



Figure 1.11: Constellation diagrams for (a) ASK, (b) PSK, (c) QPSK, and (d) multilevel QPSK formats.

1.3 Optical Communication Systems

As mentioned earlier, optical communication systems differ in principle from microwave systems only in the frequency range of the carrier wave used to carry the information. The optical carrier frequencies are typically ~ 200 THz, in contrast with the microwave carrier frequencies (~ 1 GHz). An increase in the information capacity of optical communication systems by a factor of up to 10,000 is expected simply because of such high carrier frequencies used for lightwave systems. This increase can be understood by noting that the bandwidth of the modulated carrier can be up to a few percent of the carrier frequency. Taking, for illustration, 1% as the limiting value, optical communication systems have the potential of carrying information at bit rates ~ 1 Tb/s. It is this enormous potential bandwidth of optical communication systems that is the driving force behind the worldwide development and deployment of lightwave systems. Current state-of-the-art systems operate at bit rates ~ 10 Gb/s, indicating that there is considerable room for improvement.

Figure 1.12 shows a generic block diagram of an optical communication system. It consists of a transmitter, a communication channel, and a receiver, the three elements common to all communication systems. Optical communication systems can be classified into two broad categories: *guided* and *unguided*. As the name implies, in the case of guided lightwave systems, the optical beam emitted by the transmitter remains spatially confined. This is realized in practice by using optical fibers, as discussed in Chapter 2. Since all guided optical communication systems currently use optical fibers, the commonly used term for them is fiber-optic communication systems. The term *lightwave system* is also used for fiber-optic communication systems, although it should generally include both guided and unguided systems.

In the case of unguided optical communication systems, the optical beam emitted by the transmitter spreads in space, similar to the spreading of microwaves. However, unguided optical systems are less suitable for broadcasting applications than microwave systems because optical beams spread mainly in the forward direction (as a result of their short wavelength). Their use generally requires accurate pointing between the transmitter and the receiver. In the case of terrestrial propagation, the signal in unguided systems can deteriorate considerably by scattering within the atmosphere. This problem, of course, disappears in *free-space communications* above the earth atmosphere (e.g., intersatellite communications). Although free-space optical communica-