TAPR #102 SPRING 2007

PACKET STATUS REGISTER

President's Corner

Dayton is fast approaching. As announced in the previous *PSR*, we will have a joint TAPR – AMSAT soiree this year on Friday night, at the Air Force Museum starting with a cash bar and appetizers at 6 PM. As this is our first joint dinner, the format will be quite different for both organizations. Business will be kept to a minimum, and we will not have a speaker this year so that we can focus on viewing the exhibits. We have the "run" of the place until 2200 hours.

Tickets can be purchased through the AMSAT store by visiting www. amsat.org. The cost is $35 per person, which includes the meal, tax, gratuities and admission to the museum. You can pick up your tickets at the AMSAT booth on Friday. There will be NO ticket sales at the TAPR or AMSAT booths, as we need an accurate headcount 3-4 days before the event.

As I said above, we will have no formal speaker this year. We wanted to make sure that you all had plenty of time to look around. The format for the event will be modified in the future based on the feedback from attendees, so come out, join us and give us your input.

Your volunteers have been very busy in support of the HPSDR project. The Janus and Ozy boards have been manufactured, built and tested and should be shipping as I write this. We hope to have a small number of boards that were "unspoken for" available for sale at Dayton on a first-come, first-served basis. We are now busy assisting with the development of Penelope, a 1/2- watt exciter board with coverage from 1.8 to 55 MHz. It will be a companion to the Mercury HF direct sampling HF receiver board. The HPSDR developers seem to have an abundance of energy and new ideas, so the projects just seem to "keep on coming!" Further information about the HPSDR projects can be found at www.hpsdr.org.

There has been a change in the time for the TAPR forum at Dayton. It will start at 0915 on Friday in Room 2, and end sharply at 11 AM. I'll be moderating the forum, and the schedule looks like this:

Steve Bible, N7HPR, and Scott Cowling, WA2DFI – HPSDR update including production and testing of Ozy and Janus

John Ackermann, N8UR – Updates on Timing Projects and the TAPR Open Hardware License (OHL) Initiative

Matt Ettus, N2MJI – GNURadio

David B. Toth, VE3GYQ – TAPR Q&A Session with your Board of Directors

As I said in the last issue, I look forward to seeing all of you at the TAPR booth at Dayton ... please stop by and see what other surprises we'll have in store for you.

As always, I look forward to hearing from you at ve3gyq@tapr.org ...

Dave VE3GYQ/W8

Spencerville, OH

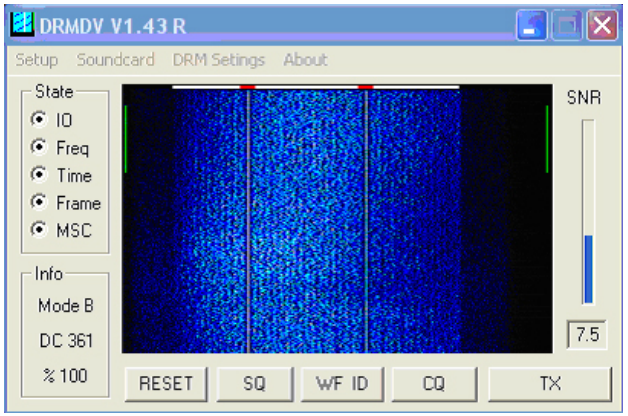
###

DRMDV

Digital Radio Mondiale - Digital Voice: A new and robust digital voice mode for HF

By Mel Whitten, KØPFX, mel@melwhitten.com

Experiments with Digital Voice over HF continue! Cesco's (HB9TLK) latest work named *DRMDV* has a simple DV-only GUI for easy operation and improved weak signal decoding down to <6 dB SNR. Only a small degradation in voice quality is noted over its predecessor, *WinDRM*. In an effort to meet the challenges of DV over HF, changes in the coding scheme for DRM/OFDM had to be made. Data is now spread across 44 carriers (down from 53), 2 rather than 3 frequency pilots are used and the FAC data cells providing the station call sign had to be removed. These and other changes in the OFDM carrier-mapping table provide the 1400 bit/s data rate using the more robust 4QAM.



