagine the number of those paths that land directly on water outside of those areas, where there are no islands or 6-meter stations. Sometimes these paths are discovered when there are maritime-mobile stations around, such as when Clint, W1LP, used to go up and down the East Coast, as well as others who went into the mid-Atlantic. During the summer of 2008, Yuri, UT1MM/mm, is one ham who is going through water grids in the Atlantic Ocean and being worked on 6 meters, often on double-hop sporadic-*E*.

Time (UTC)	Callsign	Grid
0034	N7KA	DM65
0053	W7RV	DM35
0135	K7JA	DM03
0127	W6DCC	DM13
0133	W6OAR	DM14
0136	W6PJ	DM43
0150	K7BHM	DM43
0155	N6RV	DM03
0207	WA7NB	DM42
0221	K7NN	DM42
0255	AA6DD	DM13

Table 2. Stations worked by WB2AMU (FN30) during double-hop sporadic-E opening on June 5, 2008.

Summary

What conclusion does all of this information eventually lead to? First of all, by virtue of multiple-hop sporadic-*E* formations being present, the summer season easily dwarfs the winter season. The difference is not merely in the larger number of occurrences, but actually could be expressed on the order of exponential terms! There is an average of at least ten days of double-hop sporadic-*E* activity during the summer season for most stations located in the middle-temperate zone, while double-hop sporadic-*E* during the winter is a pretty rare event.

It also points to the fact that there is a significant amount of ion activity in the *E*-region during the summer, as multiple formations can occur. This information can imply the importance of solar radiation effects on the oxygen ions in the *E*-region during the summer, whereas these effects are greatly minimized outside of the summer months.

Six-meter operators thus should keep in mind the importance of daily monitoring from May 1st through mid-August in order to capitalize on multiple sporadic-*E* events when they occur. These events help in the pursuit of DX, until the next *F2* season arrives in a few years. ■

QUARTERLY CALENDAR OF EVENTS

Current Contests

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

September: The **ARRL September VHF QSO Party** is September 13–15. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 20–21. The **ARRL 2304 MHz and Above EME Contest** is September 20–21. The following dates for the **Fall Sprints** are based on last year's dates. Please check with the sponsor for the exact dates. The **144 MHz Fall Sprint** is September 15, 7 PM to 11 PM local time. The **222 MHz Fall Sprint** is September 23, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 1, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 11, 6 AM to 12 PM local time. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 18–19. The **50 MHz Fall Sprint** is October 18, 2300 UTC to October 19, 0300 UTC.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 15–16.

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

Current Conferences and Conventions

September: The 2008 **TAPR/ARRL Digital Communications Conference** will be held September 26–28 in Chicago, Illinois, at the Holiday Inn Hotel Elk Grove Village, Illinois. For more information, see: <http://www.tapr.org/dcc.html>.

October: The 2008 **Microwave Update** conferencewill be held October 17–18, in Bloomington, Minnesota at the Holiday Inn Bloomington I-35. For further information, please check the Microwave Update website: <http://www.microwaveupdate.org>.

The 2008 AMSAT-NA Space Symposium and Annual Meeting is to be held October 23–26, in Atlanta, Georgia at the Doubletree Buckhead Hotel. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/2008/index.php>.

Quarterly Calendar

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

Aug. 2	New Moon
Aug. 3	Very Good EME conditions
Aug. 8	First Quarter Moon
Aug. 10	Moon Apogee; Very poor EME conditions
Aug. 12	*Perseids* Meteor Shower Peak
Aug. 16	Full Moon
Aug. 17	Moderate EME conditions
Aug. 23	Last Quarter Moon
Aug. 24	Moderate EME conditions
Aug. 26	Moon Perigee
Aug. 31	New Moon; Good EME conditions
Sept. 7	Moon Apogee and First Quarter Moon; Poor EME conditions
Sept. 14	Moderate EME conditions
Sept. 15	Full Moon
Sept. 20	Moon Perigee
Sept. 21	Moderate EME conditions
Sept. 22	Last Quarter Moon and Fall Equinox
Sept. 28	Good EME conditions
Sept. 29	New Moon
Oct. 5	Moon Apogee. Very poor EME conditions
Oct. 7	First Quarter Moon
Oct. 12	Good EME conditions
Oct. 14	Full Moon
Oct. 17	Moon Perigee
Oct. 19	Poor EME conditions.
Oct. 20	*Orionids* Meteor Shower Peak
Oct. 21	Last Quarter Moon
Oct. 26	Moderate EME conditions
Oct. 28	New Moon
Nov. 2	Moon Apogee. Very poor EME conditions
Nov. 6	First Quarter Moon
Nov. 9	Good EME conditions
Nov. 13	Full Moon
Nov. 14	Moon Perigee
Nov. 16	Moderate EME conditions
Nov. 17	*Leonids* Meteor Shower Peak
Nov. 19	Last Quarter Moon
Nov. 23	Moderate EME conditions
Nov. 27	New Moon
Nov. 29	Moon Apogee
Nov. 30	Very poor EME conditions

—EME conditions courtesy W5LUU

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings*, or both. For more information, questions about format, media, hardcopy, e-mail, etc., contact the person listed with the announcement. The following organization or conference organizer has announced a call for papers for its forthcoming conference:

Microwave Update: A call for papers has been issue for the 2008 Microwave Update conference, to be held in Bloomington, Minnesota. The deadline for submission is August 31. If you are interested in submitting a paper for publication in the *Proceedings,* then, please contact Jon Platt, WØZQ, at <w0zq@aol.com> for additional information.

AMSAT-NA 2008 Space Symposium: Technical papers are solicited for the 2007 AMSAT Space Symposium and Annual Meeting to be held October 23–26 in Atlanta, Georgia. Proposals for papers, symposium presentations, and poster presentations are invited on any topic of interest to the amateur satellite program. Papers on the following topics are solicited: Students & Education, ARISS, AO-51, P3E, Eagle, and other satellite-related topics. Camera-ready copy on paper or in electronic form is due by September 1 for inclusion in the printed symposium *Proceedings.* Papers received after this date will not be included in the printed proceedings. Abstracts and papers should be sent to: Daniel Schultz N8FGV by e-mail at <n8fgv@ amsat.org>.

Meteor Showers

August: Beginning around July 17 and lasting until approximately August 24, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1130–1400 UTC on August 12. A possible tertiary peak may occur around 1640 UTC. The κ-*Cygnids* meteor shower is expected to peak on August 17. The visually-impossible γ-*Leonids* is expected to peak August 25, around 0400 UTC. The α-*Aurigids* is expected to peak on August 31.

October: The *Draconids* is predicted to peak somewhere around 1030 UTC on October 8. The predicted ZHR may reach storm levels. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* is predicted to peak around 0250 UTC on November 17 . As with last year's shower, this year's peak may go largely unnoticed.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's VHF Propagation column which begins on page 63. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2008>.

The Basement Laboratory Group: A Pioneering VHF Club

Part 1—Carl Scheideler, W2AZL

Following his successful year-long series on KH6UK, Mark Morrison continues his look back at other pioneers of weak-signal VHF communications.

By Mark Morrison,* WA2VVA

The hills of northern New Jersey, bordered to the west by the Delaware River and to the east by Newark Bay, have always been rich in natural resources. History tells us that the Lene Lenape Indians first hunted and fished in these hills hundreds of year ago. In the 1800s, the rivers that cross this region supported a thriving canal system, bringing coal from Pennsylvania to the industrial centers in Paterson and Newark. Later came the railroads, transporting huge quantities of mineral ore and fueling an industrial revolution here. Hematite, an ore used in the production of iron and steel, spurred the building of factories and railroads. Copper and zinc, which were used to make wire and batteries, helped the telegraph and telephone industries grow here. Galena, an important mineral to "crystal radios" was processed into lead for batteries and other uses. Mica, which even today can be found in large sheets, became a critical component in vacuum tubes due to its electrical and thermal-insulating properties.

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Industry flourished in these hills, with names such as Edison, Marconi, RCA, and Western Electric all setting up shop. For all its natural resources, however, the greatest was that of the working class people who lived here in the first half of the 20th century. These were the people whose hard work and determination shaped the world we live in today.

With a huge technical pool to draw from, northern New Jersey played a central role in the development of amateur as well as

Photo A. Left to right: Mike Markus; unknown; John Manna, John Linse, K2HAC; Carl Scheideler, W2AZL; unknown; unknown; Benny Cembrola, WA2MTT; unknown; unknown; unknown; and Bob Henne, W2FCC.

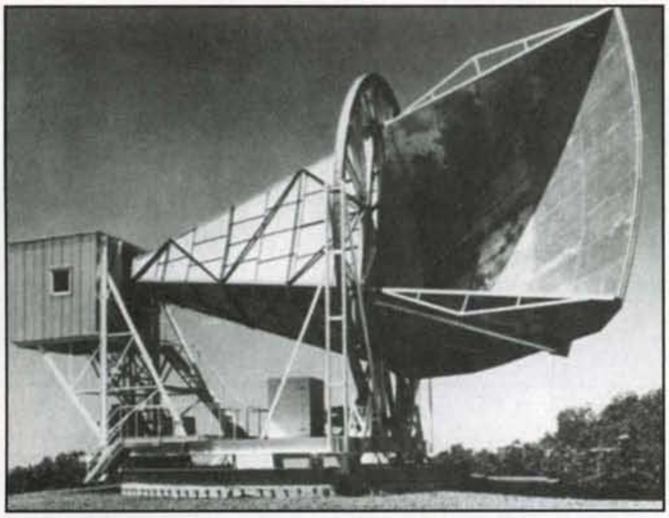

Photo B. The Holmdel horn antenna circa 1960 that was used for Project Echo. This antenna is now listed as a National Historic Landmark. (Bell Labs photo)

Operation SHOTPUT Provides V.V.F. Reflector

The first successful firing in the Operation *Shotput* series, Oct. 28, demonstrated something of the potential of these metallized balloons for reflecting v.h.f. signals. This was the first test of what will eventually be an orbiting satellite, capable of reflecting v.h.f. and u.h.f. signals over very long paths. As such it was of more than ordinary interest to v.h.f. men.

Word of the anticipated firing from Walloups Island at 1740 EST spread rapidly, and alert v.h.f. enthusiasts the length of the Atlantic Seaboard were ready for it. W4RMU, Jacksonville, Fla., W4FJ and K4EUS of the Richmond, Va., area, W4LTU, Springfield, Va., and W2CXY, Chatham, N. J., made 15-second transmissions in sequence, aiming at the anticipated trajectory of the 100-foot sphere. Nothing was heard by or from W4RMU, but all the others achieved positive results. Signals of various characteristics were reported. W4LTU heard W2CXY on some, but not all, of his transmissions, and at times noted something approximating auroral distortion on the signal. W3GKP recorded the entire test, including interesting doppler effects. K2LMG, Ithaca, N. Y., was able to copy W2CXY. Tests on 50 Mc. by W3OJU, Washington, D. C., and K2RRG, Upper Saddle River, N. J., were negative.

Three more rocket shots of this type are planned, before an attempt is made to put a balloon into orbit early in March. These will put ballons into the F_2 region of the ionosphere in a northeast trajectory, starting about 250 miles out over the Atlantic from the firing point, about 40 miles north of Norfolk, Va. Shots are planned for the last week of November, the first week of January, and the first week of February. Precise data on firing times, if available in time, will be put out on W1AW.

Figure 1. Article on Operation Shotput from November 1959 QST. *(Images in this article from* QST *courtesy of* QST *and the ARRL)*

professional communications in the years following WW II. Logbooks from the late 1940s show a spattering of VHF calls, mostly within 50 miles of each other. In those days you had to be something of a pioneer to be on VHF, as commercial equipment was not yet widely available. Before the war a typical VHF station might have been home built, but in the years following WW II, surplus equipment such as the venerable SCR-522 VHF transceiver made it possible for practically anyone with a license to get on the air.

Although commercial VHF equipment would eventually become available to hams from northern New Jersey companies such as Clegg Labs, Whippany Labs, and to a lesser extent Federal Telephone & Radio, it was helpful to know someone who happened to work for one of these companies. This was likely to happen if you belonged to one of the local radio clubs.

The Basement Lab Group

The Tri County Radio Association, one of the oldest ham clubs still in existence, became a local gathering place for numerous hams, including many notable VHF men. A small group of Tri County members with an interest in VHF radio started an informal group known as the Basement Laboratory Group, largely made up of employees of the Bell Telephone Laboratories, but open to anyone with an interest in VHF radio. Some members of this group would later play important roles in VHF radio, including many significant firsts. In this series of articles I hope to acquaint you with the members of this informal VHF group, and the roles they played in the history of amateur VHF communications.

Photo A, taken sometime in the early 1960s, shows some of the members of the Basement Lab Group . Included are some members of the Tri Country Radio Association as well as the local MARS VHF networks, both Air Force as well as Army. The location is thought to be Neptune, New Jersey. Note the classic halo VHF antenna on the bumper of the Plymouth Valiant.

The Basement Laboratory Group (BLG) was headed by Carl Scheideler, W2AZL, a talented RF design engineer who worked for Bell Labs. Carl's work is believed to have involved the microwave repeaters that were spread across the hilltops of America in the days before satellite communications. In those days both telephone and broadband television programming were distributed via microwave relay towers spaced 30 to 50 miles apart and using specially designed horn antennas. The low-noise amplifiers and traveling-wave-tube amplifiers developed for use in these towers would later be used in the satellite ground stations that ultimately replaced them. An upscale version of the repeater horn antenna (photo B) was used to track the Echo satellite, a metalized balloon recognized as the first (passive) communications satellite, although experiments of this nature were conducted by BLG members as early as 1959 (see figure 1).

In later years, this antenna would be fitted with the lowest noise receiver of the era, the newly developed MASER. The extreme sensitivity of this type of receiver, coupled with the unique ability of this horn design to distinguish weak satellite signals (Telstar used only a 3-watt transmitter) from naturally occurring background noise, eventually led scientists to discover evidence of the primordial Big Bang, but that's another story. Suffice it to say that Western Electric, the manufacturing arm of parent

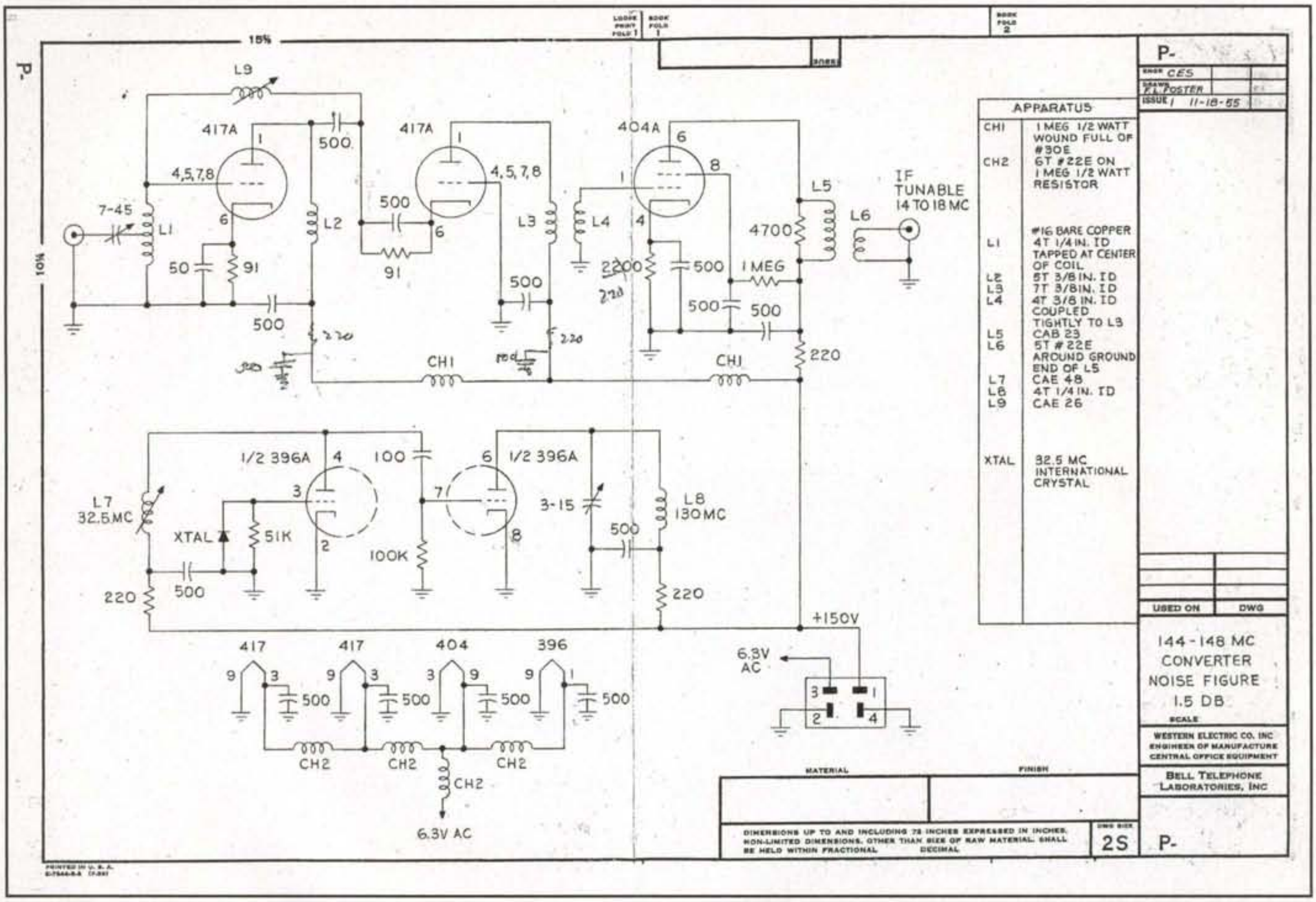

Figure 2. The original Bell Labs schematic dated 1955. Note Carl's initials "CES" in the upper right-hand corner.

company AT&T, spared no expense in doing things right and has long been recognized for high-quality components with exceptional performance. Even today, Western Electric audio amplifiers that were designed for use in public-address systems and movie theatres in the 1950s are highly prized by hi-fidelity collectors, with staggering prices paid for even simple examples. In the midst of this entire advanced engineering, it is no surprise that Carl would find one Western Electric component, the 417A planar triode, to be an ideal component for an amateur VHF converter.

The W2AZL Converter

At a time when VHF equipment could transmit farther than it could receive, largely due to the poor noise figure of commercially available equipment, having a low-noise converter that could be used with the best HF rigs of the day was a blessing to weak-signal operators. In the early 1950s Carl created his first low-noise 2-meter converter based upon the

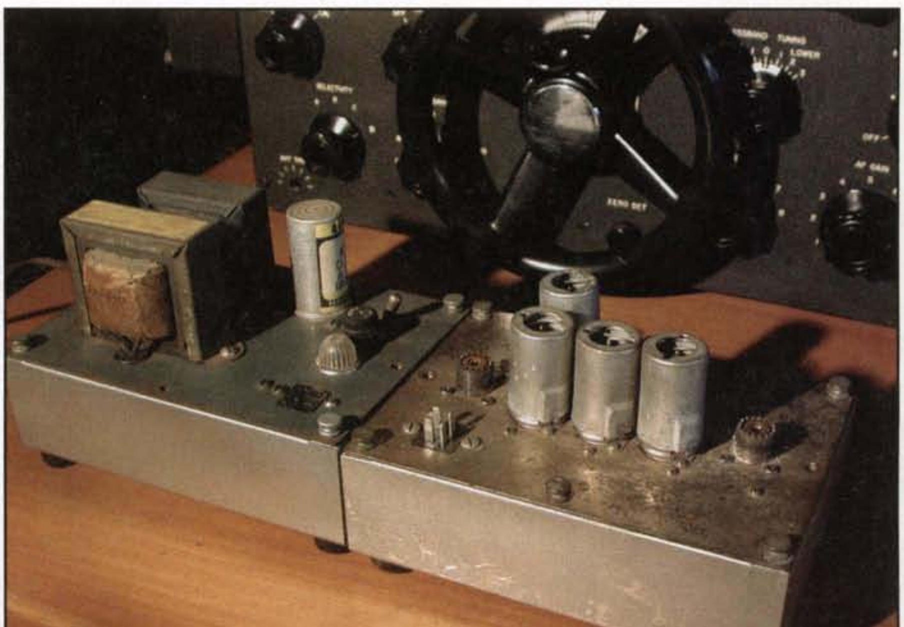

Photo C. The W2AZL converter (right) with a matching power supply (left).

