NOVEMBER 2015

Current Board of Directors

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Gary W6GDK Secretary
Richard KJ6WUY Treasurer
Dennis Baca KD6TUJ Repeater Site Chair
Glen KJ6ZQH Membership
Mark KF6WTN Repeater Technical Chair

Nominations for the 2016 Board will be announced at the November membership meeting.

Elections for 2016 Board will be held at the December membership meeting.

Save the Date

Club Meeting
4 November 2015

Learn about how PARC is supporting AMSAT's Phase 4 satellite service project.

There will be presentations and a panel discussion. See page 3 for details.

The slate for the 2016 PARC board of directors will be announced.

Board Meeting
11 November 2015

Palomar Amateur Radio Club board meeting at 7:00pm at Poway Fire Station on Community Road

Club Events
7 November 2015

Operating Day at Fry's in San Marcos! 9am - 2pm
See page 63
YES! 63! Wow!

Operating Day at Fry's Electronics in San Marcos

November 7th, 9:00 AM – 4:00 PM. At Fry's in San Marcos. Volunteers requested to meet the public, and participate in the event along with other ham radio organizations. Good opportunity to attract possible new hams. Contact Tom Martin K6RCW at (619) 778-3866 to volunteer for Operating Day, or send an email to scope@palomararc.org and your message will be forwarded to Tom.

Advertisements are free for members

Have items that need to find a new home? Advertise here! Send your ads to scope@palomararc.org

Club Members ONLY!
PARC has a tube bank that includes many 6 & 12 volt receiving tubes (and some transmitting types) for use by club members to repair their own personal equipment. Not for commercial use or resale. If we have your requests, we will pre-check the tubes and deliver them to you at the next club meeting.

Contact John WB6IQS WB6IQS@att.net

President's Corner

A very Happy Thanksgiving wish to each of you and your family!

Well, as I am sure you are aware, the holidays are upon us and family time will become more and more important as the year winds down. Please take the time to enjoy the season, and don't forget to leave clear requests for the ham radio goodies you are wanting!

The November General meeting program will be very informational and exciting. The AMSAT folks, those who developed many of the ham satellites in orbit, are planning to launch a geosynchronous ham satellite. In preparation to do so, AMSAT is implementing a network of ground stations that simulate the satellite as well as the user terminals that directly connect to the satellite. But, that's not all. There is a third type of station in the works that collects local radio traffic and bundles it up for transmission to the satellite.

PARC is going to host one of the satellite simulators at our Palomar site. This will put us in the forefront of developing future ham technology, and will give San Diego County hams an opportunity to communicate with the simulated satellites by using their ham station equipment. You will not want to miss the program!

The Club has a busy season ahead. We start with Operating Day at Fry's on Saturday November 7th. A great opportunity for you to come out and participate in actually getting on the air with a good antenna for the HF bands. No antenna restrictions in the Fry's parking lot! Furthermore, participating is a way to receive Club participating points which turn into picnic prize tickets! An inexpensive way to increase the probability you will win a prize at the Club's picnic. We need volunteers to help at the event.

The Club's Board of Directors is evaluating several projects to undertake for the benefit of you the Club member. They are projects that involve implementation and installation of new equipment at our repeater site. As the projects are evaluated, and a decision is reached to implement one or more of them, stay tuned!

There will be excellent opportunities for club members to be involved in the installation of equipment, the testing of capabilities, and then the regular use of the equipment by all club members, as well as hams throughout San Diego County. This will give us the chance to get new hams involved in "getting their hands dirty" in ham radio technical work!

In accordance with the Club's bylaws, a nominating committee was appointed to identify Club members willing to volunteer their services for the Club Board Of Directors in 2016. The result of their deliberations will be announced at this month's general meeting. Election for officers will be held in December.

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New Committee Chairs

It's been a while since PARC had an active committee system. In the October 2005 Scope, the list included ARES Info, ARES Net, Attendance, ATV, Auction, Badges (New), Batteries, BBS Monitor, Billing Ads/etc, Contest Info, Control Ops, Del Mar Fair, EmComm, Field Day Tech, Inventory, New Member, Nets, Newsletter, Patch Info, Patch Electronics, Picnic, Power AC/DC, Programs, Publicity, QSL Cards, RACES Info, RED Flag, Repeater Site, Repeater Tech, SANDARC, Seller Table, Testing, VE, Trustee, and Web.

The club is reviving the committee system and will be welcoming new chairs. If you are willing to serve, or have an idea for a particular chair that you believe the club needs, please contact the board at board@palomararc.org.

Some of these positions are no longer relevant. For example, since we don't have a phone patch, we don't currently need a committee chair for that position.

It's our pleasure to announce two new Committee Chairs for PARC. Both report to our repeater technical chair, Mark Raptis KF6WTN.

New Chair for EchoLink

An EchoLink Chair has been established for Palomar Amateur Radio Club. Bernie Lafreniere N6FN has operated PARC's Echolink node since it was established in 2010, has written a book about EchoLink, and owns and operates http://www.niftyaccessories.com/index.php

Contact Bernie Lafreniere at n6fn@niftyaccessories.com

The biggest task for the EchoLink subcommittee is figuring out how to integrate EchoLink into the System Fusion repeater system. Mark Raptis KF6WTN is currently assisting in researching how best to accomplish this.

PARC's EchoLink node is currently offline while the committee works on the best way to integrate it with the repeaters.

Bernie has recently been writing guides for the new Yaesu transceivers that incorporate the WIRES-X Internet linking capability. PARC has been offered a WIRES-X box as a donation.

If you're interested in EchoLink, then dust off that EchoLink registration and get ready for more activity!

Find out a lot more about EchoLink at http://www.echolink.org

New Chair for Mesh Networking

Phil Karn KA9Q has agreed to serve as Mesh Networking commitee chair.

Phil writes:

"I've been a ham since high school in 1971. After college I went to work for Bell Labs and became involved in AMSAT and in amateur packet radio development. In the mid 1980s I wrote the KA9Q NOS TCP/IP software package. It's long obsolete now, but it first brought the Internet to many non-hams as well as hams. I've lived in San Diego since 1991 when I came here from New Jersey to work for Qualcomm. I retired from Qualcomm in 2011, so I have time to get active in ham radio again.

I'm one of several adult mentors to the Mount Carmel High School Amateur Radio Club. We help the students design, build and fly high altitude balloon payloads. They've done three so far and are working on their fourth.

In the late 1980s, fellow AMSAT members Jan King, W3GEY, Tom Clark W3IWI (now K3IO), Bob McGwier N4HY and I conceived the "Pacsat" satellite concept: an orbiting digital mailbox with four uplink receivers, a computer and one common downlink. I am now proposing a very similar architecture for the Phase 4 project, updated to 21st century technology: a software defined receiver, able to locate and demodulate many 5 GHz uplink signals at once, feeding a single 10 GHz high speed digital downlink. Because the satellite will be in geostationary orbit, communications will be real-time (unlike the low altitude Pacsat). We are designing the system primarily for digital voice, but it will also support low to medium speed data. Because the ground terminals will be very small (< 1 meter) we expect it to get many hams onto satellites that cannot do so now because they lack the room to erect the VHF/UHF arrays now needed. We also expect it to be very useful for the early stages of a regional disaster that takes out commercial communications."

Thank you to Bernie and Phil for volunteering!

SANDARC Meeting Report

Paul KB5MU and Michelle W5NYV are serving temporarily as Palomar Amateur Radio Club's delegates to SANDARC. The most recent meeting was held 29 October 2015. Meeting minutes were approved, no treasurer's report was given.

A report about the Volunteer Examiners Appreciation Luncheon report was given. 23 SANDARC VEs enjoyed a social celebration at Giovanni's Restaurant. Reviews were very positive. Giovanni's also donated two $50 gift cards for future use.

SANDARC Committees include Education, Website Advisory, Policies and Procedures, and Convention Review and Feasibility. The Convention report is due in January.

ARRL Section Manager Steve Early talked about the successful Boy Scouts Jamboree on the Air (JOTA) event held on 18 October, and discussed Jay's upcoming license examination classes. There will be one held November 7th in La Mesa, and on the first Saturday of December. Contact SANDARC for more information on these classes.

The Miramar Air Show drew a lighter crowd than expected. Volunteer hams helped with Air Show communications support. Incidents were reported to be minimal. The Miramar Air Show will be held the last weekend of September in 2016.

250 people attended the inaugural San Diego Hamfest, sponsored by LARC. It was completed $15 in the black. The delegates congratulated LARC on a job well done. They anticipate having next year's San Diego Hamfest the first weekend of October. Due to the Miramar Air Show moving to late September, there will not be a conflict between these two events. [This also bodes well for San Diego Maker Faire, if it is held the first weekend of October for 2016.]

Southwestern REACT announced their upcoming "Silver Strand Half Marathon" on 15 November, from 6am to 11am. The race starts at the Naval Air Station and concludes at Imperial Beach. This event is encouraged as an opportunity for hams new to volunteering at public service events to give it a try. New hams are paired up with experienced volunteers to help the race run more smoothly.

Another event sponsored by SW-REACT is the Mother Goose Parade, held 21st of November. 10 different points are staffed in order to keep announcers advised and updated. 1-2 people are needed at each station, plus people to staff step-off and assembly. SW-REACT has most of these stations staffed but enthusiastically welcomes more. If interested in volunteering with SW-REACT events, let teaminfo@southwesternreact.org know.

Another event sponsored by SW-REACT is the Toy Land Parade. Held 4 December 2015 in North Park, this is also an event that welcomes hams new to volunteering in event support.

Operating Day at both Fry's Electronics on 7 November 2015 was announced (see page 63 for our flyer!)

ROARS gave a report about an upcoming event. On November 14th, there will be an open house at the Ramona airport. Antique aircraft and helicopters museum will be open. The event is from 8:30am to 4:00pm.

ROARS also reported on a successful, albeit small, JOTA in Ramona. ROARS is working hard to build membership and include both Boy and Girl Scouts in radio activities. They were advised by Steve Early to contact Kevin Walsh KK6FRK, the regional Boy Scout radio activities organizer.

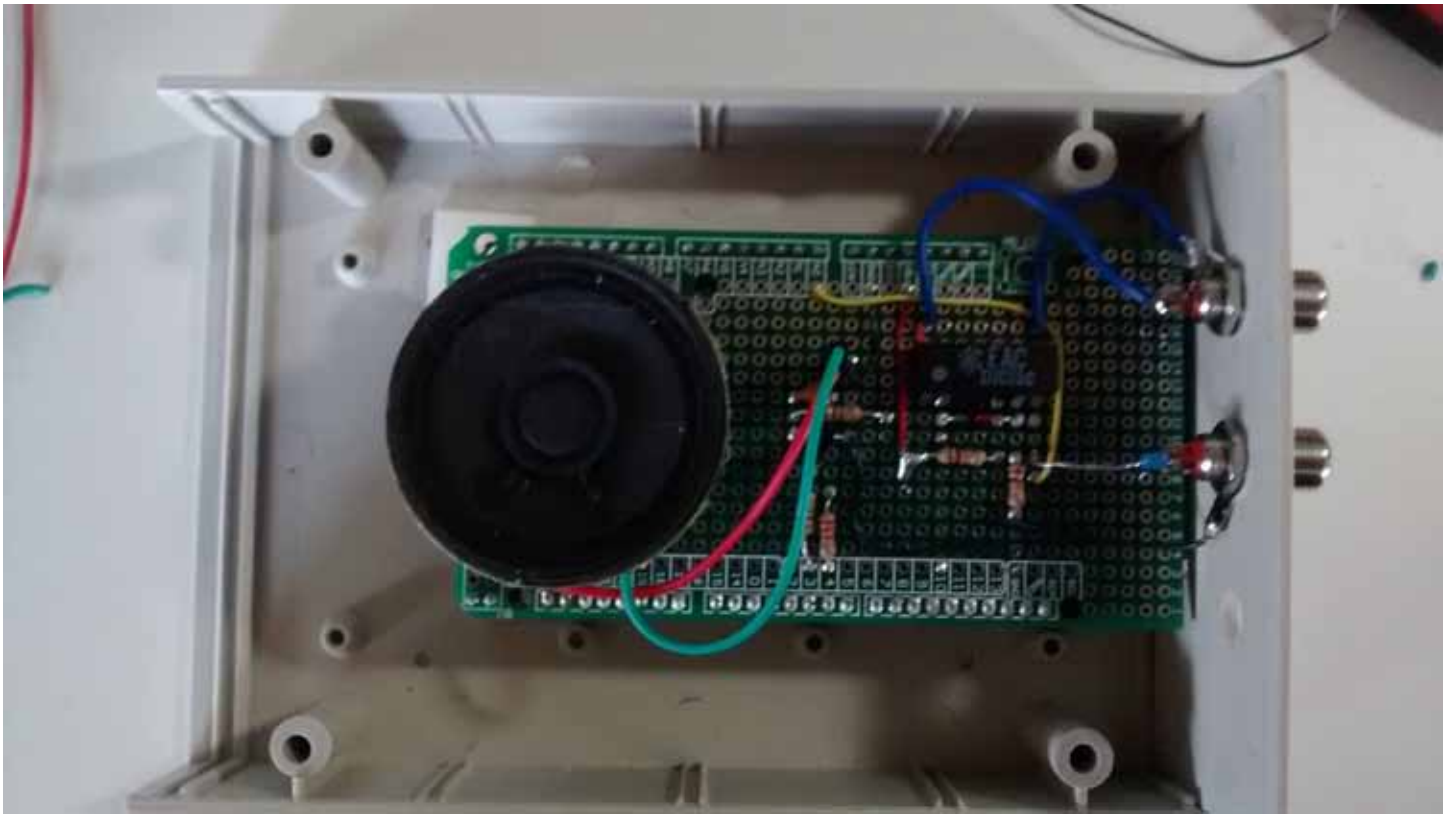
Mountain Empire's involvement in an inter-agency emergency drill held last Tuesday was described by their delegate. The goal was to practice a coordinated law enforcement response. The headquarters was described as being almost like a full-blown EOC. Mountain Empire strongly recommends that "if you ever get invited to one of these things, by all means go!"

San Diego Section Emergency Coordinator Bruce Kripton KG6IYN announced a 19 November 2015 statewide hospital drill. The drill will be held in the morning and will last until approximately 1pm. They need additional people to be "comfortable" with staffing, but can proceed as of today with the number of volunteers that have come forward.

Glen KJ6ZQH and Charlie NN3V from PARC described their highly successful educational outreach and support program with Mira Costa Colllege. More details will be in the December 2015 Scope.

Arduino Keyer Project - Success!

PARC member Guido Sansoni NO6I has been busy making an Arduino keyer. He has shared his projcct on the club's Facebook group. After this project he has plans for an Arduino-controlled antenna rotator. Here are photos from Guido documenting the build process.



Here's Guido's finished keyer, working! See the video on the Palomar Amateur Radio Club Facebook group, which can be found at:

https://www.facebook.com/groups/194674987710/

Find out more about arduino at:

https://www.arduino.cc

Please support our advertisers. Their support of the club is vital.

{special} THANKS to our sponsors

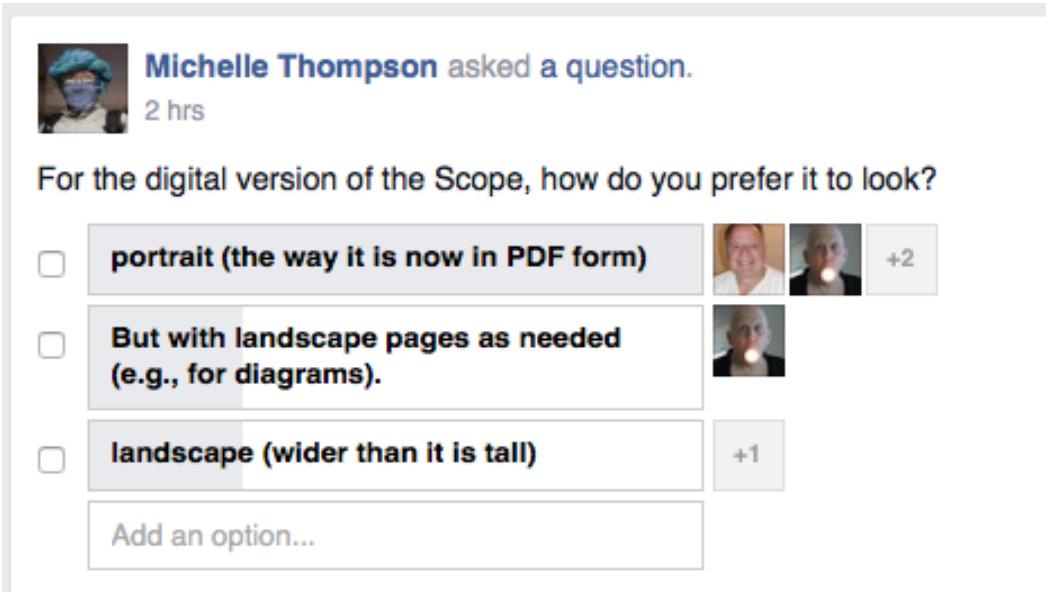
Club HF Remote Station? Proposal Time!

Current status: PARC has obtained 501(c)(3) status, and we have begun putting our HF remote station proposal in writing. This is an exciting time! We expect to complete our proposal by January 2016.

If you would be interested in helping write a club remote HF station proposal for Palomar Mountain, then please join up by writing me at scope@palomararc.org and I'll add you to the mailing list!

Mailing list archive located at
http://palomararc.org/pipermail/hfremote/

This special interest group for HF remote will write a proposal for the Palomar Amateur Radio Club board of directors to vote on. If the vote is successful, then fundraising will begin immediately.

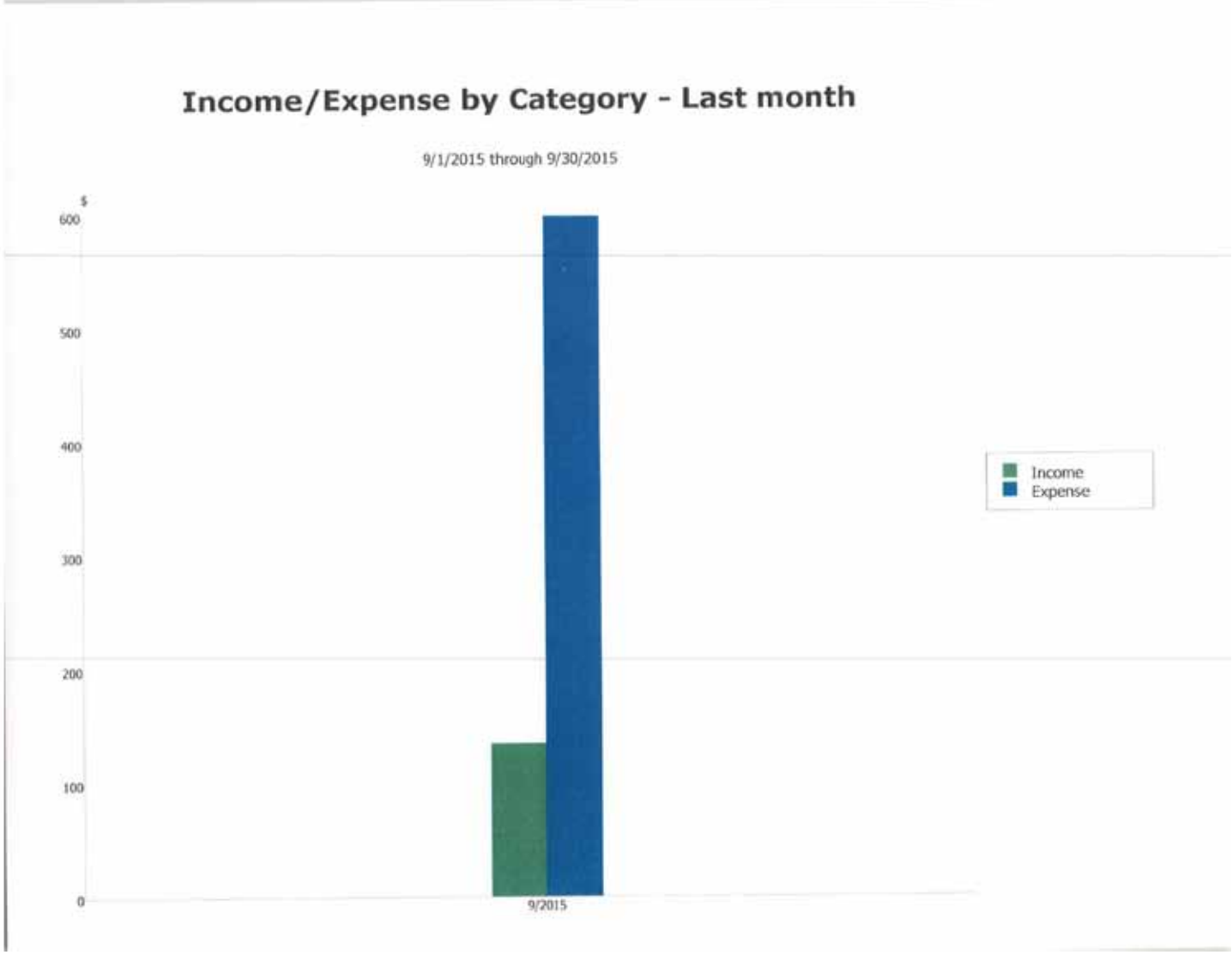


What's your opinion?

Portrait or landscape (or other option) for the digital version of the Scope?

Let us know at scope@palomararc.org

Club Financial Update



Income/Expense by Category - Last month
9/1/2015 through 9/30/2015

Category Description	9/1/2015-9/30/2015
INCOME	
Donation 501 C	100.00
Donations	15.00
Dues	20.00
TOTAL INCOME	**135.00**
EXPENSES	
Picnic	429.98
Rptr Electric	107.73
Rptr Maint	30.64
Rptr Phone	30.65
TOTAL EXPENSES	**599.00**
OVERALL TOTAL	**-464.00**

Newsletter Committee Update

by Michelle W5NYV

Greetings all. There have been a lot of changes lately for our club newsletter!

