WDM, DWDM e CWDM

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Corso di Componenti Fotonici

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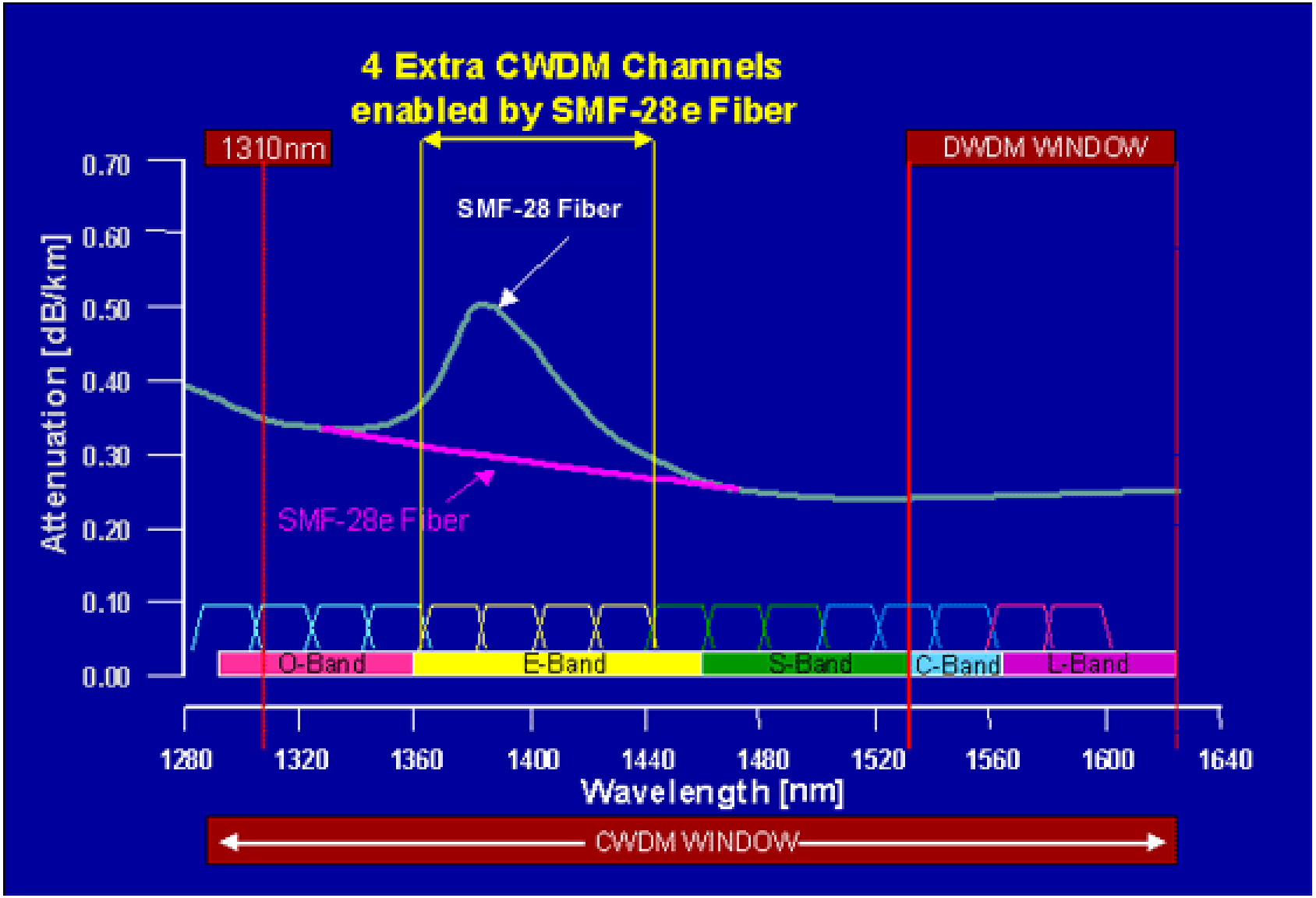
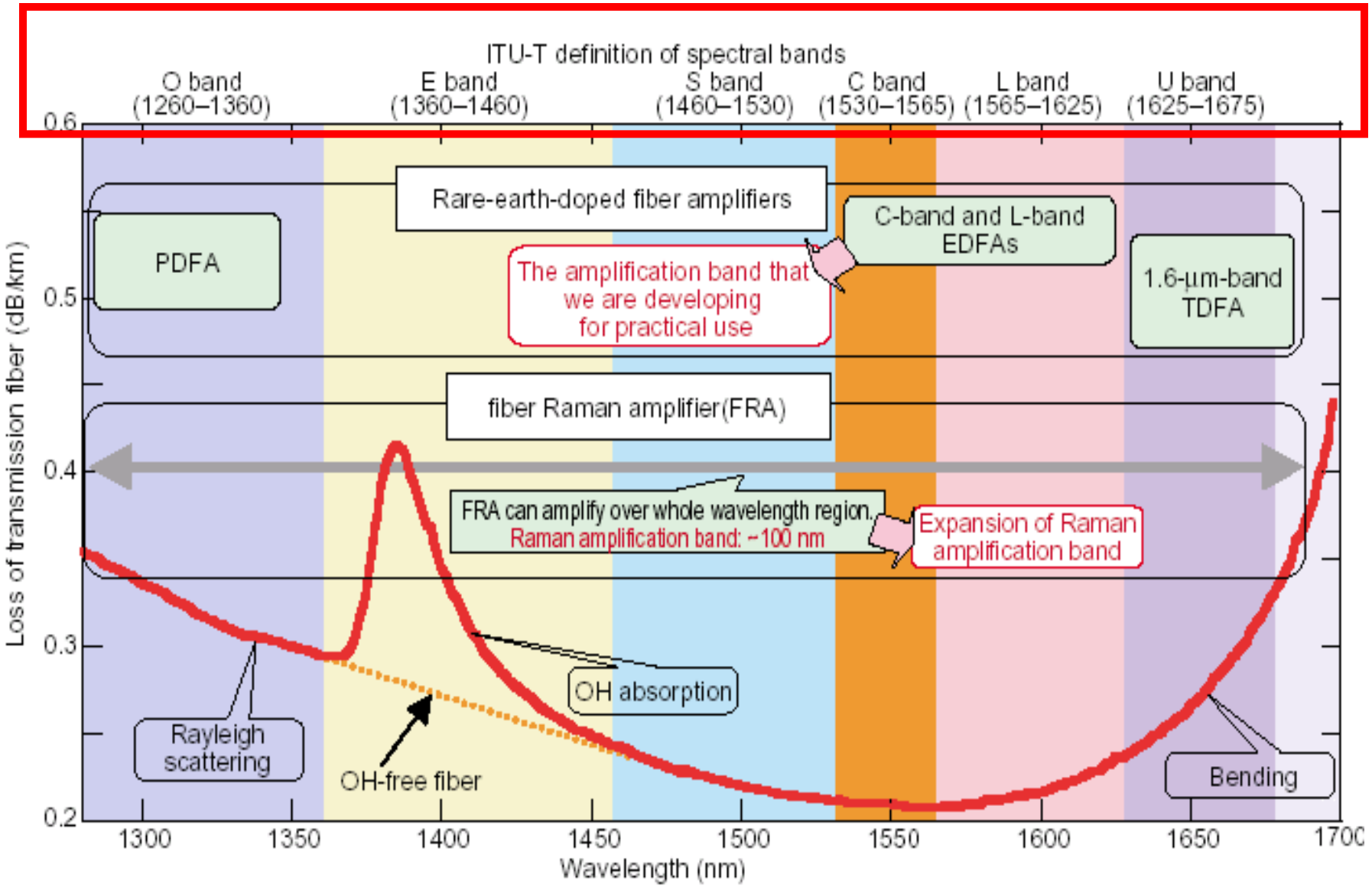