Western 417A. Figure 2 is an original Bell Labs schematic dated 1955 and shows Carl's initials "CES" in the upper right-hand corner.

Popularly referred to as the "W2AZL converter," Carl's design became a mainstay for many weak-signal operators well into the 1960s. Photo C is a picture of the converter (right) with a matching power supply (left). This equipment was used with the Collins 75A4 receiver in the background as part of the W2CXY meteor-scatter station throughout the 1950s.

Not only was this converter easy to build, but the open-chassis design facilitated simple modification as well. In the late 1950s versions of this converter were used on 6 meters as well as 108 MHz, the latter being the frequency assigned to United States satellites launched during the International Geophysical Year (IGY). By one account, this converter was even used in

Photo D. A seldom seen and unique variation of the W2AZL converter, one using the rare Western Electric 416B triode, a tube designed for operation up to 4 GHz.

A Two-Meter Converter with a Noise Figure Under 2 Db.

Optimum Performance in an Easily Duplicated Design

BY C. E. SCHEIDELER, W2AZL*

Some ten years ago I became interested in investigating propagation at very high frequencies. In deciding which band to use, consideration was given to the availability of efficient high-power tubes for transmitters, the possibility of constructing a stable sensitive receiver, and the practicability of making a high-gain antenna of reasonable size, keeping in mind that it had to be erected in any average-sized back yard. The 144-Mc. band looked as if it would satisfy the requirements.

The first project was to build a stable low-noise converter to work into a communications receiver. A survey of low-noise amplifier circuits and tubes was made and it was decided to use the "Wallman Cascode" circuit in conjunction with 417A triodes. The 417A was designed for broadband preamplifier service at 70 Mc. It has a transconductance of between 20,000 and 30,000 micromhos and is ideally suited to v.h.f. work.

When the first work was done with meteor scatter on 144 Mc. some years ago, all four participants, W2UK, W4HHK, W2NLY and W2AZL, used similar converters. This design, the work of W2AZL, has since been duplicated widely, from instructions and drawings similar to those presented here. Today the "W2AZL Converter" is practically standard equipment for v.h.f. men who want the best obtainable sensitivity on 144 Mc. Converters of this type were in use at both ends of the record-breaking 144-Mc. QSO across the Pacific, made in 1957 by KH6UK and W6NLZ. If a signal can be heard on your antenna, you can hear it with this converter.

Figure 3. Excerpt from December 1959 QST *showing the introduction of the W2AZL converter.*

2-METER STANDINGS

Figures are states, U. S. call areas, and mileage to most distant station worked.

W1REZ	29	8	1175	W5ONS	9	3	950
W1AZK	24	7	1205	W5FEK	8	2	560
W1RFU	22	7	1120				
W1OAX	22	6	800	W6NLZ	12	4	2540
W1AJR	21	7	1130	W6DNG	9	5	1040
W1HDQ	20	6	1020	W6AJF	6	3	800
W1MMN	20	6	900	W6ZL	5	3	1400
W1IZY	19	6	875	W6MMU	3	2	950
W1AFO	17	6	920				
W1ZJQ	17	6	860	W7VMP	11	5	1280
W1CLH	17	5	450	W7JRG	6	3	1040
K1ABR	16	6	810	W7LHL	4	2	1050
W1BCN	16	5	650	W7JIP	4	2	900
W1KHL	16	5	570	W7JU	4	2	353
W2CXY	37	8	1360	W8KAY	38	8	1020
W2ORI	36	8	1250	W8WXV	35	8	1200
W2NLY	35	8	1390	W8LOF	33	8	1060
W2AZL	28	8	1050	W8PT	32	8	985
K2GQI	27	8	1000	W8SVI	30	8	1080
W2BLV	25	8	1020	W8SFG	30	8	1000
K2IEJ	24	7	1060	W8LPD	29	8	850
W2DWJ	23	6	860	W8EHW	28	8	860
K2HOD	23	7	950	W8WRN	28	8	680
W2AMJ	22	6	960	W8BAX	27	8	960
W2SM	22	6	940	W8DX	26	8	720
K2CEH	21	8	910	W8ILC	25	8	800
W2LWI	21	6	700	W8JWV	25	8	940
W2RXG	20	6	700	W8NOH	21	8	975
W2UTH	19	7	880	W8LCY	21	7	610
W2RGV	19	6	720	W8BLN	21	7	610
K2RLG	17	6	980	W8BLN	18	7	780
				W8GTK	18	7	550
W3RUE	30	8	975				
W3GKP	29	8	1020	W9KLR	39	9	1160
W3KCA	28	8	1110	W9WOK	39	9	1150
W3TDF	28	8	915	W9GAB	32	9	1075
W3SGA	26	7	700	W9REM	31	8	850
W3FPH	22	8	1000	W9AAG	30	8	1050
W3NKM	20	7	730	W9ZIH	30	8	830
W3LNA	20	7	720	W9EQC	26	8	820
W3LZD	20	7	650	W9ZHL	25	8	700
				W9BPV	25	7	1030
W4HJQ	36	8	1150	W9PBP	23	8	820
W4HHK	35	9	1280	K9AQP	23	7	780
W4ZXI	34	8	950	W9LF	22	7	825
W4AO	30	8	1120	W9KPS	22	7	690
W4MKJ	28	8	850	W9PMN	19	6	800
W4UMF	27	8	1110	W9ALU	18	7	800
W4VLA	26	8	1000	W9JIY	17	8	790
W4JCJ	23	6	725	W9LEE	16	6	780
W4EQM	22	8	900	W9DDG	16	6	700
W4WNH	22	8	800	W9DSP	15	6	720
W4OLK	20	6	720				
K4EUS	19	6	710	WØSMJ	27	8	1075
W4CPZ	18	6	650	WØIHD	27	7	890
W4TLV	18	7	1000	WØBFB	27	8	1060
W4RFR	18	7	820	WØGUD	25	7	1065
W4MDA	17	6	650	WØRUF	23	7	900
K4YUX	16	8	830	WØINI	21	6	830
W4CLY	15	5	720	WØUOP	21	7	900
W4RMU	10	5	860	WØTGC	21	7	875
W4LNG	10	5	800	WØZJB	18	7	1180
W4KCQ	10	4	860	WØRYG	17	6	925
W4GIS	9	2	335	WØIFS	16	6	1100
				WØJHS	13	5	700
W5RCI	33	9	1215	WØIC	12	5	1240
W5DFU	25	9	1300				
W5AJG	22	8	1280				
W5JWL	21	7	1150	VE3DIR	28	8	1100
W5KTD	20	8	1250	VE3AIB	26	8	910
W5LPG	19	6	1000	VE3BQN	19	7	790
W5ML	15	5	700	VE3AQG	17	7	800
W5PZ	14	6	1255	VE3DER	16	7	820
W5FSC	12	5	1390	VE2AOK	13	5	550
W5HEZ	12	5	1250	VE3BPB	14	6	715
W5CVW	11	5	1180	VE7FJ	2	1	365
W5NDE	11	5	625				
W5VY	10	3	1200	KH6UK	1	2	2540

Figure 4. From October 1958 QST *"The World Above 50mc" column, this shows the W6NLZ to KH6UK contact.*

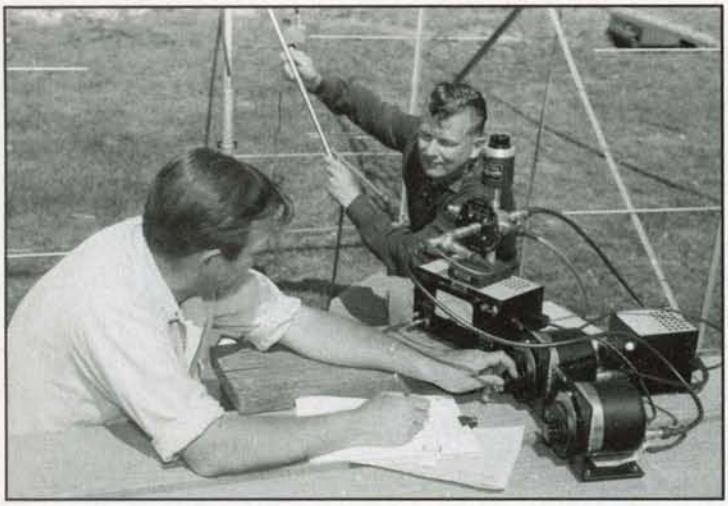

Photo E. Carl, W2AZL, assisting Walt Morrison, W2CXY, with his 2-meter array in 1956.

Photo F. This is another picture of Carl, W2AZL, at the controls. Note the slide rule in the foreground.

the Search for Extraterrestrial Intelligence (SETI)! Photo D is a rarely seen and unique variation of this converter, one using the rare Western Electric 416B triode, a tube designed for operation up to 4 GHz!

Carl distributed plans for this converter to interested parties throughout the 1950s, and even got help building and distributing them from his friend Walt Morrison, W2CXY. Eventually, Carl published a complete set of plans in the December 1959 issue of *QST* (see figure 3). Note the sidebar that gives some history on this type of converter.

Meteor Scatter

As hams started building these converters or buying similar products from Tecraft, Tapetone, and others, the range of amateur VHF communications expanded considerably. No longer limited to contacts just tens of miles away, reliable QSOs could now be made with stations hundreds of miles away. Aurora contacts accounted for many of the early VHF DX records, but when BLG associate Ralph "Tommy" Thomas, W2UK, and Paul Wilson, W4HHK, first demonstrated that meteor scatter was a viable alternative to aurora-caused propagation, it soon became possible to work stations a thousand miles away. The predictability of meteor showers also meant that operators could arrange schedules well in advance, as opposed to the unpredictable nature of aurora activity. Carl teamed up with Walt Morrison, W2CXY, as his local aurora and meteor-scatter partner, often working distant stations together and alerting one another to DX openings in progress. Both succeeded in making impressive strides in both distance worked and the number of stations contacted.

Moonbounce

In 1955, when BLG associate W2UK moved to Hawaii, the "basement engineers," as Tommy used to refer to them, would gather at Carl's QTH in Plainfield, New Jersey on most Thursday evenings. Although the purpose of these meetings was to keep in touch with Tommy, they also provided an opportunity to talk shop and simply enjoy one another's company. One topic of interest was moon-reflection work, or simply "moonbounce." When Tommy moved to Hawaii, he expressed interest in using this mode to talk to his "basement friends" back east. Having just opened the doors to meteor-scatter work, Tommy's interest in moonbounce was expected to have similar results. Carl and Walt spent many weekends fine-tuning their meteor-scatter arrays in hopes of also using them for moonbounce. Photo E shows Carl assisting Walt Morrison with

Photo G. Gathered at a luncheon honoring Dick Turrin, W2IMU, are members of the Eastern VHF/UHF Conference. Dick received a plaque for his work in UHF communications. Seated around the table (left to right) are Dick Turrin, W2IMU; Ed Chinnock, W2FZY; Roger Abson, WA2AHW; Pete Arnold, WA2DMT; Bill Legg, W2VE; Carl Scheideler, W2AZL; Vic Colaguori, W2OMS; and Bob Buus, WA2HVA. Tony Rustako, K2KII, is behind the camera. (From November 1975 QST*)* the W2CXY 2-meter array in 1956. Photo F is another picture of Carl at the controls. Note the slide rule in the foreground.

Other Activities

Affectionately known as "Pappy," Carl was revered for his engineering knowledge and willingness to share it with others. Already well known for his low-noise converter designs, Carl's recommendations were soon recognized by the Heathkit Company, which approached Carl for help with some of its products. As a result of this, Heath rewarded Carl with some free equipment.

Carl and many of the Basement Engineers were also active in the Military Affiliate Relay System (MARS). It was through MARS that top-of-the-line HF receivers, such as the Hallicrafters R-274 and Hammarlund SP-600, could be obtained as military surplus. The stability of these receivers allowed their use as the IF stage for Carl's 2-meter converter. Just as important to the VHF operator were military VHF transceivers such as the SCR-522 and AN/ARC-1, which were also available through MARS. Carl and Walt belonged to the MARS Army VHF Net 10.

Carl also made an effort, perhaps more so than many others, to attend the various VHF conventions around the country, including the "First Moonbouncers Convention" in 1962. Also in attendance were BLG associates John Linse, K2HAC, and Bill Ashby, K2TKN, as well as extended members Tony Sheppard, VE3DIR, and Lawrence Lewis, W2ALR.

Photo G shows Carl (waving) at another meeting, that of the 1972 Eastern VHF/UHF Conference honoring Dick Turrin, W2IMU. Dick was another Bell Labs employee and was well known for his series of moonbounce notes commonly referred to as the "Crawford Hill Technical Notes." That's the same Crawford Hill where Karl Jansky, another Bell Labs employee, first discovered radio waves of extraterrestrial origin in 1931, thus opening the door to radio astronomy.

At the July 1973 Central States VHF Society conference Carl was elected vice president of the Central States VHF Society for its 1974 conference, which was held in Boulder, Colorado. While driving to the 1976 CSVHF Society conference in Houston, Texas, Carl talked about one day using phased vertical whips on the roof of the car to automatically tune in the strongest signal. Curiously, Carl shares a patent on "laminated conductor directional arrays," as shown in figure 5, from 1958.

1296-MHz Moonbounce

Although Carl and Walt had sizeable stations and often talked about moonbounce, it wasn't until Carl moved to Holmdel, New Jersey in the early 1960s that things got serious. In 1962 Carl and a few others assisted Walt in building the first 1296-MHz moonbounce station in New Jersey, and one of only three in the world at that time. In April 1962 W2CXY became only the third station in history to bounce a 1296-MHz signal off the moon to be heard by others. Sam Harris, W1FZJ, remarked that this was the first signal he'd heard off the moon since the first-ever moonbounce QSO with W6HB

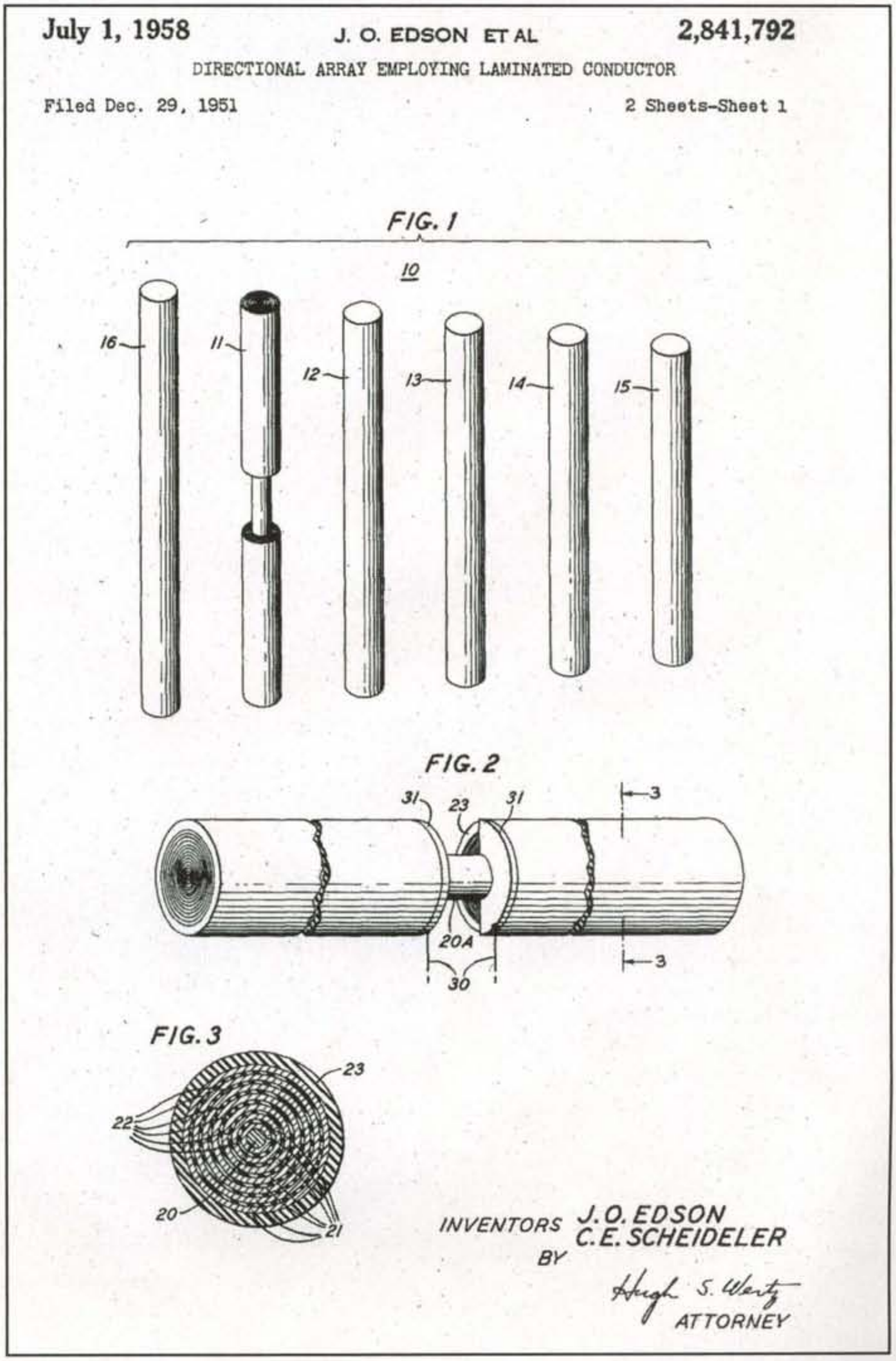

Figure 5. The 1958 patent drawing of the Directional Array Employing Laminated Conductor.

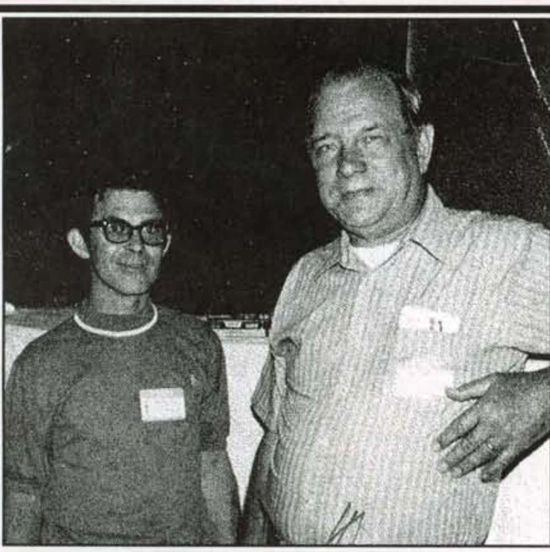

Photo H. Carl, W2AZL, with John Fox, WØLER, his partner in their historic first-ever 432-MHz meteor-scatter QSO. (From October 1972 QST*)*

in 1960. Carl's ubiquitous low-noise converter was part of that station, at least in one variation.

