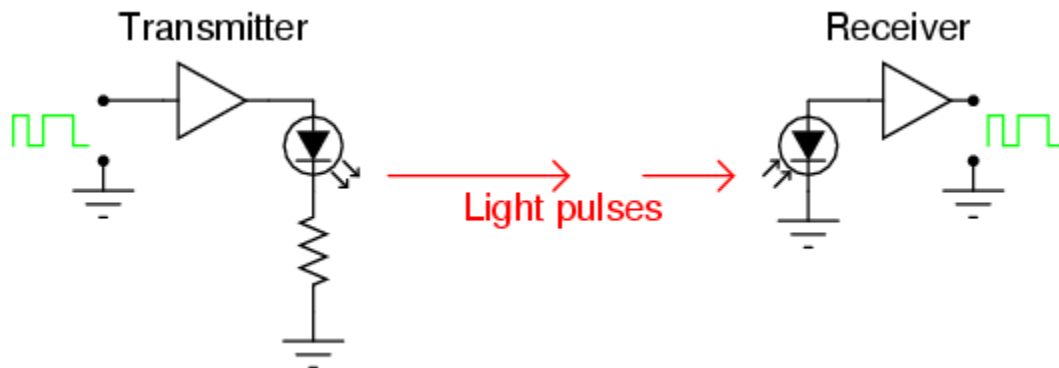
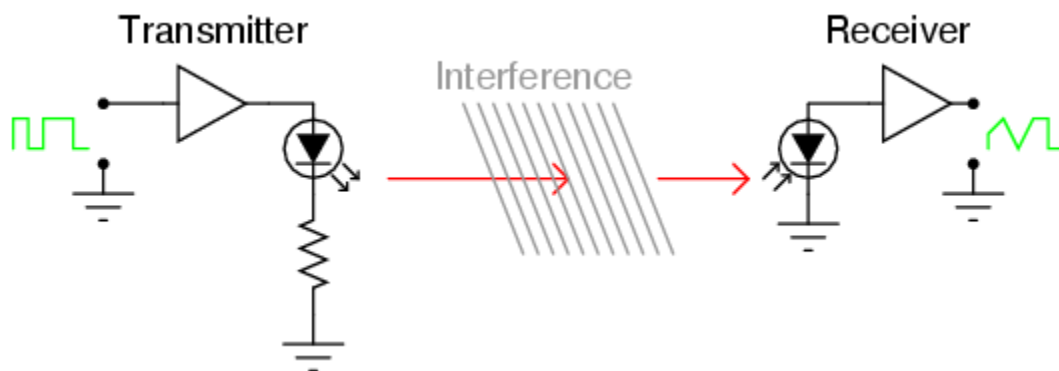


# Optical data communication

A modern alternative to sending (binary) digital information via electric voltage signals is to use optical (light) signals. Electrical signals from digital circuits (high/low voltages) may be converted into discrete optical signals (light or no light) with LEDs or solid-state lasers. Likewise, light signals can be translated back into electrical form through the use of photodiodes or phototransistors for introduction into the inputs of gate circuits.

