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Optical line systems: the road to 100Tbps

Optical system capacity enhanced by extended C-band, Super C-band, and C+L bands

Information Classification: General

Ovum view

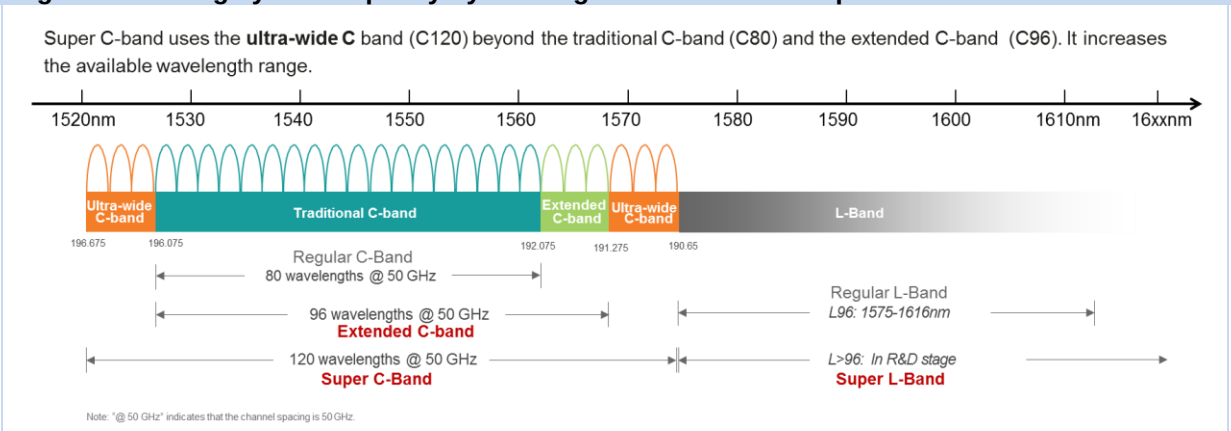
Summary

Advances in transmission, optical line amplification, and ROADM switching technologies are enabling more wavelengths to be transported on optical fiber systems. The additional wavelengths transmitted enables a greater overall transmission per fiber pair improving network economics. Today's industry transmission standard is 96 wavelengths in the extended C-band. The industry is currently in the midst of evaluating the merits of "Super C-band" and C+L solutions. The higher wavelength systems pave the way for 100Tbps transmission. Network operators are constantly searching for the lowest cost per solutions. Super C and C+L require technology ecosystem development. Once Super C and C+L achieve high volume production, the communications services providers will be able to reap the benefits of lower cost per bit systems.

From the historic 80 to today's norm 96 wavelengths per pair

From the mid-2000s, 80 wavelengths transmitted per fiber pair has been the long-standing historical standard. The industry has moved to 96 wavelengths per fiber pair utilizing the extended C-band, see Figure 1.

Figure 1: Raising system capacity by utilizing all viable band of spectrum



Source: https://www.itu.int/rec/T-REC-G.694.1-201202-I/en

Extended C-band provides a low cost, system transmission capacity boost

The extended C-band supports up to 96 wavelengths compared to the 80 wavelengths for traditional C-band for a 20% bandwidth improvement per fiber pair. For example, with 100Gbps wavelengths, the transmission bandwidth increases from 8Tbps to 9.6Tbps. Extended C-band operation leverages traditional C-band optical line systems, essentially, enabling the bandwidth improvement with minimal incremental cost in the line system.

Further capacity expansion enabled by Super C and C+L bands

The next steps in the optical transmission evolution will be utilizing the Super C-band and the L-band. There are 120 wavelengths in the ultra-wide C-band and, with C+L, there are an additional 96 wavelengths in the L-band. Both Super-C and C+L require the development of technology ecosystems to support the enhanced spectrum range. Transmission lasers, amplifiers, and switching elements within ROADMs all require an upgrade to support the expanded spectrum.

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Super C will require the tunable lasers and modulators to operate in the greater Super C-band range. Laser output power will need to be flat over the extended wavelength range. The Super C-band amplifiers also need to work over the Super C range with minimal gain variation over the range. New doping elements have been considered to operationalize amplifier gain over the Super C range. Liquid crystal on silicon (LCOS) is the volume switching technology deployed in ROADMs today. To achieve Super C switching, the resolution must be improved to adjust and control the more numerous wavelengths precisely.

Super L-band is the ultra-wide version of regular L-band and is able to provide more than 96 channels based on 50GHz standard channel spacing. To date, L-band has been a bit niche and has not achieved the status of universally adopted, practical technology. Super C and Super C+L both are in the classic technology–economic ecosystem market development catch-22. High volumes are required to enable cost effective systems but CSPs will not purchase until they see very attractive economics.

The catalyst for igniting this market will most likely be CSPs, enterprises or others that are very fiber constrained. Organizations, that have only a fiber pair on a route will be highly motivated to maximize the transmission bandwidth on their scarce fiber pairs. Those organizations will endure low volume, early market equipment costs that will be less expensive in aggregate than procuring additional fiber pairs. Market momentum will build from there, enabling the Super C and the C+L ecosystems to potentially develop into volume markets.

The industry focus is higher speed per wavelength. By utilizing, all of the economically viable spectrum, network operators can deploy more wavelengths per fiber pair, leading to lower overall cost per bit systems.

Information Classification: General

Appendix

Further reading

"5G in Japan: Large-scale rollout will require strategic infrastructure sharing," SPT002-000240, (October 2019)

Datacom Optical Components Forecast Report: 2019–24, SPT003-000047, (August 2019)

Datacom Transceiver and AOC Forecast: 2018–24, SPT003-000044, (July 2019)

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We hope that this analysis will help you make informed and imaginative business decisions. If you have further requirements, Ovum's consulting team may be able to help you. For more information about Ovum's consulting capabilities, please contact us directly at consulting@ovum.com.

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Mobile networks deliver essential, informational and entertainment services. The newest services consume more bandwidth and require very fast response times. The new services are stressing today's networks. Network operators need to have a very firm handle on network performance to ensure a high quality user experience.

Historic service assurance tools are not up to the task of today's managing the network for today's advanced services. Service assurance must now be measured in sub-seconds to pinpoint episodic traffic burst conditions that lead to network degradation. Network operators do not want to be in the position that users experience and immediately detect a network degradation event while the network operator does not have visibility of the issue.

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