Even though Walt and Tommy had move up to 1296 MHz, Carl never really left 2 meters, but did give 432 MHz a try. In 1972 this decision paid off big as Carl and John Fox, WØLER, completed the first-ever meteor-scatter contact on 432 MHz. Photo H shows Carl with 432 meteor-scatter partner WØLER in 1972.

When Ralph "Tommy" Thomas returned from Hawaii in 1964, he settled in Colt's Neck, New Jersey, not far from Carl's QTH in Holmdel. Tommy and Carl apparently partnered with Herbert Power, WA2WOM, using a 2-meter array consisting of four log-periodic antennas, quite modest in comparison to some of the Long John arrays commonly used in the 1950s. This array led to Carl's 2-meter moonbounce success, first with the 150-foot dish of Stanford University (WA6LET) and later with Bob Sutherland, W6PO.

Summary

In later years Carl would attend lunch meetings with long-time BLG associates Ed O'Connor, K2TKN, Walt Morrison, W2CXY, and a few others. The highlight of these lunches was an occasional invitation to visit the Bell Labs Holmdel facility where Carl worked in order to see what Carl was working on. One such visit made by Walt was recorded on audio tape in the 1970s and reveals that Carl's work at that time involved cryogenics. More recently, the historic Holmdel facility was sold to a developer with plans to tear it all down. This would be a sad end to the building where so many of the world's greatest discoveries were made.

I remember Carl as a good friend, not just to my father, but to everyone who knew him. He was a true gentleman, with a friendly voice and a great sense of humor. Perhaps the most amazing thing about Carl was how modest he was. When others showed interest in setting new records, Carl was there to help, always putting his friends' goals before his own. His classic 417A converter may be remembered for getting so many amateur radio operators on 2 meters. However, his work as an avid VHF person and friend to so many hams will be his lasting legacy.

BIG BLUE Projects: One Student's Perspective

The spring issue of *CQ VHF* focused on the BIG BLUE flexible-wing project. Chandler explains what his involvement has meant to him both as a student and in his profession.

By Garrett Chandler,* KY1GDC

It is astounding the effects that volunteering a little extra time to work on an extra-curricular school project can have on someone. What started as a class project turned into much more than that—both for the remainder of the semester in which I first got involved, as well as for the time that has passed since then. There is no doubt that the BIG BLUE project has had a lasting effect on me personally and professionally.

It all began when I was taking an elective electrical engineering course in microcomputer systems design at the University of Kentucky. At the time I was working on my Masters of Science degree in Biosystems Engineering. A project-based class, the nucleus of our activities was a project in its second year—BIG BLUE. Our task was to design and construct the control and communication systems to enable the high-altitude test scheduled for less than four months from the first day I learned of the project.

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It was daunting, to say the least, but the excitement of being involved in something as great as this project promised to be was too much to pass up.

Before long I was put in charge of leading the design of the airborne system architecture. Working closely with the software development team once the hardware had been completed, I was able to learn an immeasurable amount about software design and engineering in a team environment. Before it all was said and done, those volunteered hours turned into 12-hour blocks at a time. As a team we consumed many liters of Mountain Dew soda, and on more than one occasion the sun rose before we left the campus.

In brief, what emerged from the other end of our development cycle was a multiprocessor system with some good-enough checks and balances to ensure the highest chance of success. A mix of three processors served as the auto pilot to the aircraft, master system controller, and a system supervisor, respectively.

Members of the design team after presenting a design review to top-level engineers at ILC, Dover. (Photos courtesy of the author)

The three-processor, two VHF radio, redundantly powered system is packed into the fuselage for the trip to space.

Garrett Chandler, KY1GDC, brushes up on the TH-D7A manual before heading out into the field for the BIG BLUE launch.

Testing of and adjustments made to the BIG BLUE system late into the night the day before launch.

This electrical spine controlled high-pressure inflation valves, servos, a parachute deployment system, high-current control of the video transmitter, and a ballistic cutter. All very fun stuff! In addition, we chose to use something new to me for our communication systems—amateur radio.

I had never heard of this amateur radio stuff before. As I learned more and more, I realized that I was missing out on a ton of fun. To officialize and legalize my involvement I was in need of an amateur radio license. Some studying and a few multiple-choice questions later and the callsign KI4IHG was mine.

The aircraft design ended up with two communication radios—Kenwood TH-D7s, to be specific. Those built-in TNCs saved us quite a bit of weight. One of these was used for bi-directional communication with the ground station and the other was dedicated to beaconing the reports coming from a GPS receiver.

In addition to all the design, development, bench testing, and flight testing that went on in the lab and just outside the back door, the project afforded many more great experiences. Over spring break of that year, I gave my buddies who were headed to Panama City and South Padre a pat on the back and jumped into the vehicle with the BIG BLUE crew and headed to Kitty Hawk, North Carolina. Instead of lollygagging around on warm sandy beaches that year, about 15 of my newfound friends and I spent our break flight testing our systems on the cold and breezy dunes on which Orville and Wilbur Wright toiled away exactly 100 years prior.

That trip to Kitty Hawk was just a few weeks after a similarly momentous occasion. In order to get some constructive criticism on our design, a few of us traveled to Dover, Delaware, where we presented content from our CDR (critical design review) to engineers at ILC Dover. It was an honor and a privilege (and a little intimidating) to stand in front of the same engineers who had designed the airbags for the Mars landers which had seen use in the Spirit and Opportunity missions just weeks before. It was an incredible experience.

My first involvement in the project culminated in the high-altitude flight test in Colorado on May 1st that year. All of the student-designed systems worked flawlessly. It was the premature failure of the weather balloon from which we got a tow that put us off course and prematurely ended the experiment. In spite of that disappointment, much was still gained from the trip. For me, a highlight was being the operator-in-charge at the "roving" ground station. (Three ground stations were used for the experiment: the primary at the launch site, the mobile under the predicted peak altitude for the mission, and the roving station at the anticipated touchdown point and the place where the flight test was to occur.) The position at the helm was afforded to me because by that time I was a card-carrying amateur radio operator.

After my first dive into the BIG BLUE project I continued my involvement in subsequent years by serving as a student advisor to the project and later as an external reviewer during

Ground tests of the electronics, radios, and wing system on the dunes of Kitty Hawk, North Carolina. The ground crew is visible in the lower left of the photo.

Next stop, the edge of space. BIG BLUE II at T+4 seconds (wings folded inside the fuselage).

the design review cycles. However, those follow-on experiences were minuscule in comparison to the path my initial involvement launched me on. For starters, it sold me on the fact that I really needed to add a Masters degree in Electrical Engineering to my repertoire. And beyond that, it paved the way for an even larger project—KySat.

It was my involvement and leadership within the BIG BLUE program that put me in the running and eventually scored me the seat as project leader and system architect for a statewide student program to design, build, launch, and operate a satellite. As of now, KySat1 is in the final test stages before being put in the launch queue later this year. It will enable students across the state of Kentucky and the world to "play" with a spacecraft with the goal of instilling within them a sense of excitement about science and engineering. Communication and command of the craft will be open to amateur radio operators using VHF HTs signaling the system with DTMF tones. Data is exchanged with the satellite via typical satellite operator stations using common AFSK at 1200 baud. Standard APRS-compatible beacons also periodically report status and health of the system. My involvement in the project also motivated me to get a vanity callsign to be used onboard, KY1GDC.

In December 2007 I completed my M.S. program in electrical engineering, and a few short weeks ago I began the search for my next hill to climb. As I speak with both up-and-coming tech startups and the big aerospace companies, it is my extra curricular activities that started with BIG BLUE they all want to hear more about.

What started out as volunteering a little extra time turned out to be much more. Much, much more time volunteered; much, much more gained. Every second invested continues to pay huge dividends in terms of the doors that have been opened and the opportunities afforded. I look forward to the next challenge and hope that I can someday repay the amateur radio community for all that it has given me. ■

The chase team poses with BIG BLUE II at the recovery site. Members of the team, Edge Of Space Sciences, and a film crew enjoy the moment.

ARISS Inspires A New Generation of Hams

The ARISS program continues to provide students around the world with exposure to amateur radio communications. N8MS tells the story of his Earth Science students in Coloma Junior High School in Michigan.

By Matt Severin,* N8MS

Ham radio has been a part of my Earth Science instruction since 1997, when I was first licensed in Virginia. My teacher-mentor and Elmer, Jim McCloud, KU4C, encouraged me to get my license because it had many applications in the Earth Science classes we both taught. Jim explained that with ham radio the students could get local and national weather updates, learn about the electromagnetic spectrum, and even communicate with one another while on field trips. Ham radio is an excellent tool to bring into the classroom and make science real!

In early 2006, astronauts aboard the International Space Station (ISS) released an old Russian Orlan spacesuit with a ham radio transmitter and internal sensors to measure temperature and battery power. SuitSat, as it was called, was designed to transmit its condition to the ground and the message could be heard using ham radios or VHF scanners. I thought this would be a great way to introduce my Astronomy class unit (I now teach at Coloma Junior High School, in Coloma, Michigan), so I brought a small handheld radio to class with the hopes of hearing SuitSat as it flew over Michigan. Although I wasn't successful in hearing the satellite, my class did happen to catch a conversation between a school in Canada and the astronauts aboard the International Space Station.

Hearing the QSO while at school inspired me to look into contacting the ISS. A few years back I had tried to work the space station, but was never successful. Looking back, I realized that all of my attempts were too late in the day, and the astronauts were probably sleeping.

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A total of 13 Coloma students have spoken to astronauts aboard the International Space Station.

After some online research, I learned that astronaut Bill McArthur was very active on the ham bands, and the chances of working the ISS were good. With a modest station consisting of a Radio Shack HTX-212 transceiver and a homemade 2-meter copper cactus antenna stuck in a bucket of sand on the roof of the school, I started monitoring the ISS downlink frequency of 145.800 MHz. As luck would have it, March 21, 2006 was a scheduled rest day for the astronauts on the ISS, and Bill McArthur, KC5ACR, began a marathon of ham radio contacts using the callsign NA1SS.

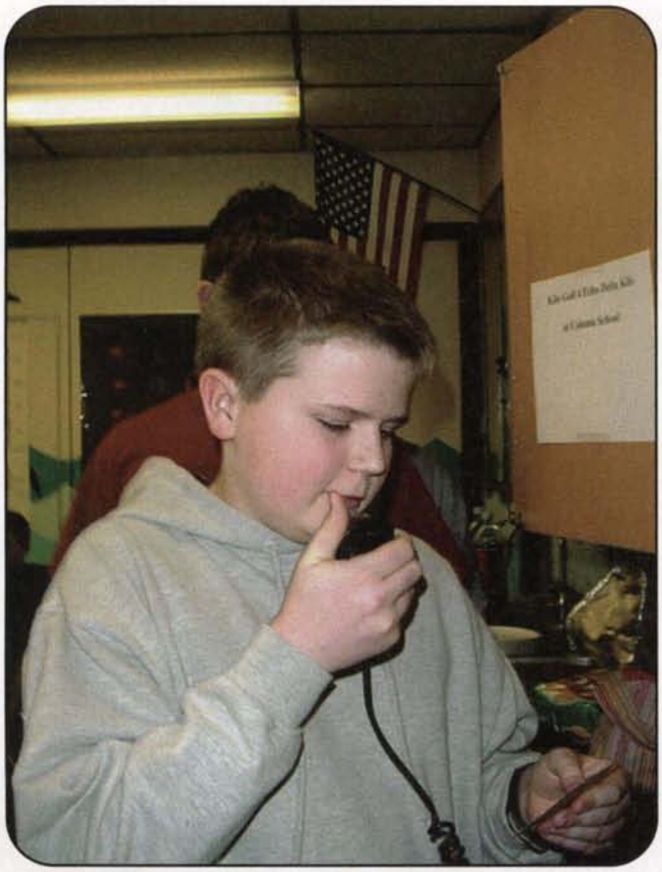
From 16:50 to 16:54 UTC (11:50 to 11:54 AM local time), 24 students in my fourth hour Earth Science class listened in on a short conversation between Bill McArthur and me. I was using my previous callsign, KG4EDK, at that time. When astronaut McArthur asked if any of my students were with me, 24 faces lit up with broad smiles as the students realized this was real: An astronaut 220 miles overhead was asking about them! McArthur stated, "We sure think Earth Science is important ...we live it every day as we observe the Earth, and it's truly spectacular." The conversation ended with a motivational greeting from the International Space Station when Bill McArthur encouraged Coloma students to "... get the best education [they] can ..."

Later that afternoon 13 more students had the opportunity to not only listen in on a conversation, but also participate in a contact! About 15 minutes before the

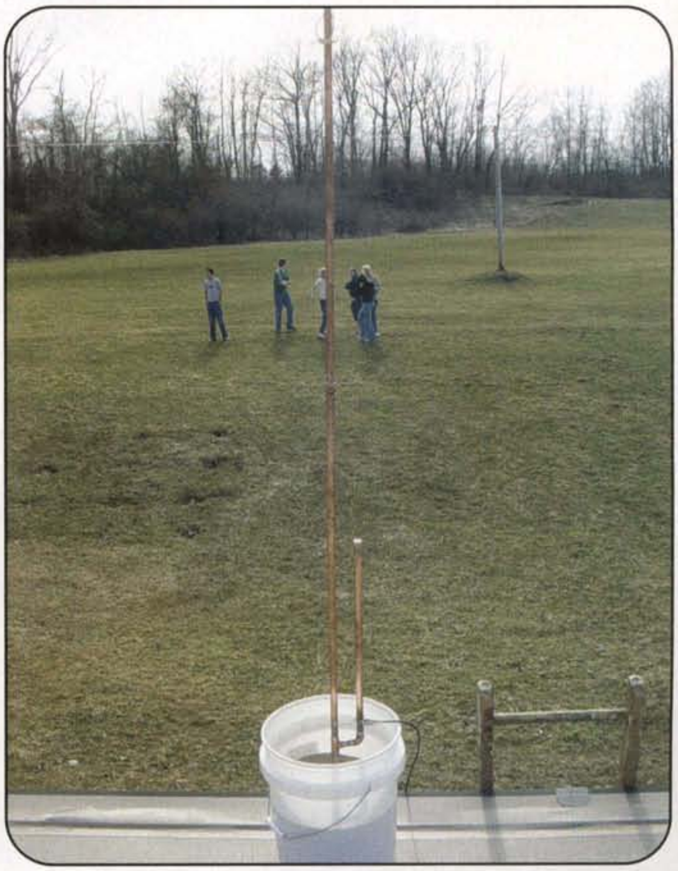
Since July of 2006, many of the Coloma students have earned their Technician license.

scheduled pass, I greeted my students with a note card and a task: Write down a question that you would ask an astronaut if given the opportunity. I established contact with the ISS at 19:58 UTC (2:58 PM local time) and passed the microphone to the first student, Monica, who asked, "What is the food like?" No one could keep a straight face when the microphone was passed to him or her. Even I had sore cheeks after the contact from smiling so much. In the end, each student who wanted to asked his or her question, and astronaut McArthur answered in great detail. McArthur described some of his daily activities, his favorite food (lamb with vegetables), and the level of education required to become an astronaut. The contact ended at 20:08 UTC (3:08 PM local time) as Bill McArthur's final transmission to Coloma Junior High School faded into the static.

"The students were really excited about the contact," said assistant principal Dave Ehlers. "My daughter ran down to my office to tell me that her class talked to the International Space Station." When asked if I had been trying to contact the station for awhile, I replied, "...well, actually no. I knew the opportunity was there, I had the right equipment, and I guess I got lucky." I added, "Never in my wildest dreams did I think I'd be able to provide this opportunity to my students. This was the ultimate teaching moment ... I couldn't let it pass by."



Nathan Conrad, KD8FFT, was inspired to get his amateur radio license after talking to Bill McArthur, KC5ACR, aboard the ISS.



A homemade 2-meter copper cactus antenna stuck in a bucket of sand on the roof of the school. (All photos courtesy of the author)

As a result of working the ISS, four of my students earned their Technician Class licenses and became active in the local ham community.

Exactly six months later, I was again able to work the International Space Station from my classroom. While students were not able to actually talk to the astronauts, they were very excited to hear me talking to Anousheh Ansari, space participant, as the ISS soared over southwest Michigan. Ms. Ansari commented that she was very excited to talk to a school, especially since it was not a scheduled contact! A few days later, just before Ms. Ansari was to return to Earth, I was able to contact her one more time, this time with a different group of students. Coloma Junior High School was buzzing with excitement!

Later that semester, the Blossomland Amateur Radio Association (BARA) of Saint Joseph, Michigan offered a Technician class, and another five students from Coloma schools took and passed their Technician tests, making the number of new hams from Coloma schools nine. Currently seven more students are studying to take the Technician test, and three of the original nine plan to upgrade.

I'm very excited to see so much interest in amateur radio. There are so many opportunities for students who are involved in ham radio. Who knows? This may have sparked an interest in a student that he or she didn't even know existed!

Currently, I have worked the International Space Station four times from school with a total of 13 students actually talking to an astronaut aboard the ISS. I have started a new ham radio youth club, the Blossomland Youth Amateur Radio Club (W8BYC), and hope to see more students become involved in ham radio. Thanks to the Victor C. Clark Youth Incentive grant from the ARRL Foundation, I have been able to purchase radio equipment for use in the classroom.

While it's very exciting for me to work the ISS, it's even more fulfilling to see my students have an opportunity like this. As stated before, this was the ultimate teaching moment. I'm always looking for special opportunities for my students. I'm a teacher because in my heart I truly believe that it's all about the kids!

Visit the Blossomland Youth Amateur Radio website at: <http://www.w8byc.com>. You can listen to the astronauts' replies to me and my students at: <http://www.w8byc.com/ISS.html>. ■

By Bob Witte,* KØNR

FM

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

Report from Dayton

Photo 1. Jim McClellan, N5MIJ, speaks to a packed crowd at this year's Dayton Hamvention® D-STAR Forum. (All photos by KØNR)

The Dayton Hamvention® is the "big one," held in Dayton, Ohio in May and sponsored by the Dayton Amateur Radio Association (DARA). I was fortunate enough to attend the event again this year, and here is a report on some of the things I saw, with a VHF emphasis.

D-STAR Action

The VHF/UHF digital modulation format known as D-STAR continues to generate a high level of interest in the ham radio community. The D-STAR forum at Dayton was packed with attendees, even though it was held in one of the larger conference rooms. The forum was moderated by Greg Sarratt, W4OZK, with the Alabama D-STAR Group.

One major theme of the forum was the strong growth in D-STAR systems and users. According to Jim McClellan, N5MIJ, the number of D-STAR users showing up on the system has gone from 534 to 2400 in the past year (photo 1). The daily usage of gateway-connected D-STAR machines has gone from 100 users per day to 700 users per day. These numbers are small when compared to the total number of licensed amateurs, but they are growing at a very fast rate. To see the level of activity yourself, go to the D-STAR Users website listed in the References section of this column. This site has a real-time listing of stations active on D-STAR and plots of usage statistics on the D-STAR network.

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Photo 2. ICOM display of D-STAR handheld radios.

Photo 3. The AMSAT booth at Dayton had the usual AMSAT material and volunteers to answer questions about operating via satellites.