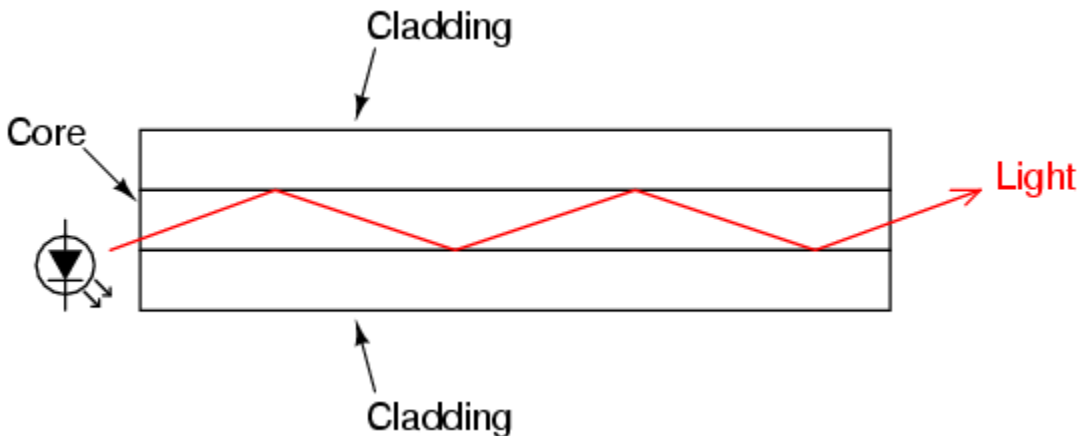


Transmitting digital information in optical form may be done in open air, simply by aiming a laser at a photodetector at a remote distance, but interference with the beam in the form of temperature inversion layers, dust, rain, fog, and other obstructions can present significant engineering problems:



One way to avoid the problems of open-air optical data transmission is to send the light pulses down an ultra-pure glass fiber. Glass fibers will "conduct" a beam of light much as a copper wire will conduct electrons, with the advantage of completely avoiding all the associated problems of inductance, capacitance, and external interference plaguing electrical signals. Optical fibers keep the light beam contained within the fiber core by a phenomenon known as total internal reflectance.

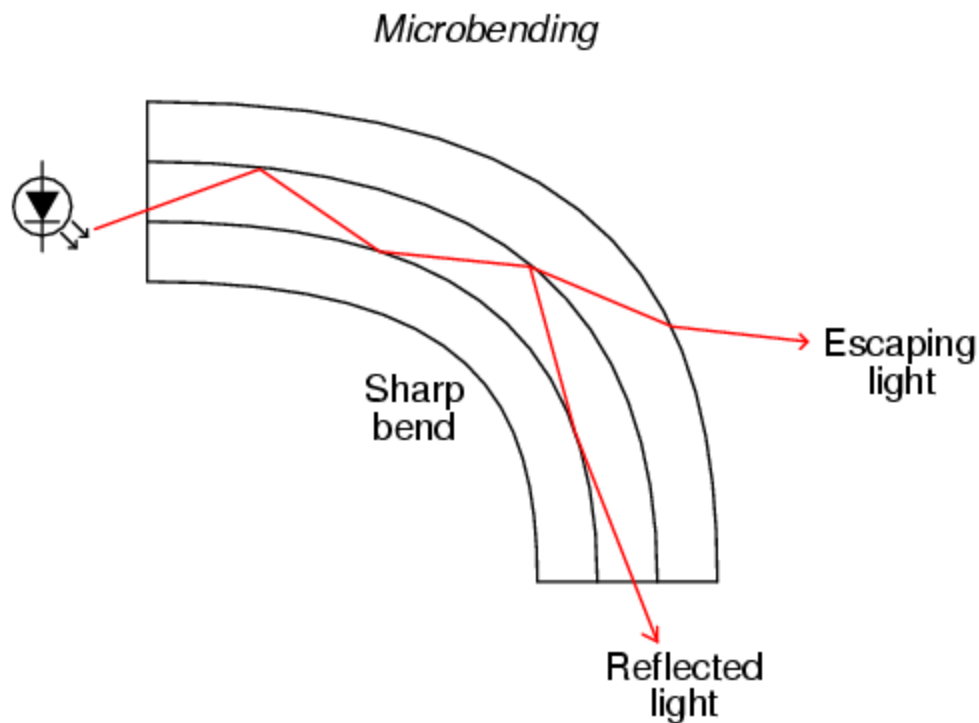
An optical fiber is composed of two layers of ultra-pure glass, each layer made of glass with a slightly different *refractive index*, or capacity to "bend" light. With one type of glass concentrically layered around a central glass core, light introduced into the central core cannot escape outside the fiber, but is confined to travel within the core:



These layers of glass are very thin, the outer "cladding" typically 125 microns (1 micron = 1 millionth of a meter, or  $10^{-6}$  meter) in diameter. This thinness gives the fiber considerable flexibility. To protect the fiber from physical damage, it is usually given a thin plastic coating, placed inside of a plastic tube, wrapped with kevlar fibers for tensile strength, and given an outer sheath of plastic similar to electrical wire insulation. Like electrical wires, optical fibers are often bundled together within the same sheath to form a single cable.

