CW-WDM MSA Technical Specifications

June 4th, 2021

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Revisions

Rev	Date	Description
0.1	June 15th, 2020	Preliminary draft
0.2	July 9th, 2020	Preliminary draft with editorial review
0.5	August 9th, 2020	Rev 0.5 with editorial review
0.51	August 10, 2020	Rev 0.51 minor editorial changes
0.6	December 1, 2020	Added 9 nm span grids. Added fixed wavelength example specifications. Updated formatting.
0.61	December 2, 2020	Public review candidate. Updates after MSA call.
0.72	May 31st, 2021	TBD changed to AS (Application Specific). AS description added to section 2.1. Tables 2.5 – 2.7 condensed to only 2 tables covering both modular and integrated sources. 2x8 grid proposal added to section 7. Section 3.6 re-written to describe updated figures. Figure 3.1 updated. Added power levels for 9nm grid. Example specifications for ELS added to section 7. Power definition changed from AOP to power as there is no modulation.
0.91	June 1st, 2021	Public review candidate. Pending approval for Rev 1.0 specification.
0.92	June 2nd, 2021	Public review candidate. Updates after promoter comments.
1.0	June 4th, 2021	First official specification ratified by promoters.

CONTENTS

TABLES

FIGURES

1 GENERAL

1.1 SCOPE

This Multi-Source Agreement (MSA) defines a set of wavelength grids, all in the O-band and covering three different spans. Lasers implementing the grids can be used for optical sources across multiple optical interconnect applications such as AI, optical computing, machine learning, and high density co-packaged optics. As part of this specification, each of the wavelength grids is defined with enough technical detail to ensure interoperability across the range of applications. Also included in this MSA document are descriptions of measurement methods that are required for compliance. Standardization of mechanical form factors will not be part of the first MSA standard but will be considered for follow-on specs.

1.2 BLOCK DIAGRAM

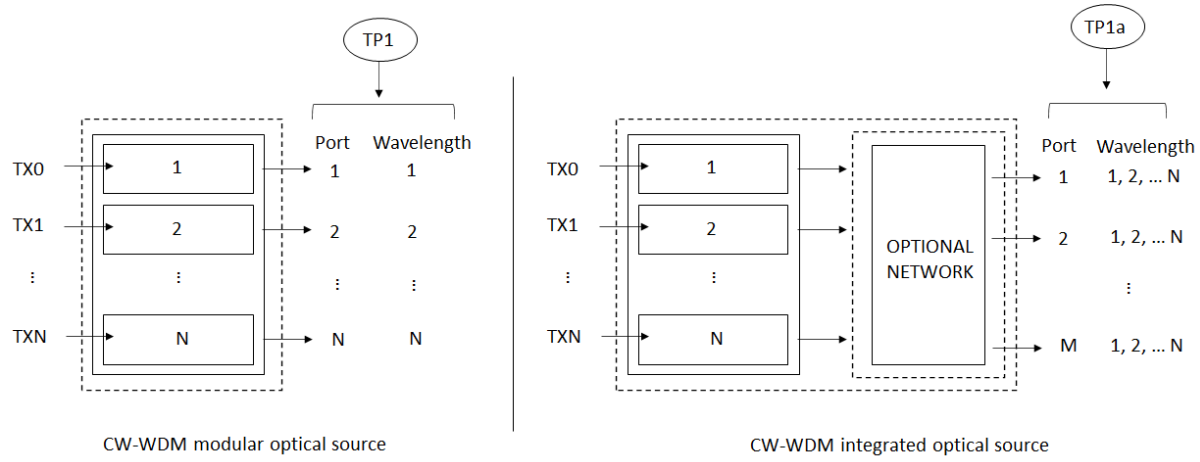

Figure 1-1 Optical Sources Block Diagrams

1.3 FUNCTIONAL DESCRIPTION

CW-WDM optical sources comply with the requirements of this document. Optical source configurations are shown in Figure 1-1. There are two configurations possible: a modular optical source with each output port carrying a single wavelength of a grid set, and an integrated optical source with each output port carrying all the wavelengths of a grid set. A port is defined as optical source output fiber.