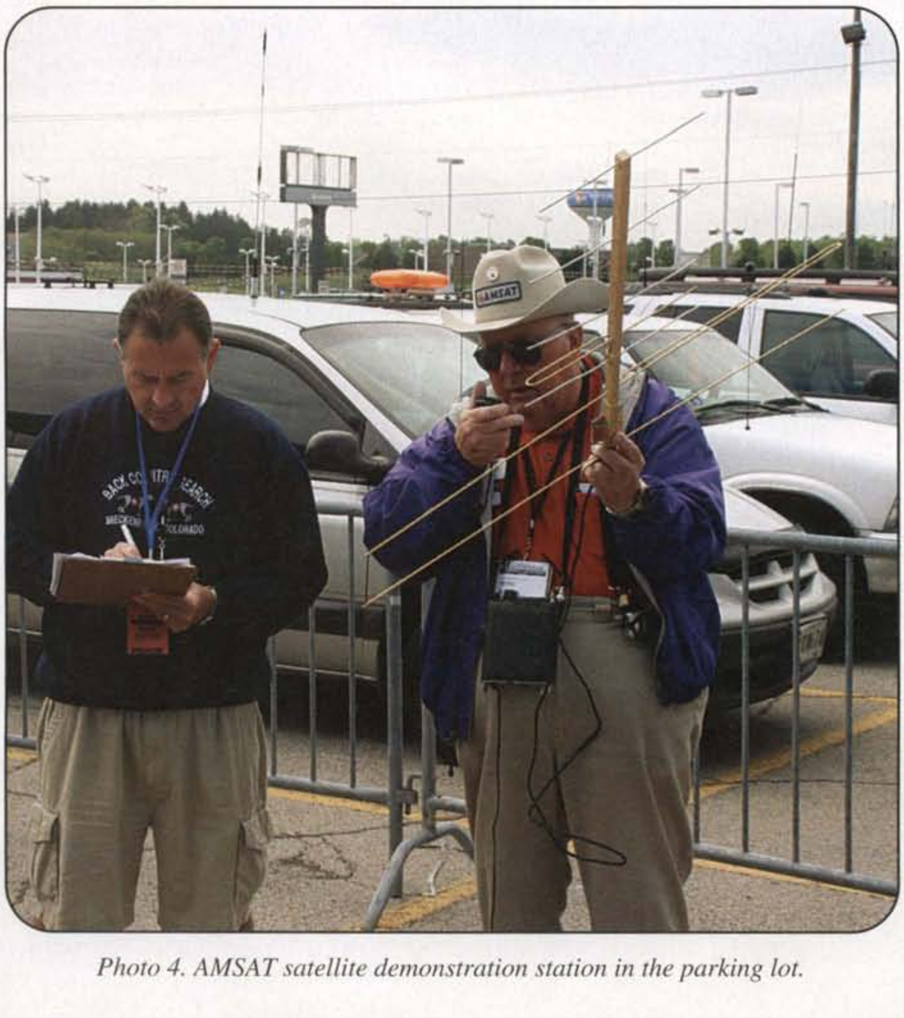

Photo 4. AMSAT satellite demonstration station in the parking lot.

Another key theme of the D-STAR forum was user education. D-STAR technology employs new methods of signal routing that your typical repeater user will need to learn. I won't go into great detail here, but I'll give you a rough idea of how the system works.

Each radio is programmed with four callsigns: MYCALL, URCALL, RPT1, and RPT2. MYCALL is the callsign of the radio user—that is, I program my radio with my call. URCALL is the radio amateur being contacted; it is the "other ham" in the QSO. You can enter a specific callsign as URCALL or use CQCQCQ to make a general call. RPT1 is generally the callsign of the repeater you are using locally, and RPT2 is a remote repeater. (This reminds me of programming an AX.25 packet TNC with your call and digipeater routing information.) There are a number of details that must be configured just right for the message routing to work, and I don't think anyone claims that this is obvious. It requires some learning on the part of the user, and you'll notice D-STAR system owners spending time educating their local radio community.

Most users are going to want to carefully set up their radios with the aid of programming software and use the memories to configured different callsign routing settings. Then flipping through

Photo 5. Carole Perry, WB2MGP, leads the Youth in Amateur Radio forum.

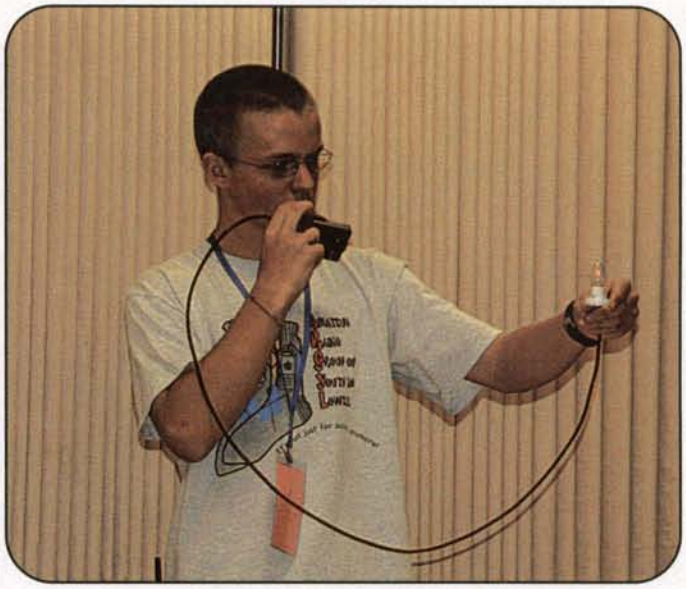

Photo 6. Ben Veltman, KD8GBY, of the ARGYL team demonstrating a light bulb used as an HT antenna.

memories will let the user call the right radio amateur or repeater system. With analog FM repeaters, the user has to select the right frequency, the right transmit offset, and (often) the right CTCSS access tone. Some users find this to be a challenge. With D-STAR you can forget the CTCSS tone, but you'll also need to set up URCALL, RPT1, and RPT2 to get the right thing to happen. (MYCALL generally will just stay the same on a particular radio.)

There is no question that D-STAR really is a different animal, and it requires some learning on the part of repeater users. This is typical of new technology entering ham radio and is a fun part of the hobby. The D-STAR presentations given at Dayton are available on the ARRL Alabama Section website (see References), including information on the callsign settings. If you are interested in this technology, take some time to review those files.

One important development is that some technically-minded hams have reverse-engineered the D-STAR protocol, including specific ICOM implementation details. Robin Cutshaw, AA4RC, touched on this briefly in his presentation and a portion of his talk is available on youtube.com (see URL in References). One product that came out of this work is the DV Dongle, which enables a PC user to converse via the D-STAR network. Yes, that's right: You can be sitting at your PC working radio hams on your favorite D-STAR repeater. This development shows that others (besides ICOM) can create products that conform to the D-STAR protocol and work with D-STAR radios and repeaters.

Inside the Hall

AMSAT was very visible at the Hamvention® with its large booth, AMSAT forum, and satellite demonstrations in the parking lot *(for more details on AMSAT at Dayton, see the "Satellites" column by Keith Pugh, W5IU, elsewhere in this issue—ed.)*. At the booth in the Hara Arena were the usual AMSAT trinkets and a model of the Eagle satellite under development (photo 3). Also on display was the Software Defined Transponder (SDX) hardware, likely to be used on the SuitSat-2 satellite. Out in the parking lot, Keith, W5IU, used a homebrew antenna and FT-817 to demonstrate working the satellites (photo 4).

Many people commented that the number of new product introductions at Dayton seemed a bit light this year. I tend to agree, especially from an FM VHF point of view. One rig that caught my attention, though, was a prototype of the Yaesu VX-8R, described as "everything the VX-7R has plus 222 MHz and APRS." It also has an optional GPS receiver and optional Bluetooth® hands-free capability. Of course, it always good to see multiband radios offering 222-MHz operation. More interesting is that Yaesu has put APRS into this radio as a standard feature. Previously, Kenwood had the built-in APRS market to

Photo 7. Tom Haddon, K5VH, demonstrates his omni-directional horizontal antennas by wearing one on his helmet.

By Joe Moell,* KØOV

Hams Help Fliers, Boaters, and Hikers One ELT at a Time

Kerry "Hutch" Hutcheson, KE7JFQ, was almost asleep as his wife drove along Interstate 5 near Roseburg, Oregon on June 7. As they crested a hill, the car was suddenly filled with a siren-like sound. At first they thought the Highway Patrol was behind them. Then they realized that it was the audio of an aircraft Emergency Locator Transmitter (ELT) on Hutch's mobile transceiver, which was tuned to 121.5 MHz.

Knowing that this transmission would soon be picked up by USA's SARSAT and Russia's COSPAS satellites, and an alert by the Air Force Rescue Coordination Center would follow, KE7JFQ went into action. Following his Amateur Radio Emergency Service (ARES) training, he reported the situation to the Roseburg 911 dispatcher. Then he called his friend and fellow ARES member Jerry Eifert, KB7WDR. Together they tracked the signal and soon found themselves at the Roseburg Regional Airport hangar (photos 2 and 3).

KB7WDR picks up the story: "I took the antenna off my hand-held and walked around the metal building. By one door there was an opening in the metal and the meter went crazy. Farther down from that door was a workbench where the unit turned out to be. It was strong even through the metal there.

"Nobody was in the hangar, so we found an airport employee who came up with a list of the tenants. I called the owner and got an answering machine. I left a message that this was Search and Rescue (SAR) from the Douglas County Sheriff's office and there was a squawking ELT in his hangar. It had to

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Photo 2. Kerry "Hutch" Hutcheson, KE7JFQ, sets his vehicle for 4-wheel drive on a mission for Douglas County ARES. Hutch was recently lauded by the sheriff's office for discovering a squawking ELT at Roseburg Regional Airport. (Photo by Jerry Eifert, KB7WDR)

Photo 1. Old-style Emergency Locator Transmitters like this one are still installed in thousands of commercial and private aircraft. They do not transmit an ID or GPS coordinates, so they must be tracked by RDF when activated. (Photo by Tom Curlee, WB6UZZ)

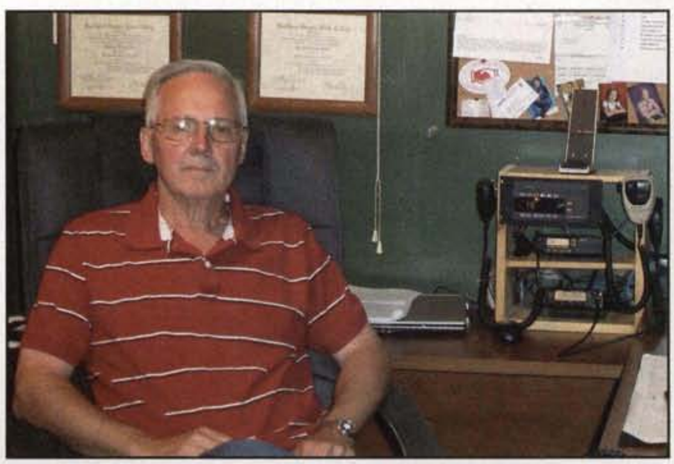

Photo 3. Jerry Eifert, KB7WDR, worked with KE7JFQ to pinpoint the location of the ELT false alarm at Roseburg Airport. He has also tracked down several other activated ELTs and EPIRBs in recent months. (Photo courtesy of KB7WDR)

be shut off, so if I didn't get a call back from him soon, we were going to break the lock. Within five minutes sheriff's dispatch called to say he was on the way.

"The owner was a 70-year-old guy. He had crashed his experimental plane through a fence into a Motel 6 parking lot a few days before. Then he had picked up all the pieces and put them in this hangar. Some friends were helping him clean up, and one of them saw this little 'radio-looking' thing and picked it up. He flipped the switch to ON and when it didn't make any sound, he set it down on the bench and left it."

Photo 4. The LL-16 Little L-Per by L-Tronics is popular with Civil Air Patrol and other agencies that are responsible for ELT/EPIRB/PLB tracking. (Photo by KØOV)

Emergency Beacons as an ARES Mission

There are well over a half-million aircraft ELTs, maritime Emergency Position Indicating Radio Beacons (EPIRBs), and Part 95H Personal Locator Beacons (PLBs) in the hands of pilots, boaters, and outdoors enthusiasts. When activated manually or by an impact sensor, they transmit continuously on 121.5 and 243.0 MHz AM until the batteries fail or they are turned off. The newest ones also send a registration number and GPS coordinates digitally on 460.025 MHz.

Even though the nationwide percentage of "false alarm" activations is in the high 90s, the authorities consider any ELT, EPIRB, or PLB signal to be an emergency until proven otherwise. Even if there is no threat to life, a squawking beacon must be turned off as soon as possible because it is being heard and reported by commercial aircraft passing overhead. What's worse, the false alarm might cover up a weaker, but genuine distress signal.

"It's good that we got it shut off before the Air Force triggered a mission," Jerry explained. "Our own sheriff's dispatchers didn't understand the seriousness until they relayed the call to Oregon Emergency Response up in Salem. Those people got really hot about it. They said, 'We want it off right now! We also want the tail number of the plane and the serial number of the ELT.'"

In southern California, where I live, most ELT activations are investigated by Civil Air Patrol staff and volunteers. That's true in many other locations, but not central Oregon. "There isn't a big CAP presence to cover Oregon," says Wayne Stinson, Emergency Services Coordinator for Douglas County. "It could take quite a while to get a CAP representative or team in from another area. We just take the task and run with it, as do many county sheriffs in the state.

Douglas County encompasses 5000 square miles and extends from the coast at Reedsport to Howlock Mountain and Crater Lake. Stinson is grateful to have a well-organized group of hams to help him. "We work very closely with our ARES folks on search/rescue and disaster preparedness," Stinson told me. "We know that you can burn out volunteers, but if you don't give them some meaningful tasks, they tend not to be around when you need them."

Stinson continues, "The ARES group sets up our county Emergency Operations Center with telephones, network cables, and all that. It fits very nicely into their area of interest and expertise. They are also involved with the hospitals and Red Cross. A while back, they showed us that they can help with emergency beacons, too. They are used to doing fox-hunting and that is very applicable. Most of our active ARES folks now monitor 121.5 MHz.

"An ELT came up in the middle of the night a couple of years ago. We called it a burglary detection tool. Our amateur folks tracked it to an apartment building and called law enforcement to knock on the door for them. The lady who answered said, 'I don't have anything like that,' but after further questioning, her son came out of his room looking sheepish. The deputy started asking him questions and sure enough, he had it stashed in his room. One of the other residents had stolen a bunch of equipment out of an airplane. We not only got the ELT and shut it off, but we closed a criminal case."

Stinson says he is proud of the way the hams handled this activation. "It's not just that they went out and took care of it, but that they did it in the right way. After they picked up the signal, they called dispatch and said who they were, what was going on, and where they were going to be. They weren't being cowboys. I wasn't notified until I came to work the next day because they handled it right."

A Boat in the Mountains

It has been a busy time for KE7JFQ, KB7WDR, and other Douglas County ARES members. "We have had four ELTs in the last nine months," says Jerry. "One of our members was driving I-5 north of Roseburg and heard one. A seaplane had landed on the river and the pilot's knee had bumped it when he got out. We got that one quickly before the Air Force called.

"Another one had us out until about 3:30 AM. There was an abandoned 40-foot ocean-going vessel up in the mountains. Someone found a big old buoy inside. There was a switch on it marked ON and AUTO. He flipped it to ON and nothing happened, so he heaved it into the back of his pickup, drove home, and parked it in his garage. I got to his property in the middle of the night, got the man's name from the mailbox, and phoned him. As I told him that we were with the sheriff's department and there was an EPIRB transmitting from his truck, I could hear his wife yelling, 'I told you so!'

"He said he'd turn it off in the morning, but I answered, 'No, you're going to turn it off right now. Every commercial airliner going over tonight is reporting it

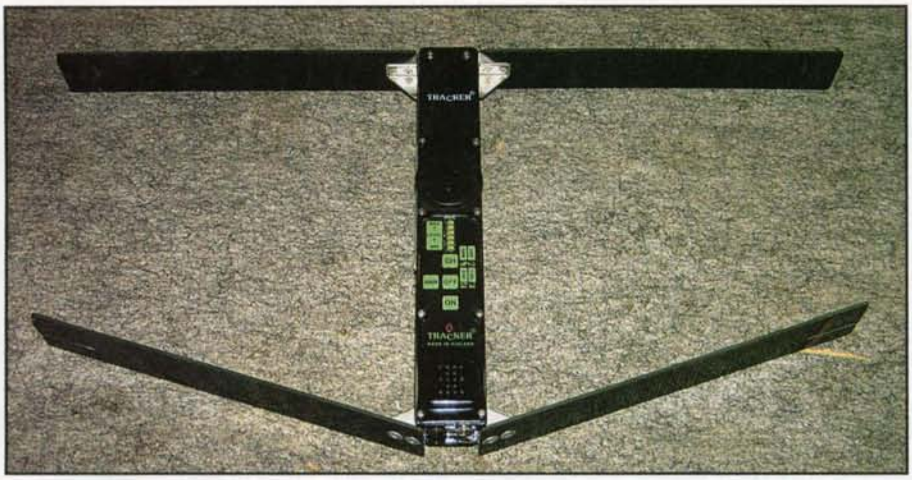

Photo 5. The Tracker FTV468C from Finland features a miniaturized VHF directional antenna with serpentine traces on circuit board material. (Photo by KØOV)

to Seattle center.' Finally he came out in his bathrobe. We took the buoy apart and got the battery out. It's our policy to insist on the battery being removed to make sure that it doesn't get accidentally turned on again.

"A couple of weeks ago we had an EPIRB activation in Reedsport, down on the coast. That one was in a ship repair yard. Again, someone had turned this 'radio' on and it didn't make a sound, so he threw it into a dumpster. We got there and found it at about 3 AM.

"We are so fortunate to have Wayne Stinson as our Emergency Manager," Jerry adds. "In some Oregon counties, the Emergency Manager doesn't want anything to do with ham radio. We do a lot of tasks for him, such as programming the department's radios and bringing new patrol cars down from Salem. In return, we have access to facilities and equipment when we need it. If we have to get up to one of our ARES repeaters in the winter, we can use Sheriff's department's snow cat.

"When we go out on ELT searches in the middle of the night, we want to look as official as possible, so we take the sheriff's Suburban. That is particularly important out around Hubbard Creek, which is a very rural and rough area. It's nice to have the red and blue lights and the star on the side when you're prowling around people's property. When they see that, they are less likely to think that you're there to steal something."

Although the newest emergency beacons send their location coordinates from an on-board GPS unit, the Douglas County hams tell me that to date they have not encountered one of them. The anonymous ELTs, EPIRBs, and PLBs that make up the vast majority of beacons still in use only transmit 100 milliwatts on 121.5 MHz with a strong second harmonic on 243.0 MHz.

Since the 1970s, the most popular radio-direction-finding (RDF) devices for 121.5 and 243 MHz have been made by L-Tronics Company of Santa Barbara, California.[1] Almost every CAP unit has one or more of the classic LH-10 "Little L-Pers." That model has a four-channel VHF/AM crystal-controlled receiver and a pair of phased vertical dipoles on a wooden frame. The antennas are switched by diodes to produce alternating left and right cardioid directional patterns. Signal strengths from each pattern are compared and the meter swings toward the signal. The user turns in the direction of the meter needle until it goes to dead center, at which time he or she is facing the signal. The zero-center direction indication is very sharp and sensitive.

