23.1: Introduction

Most radio communication systems superimpose slowly varying information on a sinusoidal carrier that is transmitted as a radio frequency (RF) signal. This modulated RF signal is sent through a medium, usually air, by a transmitter to a receiver. In the transmitter information is initially represented at what is called baseband. The process of transferring information from baseband to the much higher frequency carrier wave is called modulation. Most modulation schemes slowly vary the amplitude and/or phase of a sinusoidal carrier waveform. In the receiver the process is reversed using demodulation to extract the baseband information from the varying state, such as the amplitude and/or phase, of the modulated carrier.

Radio has evolved subject to constraints imposed by political, hardware, and compatibility considerations. New schemes generally must be compatible and co-exist with earlier schemes. This chapter discusses the many different modulation schemes that are used in radios. Nearly all modulation schemes are supported in modern radios such as 4G and 5G cellular radios, and many are supported in WiFi. Sometimes this is to provide support for legacy radios while in other situations they are used because simpler modulation formats tolerate higher levels of interference. Indeed the level of so-

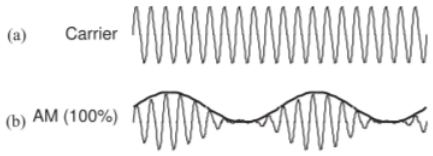

Figure 23.1.1: AM showing the relationship between the carrier and modulation envelope: (a) carrier; and (b) 100% amplitude modulated carrier.

phistication of modulation methods may need to be frequently changed to accommodate varying interference environments. Legacy analog modulation schemes and the simpler digital modulation schemes where suitable for the relatively unsophisticated hardware of years past. High-order modulation schemes enable many digital bits to be sent in each hertz of bandwidth and are only possible because of the evolution of digital signal processing and because of advances in high-density, low-power digital electronics.

Section 2.2 introduces some of the metrics that are used to compare modulation schemes and Section 2.3 introduces modulation. Section 2.4 describes analog modulation. Then Section 2.5 describes digital modulation followed by sections that deal with the specifics of various digital modulation methods: frequency shift keying (FSK) in Section 2.6; phase shift keying (PSK) in Section 2.8; and quadrature amplitude modulation (QAM) in Section 2.9. Before the discussion of PSK a concept called carrier recovery is discussed in Section 2.7 as the necessity to do this was behind the development of a variety of PSK modulation schemes. This is followed by a discussion of the metrics that can be used to quantify interference and distortion of modulated signals.

Modulation, and the hardware architectures and circuits for modulating and demodulating radio signals, are presented largely in three chapters. There is an overlap of these topics but modulation itself is largely confined to this chapter although some architecture concepts must necessarily be introduced to understand the evolution of modulation schemes. The next chapter, Chapter 3, focuses on architectures and essential circuits for modulators and demodulators.