For modular optical sources compliance is measured at TP1. For example, this could be the output fiber of an array of single frequency lasers. For integrated optical sources compliance is measured at TP1a. For example, this could be the output of a multi-frequency laser array or at the output of a laser array combined with an optical distribution network with M output fibers. The electrical interfaces in Figure 1-1 labeled TX0, TX1, … TXN are illustrative and not specified by the MSA.

1.4 HARDWARE SIGNALING PINS

The MSA does not specify hardware pins. This is left up to suppliers and users.

1.5 MANAGEMENT INTERFACE

The MSA does not specify a management interface. This is left up to suppliers and users.

1.6 OPERATING ENVIRONMENT

All specified minimum and maximum parameter values shall be met across operating temperature and supply voltages.

1.7 ELECTRICAL POWER SUPPLY AND POWER DISSIPATION

The MSA does not specify electrical power supplies for the optical sources. Power dissipation is defined for the optical source only and does not include other electronics.

2 OPTICAL SPECIFICATIONS

2.1 WAVELENGTH GRID ASSIGNMENTS

Eight wavelength grid sets are defined: 8+1, and 16+1 wavelengths in a 9 nm span; 8 + 1, 16 + 1, and 32 + 1 wavelengths in an 18 nm span; and 8+1, 16+1, and 32+1 wavelengths in a 36 nm span. Grid sets are listed in Table 2-1, 2-2, and 2-3. The shortest wavelength in each grid set is optional, for example, the L_{-4} wavelength for the 8 +1 wavelength grid. In the tables below, AS indicates parameters that are application specific that are meant to be agreed on between integrators and suppliers.

Table 2–1 9 nm wavelength span lane assignments

	8 + 1 wavelength grid set		16 + 1 wavelength grid set	
Lane	**Center wavelength (nm)**	**Frequency (THz)**	**Center wavelength (nm)**	**Frequency (THz)**
L_{-16}				
L_{-15}				
L_{-14}				
L_{-13}				
L_{-12}				
L_{-11}				
L_{-10}				
L_{-9}				
L_{-8}			1295.56 [a]	231.4 [a]
L_{-7}			1296.12	231.3
L_{-6}			1296.68	231.2
L_{-5}			1297.24	231.1
L_{-4}	1295.56 [a]	231.4 [a]	1297.80	231.0
L_{-3}	1296.68	231.2	1298.36	230.9
L_{-2}	1297.80	231.0	1298.93	230.8
L_{-1}	1298.93	230.8	1299.49	230.7
L_0	1300.05	230.6	1300.05	230.6
L_1	1301.18	230.4	1300.62	230.5
L_2	1302.31	230.2	1301.18	230.4
L_3	1303.45	230.0	1301.75	230.3
L_4	1304.58	229.8	1302.31	230.2
L_5			1302.88	230.1
L_6			1303.45	230.0
L_7			1304.01	229.9
L_8			1304.58	229.8
L_9				
L_{10}				
L_{11}				
L_{12}				
L_{13}				
L_{14}				
L_{15}				
L_{16}				

Notes:
[a] Denotes optional wavelength.