Parts for classic L-Pers have become hard to procure in this decade, so L-Tronics stopped making them and saved the parts stock for servicing the large number of units still in use. The second generation model LL-16 (photo 4) became available in early 2006. It has the same left-right RDF indication, but it has a big step up in features, including synthesized frequency coverage from 108–174 and 215–270 MHz, built-in antennas, AM and FM detection, and a waterproof case that floats.

During the transition time when new L-Pers were unavailable, a company in Finland made inroads into the USA's beacon-tracking market (photo 5). RDF sets by Tracker Radio Location Systems[2] fea-

Photo 6. The author's on-foot RDF system for VHF emergency beacons consists of a three-element tape-measure Yagi and Sniffer4 receiver. (Photo by KØOV)

Measurement	Inches
Reflector (R) length	49 7/8
Driven Element (DE) length	43 1/4
Director (D) length	41 3/4
R-to-DE spacing	9 7/8
D-to-DE spacing	15

Table 1. Dimensions for a WB2HOL measuring-tape Yagi scaled for 121.5 MHz.

ture a receiver with attenuator that also serves as the boom of a two-element directional antenna. With physical element lengths of only 0.17 wavelength and element spacing of 0.08 wavelength, the fold-out beam falls short of the gain and capture area of a standard 121.5-MHz Yagi, but directivity is good. The Tracker FTV can quickly close in on an emergency beacon once it is in range of the signal.

The Douglas County Sheriff's office owns an L-Per and a Tracker, which are available to the ARES hams when needed. KB7WDR says that it's good to be able to use them, but he often goes without because it takes extra time to fetch them from the sheriff's shop. In some cases, he has had to complete the hunt for an emergency beacon by taking off the antenna and probing with his hand-held radio, tuning off frequency to knock down the signal.

ELT Tracking on a Budget

At $750 for new L-Per LL-16s and $600 for new Tracker FTV468Cs, very few hams will buy them for themselves. However, there are low-cost options for do-it-yourselfers that work just as well as, and in some cases better than, the commercial units. For instance, a three-element measuring-tape Yagi provides excellent gain and directivity. Its flexible elements are ideal for poking around in the brush. The popular 2-meter design by Joe Leggio, WB2HOL[3] won't work on the VHF aircraft band as is, but it is easily scaled to that range by lengthening the elements and increasing the spacing in proportion to the frequency ratio.

In photo 6 is a measuring-tape Yagi for 121.5 MHz. Dimensions are in Table 1. Be sure to include the hairpin matching wire as described on WB2HOL's site. I recommend wrapping eight turns of coax around the boom behind the reflector as a choke balun. This prevents pattern distortion that can be caused by signal pickup on the coax shield.

For a ready-made aircraft-band beam, take a look at the website of Bob Miller, N6ZHZ.[4] Bob has tracked dozens of emergency beacons as a member of Bracket Composite Squadron 64 of CAP in La Verne, California. He sells fold-up Yagis for 121.5 MHz and other VHF/ UHF bands. Each is built and tuned to order.

Many amateur radio handie-talkies will receive the VHF aircraft band. When shopping, look for a model with an AM receiving mode and check the specifications to make sure that the radio has full sensitivity outside the ham bands. Wide-range multi-mode receivers such as the ICOM IC-R10 are another good choice. In either case, an S-meter is an important feature for RDF. An external offset attenuator[5] is easy to build and works much better than tuning off-frequency for knocking down strong signals.

A favorite among international-rules foxhunting fans on 2 meters, the Sniffer4 receiver by Bryan Ackerly, VK3YNG, also covers 120 to 123 MHz (photo 7). Separate detectors for AM and FM signals are built in, as is an automatic attenuation system with 15-dB steps and a single-digit readout to display the current attenuation range. With the tone-pitch signal-strength indication in one ear and the ELT audio in the other on stereo headphones, you can keep your eyes on where you're walking as you travel toward the target.

My full review of Sniffer4 is in "Homing In" in the Fall 2007 issue of *CQ VHF*. The instruction manual is available on the web.[6] Depending on the currency exchange rate and method of shipping to the USA, a Sniffer4 costs between US$220 and US$250. It is available directly from VK3YNG in Australia[7] and also from Bob Miller, N6ZHZ, in southern California.[8]

Whatever RDF method you choose, get some practice with it before you need to find a real emergency beacon. KB7WDR says that Douglas County ARES has a formal transmitter hunt for training and fun at least once a year. "One of our members converted an old ELT over to FM on 2 meters," he explains. "It makes the same siren sound. After an ARES meeting, somebody goes out five or ten miles and turns it on. Then we have a contest to see who finds it first."

Jerry proudly told me about a new UHF repeater and remote base system that his group is constructing. "It's going up on a 1650-foot mountain. The VHF transceiver can be switched remotely to link us into repeaters at Salem, Corvallis, Eugene, Grants Pass, Coos Bay, Bend, and Winchester Bay. Our county's radio system relies on microwave for long haul, so communications can fail if a heavy wind moves the dishes out of alignment. That happened last winter and they lost radio contact with deputies on the coast. Our system will be able to back that up."

That's great, but I think the remote system could be even better if it included ELT/EPIRB/PLB monitoring capability. More ARES members would be alerted to emergency beacons as they come on, and at much greater range. Such a system has been in regular use by hams in Santa Barbara County, California since 1989 to provide early detection and facilitate

Photo 7. For ELT/EPIRB/PLB tracking, Bob Miller, N6ZHZ, prefers the folding three-element beam and VK3YNG Sniffer4 that he is holding, because this high-sensitivity system provides maximum range. The rotating Yagi atop his truck is for 2-meter transmitter hunting. In its place, he can mount his home-built cubical quad for 121/243 MHz. (Photo by KØOV)

rapid response by the volunteers of Santa Barbara Search and Rescue (SBSAR).

Repeaters as ELT Sentinels

The driving force behind the Santa Barbara County ELT Monitoring System has been the team of Bruce Gordon, N6OLT, and Lou Dartanner, N6ZKJ, who are the founders and owners of L-Tronics Corporation. N6OLT says that the remote monitors are based on the classic L-Per receiver. "We took advantage of its sensitive detection system," he says. "It makes use of the fact that 121.5 and 243 have 100-kHz guard bands. We switch the receiver between 121.5 and 121.46 and do a comparison between noise levels. Broadband noise will tend to be equal on each frequency, but any signal will change that. This method detects and alarms on very weak signals that you can just barely make out by ear."

When a signal is detected, the repeater sends an audio tone that opens the squelch on SBSAR members' receivers. Bruce explains that there is a delay before alarm of ten minutes because of the voice traffic on 121.5 and 243 MHz. "I heard three instances of it just this morning, such as Air Traffic Control telling a pilot what frequency to go to for landing instructions. Perhaps the guy dropped his map book on the floor of the cockpit and couldn't get to it, so he called on 121.5 for information."

Besides being able to "snooze" the alarm, users can command the repeaters to retransmit the audio from the emergency beacon receiver. "This is absolutely essential and quite interesting," Bruce says. "For instance, if we hear a brief interruption, we know that it is sending data on 406.025 MHz. We can also learn a lot from the building and fading of the signal. We compare that with the marine weather report of the wave rate in the channel. One EPIRB turned out to be beached up on the rocks. It was at the surf line, so it was bobbing at twice the wave rate.

"By listening to how it builds and fades through the system, we can usually determine if an ELT has activated inside a moving airplane. That is not unusual. We typically have about one a week and we can tell the controllers that it's headed for Los Angeles or San Francisco by which receivers hear it when. If there are sudden jumps, then somebody may be working on it or walking by it at an airport. On two occasions we heard irregular flutter that turned out to be passing cars on a street."

Today there are six receivers in the Santa Barbara system. Four are at mountaintop repeater sites, one is near the harbor, and one is close to the airport. All are listening to 121.5 MHz. Four also monitor 243.0 MHz and one has a receiver for the new digital EPIRBs on 460.025 MHz.

The system proved its worth immediately after installation. On the second day it alerted hams to an EPIRB floating in the ocean, 22 miles offshore. In the following ten years, 315 alarms were recorded. Six were aviation emergencies and three were marine emergencies. Most of the rest were false alarms or inadvertent activations similar to the Oregon stories above. Some disappeared before being found, perhaps being discovered by their owners or moving out of range in an aircraft or vessel.

Besides its lifesaving potential, a monitoring system like this is a money saver for taxpayers. Between 1989 and 2002, SBSAR was alerted by the Air Force Rescue Coordination Center of ELT/EPIRB/PLB satellite "hits" in the vicinity only three times. The rest of the time the monitoring system made it possible to silence the transmissions before a federal alert was necessary.

SBSAR continues to upgrade the system. "We have a project to utilize the data burst from the new 406 beacons," Bruce told me. "The first unit is going into the repeater in downtown Santa Barbara. It decodes the ID and GPS information and generates a RS232 data stream, which we can put out on packet. We might also turn it into a text message to be sent to cell phones and pagers."

Who responds to emergency beacon transmissions in your area? Could these responders use your help? Investigate, and you might discover an opportunity to use your RDF skills to help your community and perhaps save lives.

73, Joe, KØOV

Notes

1. http://www.ltronics.com/
2. http://www.trackerradio.com/search-rescue-tracking/index.asp
3. http://home.att.net/~jleggio/projects/rdf/tape_bm.htm
4. http://www.rdfantennas.com/bc146Antenna.htm
5. http://www.homingin.com/joek0ov/offatten.html
6. http://www.users.bigpond.net.au/vk3yng/foxhunt/2m_sniffer/manual.htm
7. http://www.users.bigpond.net.au/vk3yng/foxhunt/foxhunt.html
8. http://www.rdfantennas.com

By Bill Brown,* WB8ELK

UP IN THE AIR

New Heights for Amateur Radio

Field Day Balloons

Field Day is a great time to demonstrate the amazing capabilities of high-altitude balloon payloads. Each year I try to fly something different that we can show to the public at the Huntsville Amateur Radio Club's Field Day site. The site is uniquely positioned in a field next to Space Camp, which always attracts quite a number of curious Space Campers and their families. I've found that balloon flights into near space definitely get their attention.

Since Field Day's main goal (in addition to the goal of eating tons of great food!) is to demonstrate emergency communications, this year I flew a 2-meter FM simplex voice repeater. From its vantage point over 100,000 feet above the Earth, this repeater would cover a great majority of the Southeast and Midwest. What better way to demonstrate wide-area emergency communications using low-power ground stations?

Simplex Repeater

A simplex repeater is a fairly easy thing to put together, consisting of just two things: a handheld radio and a voice record/playback unit. A few years ago, RadioShack sold a great module that made this a plug-n-play solution. Sadly, it discontinued the unit, so I've been relying on the increasingly rare eBay find for these. Fortunately, Scott Miller, N1VG, of Argent Data Systems (http://www. argentdata.com/catalog/) stepped in to fill the gap and introduced the ADS-SR1 simplex repeater module at the Dayton Hamvention® this year (see photo 1). Scott added quite a few bells and whistles to his version. Through touch-tone commands, you can set up voice and CW ID announcements, voice-mailboxes, and a host of other features, including up to 218 seconds of record time. However, due to the amount of traffic expected through the repeater, I chose to limit the record and playback time to 24-second intervals. Just hook up the interconnect cable from the ADS-SR1 to your handheld radio (I recommend using Eveready® lithium AA batteries), adjust the audio levels for best audio quality, stuff it all into a Styrofoam™ box with lots of duct tape, and you're ready to fly.

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

Although you can use the simplex repeater module with any HT (Argent makes a variety of interface cables for various HT models), I've had great results with several of the Alinco family. The dual-band Alinco DJ-C7T is very easy to interface and is very lightweight and rugged. Since it has an SMA connector, I find that the Comet SMA-24 whip antenna works well

Photo 1. Argent Data System's ADS-SR1 simplex repeater. (Photo courtesy of Argent Data)

Photo 2. Alinco DJ-S11T with vertical dipole modification.

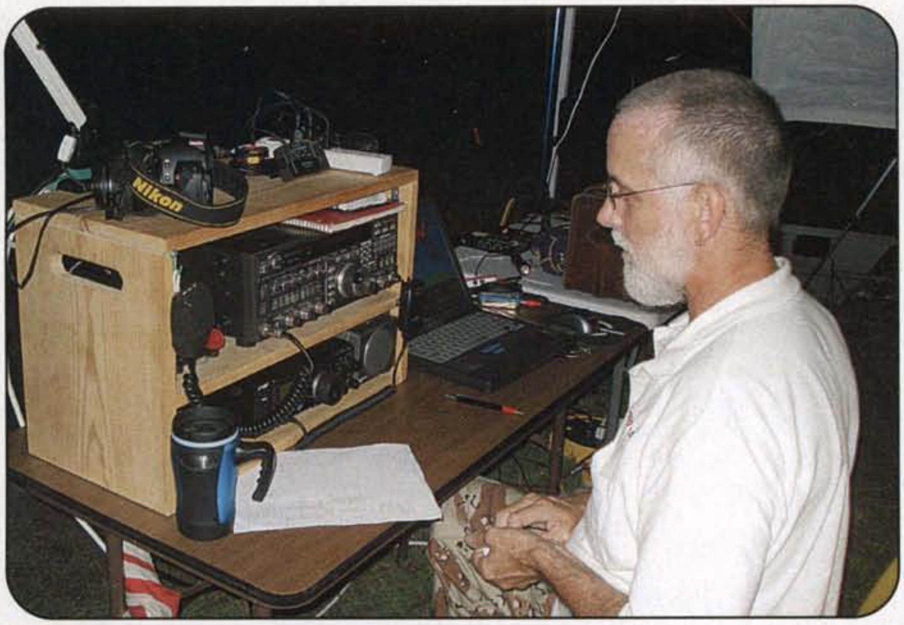

Photo 3. Alan Sieg, WB5RMG, operates the balloon net control at the Huntsville Amateur Radio Club's Field Day site.

with it. However, I do recommend powering the DJ-C7T from an external 6-volt lithium battery pack for maximum operating time and to also increase the output power to 500 mW. Another Alinco radio I've had great success with for balloon flights is the very inexpensive and lightweight DJ-S11T. You won't need an external battery pack for this radio, since it's already designed to use internal AA batteries. I once lost a payload carrying two of these radios. Seven months after my flight, a hunter found it lying in a mud puddle covered in fire ants. I powered up

Photo 4. Shane Wilson, N4XWC, tracking the balloon on mobile APRS.

the radios and they worked just fine after months of abuse.

However, I do have one recommended modification if you plan to use a DJ-S11T. The tiny whip antenna that comes permanently installed in the radio is terribly inefficient. I usually remove it and just solder two 19-inch wires to the antenna pads inside the radio and then tape the wires to a small wood or carbon-fiber dowel rod taped to the side of the radio to create a half-wave vertical dipole. You could also just install an SMA connector instead to use an antenna of your choice. In either case, you'll be amazed at the difference. Photo 2 shows the DJ-S11T with the vertical dipole modification.

The Repeater Flight

We launched the simplex repeater along with two Byonics Microtrak 300 APRS trackers. One used the Deluo GPS receiver (N4XWC-11) and the other used the Garmin GPS18-LVC (WB8ELK-11). Not all GPS receivers will work above 60,000 feet, and as expected, the Deluo unit died at 78,856 feet. Fortunately, the Garmin unit worked just fine as we reached a peak altitude of 115,078 feet.

Our net controllers (Gary Dion, N4TXI, and Alan Sieg, WB5RMG) were operating from the K4BFT (K4 Big Fat Turkey) Huntsville Field Day site (see photo 3). The audio quality through the simplex repeater was excellent, and dozens of contacts were made over a wide area of the Southeast and Midwest. Contacts were made with Field Day sites in Marietta, GA (W4LKL), Columbia, TN (KE4KVC), and Bowling Green, KY (W4HTB at KY4BG). In addition, we contacted Bob, KA9UVY, in Mt. Vernon, IL, who reported a full-scale S-meter report from 300 miles away. I was able to make a mobile-to-mobile contact with Shannon, KC9BIE, in Mt. Vernon, IL as well. It's truly amazing what a 300-milliwatt radio will do if you put a 115,000-foot tall antenna on it!

The Chase

At one point the balloon flew directly over Space Camp (22 miles above it), so we knew it would be landing fairly close to us. After the payload started its parachute descent, Shane, N4XWC (see photo 4), and I set out on the chase and watched anxiously as the payload crept closer and closer to the edge of the Redstone Arsenal Army base. Sure enough, it decided to give the 1000-acre treeless dirt field a miss and flew across the road to land in the top of a tree just a couple of hundred feet inside the arsenal, which is surrounded by barbed wire fences. We decided that the Army would take a dim view of our scaling the fence to recover the payload, so I'll be having a nice chat soon with the MPs to see if they'll let me in there. In the meantime, as I write this in early July, the simplex repeater has been operating for a couple of days, still happily repeating whatever it hears from its treetop perch.

Since we were thwarted in our attempt to recover the repeater balloon, Shane, N4XWC, Dick, W1TV, and I decided to track down the ozone sounding balloon launched just before our flight. It's a tricky beast to track, since it's wideband FM on 403 MHz and drifts like crazy. We drove around the area for an hour and all of a sudden heard it loud and strong. Since there was no GPS onboard, we had to use traditional direction-finding (DFing) to find it. Sure enough, we triangulated it to the rooftop of a large warehouse in downtown Huntsville. We now know where two balloon payloads have landed, but so far there is no way to get to them. Although we returned to the Field Day site empty-handed, we sure did have a lot of fun chasing them.

More Field Day Balloons

This year there were two other balloon missions flown for Field Day: Near Space Ventures of Kansas City (WØNSV-11) flew an APRS tracker with a simplex repeater, and Taylor University in conjunction with the Ft. Wayne Radio Club in Indiana flew an APRS tracker (KB9ZNZ-11) and a crossband 2m/70cm FM repeater. Three more groups had plans to fly for Field Day but had to scrub them: Tennessee Balloon Group (TABEL), Surfing Satellites of Ohio, and Ballon Radioamateur du Quebec (BRAQ).

Next year it is my hope that we will see Field Day balloons popping up all over the country. Just imagine the emergency communications possibilities that would demonstrate. To find out if a balloon is launching in your area, just check the ARHAB (Amateur Radio High Altitude Ballooning) website at: <http://www.arhab.org>.

73, Bill, WB8ELK

By Tomas Hood,* NW7US

VHF PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Bouncing VHF Signals Off "Shooting Stars"

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

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

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

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

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

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

Working Meteor-Scatter Mode

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

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

A great introduction by Shelby Ennis, W8WN, on working meteor scatter can be found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm >.

The *Perseids* Meteor Shower

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

Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three

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

This year the shower will be active from July 17 through August 24. The peak is expected to be around August 12, between 1130 UTC and 1400 UTC. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contacts.

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

There is a slight possibility that there will be a secondary peak around 1640 UTC on August 12. This is based on data collected in the 1990s which revealed an annual shift in the solar longitude of the "old" primary peak. This secondary peak has not been observed since 1999, however. Also, because the comit's orbital period is about 130 years, it is now receding back into the outer solar system. This means that the rate will slowly dwindle for a significant number of years, and, the secondary peak will be rare. Nevertheless, be aware that it still could occur this year.

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

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

Setting Up a *Perseids* VHF Schedule

If you have a reasonably-powered computer, with a sound card, you could try your hand at high-speed CW meteor scatter during the *Perseids* shower. Visit <http://www.vhfdx.de/wsjt/> to obtain your copy of the WSJT computer program. WSJT stands for "Weak Signal communication, by K1JT." This program was created by Joe Taylor, a 1993 Nobel Laureate in Physics for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation.