Decoding Digital Voice: N1FFX running 5 watts average power decoded by KØPFX on 14.236

Although *DRMDV* is not compatible with *WinDRM*, the configuration for sound cards, PTT control and TX/RX requirements remain the same. A USB headset (i.e., Logitech 250/350 or equivalent) may be used for the second sound card making an easy setup. A choice of two CODECs, MELP and LPC are available. The author has provided a DIY (do it yourself) kit to compile and create this slower bit rate MELP dll file. Automated "CQs" and voice recordings of the QSO are available at the click of the mouse. *DRMDV* software and documentation may be downloaded at www.n1su.com. Join in the fun and give DV a try... experience the "wow" factor of no noise, QRM/QSB over HF!

###

Joint TAPR–AMSAT Banquet at Dayton 2007

By John Ackermann, N8UR, jra@febo.com

For many years, AMSAT and TAPR have held "competing" Hamvention dinners on Friday evening. Given the tremendous overlap in membership and interest between the two groups, this has always required tough choices.

We're pleased to announce that this year, AMSAT and TAPR will be holding a joint dinner, and it will be at a great venue – the Air Force Museum.

Here are the details:

"Dinner Under the Wings" will be held Friday evening May 18, 2007 at the Air Force Museum in Dayton, OH in conjunction with the 2007 Dayton Hamvention. The doors open at 18:00 with a cash bar and appetizers in the Air Power Gallery (World War II). The buffet dinner will be served at 19:00 in the Cold War area. Following a few announcements and a short presentation you will be free to roam the museum.

Price for the dinner is $35.00 per person and includes appetizers, salad, meal, dessert, coffee, iced tea, tax and gratuity.

See http://afmuseum.com/ or www.nationalmuseum.af.mil/ for information about the museum.

The museum will close at 22:00 and everyone must be out of the museum by then.

Reservations are required and can be purchased from TAPR – go to www.tapr.org/dayton.html for more details. There will be no ticket sales at the TAPR booth this year, and sales will close on Monday night, May 14, 2007 to allow us to give the museum a count on Tuesday.

There may also be a special showing of the IMAX movie *Space Station* at 17:00 prior to the banquet. See below for details.

Banquet Menu

Roll and Butter

Salad with choice of Ranch, French or Italian Dressing

Top Round of Beef w/carver

Classic Sautéed Chicken Breast in a Sun Dried Tomato Cream Sauce

Grilled Salmon Blackened with Jack Daniel's BBQ Sauce

Roasted Red Skin Potatoes

Rice Pilaf w/ Pine Nuts and Thyme

Prince Edward Blend w/ Yellow Wax Beans, Green Beans and Baby Carrots

Sugar Snap Peas w/ Red and Yellow Peppers

Chocolate Chocolate Espresso Torte w/ berries and Melba Sauce

NOTE: A vegetarian meal choice is available; if you would like this, please let us know when you order your tickets.

IMAX Movie *Space Station*

At 1700 on Friday afternoon there will be a special showing of the IMAX movie *Space Station*. This movie is approximately 47 minutes long and contains about 4 minutes of amateur radio contacts between school children and the International Space Station. The IMAX theater is located in the museum building off the main lobby area. Attendees at the movie will be able to go to the banquet at 6:00 PM when the doors open about 10 minutes after the movie is over. The lobby contains rest rooms, telephones and some seating.

At least 50 people must sign up for the movie in advance. Reservations are required – to place yours, call the museum IMAX theater at 937-253-IMAX. Adults $6, seniors $5.50, students 8 through college 22 (student ID required) $4.50.

###

ARRL Seeks Comments on New HF Digital Protocol

The ARRL is seeking comments from amateurs concerning development of an open-source (non-proprietary) data communications protocol suitable for use by radio amateurs over high-frequency (HF) fading paths. This is not a Request for Proposals (RFP). An RFP may or not be forthcoming depending on evaluation of the information received.

