President's Corner

2016 and TAPR

By Steve Bible, N7HPR

TAPR and ARRL had another successful Digital Communications Conference (DCC) and Dave Sumner, K1ZZ, the retiring CEO of the ARRL had this to say about that.

"The ARRL thanks Tucson Amateur Packet Radio (TAPR) for all the hard work they do to make these conferences successful. Were it not for TAPR, it is possible that the conferences would not occur at all."

Thank you for the kind words, Dave!

We are already working on the next installment of the conference and have secured a hotel in St. Petersburg, Florida, as the DCC site for the weekend of September 16-18, 2016.

By the way, TAPR elections during the DCC resulted finding myself back in the President's office, Jeremy McDermond, NH6Z, in the Vice President's seat, Tom Holmes, N8ZM, counting beans in the Treasurer's slot, and Stana Horzepa, WA1LOU, taking notes in the Secretary's role.

George Byrkit, K9TRV, and John Koster, W9DDD, were reelected to the Board of Directors, while Scotty Cowling, WA2DFI, was elected to fill the slot vacated by Tom Holmes, N8ZM, whom I wish to thank for his service on the Board. Meanwhile, Laura and John Koster, W9DDD, will continue to hold down the fort in our Richardson, Texas office.

If you missed the 2015 DCC, see K9TRV's photos beginning on page 30. Meanwhile, our hard-working webmaster W9DDD has created a webpage that will help you experience the conference here: http://www.tapr.org/pub_dcc34.html, while HamRadioNow's Gary Pearce, KN4AQ, has posted videos from the DCC here: https://www.youtube.com/user/HamRadioNow/

Our next stop is the Dayton Hamvention (May 20-22). In the meantime, we look forward to great expectations in 2016 and hope you will all be active in bringing those expectations to fruition.

73,

Steve Bible, N7HPR, President TAPR

###

Raspberry Pi QRP TX Shield for WSPR on 20 Meters

Nowadays, one of the most impressive QRP modes is Joe Taylor, K1JT's WSPR (pronounced "whisper") mode. WSPR stands for "Weak Signal Propagation Reporter." Programs written for WSPR mode are designed for sending and receiving low-power transmissions to test propagation paths on the MF, HF and recently, UHF bands. Users with Internet access can watch results in real time at wsprnet.org.

The QRPi board (or shield as referred by the community today) is an inexpensive way of turning a Raspberry Pi single-board computer into a QRP transmitter.

Traditionally, a LPF removes harmonics from a transmitter output, but leaves any broadband noise intact. With the QRPi board design the harmonics are filtered by a LPF, and the broadband noise is filtered by a BPF.

To protect the clock generator output stage of the Pi, a buffer amp is provided for isolation. This also provides a boost to the TX signal.

So join the group of Whispering Raspberries on 20 meters by ordering a TAPR 20M-WSPR-Pi today.

The Shield is available for $29 plus shipping and handling. For more information and to order a Shield for yourself, visit

http://www.tapr.org/kits_20M-wspr-pi.html

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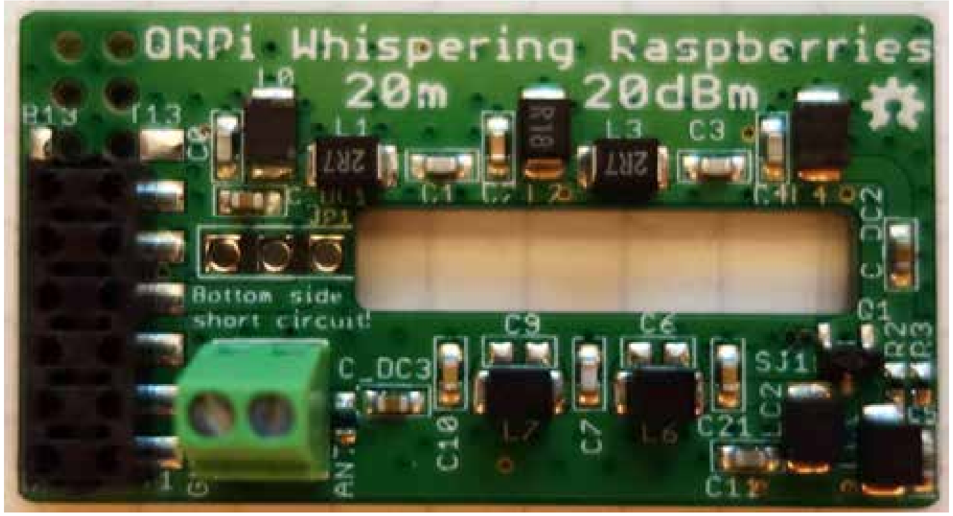

Now Available

TASS Computer-Controlled Switch System

The TASS (Totally Awesome Switch System) is a general purpose 8-port DC-150 MHz relay-based switch. The hardware is designed to be very generic, with an inexpensive processor such as an Arduino providing the system logic. Control is via USB, with Ethernet and other interfaces also available.

The TASS can be configured several ways, and multiple boards can be combined to create large switching systems. The TASS has many uses, from switching signal sources on a test bench or in a laboratory, to selecting receive antennas and filters in a ham or SWL station.

The TASS system has two boards:

* The TASS-R relay board, which does the mechanics of signal switching and provides a very simple 10-pin interface.
* The TASS-SHIELD board for use with an Arduino Mega 2560 microcontroller. The TASS-SHIELD allows up to four TASS-R boards to be controlled simultaneously.

Both boards are available now from TAPR as kits. They use through-hole parts and don't require any special assembly techniques.

The final component is open source software for the Arduino that acts as an interface between a host computer or other input system, and the switching hardware. The software is available for download from TAPR.

An introductory video is available at http://tapr.org/~n8ur/TASS/TASS_Intro_26Sep15.mp4

Software and documentation can be downloaded from http://tapr.org/~n8ur/TASS.

You may order the TASS-R and TASS-SHIELD boards by visiting http://tapr.org/kits_tass.html

###

TASS in Use

You'll recall that the TASS switch and TASS-SHIELD were designed so you could connect multiple boards together. I just finished putting together and photographing the large switch that was my ultimate reason for doing the TASS -- a matrix that selects one of 16 DUT to compare against one of 8 references, and routes the two selected outputs to one of 4 measurement devices. This uses 4 boards: two hooked end-to-end to create a 16P1T switch, a single board as a 8P1T, and another single board as a 4P2T, all controlled by one Arduino and a TASS-SHIELD.

See http://blog.febo.com/wp/?p=99

Next steps are to finish putting 4 TADD-3s in another enclosure, and 8 T2-Minis in a third (the T2-Minis will also have an Arduino controller). That'll complete the system but for the time interval counter, which for the moment continues to be an HP 5334, although I may replace that with a low cost "PicTIC" counter designed by another time-nut, to have a completely amateur-designed system.

– John Ackermann, N8UR

TAPR Board Meeting Minutes

8 October 2015, Arlington Heights, IL

Board Members present: All but David and Stana.

Guests: John Melton, Laura Koster, Joe Muchnij, Bryan Fields

Meeting called to order at 9 AM by Steven Bible. Minutes taken by George Byrkit.

Office Report

John K is concerned that the Treasury is declining with little visible income to support it. Those items in the pipeline don't seem to be 'large ticket' like the SDR items were. John is researching alternatives for the PennyWhistle heat sink.

TAPR Software Library

There are a lot of old items there. It should be re-branded as 'documentation for old projects'. There is old WinAPRS code (old versions) that should be trimmed, as newer/better is available elsewhere. Jeremy suggests putting the items onto Github. Jeremy is willing to move things from the TAPR ftp site to github.

Officer (s)election

The current officer corps (Steven, Jeremy, Tom, Stana) is willing to serve again. George moved to re-elect the officer corps. John K seconded. Tom observes 12 years as treasurer. The vote is unanimous.

Officer reports

President

Discussed attendance at previous DCC events, speculated on future locations for DCC. Some desire to get back to the West Coast. Tampa is possible for 2016. We will see a presentation on that later today. Ann Arbor has been lined up for the future.

Treasurer

Tom sent the financials out several weeks ago for us to review. He discussed the various months that were covered (since Hamvention).

Inventory status

A lot of inventory was transferred over the past few years from Oklahoma. We have a lot of parts that are not currently used in anything that TAPR currently makes.

We need to consider how to dispose of the surplus/old parts. Likely put surplus on eBay, and products on Amazon. Should likely put the early HPSDR items (PennyWhistle, Pandora, Janus, Alex Transmit, etc.) out for disposal. What we need to do is get some/any money out of them and reduce the inventory. Should also consider 'surplus of Nebraska', Mendolson's (Dayton) and other surplus outlets to see what we can get out of it.

Jeremy is working at the board meeting to set up an eBay seller's account for TAPR. An Amazon account is also being set up at the meeting.

We will send notices to OpenHPSDR group, and the TAPR email lists, about the availability of the parts, and the web URL of the html list. This will be available direct from TAPR until Jan 1, then put on eBay. It will go thru John K in TX, although shipping may be from other locations.

Items (TASS, TADD) should go onto Amazon. Other items to be put on eBay.

Github

Jeremy made an informative presentation about 'github' and the benefits of using it for TAPR projects. It started with John Stephenson's source code. John Ackermann will put the TASS code and design files onto github.

Hamvention booth report/critique

The past and possible future of the Hara site was discussed. Hack-RF sold well. It was the only real thing that sold well. We need to be looking for good items or people to have in the

TAPR booth. We need to remind people at DCC to tell us what their projects are, in case they can be presented.

Discussion of the current Board of Directors cycle

No nominations are known to have been received. All 3 current directors have put forward to serve again. Tom Holmes, George Byrkit, John Koster are those board members who are standing for election this year. Tom says that if we get one nominee from the floor, he would stand down, to promote more diversity on the board.

Monthly update emails

Darryl wanted to remind us that Stana should send out a monthly email reminding us of the 'To Do List' items.

New TAPR shirts (John Ackermann)

John has uploaded the TAPR logo to Land's End, and is waiting to hear if they are acceptable. He is proposing that we prepare to offer a new version of the TAPR polo shirt (optional name and call). There is an $85 fee to 'set up' the logo.

TASS enclosure (John Ackermann)

John presented the enclosure for the TASS that he has designed and is now for sale. 'TASS' is 'Totally Awesome Switching System'. He used Front Panel Express for his prototype panel. It's an expensive process. John will publish the FPE (Front Panel Express) files for those who want to order them on their own. He also has a rack-panel version of the system, in a 2U format. John found that using the panel design software was not at all difficult. We may need to offer an assembled version. Daun Yeagley would be the logical choice to produce the built-up kits. Likely the needed Arduino would always be a separate purchase.