The program currently supports four principal modes, two of which are primarily useful for weak-signal communications via the short pings from meteor trails. These two modes are FSK441 and JT6M. JT6M is especially optimized for working meteor scatter on 6 meters, while FSK441 works well up into the higher VHF bands.

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

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

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

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

Can You Listen In?

It is possible for you to listen for meteor-scatter bursts. Some even hook up special software to graph the meteor-shower radio activity. If you would like to hear examples of meteor pings, visit <http://www.spaceweather.com/glossary/nasameteorradar.html>. Let's look at how you might listen in with your own radio.

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

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

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

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

Other Meteor Showers of Summer

Look for the *Draconids,* a primarily periodic shower which produced spectacular, brief meteor storms twice in the last century, in 1933 and 1946. Most recently, in 2005, we saw the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. This year's peak is expected to occur on October 8 at 1030 UTC. The shower should be active from October 6 through October 10. The *Draconids* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year. For more information, take a look at <http://www. imo.net/calendar/2008>.

The Solar Cycle Pulse

The observed sunspot numbers for April and May 2008 both are 2.9. The smoothed sunspot counts for September, October, and November 2007 are 5.9, 6.1, and 5.7.

The monthly 10.7-cm (preliminary) numbers for April and May 2008 are 70.3 and 68.4. The smoothed 10.7-cm radio flux for September through November 2007 is 71.5, 71.5, and 71.1.

The smoothed planetary *A*-index (*Ap*) numbers for September through November 2007 are 7.8, 7.9, and 7.8. The monthly readings for April and May 2008 are 9 and 6.

The monthly smoothed sunspot numbers forecast for August through October 2008 are 7.4, 8.6, and 9.9. By this forecast, it looks like we are at the very beginning of the new solar Cycle 24.

The smoothed monthly 10.7 cm numbers are predicted to be 65.1, 65.4, and 66.1 for the same months. These numbersalso indicate that Cycle 24 is upon us.

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

Feedback, Comments, Observations Solicited!

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

Up-to-date propagation information can be found at my propagation center, <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing!

73 de Tomas, NW7US

By Miguel Enriquez, KD7RPP

ATV

Amateur Television for Fun and Education

Getting Yourself and Students Started in Amateur Television

When first exposed to Amateur Television (ATV), many students show immediate interest in the medium because it is something with which they grew up. Furthermore, to be able to see themselves on the television screen is an exciting proposition for them, as well. To know that the magic of television can be theirs to explore becomes a motivating factor in deciding to learn how to use it and eventually how it works. That is what is happening in our school radio shack where our ham radio club members have been enjoying ATV for over a year.

At first glance, ATV appears to be a difficult and expensive undertaking. However, the initial investment for the entire station can be less than $500. Furthermore, with some proper guidance from an Elmer who has been enjoying the use of ATV for a while, your first ATV station is not far away.

It is possible to get your station up and running while you are learning and developing the technical skills and knowledge for ATV. To do this, you will need to find an Elmer who can help you identify the necessary equipment and set up the station. If none is available, we can help you get the direction and support by way of our being your DX Elmers. Perhaps some of our students presently using ATV in the classroom can QSO with your students to answer their questions and share some of their experiences.

The costs of developing an ATV station can be kept to a minimum by looking around your shack for available materials and equipment. An old television (analog) is the first order of business. The ATV transmitter/receiver can be purchased from a couple of dealers who sell ATV equipment, or they can be found on the Internet as pre-owned equipment at several swap meet sites. An old video camera like the one you use to capture mem-

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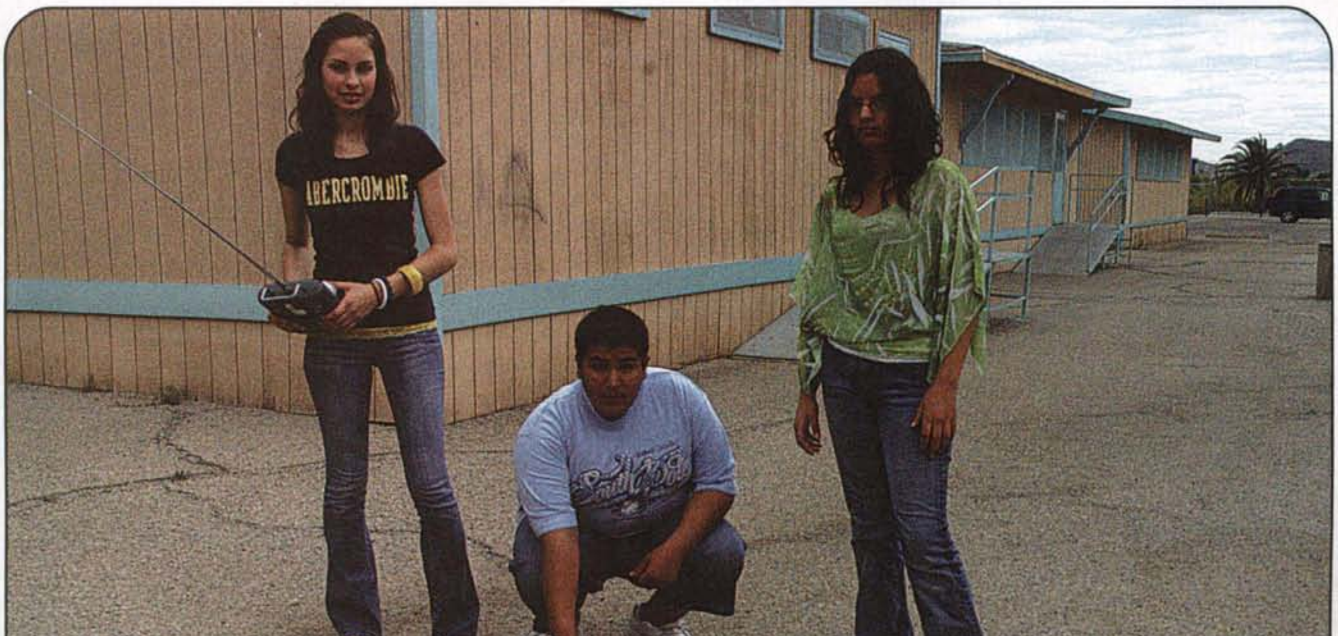
e-mail: <enriquezma@cox.net>

This column was written with a great deal of assistance from Ronald Phillips, AE6QU.
e-mail: <sunsettelcom@juno.com>



Jhovana Peralta, Juan Puig, and Ruth Colores with Pueblo Magnet High School BOE-BOT #1.

ories at your family's picnics, etc., will work very nicely.

The students can have fun constructing "Cheap Yagi" antennas from blueprint instructions readily available on the Internet, as well as in *CQ VHF*'s "Antennas" columns by Kent Britain, WA5VJB. Low-loss cable is the one thing that becomes critically important in transmitting and receiving ATV signals, because any loss of signal strength degrades the quality of the picture and sound that is transmitted or received.

ATV equipment currently on the market, new or used, is designed for ease of use. After your station is set up and calibrated, little maintenance is required. The station can be set up in any corner of the classroom or ham shack, as it does not require much space or special lighting. As you learn to use ATV equipment, you and your students will easily be able to solve any challenges the technology presents.

Perhaps the biggest problem in using ATV is finding a second station with which to converse. Transmitting distances are a limiting factor in ATV. Unless you have a repeater high up on a mountain, like we do, you are limited to line-of-sight contacts. Furthermore, the other station must have a station that transmits and receives on the same frequencies as your station. Regrettably, this has been a major problem for our club. However, finding a second school in your area or a ham club willing to set up a station to communicate with students could be part of the challenge you accept when you commit to adding ATV to your school radio shack.

If finding a second school or ham willing to add an ATV station to their shack is impossible, you can still go at it alone. ATV is designed to be portable. This means your students can build two or more ATV stations and then they can still enjoy the fun the medium brings.

Your second ATV station can go to a local hamfest where the students can show off their ATV skills to other hams. They can go into another classroom or school or other public event and transmit to the school shack while the public walks by and watches, stopping to ask what is going on and then being impressed that the students are successfully delving into television transmissions.

Another possible use of ATV is in conjunction with robotics. Today many students are into robotics. Adding ATV to a robot and having it roam outside the classroom or into the school cafeteria while the students sitting in class see and hear the images the robot is transmitting is an exciting event. When our students added an ATV camera to the BOE BOT, used in class to learn about electronics and programming, and sent it out the door to transmit temperature, direction of travel, seismographic readings, as well as video and audio signals, you would have thought that even Harold Van Dyke, KD2PH, a fellow ATV ham who monitors ours signals and who was receiving the signal in Sun City, Arizona 135 miles away would get excited. However, the students watching these same signals 115 feet away were more excited because it was their ATV station at work!

Jasmine Magdaleno explains to the class the significance of the signal received from the "MARS LANDER" roaming 90 feet outside the classroom.

Summary

In summary, the journey to ATV can be as easy or as complicated as you perceive it to be and make it. We suggest you consider the possibilities that ATV can provide for students and look into adding ATV to your school or home ham shack. If your main concern is that by adding ATV to your shack others will see the mess most of us have surrounding our transceivers, you can point the camera in the opposite direction and no one will be the wiser!

Why go through all this trouble in designing, constructing, and running an ATV station? Negative comments can range from "It's expensive," to "I don't know anything about ATV," to "Why bother?" However, the one reason why you should consider ATV is simply because it is fun, and for students, it gives them an opportunity to feel good about accomplishing a task that is truly unique.

Many students tell us they want to be important and feel successful. We guarantee that when they are able to see themselves on television and communicate with other students using ATV they will know they have accomplished something important.

Please e-mail us with your questions or specific needs for direction or information concerning ATV. We will gladly work with you to identify resources close to you to assist you in this perhaps new and exciting addition to your shack.

Future columns will provide more specific information concerning ATV technology and where to go for equipment and information resources.

73, Miguel, KD7RPP

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

ATV Antennas plus Antenna Ranges

This issue of *CQ VHF* covers several ATV (Amateur Television) topics, so it's a good time to update and revisit a pair of ATV antennas for 915 MHz (one 6-element and one 10-element) and one for 2.4 GHz. We will also go over an interesting myth about antenna ranges.

Quite a few ATV systems use 915-MHz FM video input, and for low-power video systems 2.4 GHz is the favorite band. Therefore, in this column we will cover both a 915-MHz Yagi and a 2.4-GHz patch antenna. But keep this quiet: These antennas also work well for digital, FM, SSB, 802-11, and other 900-MHz/2400-MHz services.

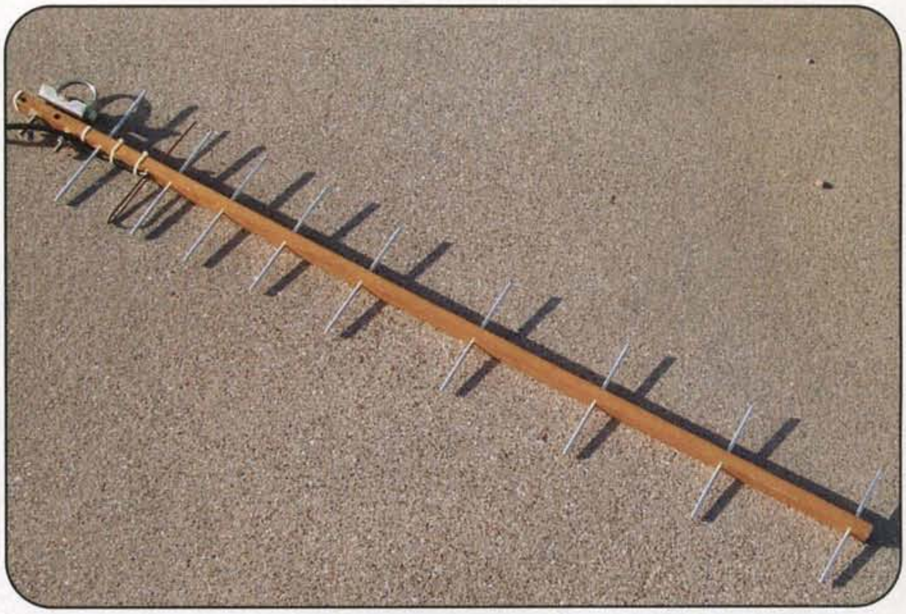


Photo A. Cheap Yagi for 915-MHz ATV.

915-MHz Antennas

We start with a 915-MHz version of the "Cheap Yagi" shown in photo A and figure 1. The boom can be any non-conductive material. Yes, PVC pipe can be used, but I find that a good hard wood about 1/2 to 3/4 inch in width is stronger and seems to last longer, especially if you give it a coat of paint. All elements are 1/8 inch in diameter. I have used ground-rod wire, #10 and #12 electrical household wire, welding rod, and hobby tubing from the model-airplane shop. Again, almost any 1/8-inch diameter metallic material can be used for the elements. However, for the driven element it is good to use copper or brass so that you can directly solder the 50-ohm coax to the driven element. Small clips have been used to clamp the wire to the driven element, and these can be fun to make, but often they corrode quickly when mounted outside.

The same driven element shown in figure 1 is used for both the 6-element and 10-element versions of the 915-MHz Yagi (see Table 1).

Patch Antenna for 2.4 GHz

Next we have an easy-to-make patch antenna for 2.4 GHz, shown in photo B. This antenna works well with the various 2.4-GHz video senders, Bluetooth®, and other wireless products. For AMSAT it can be used to listen for many of the stronger transponders, or placed at the focus of a small dish for even more gain. Gain is in the 8- to 9-dBi range, and the antenna easily has over 200 MHz of bandwidth.

Construction is simple. The back plane can be almost any sheet of metal. Of course, aluminum is easy to find, and in this case I used some old PC board. For

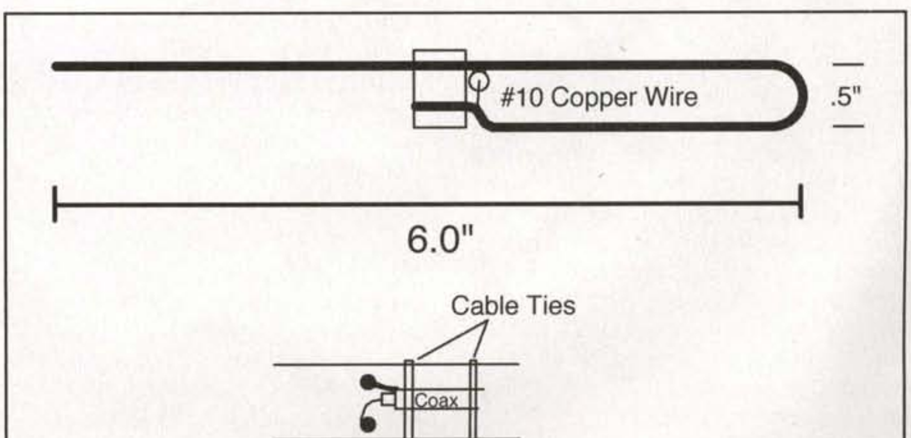


Figure 1. Dimension for the 915-MHz driven element.

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	R	DE	D1	D2	D3	D4	D5	D6	D7	D8
6 Elements										
Length	6.3	**	5.7	5.6	5.5	5.2	—	—	—	—
Spacing	0	2.4	3.5	5.0	8.25	11.5	—	—	—	—
Gain 11 dBi										
F/B 22 dB										
10 Elements										
Length	6.3	**	5.7	5.6	5.5	5.3	5.3	5.3	5.3	5.0
Spacing	0	2.4	3.5	5.0	8.25	11.5	15.0	18.0	21.1	24.25
Gain 13.5 dBi										
F/B 25 dB										

*** Driven element (see figure 1)*
R—Reflector
D#—Director
F/B—Front-to-back ratio for the antenna pattern

Table 1. Specifications for the 6-element and 10-element 915-MHz Cheap Yagi.

the patch element you want to use something that is easy to solder. Sheet brass, sheet tin, sheet copper, or another piece of PC board work well. Just build per the dimensions in figure 2 and go. If you need to make your patch more rugged, note that the very center of the patch is a null point. You can drill a hole in the middle of the patch and support the patch on a long bolt line as shown in the patch in photo C.

Antenna-Range Mistakes

"But I put both antennas in the same spot!" I heard one antenna tester say that because he puts the reference antenna and the test antenna in exactly the same spot, then his gain numbers are perfect.

Not exactly. This is only true when both the reference and the test antenna are identical. In the real world, using the same spot without making sure the test area has a uniform signal strength can result in some pretty big errors. The problem is that when you have two antennas with different gain, then they also have different capture areas, or aperture areas. The test signal must be uniform over the aperture area of the larger of the two antennas. (See figure 3.)

In figure 4 we have a typical pattern for a source antenna on an antenna range when the source antenna is mounted several wavelengths off the ground (also see figure 5 for a typical pattern of the source antenna when mounted low). Note all the peaks and nulls in the test area.

I wish my CAD package would do a better parabola, but you get the idea. If you just happen to put the reference antenna in a null and the antenna you are testing just happens to have a larger capture area, then the apparent gain of the antenna being tested can come out up to 3 dB high. If you twist the antenna being tested a little up and down, then you can get the top and bottom lobes back in phase. Now the apparent gain jumps up even higher. Put in simple terms, if a 10-dBi reference antenna is used to test a 20-dBi antenna, the results if the reference antenna is in a null can be 23 dB or more. (See figures 6 and 7.)

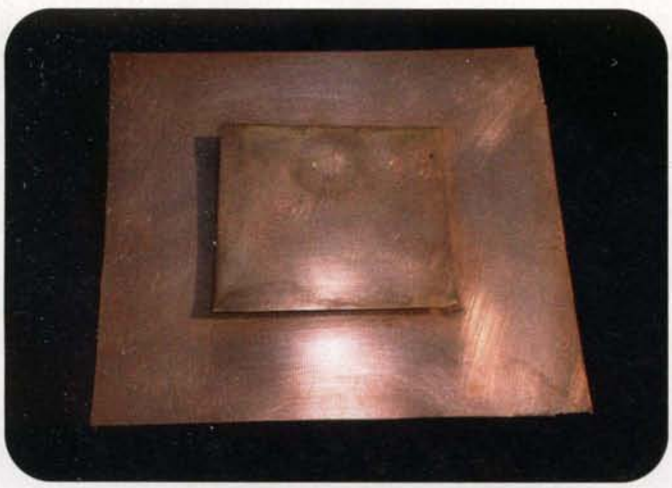


Photo B. The 2.4-GHz patch antenna.

Photo C. A version of the patch antenna with a center bolt for better mounting.

Now let's go the other way. You have a large reference antenna and a smaller antenna being tested. The big one is catching some signal and the little one is not/ Now gain can be underestimated at 7 to 8 dB, and your 10-dBi antenna measures 2 or 3 dBi.

Now let's look at when the reference antenna is perfectly in the major signal lobe but the antenna being tested has a larger capture or aperture area. The test area is a three-dimensional

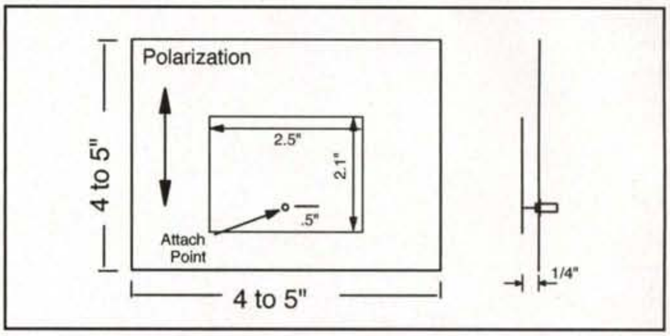


Figure 2. Dimensions for the 2.4-GHz patch antenna.