Specifically, the League is asking for comments and information on the following issues:

- **Access Method:** Is Orthogonal Frequency-Division Multiplexing (OFDM) the best candidate technology, or should other competitive technologies be considered?
- **Data Rate and Bandwidth:** What data rates/throughputs are achievable at various bandwidths up to 3 kHz bandwidth?
- **Adaptivity:** What adaptive features should be considered, such as automatic adjustment of transmitter power, modulation waveform and coding, in order to maximize throughput and efficiency in two-way contacts?
- **Robustness:** What is achievable for reliable operation at power levels typical in the Amateur Radio Service and low signal/noise and interference ratios?
- **Error control:** What are the appropriate applications of error control suitable for HF channels? For example, how should Repeat reQuest (ARQ) and Forward Error Control (FEC) be applied to two-way contacts and one-to-many (roundtable and bulletin) transmissions?
- **Activity Detection:** What is an effective method of determining whether a frequency is busy prior to transmission?
- **Operating System:** What operating systems (such as Windows or Linux) are appropriate for Amateur Radio use with this protocol?
- **Hardware:** What practical and affordable hardware platforms are suitable for amateur stations? Consider the use of personal computers with or without sound cards. Provide any information about the need for an additional "box" if needed.

Please provide the following with your response: (1) name of respondent, (2) respondent's contact information, (3) related experience, and (4) type of respondent: (individual, partnership, corporation or group). Do not include proprietary information as part of your response.

Post, fax or e-mail your response by 1900 UTC, May 15, 2007 to:

Paul Rinaldo, W4RI
Chief Technology Officer, ARRL
3545 Chain Bridge Rd
Suite 209
Fairfax, VA 22030
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###

Ham Radio 'Systems-On-a-Chip'

By Steve Bragg, KA9MVA, ka9mva@hamhud.net

Ultra-high-integration "systems-on-a-chip" (SoCs)[1] allow consumer-electronics designers to shoehorn more functionality into ever-smaller and less-expensive products. Many commercial SoCs are hard-wired for specific tasks, and most are unavailable to the radio amateur. But the latest field-programmable gate arrays (FPGAs) pack enough digital hardware to be called SoCs in their own right. Falling prices, exponentially increasing gate counts, and low-cost design software are converging to make FPGAs the right technology for emerging ham radio systems-on-a-chip.

First, we'll look at the author's conception of a ham radio system on a chip. Next, we'll look at some motivations for ham SoCs. Finally, we will preview an example implementation of this architecture: HamHUD V, a mobile ham communication system incorporating APRS and software-defined radio (SDR), which will be demonstrated in part at the Dayton Hamvention this year.

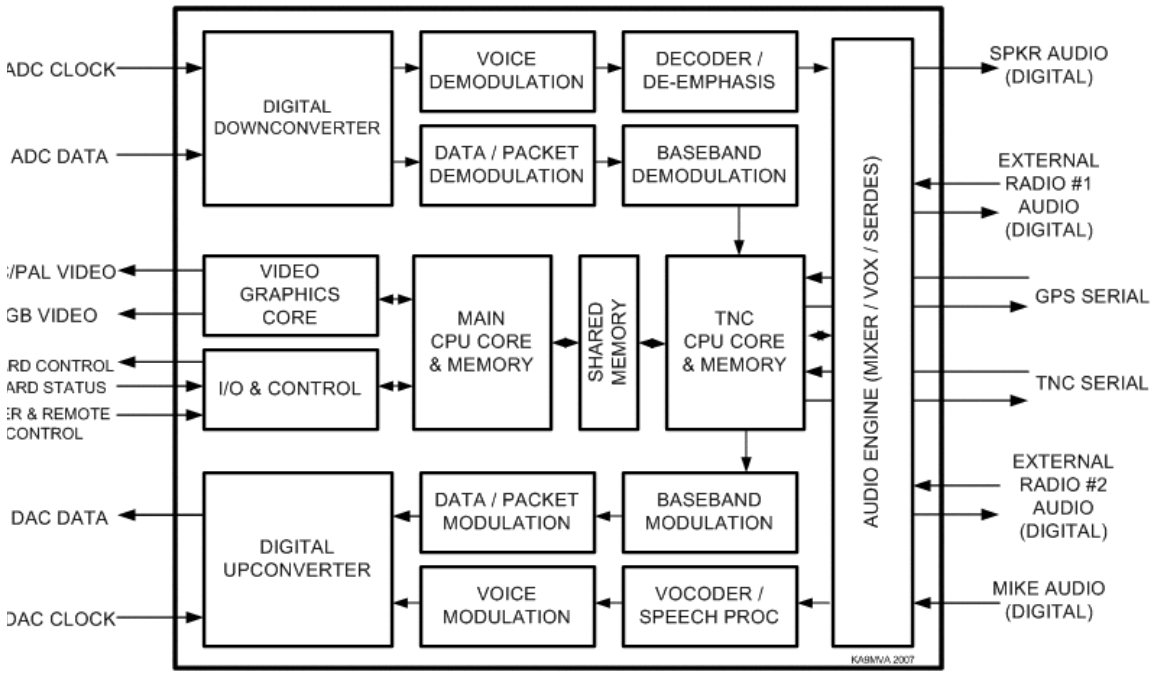
What Is a Ham Radio System-On-a-Chip?