4 Extra CWDM Channels
enabled by SMF-28e Fiber
1310nm
DWDM WINDOW
SMF-28 Fiber
SMF-28e Fiber
Attenuation [dB/km]
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
O-Band
E-Band
S-Band
C-Band
L-Band
1280
1320
1360
1400
1440
1480
1520
1560
1600
1640
Wavelength [nm]
CWDM WINDOW


ITU-T definition of spectral bands
O band (1260–1360)
E band (1360–1460)
S band (1460–1530)
C band (1530–1565)
L band (1565–1625)
U band (1625–1675)
Rare-earth-doped fiber amplifiers
PDFA
C-band and L-band EDFAs
1.6-μm-band TDFA
The amplification band that we are developing for practical use
fiber Raman amplifier(FRA)
FRA can amplify over whole wavelength region.
Raman amplification band: ~100 nm
Expansion of Raman amplification band
OH absorption
Rayleigh scattering
OH-free fiber
Bending
Loss of transmission fiber (dB/km)
0.6
0.5
0.4
0.3
0.2
1300
1350
1400
1450
1500
1550
1600
1650
1700
Wavelength (nm)

INTERNATIONAL TELECOMMUNICATION UNION

Dense WDM and its application

Dense Wavelength Division Multiplexing (DWDM), a WDM technology, is characterised by narrower channel spacing than Coarse WDM (CWDM) as defined in ITU-T Rec. G.671. In general the transmitters employed in DWDM applications require a control mechanism to enable them to meet the application's frequency stability requirements, in contrast to CWDM transmitters which are generally uncontrolled in this respect.

The frequency grid defined by this Recommendation supports a variety of channel spacings ranging from 12.5 GHz to 100 GHz and wider (integer multiples of 100 GHz). Uneven channel spacings are also allowed.

The current steps in channel spacing have historically evolved by sub-dividing the initial 100 GHz grid by successive factors of two.

Nominal central frequencies for dense WDM systems

For channel spacings of 12.5 GHz on a fibre, the allowed channel frequencies (in THz) are defined by:

$193.1 + n \times 0.0125$ where n is a positive or negative integer including 0

For channel spacings of 25 GHz on a fibre, the allowed channel frequencies (in THz) are defined by:

$193.1 + n \times 0.025$ where n is a positive or negative integer including 0

For channel spacings of 50 GHz on a fibre, the allowed channel frequencies (in THz) are defined by:

$193.1 + n \times 0.05$ where n is a positive or negative integer including 0

For channel spacings of 100 GHz or more on a fibre, the allowed channel frequencies (in THz) are defined by:

$193.1 + n \times 0.1$ where n is a positive or negative integer including 0

Frequency grid

Table 1/G.694.1 – Example nominal central frequencies of the DWDM grid

Nominal central frequencies (THz) for spacings of				Approximate nominal central wavelengths (nm)
12.5 GHz	25 GHz	50 GHz	100 GHz and above	
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
195.9375	–	–	–	1530.04
195.9250	195.925	–	–	1530.14
195.9125	–	–	–	1530.24
195.9000	195.900	195.90	195.9	1530.33

12.5 GHz	25 GHz	50 GHz	100 GHz and above	
195.8875	–	–	–	1530.43
195.8750	195.875	–	–	1530.53
195.8625	–	–	–	1530.63
195.8500	195.850	195.85	–	1530.72
195.8375	–	–	–	1530.82
195.8250	195.825	–	–	1530.92
195.8125	–	–	–	1531.02
195.8000	195.800	195.80	195.8	1531.12
195.7875	–	–	–	1531.21
195.7750	195.775	–	–	1531.31
195.7625	–	–	–	1531.41
195.7500	195.750	195.75	–	1531.51
195.7375	–	–	–	1531.60
195.7250	195.725	–	–	1531.70
195.7125	–	–	–	1531.80
195.7000	195.700	195.70	195.7	1531.90

