

DWDM Expansion over CWDM

Tom Jeffers, Associate Product Manager

ABSTRACT

Wavelength Division Multiplexing (WDM) is a technology that increases the data-carrying capacity of optical fiber by allowing multiple streams of data to be transported using different wavelengths of light. The primary benefit of WDM technology is that it requires just a single optical fiber which, in most cases, has already been deployed. Therefore, it is a much less expensive option for expanding network capacity compared to installing additional fiber cables.

With 18 total wavelengths available, CWDM is popular and a good start for most customers due to its relatively low cost and high increase in capacity versus a single data stream. However, as bandwidth demands increase, it becomes necessary for those same customers to add additional capacity. DWDM allows you to add this additional capacity without replacing your existing CWDM infrastructure and with minimal—if any—service interruption.

In addition to adding capacity, DWDM also offers other advantages compared to CWDM. This paper will provide a brief background of WDM technology and then discuss the options and benefits of expanding from CWDM into a DWDM network.

INTRODUCTION

There are two primary types of WDM technology:

- **Coarse** Wavelength Division Multiplexing (**CWDM**)
- **Dense** Wavelength Division Multiplexing (**DWDM**)

CWDM uses a maximum of 18 wavelengths spaced 20 nm apart from 1271 nm to 1611 nm. Due to optical fiber attenuation constraints in the lower end of this spectrum, typically only the upper 8 wavelengths (1471-1611) are utilized. CWDM is suitable for short-range transmission since signal amplification is not possible across the entire optical spectrum.

DWDM can support hundreds of channels with tightly-packed wavelengths spaced less than 0.8 nm apart from 1520 nm to 1577 nm. There are no significant attenuation constraints in this region. Additionally, this relatively narrow spectral region allows for signal amplification which makes DWDM suitable for long-range transmission. Table 1 below provides an overview of CWDM and DWDM technology.

Table 1—Overview of CWDM vs. DWDM Technology

CWDM	DWDM
Defined by wavelengths	Defined by frequencies (channels)
Maximum 18 wavelengths	Hundreds of channels available
Wavelengths spread far apart	Tightly packed wavelengths
Wide passband	Narrow passband
Less expensive lasers can be used	Precision lasers required
Signal amplification not possible	Signal amplification is possible
Short-range transmission	Long-haul transmission

Contrary to popular belief, it is possible to use both CWDM and DWDM in the same network. However there are some considerations to make before expanding from CWDM to DWDM. For customers anticipating the need to use both CWDM and DWDM, there are two primary options:

1. Plan Ahead—Leave CWDM wavelengths open for future DWDM expansion
2. Override—Use CWDM ports to pass DWDM channels

WDM SPECTRUM BANDS

In order to consider your options, it is first important to understand where CWDM and DWDM wavelengths are found on the optical spectrum.

There are five optical spectrum bands as it relates to WDM technology¹:

O-Band (Original):	1260-1360 nm
E-Band (Extended):	1360-1460 nm
S-Band (Short Wavelength):	1460-1530 nm
C-Band (Conventional):	1530-1565 nm
L-Band (Long Wavelength):	1565-1625 nm

Figure 1 shows these five optical spectrum bands and where CWDM and DWDM wavelengths are mapped. Notice that there is an overlap of CWDM and DWDM wavelengths near the 1531-1571 region. Therefore, you cannot use CWDM and DWDM in this region at the same time.

However, this overlapped region is actually very beneficial and is a fundamental principal to understanding options for WDM expansion.

