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Introduction

This document contains draft revised G.694.1 for consent. Changes with respect to the in-force version of G.694.1 are shown with changemarks.

Version	Revision history	Date
1.0	In-force version of G.694.1	June 2002
1.1	Increase in the number of decimal places in Table 1 and new note added.	22 May 2005
1.11	Typos in wavelengths for 195.925 and 195.8625 THz corrected	18 April 2006
1.2	Output from Geneva meeting	17 Feb 2011
1.3	Output from Seoul meeting	13 June 2011
1.4	Output of correspondence after the Seoul meeting	3 Oct 2011
1.5	Output from Geneva Q6 meeting	5 Dec 2011
1.6	As modified after joint meeting on Flexible DWDM Grid	13 Dec 2011

Summary

This Recommendation provides a frequency grid for dense wavelength division multiplexing (DWDM) applications.

The frequency grid, anchored to 193.1 THz, supports a variety of channel spacings ranging from 12.5 GHz to 100 GHz and wider.

Edition 2.0 of this Recommendation also includes a flexible DWDM grid.

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ITU-T Recommendation G.694.1

Spectral grids for WDM applications: DWDM frequency grid

1 Scope

The purpose of this Recommendation is to provide the definition of a frequency grid to support dense wavelength division multiplexing (DWDM) applications.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[ITU-T G.671] – ~~ITU-T~~ Recommendation ITU-T G.671 (2009~~2~~), *Transmission characteristics of optical components and subsystems*.

3 Definitions

3.1 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.1.1 Frequency ~~G~~grid: A frequency grid is a reference set of frequencies used to denote allowed nominal central frequencies that may be used for defining applications.

3.1.2 Frequency slot: The frequency range allocated to a slot and unavailable to other slots within a flexible grid. A frequency slot is defined by its nominal central frequency and its slot width.

3.1.3 Slot width: The full width of a frequency slot in a flexible grid.

3.2 Terms defined in other Recommendations

This Recommendation uses terms defined in [ITU-T ~~Rec.~~ G.671]:

– Coarse Wavelength Division Multiplexing (CWDM).

– Dense Wavelength Division Multiplexing (DWDM).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

CWDM Coarse Wavelength Division Multiplexing

DWDM Dense Wavelength Division Multiplexing

WDM Wavelength Division Multiplexing

5 Dense WDM and its applications

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 fixed channel spacings ranging from 12.5 GHz to 100 GHz and wider (integer multiples of 100 GHz) as well as a flexible grid. Uneven channel spacings using the fixed grids are also allowed.

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

6 Fixed grid ~~N~~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

Table 1 illustrates some nominal central frequencies within the C and L bands based on the 12.5 GHz minimum channel spacing anchored to the 193.1 THz reference. Table 1 also illustrates the 25, 50 and 100 GHz grid frequencies within the same region. The endpoints shown are illustrative, not normative.

Note that the value of "c" (speed of light in vacuum) that should be used for converting between frequency and wavelength is 2.99792458×10^8 m/s.

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) (Note)
12.5 GHz	**25 GHz**	**50 GHz**	**100 GHz and above**	
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
195.9375	–	–	–	1530.041304
195.9250	195.925	–	–	1530.138914
195.9125	–	–	–	1530.236524
195.9000	195.900	195.90	195.9	1530.334133
195.8875	–	–	–	1530.431843
195.8750	195.875	–	–	1530.529553
195.8625	–	–	–	1530.627163
195.8500	195.850	195.85	–	1530.724872
195.8375	–	–	–	1530.822582
195.8250	195.825	–	–	1530.920392
195.8125	–	–	–	1531.018002
195.8000	195.800	195.80	195.8	1531.115712
195.7875	–	–	–	1531.213521
195.7750	195.775	–	–	1531.311231
195.7625	–	–	–	1531.409041
195.7500	195.750	195.75	–	1531.506851
195.7375	–	–	–	1531.604660
195.7250	195.725	–	–	1531.702470
195.7125	–	–	–	1531.800380
195.7000	195.700	195.70	195.7	1531.898190
195.6875	–	–	–	1531.996002.00
195.6750	195.675	–	–	1532.093809
195.6625	–	–	–	1532.191719
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•