First of all, we've moved to offering only a digital publication. This is the second digital issue of the Scope since our transition from print. There are a lot of advantages to going digital, but there are some disadvantages as well. The decision was not taken lightly and was discussed over many months.

Our intent is to continue to provide a print issue to those that require it. If you require a printed Scope due to not having convenient access to a computer or for another reason, please contact the board at board@palomararc.org.

Aside from the cost and the growing scarcity of small-volume printers, the lack of a volunteer team to fold, staple, and deliver the Scope to the post office proved to be a very large factor in deciding to move to digital. While Charlie NN3V has communicated some of these challenges in the past few months, I'd like to not only reiterate them, but also emphasize the advantages to going to a freely-available digital publication.

At the close of the 2015 Microwave Update, I had the opportunity to talk with Marty Woll, the Vice Director of Southwestern Division of the ARRL. Among many other subjects, we discussed print vs. digital publications, advertising revenue, and how subscription numbers and advertising rates work within a membership organization that also provides publications.

While ARRL has over 160,000 members, and we are three orders of magnitude smaller, we face many of the same issues when it comes to providing printed publications. We are hardly isolated in wrestling with how to deal with expensive printing costs.

ARRL provides both digital and print QST, but they opted to publish QST with DRM (digital rights management). In other words, not just anyone can read the digital version of QST. You have to pay for a subscription.

We offer the Scope in PDF format, without DRM, and without limiting it to our membership. Anyone on the internet can read our newsletter. While our costs are lower, they are not zero. We have to pay for the hosting and file storage. These costs are much lower than printing and postage. However, without income from the dues from membership, there is no PARC website, and therefore no home for the Scope. With no members, there's no primary audience.

In other words, we are giving the newsletter away, essentially for free. This has not been an entirely uncontroversial choice over the years!

Why do we do this? Mainly because we want to attract new members. We feel that if someone local finds the newsletter to be a worthwhile read, and becomes interested in the club and all the activites supported by the club, that there is a very good chance that they'll join the club.

That is not the only reason. Open access to information is a philosophical and cultural ideal that we as a club have actively embraced. Our newsletter is free for all to read not just as an advertisement of how totally awesome we are, but also as a unimpeded contribution to the conversation in the amateur radio community.

Making the newsletter freely available is a different approach than ARRL takes with a publication like QST, but it is in line with what other clubs in San Diego County do with their newsletters.

For example, EARS has the current issue of their newsletter available for download on their website as a PDF. It's on the lefthand side of the home page at http://www.earsclub.org

While EARS doesn't seem to have links to past issues, if you know the month and year, you can create the right URL and download back issues.

Fallbrook Amateur Radio Club has their newsletter on their website as a webpage. Newsletters for the current year are available from their newsletter page at http://www.fallbrookarc.org/bulletin.html

Other clubs in the area have moved to digital publications of their newsletters. Just this week, North County Photo Society announced their newsletter would soon go digital.

However, not all of them have. The San Diego Astronomy Association maintains both digital and print newsletter options for members.

Many major magazines have found their

advertising revenues falling to the point where the entire magazine goes out of business. Some convert to digital, some completely go away.

QST retains good advertising revenue by, in part, providing advertisers a full-service experience. An advertiser with QST may get graphics and ad copy support and valuable feedback on what subscribers want or do not want to see.

The advantages to digital are numerous. We can include videos, animations, audio files, and other interactive content. An observant member would point out that we were already including these sorts of things with the digital version of the newsletter while we were still sending out a printed copy. The single biggest advantage that dropping print allows us to enjoy is that there is no longer a page limit.

A smaller print version could be printed each month, while putting a much larger digital version online. However, the Scope committee did not feel that this was a fair thing to do. Members should get the same content for their membership fee regardless of whether they get a printed copy or a digital download.

As we embark upon a new era for the Scope, it's more important than ever to create fun, entertaining, and educational articles and content for the membership.

The Scope committee currently consists of myself, Michelle W5NYV, as chair, Ellen N6UWW as copyeditor, Paul KB5MU as copyeditor, writer, and photographer, and a large number of situational and regular contributors.

Our newest addition is Kerry Banke N6IZW, who has agreed to keep us up to date about local microwave activity. One of our longest-serving and most reliable contributors is Dennis N6KI, who provides regular updates on the many contest activities that he organizes or is aware of, along with many other entertaining observations.

I want to continue to expand the committee. Interested PARC members are encouraged to consider joining. With so much more additional space, there are so many more opportunities for articles and content. This also means more work.

If you've always wanted to have a regular (or irregular) column about amateur radio, then why not start out by writing one for the Scope? It just might turn into a bigger opportunity.

Do you have a mobile installation that you would like to share?

Are you working on a technical project?

Volunteering in emergency communications?

Have an opinion about some commercial gear and want to write a review?

Need to get rid of a few things? Looking for a few things?

Have an idea for a quiz or challenge? Feel up to the challenge of constructing amateur radio themed puzzles?

See a local regulatory need?

Attended a ham convention or conference and want to share your experiences? Know about an upcoming conference?

These are the things we love to publish and that club members love to read about.

Something that will return to the Scope, now that we have less of a limit on space, is the "boilerplate" that used to make up a large fraction (up to 40%) of the Scope. Recurring content, such as the repeater frequencies and other lists was moved to the PARC website to make more room for articles in the print publication. While it did dramatically increase the amount of space available for interesting articles, it did force members to find the information on the website instead. We're going to return to running "boilerplate" information about the club, such as repeater frequencies, nets, board members, and other information, in the Scope.

Something that vanished not only from the Scope, but also from the club in general, is a list of active committee chairs. The committee chair system from several years ago showed a diverse and active volunteer corps that assisted the board in achieving many club goals.

Reviving this tradition and filling in the many roles has great potential to substantially improve the level of club activity and enjoyment.

As you can see, there's a committee behind each issue of the newsletter. The quality goes up with more voices, more collaboration, and more points of view represented. Our goal is to make this newsletter the best amateur radio publication that we can. You are the reason we research, explore, and write, and you are welcome to be part of the process!

Using a Raspberry Pi with PiFM

11 Naughty Signals; or, the Abuse of a Raspberry Pi

by Russell Handorf

There are a lot of different projects that have rejuvenated interest in HAM Radio, more notably Software Defined Radio (SDR). The more prominent projects and products are the USRP by Ettus Research, BladeRF by Nuand, and the HackRF by Mike Ossmann (in the order from the most expensive to least expensive). These radios vary in capability and have their own distinct utility, depending on what radio communication you'd like to study; however, if all you are specifically interested in is receiving a simplistic signal, then the Realtek SDR is typically the best and cheapest choice. This article will show you how to combine a Realtek SDR and a Raspberry Pi into a poor man's software defined radio tool for exploring how to receive and transmit in related radio systems.

11.1 Bandpass Filter

It is very important to have and to use a band-pass filter when using the Raspberry Pi as an FM transmitter, because PiFM is essentially a square wave generator. This means that you'll have a lot of harmonics as depicted in Figure 21. While the direct operational frequency range of PiFM is approximately 1 MHz to 250 MHz, the harmonics are still strong enough to reach frequencies below 1 MHz and as high as 500 MHz.

Because of these square wave characteristics, a mechanical SAW filter would be ideal to be able to control the frequencies you wish to transmit. However, there filters can set you back more than the Raspberry Pi, and may be hard to come by, unless there's a neighborly Ham Radio Outlet near you. So you may have to make your own band-pass filter.

To make your own high band and/or low band pass filters, you can assemble them based on the schematic in Figure 19.[54] Parts for the various amateur bands are listed in Figure 20.

11.2 Raspberry Pi FM Transmitter

For over a year now, it has been documented how to turn the Raspberry Pi into an FM transmitter by using the PiFM software.[55] Richard Hirst first demonstrated this technique in some C and Python code that generated spread-spectrum clock signals to output FM on GPIO pin #4. Oliver Mattos and Oskar Weigl have since enhanced PiFM to add more capabilities.

Be aware, however, that this technique has another problem beyond bleeding RF and having to use filters. Namely, the transmitter doesn't shut down gracefully after you quit PiFM. Therefore, you'll need a script to silence the transmission. We'll call it `pi-shutdown.sh` in the various examples that follow.

```
1 #/bin/bash
  #pi-shutdown.sh
3 touch /tmp/empty && /home/pi/pifm /tmp/empty
```

11.3 AFSK

Audio Frequency Shift Keying (AFSK) is simply a method to modulate digital data as an analogue tone; you'll certainly recognize this as the tones your modem made. AFSK characteristically represents 1 as a "mark" and 0 as a "space". While not fast, AFSK does work very well in many applications where data is communicated over a consistent radio frequency. Because of these attributes, AFSK is frequently used for radio communications in industrial applications, embedded systems, and more. Using a program called `minimodem`, you'll be easily able to receive and transmit AFSK with a Realtek SDR and a Raspberry Pi. Marc1 from `kprod.eu` demonstrated some very simple techniques for doing so, which a few other neighbors have been tweaked and updated in the examples to follow.

To receive 1200 baud AFSK transmissions, a one-line script is all that's needed:

```
1 rtl_fm -f 146.0M -M wbfm -s 200000      \
        -r 48000 -o 6                     \
3 | sox -traw -r48k -es -b16 -c1 -V1 -     \
      -twav -                             \
5 | minimodem --rx -8 1200
```

What's happening here is that the program `rtl_fm` is tuned to 146.0 MHz, sampling at 200,000

[54] `http://www.kitsandparts.com/univlpfilter.php`
[55] `https://github.com/rm-hull/pifm`

samples per second and converting the output at a sample rate of 48000 Hz. The output from this is sent to `sox`, which is converting the audio received to the WAV file format. The output from `sox` is then sent to `minimodem`, which is decoding the WAV stream at 1200 baud, 8 bit ASCII.

Transmitting an AFSK signal is just as easy:

```
echo "knock knock... : `date +%c`"       \
| minimodem --tx -f -8 1200               \
             -f /home/pi/sentence.wav
/home/pi/pifm /home/pi/sentence.wav       \
              146.0 48000
/home/pi/pi-shutdown.sh
```

11.4 Other Transmission Examples

Because of the scriptability and simplicity of PiFM, other forms of transmissions become easily achievable too.

Morse Code (CW)

Either done by playing a pre-made audio file with dits and dahs, or by using the `cwwav` program written by Thomas Horsten to output directly to PiFM.[56]

```
echo hello world                          \
| cwwav -f 700 -w 20                      \
         -o /home/pi/morse.wav
/home/pi/pifm /home/pi/morse.wav          \
              146.0 48000
/home/pi/pi-shutdown.sh
```

[56] `https://github.com/Kerrick/cwwav`
[57] `http://www.qsl.net/py4zbz/eni.htm`
[58] `http://www.hides.com.tw/product_cg74469_eng.html`

Numbers Station

A numbers station is typically a government-owned transmitter that sends encoded messages to spies, operators, or employees of that said government anywhere in the world, where the messages are typically one way and seemingly random. The script below mimics the Cuban numbers station identified as HM01.[57] What is interesting about it is that the data it sends is encoded with a common HAM Radio protocol called RDFT. Transmitting RDFT on a Raspberry Pi can be difficult, therefore using a simple FM transmission of THOR8 or QPSK256 should be adequate; using FLDIGI should be of great help to create these messages.

A script can easily speak a series of words into the air by piping them into the `text2wave` utility:

```
system("echo $text | text2wave -F 22050 - "
       "| /home/pi/pifm - 144 22050");
```

DVBT with Metadata

One common practice for those who work with the RTL dongle is to remove to remove the DVB-T digital television kernel module. To receive this challenge, however, you will need to re-enable that module. To transmit it, you'll need hardware from Hides,[58] which can be had for a very low cost. The script below works with the UT-100C.

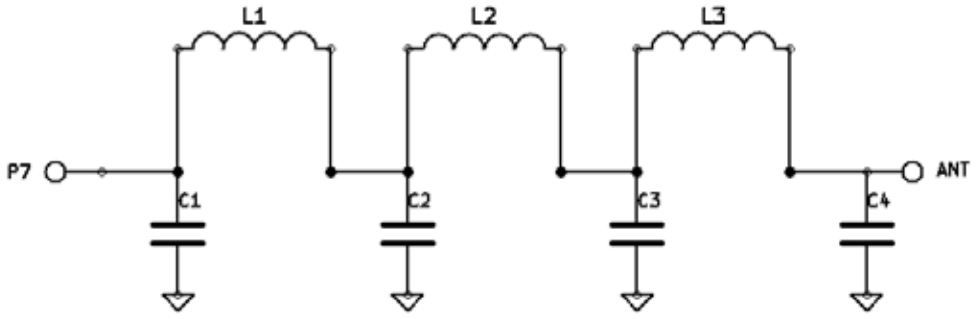


Figure 19: Bandpass Filter for Reducing PiFM Harmonics

```
modprobe usb-it950x
mkfifo ~/desktop
avconv -f x11grab -s 1024x768                \
  -framerate 30 -i :0.0                      \
  -vcodec libx264 -s 720x576                 \
  -f mpegts                                  \
  -mpegts_original_network_id 1              \
  -mpegts_transport_stream_id 1              \
  -mpegts_service_id 1                       \
  -metadata                                  \
     service_provider="FCC CALL SIGN"        \
  -metadata                                  \
     service_name="Dialin for Dollars!"      \
  -muxrate 3732k -y ~/desktop &
tsrfsend ~/desktop 0 730000 6000 4           \
                   1/2 1/4 8 0 0 &
```

SSTV

Gerrit Polder developed a simple means of converting an image into a SSTV signal and then sending it out via the PiFM utility. Using his program, *PiSSTV*, command line transmissions of SSTV broadcasts with the Raspberry Pi are easy to achieve without the need for a graphical environment.

11.5 Howdy to the caring Neighbors

Thanks to the PiFM program, there are many portable options allowing HAM operators, experimenters, and miscreants to explore and butcher the radio waves on the cheap. The main goal of this article is to document the work of many friendly folks in this arena, gathering in one place the information currently scattered across the bits and bobs of the Internet. Owing to the brilliant hacks of these neighbors, it should become apparent why any radio nut should consider having a Raspberry Pi armed with a filter and some code. While out of scope for the article, it should also become clear how you too can make a very inexpensive and portable HAM station for a large variety of digital and analog modes.

I'd like to extend a warm, hearty, and, eventually, beer-supplemented thank-you to Dragorn, Zero_Chaos, Rick Mellendick, DaKahuna, Justin Simon, Tara Miller, Mike Ossmann, Rob Ghilduta, and Travis Goodspeed for their direct support.

Band λ Meters	C1, C4	C2, C3	L1, L3	L2
160	820	2200	$4.44\mu H, 20T, 16''$	$5.61\mu H, 23T, 18''$
80	470	1200	$2.43\mu H, 21T, 16''$	$3.01\mu H, 24T, 18''$
40	270	680	$1.38\mu H, 18T, 14''$	$1.70\mu H, 20T, 15''$
30	270	560	$1.09\mu H, 16T, 12''$	$1.26\mu H, 17T, 13''$
20	180	390	$0.77\mu H, 13T, 11''$	$0.90\mu H, 14T, 11''$
17	100	270	$0.55\mu H, 11T, 9''$	$0.68\mu H, 12T, 10''$
15	82	220	$0.44\mu H, 11T, 9''$	$0.56\mu H, 12T, 10''$
12	100	220	$0.44\mu H, 11T, 9''$	$0.52\mu H, 12T, 10''$
10	56	150	$0.30\mu H, 9T, 8''$	$0.38\mu H, 10T, 9''$

Figure 20: Filter Bill of Materials

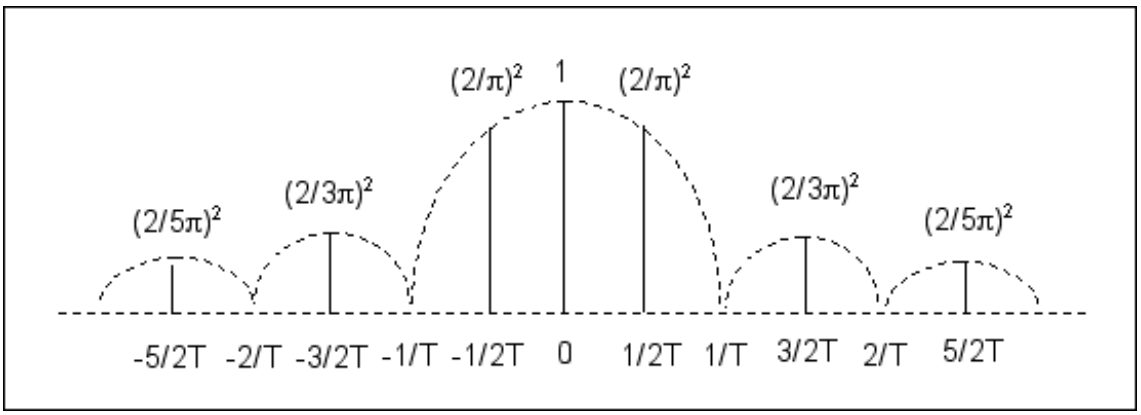
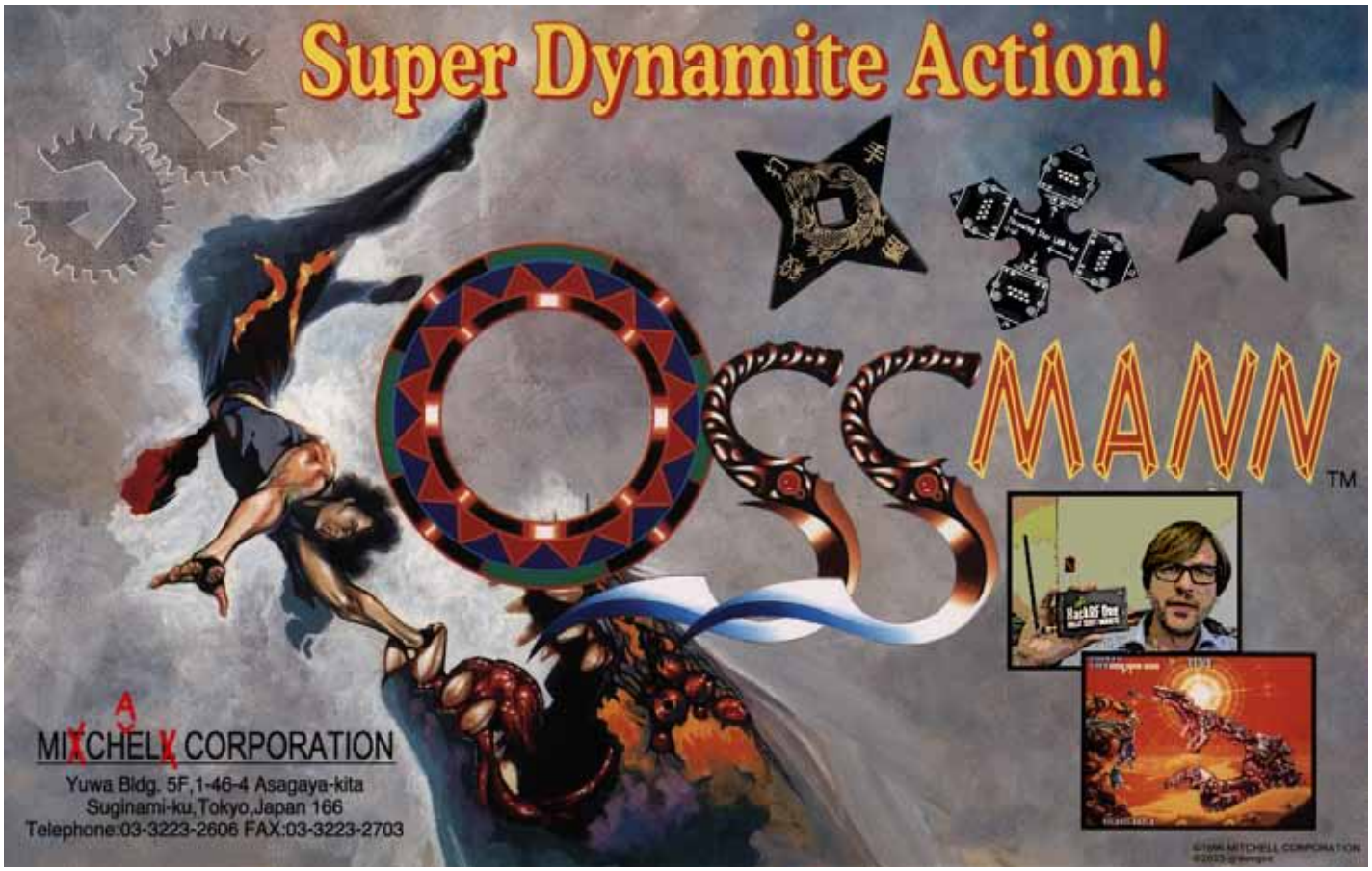


Figure 21: PiFM Harmonic Emissions



PARC, SDMG Dominates Microwave Update

Club members from Palomar Amateur Radio Club and San Diego Microwave Group dominated the just-concluded Microwave Update 2015, held in San Diego.

Kerry Banke N6IZW, Andre Hanson K6AH, and Michelle Thompson W5NYV all had papers accepted for the proceedings. Each also made presentations in the main lecture hall. All three papers are reprinted in this issue of the Scope as a special section.

This annual event draws microwave enthusiasts from all over the world. This year, 78 participants came from all across the United States, Great Britain, Australia, and Japan.

A proceedings and lecture schedule, dinner with keynote speaker, awards presentation, numerous prizes, ample opportunity for socializing and scheming, test lab, antenna range, vendor area, and flea market are all Microwave Update traditions handily upheld this year by the 2015 sponsoring club, San Bernardino Microwave Society.

At the Saturday evening banquet, Ed Munn W6OYJ was awarded the Don Hilliard Award for Technical Contributions to the Microwave Community. This award is given annually at Microwave Update for outstanding technical contributions. Ed is pictured above (center) with fellow San Diego Microwave Group members Kerry Banke N6IZW at left and Greg Bailey K6QPV on the right.

