Fibre Optics

Principles and Practices

Abdul Al-Azzawi

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Figure 6.12 illustrates the isolator operation. An optical isolator is composed of a magnetic garnet crystal acting as a Faraday rotator; a permanent magnet for applying a designated magnetic field; and polarizing elements that permit only forward light to pass, while shutting out backward light. For this reason, optical isolators are indispensable devices for eliminating the adverse effect of back reflection in fibre optic systems. The optical isolator consists of two polarization elements and a 45° Faraday rotator placed between the polarization elements. The polarizer and the analyzer have a 45° difference in the direction of their light transmission axes. Forward light passing the optical isolator undergoes the following:

- When passing through the polarizer, the incident light is transformed into linearly polarized light.
- When passing through the Faraday rotator, the polarization plane of the linearly polarized light is rotated 45°.
- This light passes through the analyzer without loss, since the light polarization plane is now in the same direction as the light transmission axis of the analyzer, which is tilted 45° from the polarizer in the direction of Faraday rotation.

On the contrary, backward light undergoes a slightly different process:

- When passing through the analyzer, the backward light is transformed into linearly polarized light with a 45° tilt in the transmission axis.
- When passing through the Faraday rotator, the polarization plane of the backward light is rotated 45° in the same direction as the initial tilt.
- This light is completely shut out by the polarizer because its polarization plane is now tilted 90° from the light transmission axis of the polarizer.

6.11 OPTICAL CIRCULATORS

Optical circulators are used in a wide variety of applications within fibre communication systems. In advanced optical communication systems, optical circulators are used for bi-directional transmissions, wavelength division multiplexing (WDM) networks, fibre amplifier systems, optical time domain reflectrometers (OTDR), etc. Optical circulators are nonreciprocal devices that redirect a signal from port to port sequentially, in only one direction. The operation of an optical circulator is similar to that of an optical isolator; however, its construction is more complex. Figure 6.13(a) shows a three-port optical circulator. An input signal (λ_1) at Port 1 exits at Port 2, an input signal

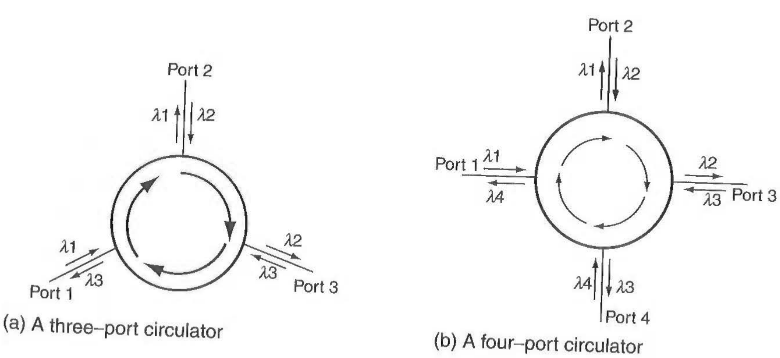

FIGURE 6.13 Circulator principle.

rays, which are called the ordinary (O) and extraordinary (E) components. The ordinary component passes through birefringent block 1 without refraction. The extraordinary component is refracted when it passes through birefringent block 1. Both ordinary and extraordinary components pass through the Faraday rotator and phase retardation plates. As a result, both components are rotated 90° clockwise. The component that was the ordinary in block 1 becomes the extraordinary component. The extraordinary component in block 1 becomes the ordinary component. The two components meet birefringent block 2, which is similar to block 1. Then, the two components re-combine to form the original light ray when exiting block 2, which enters Port 2, as shown in Figure 6.14.

On the other hand, a light beam entering at Port 2 will exit from Port 3, as shown in Figure 6.15. The light entering Port 2 is split by birefringent block 2 into two separate rays, similar to the light passing through birefringent block 1. The ordinary component passes through birefringent block 2 without refraction. The extraordinary component is refracted when it passes through birefringent block 2. The two components meet birefringent block 1, the ordinary component passes through to the polarizing beam splitter, and the extraordinary component refracts towards the reflector prism. The two components recombine at the polarizing beamsplitter prism to form the original light ray, which exits from Port 3. Using the same principles, light can be traced when it enters at Port 3 and exits at Port 1.

6.12 OPTICAL FILTERS

Optical filters are used in a wide variety of applications within optics and optical fibre devices. They are also used in a wide variety of optical applications in the fields of microscopy, photometry, radiometry, imaging, instrumentation, displays, charge-coupled devices (CCDs), astronomy, aerospace, etc. Scientific, electronic, analytical, imaging, and medical instrument companies are designing the next evolution of their products using a range of selected optical filters. There are many devices that are not called filters but have the same characteristics as a filter. Such devices are switches, modulators, array waveguide gratings, grating diffractions, grating multiplexers, etc. These devices are presented in detail in different chapters throughout the book.

Optical filters are devices that allow specific wavelengths to pass while rejecting all other wavelengths. Optical filters can be divided into two categories: fixed filters and tunable filters.

6.12.1 Fixed Optical Filters

Fixed optical filters are commonly made from coloured glass (silica), thin metallic films, or thin dielectric films, as shown in Figure 6.16. Some metallic films, such as inconel, chromium, and nickel, are particularly insensitive to wavelength for absorption. On the other hand, the amount of absorption by coloured glass can vary as much as several orders of magnitude over only tens of nanometres of wavelength.

There is an extensive range of optical filter types. The following filters can be found in the market: visible filters, combination filters, infrared radiation cut-off filters, narrow bandpass filters, calibration filters, laser application filters, ultraviolet transmitting filters, infrared transmitting filters, light balancing filters, skylight filters, sharp cut filters, contrast filters, colour temperature conversion filters, special application filters, etc.

Optical filter selection depends on a multitude of factors, including wavelength selection, shape and passband width, blocking outside the passband, transmittance colour matching, material and thickness, vibration and shock resistance, ordinary and advanced anti-reflection coatings, heat absorption, and long-term stability.