Gary Pearce presentation

'Twit' (This Week In Tech, by Leo LaPorte) and other presentations targeting young people rarely even mention Ham Radio. Why is nothing about ham radio in these presentations? The journalists who prepare these programs (social technical programs) seem to be unaware of ham radio. What gets to these people? Stories. Stories of people doing things. Gary would like to try to capture some of these stories here, this weekend.

The views on the DCC videos are often between 500 and 1500 or so. Only a small percentage of the viewers reach the 50% point of the video. How can we get this up? (Discovery is the hard part)

One goal might be to get more people involved with the hobby. A better goal is to simply have more people aware of our existence (and hopefully with favorable opinions.)

Zoltan Doczi's project and Andras Retzler's project

Zoltan has developed what is initially a WSPR transmit board. At least 20 meters initially. He's an RF engineer, who is a Microchip consultant. We propose to sell his board for $29. Build 500. Give one to John Melton for SW development. Andras did an open source reimplementation of WebSDR, called OpenWebRX.

The WSPR board could have follow-up boards on other bands.

SM1000 FreeDV device distribution agreement with David Rowe

Points 4 and 5 need more clarification. The support issues need much more clarification. At what cost would we buy it from his manufacturer? $195 AUS is $141.50 US. Concerns that we have are:

1)FCC part 15 certification? Make into a kit to not have to certify?

2) Exactly what 'support issues' are there?

3) Customs and duty?

4) What would be the minimum order quantity?

5) At what price?

6) Are we buying from Edwin Chen or from David Rowe?

Mel showed up and was able to suggest answers to points 4 (will TAPR take care of support for its sales?) and 5 (can TAPR assist in open source development?) Parts cost (w/o case) is about $50.

Mark Thompson brought up a USB stick device

It's originally a German product that sells for about 100 Euros. Uli, a German expat in Florida, has obtained rights to manufacture and sell this product in the US. He is thinking of selling at about $129 US. It implements DSTAR, DMR and C4FM. There are a number of business concerns here. Mark will have further discussions with Uli.

Brian Fields arrived to report on Tampa as a possible 2016 DCC site

Brian presented on his search for a hotel site for DCC. There is no typical direct airport shuttle. And the county tourism board will fund about $1000 transportation credit. Brian presented a number of hotels. Favorite is the Downtown St Pete Hilton. Covers Clearwater and St Pete. Not Tampa. Runner up is Grand Hyatt Tampa.

The board meeting is adjourned at 5 PM to on-line.

Respectfully submitted,

George Byrkit, K9TRV

###

TAPR Board of Directors meeting in suburban Chicago, October 8, 2015.

TAPR Annual General Membership Meeting Minutes

10 October 2015, Arlington Heights, IL

Meeting called to order by TAPR President Steven Bible at 4:05 PM Central Daylight Time

Minutes recorded by TAPR board member George Byrkit

Not present (Stana Horzepa, Daryl Smith, Mark Thompson)

Results of the board meeting on Thursday were reported (same officers)

Tom Holmes presented a review of the treasury report. Bruce Perens and Bryan Fields asked for some clarification on the data.

New projects this year include:

1) N8UR – T.A.S.S. (Totally Awesome Switch System)

2) HA7DCD RPi WSPR Board

3) GIT repository (github) to support the current FTP historical contents, the John Stephenson project, the TASS project, and other project schematics, gerber files, source code.

4) eBay store

5) Amazon store

6) A new round/edition of TAPR polo shirts via Land's End

Annual Election:

Scotty Cowling was nominated from the floor. Tom Holmes is no longer standing for re-election. The other people standing are George Byrkit and John Koster

Jeremy moved to close nominations. Bruce Raymond seconded the nomination. All present voted to close the nominations. The current slate, since it matched the number of seats up for election, was declared elected. Scotty Cowling, George Byrkit, and John Koster will each serve a 3 year term.

Jeremy reminded the members that we are a 501-c-3 corporation, and can take donations and bequests that can be used to reduce your taxes.

DCC 2016 was discussed. Tampa/St Pete is a possible location. Issues include no free airport shuttle. Also on-site parking fee. Ann Arbor, MI also suggested. Also Portland, OR.

For this year's DCC, TAPR funded the two hams from Hungary traveling here to present to us.

Bryan Fields pointed out that members with excess airline miles could donate them to fund the travel of good candidates. Bruce Perens suggested TAPR could reach out to rest-of-world and possibly giving a forum in Japan or other places.

Meeting adjourned at 5:03 PM.

Respectfully submitted,

George Byrkit, K9TRV

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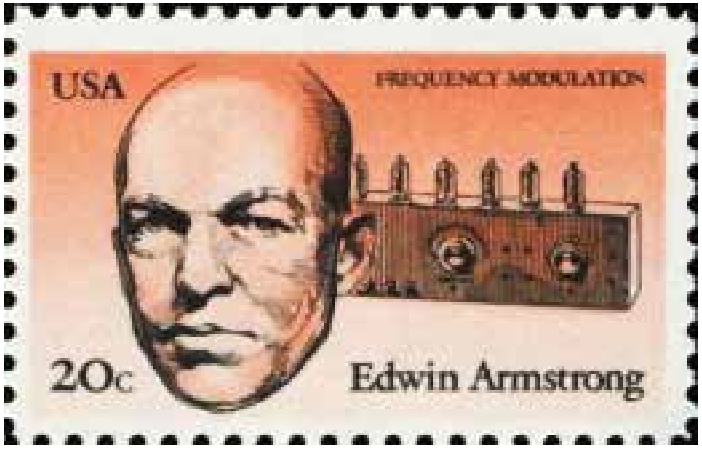


Eastnet Meets TAPR

By Stana Horzepa, WA1LOU

On November 7, I spoke at the Eastnet meeting evangelizing TAPR.

Eastnet is the backbone packet radio network that covers the northeast. There were 14 people in attendance primarily from Southern New England, Eastern NY and Long Island NY. Some of the attendees are long-time packeteers and well acquainted with TAPR. The others, not so much.

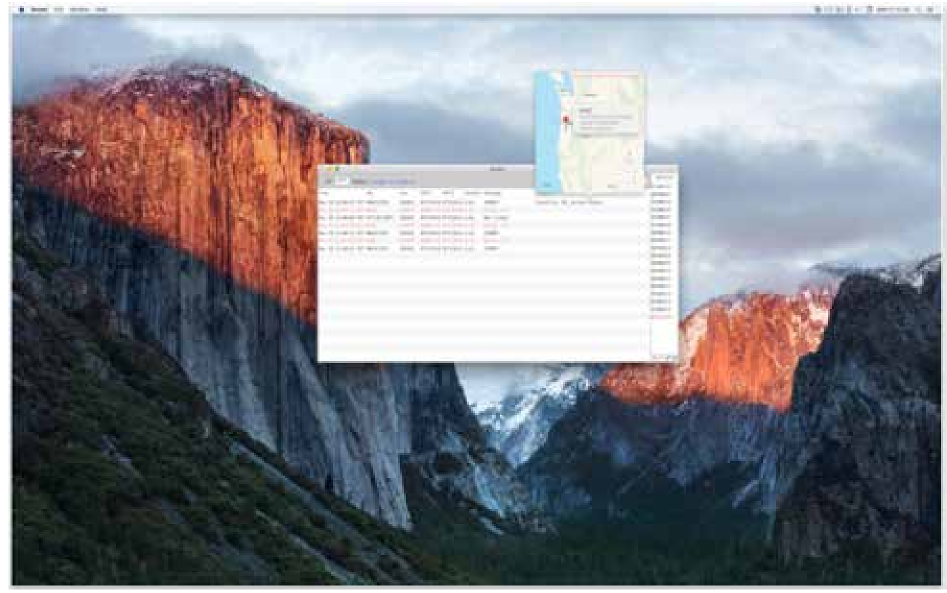
My 15-minute presentation went well and I managed to get two memberships (one renewal and one new) from the attendees.

Brian Rogers, N1URO, wrote the following in the minutes of the meeting, "New business began and first up was Stana WA1LOU from TAPR. Stana gave a very good self introduction and then a great history summary about the early days of TAPR. She metioned some of the services TAPR offers, the kits, the digital conferences, etc. Membership forms were offered to those in attendance for both new and renewal memberships. N1URO added that TAPR runs the list servers for his URONode and axMail softwares, and how thankful he was for TAPR's beliefs in his projects and the support TAPR has given him and all hams in the digital world."

###

Buster

By Jeremy McDermond, NH6Z



Buster is a Mac application that allows Amateur Radio operators to access the D-STAR digital voice network from their Internet connected Mac. The program requires a hardware encoder chip to translate the audio data into the required AMBE format for transmission on the D-STAR network. Buster currently supports either the ThumbDV or PiDV over the network. These products are available from Northwest Digital Radio at http://www.nwdigitalradio.com

Buster supports all three major reflector protocols (DPlus, DExtra and DCS) plus the ability to link to repeaters.

The application is available for free from the iTunes store: https://itunes.apple.com/us/app/buster/id1060175273?mt=12

###

Know KD6OZH's Work?

TAPR is still looking to connect with anyone who had worked with the late John Stephensen, KD6OZH, on his ODFM and/or HSMM technology developments and experiments.

TAPR is in possession of John's technical work on ODFM & HSMM and would like to identify hams who are interested and capable of moving his developments forward.

If you have worked with KD6OZH or are interested in advancing his technical work please contact John, W9DDD at the TAPR Office at: w9ddd@tapr.org

In the meantime, you can learn more about KD6OZH's technical work at: http://www.arrl.org/high-speed-digital-topics

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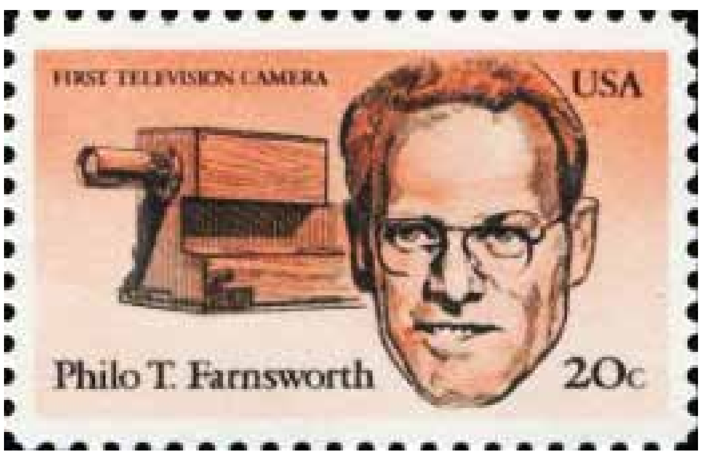

Write Here!