The next Microwave Update will be held in St. Louis, Missouri on 14-16 October 2016.

One tradition that was not continued at the San Diego Microwave Update was a tour or visit to a local surplus site. The number and variety of surplus stores and facilities allowing amateurs to come in and take surplus gear in San Diego has declined to the point where there was no compelling options to schedule. This caused quite a bit of conversation over the weekend, with many participants remarking upon how they've switched most of their gear-hunting to eBay and Craig's List.

Members from the sponsoring club, San Bernardino Microwave Society, are generally based in Riverside County, and have more access to the surplus sites that remain "up North".

The Australian amateurs that came to Microwave Update gave a repeat performance of their talk about their Microwave DXpedition on Monday evening at the San Diego Microwave Group meeting. Alan Devlin VK3XPD and David Minchin VK5KK made an additional presentation of "A VK Millimeter-Wave DX Expedition to Europe" to an enthusiastic group of microwavers before heading home on Tuesday.

One of the most remarkable achievements of their expedition was the deployment of 122GHz transceivers.

A special track about earth-moon-earth (EME) modes and equipment was presented on Sunday morning. Chaired by Doug Millar K6JEY, this session covered EME from beginner, and relatively inexpensive, to extremely advanced and expensive.

Microwave Update - N6IZW

A Simple, Experimental 10 GHz Transmitter Hunt Setup

K.Banke N6IZW and Drew Arnett KB9FKO – SDMG (San Diego Microwave Group)

The second Maker Faire[1] in San Diego[2] scheduled for October this year, just before MUD. I was trying to come up with a hands-on microwave related activity that might be of interest to the kids, families, and grown-ups who will be there. At a previous SDMG meeting, Drew demonstrated an experiment using a LNB with the IF connected to an AD8307[3] log amplifier/ detector connected to an audio amplifier and speaker. An inexpensive DRO type intrusion alarm module is supplied with a 5V square wave turning it on and off at 1 KHz rate. The receiver detected the signal and produced an audio tone. I thought this might be used for a simple T-Hunt activity. (Several members of the SDMG are into serious transmitter hunting.[4])

Prototyping

The prototype I put together used one of the Avenger PLL type KU Band LNBs. The first attempt at duplicating Drew's setup showed me that the compressed audio square wave out of the AD8307 would make it hard to determine signal strength from the audio amplitude. More on that below.

I thought it would be important to add some IF filtering to narrow the BW to improve sensitivity and, perhaps more importantly, to reduce the likelihood of interference from actual intrusion alarms or perhaps Walter Clark's excellent X band demonstrations he brought to the first San Diego Maker Faire.

I purchased a 638 MHz 11 MHz BW SAW filter off the web which puts the received X band center frequency at 10388 MHz. The DRO unit easily tuned down to that frequency with the DRO puck tuning slug, and the frequency stability was well within the SAW filter BW.

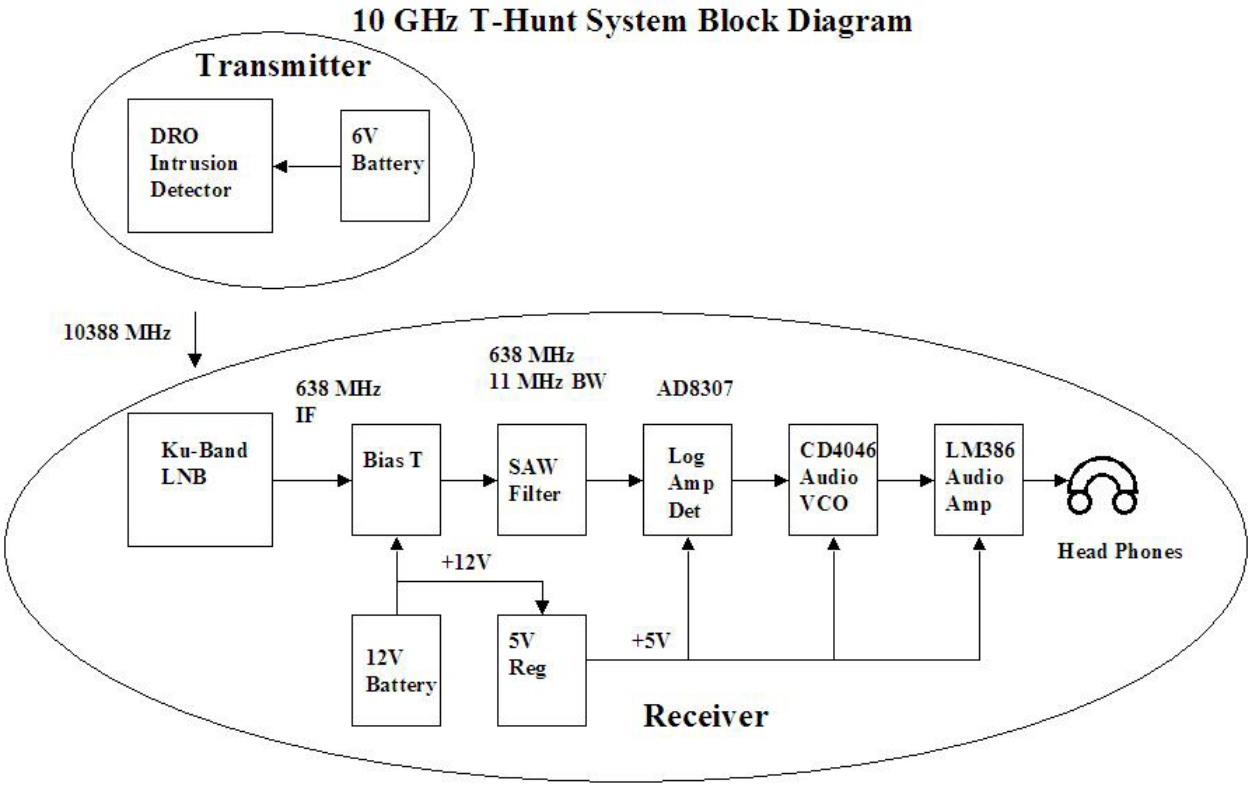
I modified a W1GHZ Sensitive RF Detector for Sun Noise board[5] that also used the AD8307. It is being operated above its rated frequency but the gain of the LNB makes up for the reduced sensitivity at IF. The DC log output from the AD8307 is used to vary the frequency of a CD4046 PLL chip using just the VCO as an audio oscillator. A LM386 audio amp is used to drive a pair of headphones with plenty of output for a speaker if needed. With this setup, the DRO provides a CW carrier only with no modulation and the receiver tone pitch indicates received signal strength. The higher the received signal strength, the higher the audio tone frequency is.

Power for the DRO is provided by 4 AA batteries with the unit drawing about 40 ma. The receiver needs a minimum of about 7V at 140 ma to operate the LNB. I used 8 AA batteries but may eventually replace them with a 7.4V LiPo battery.

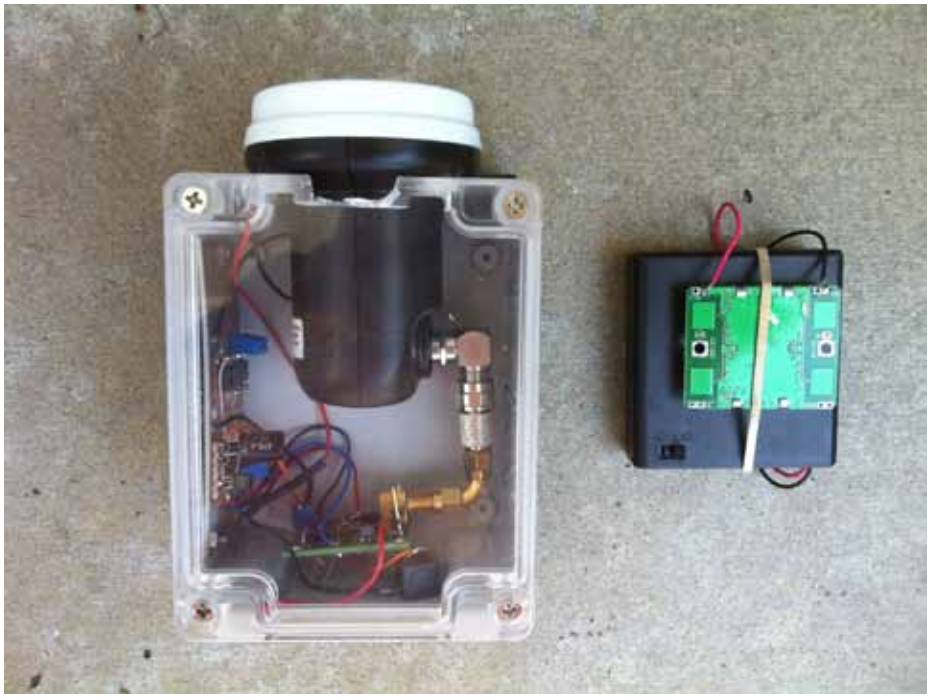
The dynamic range of the receiver IF/audio system is about 50 dB with the MDS around -45

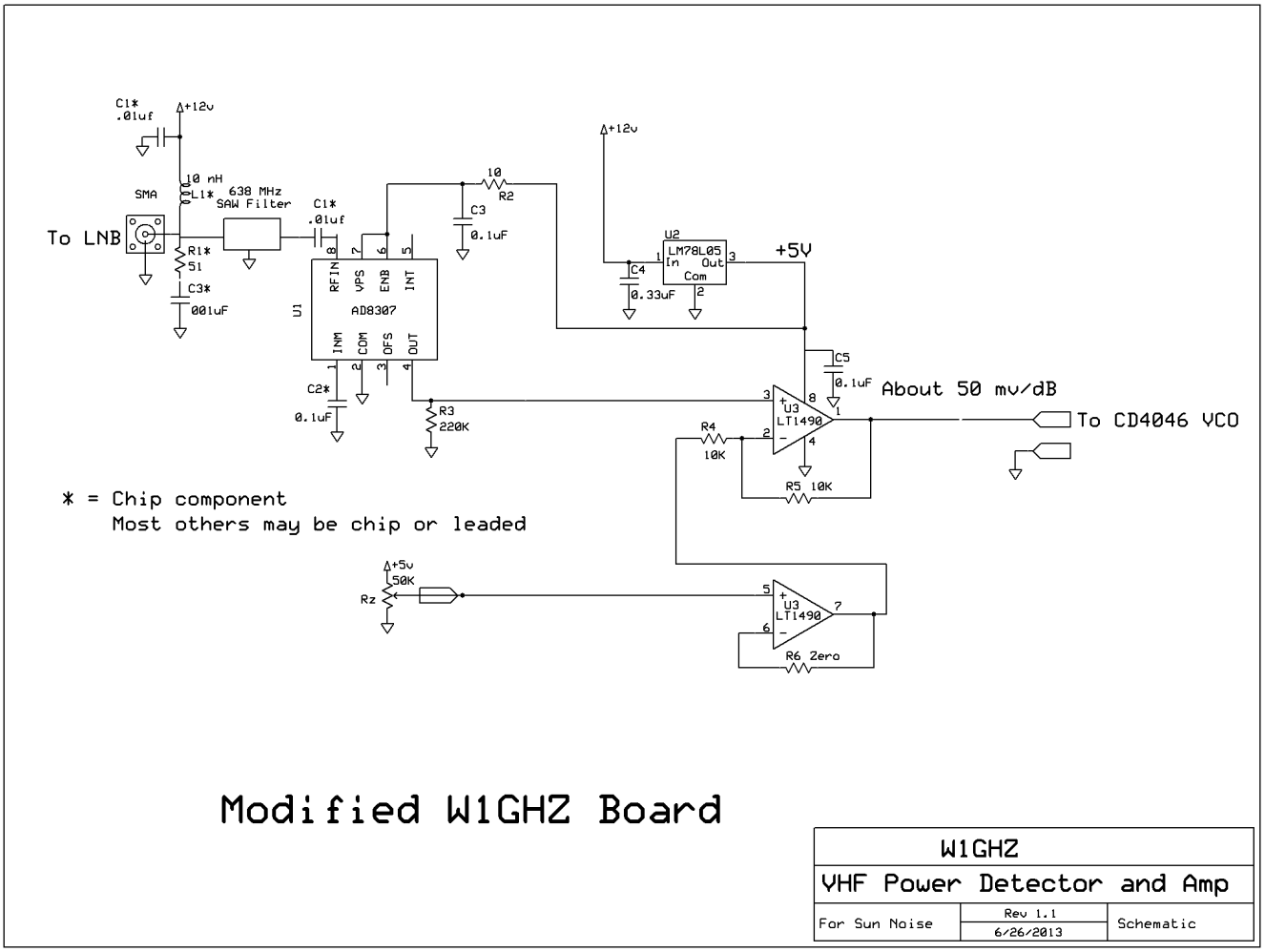
dBm and max tone at about +5 dBm in to the AD8307. The minimum sensitivity is determined by the noise BW out of the LNB after the SAW filter. The sensitivity is good enough that difference between pointing the receiver to cold sky and warm earth is very obvious. Both the TX and the RX have linearly polarized antennas. It's suspected that the antenna polarities need to be matched, or it may result in confusion from reflected signals. Tests performed at about 220 feet provided about 44 dB margin indicating this system should be good for several miles LOS.

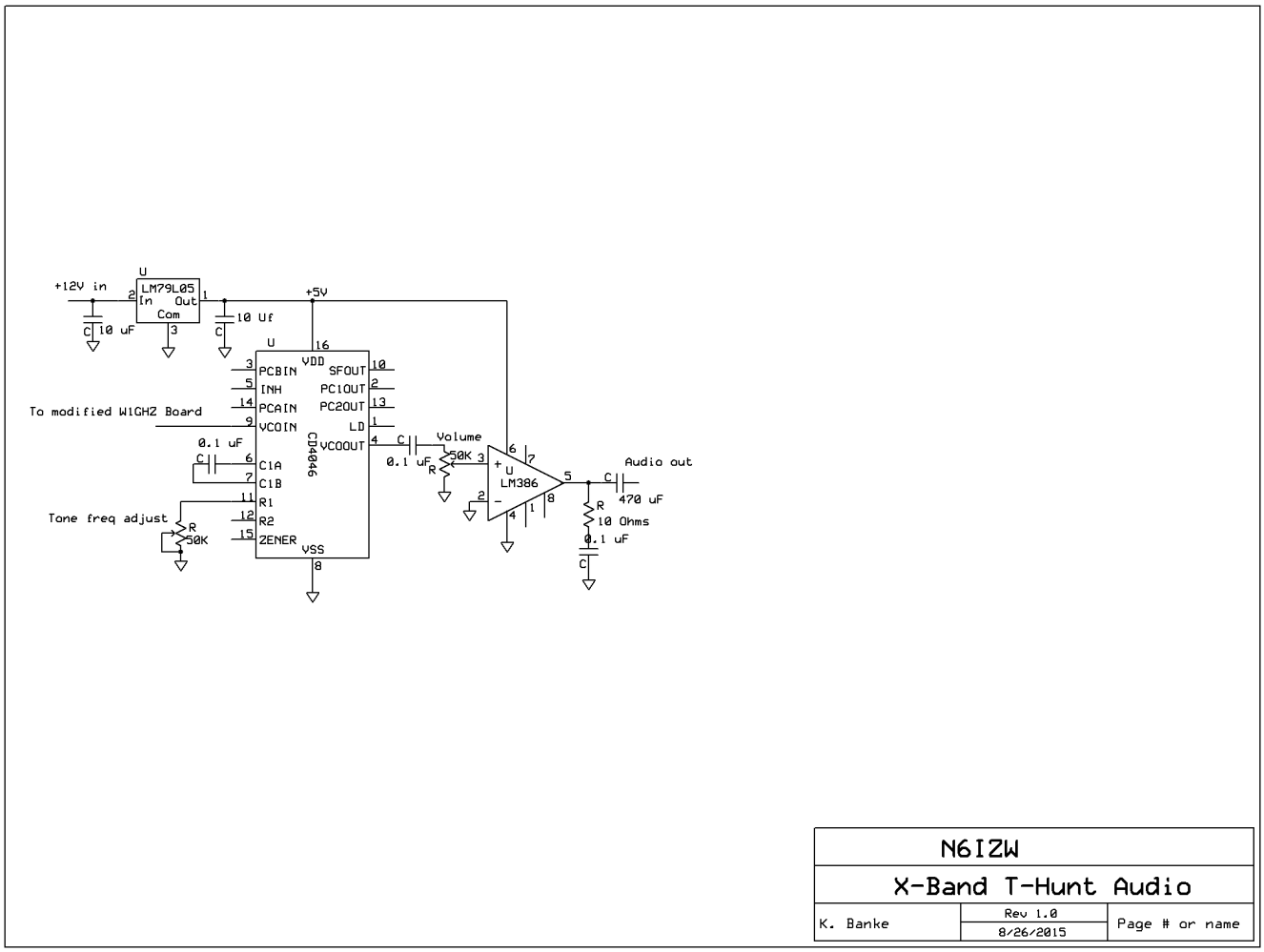
The transmitter is hunted by sweeping the receiver from side to side and heading in the direction of highest frequency tone. Early backyard testing showed that it is easy to determine the location of the transmitter by sweeping the RX direction to find where the signal drops off to the left and right and splitting the difference.



The photograph below shows the prototype as described in the block diagram above.




C1*
.01uf
+12v
10 nH
L1*
638 MHz
SAW Filter
SMA
To LNB
R1*
51
C3*
001uF
C1*
.01uf
U1
AD8307
RFIN
VPS
ENB
INT
INM
COM
OFS
OUT
C2*
0.1uF
R3
220K
10
R2
C3
0.1uF
+12v
U2
LM78L05
In
Out
Com
+5V
C4
0.33uF
C5
0.1uF
About 50 mv/dB
U3
LT1490
R4
10K
R5 10K
To CD4046 VCO
* = Chip component
Most others may be chip or leaded
+5v
50K
Rz
U3
LT1490
R6 Zero
Modified W1GHZ Board
W1GHZ
VHF Power Detector and Amp
For Sun Noise
Rev 1.1
6/26/2013
Schematic



Drew's Demonstration

I had been hearing about the DRO modules, available for about $6 delivered, for a while from a number of sources. One of which is at least one writeup[6] from Walter Clark who has been doing a number of outstanding, fascinating physics demonstration experiments. Even though these modules lend them selves readily to FM as Gunnplexor modules also did, I wanted to try AM style detection with them. These modules have a DRO oscillator, splitter, mixer diode, and patch antennas for TX and RX. Connections are power, ground, and IF. Pout is about 15 dBm EIRP, and the antenna patterns have a 40 by 80 degree 3 dB beamwidth.

First, I wanted to AM the DRO modules. Later, I spent some time in the lab and looked over the supply voltage range to see if there was a useful range for somewhat linear AM. My measurements did not look promising, but my methodology wasn't careful. It wouldn't hurt for this experiment to be repeated.

Kerry would whip up an analog circuit to do so, likely with a 555. I had a few Arduino UNOs[7]

available (which are available from Digikey and others for $20) and had been using one with the outstanding K3NG CW keyer application[8] for HF CW contesting. Recalling the square wave sidetone output, I wired that up to a transistor switch to the supply connection of a DRO module.

Now for detection. There were many candidates, and I was interested in diode detectors, but didn't have anything built up, yet. I did have both an Avenger LNB and one of the RTL DVB-S USB SDR dongles. The SDMG had demonstrated this pairing used for 10 GHz EME reception. Before that, though, I grabbed an AD8307 based RF power meter described by W7ZOI and W7PUA and kitted by KangaUS. The AD8307 output is available on a connector which I connected to a Radio Shack amplified speaker.

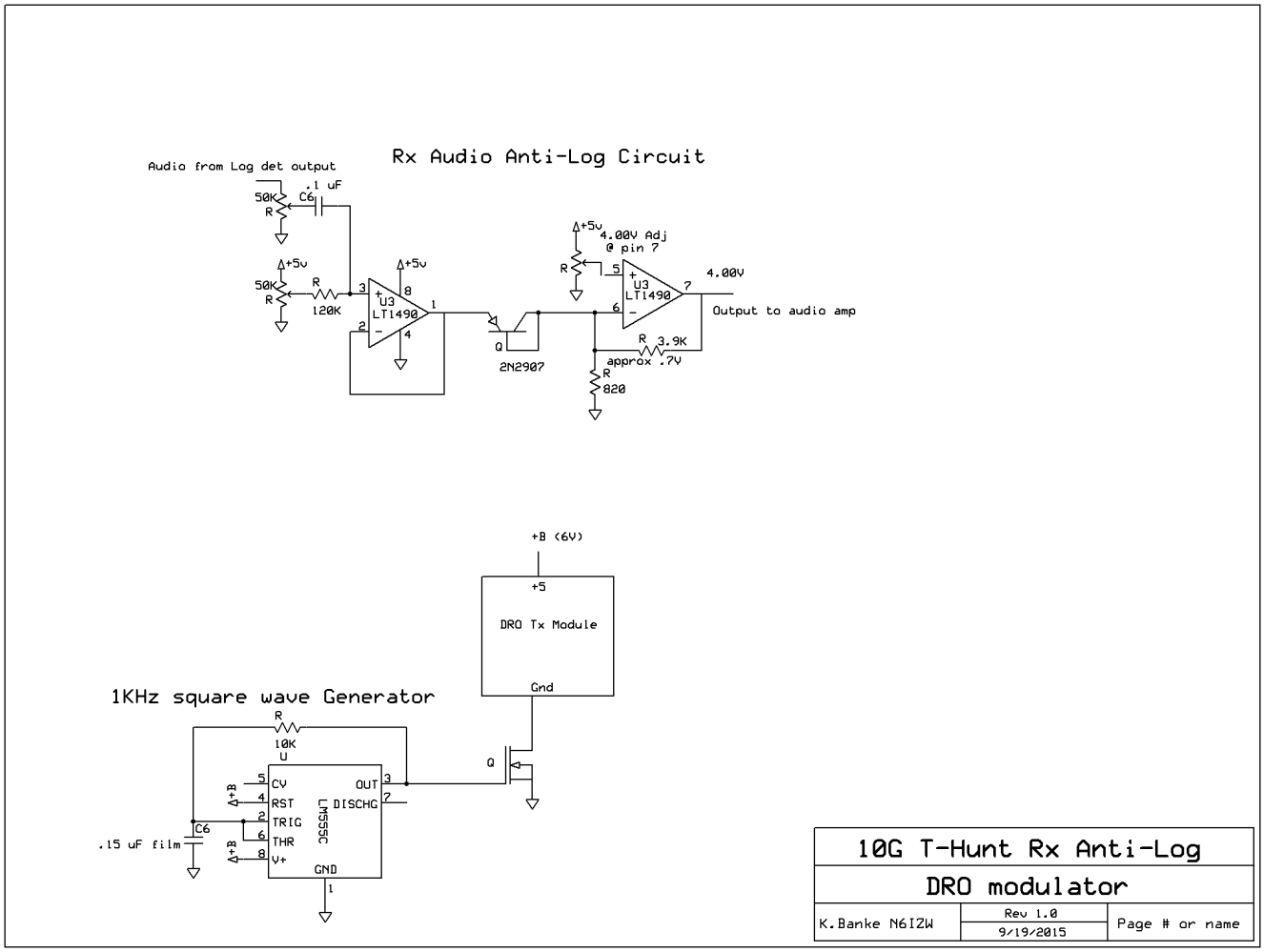
It worked great. The RF power meter has an input LPF at 500 MHz greatly reducing sensitivity to the approximately 800 MHz IF. A backyard measurement at about 80 feet showed enough signal margin that 300 feet or more of range should be possible. This system is what I demonstrated at the SDMG.