For our purposes, a ham radio SoC means putting the core functionality of a stand-alone, multimode ham radio station into a single silicon chip.

We are speaking here of high-density FPGAs, with densities of a million gates or more. These FPGAs include not only general-purpose gates, but also dozens of dedicated function blocks such as wide multipliers, multi-kilobyte RAMs, clock PLLs, and routing fabric. Such FPGAs cost less than thirty dollars in volume as of this writing. While this may sound expensive, there is a premium for leading-edge technologies. Consider that the 6502 microprocessor was a runaway seller at $25 in 1976[2]!

We are not talking about placing the entire station onto the SoC. Of course there will have to be other ICs on the board: analog-to-digital and digital-to-

FIGURE 1. Ham Radio "System-On-a-Chip" FPGA.



analog converters of various kinds, memory, and interface ICs.

A block diagram of the author's concept of a ham radio system-on-a-chip is shown in Figure 1.

A ham radio SoC includes signal processing 'blocks' for the most popular modes of ham radio: analog and digital voice, ATV/SSTV, packet, data and APRS®. Vocoders and decoders, such as that developed by G4GUO and G4JNT[3] can be included. Audio processing (such as speech processing, VOX and stereo synthesis) can be in the SoC. Packet engines and TNCs should also be included.

An example of an FPGA-based TNC device is Nico Palermo, IV3NWV's YAM modem[4], released in 1997. The TNC-like YAM was based on the Xilinx XC5200-series FPGA, the equivalent about 3,000 gates[5]. IV3NWV's clever coding crammed both 1200-bit/s AFSK and 9600-bit/s G3RUH modems into a small Xilinx FPGA. Today, the equivalent of the YAM, and much more besides, can be incorporated into a ham radio SoC.

Since we are envisioning the ham SoC as a standalone radio station, some computer functionality must exist, including user interface, data presentation and display. Interfaces to all familiar ham communication I/O devices must be included: DTMF control-type microphones, audio speakers, cameras, displays, even code keys. Data presentation programs, such as the APRS® implementation in the HamHUD device, are included, as are serial interfaces for GPS and an external PC or other computer.

With the incredible horsepower available in today's FPGAs, even the RF portions of the ham station may be included in our SoC, using the technology of software-defined radio. Digital up converters and down converters, handling A/D and D/A converters sampling at over 100 MHz, are possible with these FPGAs. For weak-signal HF operation, direct RF ADCs and DACs are practical[6]. For 2-meter FM repeater operation, the phase noise and dynamic range requirements are lower, and digital-to-RF is now practical[7].

FPGA-based software-defined radio projects, including Eric Blossom's Gnu Radio[8] and the HPSDR[9] group's effort, point the way to ham radio SoCs. The Gnu Radio Universal Software Radio Peripheral[10] (amusingly abbreviated 'USRP') is based on a 288,000-gate-equivalent[11] Altera Cyclone FPGA[12]. (However, modulation and demodulation are done in an external PC.) One of the HPSDR boards, the Ozymandias or simply 'Ozy', contains an Altera Cyclone-II FPGA[13], with about 110,000 gates, used as a digital down-converter/up-converter.

Why a Ham Radio System-On-a-Chip?

The trend in ham radio, as it has been in consumer electronics, is increasing integration. Manufacturers want fewer IC packages and less 'glue' logic and discretes, while incorporating more functionality, all at a lower cost (and therefore price) than last year's model. Amateur radio manufacturers have similar goals in mind, and since ham radio operators are famously "cheap", a discounted price tag is welcome.