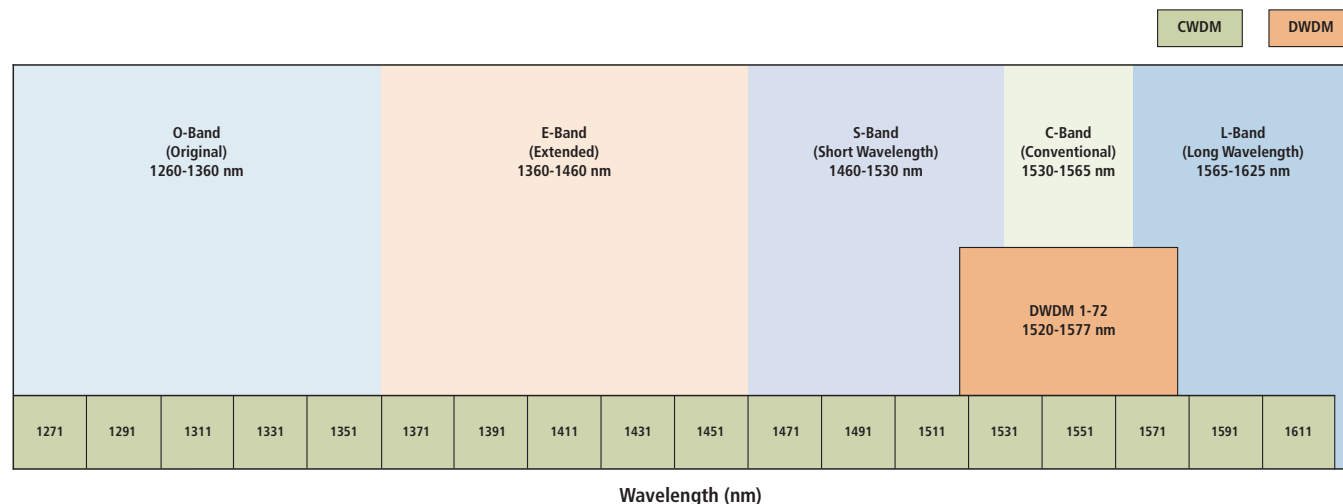


Figure 1—CWDM and DWDM on the Optical Spectrum

CONVENTIONAL BAND (C-BAND) 1530-1565 nm

If we zoom in on the 1531-1571 region (Figure 2), we can see all individual DWDM channels and how they overlap with the CWDM wavelengths. Most of these DWDM channels are found in a region known as the Conventional Band (C-Band).

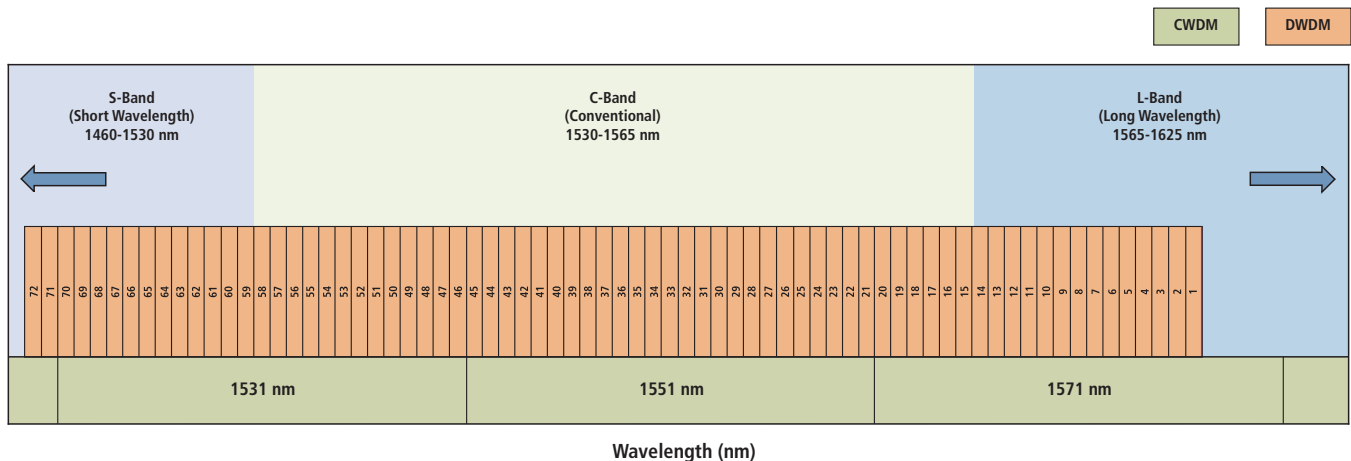


Figure 2—Conventional Band (C-Band)

The C-Band is a very significant piece of the optical spectrum. In addition to providing expansion options, there are two key benefits to this region:

1. Low level of attenuation
2. Optical amplification is possible

Low attenuation + Optical amplification = Long-haul transmission

The inherent low attenuation of this region plus the ability for optical amplification makes DWDM ideally suited for long-haul transmission. This is a primary benefit of DWDM technology, and another factor in deciding to add DWDM signals to your network..

