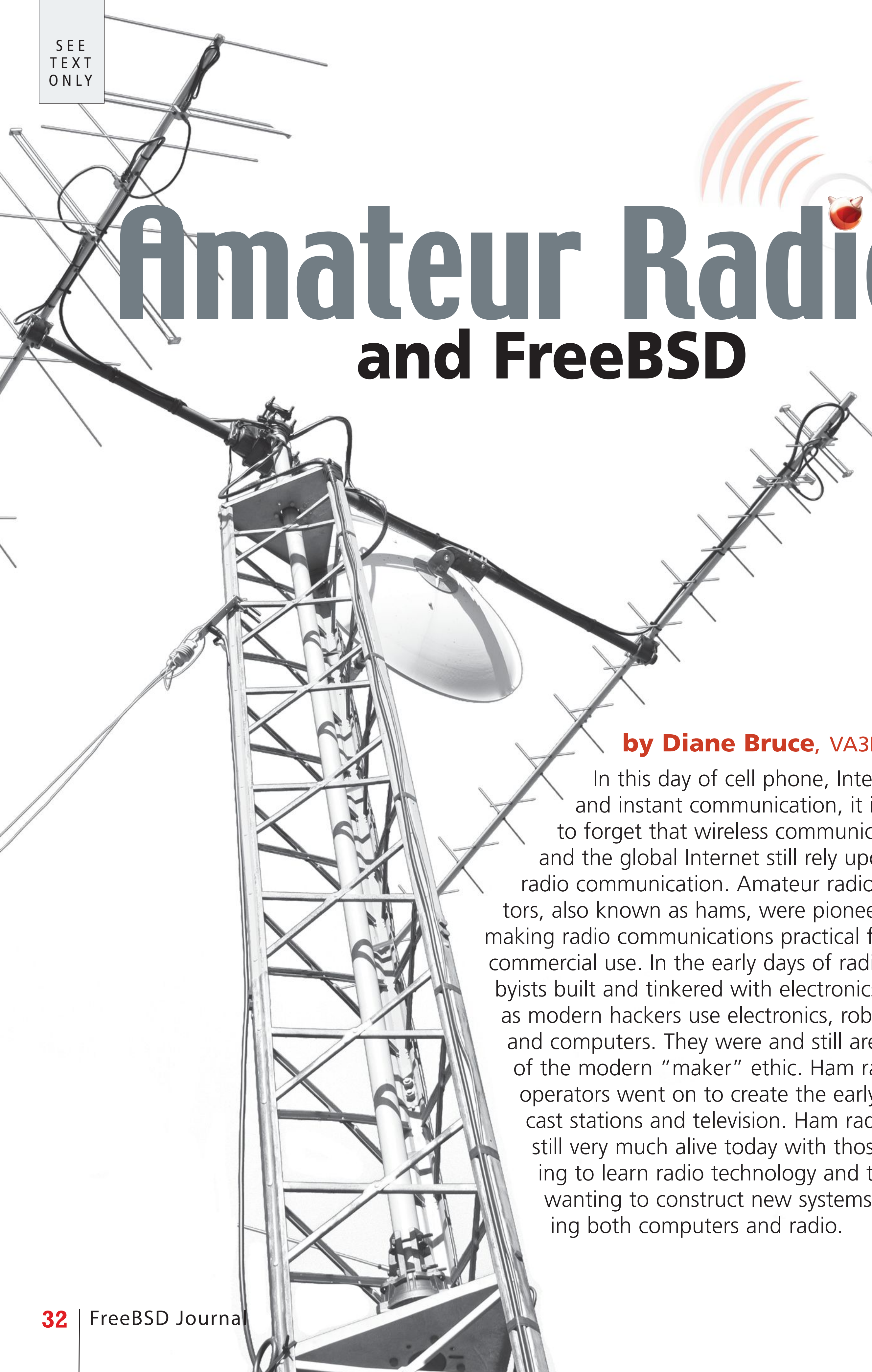
SEE TEXT ONLY

Amateur Radio and FreeBSD



by Diane Bruce, VA3DB

In this day of cell phone, Internet, and instant communication, it is easy to forget that wireless communication and the global Internet still rely upon radio communication. Amateur radio operators, also known as hams, were pioneers in making radio communications practical for commercial use. In the early days of radio, hobbyists built and tinkered with electronics much as modern hackers use electronics, robotics, and computers. They were and still are part of the modern "maker" ethic. Ham radio operators went on to create the early broadcast stations and television. Ham radio is still very much alive today with those wanting to learn radio technology and those wanting to construct new systems involving both computers and radio.