An important reason to put a ham radio system on a chip is to facilitate homebrewing and equipment modification. (Yes, you read that sentence correctly.) What's that you say, OM? "FPGAs come in ball-grid-array packages no sane radio amateur would attempt to solder! True, but the soldering problem can be left to manufacturers with proper equipment, and the ham can work with FPGA development boards such as the XESS Corporation[14] XSA-3S1000 (which the

author uses). With an open-source ham SoC and low-cost/free software tools, the technically minded ham can modify the SoC's functionality in any way he or she can dream up. New modes can be quickly implemented. With ham SoCs, we may be on the verge of another golden age of homebrewing!

Finally, ham radio SoCs represent an interesting way to extend the state of the art in radio communication, a subject near and dear to many PSR readers' hearts.

A Ham Radio SoC Example: HamHUD V

The author, together with Dale Seaburg, KG5LT, and Jason Rausch, KE4NYV, is designing the next version of HamHUD, which began as a mobile APRS packet terminal back in 1997. HamHUD V ("vee" for "versatile" and "video") is envisioned as a standalone multimode mobile ham station, although it can utilize external ham transceivers.

HamHUD V incorporates a 1.2-million-gate Xilinx Spartan-3E FPGA[15] as a ham radio system-on-a-chip. Figure 1 is in fact the block diagram of the eventual HamHUD V SoC, which is being developed incrementally, a subsystem or two at a time.

A demonstration version of the SoC will be shown at the 2007 Dayton Hamvention. As of this writing, the TNC CPU, Main CPU, and video cores are implemented, as are the GPS/TNC serial and memory interfaces. Partially functional are the AFSK modem (baseband blocks in Figure 1), as well as the audio engine and user/remote control interface. Firmware to implement APRS operation and voice processing is running on the two CPU cores. The NTSC video interface is operational, with a rudimentary graphical user interface (GUI). As of this writing, only prototypes of the software-radio (up-conversion/down-conversion, modulation/demodulation) sections have been exercised.

The HamHUD V SoC is implemented almost entirely in open-source VHDL, with some vendor-provided functional blocks (without source code). Many of its functional units were "borrowed" from other FPGA projects on the Internet, such as the OpenCores[16] and FPGA Arcade[17] T80 CPU and UARTs. Other blocks, such as the modem, packet engine, and graphics processor, were written by the author.

All of the firmware was written in C. The two-processor cores communicate through a shared memory interface, which is implemented using on-chip block RAMs. These same block RAMs also implement local CPU memory, data buffering, and FIR filters.

Free and low-cost software tools were used throughout development. Xilinx' free WebPack ISE software tools were used to compile and debug the SoC. Iowegian[18]'s ScopeFIR filter synthesis tool ($199) was used to design digital filters. Firmware development was done with free compilers and tools, such as SDCC and Gnu gcc.

The author expects to write further about the architecture and implementation of the HamHUD V SoC; please check back at the HamHUD web site, www.hamhud.net.

Closing Thoughts

Today's FPGAs offer the radio amateur the possibility of placing a large part of a multimode amateur radio station on a single chip. This paper introduces the concept of a ham radio "system-on-a-chip", and explains some of the motivations for such a project. Finally, we took a brief look at a ham radio SoC design presently in development, the HamHUD V. Much work remains to be done, and the author hopes this paper will increase interest in

FPGA SoCs among digital radio amateurs.

1 Also called Application-Specific Integrated Circuits (ASICs) – a commercial example is BroadCom's series of media processors for television set-top boxes, www.broadcom.com/products/Consumer-Electronics/High-Definition-Audio-Video-Graphics-System-Processors

2 Brian Bagnall, On The Edge: The Spectacular Rise and Fall of Commodore, Variant Press, 2007. See www.variantpress.com/books/on-the-edge

3 Charles Brain, G4GUO, and Andy Talbot, G4JNT, "Practical HF Digital Voice", *QEX*, May/June 2000, www.arrl.org/tis/info/HTML/digital_voice/0056x003.pdf

4 YAM Modem, www.nordlink.org/yam/

5 Xilinx XC5200 series data sheet, http://direct.xilinx.com/bvdocs/publications/5200.pdf

6 James Scarlett, KD7O, "A High-Performance Digital-Transceiver Design, Part 1", *QEX*, July/Aug 2002.

7 James Scarlett, KD7O, "A High-Performance Digital-Transceiver Design, Part 2", *QEX*, Mar/Apr 2003, and a private conversation between the author and KD7O.