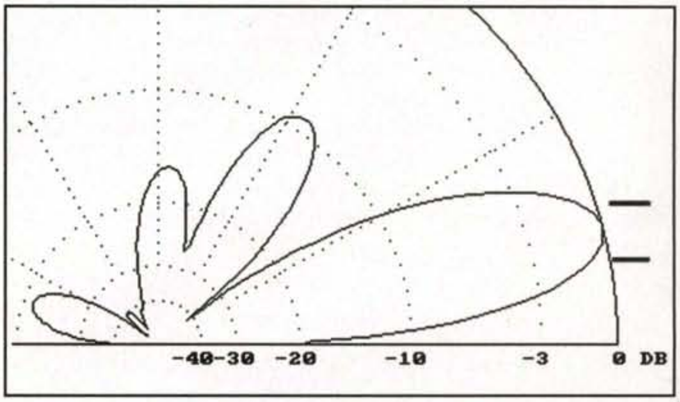


Figure 3. Antenna testing with a low source antenna and a more uniform test area.

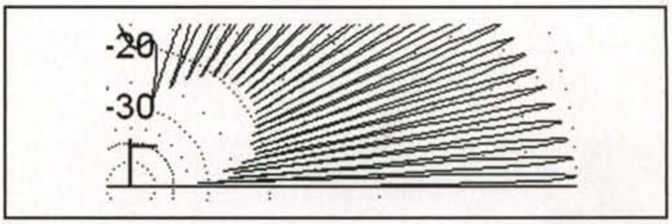


Figure 4. Typical pattern of the source antenna when mounted high.

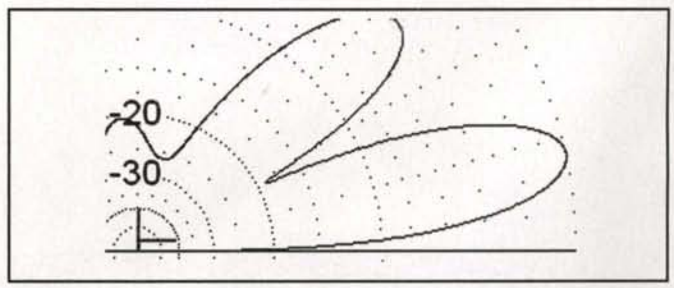


Figure 5, Typical pattern of the source antenna when mounted low.

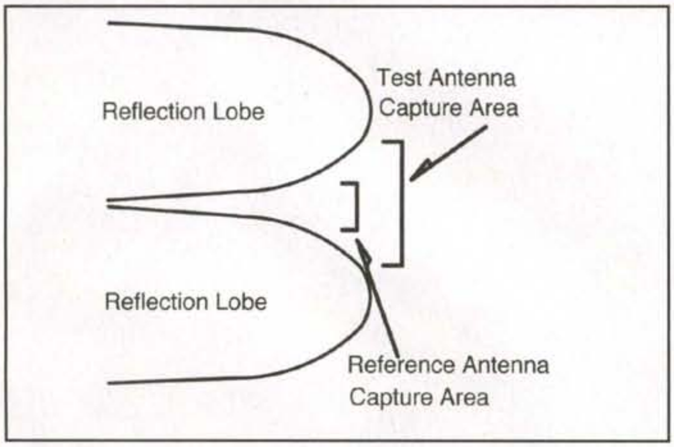
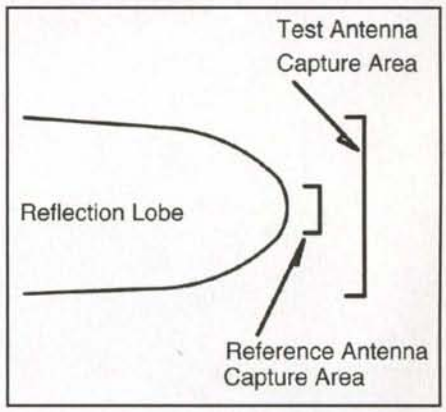


Figure 6. Antenna testing in a ground bounce null.

Figure 7. Antenna testing in a ground bounce peak.



volume that has been simplified for these examples. Even the conductivity of the ground can change the depth of the nulls, but these error values are what you would see in a poor range setup.

In short, simply using an antenna range without making sure your test area has a nice, uniform signal strength can really misrepresent the actual gain of the antenna. Most errors make the test antenna look worse. Errors can make the antenna test show as much a 3 dB better than it is, or as bad as 8 dB worse than it really is. The 11 dB of measurement error makes the test results more a list of random numbers than meaningful antenna measurements.

Using the same antenna-range geometry on several frequencies without knowing that the test area has a uniform signal does not produce accurate results.

When you set up an antenna test range you have to sample the area. Move your reference antenna up, down, left, and right. If the signal strength varies more than a dB, find another test area, change the range geometry, but do something or your results are meaningless.

As always, our readers are one of the best sources of ideas for future antenna projects. Any antenna questions, or antenna projects you would like to see, just drop an e-mail to <wa5vjb@cq-vhf.com>, or visit <www.wa5vjb.com> for additional antenna projects.

73, Kent, WA5VJB

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Back to the Present

In the Spring 2008 issue of *CQ VHF* we reviewed the history of AMSAT. In this issue we will talk about where we are today in satellite availability, equipment ideas, and operating techniques. I will lean on experiences at this year's Dayton Hamvention®, Ham-Com, and ARRL Field Day 2008.

Satellite Availability

Today we have a real mixture of the "old and the new." We regularly use our oldest operational satellite, AO-07, and we listen to the seven new CubeSats (Cute-1.7, SEEDS, Delfi-C3, AAUSat-II, COMPASS-1, CanX-2, and CanX-6) and RS-30, Yubileiny. AO-07 was launched in 1974. The CubeSats were launched in April 2008, and RS-30 was launched in May 2008. Between these extremes we have AO-27, GO-32, SO-50, AO-51, the ISS, and VO-52, all of which still have active transponders.

Earlier this year one of the original Microsats, AO-16, was given a change in mission and was active for several months while it was in an eclipse-free period. It apparently has a temperature problem that has shown up now that it is undergoing eclipses again. Hopefully, we will see more use of it when it becomes eclipse-free again. It is also possible that we may be able to do the same "trick" on one or more of the other old Microsats and see some more use out of them.

ID	Frequencies (Uplink/Downlink)	Modulation Modes
AO-07	U/V, V/HF	SSB and CW
AO-27	V/U	FM Voice
GO-32	V/U	FM Packet
SO-50	V/U	FM Voice
AO-51	V/U, V/S, L/U, L/S	FM, FM Packet, SSB/CW, etc.
ISS	V/V, U/V	FM Voice, FM Packet
VO-52	U/V	SSB and CW

Table 1. The "birds" that have active transponders support the frequencies and modes listed above.

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e-mail: <w5iu@swbell.net>

Cheap circularly polarized L-band Yagis with white box full of up-converter and amps. Note the expensive rain cover on the white box.

The "birds" that have active transponders support the frequencies and modes listed in Table 1.

AO-51 continues to be a real "hoot" to work with its good signals and variety of modes and capabilities. At Ham-Com in Plano, Texas in June, it was in V/S and on Field Day 2008 it was in V/U and L/U simultaneously.

Complete details on these "birds" are available on the AMSAT web page: <http://www.amsat.org>. Details on the CubeSats are available on Ralph Wallio's (WØRPK) web page: <http://showcase.netins.net/web/wallio/CubeSat.htm>. Details on RS-30 are still somewhat "sketchy."

Dayton Hamvention®

AMSAT had an expanded presence at Dayton this year. An additional booth space was devoted to demonstrations and live discussions of the current AMSAT projects. Engineering team leaders of all of the projects were available for questions and discussions. Featured projects were: Eagle, Advanced Communications Package (ACP), ACP Ground Segment, SuitSat 2, and Phase 3E. ACP is planned to be a common payload for both the AMSAT Eagle and Intelsat Phase IV Ride Share projects.

Team Namaste, including both ACP and ACP Ground Segment, was introduced at Dayton. ACP is under the leadership of Matt, N2MJI, and the ACP Ground Segment is led by Michelle, W5NYV. This exciting new capability generated great interest. In particular, the Ground Segment is being planned as an affordable, transportable, microwave digital communications package that will be within the capabilities of the average ham to assemble and operate. Details are available at: <http://www.amsat.org/namaste>.

A working Software Defined Transponder (SDX) for SuitSat 2 was demonstrated at Dayton, along with other plans for SuitSat 2.

Presentations were given during the Saturday morning AMSAT Forum on all of these projects, along witha report on AMSAT's general status and updates on AO-51 and AO-16 activity.

Finally, yours truly along with Mark Hammond, N8MH, and Roger Ley, WA9PZL, did the outdoor live satellite demos. This year we featured the simple Cheap LEO Antennas designed by Kent Britain, WA5VJB, and the Manual Positioner designed by me. All of this hardware was described in past issues of *CQ VHF*. All demos were done with either one or two Yaesu FT-817s running barefoot at 5 watts. We were able to do live demos on all three days through AO-51, AO-27, AO-07, and VO-52. For unknown reasons, we did not make it through SO-50. Mark succeeded in commanding AO-16 back on twice from the demo area, but it did not stay on due to the suspected temperature problem mentioned previously. We also communicated from the outdoor demo area through the SuitSat 2 SDX at the AMSAT booth inside the arena.

Ham-Com

Ham-Com was held only a couple of weeks after Dayton in Plano, Texas. For those who are geographically challenged, Plano is a northern suburb of "Big D" (Dallas). The AMSAT booth, forums, and demos were on a smaller scale than those at Dayton, but AO-51 was in mode V/S during Ham-Com. This gave us the possibility of demonstrating communications through AO-51 with a Cheap LEO Antenna fed by a Kenwood TH-D7 and received by a hand-held K5GNA S-band down converter and antenna into one of the FT-817s as a 2-meter IF. We were able to make excellent AO-51 V/S demos on both days of Ham-Com. Demos on all of the other "birds" were accomplished with the same setups used at Dayton.

ARRL Field Day 2008

Last year at this time I featured my Field Day station setup using two FT-817s, SatPC32, Yaesu rotors, and Hy-Gain satellite antennas, along with a homebrew helical antenna for L-band. I bring this up again because of a change in the L-band antennas used for AO-51 mode L/U operations. This year I used a pair of WA5VJB Cheap Yagis on L-band instead of the WD4FAB helical antenna. These were fed as a circularly polarized pair in accordance with Kent's article in the Fall 2003 issue of *CQ VHF*. Actually, I borrowed from Kent's the prototype antennas for the article and provided the first real "on the satellite test" of these antennas. The setup is shown in the accompanying photos. Once again, the white plastic box contains the L-band up-converter and power amps.

We actually made it through the "bird" without the final power amp keyed. When our mistake was discovered and corrected, the signal was stronger, but the fact remains that we made it through the "bird" with about 10 watts of power instead of the planned 25 watts.

Satellite Field Day went well considering the fact that a thunderstorm gust front took down our meager shelter just after the first evening AO-27 pass and before the evening flock of "birds"

Feed details for L-band Yagis. Note that Yagis are rotated 90 degrees with respect to one another, and one is spaced a quarter wavelength down the boom from the other. The power splitter is made from two equal lengths (each an odd multiple of a quarter wavelength long) of 72-ohm coax.

came over. We had to scramble to place the rigs, computer, etc., in my mini van for protection from the rain that followed. We literally "blew off" the evening passes and again set up everything for the Sunday morning passes. We actually made it through all of the FM "birds" for our allotted one contact each. The remainder of our contacts were made on AO-07 and VO-52 SSB.

Here's one more Satellite Field Day "word to the wise." We were barely able to get through AO-27, SO-50, and AO-51 V/U FM with about 40 watts and a 16-element, computer-steered Hy-Gain antenna. It took patience and perseverance to make it. A good part of the time all we could hear was the noise level created by hundreds of signals getting to the satellite at about the same strength. Eventually, someone would exceed the threshold and a contact was made. Compare that with the Dayton and Ham-Com demos, where all contacts were made relatively easily with a 2- or 3-element Cheap LEO Antenna and 5 watts. The FM "capture effect" is alive and well.

Summary

This column is intended to illustrate the variety of satellite communications that is available today and the current projects planned for the future. In particular, it is meant to emphasize the "cheap and easy" concept of working satellites.

Don't forget to support AMSAT in its education and fund-raising efforts so that we can continue to put more "birds" on the air. In particular, support Phase IIIE, Eagle, and the Intelsat Phase IV Ride Share projects so that we can get back into the HEO (High Earth Orbit) satellite business. 'Til next time . . .

73, Keith, W5IU

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2008)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38
80	JH1HHC	2,5,7,9,18,34,35,37,40.
81	PY2RO	1,2,17,18,19,21,22,23,26,28,29,30,38,39,40
82	W4UM	18,19,21,22,23,24,26,27,28,29,34,37,39
83	I5KG	1,2,3,6,10,18,19,23,27,29,32.
84	DF3CB	1,2,12,18,19,32

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

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

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

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

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

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

National Science Education Standards

You may have read in recent issues of the *AMSAT Journal* about plans to develop an AMSAT Teacher's Institute to provide educators with the background necessary to incorporate satellites into their curricula. This column summarizes the standards with which such an effort must comply.

The fundamental law governing education throughout the U.S. is No Child Left Behind (NCLB, which is pronounced "nickelbee" by educators). NCLB mandates achievement testing for all students in the areas of reading and mathematics, and ties federal funding for school districts not to test results *per se*, but rather to *improvement* in test results from year to year. In other words, the goal of NCLB is to show annual progress. Most school districts set achieving NCLB guidelines as their highest priority. At present, there are no accepted standardized achievement tests in the sciences, and hence no NCLB science standards. Most educators with whom I've spoken expect NCLB science standards to be established eventually, but this is not likely to happen for a decade or more. Hence, professional development in the sciences is not currently a priority for educators or school districts.

National Science Education Standards do exist, but compliance is strictly voluntary on the part of individual school districts. These standards were developed jointly by the National Science Teacher's Association (NSTA), American Academy for the Advancement of Science (AAAS), National Science Resources Center (NSRC), National Research Council (NRC) National Science Foundation (NSF), and several smaller organizations, working through the National Committee on Science Education Standards and Assessment (NCSESA). The standards emphasize benchmarks for science literacy and were distributed in draft form in 1994 to 18,000 individuals and 250 groups.

The goals for school science that underlie the National Science Education Standards are to educate students who are able to:

• experience the richness and excitement of knowing about and understanding the natural world;

• use appropriate scientific processes and principles in making personal decisions;

• engage intelligently in public discourse and debate about matters of scientific and technological concern; and

• increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

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Logically, any AMSAT educational endeavor should show compliance with these four points.

The National Science Education Standards address continuing education and professional development requirements for teachers. The standards address various professional development areas, which can be summarized as: learning science, learning to teach science, and learning to learn. Specific standards in these areas are excerpted below.

Standard A

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must:

• Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.

• Address issues, events, problems, or topics significant in science and of interest to participants.

• Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.

• Build on the teacher's current science understanding, ability, and attitudes.

• Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.

• Encourage and support teachers in efforts to collaborate.

To meet the standards, all teachers of science must have a strong, broad base of scientific knowledge extensive enough for them to:

• Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry.

• Understand the fundamental facts and concepts in major science disciplines.

• Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects.

• Use scientific understanding and ability when dealing with personal and societal issues.

Standard B

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must:

• Connect and integrate all pertinent aspects of science and science education.

• Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.

• Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning.

• Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

Standard C

Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must:

• Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.

• Provide opportunities for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.

• Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.

• Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.

• Provide opportunities to know and have access to existing research and experiential knowledge.

• Provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.

Standard D

Professional development programs for teachers of science must be coherent and integrated. Quality preservice and inservice programs are characterized by:

• Clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards.

• Integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.

• Options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.

• Collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each.

• Recognition of the history, culture, and organization of the school environment.

• Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.

If AMSAT Teacher's Institutes are to be a credible professional development avenue for educators, we cannot simply teach satellites, or let the teachers play in the lab. We have to show very specifically how our program addresses these individual points. The next "Orbital Classroom" column will discuss how AMSAT can best meet these standards.

73, Paul, N6TX

By John Champa,* K8OCL

HSMM and Field Day – raison d'être

Field Day use of HSMM (high-speed multi-media) radio is increasing dramatically to the point where most major club Field Day sites have full intranet radio service among the various stations scattered across the countryside. Often they also have some Internet access to keep family and friends posted on their progress and to communicate vital needs to outside supporters. We will have more on these exciting events in the next issue, but of all the many uses radio amateurs have made of HSMM technology, Field Day is clearly its raison d'être (reason for being). When you must move a lot of data very quickly and accurately and there are no wires, HSMM radio techniques are tough to beat.

Although emergency communications applications of HSMM radio are frequently discussed and written about, the fact remains that too few radio amateurs know enough about IP-networked radios to set up such systems in the field and in a hurry. That is changing, but it will take time.

SSID Protocols

The ARRL HSMM Working Group never established an SSID standard for HSMM radio. However, the ARRL Michigan Section DRG (Digital Radio Group) has proposed such a standard. For example, the author's SSID is k8ocl-2. We encourage the further development and use of this DRG standard.

SSID	Purpose
-0	home stations
-1	home-station personal mailboxes
-2	gateways
-3	full-service BBS (those that forward mail and bulletins)
-4	network nodes (having two or more radio ports that perform TCP/IP routing)
-5	console, keyboard, printer, etc.
-6	conference bridges
-7	crossband digipeaters (802.11g and 802.11a, etc.)
-8	crossband digipeaters (other)
-9	mobile, modats, etc,
-10	WL2K
-11	HSMM airborne nodes (balloon, aircraft, etc.)
-12	HSMM satellite (OSCAR) nodes
-13	unassigned
-14	unasssigned
-15	downlink address when exiting the far end of a network

Note: There is now a page for listing your D-Star DD or 802.11 HSMM installations: <http://en.wikipedia.org/wiki/List_of_hsmm_nodes> (Thanks to KF4YFD for this information.)

*Former Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking
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Coaxial Cable Feedlines

All present-day HSMM radio experimenting is done at 900 MHz and above, with the majority of it being on the 2.4-GHz band. Thus, please pardon me while I state the obvious: All 1/2-inch coaxial cable is not created equal. Even though the 1/2-inch black cable has quality N-series connectors at each end, this does *not* make it suitable for HSMM work; RG-213 and RG-214 are prime examples. Here is what I recommend in the way of "1/2-inch" coaxial cables, as they are far more suitable.

Cable Type	2.5 GHz Loss (dB/100 ft.)	5.8 GHz Loss (dB/100 ft.)
LMR400 (good)	6.8	10.8
1/2" Heliax (better)	5.7	10.5
LMR600 (best)	4.45	7.25

When installing coaxial cable for your antenna projects, exercise some care:

1. If you pull coaxial cable too hard, its loss properties may increase.
2. Bends in coaxial cable must not exceed the cable's spec for bend radius.
3. The longer the run the higher the loss, so keep runs as short as possible.
4. If the antenna is outside, you must provide for lightning protection.
5. Even weather-tight connections should be sealed outside.

The Biggest HSMM Events of the Year!

