23.4: Modulation Overview

There are two families of modulation methods with analog modulation used in early radios including 1G cellular radio, and digital modulation used in modern radios starting with 2G cellular radio. While 1G cellular radio transmitted voice signals using analog modulation, 1G also used a simple type of digital modulation for signaling. With the exception of **ultra-wideband** (**UWB**) pulse radio [5], all modern radio modulation schemes slowly vary the amplitude, phase, or frequency of a sinusoidal signal called the carrier. This results in a narrow bandwidth modulated signal perhaps with fractional bandwidth typically in the range of 0.002% to 2%. The early spark-gap wireless telegraph systems were ultra-wideband but they were soon discontinued because they interfered with conventional radios which were soon developed and assigned specific parts, i.e. bands, of the spectrum. The initial pulse radio concept of the 1990s occupied most of the spectrum between 3.1 and 10.6 GHz but was never deployed mainly because capacity was relatively poor. The term ultra-wideband wireless is now widely taken to mean a wireless device such as a radar or radio with a bandwidth which is at least the lesser of 500 MHz or 20% of the carrier frequency [6]. So even the UWB millimeter-wave radios exploiting the high bandwidth available at millimeter wave frequencies still employ a relatively slowly varying modulation of a carrier.