Amateur radio is a federally licensed hobby. As the radio spectrum is shared among many services, and hams are involved in experimentation, a basic knowledge of radio technology and regulations is important to prevent interference with other services. Amateur radio is one of the few radio services that are allowed to build their own radios, new protocols and systems.

Licensing requirements are easily met by anyone with a technical background, and no, Morse code is not needed.

Amateurs have worked on cell phone development and satellite systems, as well as helping build the modern Internet. Scientists, computer programmers, and electronics engineers all have a keen interest in amateur radio.

But why use computers with ham radio in the first place? The technology of computers and radio itself has changed radically over the past few years. The modern radio ham uses computers to handle satellite prediction, digitally encoded voice, logging, digital modes, software-defined radio, and a myriad of other tasks.

This has resulted in many applications written for amateur radio use, many written to run on the Linux operating system. Those of us (https://wiki.freebsd.org/Hamradio On FreeBSD) who work on ham radio ports for FreeBSD would love to change this attitude and bring BSD into the office as well. Fortunately, many of the applications written generically or specifically for Linux are easily transferred to FreeBSD.

`fldigi` **running on FreeBSD desktop.**

Ham radio operators were early adopters of personal computers for use in sending and receiving radio teletype signals. Radio teletype (RTTY) for the amateur in the early days utilized surplus, obsolete teletype machines such as the model 15 with an external modem.

You can imagine how these clunky machines made RTTY impractical for many amateurs! These machines used a predecessor to modern 8-bit ASCII code often called Baudot (Murray code for the pedantic), which was a 5-bit (5-level) plus start/stop bit code. These machines were then coupled to a modem made for radio use that did extensive filtering of the audio signal to reduce interference from other signals. RTTY was a natural for the early home personal computer and is easily one of the earliest digital modes. It was very easy to generate and decode 5-level code using an early 8-bit computer such as an Apple II, but still using the external modem. Computer power has reached the point where it is trivial to use signal processing instead of an external modem to decode off-the-air, radio teletype directly, and display the decoded text. A typical program used for this with FreeBSD is fldigi.

fldigi itself is the modern Swiss army knife of many off-the-air short wave signals such as RTTY and Hellschreiber and more modern protocols such as PSK31.

wikipedia photo

Model 15 teletype.

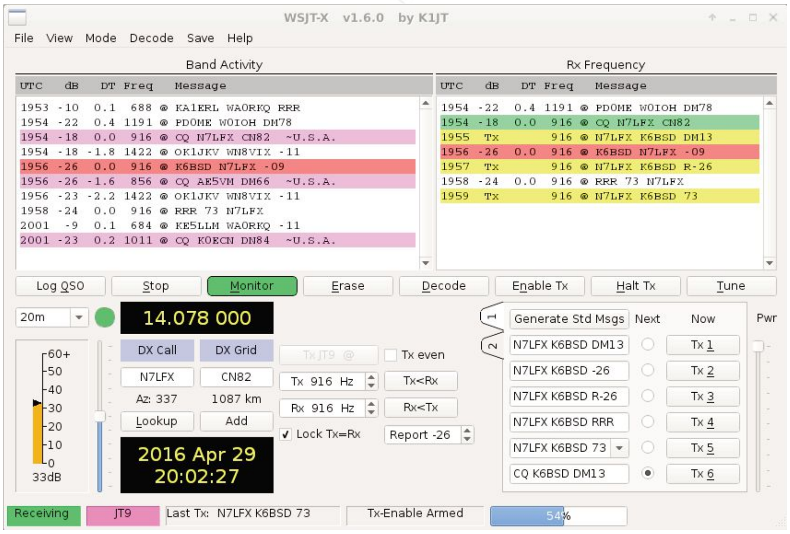
Old 1950s ham radio operator's station.

http://www.gladlylearn.com/Amateur Radio/RSGB/RSGB_39_Late1950s.JPG

wikipedia photo

Hellschreiber machine from WWII. Tones were used to draw characters upon a moving drum.

For more information, see wikipedia https://en.wikipedia.org/wiki/Hellschreiber.

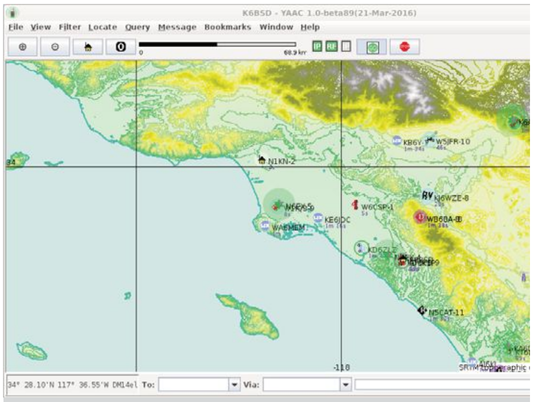


`WSJTX` **used on 20 meters.**

Typical antenna setup needed without `WSJT`.

