Engineering Standards and Technology

WDM Product Notes

CLEARFIELD

In the field of fiber-optics, WDM stands for Wavelength Division Multiplexing. This is a technology which combines many optical signals onto one fiber by using different light wavelengths (i.e. colors) of laser light. This technique also enables bi-directional communications over one strand of fiber, as well as multiplying the capacity of fibers used in fiber optic networks. The concept was first published in 1970. By 1978, WDM systems were being tested in the laboratory. Most WDM systems operate on single mode fiber optic cables. Some forms of WDMs are made to work with multimode fiber cables.

WDMs combine or multiplex (Mux) more than one wavelength onto one fiber. This is done by a discrete device, using fiber pigtail collimators and wavelength/light filters that are aligned and mounted in a glass sub-straight and typically packaged in a stainless steel tube for increased protection. The optical filtering devices used are typically solid-state, single-frequency Fabry–Pérot interferometers in the form of thin-film-coated optical glass filters. The wavelength/light filters only allow specific wavelengths of light to pass through the filter and the remainder of the wavelengths to be reflected back. WDMs can also be used to separate or demultiplex (demux) more than one signal using the same device and transmitting the signal in the opposite direction. Wideband WDMs typically are 1,310 nm and 1,550 nm devices with an operating window of ± 50 nm of each specific wavelength. The 1,310 nm port will have an actual operating wavelength window of 1,270 nm to 1,360 nm. The 1,550 nm port will have an operating wavelength window of 1,500 nm to 1,600 nm.

Fiber Optic WDMs are used to increase the amount of information that can be transmitted over a single fiber. A typical two channel WDM will be used to multiplex (Mux) two different wavelengths onto one fiber. This allows you to simultaneously transmit two different networks/systems over the same fiber. If you are using a WDM multiplexer at the beginning of your network, you will most likely need to use a WDM Demultiplexer (Demux) at the opposite end to separate (or demultiplex) the wavelengths to allow them to be directed to the correct receivers. Using a simple two wavelength WDM can increase the service capacity by two times for the same number of fibers. If you are currently using four fibers, you will be able to double your capacity and free up fibers for other use.

Today's WDM systems can handle as many as 160 signals and can transmit a basic 10 Gbit/s system on a single fiber, to over 1.6 Tbit/s on a single fiber. This is achieved by using Course Wave Division Multiplexing (CWDM) and Dense Wave Division Multiplexing (DWDM) - other forms of WDMs. Course Wave Division Multiplexing (CWDM) works very similarly to the WDMs mentioned earlier, however CWDMs offer more channels using wavelength/channel spacing of 20 nm with a working passband of ± 6.5 nm from the wavelength's center. This allows you to add multiple wavelengths onto one fiber and gives us the ability to use 2, 4 or 8 channels and even up to 16 or 18 channels, depending on the actual classification of the glass fiber being used. In 2002, the ITU standardized a channel spacing grid for use with CWDM (ITU-T G.694.2), using the wavelengths from 1,270 nm through 1,610 nm with a channel spacing of 20 nm. (G.694.2 was revised in 2003 to shift the actual channel centers by 1, so that strictly speaking, the center wavelengths are 1,271 to 1,611 nm, but are still typically referred to by 1,270 nm to 1,610 nm). Depending on the optical glass fiber used, many CWDM wavelengths below 1,470 nm are considered "unusable" on older G.652 specification fibers, due to the increased attenuation in the high water peak band of 1,360 nm to 1,460 nm. Improved fibers which conform to the G.652.C and G.652.D standards nearly eliminate the "water peak" attenuation and allow for full operation of all 18 ITU CWDM channels. CWDM is popular with the Cable TV networks, where different wavelengths are used for the downstream and upstream signals. In these networks, the wavelengths used are often widely separated. For example, the downstream signal might be in the 1,470 nm to 1,610 nm range, while the upstream signal is typically the 1,310 nm wavelength.

Dense Wavelength Division Multiplexing (DWDM) takes the WDM and CWDM one step further by narrowing the channel spacing in the C and L Band range. DWDM signals within the ITU C Band, are wavelengths between 1,530 nm and 1,565 nm (C band) and 1,570 nm to 1,625 nm (L band) adhering to the DWDM ITU-T G.694.1 frequency grid. DWDMs allow you to increase your wavelength capacity even further by offering more channels in these bands. DWDM offers multiplexing of multiple channels using 200 GHz, 100 GHz and 50 GHz spacing with the option to have an added Expansion port and/or Monitor port. Some technologies are capable of 12.5 GHz spacing (sometimes called ultra dense WDM). Such spacing is only achieved by free-space optics technology. New amplification options enable the extension of the usable wavelengths to the L-band, more or less doubling the number of channels. Early DWDM systems contained 4 or 8 wavelength converting transponders in the mid 1990s. By the year 2000, commercial systems capable of carrying 128 signals were introduced. There have been even more advancements in DWDM technology where they are starting to test over 1,000 channels, but this is in its early developmental stages and is not yet ready for commercial use.

WDM systems are popular with Telecommunication, Cable TV and Internet providers because they allow them to expand the capacity of the network without laying more fiber. By using WDM technology and optical amplifiers, they can accommodate several generations of technology in their optical infrastructure without having to overhaul the fiber optic backbone network. Capacity of any fiber network can be multiplied simply by upgrading to WDM, CWDM or DWDM technology.

WDM, CWDM and DWDM are all based on the same concept of adding multiple wavelengths of light onto a single fiber, but differ in their spacing of wavelengths, number of channels and the ability to amplify the multiplexed signals. EDFAs provide an efficient means of amplification for the DWDM wavelengths. However, CWDM optical amplification is not available, limiting the CWDM optical spans to several tens of kilometer.