To Do

The working prototype as it is now will be sufficient for an excellent hands-on activity at the 2015 SD Maker Faire. However, we have plans for several improvements and future experimentation.

Arduino Shield: Drew is currently designing an Arduino shield to be ready for the Maker Faire. A battery pack will plug into it, and it will provide power to the Arduino UNO it is plugged into as well as the DRO module that will plug into it. A trim pot will allow adjustment of the supply voltage to the DRO module, which may be used for frequency fine tuning. A rotary hex switch will allow the unit to be configured in one of several different modes. TX always off, TX always on CW, TX always on with constant AM tone, CW Morse via key jack, AM tone Morse via key jack, Morse beaconing with single letter ID, A through F, and perhaps with different audio tones for each letter.

Better AM RX: It would be great to have a real AM RX, so we could hide several transmitters for the kids to find. We will try the log amplifier/detector to test our hypothesis as to how that will work in a multiple TX environment. It certainly doesn't allow for easy discernment of signal strength. One idea is to take the 50 dB log signal and antilog it over about 30 dB. (30 is a rough guess as to the audio levels that would fit between not too quite to hear in a noisy Faire and not too loud to be a safety concern.) We have several other ideas, but we would welcome ideas and suggestions from the reader.



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3. http://www.analog.com/en/products/rf-microwave/rf-power-detectors/non-rms-responding-detector/ad8307.html
4. http://www.sdthunters.com
5. July 2013 *QST* and http://www.w1ghz.org/small_proj/small_proj.htm
6. http://www.ham-radio.com/sbms/presentations/Walt_Clark/DROplexer.pdf and correspondence with Walter Clark
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8. http://blog.radioartisan.com/arduino-cw-keyer/

A 2 meter Direct Conversion DSB Transceiver for use with Transverters

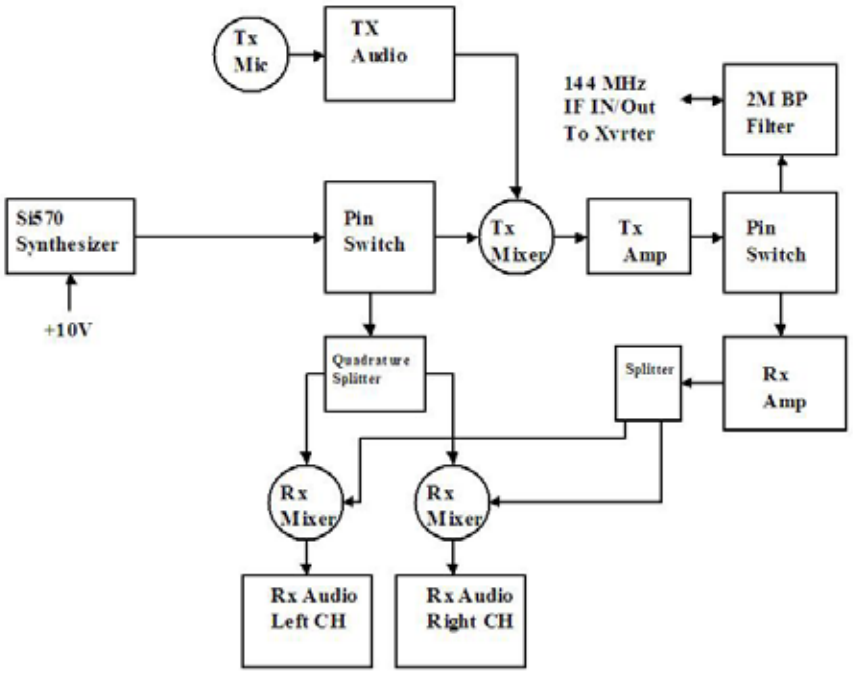
K. Banke (kbanke@sbcglobal.net) N6IZW San Diego Microwave Group

As we have new members join our SDMG, the need for entry level IF radios for use with transverters is becoming more and more an issue. The low cost, single band 2 meter radios capable of operation in Sunlight are becoming harder to find and are aging to the point of self destruction. This project was an experiment to convince myself whether a very basic 2 meter DC DSB transceiver would be useful. Fortunately the basic requirements of an IF radio for use with a 10 GHz transverter are fairly easy to achieve. Noise figure and narrow selectivity are typically not an issue as a transverter IF radio and +10 dBm in Tx is easy to achieve. LO leakage in to the front end is also much less an issue when used with a transverter.

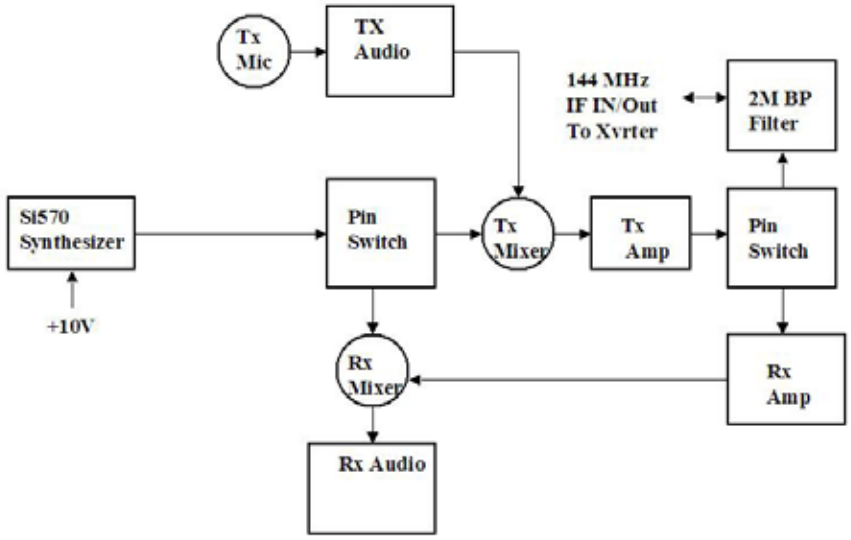
What prompted me to give this approach a try was a recent project (Portable ERP/MDS Test Box) I had just finished which utilized a low cost ($50) SI570 board as the signal generator covering 3-160 MHz with down to 1 Hz tuning steps and an LCD display easily readable in direct Sunlight.

I wanted to try the simplest form of DC transceiver to keep the cost and construction effort to a minimum. That meant DSB for both Tx and RX with no quadrature and phasing networks.

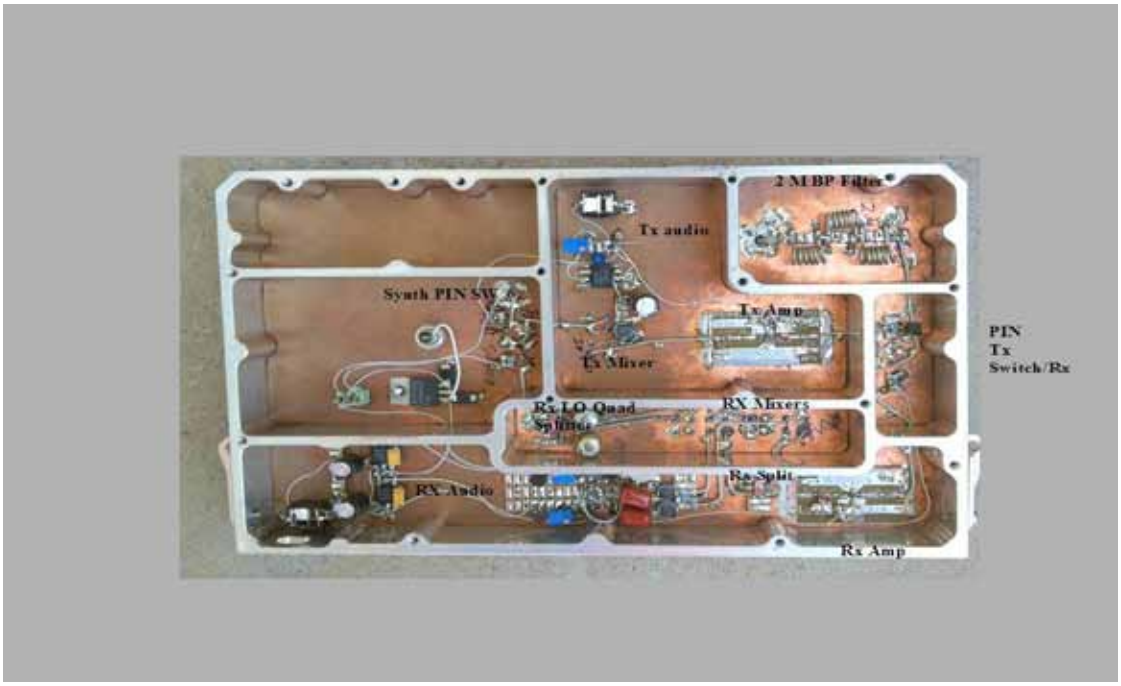
That being said, I became intrigued with some articles describing “Binaural” reception and wanted to give it a try even though it added complexity to the unit. Striping out the components required for the Binaural capability would simplify the design and construction considerably. The Rx sensitivity is about -135 dBm for MDS and TX output is about +10 dBm. The Rx Binaural audio is interesting in that as one tunes through a CW signal the tone appears to pass from one head phone to the other. Of course the disadvantages with DSB are only half the Tx power is in one sideband that SSB radios will be receiving and Rx noise from two sidebands. With those caveats in mind, it can provide a very useable radio for outdoor operation.



2 meter DSB transceiver for transverters Binaural Rx



2 meter DSB transceiver for transverters simplest form


2 MBP Filter
Tx audio
Synth PIN SW
Tx Amp
Tx Mixer
PIN
Tx
Switch/Rx
Rx LO Quad
Splitter
RX Mixers
RX Audio
Rx Split
Rx Amp

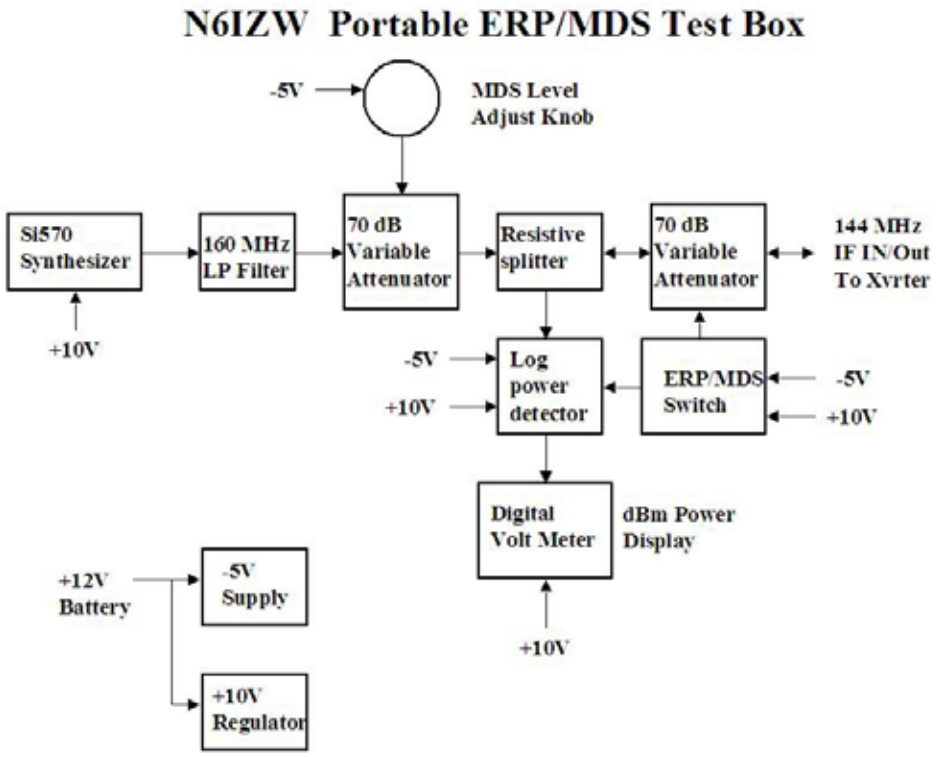
A Portable ERP/MDS Test Box

K.Banke N6IZW kbanke@sbcglobal.net

This experimental test box was developed to replace the 145 MHz range RF signal generator and power meter setup used to perform ERP/MDS testing in the field. It is used as the IF signal source and power meter in conjunction with a microwave up/down converter. The unit is designed to operate at an IF frequency in the 2 meter range but the log amplifier and variable attenuator components are good from DC to 500 MHz. The SI 570 signal source is good from 3-160 MHz.

With the ERP/MDS switch placed in the MDS mode, the variable attenuator control
is manually set (CW)for maximum output power and then reduced.
The level in dBm supplied to the IF in/out port is displayed on the digital display in -dBm.
This unit was calibrated to operate next to the transverter without the long IF cable.
Recalibration can be done to accommodate a long IF cable.

In the ERP mode, the attenuator control is turned to minimum (CCW) to
prevent the RF generator output from interfering with the ERP measurement.
The digital display has been calibrated to display the ERP value directly as when using the attenuator, amplifier and power meter setup.



Block diagram Description

The SI570 synthesizer is the The Si570 Controller and Frequency Generator Kit #2
from http://www.qsl.net/k5bcq/Kits/Kits.html
The unit is a complete synthesizer covering 3-160 MHz with variable step size down to1 Hz and an output of about +10 dBm.

The 160 MHz LP filter is a basic three pole filter to remove harmonics.

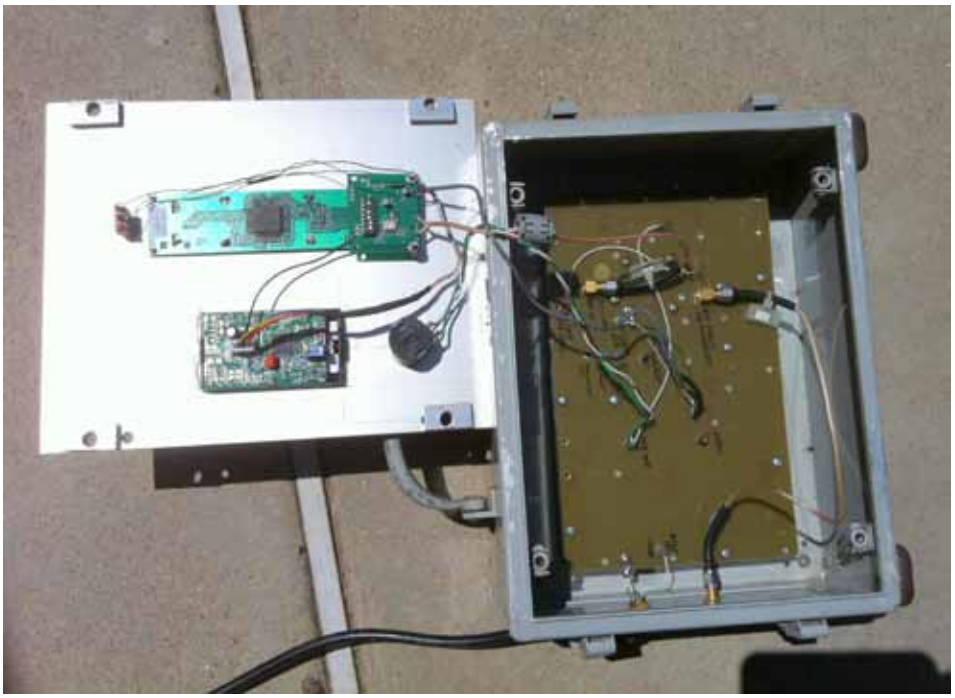
The 70 dB variable attenuator blocks are each two 35 dB voltage variable attenuator chips (MACOM at-635TR) in series using a control voltage of about 0 to -4V DC.

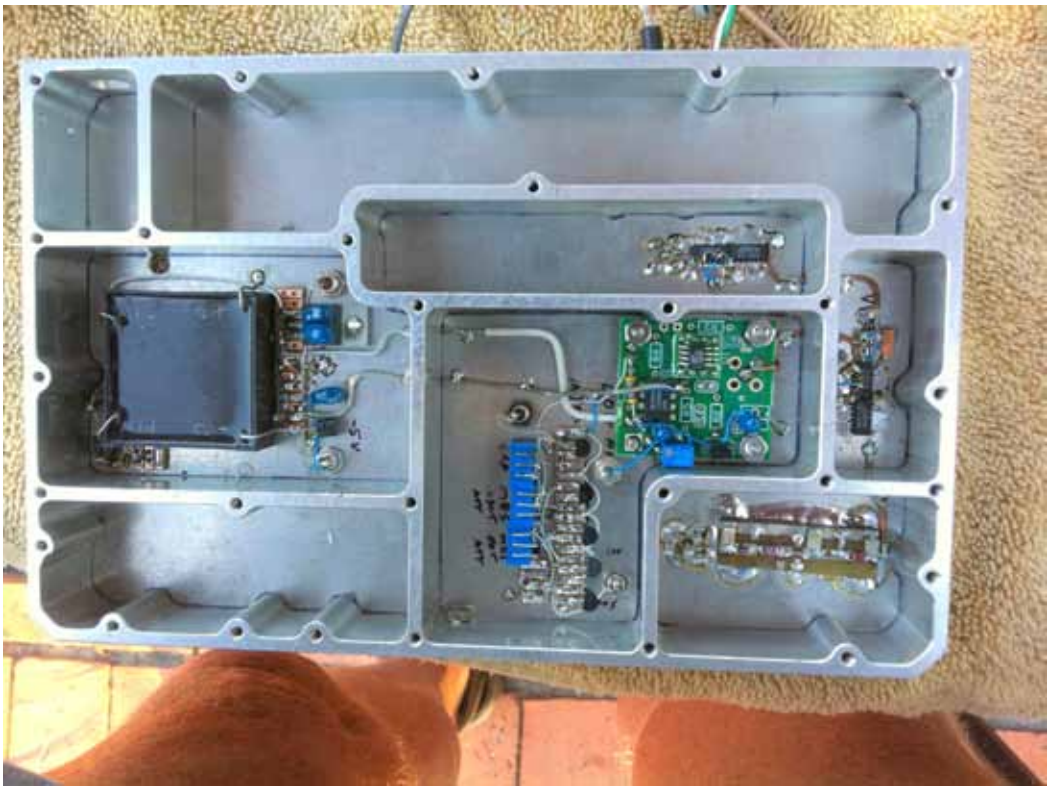
The MDS variable attenuator is controlled by the 10 turn MDS pot.
The second 70 dB variable attenuator is used to apply attenuation as required for calibration in both ERP amd MDS modes and is controlled by the ERP/MDS switch.

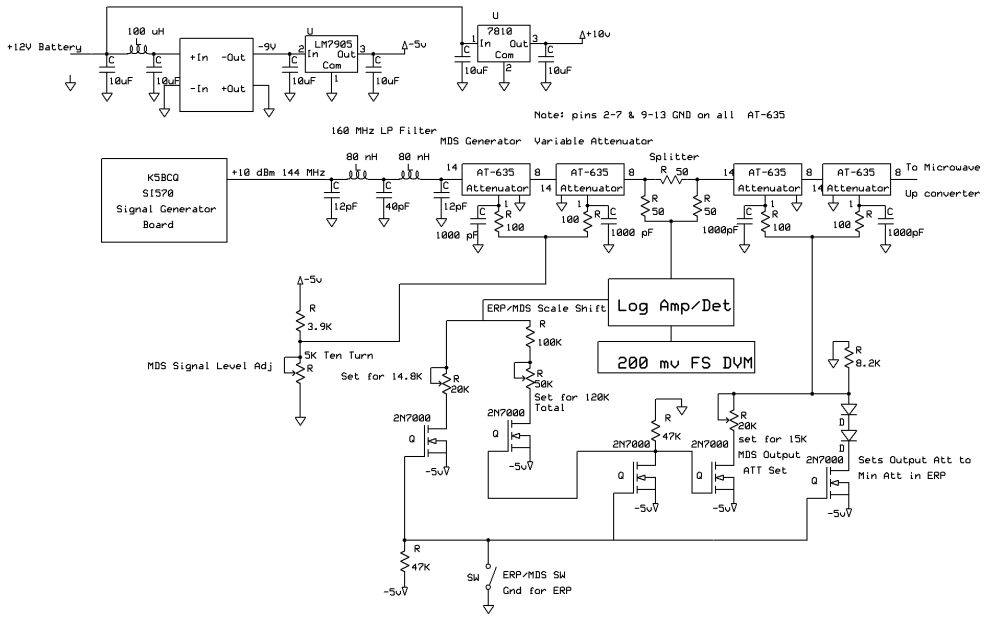
The resistive splitter allows the log power detector to measure both output of the Si570 in MDS mode and the receive power level in ERP mode.

