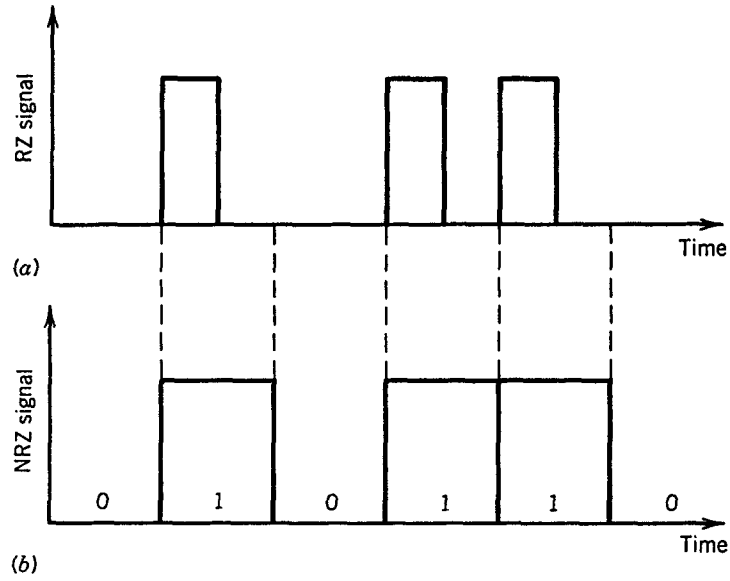

Figure 1.9: Digital bit stream 010110... coded by using (a) return-to-zero (RZ) and (b) nonreturn-to-zero (NRZ) formats.

tical pulses that spread over multiple bit slots quickly as they propagate down the fiber link. This spreading reduces the peak power and lowers the impact of several nonlinear effects that may prove detrimental otherwise. Pulses are eventually compressed back to their original width using a dispersion-management technique. Such systems typically employ an interesting variant of the RZ format, known as the chirped RZ (or CRZ) format, in which optical pulses are prechirped before they are launched into the fiber.

An important issue is related to the choice of the physical variable that is modulated to encode the data on the optical carrier. The optical carrier wave before modulation is of the form

$$\mathbf{E}(t) = \hat{\mathbf{e}} a \cos(\omega_0 t - \phi) = \hat{\mathbf{e}} \mathrm{Re}[a \exp(i\phi - i\omega_0 t)], \tag{1.2.5}$$

where $\mathbf{E}$ is the electric field vector, $\hat{\mathbf{e}}$ is the polarization unit vector, a is the amplitude, ω_0 is the carrier frequency, and ϕ is the phase. The spatial dependence of $\mathbf{E}$ is suppressed for simplicity of notation. One may choose to modulate the amplitude a, the frequency ω_0, or the phase ϕ. In the case of analog modulation, the three modulation choices are known as amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). As shown schematically in Figure 1.10, The same modulation techniques can be applied in the digital case and are called amplitude-shift keying (ASK), frequency-shift keying (FSK), and phase-shift keying (PSK), depending on whether the amplitude, frequency, or phase of the carrier wave is shifted between the two levels of a binary digital signal. The simplest technique consists of simply changing the signal power between two levels, one of which is set to zero, and is often called *on–off keying* (OOK) to reflect the on–off nature of the resulting optical signal. Until recently, OOK was the format of choice for most digital lightwave systems.