Ham Radio Experiments #1 - Digital Modes

An investigation into what digital signals can be found on Amateur Radio frequencies, and how to decode them.

In 2020 I came back. It has been over a decade since I was involved in ham radio, and very little of that was on HF frequencies. At that time a new digital mode called “PSK-31” was the rage. It uses phase-shift keying to send teletype-like text using only 31 Hz bandwidth, similar to CW/Morse Code bandwidth. The PSK-31 signal is not decoded by ear, but rather by a computer using the audio-input or microphone-in to digitize a signal from a radio receiver. The computer then uses digital signal processing to detect the digital data from the incoming waveform – in real time. (And synthesized waveforms are sent to audio-out/Headphone-out for transmitting, but that was too advanced for me.)

PSK-31 was quite an improvement from Radio TeleTYpe, or RTTY, a system that most commonly uses Baudot alphabet and Frequency Shift Keying to send telegram-like text. So I was fascinated with PSK-31. Since then “Digital Modes” have evolved quite a bit, with perhaps a hundred new modes, each with their own use case of data rate, signal to noise ratio, decoding complexity. I wanted to know where to get started, and to know what sort of signals I would hear on the ham bands.

Step 1: Try out some software

Several months ago I installed Fldigi.exe on my Windows 10 PC. (http://www.w1hkj.com/) To try it out I took a microphone and put it right on top of ny receiver’s top mounted speaker opening. I get a fairly good signal, though not all that linear or wide audio bandwidth… It took some doing to have the computer listen to a microphone hooked to my microphone-in, but I figured it out somehow. Now fldigi gets the signal picked up from the radio’s speaker (see red microphone in the picture)

I wanted to use Fldigi, Unfortunately, the vast number of modes listed under “Op-Mode” discouraged me. I could hear squeaks and buzzes in the CW/Digital portion of 80 and 40 Meters, but couldn’t figure out how to decode them. Where do I start??

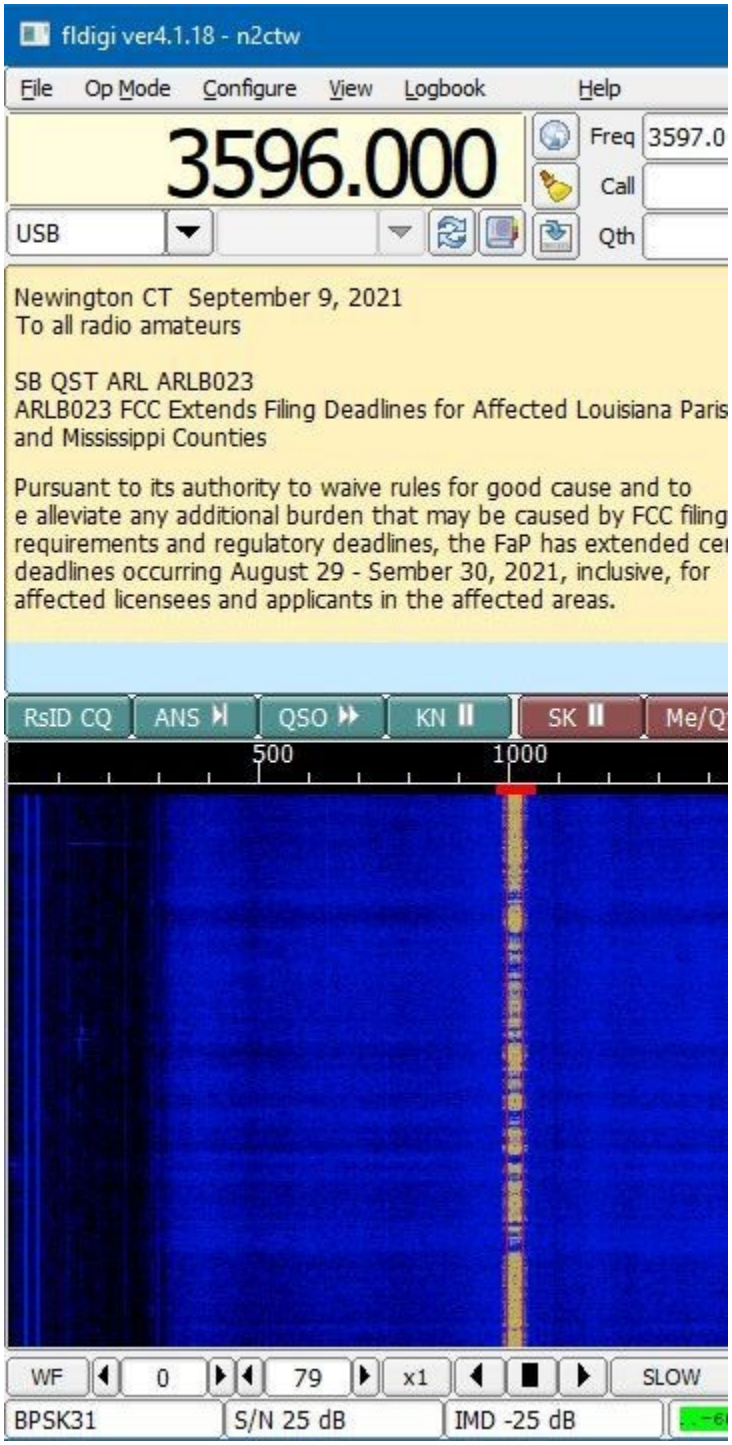
Step 2: Listen to W1AW Digital Bulletins