Your *PSR* editor is patiently waiting for a few good writers, particularly ham radio operators working on the digital side of our hobby, who would like to write about their activities and have them published here in *PSR*.

You don't have to be Hiram Percy Maxim to contribute to *PSR* and you don't have to use *Microsoft Word* to compose your thoughts.

Your *PSR* editor can handle just about any text and graphic format, so don't be afraid to submit whatever you have to wa1lou@tapr.org, she can handle it!

The deadline for the next issue of *PSR* is April 1, so write early and write often.

If *PSR* publishes your contribution, you will receive an extension to your TAPR membership or if you are not a member, you will receive a TAPR membership.

###

The Problem is Pointing

By Michelle Thompson, W5NYV, w5nyv @ yahoo.com

Large powerful telescopes with small field of view can be hard to point at any particular star. The way astronomers have overcome this challenge is to use a spotting scope. The spotting scope has less magnification and light gathering ability but a wider field of view. It allows one to see more of the sky, become oriented to the area being observed, and if the spotting scope is aligned well enough with the primary scope, then the primary scope can be accurately pointed based on the assist from the spotting scope. Of course, this depends on the existence of bright stars in the vicinity of the object to be observed.

Phase 4* radios can be used with a variety of antennas. We're assuming that a common use case is that they will be used with a DirecTV dish on the order of 60cm in diameter. The beamwidth of this class of dish at 10GHz is 3.3 degrees. Pointing a Phase 4 radio dish at the satellite with a 3.3 degree beam width can be challenging. It's a task roughly equivalent to pointing a DirecTV dish at a DirecTV satellite. The Phase 4 ground team would like to minimize the difficulty of antenna pointing.

One way to make pointing less difficult is to use the equivalent of a spotting scope: an antenna with a broader beam (and thus lower gain). There are several ways to achieve this. One can defocus the main dish by moving the feed. One can also make the dish effectively smaller (under-illuminated) by using a feed with narrower coverage. Or, one can literally emulate the concept of a spotting scope by using a smaller antenna, like a patch antenna, mounted at the side of the main dish.

The baseline design for the Phase 4 downlink is a single time-multiplexed signal 10 MHz wide at a certain power level. The ground station needs a 60cm class dish in order to receive and demodulate such a downlink signal. It cannot be received with a much lower-gain antenna. We only need to detect it, not receive it, but with a simple broadband data modulation there's no obvious trick to detect it with the spotting antenna.

However, we can make a simple modification to the downlink signal to make detection extremely easy. If we allocate a small percentage of the downlink time to emitting an unmodulated carrier instead of the 10 MHz wide data signal, it becomes quite detectable with a very low-gain antenna. With, say, an antenna with only 6 dB of gain, the operator could easily eyeball the correct pointing within a 90-degree sector. The operator would then use a simple signal-strength indicator to peak up the signal to get fairly accurate pointing. With some experimentation a suitable antenna design could be developed that is able to detect the carrier signal without much pointing and also able to peak up with signal within 3 degrees or so, close enough that the main dish can detect the signal.

Once we have allocated a chunk of the downlink time to this acquisition beacon signal, can we do anything else useful with it? A quick inspection of the link budget suggests that we can modulate the beacon signal with low rate data without significantly impairing its function as a pointing aid. For the sake of argument, let's say we can put 1000 bits per second of data onto the acquisition beacon. That's not a lot of data, but it could still be useful.

One possible use for the beacon data would be to provide the ground terminal with information it needs before it can receive the main downlink data. This might include information about what mode the main downlink is currently in, if there are ever multiple modes. It could include time of day and orbital parameters for the spacecraft, in case

** Phase 4: Amateur satellite in geostationary orbit.*

the ground station finds it convenient to compute the precise pointing angles rather than search them out. It could include a unique identifier for the spacecraft, against the day when we have a whole fleet of Phase 4 spacecraft. Probably none of this information is really required for the baseline design.

The details of spacecraft access control have yet to be worked out, but a basic requirement is that access to the spacecraft be limited to authorized stations, at least in a special emergency mode. It might be useful to initialize the authorization procedure with some sort of cryptographic challenge in the broadcast data.

It can also serve as a broadcast channel for textual data. This could include satellite operational bulletins, like notifications of emergency situations that restrict access to the satellite. It could include routine AMSAT News Service bulletins, or anything else of general interest. These bulletins can and should be carried on a data channel in the main data stream as well.

As a side effect, this modification means that stations that are not able to deploy a 60cm dish can still get some good out of the satellite. A much smaller, more portable, less expensive station could at least receive the beacon. For an amateur radio service mission, this is much more valuable than it might seem. It gives an easy way to get involved, and could serve to generate a lot of extra excitement in the amateur community.

Now, what can we do to make that smaller station even more useful? What if there was also a low-rate uplink channel? Adding stuff like this to the mission makes it harder to implement and harder to explain, but it might be worth it. I think it's worth investigating further.

###

APRS Satellites with PSK31 and DTMF/Voice

By Bob Bruninga, WB4APR, US Naval Academy, WB4APR @ amsat.org

Abstract: After an 8 year hiatus, the next three APRS specialty satellites are here now and coming soon. Although they use APRS for command and control and telemetry, their primary missions are to support other popular digital modes for amateurs. PSAT [1], which contains a new PSK31 multi-user transponder was launched May 2015 and the coming QIKCOM-2 [2] satellite will launch this spring which opens up satellite operation to anyone with an FM radio and DTMF keypad. Neither of these require any special equipment. An HF rig and any UHF walkie-talkie can be used for PSK31 and anyone with an FM radio and DTMF keypad can sent grid squares, positions, and messages via QIKCOM-2 and into the global APRS network. The DTMF users will hear Voice feedback to complete the communications loop.

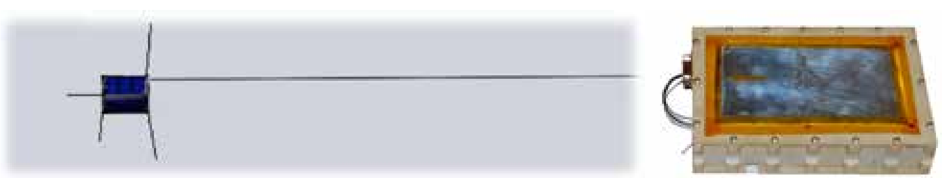

Figure 1. PSAT-1 with antennas deployed and QIKCOM-2 module with antennas stowed.

APRS Global Network

Both satellites operate a 1200 baud AX.25 Packet Radio digipeater similar to what is flying on PCSAT since 2001 and the ARISS experiment on the ISS. They digipeat user packets worldwide which are also captured by the global network of volunteer ground stations which also feeds the two downlink capture pages [3][4]. These pages display live maps of the most recent user position data and capture all message traffic between users. Figure 2 shows both the PSK31, APRS and DTMF relay capabilities that are not only on these two spacecraft, but will all be combined into our next PSAT-2 for launch later in 2016.

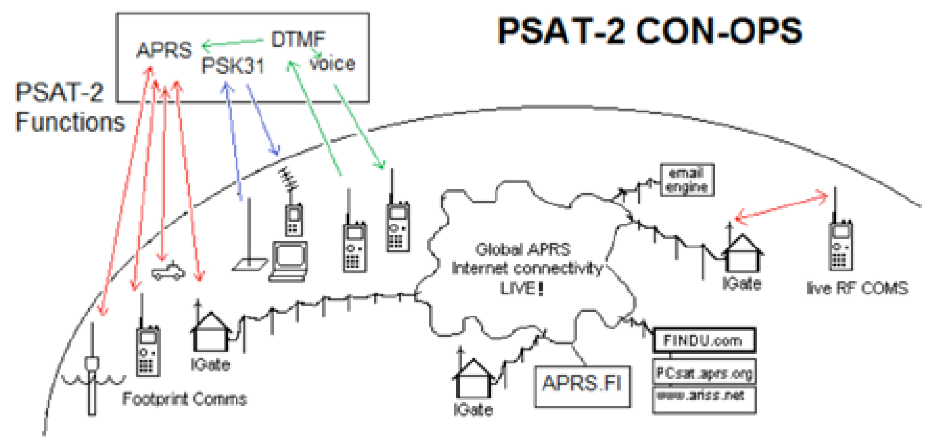

Figure 2. The global APRS network consists of terrestrial as well as internet and satellite links.

This APRS portion of the satellites, is as simple as flying a simple off-the shelf APRS MicroTracker from Byonics.com shown in Figure 3. This latest model has a 10W power amp to make a cubesat that can rival the ISS with downlink power. We are re-laying out these components to fit on the 3.5” square card of a typical cubesat.

Figure 3. Byonics.com Microtrack-4 Transponder

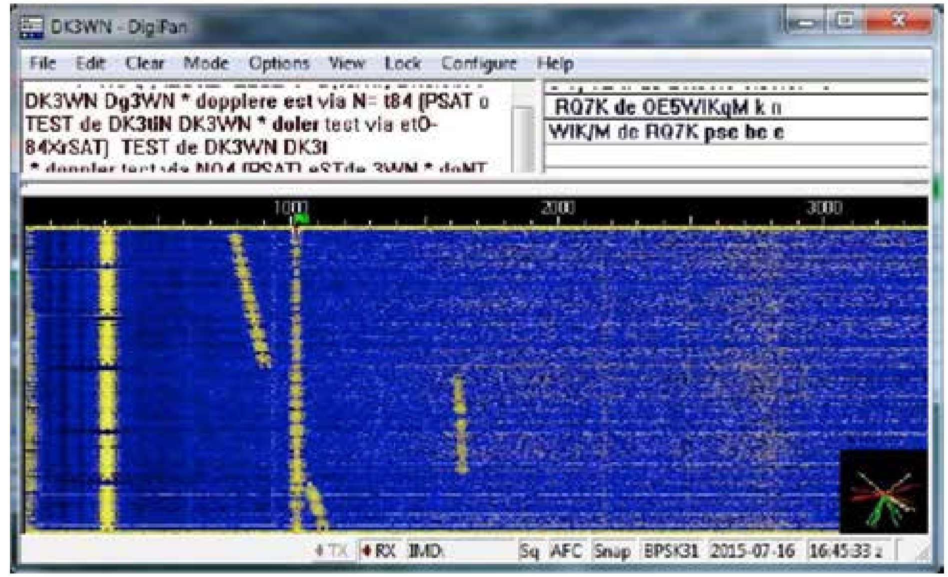

Figure 4. Downlink waterfall shows stations with and without Doppler.