With the increased power of modern computers, weak signal detection using modern digital signal processing has improved immensely. Joe Taylor, a Nobel Prize-winning physicist who is also known by his ham radio call sign K1JT, wanted a way to send signals to the moon and back (Earth-Moon-Earth or simply EME or moon-bounce) to send signals around the globe via the moon. Using his expertise in radio astronomy, he used modern advanced signal processing to develop Weak Signal JT (`WSJT`), using a new mode JT65. Early ham radio EME operations required very expensive and large antenna arrays with high-powered amplifiers. `WSJT` brings EME to amateurs using a more modest station that is far less expensive to set up.

Ham radio operators all over the world now use `WSJT`, `WSJTX`, and its offspring, `WSPR`, in daily use and to communicate with very low power around the globe and not just via the moon, but by traditional



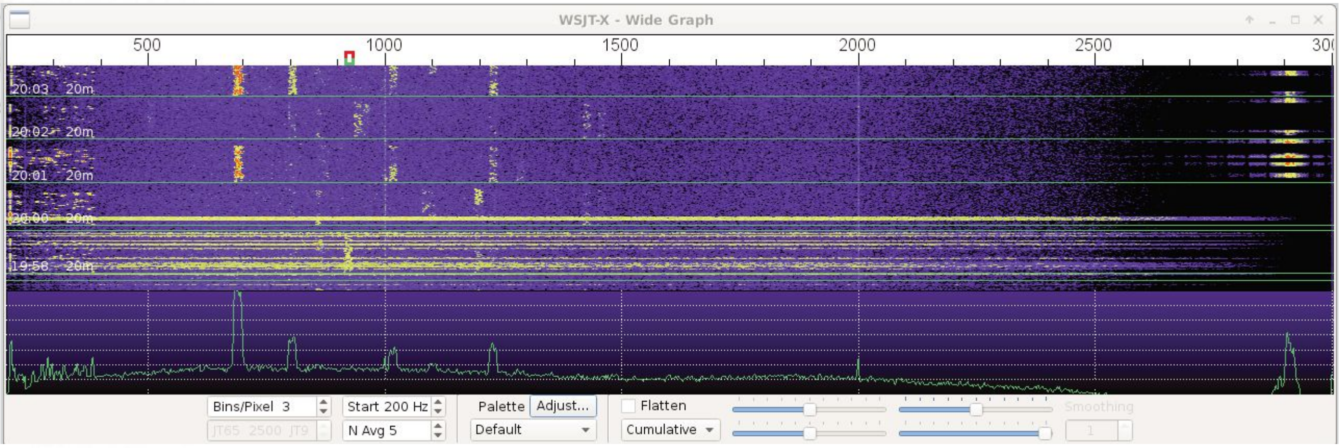
Map of stations and locations as seen by `YAAC` (west coast of USA).

short wave using the ionosphere. (See http://physics.princeton.edu/pulsar/K1JT/)

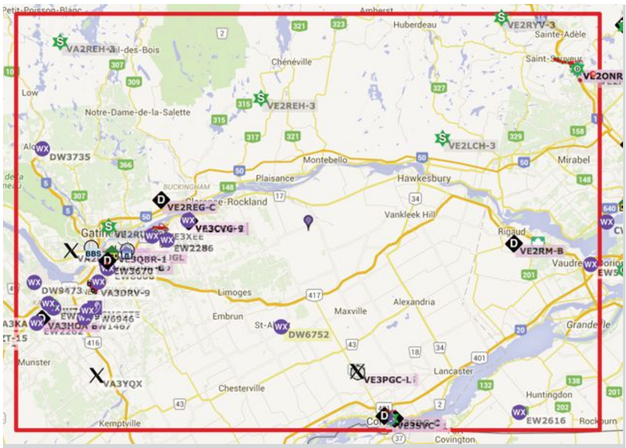
A recent trans-Atlantic 2m attempt was found to have succeeded simply due to the signals bouncing from the International Space Station, which just happened to be in the right place at the right time! (July 14, 2014 see http://www.brendanquest.org/)

PSK31 is a low-bandwidth mode that is also very popular with modern hams. Its ability to be heard below the noise floor makes it very popular for low-power operators. Again fldigi is the program of choice here for most hams.