DWDM EXPANSION OPTION #1—PLAN AHEAD

In order to maximize the number of DWDM channels that will be available for future expansion, it is necessary to plan ahead. Remember, since CWDM and DWDM regions overlap on the optical spectrum, it is not possible to use those overlapped regions for CWDM and DWDM at the same time.

If the DWDM region is already allocated to CWDM, then those DWDM channels will not be immediately available without first disconnecting the CWDM signals. By leaving the DWDM region unused, this section of the spectrum will be available to seamlessly add DWDM channels. An example of this is shown in Figure 3.

The advantages of planning ahead are that the maximum number of DWDM channels can be added directly into your CWDM network without any service interruption or replacement of CWDM infrastructure.

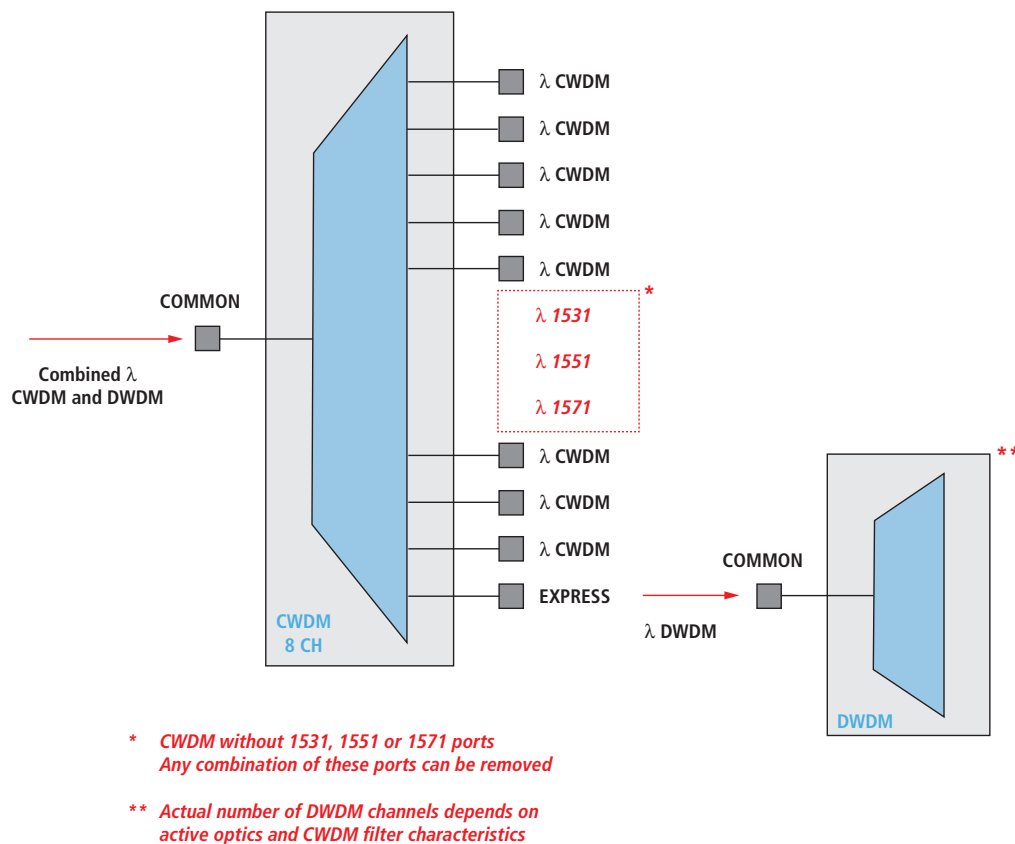


Figure 3—DWDM Expansion Option #1—Plan Ahead

DWDM EXPANSION OPTION #2—OVERRIDE

The best option to maximize the number of DWDM channels that will be available for future expansion is to plan ahead. However, in most cases CWDM is already being deployed using wavelengths that are common to the DWDM region. The good news is that there are still ways to expand and obtain a high number of DWDM channels.

CWDM ports can be used to pass a limited number of DWDM channels. An example of this is shown in Figure 4. However, it is typically not possible to add DWDM channels directly into the network without some interruption to your existing network. CWDM signals will need to be disconnected before running DWDM over the same fiber.

By using CWDM ports to pass DWDM channels, a high number of channels can be added. However, the number of channels obtained will be less than Option #1 and some service interruption will usually occur.