PSK31 Transponder

The real excitement of PSAT is the PSK-31 multi-user transponder [5] experiment built at Brno University that downlinks a full multi-user PSK31 waterfall as shown in Figure 4. Since the UHF downlink is FM audio, the 18 kHz Doppler does not affect the individual PSK31 signals but only the FM receiver passband tuning. Users simply re-tune their FM receivers 5 times during the pass in 5 kHz steps to stay in the passband like most other UHF satellites.

The multiple PSK-31 users transmit full duplex using SSB on the 10 meter uplink. There, the Doppler is linear but because it is 15 times lower in frequency than the typical UHF downlink, the total Doppler shift is only about 1 kHz over the pass and typically on the order of about 1 Hz per second during the lower elevation portions of the pass. Most PSK31 software can track this rate. But as the elevation gets higher the rate of Doppler change increases to as much as 6 Hz per second and most clients fail at 2 Hz/s and above.

To solve the Doppler, Andy Flowers, K0SM has written an uplink PSK31 application [6] that not only uses the satellite tracking elements to pre-adjust the uplink for Doppler, but as a separate program, allows the user to operate full duplex with his existing PSK31 software being used for downlink. This allows everyone to chat with everyone simultaneously during the pass. Users of this application will appear fixed in the downlink waterfall as shown in Figure 4 and are easy to decode by everyone. The strong signal at 300 Hz is the telemetry beacon and the one of the compensated users, DK3WN is at 1000 Hz.

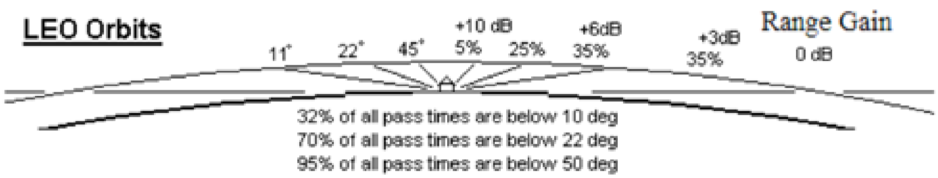

Figure 5. The LEO geometry has over 10 dB of range gain as the satellite rises in elevation.

HF Uplink stations do not need gain antennas but can use a vertical omni antenna because of the range-gain match of the LEO orbit geometry as shown in Figure 5. Unfortunately, about 100 watts is needed due to losses of the poor antenna matching on the cubesat, but the vertical antenna combination and range gain variation gives an uplink power per user of less than +/- 4 dB over 90% of the duration of the pass [7]. Also the 6' HF receive antenna is not cross polarized as shown in Figure 1 and so there will be periodic fades as the spacecraft tumbles. Figure 6 shows the challenge of getting all 4 antennas (VHF, HF & 2 UHF) to all meet at the one burn resistor.

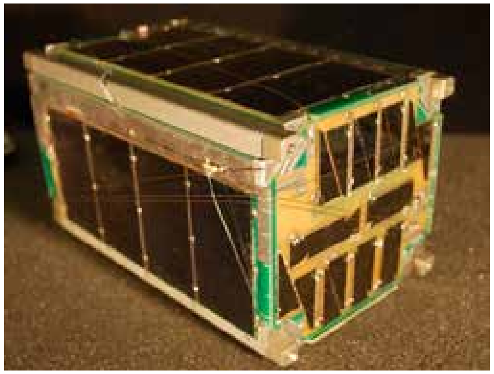

Figure 6. The UHF, VHF and HF antennas on PSAT are all released by one burn resistor.

PCSAT Unique Power System

Typically, solar cells on each panel have to all sum to the spacecraft bus voltage usually requiring lots of smaller cells in series. In contrast, PSAT has a unique charging arrangement and uses only 4 large/efficient solar cells per side that sum to 3.2 volts to charge only two NiCd cells per side. These 4 side-panel/NiCd-pairs, that are separately charged in parallel, are then operated in series for a total 9.6v bus. This parallel charging reduces the failure mode of uneven charge balance that accumulates when entire strings are charged in series, but it requires the spacecraft to spin about the Z axis for even charging. Because PSAT is a 1.5 unit cubesat, its tall shape would not naturally spin about its Z axis, so all of the mass had to be concentrated at the center to give the Z axis the maximum moment of inertia as shown in figure 7.

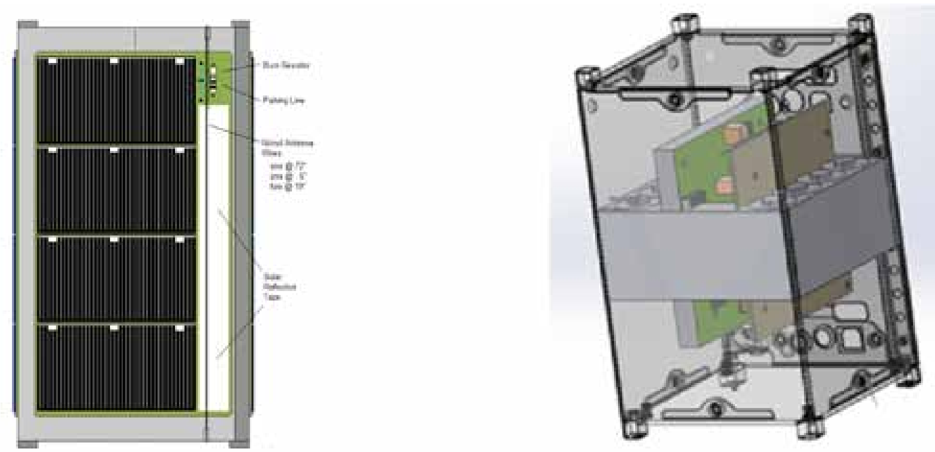

Figure 7. The sides are black/white and the mass is concentrated at the center.

The spin comes from the offset color pattern on the side panels that use differential solar radiation pressure to spin the spacecraft. Once a minute PSAT sends an easily readable Sun vector telemetry in its S# packet that is easily decoded and plotted, even by hand.

DTMF - APRS for Everyone

Although QIKCOM-2 includes the same APRS digipeater as PSAT for those with APRS radios, its primary mission is to introduce a DTMF uplink capability for users with only a radio and keypad so that anyone with any radio can participate, not just those with APRS radios. This is a space application of the APRStt (Touch-Tone) capability previously presented in the TAPR Status Register Summer 2013 [8].

The DTMF user stores his call sign and grid in a DTMF memory and can send it at the press of a button when the satellite is in view. The spacecraft not only converts this DTMF report into an APRS packet on the downlink so the user is included in the APRS network distribution, but also the spacecraft repeats the message in Voice so that all of the DTMF-only users can hear what is happening. The DTMF is received with a Byonics DTMF micro-receiver and DTMF decoder chip and then converted to APRS and speech with the DTMF/Speech board shown in Figure 8 consisting of a BS2pe Basic Stamp module, a speakJet voice synthesizer and a text-to-speech processor chip.

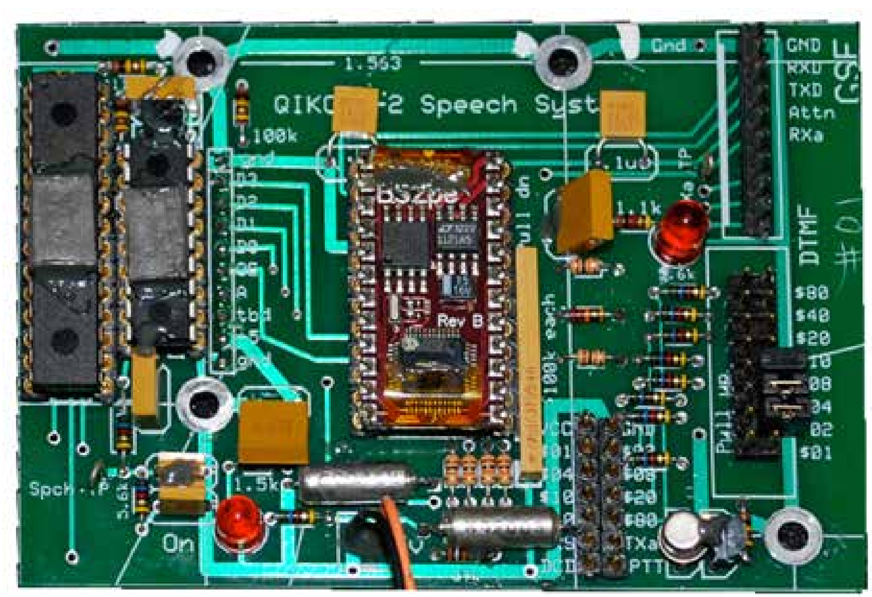

Figure 8. DTMF/Speech board on QIKCOM-2

DTMF Format

What makes all of this possible is the 16 digit key DTMF memories in most handheld radios. QIKCOM-2 can store not only the full call sign, but also the grid in only 14 digits plus the starting * and ending # key. The grid was compressed to 4 digits by noticing that only 99 grids actually have human populations in them, so the normal letter part of the grid can be reduced to two digits (00 to 99) according to the Figure 9. The grid FM19 becomes 1819 because it is the 8th one in the USA(1) group.

Figure 9. The 99 populated grids can encode all of the XX populated lettered grids.

DTMF Call sign

To encode the 6 character call sign would normally require 12 digits on a DTMF key pad. But QIKCOM-2 can do it in 10. The first 6 digits are simply the 6 digits that match the letters. Then the next 4 decimal digits represent the 12 bit binary number of 6 pairs of 2-bit representations of where the letter is on each DTMF key as shown below in Figure 10. So WB4APR is the call digits of 924277. Then the location of W on its key is 1, B is the 2nd letter on its key, 4 is the 0th letter, A is the 1st letter , P is the 1st letter and R is the 2nd letter. So those six 2-bit locations are 120112 which are converted to decimal 1558. These 4 digits are the only digits that need to be calculated and are added on the end of the 6 digit call sign to become 9242771558. Combining that with the 1819 grid square results in the full DTMF position report of *18189242771558#.