The log power detector is a modified "Sensitive RF Detector for Sun Noise and other uses" board by W1GHZ. It is built around an AD8307 log amplifier/detector providing up to 80 dB of dynamic range.

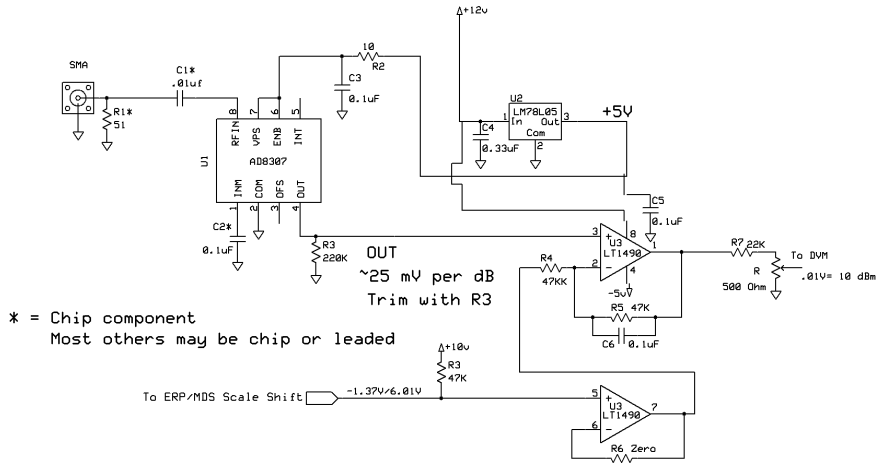
The dBm power meter display is a 200mvFS DC digital panel meter.
The ERP/MDS switch changes both the output attenuator level as well as the AD8307 detector offset between modes.







N6IZW		
Portable ERP/MDS		
Designer's name	Rev 1.0 8/26/2015	Page # or name



Modified Log Amp/Det for ERP/MDS Unit

W1GHZ		
VHF Power Detector and Amp		
	Rev 1.1 8/27/2015	Schematic

Portable ERP/MDS unit advantages:
Portable, compact, battery powered, Sunlight readable LCD display
Low cost

Disadvantages:
Unit needs to be built and calibrated
Careful attention to RF shielding/leakage at 145 MHz range

Standard test equipment setup advantages:
Calibration accuracy/stability
Off the shelf equipment
Shielding/leakage at 145 MHz range usually not a problem

Disadvantages:
Multiple pieces of equipment not easily portable
Requires AC power or large inverter with battery
Most equipment not easily Sunlight readable
Relatively expensive signal generator and power meter

Microwave Update - W5NYV

by Michelle Thompson W5NYV with Kerry Banke N6IZW

Introduction

3D printing is a set of tools and techniques that allow the creation of custom objects with a 3D printer. The 3D printer technology described in this paper is heated filament deposition printing. This is analogous to having a CNC hot glue gun. Plastic filament is extruded through a nozzle in a heated head. The printer that I use has two stepper motors to move the heated head for print length and width, one stepper motor to raise and lower the heated bed for print height, and a stepper motor that moves the filament into the heated head. These motors provide three-dimensional control of the print space as well as control over the rate and direction of filament feed.

Melted filament forms the layers of a 3D printed object. After each layer is printed, the bed is lowered, and the next layer printed on top of the previous one. Each layer adheres to the previous layer due to heat fusion. In general, the Z axis (up and down) is considered to be perpendicular to the deposited layers, which are on the X Y plane. The usable thickness in the Z direction of the melted filament determines the resolution along the Z axis. If the next layer is started too high above the previous layer, there will not be sufficient adhesion. If the next layer is started too low in relation to the previous layer, then the previous layer will be damaged or disturbed by the heated head as it attempts to cram new melted filament on top of older already-cooled filament.

3D models of objects are created in software by either scanning or specification. The 3D model is then sliced into layers that correspond to the thickness of the layer of heated filament that the 3D printer produces. The process of taking a concept or drawing all the way from a sketch to a set of instructions that the printer will understand is generally referred to as 3D modeling.

There are two main types of plastic used in 3D printers, PLA (polylactic acid) and ABS (acrylonitrile butadiene styrene). The plastic filament is generally purchased on reels, and is on the order of 2mm in diameter. Matching the filament size to the size of the nozzle in the heated head is important. Matching the material to the purpose and characteristics of the type of object printed is important.
Similar to machining, sewing, software programming, and other crafts, there is an ensemble of skills involved in successfully producing a quality 3D print. Troubleshooting, materials selection, experimentally determining the right settings for any particular job, cleaning, and maintenance are all very much part of the 3D printing process.

The main reward of 3D printing is the ability to make shapes that are difficult to manufacture otherwise. For the case of microwave horn antennas, experimenting with non-rectangular horns means more difficult fabrication techniques. The ease of cutting shapes out of sheet metal and bending them into rectangular horns is undeniable, especially compared to making horns with curved sides.

Instead of the straight sides of a rectangular horn, the sides of a microwave horn antenna can be curved. This is called a taper. Some examples of tapers are elliptically or exponentially tapered sides. An example of an audio horn with tapered sides can be seen in Figure 1.

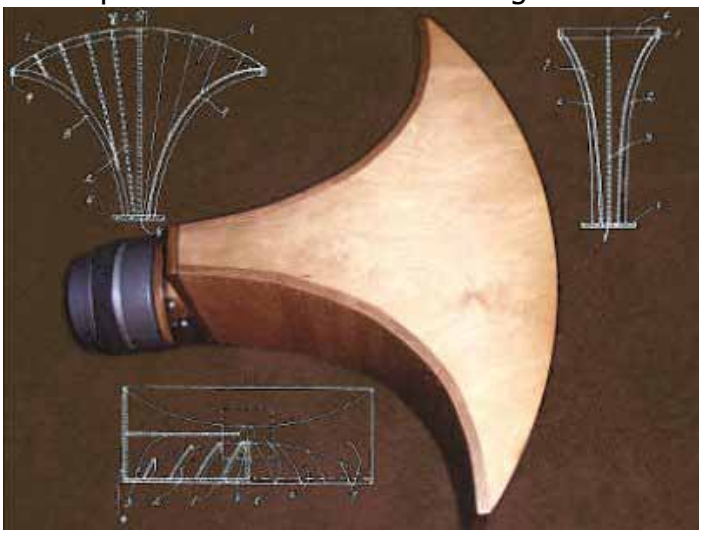


Figure 1

In order to control the taper, either a form or some sort of press would be required to control the creation of the specified curve. When the cost and hassle of making equipment to make equipment is substantially more time and trouble than an easy-to-make alternative, then the easier alternative will be chosen, even if the performance is compromised.

3D printing allows the specification in software of arbitrary shapes, like elliptically tapered sides,

or other complex curves. Printing a horn or other part, then applying a conductive coating, allows experimentation with almost any shape. This opens up tremendous possibilities for microwave enthusiasts to try out all sorts of crazy ideas. Adding in the recent trend towards circuit printers, the possibilities expand even more. The question under consideration for this paper was whether or not new horn designs could be successfully printed that would allow experimentation with complex tapers.

Printing a Rectangular Horn Antenna

A rectangular horn design by Kodera2t was obtained from Thingiverse (http://www.thingiverse.com/thing:87574) and printed on my Ultimaker2 3D printer. See Figure 2 for an image of the horn as printed by Kodera2t in Japan, and

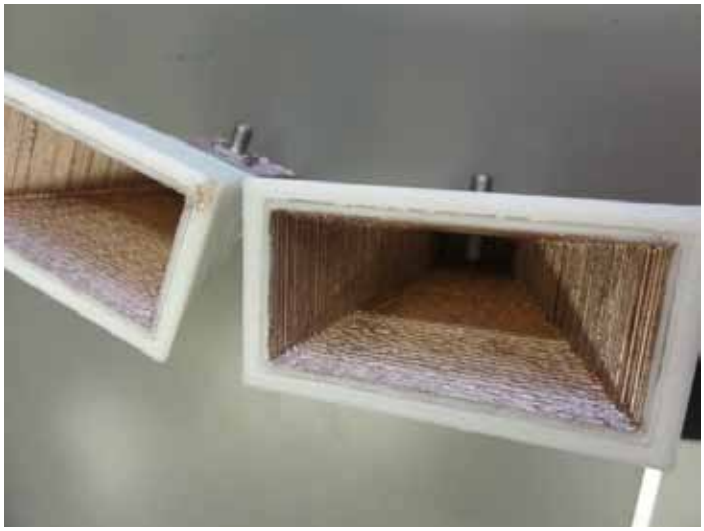


Figure 2

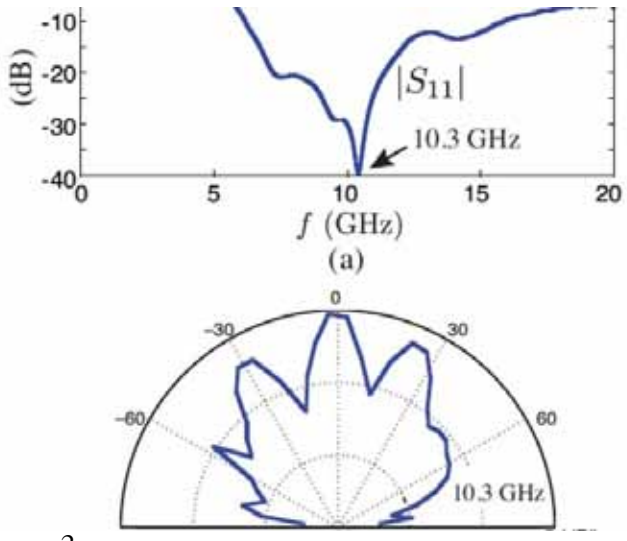


Figure 3

Figure 3 for Kodera2t's initial results, also from his experimentation in Japan.

One of the purposes of printing this design was to confirm the ability to print, metallize, and characterize a "known good" horn antenna. Any problems inherent in the printing, metallization, connectorization, and measurement stages could be addressed with some confidence that they weren't due to the horn design itself.

Horn antennas are very popular in the microwave band. Rectangular horns provide high gain, low SWR, and relatively wide bandwidth, and rectangular horns are not difficult to make.

What About Copyright?

Being able to share 3D models like this makes experimentation with objects much easier. Kodera2t speaks more English than I speak Japanese, but if we weren't able to simply share the 3D model, collaboration would be much more difficult. Freely sharing 3D (and 2D) models on sites such as Thingiverse directly supports the open source movement, where work output is given away to the public domain, and others are encouraged to use, modify, and republish the work for their own applications and needs. This is not mandatory. Many 3D models are unpublished or controlled, for all sorts of reasons. This brings up the question of where 3D printed objects fall in the universe of patents, trademarks, and copyrights. A good starting point for understanding these issues is the white paper "What's the Deal with Copyright and 3D Printing?" by Michael Weinberg (https://www.publicknowledge.org/files/What's%20the%20Deal%20with%20Copyright_%20Final%20version2.pdf).

There are multiple patents on a wide variety of horn antennas. Almost any creative image of a horn antenna has a copyright. A horn antenna as part of a logo of a specific manufacturer or seller would be a trademarked image. All parts of the process of 3D printing largely fall into the existing framework of intellectual property, but there are new challenges and novel legal questions that will have to be addressed in the coming years as 3D printing becomes more and more widely available. Being able to make 3D scans of objects, and then recreate them with a high degree of precision, means that the market for some useful manufactured objects might decrease, whenever a 3D model is made available. This is similar to the challenges the music industry believes they are facing with people being able to easily copy and share music files instead of being forced to buy their own copy of every song or album. One specific example is wargaming models such as ones from

Games Workshop (http://www.games-workshop.com). These small gaming models are expensive and only available from one manufacturer. If one could scan a completed model and then print out an entire army, it would save hundreds or thousands of dollars. I will not be revealing how much money I have invested in Games Workshop models!

The counterargument is that 3D printers are not yet, and may never be, a good solution for mass manufacture. They are (still) very expensive. High-resolution printers can cost thousands of dollars. The filament is expensive at about $40 a kilogram. Many prints fail for a variety of reasons. Home 3D printing is not in any way as cheap and easy as making a copy of a CD or DVD or MP3. Injection molding is still superior in terms of resolution. For mass manufacture, even a very expensive mold for an injection machine is the most profitable way to create objects for sale. In Games Workshop tabletop wargaming, it has always been acceptable to use scratch-built models instead of the purchased ones. The community standard is that if you have a proxy or a scratch-built model of the proper size it is a legitimate model and it can be used in a game. It would be considered poor form to show up with a 3D printed model that was an exact copy of the models offered by the company that makes the game because supporting the company means more versions and updates to the game. However, conversions and scratch building and now 3D modeling and printing are an accepted part of the gaming landscape. I've used 3D printing to make very successful custom characters and terrain for wargaming. It's quite enjoyable to field a model of your own design on the tiny battlefields of tabletop wargames such as Warhammer 40k. This is the same type of satisfaction that we feel when we put a custom-designed or homebrew rig on the air.

Elliptical Taper Horn Design

The next step in the project was to attempt to create a 3D model in software of a more complex horn.

There are many different types of tapers to choose from. The horn shape that gives minimum reflected power is an exponential taper (Bakshi, K.A.; A.V. Bakshi, U.A. Bakshi (2009). Antennas And Wave Propagation. Technical Publications. pp. 6.1–6.3. ISBN 81-8431-278-4). This means that this taper is the most efficient way to get the signal from the wire or waveguide into the air. Tapers also affect phase error. The waves are leaving the antenna as spherical waves. If the waves encounter straight sides, then parts of the wave will be reflected at slightly different times. See Figure 4 for a drawing that shows the phase error in a rectangular horn. Tapers that make an effort to comply with the spherical wave front have less phase error.

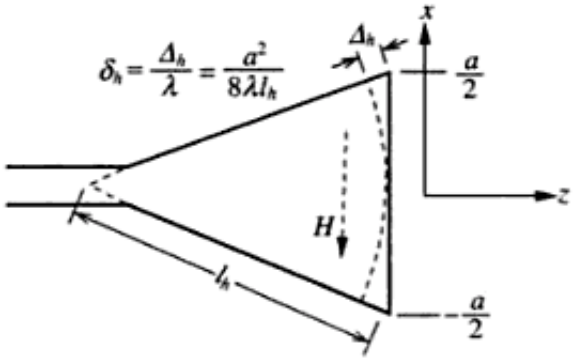


Fig. 4.8 Phase Error of Pyramidal Horn Antenna Aperture (H-plane)

Figure 4

See Figure 5 for a comparison of many different tapers investigated by the audio horn community. This image was sourced from the discussion at http://www.diyaudio.com/forums/multi-way/248198-midbass-horn-35.html. Another type of taper is the elliptical taper. These horns are described in the literature as high performance. The claim is that the elliptically curved sides are more efficient, and have less phase error than an equivalent straight-sided horn.

I had recently read an essay about ellipses, so I decided to try to model an elliptically tapered horn. 3D modeling generally falls into one of two classifications. One is either defining the shapes with instructions, much like writing a computer program, or one is dragging and dropping, pushing and pulling various solids or meshes. Using OpenSCAD (http://www.openscad.org) I began to describe the shapes I wanted in OpenSCAD's scripting language. See Figure 6 for an example of what the 3D modeling workspace looks like.

For the elliptical horn, I decided to create the horn using four solid ellipses. These four solid ellipses had surfaces that would be the inside, or throat, of the horn. I then used the difference function in OpenSCAD to subtract a slightly smaller ellipse to turn the solid ellipses into a set of curved walls. This process is somewhat similar to using one layer of an onion, instead of the

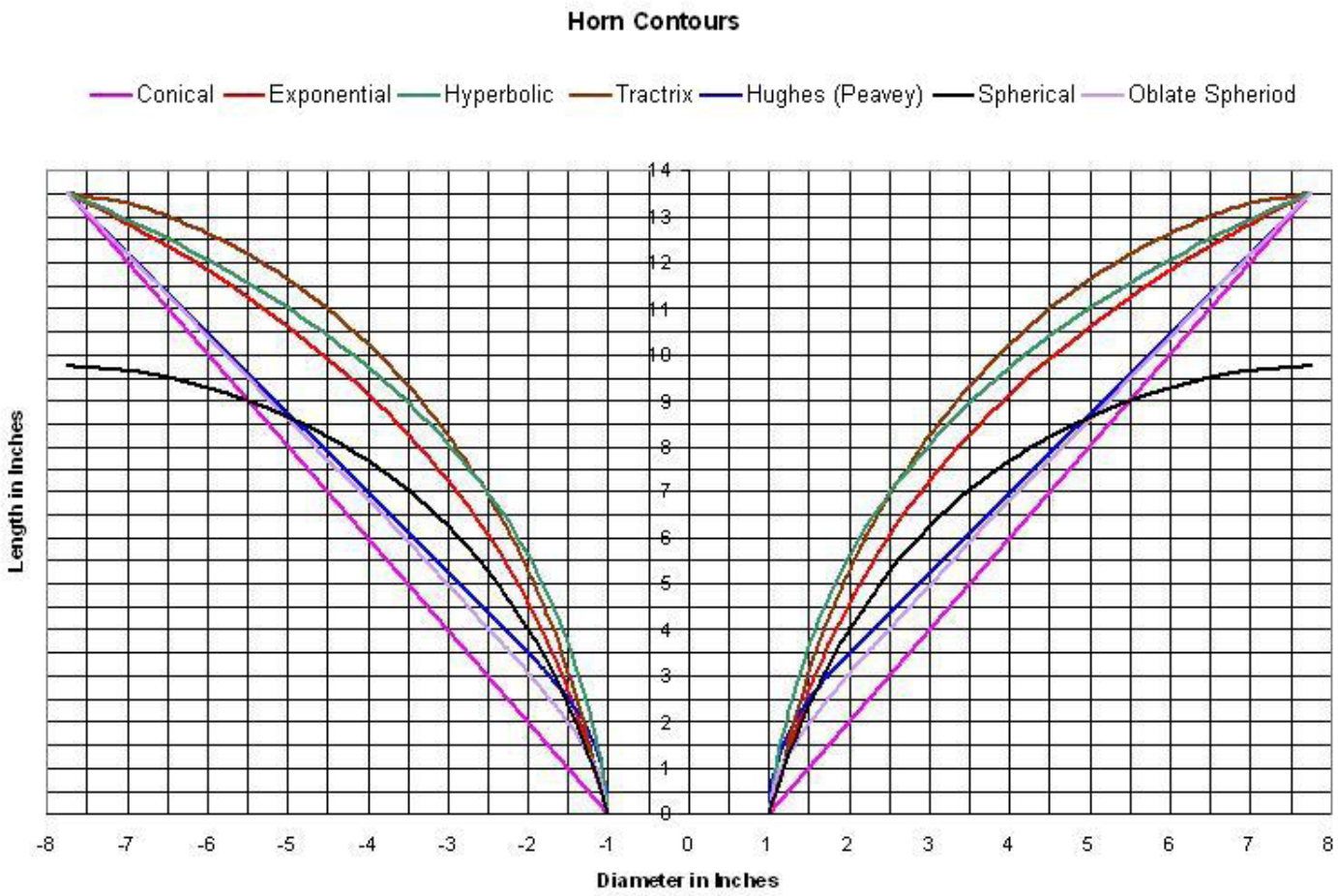


Figure 5

entire onion.

It was then that I encountered one of many interesting problems with 3D modeling a complex shape. Simply scaling down the ellipse I wanted to subtract meant that the wall thickness was not constant. I had to scale the major and minor axes differently in order to have constant wall thickness. After that was fixed, the horn wall thickness was consistent, and attaching the SMA connector could be done with a greater amount of confidence. If the wall where the connector is attached isn't controlled in the model, it can end up being too thin to attach the connector. Screws might protrude into the throat of the horn, or the antenna might end up being too short or too long. Part of good 3D design, especially when the model is parameterized, is controlling the repercussions of changing the parameters. Code for all of the horns can be found at https://github.com/Abraxas3d.

Printing the Elliptical Horn

Each elliptical horn was printed in two pieces. This was necessary because the dimensions of the elliptical horn were greater than the available print dimensions on the Ultimaker2. In Figure 6, one can see the transition from the waveguide/SMA portion of the antenna, to the tapered part of the antenna leading to the aperture. Where the color changes is where I separated the model in OpenSCAD.

I wanted to print the horn with the aperture facing up in order to make the inner surface as smooth as possible. I decided not to use support material for the outside surface, which would overhang to near horizontal at the aperture. Support material is a lacework of 3D printed filament that allows the printing of overhangs. Wherever the solid object has a horizontal part projecting into the air, support material is "grown" up from the platform so that the overhanging structure somewhere up above the platform has something to sit upon. It's somewhat like scaffolding when building a construction project. The decision to skip support material was somewhat risky because there is an overhang at the top of the print.