The ARRL sends out information of interest to amateurs several times a day using voice, Morse Code, and three digital modes. If I could get my receiver and computer setup to decode the three types of W1AW signals, then I could gain some proficiency with using it, and go from there. W1AW transmits in “Baudot, BPSK31 and MFSK16” – that is, RTTY, PSK-31 and Multiple Frequency Shift Keying with 16 frequencies.

The signals came from a borrowed IC-746PRO with an MFJ Deluxe Versa Tuner II and a short long wire… 15 feet maybe… strung out of my second floor window. I can’t transmit into it, but I can hear signals on 20,40, and 80 at least. I could hear squeaks and blurps on the cw portion of 80 meters...

And, fldigi also decodes CW signals! So first I copied the W1AW code bulletin, receiver set to USB and tuning to 3580 kHz. The signal I heard was at 3581.5 kHz, and the loudest thing on the band, at least in central NJ. Clicking on the signal I wanted on the Waterfall display told the computer which cw signal to decode. So I knew the basic radio-speaker-microphone-sound card-computer data path worked. Now on to digital modes.

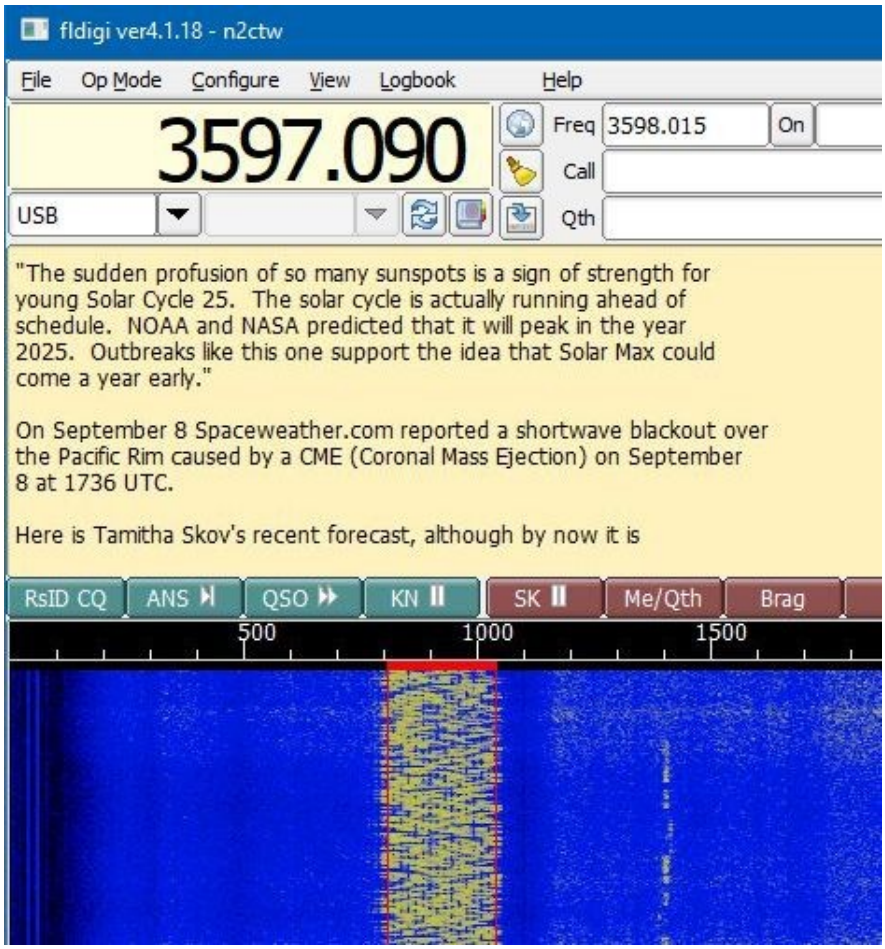
Digital Bulletin Frequencies are 3597.5 kHz, 7095 kHz. Initially I turned to 3.596 USB, and hoped to find PSK-31 at 1.5 kHz audio (that is, the listing was the actual frequency of the PSK carrier). In fact, PSK31 started on 3598kHz, up 500 Hz from where I expected it to be, so I tuned the radio to make the carrier 1 kHz audio. (Other nights the frequency was lower, they seem to select an empty frequency near the published value.)



Decoding of BPSK31 text seemed solid and it's nice to have formatting of the text (carriage returns!) in general things look solid. The picture above shows the decoded bulletin text. The PSK bulletin is a bit fancier than the CW one, because "http://" and "()" can be sent in the message, and there is lower case!