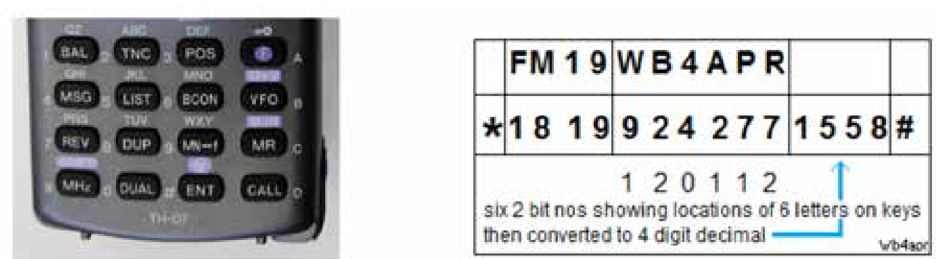

Figure 10. The FM19 Grid report from WB4APR encoded into 16 DTMF digits.

On the spacecraft, this DTMF sting gets repeated back by voice as “Grid FM19 from WB4APR” and is also formatted in an APRS report and transmitted on the APRS downlink. This seems like a simple report, but this communications represents a good proportion of what hams do via satellites. Bob Wood, WA7MXZ has written an on-line calculator for those that are 12 bit binary-challenged:

http://aprs.org/aprs_translator.htm

DTMF Messages

But DTMF users can also send text messages! We use the trick, that most of what anybody says has already been said before. So instead of spelling out every message to be sent, we simply store the top 99 on the spacecraft and then just call them up by number. Ham radio has always used this shortcut for frequent messages in the 47 standardized ARL Numbered Radiograms [9] plus a few dozen more we have added. So we can communicate quite well with just a 2 digit message number and a 2 digit "modifier". These modifiers can be injected into any standard message that has a blank number field. Such as "1140" means message number 11 "Establish Amateur radio operations on 40 meters."

Just like the Grid report, the fully spelled out message is converted to APRS packet format on the downlink and also spoken for the benefit of all the other DTMF-only users.

Conclusion

We hope these two new spacecraft will not only contribute to better connectivity of the APRS Space constellation of relay satellites but will also excite many more hams who may only have access to PSK31 and/or their old reliable DTMF walkie-talkie. Now they too can communicate position and text messaging from anywhere on Earth. Late entry: The Chinese hams have also just launched an APRS satellite on the same 145.825 frequency, but it is in an equatorial orbit and is only accessible by those who live below 30 degrees Latitude.

References:

[1] http://aprs.org/psat.html

[2] http://aprs.org/qikcom-2.html

[3] http://aprs.org/pcsat.html

[4] http://ariss.net

[5] http://aprs.org/psk31uplink2.html

[6] http://www.frontiernet.net/~aflowers/dopplerpsk/dopplerpsk.html

[7] http://aprs.org/PSK31/PSK31 Link Budgets for Psat-b.doc

[8] TAPR PSR #123 Summer 2013, page 9

[9] http://nts.ema.arrl.org/node/30

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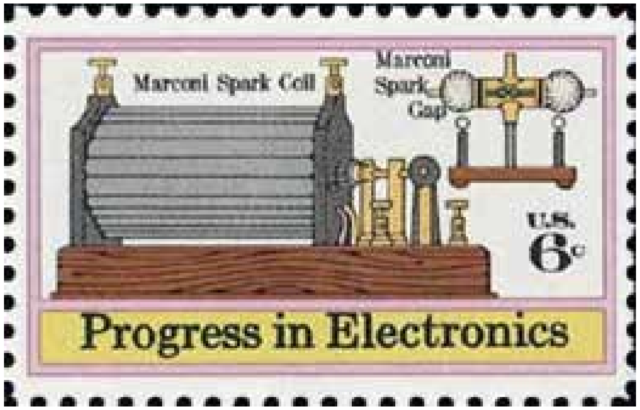
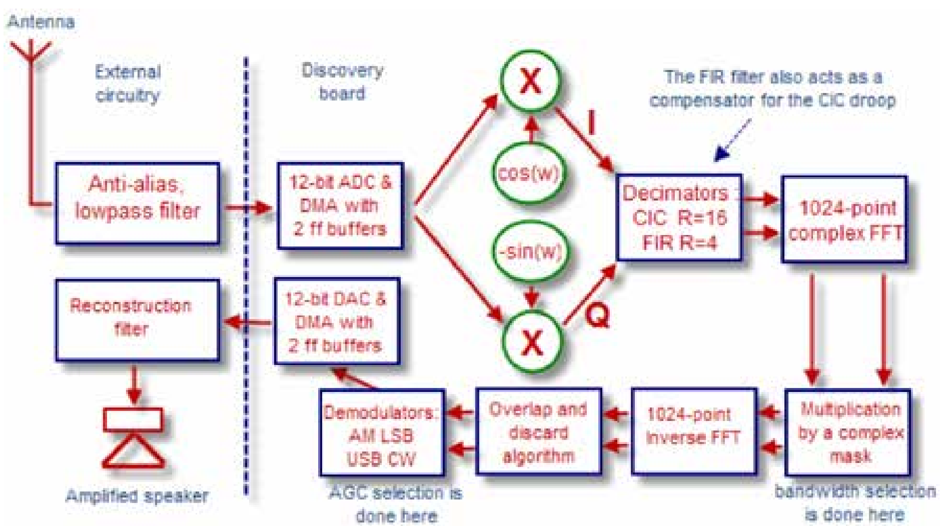


ARM Radio

By Alberto di Bene, I2PHD, i2phd @ weaksignals.com

General Description

The goal of this project is to implement a SDR (Software Defined Radio) using the STM32F429 Discovery board, with a minimal amount of external hardware, using all the facilities offered both from the various devices of the chip itself and the middleware support (HAL, CMSIS, emWin, etc.) of the Keil compiler. This SDR is of the direct RF sampling variety, where the RF is immediately sampled by an ADC, then processed in numerical form with various DSP algorithms, all implemented taking advantage of the floating point core of the STM32F429 chip and the CMSIS library, and finally sent to the on-chip DAC to be transformed again in analog format, for reproduction by a speaker after being passed through a reconstruction filter.

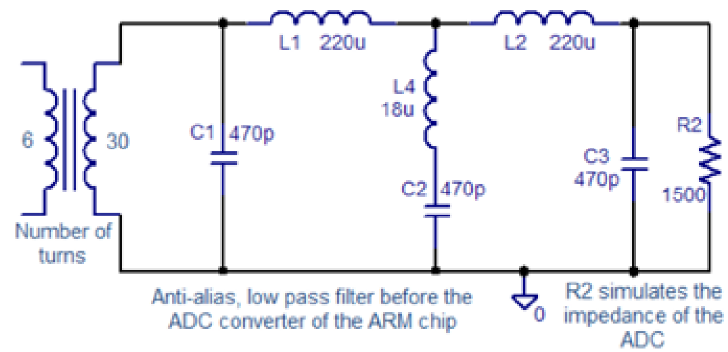


Detailed Description

The block diagram of the flow of the signal inside the program is shown below. A detailed description of each block follows. In this block diagram the GUI (Graphical User Interface), i.e. the driving of the TFT display of the Discovery board is not shown, it will be done separately at the end of this document.

Anti-alias, lowpass filter

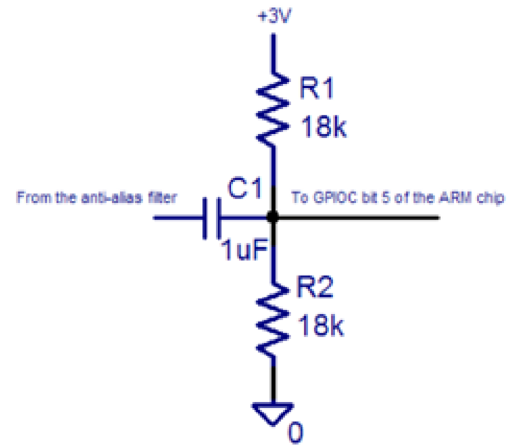
The need for an anti-alias filter in front of an ADC derives from the Shannon-Nyquist theorem, which, in its simplest form, states that no frequency components should be sent to an ADC with a value greater than half the sampling frequency. Otherwise aliasing will occur, i.e. the appearance of signals where they are not… in this project the sampling frequency is, nominally, 1.785714286 MHz (more on this later), so the low pass filter should attenuate substantially all the frequency components greater than 892.857143 kHz (again, nominal value). Given also that the ADC has an input impedance of a few kohms, compared with the usual 50 ohm of a properly dimensioned antenna, the filter does also an impedance transformation. The following is the circuit adopted :



This is its Bode plot :

The incoming RF signal is centered on the zero value, and can have positive and negative values, while the ADC of the ARM

chip has a digitizing range going from 0 to 3V. So it is necessary a simple level-shifting circuit, as follows :



Analog-to-Digital-Converter

The STM32F429ZIT6 ARM chip of the Discovery board sports three 12-bit ADCs, each capable of a sampling frequency of 2.4

MHz. They can be combined in interleaved mode, thus reaching 7.2 MHz. While this at first looked highly desirable, allowing to cover up to the 80-meter ham band, subsequent tests did show that the computing power of the ARM chip, given the complex algorithms for the digital processing used, did not allow to go so high in sampling frequency. The time spent in each task was measured with the technique of flipping a bit in one of the GPIO ports, and then using an oscilloscope to have a measure of how many microseconds the task duration was. This was done at various system clock speeds, trying to achieve the highest possible sampling rate.

After some measurements, it was decided to use a clock frequency of

200 MHz for the ARM chip (it was tested also at 220

MHz for several days, with no glitches, but to stay on the safe side, 200 MHz was considered a good choice). Given the architecture of the ADC converters, to have the finest choice in the granularity of the sampling rate, the more logical choice seemed that of using two of the three ADCs in interleaved mode, with a delay of 14 cycles between the relative conversion starts. Shorter delays would have given a faster sampling rate, but the processor didn't have enough steam to process timely the data. That delay of 14 cycles gives a sampling frequency of :

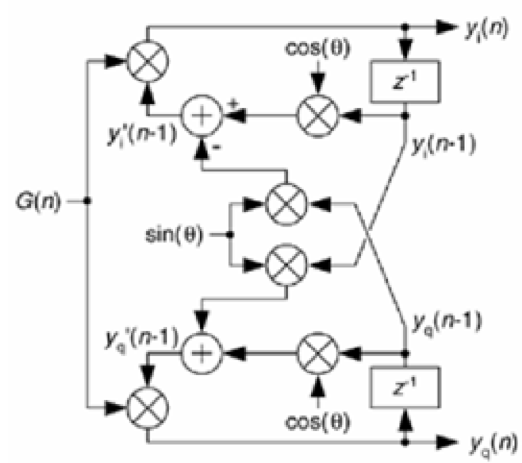
Fs = (Fclock)/2/4/14 where Fclock = 200e6, giving Fs = 1.785714286 MHz (supposing the board xtal is spot on 8 MHz…) With this sampling frequency, the coverage of the receiver goes from almost the DC (it is limited in the code at 8 kHz) up to

the first part of the MW (Medium Waves), covering all the LF and the NDB band. The ADCs rely on the DMA controller to store

the sampled data in two flip-flop buffers, each of 512 entries. While one buffer is filled by the DMA, the other buffer is processed, and so on. The two ADCs sample with an amplitude resolution of 12 bits, in a short word format. This format is converted to floating point, normalized to 1, for the subsequent processing.