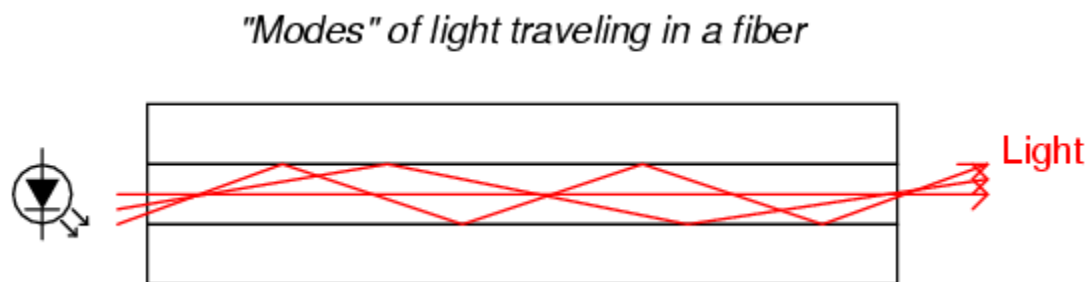
Optical fibers exceed the data-handling performance of copper wire in almost every regard. They are totally immune to electromagnetic interference and have very high bandwidths. However, they are not without certain weaknesses.

One weakness of optical fiber is a phenomenon known as *microbending*. This is where the fiber is bend around too small of a radius, causing light to escape the inner core, through the cladding:

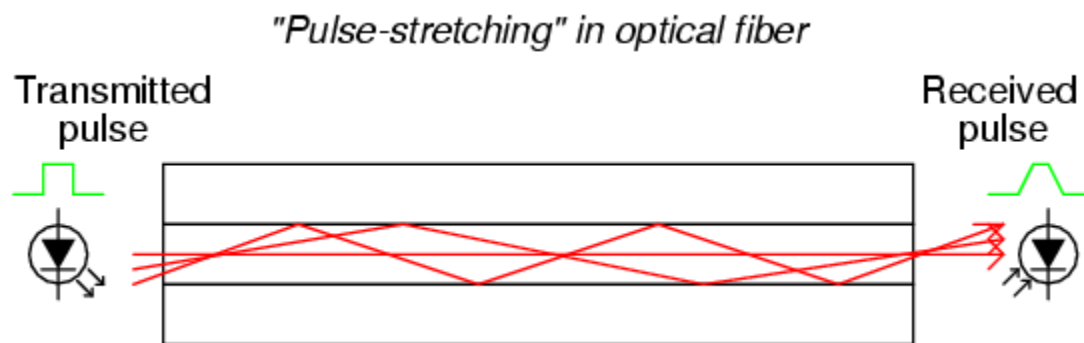


Not only does microbending lead to diminished signal strength due to the lost light, but it also constitutes a security weakness in that a light sensor intentionally placed on the outside of a sharp bend could intercept digital data transmitted over the fiber.

Another problem unique to optical fiber is signal distortion due to multiple light paths, or *modes*, having different distances over the length of the fiber. When light is emitted by a source, the photons (light particles) do not all travel the exact same path. This fact is patently obvious in any source of light not conforming to a straight beam, but is true even in devices such as lasers. If the optical fiber core is large enough in diameter, it will support multiple pathways for photons to travel, each of these pathways having a slightly different length from one end of the fiber to the other. This type of optical fiber is called *multimode* fiber:



A light pulse emitted by the LED taking a shorter path through the fiber will arrive at the detector sooner than light pulses taking longer paths. The result is distortion of the square-wave's rising and falling edges, called *pulse stretching*. This problem becomes worse as the overall fiber length is increased:



However, if the fiber core is made small enough (around 5 microns in diameter), light modes are restricted to a single pathway with one length. Fiber so designed to permit only a single mode of light is known as *single-mode* fiber. Because single-mode fiber escapes the problem of pulse stretching experienced in long cables, it is the fiber of choice for long-distance (several miles or more) networks. The drawback, of course, is that with only one mode of light, single-mode fibers do not conduct as much light as multimode fibers. Over long distances, this exacerbates the need for "repeater" units to boost light power.

Source: [http://www.allaboutcircuits.com/vol\\_4/chpt\\_14/5.html](http://www.allaboutcircuits.com/vol_4/chpt_14/5.html)