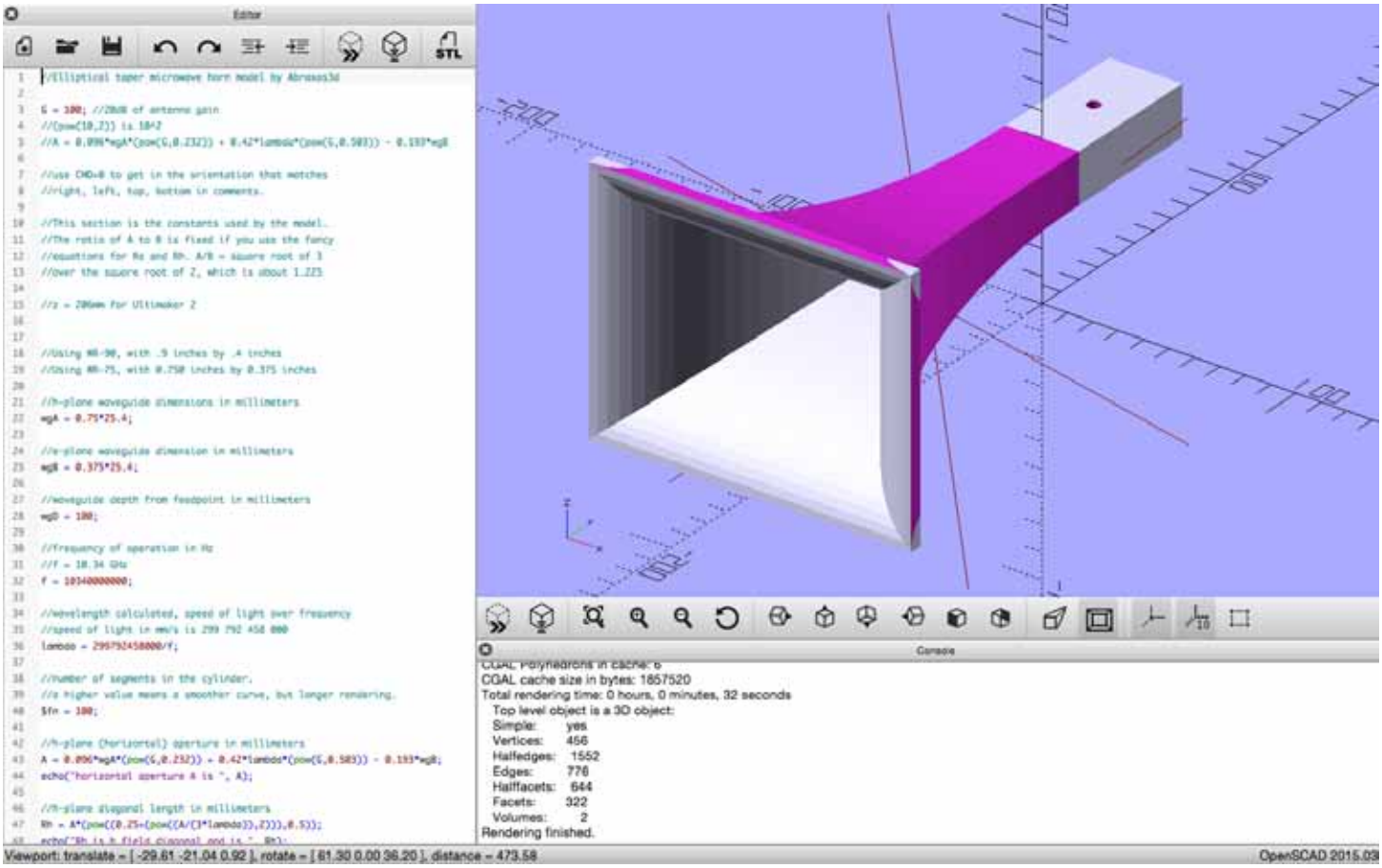


Figure 6

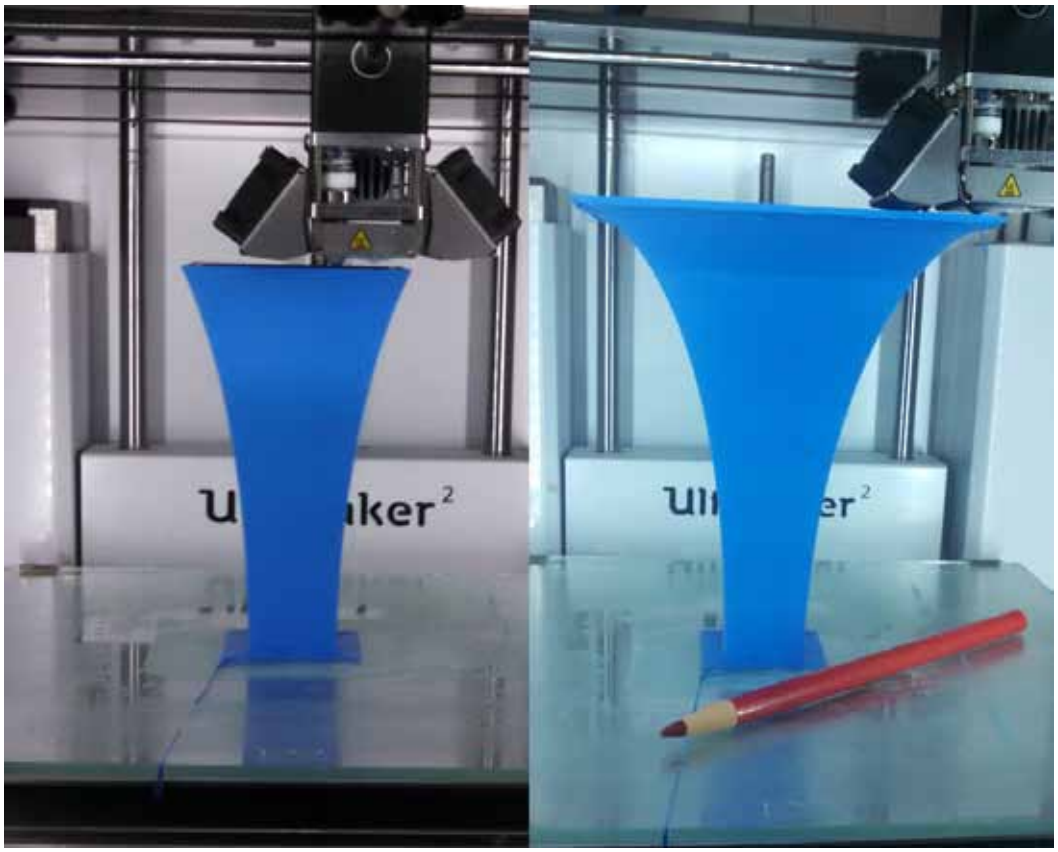


Figure 7

Figure 7 shows the print at two points in time. Pencil is for scale. On the left is the print at about the halfway point. On the right is the print nearly complete. Note some of the filament is loose on the overhang on the right-hand image. Support material prevents this. However, printing the amount of support material required for a tall print like this is risky as well. The lacework would have to print perfectly all the way up to meet the relatively small amount of overhang. The print took approximately 40 hours without support material. The driver software estimated 55 hours if support material had been included. Two horns were successfully printed out of two attempts.


Figure 8

The four parts were metallized with conductive spray paint (MG Chemicals 843-340G Super Shield Silver Coated Copper Conductive Coating, 5-Ounce Aerosol, $40).

See Figure 8. Dinosaur is for scale.

The waveguide/SMA sections were then super-glued to the tapered sections.

Initial Testing of Rectangular and Elliptical Horns
SMA connectors and advice were obtained from RF Parts in San Marcos, CA. Kerry Banke N6IZW assisted with installing SMA connectors for the 3D-printed rectangular horns as well as the 3D-printed elliptically tapered horns. We made initial measurements in his lab of both the rectangular and elliptically tapered horns. The first rectangular horn tested was one that didn't print well. I selected one that had voids and other problems with the print in order to test whether the conductive paint would work at all as a reflective surface at 10GHz. While confidence was high, and measured resistance was very low (1 Ohm across the horn), I didn't want to use one of the nicer prints if conductive paint would fail to properly metallize the printed shapes.

The backup plan was to apply copper foil to the surfaces of the horns. While this would be much more painstaking to apply, copper foil would definitely work. I knew this due to advice from Professor Nuno Borges Carvalho, from the Instituto de Telecomunicacoes, Universidade de Portugal. He presented extensively about 2D printed circuits and 3D printed horn antennas at the 3D printing workshop at IEEE Radio Wireless Week conference held in January 2015. He and his graduate students used copper foil to metallize their 3D printed 10GHz horn antennas. They are advocating for a two-part 3D printer that would metallize as part of the printing process.

The first thing we noticed when we tested the spray-painted rectangular horn is that I had neglected to paint the rear surface of the waveguide-shaped section of the rectangular antenna. I had painted the horn while it was sitting on its rear surface, so that part wasn't covered with the conductive paint.
A whole lot of signal was blasting out of both the front and back of the antenna. This gave us a lot of confidence that the conductive paint actually worked as a reflective surface. We added some foil to the back of the horn, and achieved 30dB front-to-back ratio. We removed the foil, painted the rear surface in the driveway with conductive paint and retested. The painted surface was now "closed" and reflected RF to the same level as the copper foil.

This particular rectangular antenna had several large voids in the layering of the print. Sniffing around with a probe revealed RF leaking through the void. Since we could literally see through this void to the other side, this result was not surprising.

The elliptical horns were painted with conductive paint only on the inside, with the SMA connector hole painted as well. This turned out to not be enough in order for them to work. I took back the horns and coated the outside of the horns as well.

N6IZW attached one horn with SMA to a network analyzer. It had a return loss of 15dB at 10GHz with large dips at 7.5GHz and 9GHz. Kerry removed the SMA connector and found that the conductive coating had not been sufficiently applied. Additional conductive material was added below the SMA and the dips were substantially reduced.

Gain was measured with comparison to a reference antenna and found to be at least 12dB.

The second elliptical horn had 0dB gain and was returned for more conductive coating.
The waveguide of the horn is designed to be WR-75, with inner dimensions of 0.750 inches by 0.375 inches. The dimensions of the waveguide affected the size of the horn, with WR-90 making the horn large enough in some dimensions to not fit as desired on the print surface. WR-75 was chosen because it was the smallest waveguide that would work on 10GHz and also allow the horn to print completely within desired printer dimensions. WR-75 works from 10.0 to 15.0 GHz. The next size up, WR-90, works from 8.20 to 12.40 GHz. WR-90 puts 10GHz much more comfortably in the middle of the range, at

the cost of making the print slightly larger. Some of the results that we were seeing could be due to choosing WR-75 over WR-90 for the prototype horns.

Range Party Results

An elliptical horn antenna was tested at the San Diego Microwave Group range party on 27 July 2015. Fourteen operators attended with gear covering 10-47GHz. The range tests include measuring output power and minimum discernible signal.

See Figure 9 for Kerry N6IZW holding up the elliptical taper 3D printed horn in operation at the range test.

This horn performed well at the range test. It was directional and had at least 12dB of gain. The second elliptical taper horn was re-painted and the SMA connecter re-seated. In late August 2015, this horn underwent further tests. Performance was not in line with the first horn, so the tapered part was separated from the waveguide and tested with a known good SMA to WR75 transition held firmly in place. The antenna worked well, achieving a gain of about 20 dB. The transition from taper to waveguide was determined to be problematic, even after rework. However, the antenna shape, surface texture and conductive coating all performed very well.

Suggested Improvements

Several improvements were suggested based on experiences with handling, printing, and testing the 3D printed 10GHz horns.

First, we should consider adding a radius to the corners in the model. The edges are all sharp. It would improve paint adherence to radius the corners without much cost in terms of gain or phase performance. This can be achieved with a relatively simple function in OpenSCAD. Second, we could print the model so that the horn is assembled around the SMA connector. The horn could be printed in pieces where the connector can be captured by the sides, instead of fitting through an SMA hole. With the current design, screws to hold the SMA connector are going into the surface of the 3D print. There is a layer of solid PLA for the outside wall of the print. However, the inside of these prints is a honeycomb. It's not solid plastic all the way through.

The amount of material used for a print is made at print time. In general, the outer walls are a few layers thick, and the interior is a honeycomb of about 20% material and 80% air. Rectangular and hexagonal honeycomb are the most popular. Printing a large object such as this horn in solid plastic would take a very large amount of additional print time and filament. I chose 25% fill for the honeycomb for these prototype horns. For an antenna with a connector, reinforcing the area where the holes for the SMA connectors go seems to be a necessary improvement. The area immediately around the SMA connector can be solid plastic all the way through without costing much additional printing time. This would improve the seating of the connector and reduce unreliability of this particular interface.

However, we came to believe that printing horn antennas that directly connect to a waveguide with a flange would be superior to attempting to incorporate an SMA connector. This leads to the next suggested improvement.

Third, we explored the idea of building in an RF choke flange into the design wherever a transition was required. This would improve the reliability of any interface, whether the transitions were due to having a multi-part print or when the horn was designed to attach to a waveguide.

Conclusion

Rectangular and elliptical taper 3D-printed 10GHz horn antennas were designed, printed, metallized, and tested. 3D printing technology can be used to create complex tapers for 10GHz horn antenna experimentation.

It is believed that the reliability of the horns can be improved by making the improvements discussed in this paper. Future work will implement these improvements.

Figure 9

Microwave Update - K6AH

AMATEUR RADIO EMERGENCY DATA NETWORK

AT THE CENTER OF EMERGENCY COMMUNICATIONS PREPAREDNESS

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Abstract

Mesh technology has been around for ten years or more. Over the past two years a team of developers has advanced the art by porting Broadband-Hamnet's extremely popular mesh firmware to the Ubiquiti airMAX line of commercial Wireless ISP routers and expanded its utility across a wide range of microwave bands. This has literally changed the complexion of mesh technology from an experimental, hobby-oriented, novelty into a viable alternative network suitable for restoring some degree of Inter/intra-net connectivity "when all else fails."

In the midst of this work the AREDN Project was kicked off to focus development on taking this technology to the next level in EMCOMM communications.

This paper begins with an introduction to the AREDN Project and mesh networking and concludes with a roadmap for the Project's future. It dives into implementation techniques and aggressive plans to implement across broad portions of the Southwestern US.

Keywords: AREDN, EMCOMM, mesh, BBHN

The AREDN Project

Background

The ARDEN Project has its roots in the ARRL's 2001 Technology Task Force headed by John Champa, K8OCL (SK) to explore the development of High Speed Digital Mesh Networks for the Amateur Service. For many years the HSMM / Broadband Hamnet (BBHN) group carried the torch for Amateur mesh technology, making creative use of the familiar Linksys desktop WiFi routers as a means of demonstrating the utility of the technology.

It became popular quickly… but for years that is where the technology stood… being utilized perhaps for Field Day logging, support of local runs and races, personal security camera networks and extending in-home LAN services out to the shack. The home/office nature of the hardware did not lend itself to the more robust network designs required for EmComm to really embrace it.

Then in 2013, Conrad, KG6JEI, and the author, K6AH, offered to develop BBHN software for commercial routers in use within the Wireless ISP industry. These environmentally robust devices were ideally suited for towers and mountain-top deployments.

The first commercial devices to leverage the new strategy in 2013 were in the Ubiquiti AirMax 2.4 GHz line in release 1.01. Operating on channels shared with WiFi routers, the RF spectrum was crowded, but it worked… often over link-distances of 20+ miles.

This literally changed the complexion of Broadband Hamnet from an experimental, hobby-oriented, novelty into a viable alternative network suitable for restoring some degree of Inter/intra-net connectivity when "all else fails." Emcomm finally had what was needed to exploit this technology.

Since then the team has been augmented with other developers: Joe, AE6XE, Darryl, K5DLQ, and Randy, WU2S, and the technology has been extended beyond 2.4 GHz to the 900 MHz, 3 GHz, and 5 GHz bands and to a variety of bandwidths and channels, many entirely within the ham bands. As you will see, this technology works very well now and is ready for production EmComm deployment.

Due in large part to the EmComm passion Conrad and the author brought to the project, the pressures the original BBHN group was getting from their "legacy" Linksys user community, and the resultant lack of focus EmComm was getting, the development team made the tough decision to spin up a separate AREDN Project to focus strictly on supporting the EmComm implementation of this technology. The software is Open Source under the GPLv3 license, and to this point at least, BBHN continues to utilize this team's software in their own offering.

Objectives

So the AREDN Project's focus is EmComm. It seeks to provide hams a means to implement this technology in practical ways to support local and regional emergency communications needs. To that end, the project's primary focus is on:

- Refining the software to make implementation easier, more reliable, and more manageable
- Expanding the range of equipment the software runs on, particularly where it adds new utility
- Exploiting what has already been proven
- Defining standards for inter-network integration
- Exploiting the strength of the technology and championing it where it is best suited
- Supporting those in the process of designing and implementing EmComm networks
- Providing an Open Source, collaborative environment for technically qualified hams wishing to contribute

The project typically does not:

- Experiment with other techniques and technologies unless it becomes necessary to fulfill its objectives
- Support the non-EmComm mesh user community
- Support the earlier Linksys device

Team Composition

The team is currently comprised of:

- Conrad, KG6JEI, the primary architect and lead software developer
- Joe, AE6XE, software developer working primarily on the User Interface; technical strategist
- Darryl, K5DLQ, software developer working primarily of peripheral features and functionality
- Randy, WU2S, Webmaster, as well as team and technology promotion
- Gordon, W2TTT, ARRL and regulatory liaison, tactician
- Andre, K6AH, project evangelist, project manager, and spokesperson

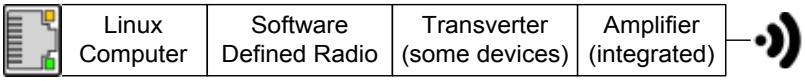
Mesh Technology

Brief Introduction

AREDN is an RF network mesh of radio/routers operating under the FCC rules, Part 97 in the ham microwave bands, controlled by hams with a Tech license or higher. It's a high-speed data network capable of rates of 54 Mbps and greater, designed to provide a TCP/IP medium when other network infrastructure has failed. While technically capable, it is not intended to be a general Internet access alternative.

AREDN software replaces the manufacturer's device operating system, repurposing the hardware for a new set of objectives.

The diagram illustrates the functional elements of the hardware:



The Ethernet interface on the left provides a means of connecting to and communicating with the device locally. VLAN techniques are used in conjunction with a compatible outboard Ethernet Switch to distinguish LAN, WAN, node-to-node traffic, from local access to a Linux computer which executes the AREDN software. The AREDN code controls a Software Defined Radio, based one of several chips in Qualcomm's Atheros 802.11 wireless portfolio. In some cases a transverter is used to move the device to another band. Such is the case for Ubiquiti's 3 GHz line, which are based on their 5 GHz devices transverted 2 GHz down to 3 GHz.

In some cases the Atheros native RF power output is augmented with an integrated RF linear amplifier, giving these devices a respectable output of from 23 to 28 dBm (200mW – 630mW).

The hardware is manufactured using components with a wide environmental range (-40° to 176°F), and packaged to withstand weather extremes.

Figure 1 - Ubiquiti AirMax product line

Software Components

The software is comprised of:

- Graphical User Interface (GUI) – A web browser-based system providing access to mesh management tools and manually configurable parameters such as Ham Callsign, RF channel, bandwidth, etc.
- OpenWRT – the core routing utility which frees the project from having to deal with the unique nuances of the disparate devices on which our software runs. This core empowers us to use these devices in ways never envisioned by the manufacturer.
- An auto configuration utility – A key advantage of AREDN/BBHN software is that it automatically configures network operating parameters, so one doesn't need to know very much about the operating environment or networking in general, to deploy ad hoc nodes during an emergency.
- Optimized Link-State Routing (OLSR) – A mesh routing protocol which determines the most efficient way of sending data through the network. The quality of each link is propagated throughout the mesh giving all nodes the ability to determine these best routes.

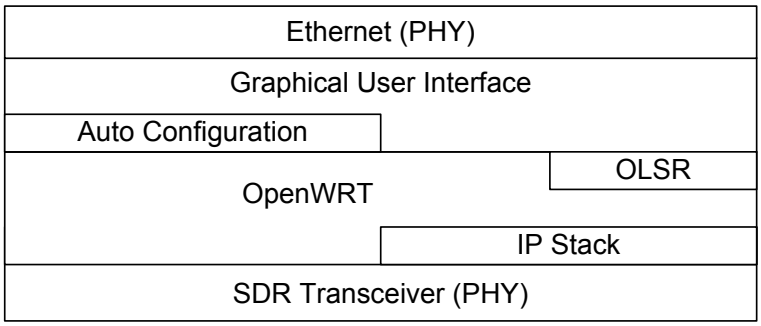


Figure 2 - The Software stack book-ended by the physical interfaces

How it Works

Mesh routing protocols are evolving and OLSR is being used not so much because the team has done an exhaustive examination of the alternatives, but because it was inherited from the BBHN legacy system and there has been no compelling reason to revisit the choice. Should another routing protocol prove better suited for the project's purposes, then we would surely look at it. Again here, the project doesn't spend a lot of time experimenting with other techniques and technologies unless it becomes necessary to fulfill its objectives. We do keep an eye on protocol competitions such as Wireless Battlemesh (battlemesh.org).

Here's a high-level description of how the system works:

In the Standard WiFi diagram below, we see two distinct “domains.” The User domain includes both wired and wireless devices. These are all in the same address space and nothing distinguishes them aside from how they connect to the WiFi router.

The second domain is for the Internet. You will note a firewall protects the User domain from unauthorized access and other threats from this external domain.

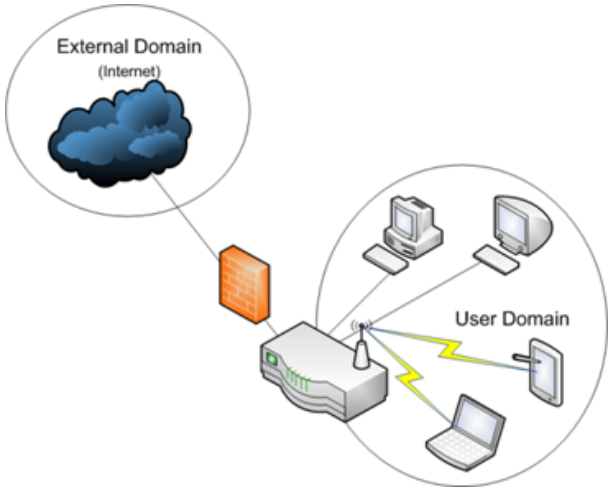


Figure 3 - Standard WiFi

In the repurposed AREDN software model illustrated below, the two domains in the Standard WIFI diagram have now become three. We see the familiar external and user domains... although the user domain now contains computers which deliver services such as email, FTP, VoIP, chat, etc.

The new domain here is an RF mesh network which forms the business end of the AREDN technology.