NCO (Numerically Controlled Oscillator)

The NCO is used to bring at zero IF the reception frequency desired, using two complex mixers, generating the I/Q components of the analytic signal at zero IF. A first implementation of the NCO was attempted with a 16384-entry sine table, scanned at various speeds, more or less like a DDS works. That worked, but had the inconvenient that at some frequencies the granularity was rather coarse, not permitting a fine tuning. This could have been alleviated by using a larger sine table, but at the expenses of an excessive use of memory. At this point the NCO was implemented using a quadrature coupled complex oscillator, practically a double IIR filter brought on the verge of oscillation, complete with level stabilization code.



This worked quite well, albeit requiring some more CPU cycles than the sine table approach… but applying some optimization to the code, that was acceptable. The code for the NCO is in the routine SDR_ComputeLO in the module SDR_math.c

The algorithm for the quadrature coupled complex oscillator was lifted from the Richard Lyons' book mentioned in the

Decimators paragraph, just below.

Complex mixers

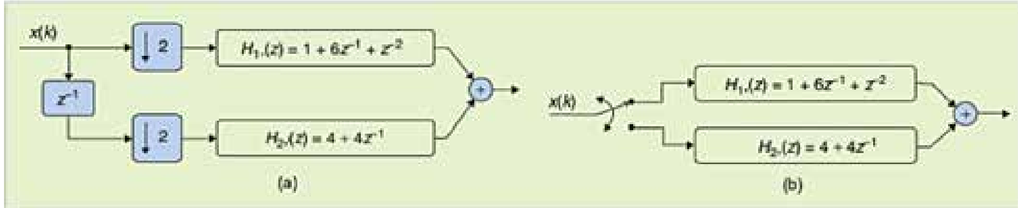
In the digital world it is possible to implement that ideal mixer that in the analog world is only a chimera… an ideal mixer is… a multiplication, nothing more, nothing less. The signal coming from the ADC is real, while the one provided by the NCO is complex, so the output of the two multipliers is a complex signal, conventionally designated as I and Q components. This output signal is centered at zero IF, but still has the original sampling frequency of the ADCs. So it must be downsampled to bring it to a more manageable value for the baseband processing.

Decimators

It was decided to first downsample by a factor 16 using a 4th order CIC, then by another factor 4, using a 64-tap FIR filter, computed so to also compensate for the typical droop of a CIC filter, which, in this case, was really very small, but it was nevertheless compensated, given that it did not require any additional CPU cycles.

The CIC filter was not designed according to the original 1981 Hogenauer paper, but, following what Richard Lyons writes in his excellent book "Understanding digital signal processing", a polyphase decomposition approach was used, that has the advantage of eliminating the integrating part of the CIC, thus allowing the use of floating point, which is rather fast on the Cortex M4F chip, given also the excellent optimization of the C code performed by the Keil compiler.

This is an example of how the implementation of one section of a CIC implemented with the polyphase decomposition works :

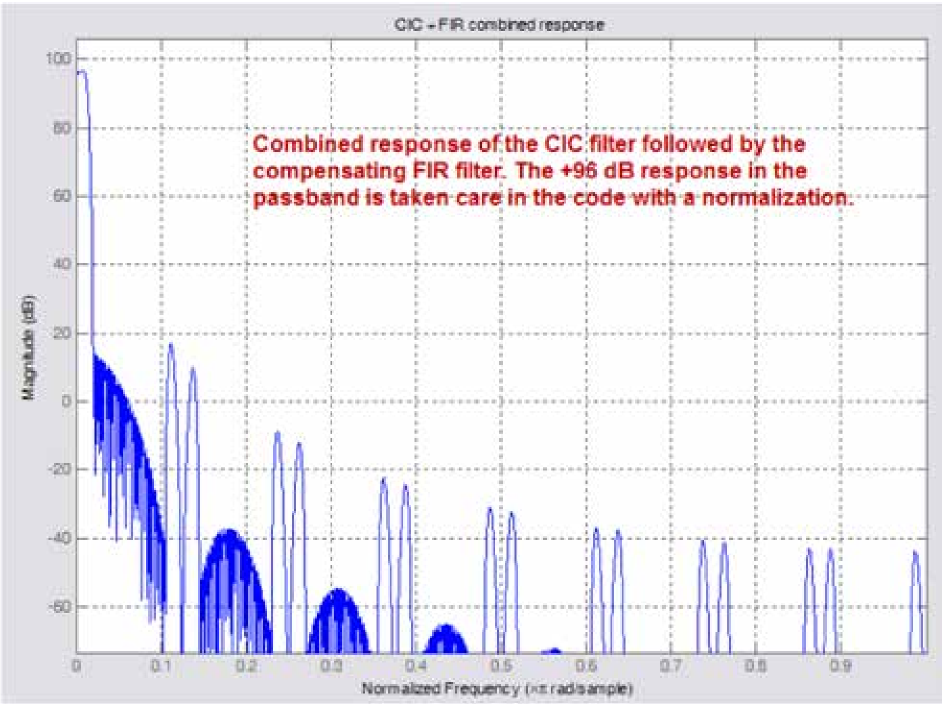


The CIC is followed by a 64-tap FIR filter, computed with the Remez exchange, equiripple algorithm. The combined response of the CIC and the FIR is reported in the following figure. The decimation by 64 gives a processing gain that can be computed with this formula :

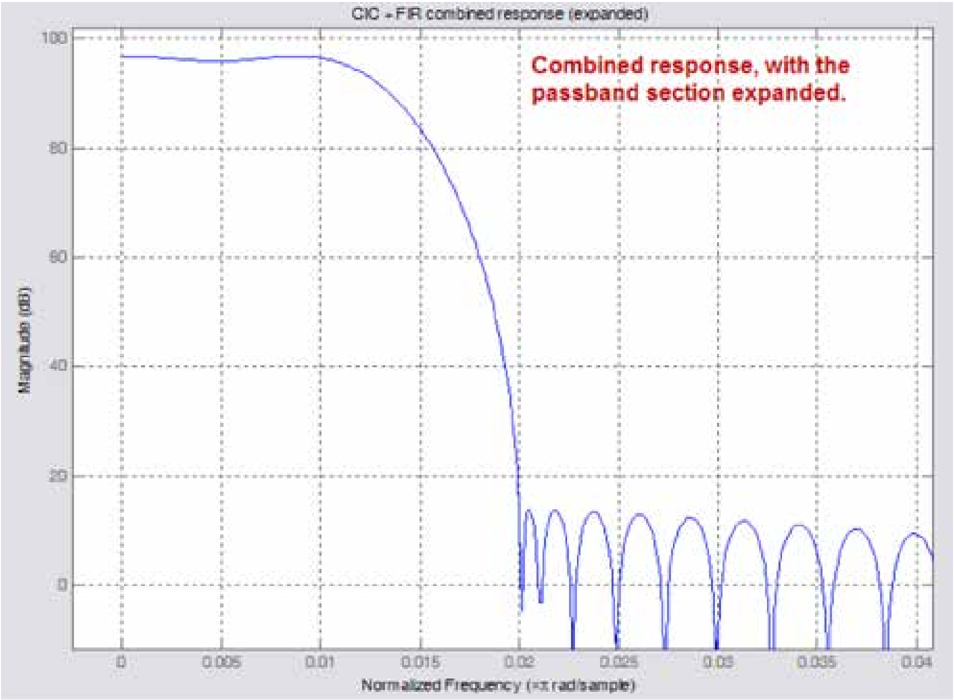
SNR = (6.02N + 1.76) + 10*log10(Fs/Fd) dB

Where N is the number of bits of the ADC, Fs/Fd the decimation ratio, and SNR the Signal-to-Noise ratio that can be expected. Putting numbers in the formula, we have a theoretical SNR of about 92 dB. This of course if the ADC had an ENOB equal to the number of bits used for the digitization, which unfortunately is not always the case…

Combined response of the CIC filter + the FIR filter:



This is an expanded view of the passband :



The FIR was implemented using the optimized CMSIS routine arm_fir_decimate_f32 which proved quite effective as far as the optimization level was concerned.

The CIC code can be found in the routine DMA2_Stream0_IRQHandler in the SDR_func.c module. That routine runs at the highest priority (NVIC level 0), being the routine that serves the DMA2, Stream 0, interrupts, those generated when one of the two flip-flop buffers is filled.

The FIR code can be found in the routine EXTI1_IRQHandler in the SDR_func.c module. That routine serves the software interrupt generated by the DMA2_Stream0_IRQHandler routine, every time a CIC-downsampled buffer is ready. Its priority is just below that of the previous routine.

Bandpass Filtering

Bandpass filtering is performed with the fast convolution algorithm, which consists in computing the FFT of the input signal, multiplying it with a selectable mask, and then computing back an inverse FFT. This is made possible by the fact that a convolution in the time domain is equivalent to a multiplication in the frequency domain. So, if a suitable kernel for a FIR filter is computed, its Fourier transform can be used as a mask to be multiplied by the Fourier transform of the input signal. Of course, as the elementary DSP theory preaches, simply doing that would result in a circular convolution, not in the desired

linear one. This latter can be had by using one of two methods, namely the overlap-and-add, or the overlap-and-save, which I prefer to call overlap-and-discard, given that only a part of the computed inverse FFT is retained.

Describing in details the two methods is inappropriate for a document like this, a very good description can be found in the aforementioned Richard Lyons' book.