8 Gnu Radio, www.gnu.org/software/gnuradio/doc/exploring-gnuradio.html

9 High-Performance Software-Defined Radio; on the Web: http://hpsdr.org/

10 URSP, www.comsec.com/wiki?UniversalSoftwareRadioPeripheral

11 Logic element to gate equivalency is controversial in the FPGA world; for more, see this article in the online version of the FPGA Journal: www.fpgajournal.com/articles/20040706_tango.htm

12 Altera Cyclone Data Sheet, www.altera.com/literature/hb/cyc/cyc_c5v1_01.pdf

13 Altera Cyclone-II Data Sheet, www.altera.com/literature/lit-cyc2.jsp

14 XESS Corporation, Apex, NC, www.xess.com

15 Xilinx Spartan-3E Data Sheet, http://direct.xilinx.com/bvdocs/publications/ds312.pdf

16 OpenCores Project, www.opencores.org

17 FPGA Arcade, www.fpgaarcade.com/

18 Iowegian International, :www.iowegian.com/

###

New Digital Group

By Mark Thompson, WB9QZB, wb9qzb@arrl.net

This group is dedicated to the discussion and development of amateur / ham radio use of digital voice and data communication techniques utilizing D-STAR digital voice and data, APCO P25 digital voice, HF digital voice, packet radio (including APRS), HSMM (High Speed Multi Media)/Wi-Fi, and PSK/FSK.

Join the group to exchange ideas and information and learn about operating the digital modes. Dozens of Files and Links about all digital modes are available on the group. Hams from all areas are welcome. Use this URL to join: http://groups.yahoo.com/group/illinoisdigitalham/

###

OpenTracker+

Low-Cost APRS Gets Smarter

By Scott Miller, N1VG, scott@n1vg.net

Back in late 2003, when I started developing the OpenTracker as a test platform for my proposed OpenTRAC protocol, I figured I'd build a couple dozen for interested experimenters. While a few people did use it for that purpose – and development work continues on the protocol – the kit turned out to be far more popular as a general-purpose APRS encoder. Since 2004, thousands of kits have shipped to more than 40 countries and all seven continents. I'm continually amazed by the range of applications people have found for such a simple device.

Recently, though, Freescale Semiconductor threw a monkey wrench into the works by announcing that they were ceasing production of the MC908KX8 processor used in the OpenTracker. Despite the fact that they were still taking orders and will continue to ship through November of this year, the part suddenly became almost impossible to find.

Those of you who attended DCC last year know that I'm working on the Tracker2 – an evolution of the OpenTracker that includes a TNC2-style demodulator and adds features

like digipeating, a command console, KISS support, and remote control. It's unavoidably more complicated, though, and not as simple or inexpensive to build as the original OpenTracker. It's also overkill for many applications.

With that in mind, I decided to redesign the OpenTracker using a different processor in the HC08 series. Freescale didn't offer a direct replacement for the KX8, so I chose the new MC908JL16. With 16k of flash, it has more than twice the program space of the old processor, and three times as much RAM.

The circuit I built around the new processor emphasizes simplicity and ease of construction. It actually has *fewer* parts than the OpenTracker, and can be assembled in about 25% less time. The potentiometers – probably the least reliable components in the original design - have been eliminated, replaced with software settings. There's still a single LED for status, but it now displays three colors to make it easier to see what the tracker is doing.

The simpler design still provides all of the features of the original, though, plus some new ones. Most importantly, the OpenTracker+ uses DSP techniques to demodulate the received signal. APRS packets are parsed and converted into NMEA $GPWPL strings, so that received stations are plotted on supported GPS receivers as waypoints.

It's not as full-featured as the waypoint output on the Tracker2 – there's no symbol or comment output, and no range limiting at

this time – but it does include optional name truncation for GPS receivers that don't support long waypoint names.

At this point, the DSP code is still being refined. The HC08 isn't a high-powered processor, and the demodulator performance will probably never quite match that of a real TNC, but I suspect there is still room for improvement. As it is, it works remarkably well given a reasonably strong and properly adjusted signal, and provides a reliable DCD mechanism for operating open squelch. Best of all, it adds absolutely nothing to the cost of the kit.