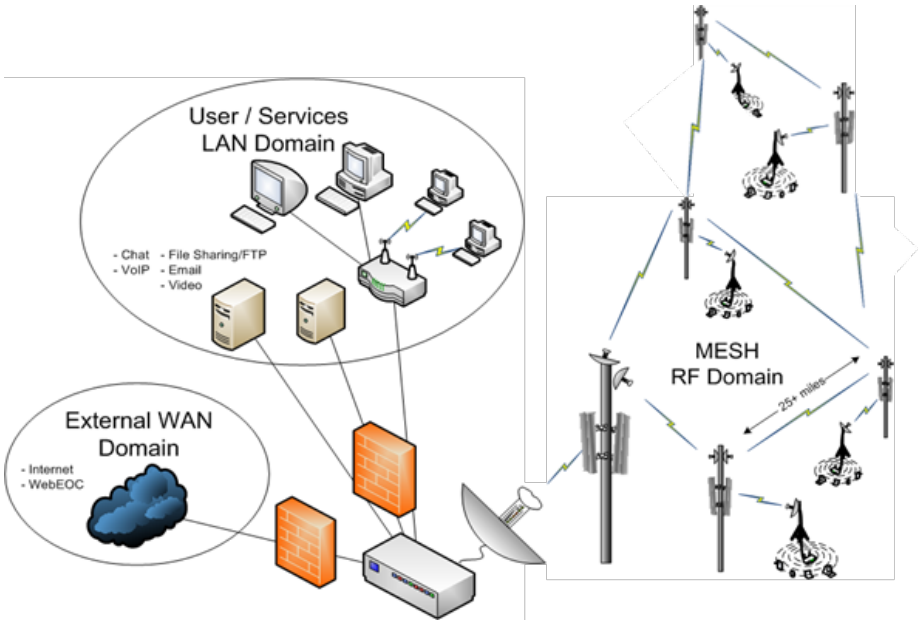


Figure 4 - Repurposed with AREDN Software

The four devices, all Ubiquiti NanoStations, illustrated below have formed a “mesh.”

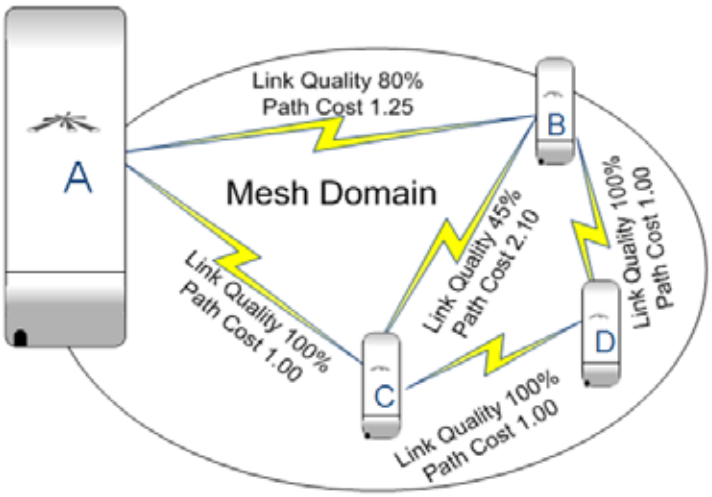


Figure 5 - OLSR Routing

The route data will take through this network is dependent on the reliability of the links between them. Note the link between Node A and Node B. Through historical broadcast reception, Node A knows that 80% of the data from Node B is received without error… it is said to have an 80% Link Quality (LQ). Based on this, it assigns a “cost” to that link which is inversely proportional: $1.25 in this case. All traffic from A to B will take this path, because there are no less expensive routes available.

If the link between A and B where to fail, then Node A would quickly calculate an new lowest-cost path. Two are available for it to evaluate:

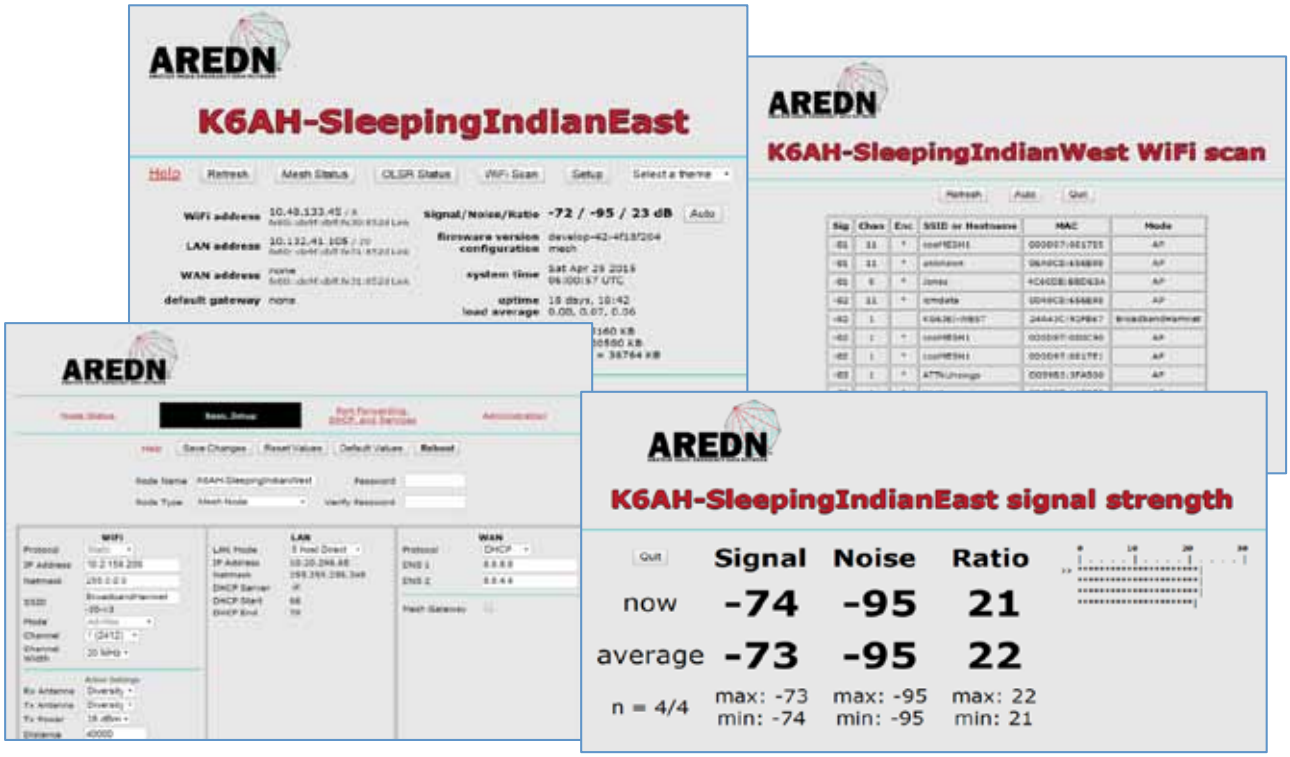
- Path A-C-B at a cost of $1.00 + $2.10=$3.10
- Path A-C-D-B at a cost of $1.00 + $1.00 +$1.00= $3.00

Node A’s routing table is updated with the new optimal path of A-C-D-B. These updates are performed multiple times each second, with routing table propagations through the mesh taking some amount of additional time depending on the size of the mesh.

The Graphical User Interface is generated using HTTP by the AREDN software running on the embedded Linux computer. The GUI provides access to a variety of administrative and operational functions, such as:

- Checking for traffic / congestion on the channel
- Reporting the current node status and other nodes both directly or indirectly connected
- Basic node configuration settings

- More advanced administrative setting for
  - Port Forwarding / DHCP / Advertised Services
  - Network Address Translations for complex network environments
  - Updating the AREDN firmware
  - Installing useful service packages on the node



Strengths (and limitations) of the Technology

The AREDN system utilizes the CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance) transmission control protocol to gain access to the air (the RF ether). I have heard this is analogous to polite people sitting around a table talking---'polite' being the operative word here. It's well suited for many nodes that can all hear each other and very well suited for accommodating newcomers to the table. These are exactly the attributes we want, because we don't know who might join the network, and we have no idea how much of the network they might demand for their traffic. Such a protocol is also good at handling random channel access, nodes coming/going and being moved around.

In contrast, the TDMA (Time Division Multiple Access) protocol, as the name suggests, assigns time slices for each neighboring node. When a new node join the network, the time gets divided among the now larger group with the effect of allocating less time for everyone. While TDMA implementations are generally proprietary to a given manufacturer, they typically have some means of manually or dynamically adjusting time slice sizes bases on link bandwidth requirements. TDMA is preferred for static networks where little change occurs in the network topology. TDMA would not be suitable for ad hoc, mesh networks.

The other major strength of the AREDN/BBHN technology is the automated configuration of the node's network parameters. A ham need know nothing about the network he/she wants to connect other than the channel to use and the bandwidth which are established in advance or conveyed over radio in a deployment. The nodes IP address, net mask, gateway, etc. are determined by the software and assured to be unique throughout the network. This significantly speeds deployment and virtually eliminates concerns over multiple devices having the same address. This is accomplished using the devices MAC address to compute a unique address in the 10.X.X.X address space.

Network Design

Choosing Devices

Ubiquiti airMAX M-series wireless routers obtain their operating power from the CAT5 cabling (PoE or Power over Ethernet). They have a broad DC input voltage specification to accommodate the voltage drop over a wide range of cable lengths which may be required for tower applications: 10.5 to 24VDC at the CAT5 connector.

Many utilize a combination of horizontal and vertically polarized antenna to minimize unwanted interference from on-channel or adjacent channel WiFi noise. When conditions allow, they also support the combining of these polarizations for increased data throughput—called MIMO (Multi-In, Multi-Out).

Here are a few representative devices and characteristic selection criteria:

- Rocket – A two RF port MIMO node (500mW) that is "plug and play" with a variety of Ubiquiti antenna systems: 90° and 120° Sector antenna, Dual-polarization Verticals, and 30-34dBi Dish antenna. Note that MIMO nodes split the power between the vertical and horizontal domains.
- Bullet – A single RF port high-power (600mW), non-MIMO node with an N-Type female connector suitable for direct connection to many 3rd party antennas. With the right antenna this could achieve link distances of 50+ km.
- NanoStation – A fully contained node with an internal 11dBi patch antenna and a 45° coverage pattern.
- airGrid – A larger node available in several size/gain grid-reflector antenna configurations. Designed to be a highly directive, it performs at a range of from 10 to 30 km

In planning to deploy the core nodes it is advisable to use propagation prediction software such as Radio Mobile to avoid the hassle and expense of experimentation.

I will diverge for a bit for the benefit of those unfamiliar with this type or software.

Radio Mobile is a free propagation simulation system. It utilizes data from the Space Shuttle Radar Terrain Mapping Mission (SRTM) resulting in elevation contours which have then been overlaid with satellite imaging and road maps. It further utilizes the Longley-Rice radio propagation prediction method, which computes the attenuation of radio signals using an "irregular terrain model"... a technique that has been successfully used in commercial radio coverage planning since the 1960's.

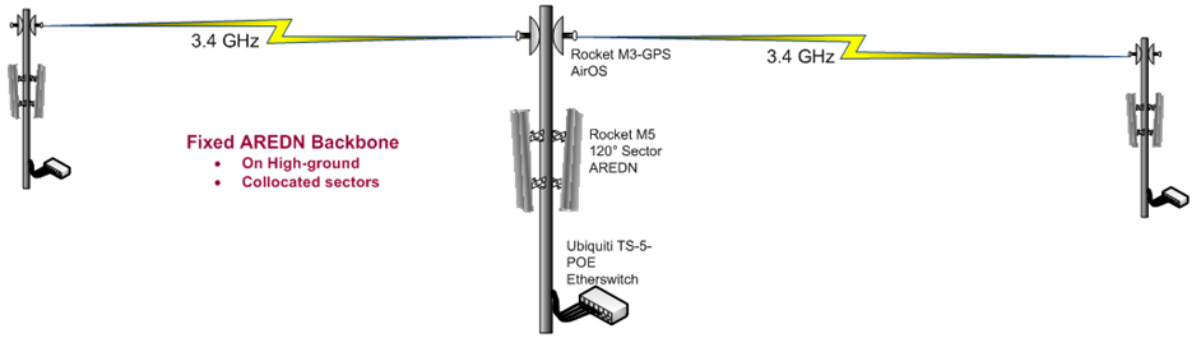
It is available both as a software download and a Web-based tool. While the download results in a more flexible tool, its installation is not for the faint-of-heart. I would advise that, if you do not consider yourself a computer expert, then the Web-based tool will more than adequately meet your needs. The English language portal is at: http://www.cplus.org/rmw/english1.html

Sufficient use of this tool to explore the variables of band, node-model receiver sensitivity, and node-model power output, will result in the required antenna gain in either point-to-point (PtP) or point-to-multi-point (PtMP) topologies.

Conceptual Network Design

One conceptual model, currently being implemented in San Diego and Imperial Counties, incorporates both mesh and traditional backbone elements.

Taking a layered look at it, the top level I will refer to as the backbone.



It's comprised of Ubiquiti 3 GHz "Rocket" nodes coupled to a 2' diameter, RocketDish (26dBi). They are loaded with Ubiquiti's factory software and are configured to use TDMA for their transmission control protocol. Under typical conditions they will use 20 MHZ of bandwidth, but under ideal conditions, will double their throughput by establishing independent data paths on the vertical and horizontal polarization axes.

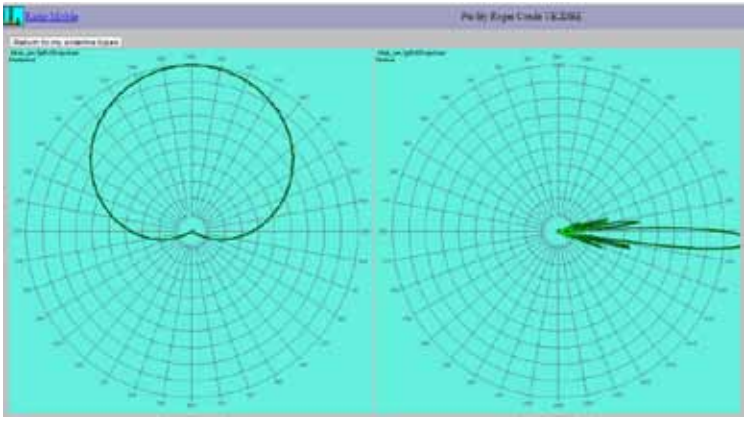
Figure 6 - Ubiquiti RocketDish and Sector antennas

These devices comfortably span links of 50 miles and beyond, supporting multi-megabit to fractional gigabit data rates. Note that these are fixed installations with care taken to align their narrow beamwidths. 3 GHz is chosen to avoid competition and interference from commercial installations generally found on the same towers/mountaintops. This band has no commercial allocations within the US and, when coordinated with other ham users, can be an outstanding medium for long-haul links.

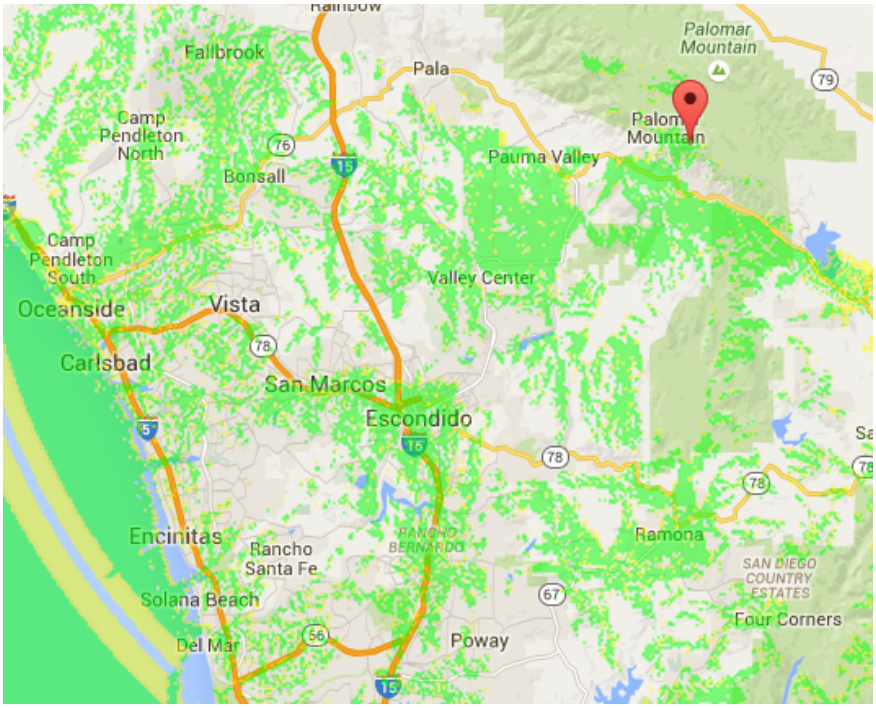
3.4 GHz													
	Channel	76	77	78	79	80	81	82	83	84	85	86	87
	Status	Ham Band											
	Freq	3.380	3.385	3.390	3.395	3.400	3.405	3.410	3.415	3.420	3.425	3.430	3.435
		88	89	90	91	92	93	94	95	96	97	98	99
		Ham Band											
		3.440	3.445	3.450	3.455	3.460	3.465	3.470	3.475	3.480	3.485	3.490	3.495

Figure 7 - AREDN supported channels in the 3 GHz ham band

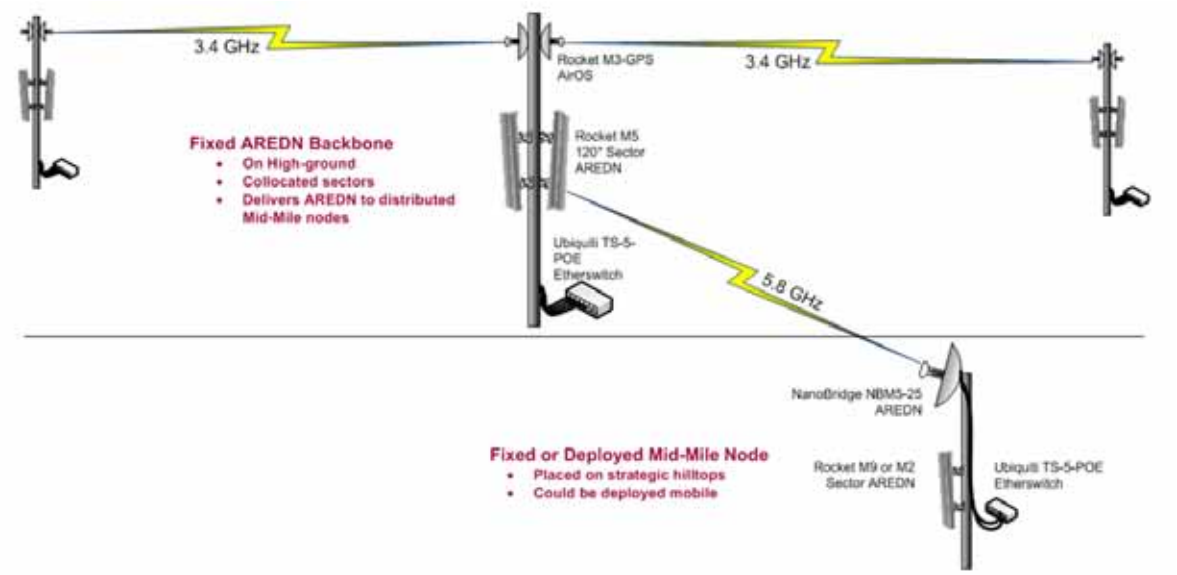
The objective of this backbone layer is to deliver the network to the next layer down which they typically do using sector antennas and again, Rocket nodes. This configuration covers a 120° "swatch" from the horizon to 7 degree below the horizon making them ideally suited for mountain top installations.



The sector antenna can be tilted to optimize a particular coverage area. Here's an example of one such San Diego installation plotted in Radio Mobile to predict its coverage.



The green shade identifies locations suitable for the next layer of the network, the Mid-Mile nodes:



These nodes serve as relays connecting the backbone to the served agency and deployed hams in the next layer, down. They can be either fixed or deployed based on an agency's needs and ham communications plan. They typically have a high-gain antenna pointed up to the backbone layer and again utilize a sector antenna to distribute the AREDN-developed mesh network to the lowest layer. The 5 GHz band is chosen due to the availability of a relatively large ham-only sub-band and the lower cost of these devices.