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) (Note)
12.5 GHz	**25 GHz**	**50 GHz**	**100 GHz and above**	
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
193.2375	–	–	–	1551.419742
193.2250	193.225	–	–	1551.520052
193.2125	–	–	–	1551.620462
193.2000	193.200	193.20	193.2	1551.720872
193.1875	–	–	–	1551.821282
193.1750	193.175	–	–	1551.921692
193.1625	–	–	–	1552.022002
193.1500	193.150	193.15	–	1552.122512
193.1375	–	–	–	1552.222922
193.1250	193.125	–	–	1552.323432
193.1125	–	–	–	1552.423942
193.1000	193.100	193.10	193.1	1552.524452
193.0875	–	–	–	1552.624962
193.0750	193.075	–	–	1552.725473
193.0625	–	–	–	1552.825983
193.0500	193.050	193.05	–	1552.926593
193.0375	–	–	–	1553.027003
193.0250	193.025	–	–	1553.127613
193.0125	–	–	–	1553.228223
193.0000	193.000	193.00	193.0	1553.328833
192.9875	–	–	–	1553.429443
192.9750	192.975	–	–	1553.530053
192.9625	–	–	–	1553.630763
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•

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) (Note)
12.5 GHz	**25 GHz**	**50 GHz**	**100 GHz and above**	
•	•	•	•	•
•	•	•	•	•
184.7750	184.775	–	–	1622.473147
184.7625	–	–	–	1622.582858
184.7500	184.750	184.75	–	1622.692669
184.7375	–	–	–	1622.802480
184.7250	184.725	–	–	1622.912291
184.7125	–	–	–	1623.022002
184.7000	184.700	184.70	184.7	1623.131913
184.6875	–	–	–	1623.241724
184.6750	184.675	–	–	1623.351635
184.6625	–	–	–	1623.461546
184.6500	184.650	184.65	–	1623.571457
184.6375	–	–	–	1623.681368
184.6250	184.625	–	–	1623.791279
184.6125	–	–	–	1623.901290
184.6000	184.600	184.60	184.6	1624.011101
184.5875	–	–	–	1624.121112
184.5750	184.575	–	–	1624.231123
184.5625	–	–	–	1624.341134
184.5500	184.550	184.55	–	1624.451145
184.5375	–	–	–	1624.561256
184.5250	184.525	–	–	1624.671267
184.5125	–	–	–	1624.781378
184.5000	184.500	184.50	184.5	1624.891489
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
Note – The wavelengths given in this table are approximations only. The specifications applied to DWDM applications are defined with respect to the				

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) (Note)
12.5 GHz	**25 GHz**	**50 GHz**	**100 GHz and above**	
nominal central frequencies and not the approximate wavelengths.				

7 Flexible DWDM grid definition

For the flexible DWDM grid, the allowed frequency slots have a nominal central frequency (in THz) defined by:

193.1 + n × 0.00625 where n is a positive or negative integer including -0
and 0.00625 is the nominal central frequency granularity in THz

and a slot width defined by:

12.5 × m where m is a positive integer and 12.5 is the slot width granularity in GHz.

Any combination of frequency slots is allowed as long as no two frequency slots overlap.

Further information on the use of the flexible grid can be found in Appendix I.

Appendix I

Use of the flexible grid

(This appendix does not form an integral part of this Recommendation)

I.1 Flexible grid examples

In addition to the fixed spacing DWDM grids defined in Clause 6, a newer flexible DWDM grid has been introduced in Clause 7. One of the motivations for the flexible grid is to allow a mixed bit rate or mixed modulation format transmission system to allocate frequency slots with different widths so that they can be optimized for the bandwidth requirements of the particular bit rate and modulation scheme of the individual channels. Because of the complexity of defining multi-vendor interoperable transmission systems containing mixed bit rates or modulation formats, there are currently no DWDM optical interface Recommendations that make use of this grid.

An example use of the flexible DWDM grid is shown in Figure I.1 where two 50 GHz slots are shown together with two 75 GHz slots. For each slot in the figure, the values of n and m in the formulae defining the slot parameters in Clause 7 are also given. The frequency range between 193.125 THz and 193.18125 THz is shown unallocated. This range could be left as a "guard band" between the two sets of channels or it could subsequently be allocated to an additional slot with a

width of 50 GHz (n=8, m=4), leaving 6.25 GHz unallocated, or other alternatives (e.g., two 25 GHz slots n=6, m=2 and n=10, m=2).