Coarse Wavelength Division Multiplexing (CWDM)

- La tecnologia di trasporto ottico basata sulla multiplazione di lunghezza d'onda a spaziatura larga, si sta rapidamente affermando
- Soluzione efficiente ed economica per un utilizzo in ambito metropolitano e di accesso, sia in reti Lineari (Punto-Punto, Bus) che ad Anello (Ring).
- Il CWDM è nato con lo specifico obiettivo di operare in ambito metropolitano al fine di ridurre i costi di trasporto, laddove **non** sono richieste prestazioni elevate in termini di banda, numero di canali e distanza trasmissiva.
- Il contenimento dei costi deriva in particolare dagli elementi chiave di tale tecnologia, che consente l'impiego di sorgenti ottiche a basso costo e di Multiplazione/Demultiplazione ottica passiva, oltre a prevedere l'assenza di amplificazione ottica.

International Telecommunication Union sets Global Standard for Metro Networks

- Standard needed to satisfy the demands of voice, data and multimedia services for low-cost short-haul transport solutions in urban centres.
- The ITU has set a global standard for Metro 'Optical Fibre' Networks that will expand the use of Coarse Wavelength Division Multiplexing (CWDM) in metropolitan networks.
- This standard is necessary to meet the increasing demand of voice, data and multimedia services for low-cost short-haul optical transport solutions.
- CWDM applications are especially good for coverage of up to 50 kilometres.
- Where the distances are shorter and the need for capacity is less, CWDM applications are able to use wider channel spacing and less expensive equipment, yet achieve the same quality standards of long-haul optical fibre systems.

DWDM vs CWDM

- Dense WDM optical systems require a thermoelectric cooler to stabilize the wavelength emission and absorb the power dissipated by the laser.
- This consumes power while adding cost.
- For short transmission distances a 'coarse' wavelength grid can reduce terminal costs by eliminating the temperature control and allowing the emitted wavelengths to drift with ambient temperature changes.

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.694.2

(12/2003)

Nominal central wavelengths for coarse WDM systems

The nominal central wavelengths for coarse WDM systems are used as a reference to define, for each channel used, an upper wavelength bound and a lower wavelength bound. These bounds define limits for the wavelength of the transmitter under all conditions and at the same time the wavelength limits over which the specifications of the optical multiplexers and demultiplexers must be met.

The upper wavelength bound is the central wavelength of the channel plus the central wavelength deviation found in the Recommendation defining the application.

The lower wavelength bound is the central wavelength of the channel minus the central wavelength deviation found in the Recommendation defining the application.

The CWDM grid wavelengths within the range 1271 nm to 1611 nm are shown in Table 1. The value of "c" (speed of light in vacuum) that should be used for converting between wavelength and frequency is 2.99792458×10^8 m/s.

Table 1/G.694.2 – Nominal central wavelengths

Nominal central wavelengths (nm) for spacing of 20 nm
1271
1291
1311
1331
1351
1371
1391
1411
1431
1451
1471
1491
1511
1531
1551
1571
1591
1611
NOTE – The endpoints of this table are illustrative only.

Central wavelength spacing and wavelength variation

Effective CWDM realizations with uncooled lasers and wide passband filters require a nominal central wavelength spacing of not less than 20 nm. Total source wavelength variation of the order of ±6-7 nm is expected to be compatible with current filter technologies. As for the guardband, one third of the minimum channel spacing is sufficient. Therefore, in order to maximize the number of channels, 20 nm has been chosen.

Specific values and allocations of this variation will be defined in individual applications.

The wavelength variation is determined by mainly two factors. First, the laser manufacturer is allowed a wavelength variation around the nominal wavelength in order to achieve a higher yield and/or relax fabrication tolerances. Second, the use of uncooled lasers will cause the wavelength to change with temperature within the specified temperature range of the laser.