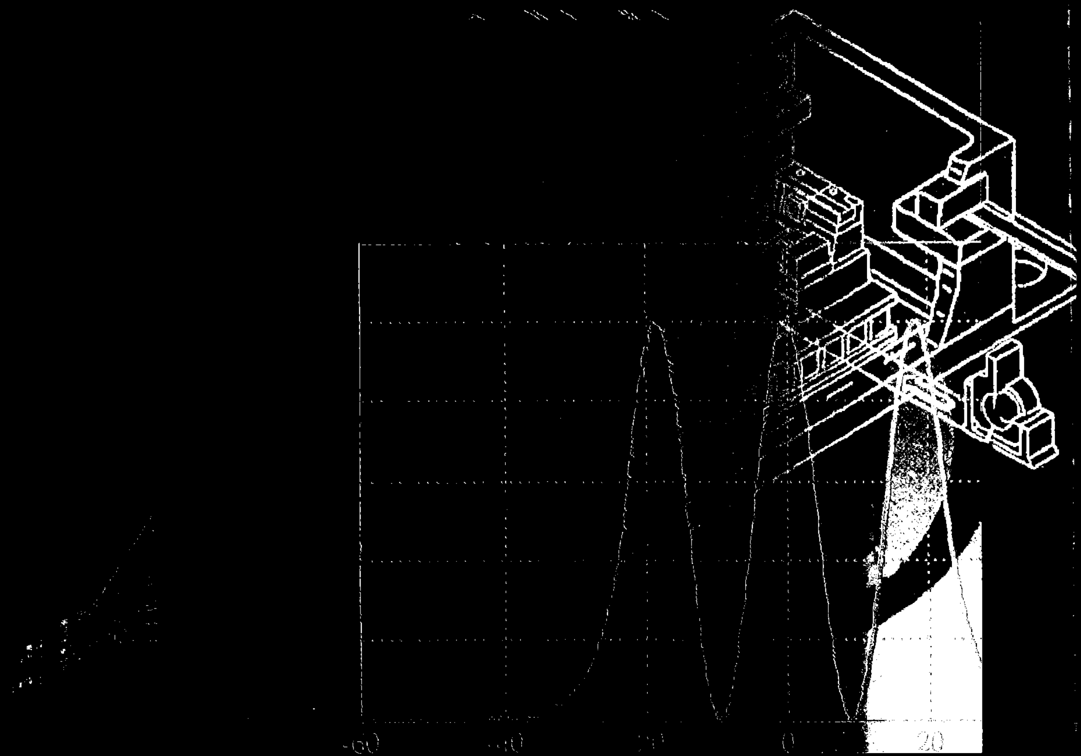
Optical Fiber Communication Systems



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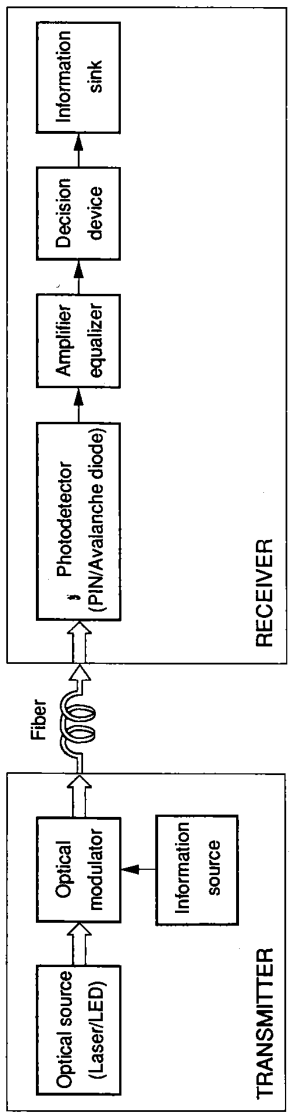

Figure 3.1 Block diagram of the basic IM-DD optical binary communication system.

the information channels in the frequency domain, a key feature for the exploitation of the huge bandwidth of optical fibers, particularly in the context of communication networks, where the frequency selectivity of conventional radio systems combined with the immense bandwidth of optical fibers opens up a wide range of new applications for telecommunications. Moreover, coherent technology has the potential of reducing by a factor of up to 4–5 the bandwidth through the use of multilevel transmission.

Further benefits have to do with the possibility of using constant envelope modulation schemes, like PSK and FSK. The former requires an external modulator but yields a reduced impact of stimulated Brillouin scattering (from 3 dBm to 30 dBm), whereas the latter can be obtained by direct modulation of the laser source, like for direct detection ASK modulation. With respect to direct detection, however, it has the advantage of significantly reduced chirp effects.