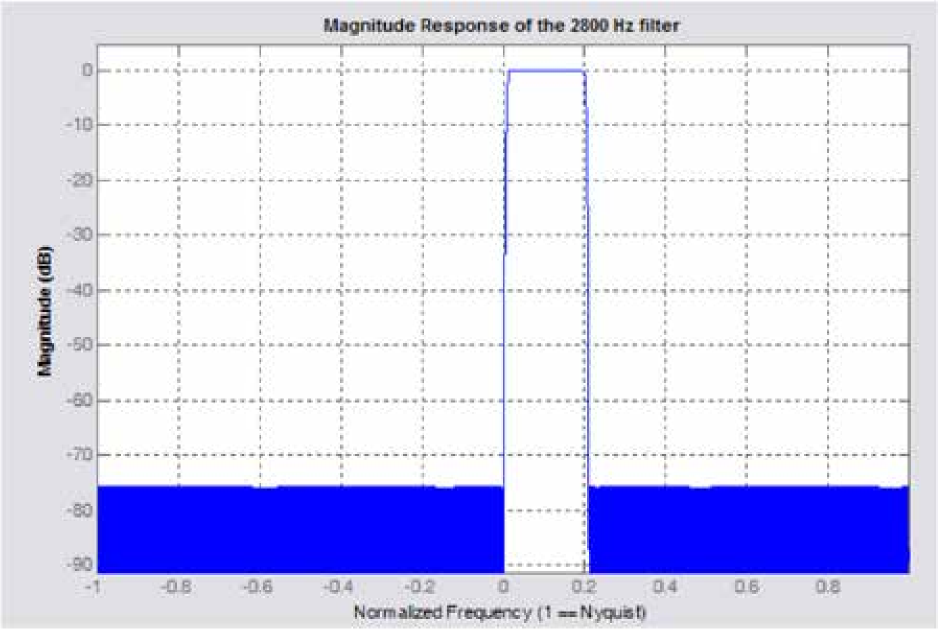
The latest release of the CMSIS library has a very good and fast implementation of the floating point complex FFT, using a mixed radix approach, so it was used both for the direct and inverse FFT, with a size of 1024 points. The masks were computed using Matlab m-functions, written ad-hoc. First a 513-tap kernel is computed, with the passband as in the following table, using the firpm primitive of Matlab, and then it is expanded up to a length of 1024, adding zeros. At this point a 1024- point FFT is computed, with its real and imaginary parts written to an external file, to be then imported as an .h file in the source of the application.

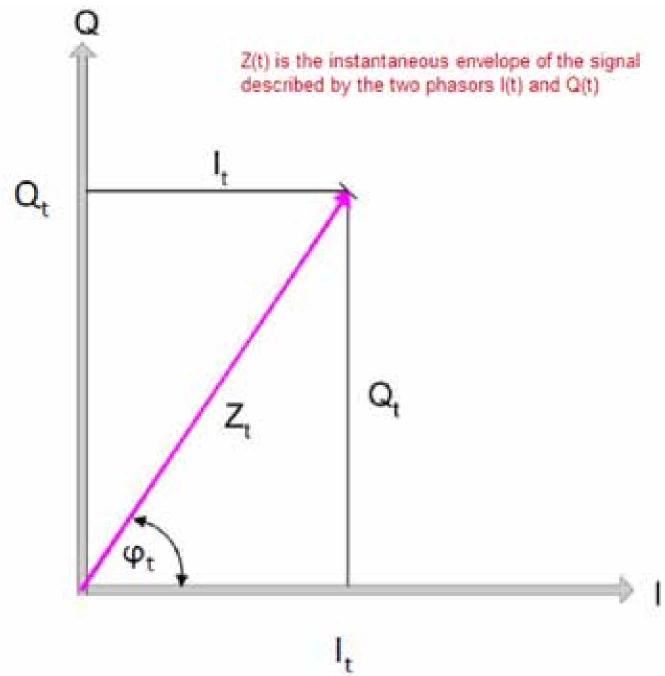
Bandwidth table

	Narrow	Wide
AM	3500 Hz	5500 Hz
SSB	2200 Hz	2800 Hz
CW	300 Hz	600 Hz

Additionally, in CW mode and with the Narrow bandwidth selected, the signal passes through a double IIR filter, implemented with a complex resonator with two conjugates poles placed inside the unitary circle at a radius of 0.987 from the origin, and with an anomaly corresponding to the CW pitch, namely 650 Hz. This further cleans the CW signal.

As just an example of the selectivity achieved with the fast convolution method, the following is a Matlab plot of the 2800 Hz SSB filter :





Demodulators

After the filtering, the signal is sent to the demodulator specific for the chosen mode. The CW demodulator is the same as the SSB demodulator, the only difference being that the frequency of the NCO is offset by the amount of the CW pitch (650 Hz) with respect to the tuned frequency.

Having the signal in analytic form (I and Q) makes the demodulation more easy. For AM demodulation what is needed is the envelope of the signal. This can be easily computed using the Pythagorean theorem :

Of course, there is a residual DC component which represents the magnitude of the AM carrier, and which must be eliminated. This can be done with this simple IIR filter :

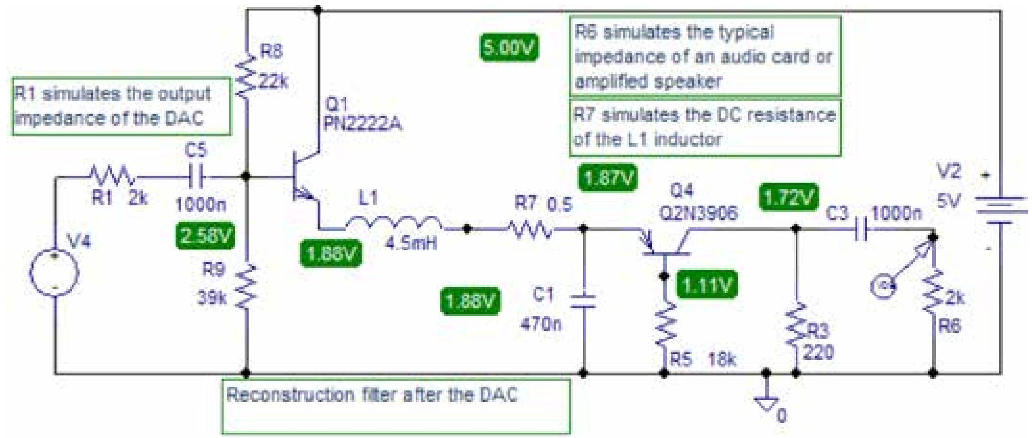
```
// DC removal filter -----------------------
w = audiotmp + wold * 0.96f;
fAudio[j++] = w - wold;
wold = w;
// -----------------------------------------
```

The SSB demodulation is a misnomer, as nothing must be demodulated… the audio is just the real part of the complex signal resulting from the overlap-and-discard algorithm. For the LSB mode, a spectral inversion is done after the direct FFT, before the multiplication by the convolution mask.

The resulting audio signal is then subject to AGC, with a hang time and a decay time depending on the user choice (Fast or Slow). At this point the processing is almost done, the signal is converted back from normalized floating point format to 16-bit short integer words, ready to be sent to the DAC. The DAC is clocked by the Timer 6 of the ARM chip, with a frequency derived from the system clock, thus synchronous with the acquisition clock. Also for the DAC the services of the DMA controller are used, namely the Stream 6 of DMA 1, again with two flip-flop buffers. One is filled by the code while the other is emptied by the DMA controller, and so on.

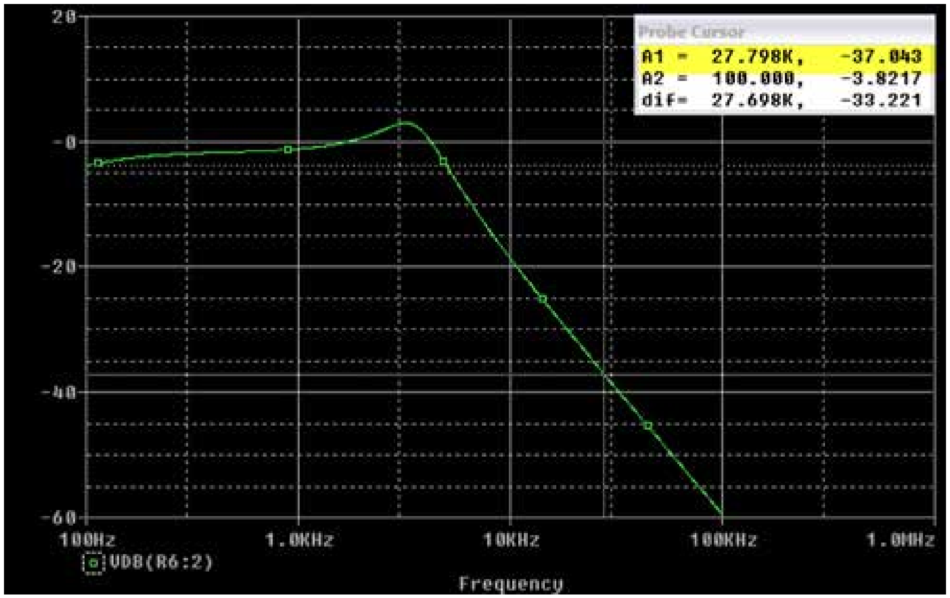
Reconstruction filter

The output of the DAC must be filtered, again according to the Shannon-Nyquist theorem, with what is commonly known as a reconstruction filter, whose task is essentially that of filtering out the DAC sampling frequency. A first attempt using a passive implementation showed that the value of the inductors needed, considered the output impedance level of the DAC, was so high to make them of a not easy availability, making difficult to replicate the circuit. At this point an active approach was chosen, with a couple of transistors that allowed working at much lower system impedance. This is the schematic :



In the actual circuit C5 is connected to bit 5 of GPIOA, which is the output of channel 2 of the DAC.

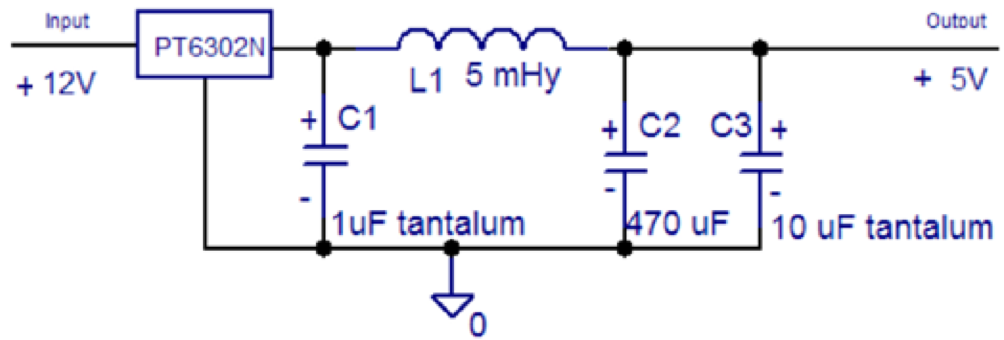
This is the Bode plot of that circuit. The sampling frequency is attenuated more than 37 dB, a value deemed adequate.