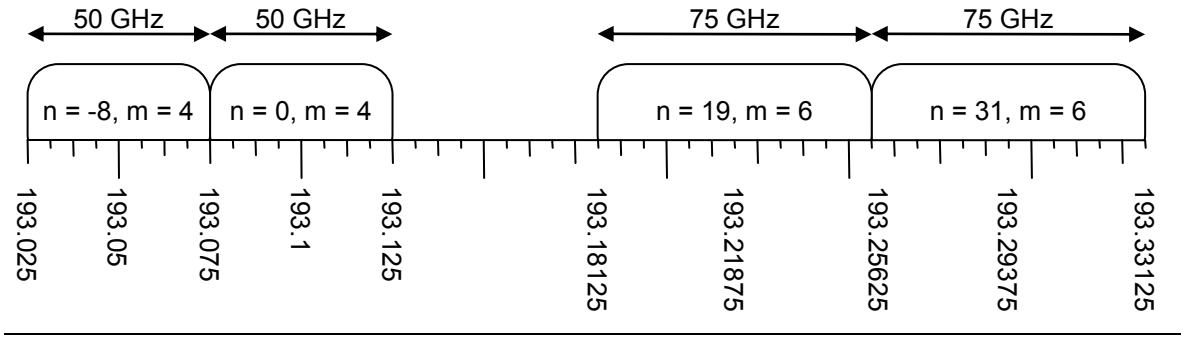

Figure I.1 – An example of the use of the flexible grid.

The granularity of the nominal central frequency and slot width parameters for the flexible DWDM grid have been chosen so that any of the fixed spacing DWDM grids defined in Clause 6 can also be described via suitable choices of slots in the flexible DWDM grid. For example, the 50GHz fixed spacing DWDM grid is shown in Figure I.2 represented using the DWDM flexible grid.

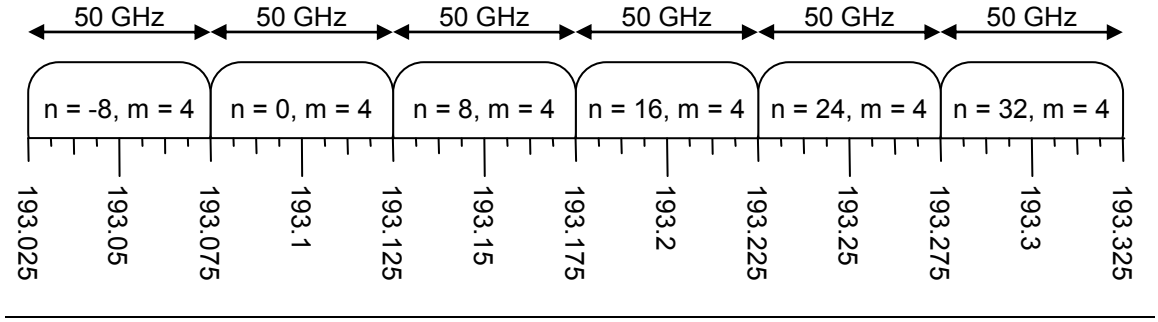

Figure I.2 – The 50 GHz fixed spacing grid represented using the flexible grid.

Since the smallest spacing fixed grid is 12.5 GHz, the slot width granularity needs to be 12.5 GHz. In order to be able to place a slot that has a width that is an even multiple of 12.5 GHz next to one with a width that is an odd multiple of 12.5 GHz without a gap, the nominal central frequency granularity needs to be 6.25 GHz. An example of this is shown in Figure I.3.

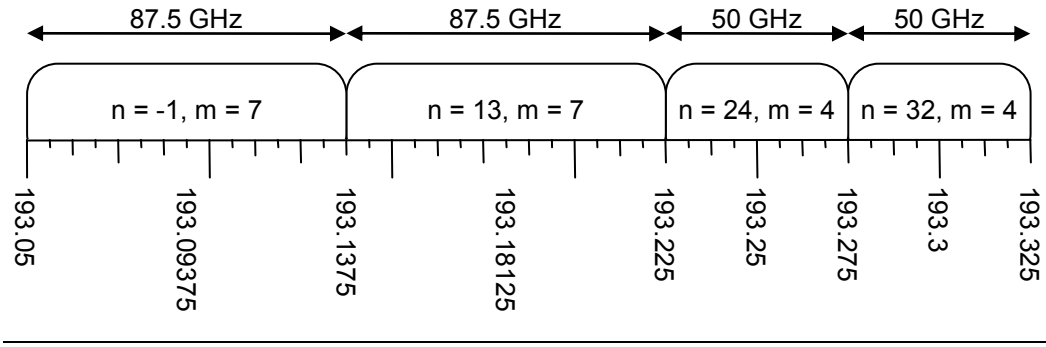

Figure I.3 – Example showing the need for 6.25 GHz nominal central frequency granularity.

I.2 Flexible grid compliance

The flexible DWDM grid defined in Clause 7 has a nominal central frequency granularity of 6.25 GHz and a slot width granularity of 12.5 GHz. However, devices or applications that make use of the flexible grid may not have to be capable of supporting every possible slot width or position. In other words, applications may be defined where only a subset of the possible slot widths and positions are required to be supported.

For example, an application could be defined where the nominal central frequency granularity is 12.5 GHz (by only requiring values of n that are even) and that only requires slot widths as a multiple of 25 GHz (by only requiring values of m that are even).

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