Brass Tacks

An in-depth look at a radio-related topic

Digital radio

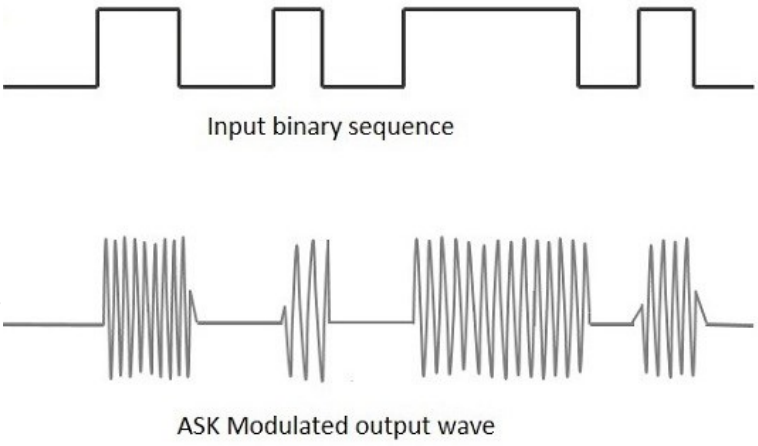
There's been quite a lot of talk recently about digital radio and digital modes, and rightly so. It's no longer a thing of the future, but a technology of the now, so I thought it only appropriate to talk a little about it, and maybe even unmask some of its mystery. Digital radio is a ***huge*** topic that covers a ***broad*** discipline within amateur radio. Just so you and I are on the same page, however, let's distinguish between three areas of thought on what we mean by ***digital*** as it relates to radio: internal circuitry, data protocols, and digital signal.

Most modern transceivers use embedded digital circuitry (think AND gates and ADCs and processors) deep inside their guts, to filter signals, to enhance modulation / de-modulation, and to move data around. This internal digital processing is extremely important today, and differences between chipsets, digital logic, and features are often what distinguishes quality radios from cheaper units, but ***the internal digital circuitry isn't what we're addressing here.***

There are also many ways to digitally encode (not encrypt, which is prohibited) the data that eventually gets transmitted, highlighting features such as data compression, weak signal detection, and error detection / correction. These are known as data protocols (such as JT65, FT8, MFSK, PSK31, etc.), but ***also not the topic of discussion in this article.***

What we're talking about is ***the stream of ones and zeroes that are actually being transmitted through your antenna.*** Let's take a look. It seems like the best way to describe what a digital signal looks like is to show it both in AM and in FM, since those are the fundamental modulation methods (most *basic* modulation methods, such as SSB and C4FM, are derivatives of these two) for transmitting digital signals, and then introduce PSK. Furthermore, it's probably best to view them as a **waveform** in the time domain, since in the frequency domain digital signals and analog signals appear nearly identical.

ASK



The simplest waveform to examine is ASK, or *amplitude-shift keying*, which is nothing more than a steady hum at a single high frequency (the **carrier wave**), except that the signal strength (**amplitude**) of the wave is either strong (for a digital **"1"**) or weak (for a digital **"0"**). The simplest form of ASK is called OOK, or *on-off keying* (shown here), in which the signal is either present (digital **"1"**) or absent (digital **"0"**), and is in fact what's being sent in CW operation. This means that ***digital radio communication is actually amateur radio's first modulation method***, preceding analog radio by decades. CW, or *continuous-wave*, is a **mode** that involves sending Morse code in OOK, using short digital ones (dots), long digital ones (dashes), and digital zeroes (spaces). ASK requires little bandwidth as a result of using a single frequency.

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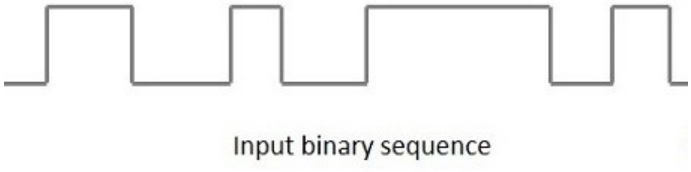
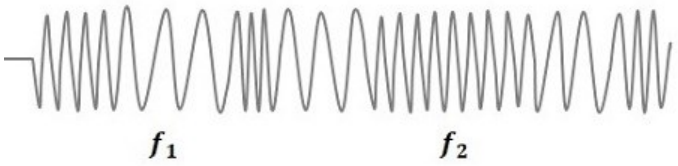
continued

FSK

Another way of representing a stream of digital ones and zeroes is FSK, or *frequency-shift keying*, which is done by sending the carrier signal at a constant amplitude, but at two different frequencies, one for a digital **"1"** and the other for a digital **"0"**. (*NRZ* is often used, in which the *transition* from one frequency to the other switches from a digital **"0"** to digital **"1"**) Because FSK uses more than one frequency, it requires more bandwidth than does ASK, but can carry more information in a shorter amount of time than can be done with ASK.



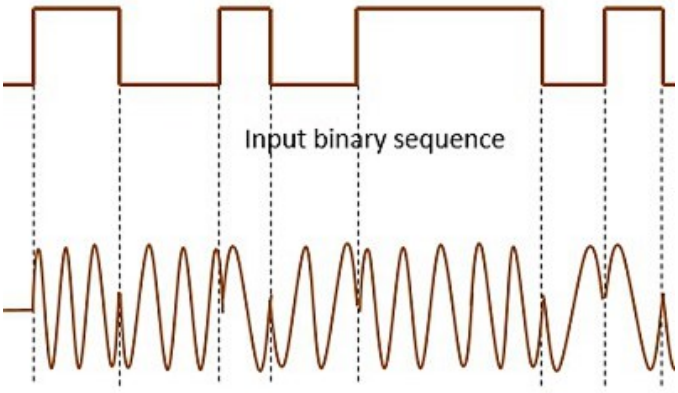
Input binary sequence



FSK Modulated output wave

PSK

A third method of sending digital radio is PSK, or *phase-shift keying*, whose waveform appears similar to the constant-amplitude FSK, except that it uses a single carrier signal, but shifted by an angle (digital **"1"**) or not shifted (digital **"0"**). The simplest form of PSK is BPSK, or *binary phase-shift keying* (shown here), in which the shift is by 180°, and can easily be accomplished by **inverting** the signal (digital "**1**") or not (digital "**0**"). (PSK also uses *NRZ*.)



PSK Modulated output wave

Putting it all together

Digital radio is nothing more than the sending of ones and zeroes over radio waves. Yet there are various ways to accomplish this, and more than what was described in this article, but these three are the most fundamental. So, how does one send and receive these digital signals? Well, that often requires special hardware or even special software that can form these ones and zeroes before sending and receiving them through your antenna, and is a feature that's built in to some of today's transceivers, but a topic for another day.

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