Amateur radio operators were instrumental in early work with packet radio, which has found its way into encrypted digital systems for police and other emergency services. Store and forward networks using a modified X.25 protocol, AX.25, are still in use all over the world. This forms the backbone of the tracking system known as Amateur Positioning



`WSJTX` **in so-called waterfall display showing region of frequencies vs. time.**



View of stations in Ottawa Ontario, Canada using APRS as seen by http://aprs.fi.

Radio System (APRS). This system is well supported from FreeBSD using `Xastir` and `YAAC`.

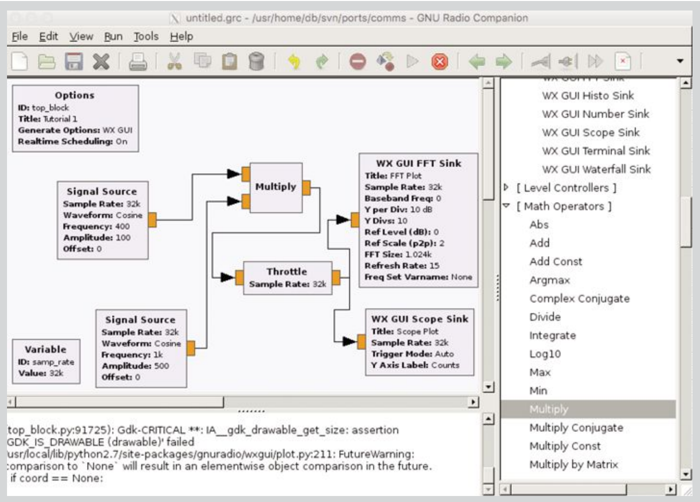
Stations use GPS receivers to broadcast their current positions via APRS over AX.25. This system is invaluable for volunteers using amateur radio who help the professionals who do search and rescue—Civilian Air Patrol (CAP), for example. These signals are also relayed on the Internet to allow worldwide tracking of stations; e.g., http://aprs.fi/#!addr=FN25 will show my neck of the woods in the Ottawa area.

Software-defined radio is one of the hottest new techniques being experimented with by radio amateurs. By using fast A/D converters, radio signals can be sampled directly from the air, converted to quadrature (two signals with a 90 degree phase shift between them) digital samples, commonly referred to as I/Q signals to be decoded using computers. For the radio, amateur signals can also be generated using D/A converters and transmitted.

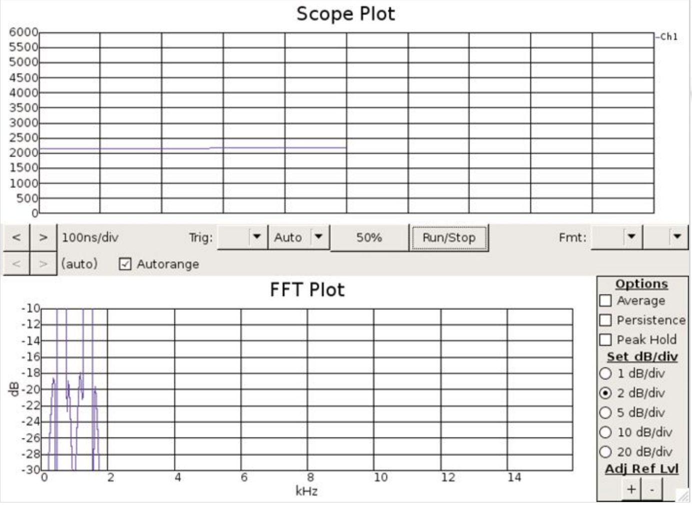
When Adrian Chadd (ham radio call sign KK6VQK, adrian@FreeBSD.org) wanted to look at the layout of frequencies used by WiFi transmission, he needed a software-defined radio (SDR) package that was well supported. That meant Adrian had to help port software to support the Ettus systems USRP to FreeBSD if he wanted to use it on his BSD systems with `gnuradio`. `gnuradio` is a software framework of components that can be linked together using a graphical interface to put together SDR radio systems.

High end RF A/D D/A systems can handle many Mhz of frequencies at once, much as you would have to do with radio astronomy or in WiFi signal analysis. However, much SDR can be done using the standard audio card that comes with any modern computer system or using a DVB-T TV tuner USB dongle based on the RTL2832U chipset. The sound card is limited to sampling baseband audio signals; hence, any RF signals must be down converted to base band before they can be decoded. The so-called "SoftRock" is a low cost RF converter that can be used with programs such as QUISK to decode traditional short wave modes including single sideband (SSB), FM, and AM.