Every year a team from the HSMM Working Group of the Texas Microwave Society puts together huge HSMM radio networks to service the Wild Ride Against Cancer and the Plano (TX) Balloon Festival. We all can learn much from this team's experience. The notes and photos that comprise the remainder of this column were supplied by Kipton Moravec, KE5NGX (kip@kdream.com):

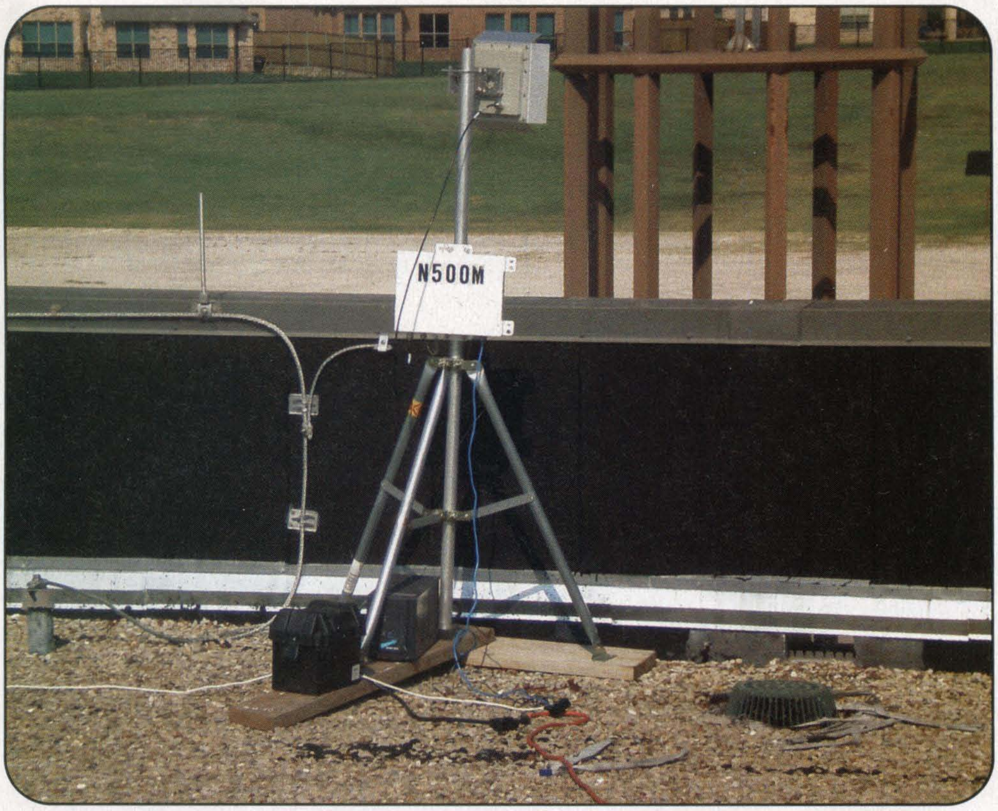
Standard terminology for a router setup:

The **host router** is the router that has the Internet connection and is going to share it with other routers. In our case, this is the church.

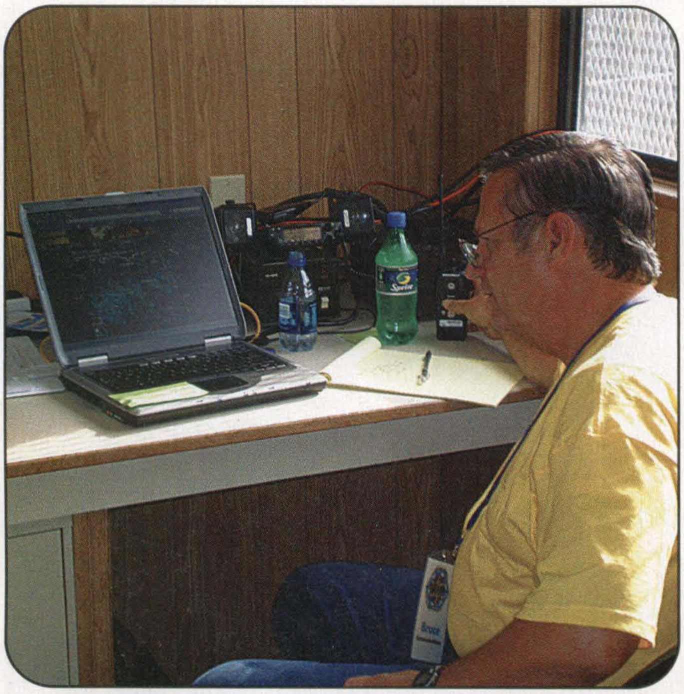
The **client router** is the router which does not have an internet connection. This is the officials area, ramp, and scissor lift units.

Setup:

Save the configuration on all routers: **Administration -> Backup**. Click the "Backup" button and follow prompts to save nvram backup files—i.e. nvram_host.bin, and nvram_client.bin. The configurations can be restored if the setup doesn't work



This is John Beadles, N5OOM's unit on the second-story roof of the First United Methodist Church of Plano, Texas. Since it is a flat roof, we attached the tripod to two 2' × 6' pieces of wood so it would not damage the roof, and weighted them down with the uninterruptible power supply and extra battery so the wind would not blow over the tripod. The site on the roof had a clear view of the Balloon Festival field. The 15-dB gain flat-panel antenna had about a 30-degree beam width, which covered all of the antennas on the field. The farthest was about 2500 feet away. A Linksys router with DD-WRT software was mounted in the antenna case. (Photo by Kipton Moravec, AE5IB)



Bruce Dingman, N5BYL, was one of the amateurs in the communications trailer. Since the trailer was metal, we ran an Ethernet cable in from the antenna and router mounted on the outside of the trailer to provide them with Internet access to monitor weather and the balloons with APRS trackers. The people in the communications trailer monitored the commercial handheld radios from the Balloon Festival staff, and the Amateur Radio Balloon Festival Net acted as the interface between both groups. (Photo by AE5IB)

out and you need to quickly get back to a different (working) configuration.

DD-WRT default login is *root* and the password is *admin*. I am leaving mine to the default for now. Later we changed to login *root* and password *Sband*.

Reset the routers to factory default settings so other settings will not have a possible conflict: **Administration -> Factory Default, select yes, click "Save Settings" button.**

Screen by Screen Setup Procedure:

Setup -> Basic Setup

Wireless Setup

For the Host (on the church)

Connection Type:	**Automatic Configuration - DHCP**	This is for the WLAN port
STP:	**Enable**	Not sure what this does

For the Clients

Connection Type:	**Disable**	This is for the WLAN port
STP:	**Enable**	Not sure what this does

Optional Settings

Name:	Use router/SSID name (i.e., KE5NGX-AP1)
Host Name:	Leave Blank
Domain Name:	Leave Blank
MTU:	**Auto**

Network Setup

Local IP Address: This is for the Wireless and LAN ports. Give the routers a different IP address, i.e.:

192.168.157.1	N5OOM-2AP at the Church.
192.168.157.2	N5OOM-1AP at the Officials Area
192.168.157.3	N5OOM-4AP at the Ramp
192.168.157.4	N5OOM-3AP at the Scissor Lift
192.168.157.5	KE5NGX-AP1 Backup
192.168.157.6	KE5NGX-AP3 Church Backup

Subnet Mask:	**255.255.255.0**	
Gateway:	**192.168.157.1**	For clients only
Local DNS:	**192.168.157.1**	We do not have one

WAN Port

Assign WAN Port to Switch: **Unchecked**

This makes WAN port a 5th LAN port if checked. Let's not use it unless we need it.

Network Address Server Settings (DHCP)

DHCP Type: **DHCP Server**

Start IP Address:

192.168.157.200	N5OOM-2AP at the Church
192.168.157.20	N5OOM-1AP at the Officials Area
192.168.157.30	N5OOM-4AP at the Ramp
192.168.157.40	N5OOM-3AP at the Scissor Lift
192.168.157.50	KE5NGX-AP1 Backup/Field Ops if needed

Maximum DHCP Users: **10** Default to 10 per router (because it is easy)

Client Lease Time:	**1440** Minutes	Seems to be default
Static DNS 1:	**192.168.1.1**	I got it from the church/this is the router we connect to
Static DNS 2:	**208.67.222.222**	(OpenDNS as backup)
Static DNS 3:	**208.67.220.220**	(OpenDNS as backup)

Other ones if these doesn't work:

68.238.96.12	Verizon FiOs Primary DNS at Kip's House
68.238.64.12	Verizon FiOs Alternate DNS at Kip's House

This is a view of the antenna on the communications trailer and the antennas from the Amateur Radio Field Operations Command Center. The HSMM antenna is pointed towards the church for Internet access, but the laptop computers in the Command Center were able to access the HSMM signal from the side lobe of this antenna. It was about 100 feet away. (Photo by AE5IB)

A late afternoon balloon launch from the launch field. Amateur radio operators on the field announced each balloon number as it took off so that the amateur radio recovery teams and the Balloon Festival staff knew which balloons had taken off. This information was also used to determine if all the balloons had been recovered. (Photo by AE5IB)

Use DNSMasq for DHCP:	**Checked**
Use DNSMasq for DNS:	**Checked**
DHCP Authoritative:	**Checked**

Time Settings

Time Zone/Summer Time (DST):
UTC—6:00/First Sun Apr – Last Sun Oct

Use Local Time: **Checked**

Save Settings

If the IP address changed or the Start IP Address changed, you will probably have to go to the command prompt (or DOS window) and type **IPCONFIG /RELEASE** then **IPCONFIG /RENEW** to get your computer to get a new IP address. The gateway is the IP address you want to go to.Use Internet Explorer to get back in the router.

Turn off security on both routers (this should already be done if you reset as above). Security can be re-enabled after all other steps are complete, but in order to minimize troubleshooting, it's best to get things set up with no security active: **Wireless -> Wireless Security -> Security Mode -> Disabled**

Put both routers into AP mode and on channel 1. **Wireless -> Basic Settings**

Under **Wireless -> Basic Settings**, set the SSID to the name of the router. The format I prefer is <Call Sign>-AP<number>—for example, KE5NGX-AP1 and KE5NGX-AP2. For WPA WDS, the SSID for the routers needs to be the same. For WEP, different SSIDs can make troubleshooting easier. We will use WEP.

If you plan to use WPA later, then select **G-only** in **Wireless -> Basic Settings**. You cannot use B-only with WDS.

Sensitivity Range (ACK Timing) for the Balloon Festival, the longest distance is 2505 feet, which is 763.5 meters. Since that is less than 2000 meters, we will stay with the default. If we ever have a link longer than 2000 meters, we will need to change this. Otherwise it times out before getting an ACK and then retries. This slows down the link a lot.

Open WDS configuration on both routers. **Wireless -> WDS**

On each router, you will see its wireless MAC address at the top of the **Wireless -> WDS** page. Put each router's MAC into the table of the other router, and select **LAN** for the type. Note that this MAC address is different from the one that may be printed on your case, because each router has three MAC addresses: WAN, LAN, and Wireless.

Here are known Wireless MAC Addresses for our routers:

Unit Name/SSID	Wireless MAC Address	Make
KE5NGX-AP1	**00:16:01:B9:87:A4**	Buffalo WHR-HP-G54
KE5NGX-AP2	**00:16:01:B9:92:16**	Buffalo WHR-HP-G54
KE5NGX-AP3	**00:13:10:94:92:09**	Linksys WRT54G v.3
N5OOM-1AP	**00:0F:66:A6:24:41**	Linksys WRT54G v.
N5OOM-2AP	**00:0F:66:A6:1E:C8**	Linksys WRT54G v.
N5OOM-3AP	**00:0F:66:A4:9D:B9**	Linksys WRT54G v.
N5OOM-4AP	**00:12:17:CE:F1:9F**	Linksys WRT54G v.
N5OOM-5AP	**00:12:17:D9:93:2A**	Linksys WRT54G v.

I am putting in all of the other routers in the table, and if not used, leaving it disabled, so in the future we can reconfigure more quickly. The interface is not very user friendly, and when you change type, anything not saved gets wiped out. Therefore, either save line by line, or change the type on all the lines first, then type in the MAC address. Then you should save. Then disable the ones that need to be disabled.

I am making a label for each of my units that has SSID, LAN MAC, WAN MAC, Wireless MAC, Login, and Password. It looks like this:

KE5NGX-AP1	
LAN MAC	**00:16:01:B9:87:A2**
WAN MAC	**00:16:01:B9:87:A3**
Wireless MAC	**00:16:01:B9:87:A4**
Login: root	**PW: admin**

If you send me the data, I will also print one for you. It helps with setup.

There is no need to enable **Lazy WDS** or **WDS subnet** on either router.

Test that you can ping the gateway from the client. Note that it may take a short amount of time for the WDS to be established, and you may need to reboot both the gateway and the client.

Enable encryption now, if you like (highly recommended). We must use WEP encryption. The encryption code we will use is: "HSSM_" or 95440EDCE0.

The other parameter we can play with is the power. The default is 28 mW, which is low. It says you can set it from 0 to 251 mW, but the help says 70 mW would be suitable for most applications. Higher power settings are not recommended for users due to the excessive heat generated by the radio chipset, which can affect the life of the router. We needed to play a little in the field to find out what is required. It turns out 28 mW is good enough.

Some Comments in the Setup

In some cases it may help to put the IP of the client router as a DMZ'd machine in the host router. Of course, this only works with a WDS between 2 routers. See: <http://www.dd-wrt.com/phpBB2/viewtopic.php?t=669&highlight=dmz>. *I did not see this in my experiments, but we will watch for it.*

If you have G-only enabled, you must use channel 1, 6, or 11. See: <http://www.dd-wrt.com/phpBB2/viewtopic.php?t=628&highlight=wds>. *We will use channel 1 only.*

The source material for this list comes primarily from the following DD-WRT forum posts:

Guide to Setting up WDS
<http://www.dd-wrt.com/phpBB2/viewtopic.php?t=124>

If you're using encryption, remember to configure it on all routers!

On the main **Status** page and the **Wireless Status** you can see the signal strength for any other routers in the WDS. If they are showing 0, then you're not connecting to them for some reason (wrong MAC address or, for WPA links, wrong SSID). *This is very helpful. You can see all wireless clients attached.*

It seems that when WPA2 is enabled, WDS does not work well with TKIP+AES: Client router reports no signal from the host router, while the host router reports a valid signal from the client routeur. Using TKIP only helps.

WPA2 works fine with TKIP+AES. Set both client and host to the same security settings, with the same password. Version in use is v24 Beta (07/12/07) – std on 2 Buffalo WHR-G125s. *We will use WEP so this is not a problem.*

We thank KE5NGX for his input for this column. Until next time . . . 73, John, K8OCL

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Light Speed

... we see that in about the last 10-thousand years, our planet has traveled about one light year. Ten thousand years ... let's see ... that's about how long it's taken us humans to advance from primitive hunter-gatherers to ... primitive hunter-DXers.

Tuning the bands in search of an interstellar CQ, we become aware that the universe is immense. When contemplating its magnitude, we need a whole new yardstick. For astronomers, that yardstick is the light year, the distance light travels in one year.

However, that doesn't tell us very much, does it? I mean, how many of us can close our eyes and visualize the speed of light? I can't. I can board an airliner and know that I am traveling at, say, 78 percent the speed of sound, but even that velocity challenges my comprehension.

Therefore, just how fast does light travel, how far does it go in a year, and how can we use that knowledge to assess our place in the universe? I could tell you that a light year is a quarter of the distance to the nearest star, but from my vantage point under this ocean of air, one star looks pretty much as remote as the next, so that doesn't clarify things at all.

Still, Mach One, the speed of sound, is a familiar concept to many of us. We know that if we see lightning flash and then five seconds later we hear the thunder roar, the storm must be about a mile away. We know this because sound travels at about five miles per second, and light (at least over such limited distances) seems to arrive instantaneously.

Well, in fact, light travels about a million times faster than sound, so we can quantify the speed of light, very approximately, as Mach One Million. Thus, a light year is about how far we would go in a million years, traveling at Mach One, or how far the Concorde (which flew at Mach Two) would have gone in 500,000 years—if it didn't have to stop for gas.

Of course, we all have to stop for gas, sooner or later. My little Volkswagen Beetle gets about 30 miles to the gallon, on a good day. Just how many gallons of fuel would I need to drive a light year, and how many times would I have to stop to fill up?

The textbooks tell us that one light year is about 6-trillion miles. Let's see if we can sink our teeth into that one. Well, 6 trillion is 6,000 billion, so at 30 miles per gallon, we merely need to divide 6,000 by 30 (that equals 200), and then tack a billion on the end.

Okay, 200-billion gallons of fuel. A 20-gallon gas tank means we need to fill up (let's see, 200 billion divided by 20 equals...) 10-billion times. How long do you suppose that will take us?

Each gas stop consists of pumping the petrol, paying for it, visiting the restroom, grabbing a cup of coffee, and maybe making a phone call home to keep the spouse apprised of our progress. Let's say 12 minutes per pit stop. That's 5 to the hour, which means we spend—let's see now, 10 billion divided by 5 equals ... 2-billion hours lost at interstellar service plazas. I wonder what that is in years.

Now there are 24 hours in a day, and 365 days in a year. Multiplying the two together, we see that a year consists of just under 10-thousand hours. (I told you this would be approximate.) Dividing 2 billion by 10 thousand, we find we're spending 20,000 years just fueling up. That's for a hypothetical one-light-year trip, and we haven't even begun to calculate driving time!

Were this space ship on which we reside traveling at the speed of light, it would of course travel one light year in exactly one Earth year. However, Earth is a slow boat to nowhere. Is it possible that, during its brief history, our planet has traveled light years? In fact, it has, if you count its curved path around our Sun. Let's calculate the Earth's annual orbit, in light years:

We start with the known fact that it takes 8 minutes for sunlight to reach us. (We know this because when we flip the switch to turn off the Sun, it takes 8 minutes for the sky to go dark.) Well, that places the Earth 8 minutes from its source of power, so we'll use 8 light minutes for our orbital radius.

One trip around the Sun takes us just a year. Not counting the Sun's own motion around the galactic center, the distance we travel in a year is (pi times diameter equals ... two pi times radius, equals ...) 50 light minutes. Rounding up, we'll call it a light hour.

Since Earth travels about a light hour per year, and a year is almost 10-thousand hours long (remember?), we can see that we're orbiting the Sun at one 10-thousandth the speed of light, or Mach 100. Did you realize that you live on a supersonic spacecraft? Furthermore, we see that in about the last 10-thousand years, our planet has traveled about one light year.

Ten thousand years ... let's see ... that's about how long it's taken us humans to advance from primitive hunter-gatherers to ... primitive hunter-DXers.

What does all this have to do with interstellar communications and the search for radio signals in space? Actually, more than a bit. Let's imagine our planet as a starship. We somehow manage to snap the gravitational rubberband that binds us to our Sun, and we shoot off in a straight line, toward the stars. Here we go, at one 10-thousandth the speed of light. It takes us 10-thousand years to travel one light year. If we're lucky enough to be shooting off in the right direction, it takes us about 40-thousand years to reach the next nearest star. If we visit about a thousand stars, we're likely to find one being circled by a habitable planet. That means shopping for a new home could take us 40-million years, give or take.

Is it any wonder that some of us choose to embrace electromagnetic communications, rather than merely go there?

73, Paul, N6TX

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5 W Heavy Duty Submersible 2 m/70 cm Dual Band FM Hand held
VX-6R
5 W Heavy Duty 2 m/70 cm Dual Band FM Hand h
FT-60R
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