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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Transmission media and optical systems characteristics – Characteristics of optical systems

Spectral grids for WDM applications: DWDM frequency grid

Recommendation ITU-T G.694.1

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Recommendation ITU-T G.694.1

Spectral grids for WDM applications: DWDM frequency grid

Summary

Recommendation ITU-T G.694.1 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 3.0 of this Recommendation also includes a flexible DWDM grid and definitions for "frequency slot" and "slot width" that can be applied also in fixed grid applications.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.694.1	2002-06-13	15	11.1002/1000/6051
2.0	ITU-T G.694.1	2012-02-13	15	11.1002/1000/11482
3.0	ITU-T G.694.1	2020-10-29	15	11.1002/1000/14498

Keywords

DWDM, flexible grid, frequency slot, slot width.

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Recommendation ITU-T 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.671] Recommendation ITU-T G.671 (2019), *Transmission characteristics of optical components and subsystems*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms as described in [ITU-T G.671] in relation to CWDM devices and DWDM devices:

– Coarse wavelength division multiplexing (CWDM).

– Dense wavelength division multiplexing (DWDM).

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 frequency grid: A reference set of frequencies used to denote allowed nominal central frequencies that may be used for defining applications.

3.2.2 frequency slot: A contiguous frequency range characterized by its nominal central frequency and slot width. The frequency range allocated to a frequency slot is unavailable to other frequency slots.

3.2.3 slot width: The full width of the contiguous frequency range allocated to a frequency slot.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CWDM Coarse Wavelength Division Multiplexing

DWDM Dense Wavelength Division Multiplexing

WDM Wavelength Division Multiplexing

5 Conventions

None.

6 Dense wavelength division multiplexing and its applications

As defined in [ITU-T G.671], dense wavelength division multiplexing (DWDM), a wavelength division multiplexing (WDM) technology, is characterized by narrower channel spacing than coarse WDM (CWDM). 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.

7 Fixed grid 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 – 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	–	–	–	1530.0413
195.9250	195.925	–	–	1530.1389
195.9125	–	–	–	1530.2365
195.9000	195.900	195.90	195.9	1530.3341
195.8875	–	–	–	1530.4318

Table 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**	
195.8750	195.875	–	–	1530.5295
195.8625	–	–	–	1530.6271
195.8500	195.850	195.85	–	1530.7248
195.8375	–	–	–	1530.8225
195.8250	195.825	–	–	1530.9203
195.8125	–	–	–	1531.0180
195.8000	195.800	195.80	195.8	1531.1157
195.7875	–	–	–	1531.2135
195.7750	195.775	–	–	1531.3112
195.7625	–	–	–	1531.4090
195.7500	195.750	195.75	–	1531.5068
195.7375	–	–	–	1531.6046
195.7250	195.725	–	–	1531.7024
195.7125	–	–	–	1531.8003
195.7000	195.700	195.70	195.7	1531.8981
195.6875	–	–	–	1531.9960
195.6750	195.675	–	–	1532.0938
195.6625	–	–	–	1532.1917
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
193.2375	–	–	–	1551.4197
193.2250	193.225	–	–	1551.5200
193.2125	–	–	–	1551.6204
193.2000	193.200	193.20	193.2	1551.7208
193.1875	–	–	–	1551.8212
193.1750	193.175	–	–	1551.9216
193.1625	–	–	–	1552.0220
193.1500	193.150	193.15	–	1552.1225
193.1375	–	–	–	1552.2229
193.1250	193.125	–	–	1552.3234
193.1125	–	–	–	1552.4239
193.1000	193.100	193.10	193.1	1552.5244

Table 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**	
193.0875	–	–	–	1552.6249
193.0750	193.075	–	–	1552.7254
193.0625	–	–	–	1552.8259
193.0500	193.050	193.05	–	1552.9265
193.0375	–	–	–	1553.0270
193.0250	193.025	–	–	1553.1276
193.0125	–	–	–	1553.2282
193.0000	193.000	193.00	193.0	1553.3288
192.9875	–	–	–	1553.4294
192.9750	192.975	–	–	1553.5300
192.9625	–	–	–	1553.6307
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
184.7750	184.775	–	–	1622.4731
184.7625	–	–	–	1622.5828
184.7500	184.750	184.75	–	1622.6926
184.7375	–	–	–	1622.8024
184.7250	184.725	–	–	1622.9122
184.7125	–	–	–	1623.0220
184.7000	184.700	184.70	184.7	1623.1319
184.6875	–	–	–	1623.2417
184.6750	184.675	–	–	1623.3516
184.6625	–	–	–	1623.4615
184.6500	184.650	184.65	–	1623.5714
184.6375	–	–	–	1623.6813
184.6250	184.625	–	–	1623.7912
184.6125	–	–	–	1623.9012
184.6000	184.600	184.60	184.6	1624.0111
184.5875	–	–	–	1624.1211
184.5750	184.575	–	–	1624.2311
184.5625	–	–	–	1624.3411
184.5500	184.550	184.55	–	1624.4511
184.5375	–	–	–	1624.5612

Table 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**	
184.5250	184.525	–	–	1624.6712
184.5125	–	–	–	1624.7813
184.5000	184.500	184.50	184.5	1624.8914
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
NOTE – The wavelengths given in this table are approximations only. The specifications applied to DWDM applications are defined with respect to the nominal central frequencies and not the approximate wavelengths.				