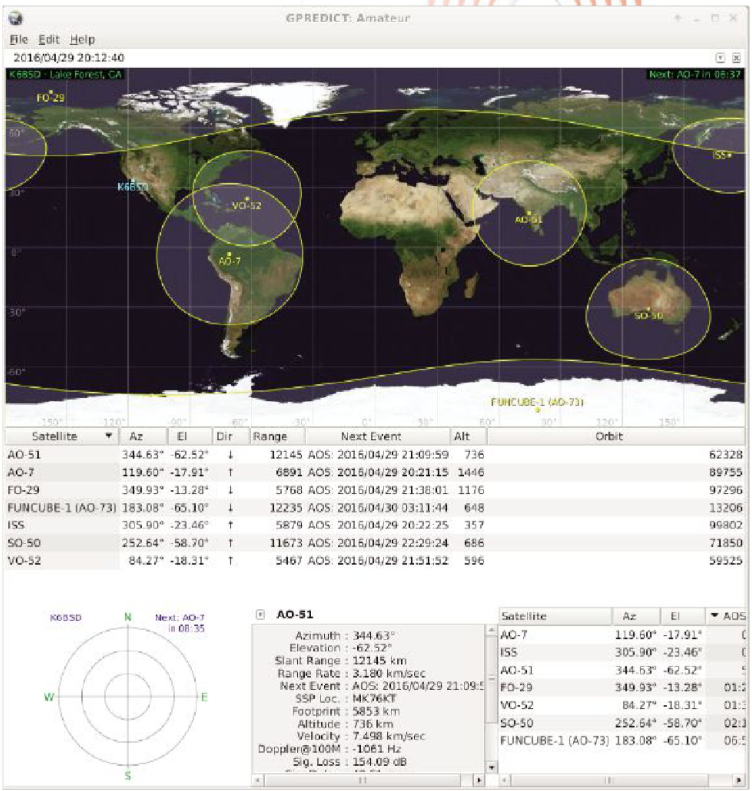
A TV tuner USB dongle can be used to directly sample RF signals well up into the UHF radio spectrum, and as such can be used to monitor ham radio frequencies in this spectrum or even just tune in a broadcast FM station; e.g., the `rtl-sdr` port can be used in conjunction with `gnuradio`. Many ham radio enthusiasts have



`gnuradio-companion` **graphical interface being used to set up a simple DSP tutorial.**



`gnuradio` **display of scope and fft plot of sample generator.**



gpredict satellite prediction program shows coverage areas of satellites being tracked.

QSSTV program used to decode slow scan TV.

Early amateur radio built satellite AO-7.

built-up converters to GNU Radioas used by gnuradio.org that convert low, short-wave received frequencies up into the region that a TV tuner dongle can receive.

Ham radio operators have designed and built their own satellites. AO-7, first launched in 1974, is still going, albeit in a severely degraded mode as the batteries have now died.

Building a satellite takes knowledge in diverse fields, such as power engineering, battery technology, radio, and embedded computer systems. These are the sorts of people who work for NASA. For the average amateur radio operator, knowing where to aim the antenna and at what times for each satellite takes tracking software. Such programs as predict and gpredict are commonly used here.

The International Space Station has licensed amateur radio operators on board and in a low-earth orbit. It is a very easy station to hear when it is in automated mode and to talk to when they are active. As can be expected, the astronauts on board don't have a lot of time to spare for talking directly to ham radio operators on the ground, but often will make special arrangements to talk to schools on the ground. You can see this satellite listed in the screenshot of `gpredict`.

Amateur radio television is a mode that is in use by some hams, though most of the activity is with a low bandwidth form of television called slow scan TV (SSTV) SSTV in the early days required surplus radar tubes with a long persistence (P7) phosphor that was very harsh on the eyes, but would allow the picture to be painted before it faded. Nowadays, this is all done using computer decoding and allows us full color pictures. The ISS has been known to broadcast SSTV signals to the earth for ground stations to view as well.

Repeaters are used to extend the distance of mobile stations by putting a receiver on a hill or tall building along with a transmitter that relays the signals from the mobile stations. It is a trivial matter to link local city repeaters across the world via the Internet. This can be done using **thebridge** or **svxlink**.

Amateur radio can be as technical as you want it or just a relaxing hobby. There are so many diverse interests in the hobby with so many different aspects that I can only cover a small part of it. The era of inexpensive computing has, and is, making amateur radio much more interesting. Perhaps you yourself now have an interest. For further reading I would suggest starting with http://www.arrl.org in the U.S. and http://www.rac.ca in Canada.

DIANE BRUCE has done computer programming in one form or another for over 40 years, and has 35+ years' experience in embedded/real-time. Diane currently contributes to the FreeBSD Project, mostly in ports. Her hobbies include amateur radio, writing, and music (amateur musician). She was first licensed as a radio amateur in 1968. db@Freebsd.org