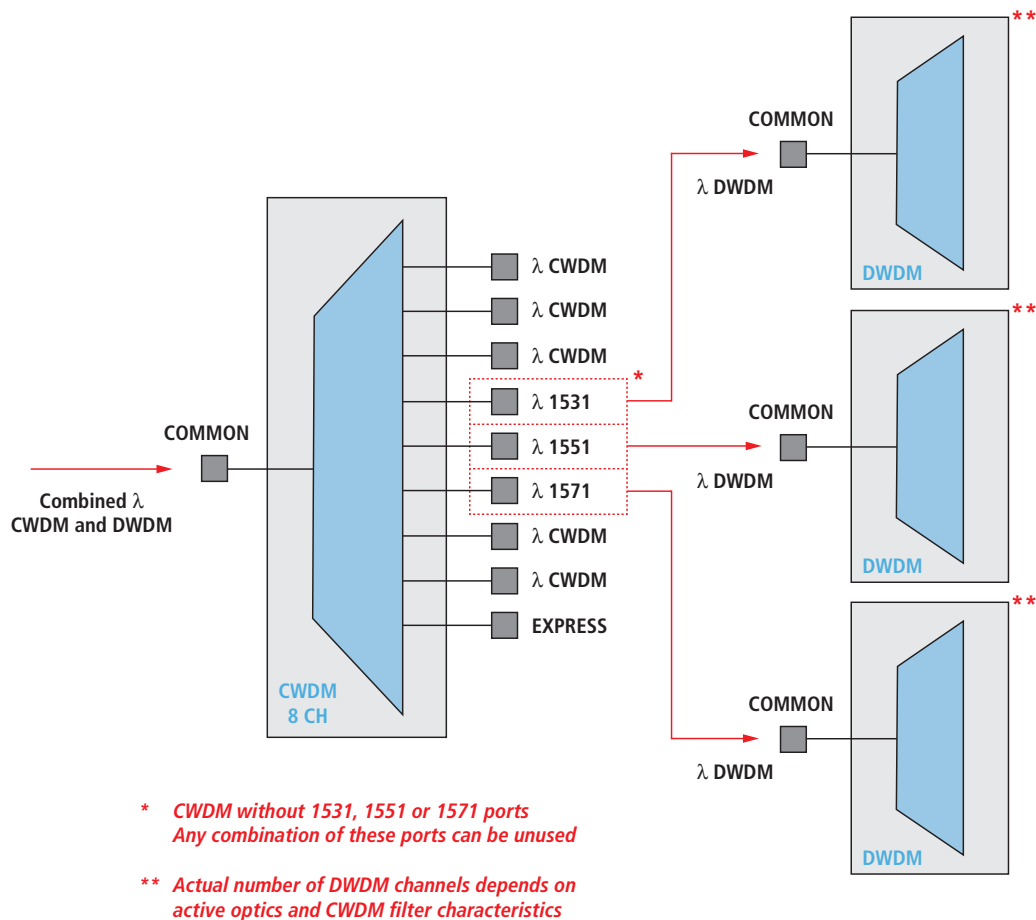


Figure 4—DWDM Expansion Option #2—Override

SUMMARY

WDM technology provides a cost-effective way to add hundreds of channels to your network. Planning ahead can save time and maximize the number of channels available, but a high number of channels can be obtained no matter how your network is structured. Most customers start with CWDM, but when that capacity is exhausted, there are always options for expansion using DWDM without having to replace CWDM infrastructure. Not only does DWDM increase the total number of channels available, it has additional advantages over CWDM which make it a great way to prepare your network for the future.

AUTHOR

Tom Jeffers, PMP, is an associate product manager for AFL's Optical Connectivity and Apparatus (OCA) division. Prior to joining AFL, Tom spent ten years with Emerson Network Power Connectivity Solutions where he developed custom fiber optic products for the military, aerospace, and commercial markets. His experience includes project management, new product development, R&D, product management, manufacturing engineering, and testing.

REFERENCES

1. https://www.rp-photonics.com/optical_fiber_communications.html
2. ITU-T G.694.1. "Spectral Grids for WDM Applications: DWDM Frequency Grid," International Telecommunications Union (ITU), Telecommunication Standardization Sector of ITU, February 2012.
3. ITU-T G.694.2. "Spectral Grids for WDM Applications: CWDM Frequency Grid," International Telecommunications Union (ITU), Telecommunication Standardization Sector of ITU, December 2003.



www.AFLglobal.com