I'm planning to make the OpenTracker+ available in two formats. The first is similar to the OpenTracker 1x, with 9-pin d-sub connectors at either end of a plastic case. The second is a 24-pin DIP module, with or without pins installed. This version is still being tested, and might undergo another revision before it's ready, but it ought to be a viable replacement for the old APRS MIM board in telemetry applications.

More telemetry features are on the way to take advantage of the extra analog inputs that the new design offers. I'm also considering some simple remote control features to allow the tracker to receive remote commands. And the free version of Freescale's CodeWarrior development environment will compile the OpenTracker+ firmware, so if you don't mind getting your hands dirty with some embedded C programming, you can add whatever additional features you need, and download the new code with nothing more than a null modem cable.

The standard OpenTracker+ kit should be available by the start of May, at the same price as the old kit - $32 for one, or $25 each for 10. The assembled surface mount version should be around $40 when it's available. They'll all be listed on my web store at www.argentdata.com/catalog as soon as they're ready. And if you're coming to Dayton this year, be sure to check out the new kits at booths 503-505.

###

APRS Helps Conservation Group

By John Carnakis, KE6DKY,
ke6dky@sbcglobal.net

The Society for the Conservation of Bighorn Sheep (SCBS) builds and maintains water catchments sites in the California desert for the benefit of wildlife in particular Desert Bighorn Sheep. SCBS has over 70 of these sites, which need to be inspected twice a year, spring and fall.

But real time knowledge of water availability is need during the summer months. Eight of these sites are instrumented with water depth sensors and the data is returned via earth orbiting satellites. This approach has been an expensive venture for SCBS. APRS shows promise for a low cost solution for the return of water depth data. An APRS reporting system and a water depth sensor developed by Xpondr Corporation called Flood Advisor <www.xpondr.com/> provides real-time data collection and return at a low cost.

To view a SCBS water data site via Steve Dimse's FindU click this URL: www.findu.com/cgi-bin/find.cgi?call=ke6dky-10

###

2006 TAPR Financial Report

Our Total Assets are up $1343.60 over 2005. This includes cash in the Savings and Checking accounts, value of Inventory, and remaining value of depreciating assets. Cash on hand is up approximately $7000, while inventory is down about $5000. Depreciating assets are worth about $1200 less than in 2005.

Income is up substantially over 2005, as were expenses. Income was up, a bit more than $19,000 over 2005, to $105,390.38. Expenses were also up more than $7000, to $104,113.10. As our 2005 loss was almost $11,000, we have made a substantial improvement in our performance this past year. Our net revenue was $1277.28.

Income from new members was up $600, but renewing member income was actually down $3,500.

Product sales totaled $62,554 in 2006, vs. 50,817.22 in 2005. This was an increase of $11,736.78. Other income, mainly from licensing the VNA to Ten-Tec, amounted to $9,628.82, up from $0 in 2005.

On the expense side, we spent an extra $1,500 to attend Hamvention in 2006, but reduced the cost of DCC by almost $3000. Cost of sales was up about $7,200, but not inconsistent with the increase in sales dollars. Postage was up $2,200, also consistent with increased sales. R&D Expense was up about $2,200, reflecting the early costs of HPSDR, and also of John Ackermann's TADD project.

Overall, TAPR has done a very good job of keeping expenses contained while generating additional revenue from new kits. Based on what is known currently about the sales of HPSDR related products and the associated expenses, 2007 should generate record levels of income for TAPR, and hopefully, expenses can be kept under control so that we will have funds available to pursue more exciting projects.

Respectfully submitted,

Tom Holmes, N8ZM

Treasurer

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TAPR is a community that provides leadership and resources to radio amateurs for the purpose of advancing the radio art.

Submission Guidelines

TAPR is always interested in receiving information and articles for publication. If you have an idea for an article you would like to see, or you or someone you know is doing something that would interest TAPR, please contact the editor **(wa1lou@tapr.org)** so that your work can be shared with the Amateur Radio community. If you feel uncomfortable or otherwise unable to write an article yourself, please contact the editor for assistance. Preferred format for articles is plain ASCII text (Microsoft Word is acceptable). Preferred graphic formats are PS/EPS/TIFF (diagrams, black and white photographs), or TIFF/JPEG/GIF (color photographs). Please submit graphics at a minimum of 300 DPI.

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