8 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 dense wavelength division multiplexing (DWDM) grids defined in clause 7, a newer flexible DWDM grid has been introduced in clause 8. 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 8 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).

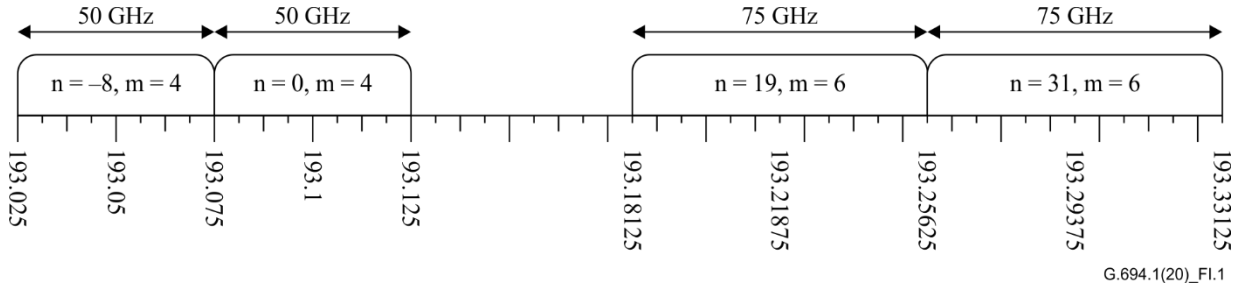

Figure I.1 – An example of the use of the flexible grid

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 7 can also be described via suitable choices of slots in the flexible DWDM grid. For example, the 50 GHz fixed spacing DWDM grid is shown in Figure I.2 represented using the DWDM flexible grid.

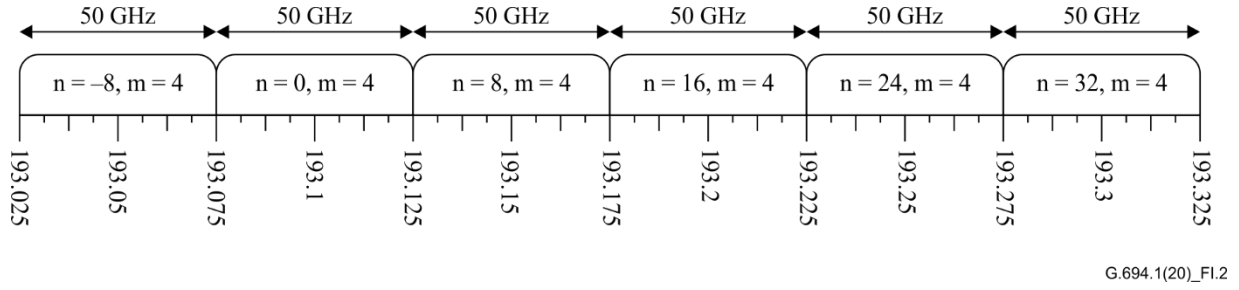

Figure I.2 – The 50 GHz fixed spacing grid represented using the flexible grid

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.

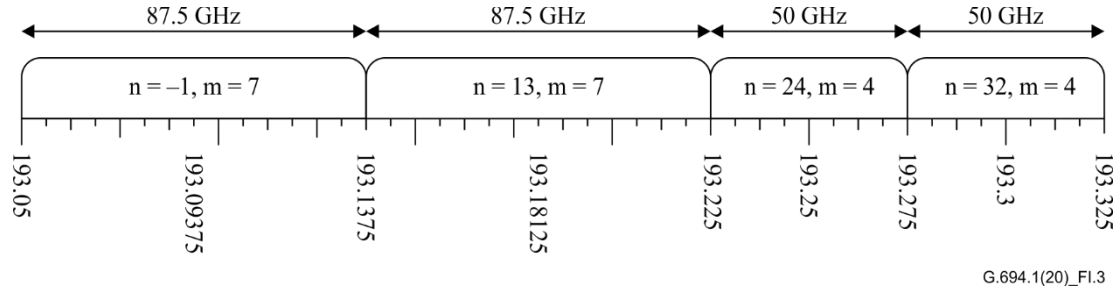

Figure I.3 – Example showing the need for 6.25 GHz nominal central frequency granularity

I.2 Flexible grid compliance

The flexible DWDM grid defined in clause 8 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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