The audio signal is now ready, and it is present on a jack for connection to an amplified speaker.

Power supply

The Discovery board accepts both 5V or 3.3V as supply voltage. In this realization, a small PT6302N module was used, a positive step-down switching regulator. It accepts input voltages from 9 to 30V, with a 5V output, with 3A max current. Being it a switching regulator, its output was examined with an oscilloscope and found to be not completely clean from the switching frequency. It was then decided to filter the output with this simple network :

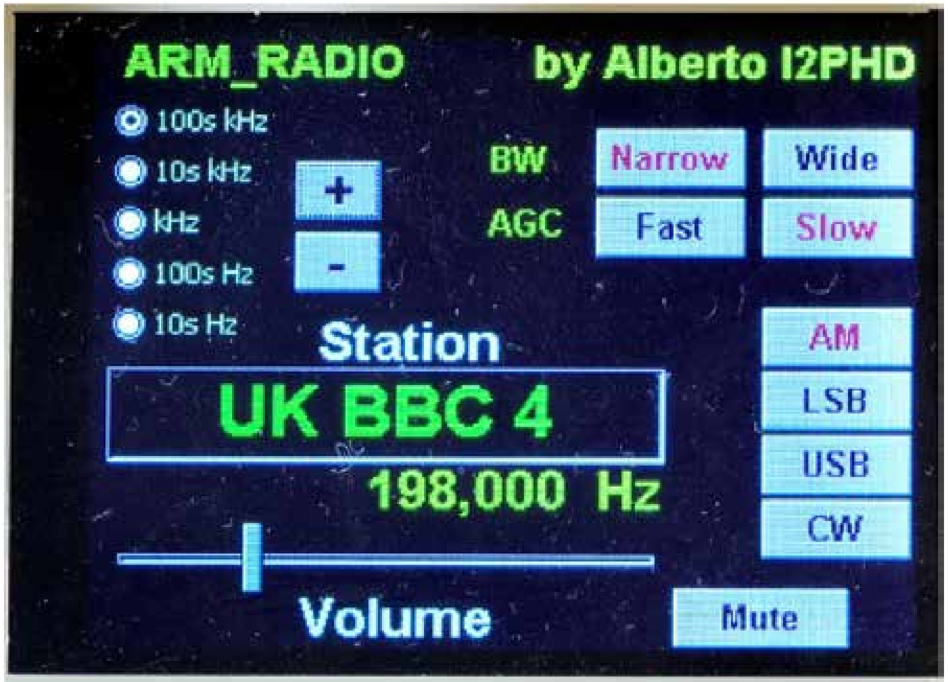


The 5V output, observed with an oscilloscope, resulted very clean.

GUI (Graphical User Interface)

The user interacts with the program using the touch screen, and the on-board User button. The panel was designed using the middleware component emWin of the Keil uVision environment (the GUIBuilder utility), and managed with the emWin primitives (GUI_Exec, GUI_Touch_Exec, etc. etc.). The emWin Exec functions, those who refresh the screen and take care of the touch gesture of the user, are executed at the lowest level of priority, the idle priority, when both the input acquisition task and the signal processing task had completed their chunks of work, waiting for the next buffer to arrive. That notwithstanding, the responsiveness is excellent, no slugginess is perceived.

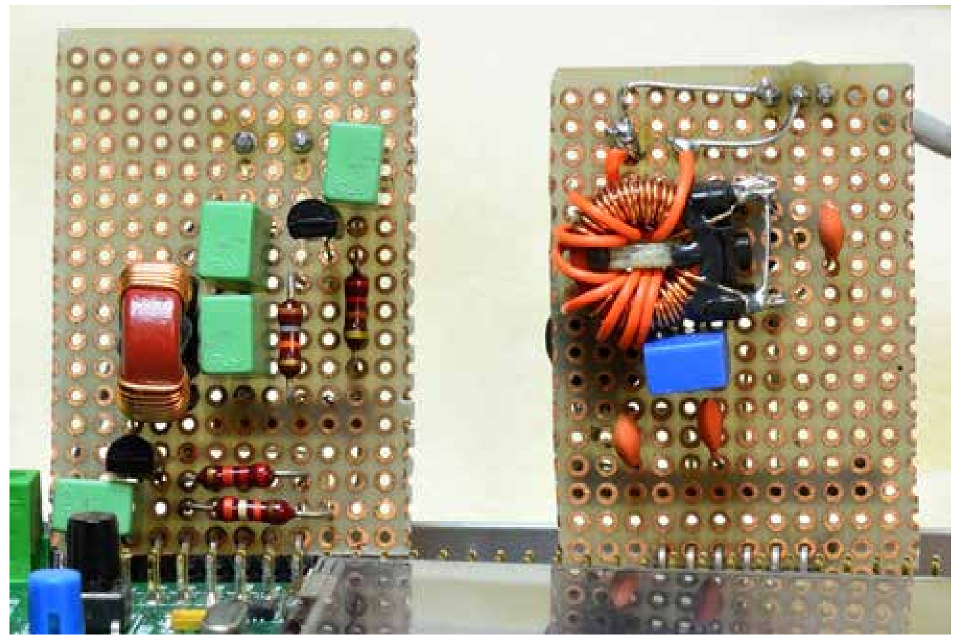
The User button, present on the Discovery board, is used to cycle among a few station presets, whose name, mode, bandwidth and AGC settings are in a table contained in a .h module, easily modifiable. This is a sample of the appearance of the screen, tuned to BBC 4 at 198 kHz :



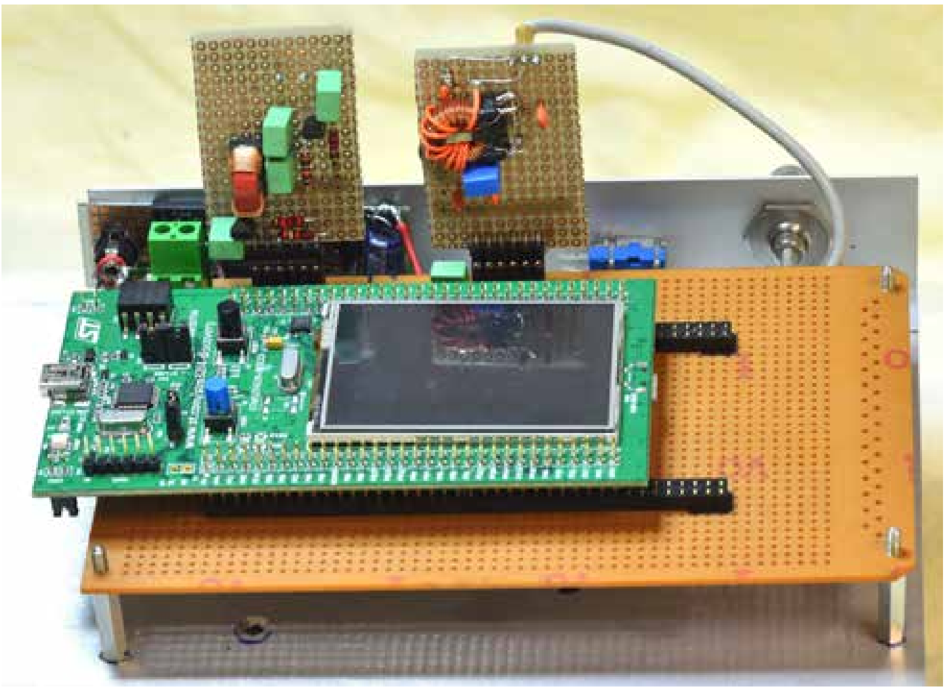
By touching the on-screen buttons, it is possible to change the tuned frequency (+ or -) by the amount selected with the radio buttons. Also the bandwidth, the AGC speed, the demodulation mode and the volume are all settable with the touch- enabled buttons.

A few photos of the realization

The realization is done in a very amateurish fashion, the filter are hand-soldered on a couple of breadboard circuits, this is a picture of them :



Here it is possible to see the entire project, the Discovery board with the two breadboard circuits, the input and output filters:



And finally this is a photo taken when the program was running, tuned to the Radio Europe 1 station:

There is a Web page devoted to this project, at this URL:
http://armradio.weaksignals.com

Going there, it is possible to download the C source code of the program. Make sure to read the ReadMeFirst.txt file contained in the ZIP archive. Also a couple of MP3 audio files representing the reception possible with this project can be downloaded from that page.

Thanks for reading this.

###

DCC Video Online

By Stana Horzepa, WA1LOU

Gary Pearce, KN4AQ, HamRadioNow's main man has posted on YouTube a slew of videos from the ARRL-TAPR Digital Communications Conference (DCC) held this past October in Chicago.

At https://www.youtube.com/user/HamRadioNow/ look for HRN video numbered 218, which is the first in the series of 2015 DCC videos. They continue in ascending order to at least HRN 237 and probably go beyond that number by the time you read this.

###

On the Net

By Mark Thompson, WB9QZB

Facebook

As you may know, TAPR has a Facebook page, www.facebook.com/TAPRDigitalHam.

However, I also created a TAPR Facebook Group, www.facebook.com/groups/TAPRDigital/.

If you have a Facebook account, "Like" the TAPR Facebook page and join the TAPR Facebook Group.

If you join the group click on the Events link and indicate you're Going to the events.

On Twitter, Too

Access the TAPR Twitter account at

www.twitter.com/taprdigital.

Also on YouTube

TAPR now has its own channel on YouTube: the TAPR Digital Videos Channel: www.youtube.com/user/TAPRDigitalVideo.

At this time, there are a slew of videos on our channel including many from the TAPR-ARRL Digital Communications Conference (DCC) that you may view at no cost, so have at it!

###

Steve Bible, N7HPR & John Ackermann, N8UR

DCC Photos

By George Byrkit, K9TRV

Adam Farson, VA7OJ /AB4OJ

Andras Retzler, HA7ILM

Bruce Perens, N6BP

Bryan Hoyer, K7UDR

John Melton, G0ORX/N6LYT

John Hays, K7VE

Dan White, AD0CQ

Ken Konechy, W6HHC

Mark Thompson, WB9QZB & Mike Urso, K9FE

Phil Theis, K3TUF

WB9AZB & Catherine Schindler, WB0UDN

Tom McDermott, N5EG

Ward Silver, N0AX & Steve Bible, N7HPR

Zoltan Doczi, HA7DCD

Stephen Hicks, N5AC

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Phone 972–671–TAPR (8277)

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PSR Editor:

Stana Horzepa, WA1LOU

E-mail wa1lou@tapr.org

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