5.8 GHz														
	Channel	133	134	135	136	137	138	139	140	141	142	143	144	145
	Status	Shared Ham and ISM/WiFi Band												
	Freq	5.665	5.670	5.675	5.680	5.685	5.690	5.695	5.700	5.705	5.710	5.715	5.720	5.725
		146	147	148	149	150	151	152	153	154	155	156	157	158
		Shared Ham and ISM/WiFi Band												
		5.730	5.735	5.740	5.745	5.750	5.755	5.760	5.765	5.770	5.775	5.780	5.785	5.790
		159	160	161	162	163	164	165	166	167	168	169	170	171
		Shared Ham and ISM/WiFi Band												
		5.795	5.800	5.805	5.810	5.815	5.820	5.825	5.830	5.835	5.840	5.845	5.850	5.855
		172	173	174	175	176	177	178	179	180	181	182	183	184
						Ham Band								
		5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920

Figure 8 - AREDN supported channels in the 5 GHz ham band

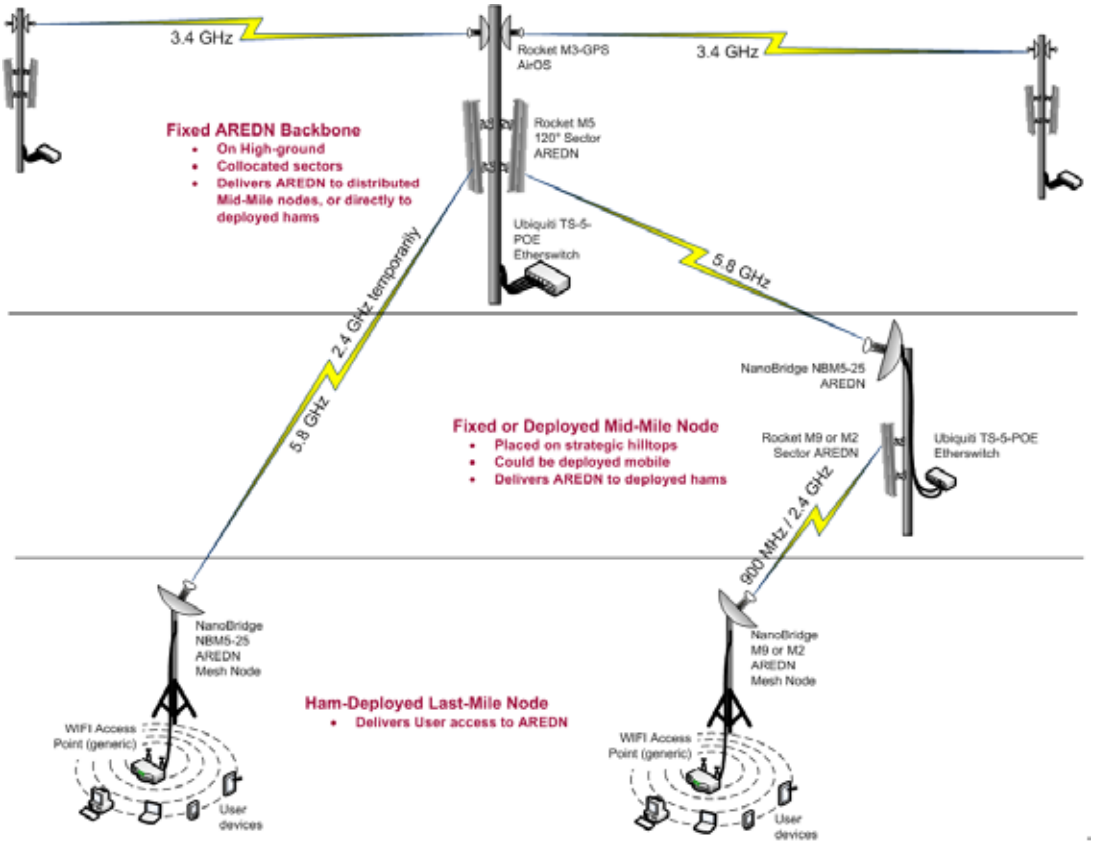
The lowest layer is comprised of users connected to the network via deployed ham resources. These devices also use AREDN-developed mesh software and auto-configure the node is configured to the prearranged channel and bandwidth… which is typically channel -2 with a bandwidth of 5 MHz. These are chosen due to the lack of congestion found in the shared sub-band. This gives users between 1-1.5 Mbps of data bandwidth based on last-mile link quality.

2.4 GHz									
Channel	-2	-1	0*	1	2	3	4	5	6
Status	Ham Band			Shared Ham and ISM/WiFi Band					
Freq	2.397	2.402	2.407	2.412	2.417	2.422	2.427	2.432	2.437

*Not available for use

Figure 9 - AREDN supported channels in the 2 GHz ham band

One last comment on the conceptual network design…



Deployed hams may also elect to connected directly to the backbone should that link prove possible. The San Diego implementation supports this through backbone sectors nodes on each of 5 GHz and 2 GHz. This also tends to allow more hams to connect to the network while mid-mile nodes are being deployed---which can take time considering the many property arrangements and the considerable equipment expense.

Practical EmComm Uses

Restoration of email is the single biggest benefit of the network. There are several other less-obvious applications users will find useful.

For users who have brought their own PC:

- Pre-defined Client (EOC, Red Cross, etc.) Services
- Skype-like video conferencing (when cost/benefit justified)
- Voice over IP calling to similarly configured PCs within the network

Users who have brought their own smartphone:

- SIP-based direct-dial calling to similarly configured smartphones within the network
- Gateway to PSTN when Internet is available to a node
- Chat, video (when cost/benefit justified)
- Pre-defined Client (EOC, Red Cross, etc.) Services

Implementation

Here is a collection of photos and diagrams illustrating AREDN Implementations

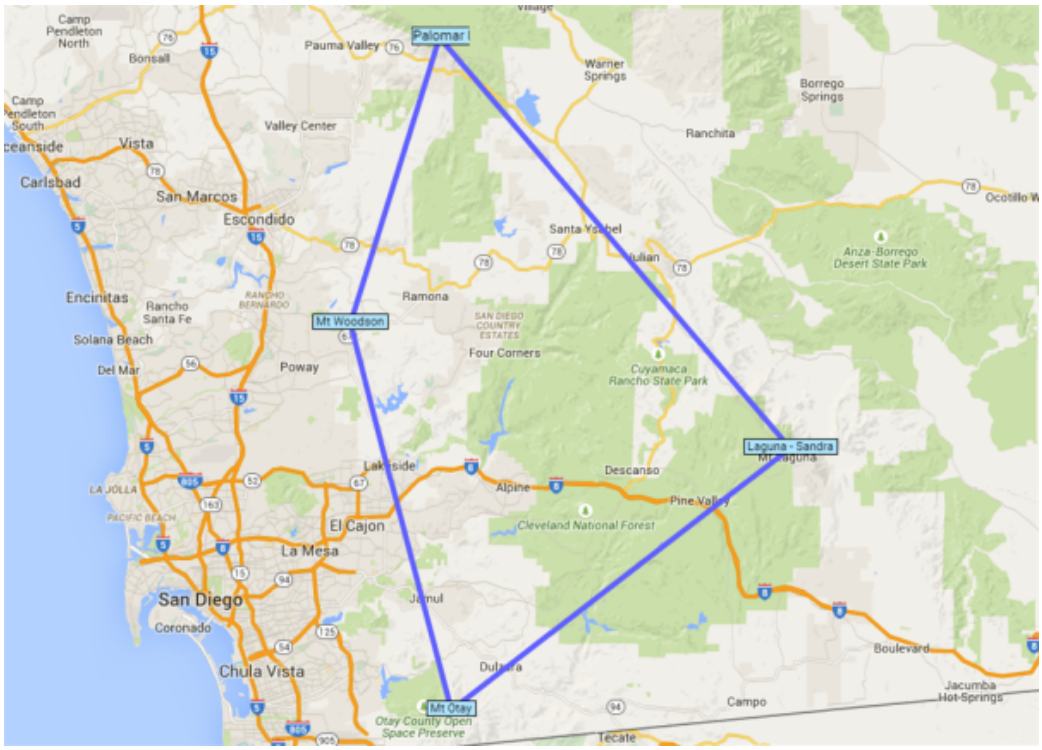


Figure 10 - San Diego Backbone links

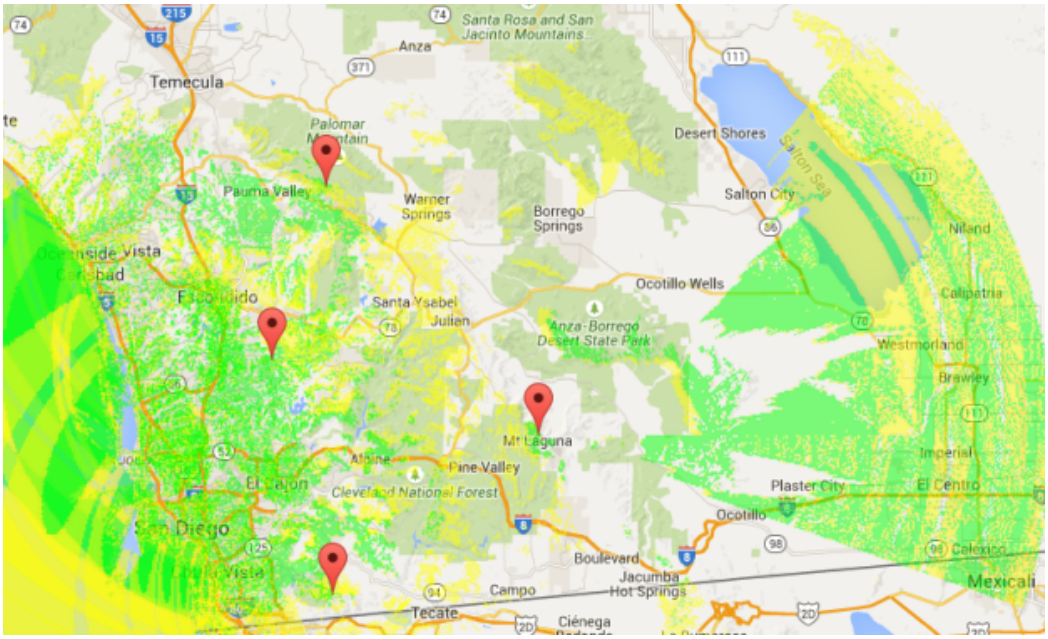


Figure 7 – San Diego 5 GHz Backbone Downlinks

Figure 11 - Mid-mile node "in the wild"

Figure 12 - Another mid-mile node "in the wild"

Figure 13 - Pleasant Peak backbone site

Figure 14 - Mid-mile sites need not be complicated

Figure 15 - Qualcomm mid-mile site

Figure 16 - Bonsall mid-mile node

Figure 17 - Security is a consideration when deploying nodes “in the wild”

Figure 18 - Deployable network access

Looking Forward

Regional implementations

Regional implementations are now in process in many western California counties, with planned coverages into all or significant parts of San Diego, Imperial, Riverside, San Bernardino, Kern, Orange, Los Angeles, Ventura, Santa Barbara, San Luis Obispo, Monterey, Santa Cruz, Santa Clara, San Mateo, and Alameda.

Regional Integration

Representatives from these initiatives have begun to discuss network integration standards with the objective of building one seamless network throughout the Southwest US where deployed hams with AREDN mesh nodes can provide EmComm services to disaster agencies.

Figure 19 – Initial estimate of the potential West Coast mid-mile node coverage

Development Priorities

The AREDN Project continues work on improving its product with the following priorities:

- Network Monitoring/Management – The current beta release, 3.15.1.0b02 includes support for Simple Network Management Protocol (SNMP) providing operational metrics to most commercially available Network Management System (NMS). While usable in this fashion, this priority adds a custom Management Information Base (MIB) for parameters unique to AREDN nodes.
- Quality of Service (QoS) – This priority recognizes the need to differentiate and prioritize critical traffic. Real EmComm traffic is more important than general ham traffic, thus should be provided a higher-level of service through the network. As it exists today, all traffic receives the same treatment.
- Support for a broader collection of Ubiquiti hardware – This manufacturer made a major change to their physical hardware last year which is not yet supported by AREDN (or any other mesh system for that matter).
- A more advanced, flexible, Graphical User Interface – The great majority of our users won't require more than what is already provided in the AREDN GUI. However, there is a group of sophisticated users who deserve the ability to configure the more advanced operational parameters.

Challenges

- Software Configuration Control – It would appear the FCC doesn't want the OpenSource community installing code on commercial routers. This proposed rulemaking requires manufacturers to lock down their devices to prevent the software from being replaced. This could have a dramatic effect on the AREDN / BBHN projects, essentially forcing us to design and build our own hardware.
- Citizens Broadband Radio Service (CBRS) – this is a shared spectrum allocation recently announced that carves out 3550-3700 MHz for mobile broadband and commercial use. How this might impact the AREDN Project is not yet clear.
- Impact on other ham operations – Due to the low power densities involved in mesh technology, interference sounds a lot like low-level noise. The team recognizes that broad acceptance of this technology will tend to raise the overall noise floor for all hams that utilize the microwave bands. While we seek to be good stewards of these resources, inevitably there will be conflicts which will need to been discussed, addressed, and overcome.

Conclusion

There are a variety of mesh network systems today. AREDN is unique in that it operates in Part 97 under the authorizations inherent in our Amateur license grant. It is easy to configure and is deployable by hams to served agencies without any knowledge of data networking or the design of the mesh to which their node is being connected. It can be used to provide a variety of IP-based services or to restore failed intranet-based agency services.

The AREDN Project team provides support via its website at www.aredn.org to Emcomm groups wishing to deploy this technology. There is a fabulous getting-started primer entitled "Wireless Networking in the Developing World" which I encourage anyone interested in this technology to read. It is available for free as a PDF download at: www.wndw.net.

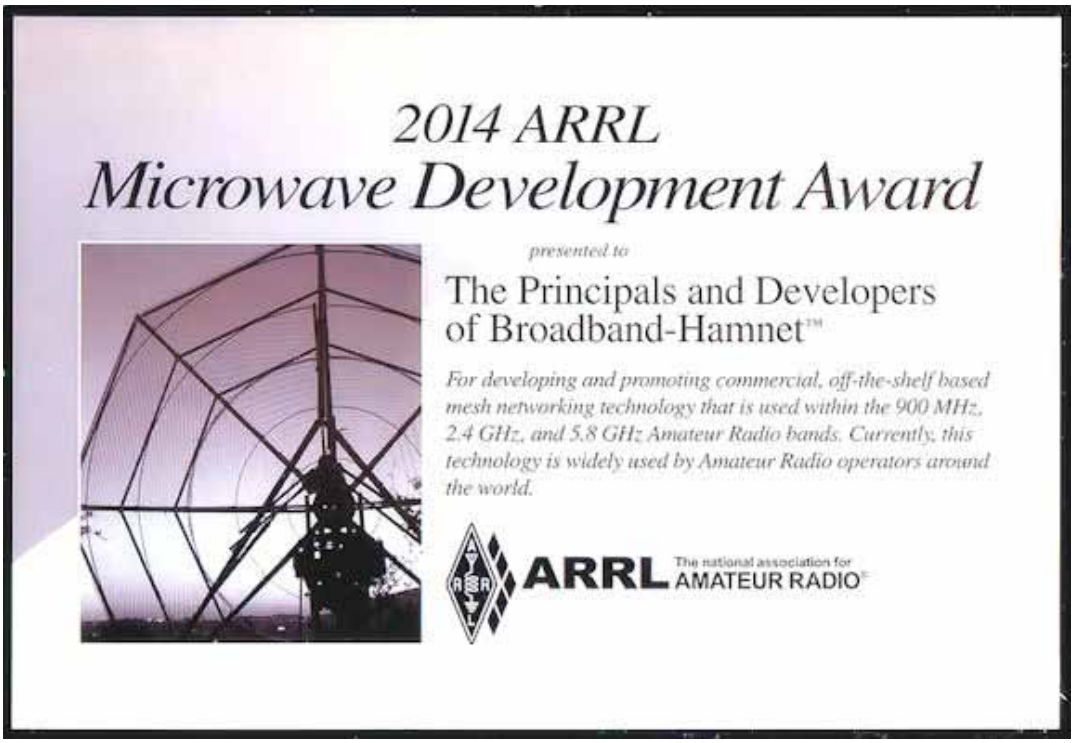
AREDN Team Receives ARRL 2014 Microwave Development Award

by Andre N6AH

Two PARC members, Conrad Lara, KG6JEI, and Andre Hansen, K6AH, were recently honored by the ARRL as recipients of their 2014 Microwave Development Award.

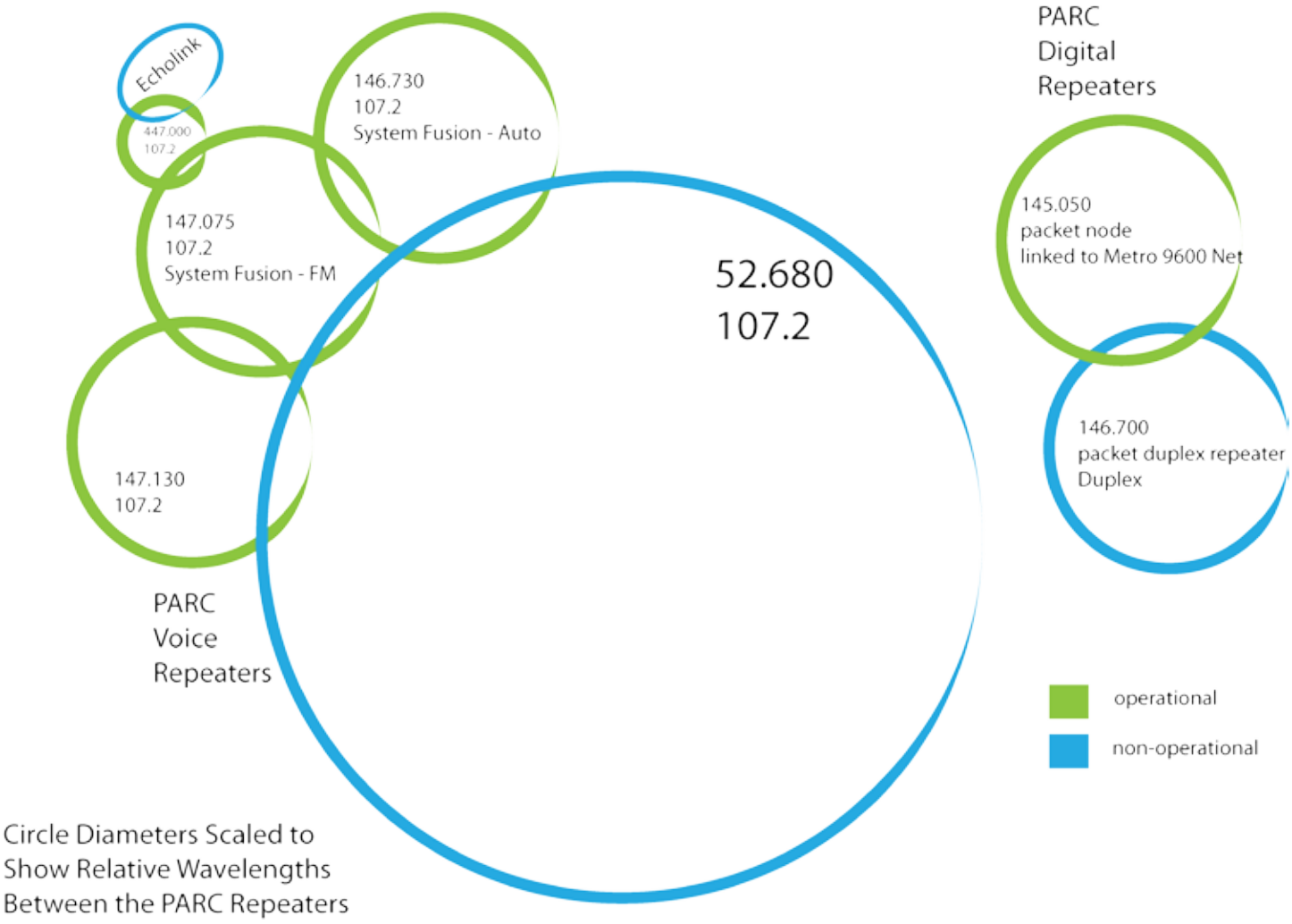
Members of the AREDN (Amateur Radio Emergency Data Network) Project accept the 2014 ARRL Microwave Development Award for the microwave mesh networking advancements they achieved as the development arm of Broadband-Hamnet™ in 2014. Dick Norton, N6AA, Director-ARRL Southwestern Division, presented the award at the ARRL 2015 Southwest Division Convention's evening banquet.

Andre, K6AH, presented a paper on this project at Microwave Update, October 15-18, at the Crowne Plaza Hotel in Mission Valley (http://ham-radio.com/sbms/mud2015/mud_index.html).



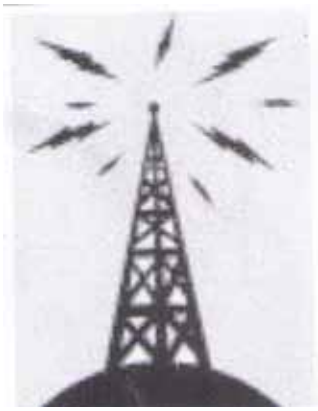
From left to right: Randy Smith, WU2S; Conrad Lara, KG6JEI; Andre Hansen, K6AH; and Joe Ayers, AE6XE (not pictured: Darryl Quinn, K5DLQ and Gordon Beattie, W2TTT).

Repeater Status as of 26 October 2015



OPERATING DAY

Saturday, November 7, 2015



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Come operate on the ham bands at Fry's
70cm, 2m, 6m, 10m, 15m, 20m

PARC Demo 24 October - Fire Days!

by Dennis KD6TUJ

Oceanside Fire Day occurred Saturday October 24 at Oceanside Fire Station 7. Set up was scheduled for 7:30 AM. Equipment was set up in advance on Friday evening as a result of a logistics meeting Jo N6JO asked me to attend on Wednesday with Ron and Linda of the Fire Department. Unexpected help was provided by Greg and Conrad.

On Saturday, Glen KJ6ZQH arrived at 7:30. Greg KI6RXX arrived shortly after. We all helped set up the trash/recycle receivers and tables. After "Big Mike", the historical engine operated by the Fire Department members, was moved to it's display posistion, CERT and PARC set up the tables and displays. Open hours were listed from 9 AM to 2 PM. Quite a few came by and asked questions including a Brownie Girl Scout Troop. Other members who stopped by were John AC7GK, Don WD6FWE, and Conrad KG6JEI.

As noted earlier in the process of coordination, I was working from the event and was called to work for a CHP request for service at 1:10 PM. It was fortunate that Greg managed to get away from work to staff the table. I also want to thank Conrad for staying and providing transport to storage when the event was over. The other choice was for me to come back Sunday, interrupting my wife's schedule.

Thanks to all who lent support letting the public understand more about Amateur Radio and how it can help in emergencies.

Photo by Lauren Bushey , City of Oceanside Emergency Coordinator

PARC at Fire Days - photos by Don WD6FWE

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PERIODICALS

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Questions? Ideas? Comments? W6NWG@amsat.org

Featured Program:

At 7:30pm on 4 November 2015, Palomar Amateur Radio Club will present a Program about PARC's involvement in AMSAT Phase 4. What have we gotten ourselves into?! Come at 7pm to socialize and for advanced demonstrations. We look forward to seeing you at the Carlsbad Safety Center, 2560 Orion Way, Carlsbad, CA.

Sign up for the PARC Email Lists:

http://www.palomararc.org/mailman/listinfo