Optical coherent communication uses the optical field as a very high frequency carrier whose amplitude, phase, frequency, or polarization may be modulated by the information-bearing signal. Although this is very much the same as is commonly done for electromagnetic fields at lower frequencies, the big difference between the carrier frequency and the information signal bandwidth poses in the optical case some peculiar technological problems. Even the term *coherent* has here a different meaning from the standard radio environment. In fact, it is customary in the optical communication community to associate the adjective *coherent* to those systems in which a local oscillator lightwave is added to the incoming signal, even if subsequent processing and demodulation completely ignore the phase and frequency, as is the case of envelope detectors. This contrasts with the meaning of *coherent systems* in the classical communication literature, which require the recovery and use of the phase and frequency of the carrier to perform the demodulation and detection.

The basic configuration of a coherent communication system is shown in Figure 4.1. A laser-emitted light possessing a sufficiently stable frequency (quasi-monochromatic signal) is used as the carrier wave and modulated (in amplitude, frequency, phase, or polarization) by the information signal. At the receiver site, the

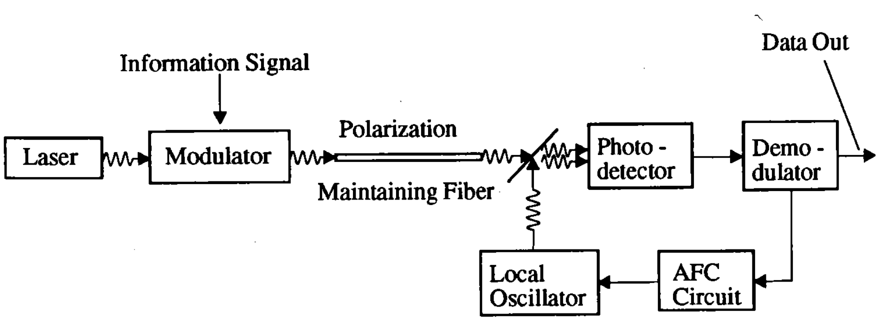

Figure 4.1 Block diagram of a coherent optical communication system.

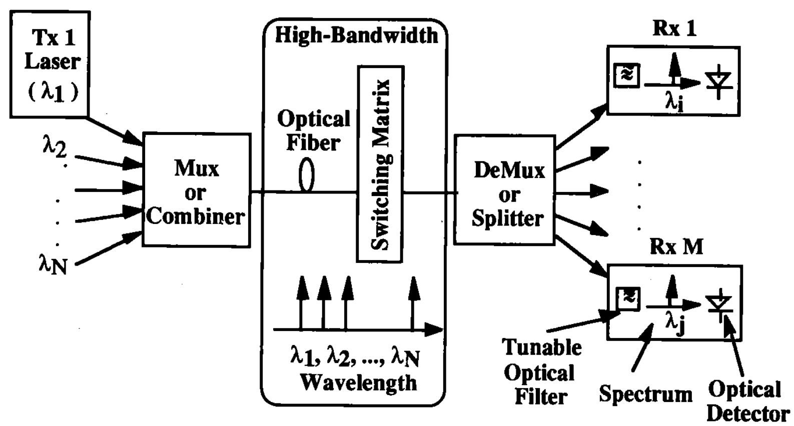

Figure 7.15 Diagram of a simple WDM system.

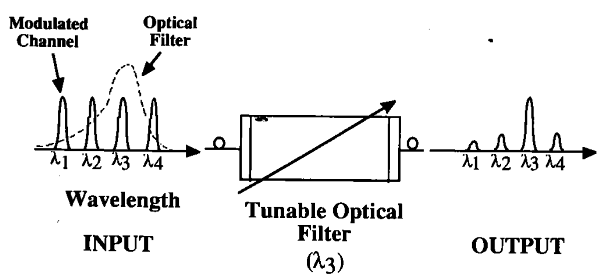

Figure 7.16 Optical WDM channels being demultiplexed by an optical filter.

filter. In the figure, four channels are input to an optical filter that has a nonideal transmission filtering function. The filter transmission peak is centered over the desired channel, in this case, λ_3, thereby transmitting that channel and blocking all other channels. Because of the nonideal filter transmission function, some optical energy of the neighboring channels leaks through the filter, causing interchannel, interwavelength cross-talk. This cross-talk has the effect of reducing the selected signal's contrast ratio and can be minimized by increasing the spectral separation between channels. Although there is no set definition, a nonstandardized convention exists for defining optical WDM, dense WDM, and *frequency-division multiplexing* (FDM) as encompassing a system for which the channel spacing is approximately 10 nm, 1 nm, and 0.1 nm, respectively. However, we will not make any distinction among those system labels in this book.