When the PSK was done, it seems it was too close to 9:45 PM, when the phone bulletin would be sent, so they did not transmit any of the other modes.

Four days later, Tuesday night, I was able to copy not only the CW (using fldigi) but also BPSK31 and then MFSK16 bulletins from W1AW. I set fldigi to “Op-Mode>MFSK>MFSK-16” which decodes Baudot sent at 45.45 cps.

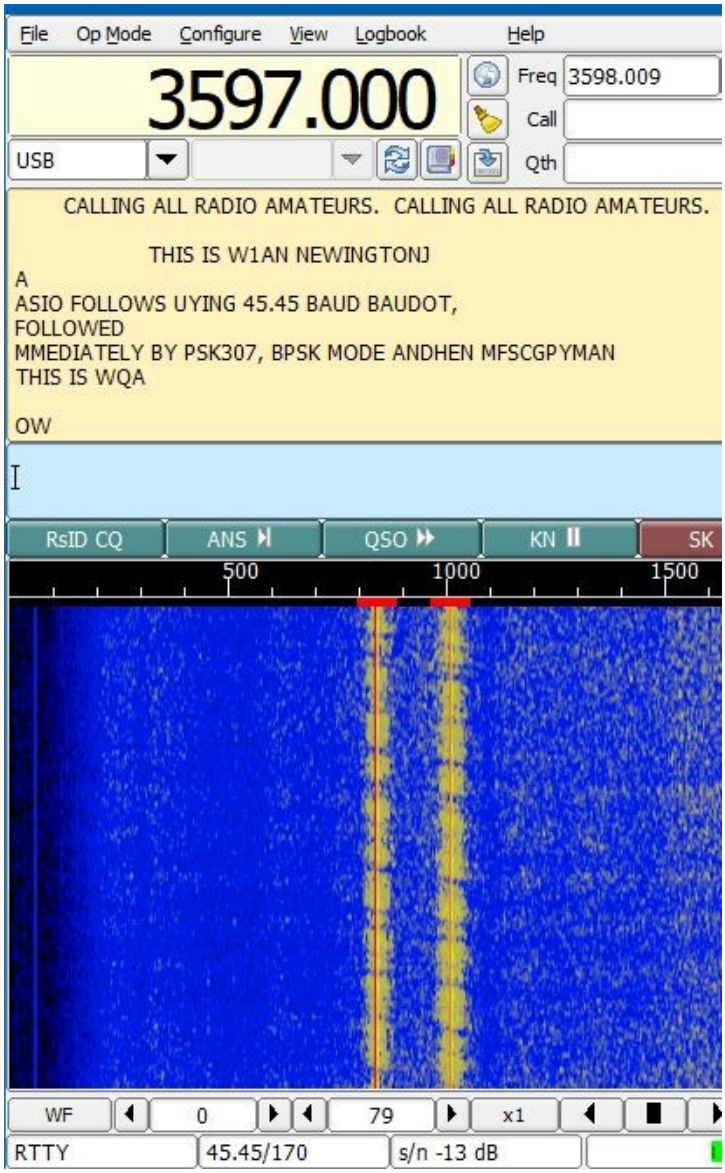


The MFSK16 is 250 Hz wide, with the highest frequency at 3.598 MHz, perhaps 200 Hz high on my dial. The “Waterfall” shows the MFSK signal as it bounces between 16 frequencies over about 250 Hz.

For decoding MFSK16 I used Upper Sideband, and slow AGC and a narrowed audio filter, to get rid of noise 1 kHz away. Noise blanker was not needed, NR (noise reduction) made the waterfall look better, but did not improve the reception. Momentary fades causing bad data decodes.

The last mode, RTTY/Baudot, took several tries, but finally I found a night without thunderstorms and with enough time for Baudot to be transmitted. One night I thought I had tuned it correctly, but all I could copy was strings of numbers… so I assumed I was doing something wrong-- but it was actually a table of orbital parameters for ham satellites. Later I tuned in when the bulletin was actual paragraphs. To copy RTTY I learned to not use the “RTTY” setting on my radio-- it demodulates the frequencies in lower sideband, so the frequency shift is the wrong direction. Instead, use Upper Sideband (USB) and regular SSB filtering.

I set the Fldigi software to “Op-Mode>RTTY>RTTY-45” which decodes Baudot sent at 45.45 baud.



The reception actually got quite a bit better after I took this photo. RTTY sounds like two stations sending very fast CW at two frequencies 180 Hz apart. Settings for filters, AGC and sideband were the same as MFSK16.

Conclusion: Success.

So I am now capable of listening to and decoding three digital modes (other than CW) at least for strong W1AW signals. Later I copied other stations using PSK-31 with no problem. I can also identify signals by how they look on the waterfall display, and how they sound, as well.

Charlie N2CTW
9/20/21

Beyond that I explored FT8 and Wspr, both decoded using the same setup, but with “wsjt” software; but that’s another story.