Table 2–2 18 nm wavelength span lane assignments

	8 + 1 wavelength grid set		16 + 1 wavelength grid set		32 + 1 wavelength grid set	
Lane	**Center wavelength (nm)**	**Frequency (THz)**	**Center wavelength (nm)**	**Frequency (THz)**	**Center wavelength (nm)**	**Frequency (THz)**
L_{-16}					1291.1[a]	232.2[a]
L_{-15}					1291.65	232.1
L_{-14}					1292.21	232.0
L_{-13}					1292.77	231.9
L_{-12}					1293.32	231.8
L_{-11}					1293.88	231.7
L_{-10}					1294.44	231.6
L_{-9}					1295.00	231.5
L_{-8}			1291.1[a]	232.2[a]	1295.56	231.4
L_{-7}			1292.21	232.0	1296.12	231.3
L_{-6}			1293.32	231.8	1296.68	231.2
L_{-5}			1294.44	231.6	1297.24	231.1
L_{-4}	1291.1[a]	232.2[a]	1295.56	231.4	1297.80	231.0
L_{-3}	1293.32	231.8	1296.68	231.2	1298.36	230.9
L_{-2}	1295.56	231.4	1297.80	231.0	1298.93	230.8
L_{-1}	1297.80	231.0	1298.93	230.8	1299.49	230.7
L_0	1300.05	230.6	1300.05	230.6	1300.05	230.6
L_1	1302.31	230.2	1301.18	230.4	1300.62	230.5
L_2	1304.58	229.8	1302.31	230.2	1301.18	230.4
L_3	1306.85	229.4	1303.45	230.0	1301.75	230.3
L_4	1309.14	229.0	1304.58	229.8	1302.31	230.2
L_5			1305.72	229.6	1302.88	230.1
L_6			1306.85	229.4	1303.45	230.0
L_7			1308.00	229.2	1304.01	229.9
L_8			1309.14	229.0	1304.58	229.8
L_9					1305.15	229.7
L_{10}					1305.72	229.6
L_{11}					1306.29	229.5
L_{12}					1306.85	229.4
L_{13}					1307.42	229.3
L_{14}					1308.00	229.2
L_{15}					1308.57	229.1
L_{16}					1309.14	229.0

Notes:

[a] Denotes optional wavelength.

Table 2–3 36 nm wavelength span lane assignments

	8 + 1 wavelength grid set		16 + 1 wavelength grid set		32 + 1 wavelength grid set	
Lane	**Center wavelength (nm)**	**Frequency (THz)**	**Center wavelength (nm)**	**Frequency (THz)**	**Center wavelength (nm)**	**Frequency (THz)**
L_{-16}					1282.26[a]	233.8[a]
L_{-15}					1283.36	233.6
L_{-14}					1284.46	233.4
L_{-13}					1285.56	233.2
L_{-12}					1286.66	233.0
L_{-11}					1287.77	232.8
L_{-10}					1288.88	232.6
L_{-9}					1289.98	232.4
L_{-8}			1282.26[a]	233.8[a]	1291.10	232.2
L_{-7}			1284.46	233.4	1292.21	232.0
L_{-6}			1286.66	233.0	1293.32	231.8
L_{-5}			1288.88	232.6	1294.44	231.6
L_{-4}	1282.26[a]	233.8[a]	1291.10	232.2	1295.56	231.4
L_{-3}	1286.66	233.0	1293.32	231.8	1296.68	231.2
L_{-2}	1291.10	232.2	1295.56	231.4	1297.80	231.0
L_{-1}	1295.56	231.4	1297.80	231.0	1298.93	230.8
L_0	1300.05	230.6	1300.05	230.6	1300.05	230.6
L_1	1304.58	229.8	1302.31	230.2	1301.18	230.4
L_2	1309.14	229.0	1304.58	229.8	1302.31	230.2
L_3	1313.73	228.2	1306.85	229.4	1303.45	230.0
L_4	1318.35	227.4	1309.14	229.0	1304.58	229.8
L_5			1311.43	228.6	1305.72	229.6
L_6			1313.73	228.2	1306.85	229.4
L_7			1316.03	227.8	1308.00	229.2
L_8			1318.35	227.4	1309.14	229.0
L_9					1310.28	228.8
L_{10}					1311.43	228.6
L_{11}					1312.58	228.4
L_{12}					1313.73	228.2
L_{13}					1314.88	228.0
L_{14}					1316.03	227.8
L_{15}					1317.19	227.6
L_{16}					1318.35	227.4

Notes:

[a] Denotes optional wavelength.

2.2 PORT ASSIGNMENTS

For modular optical sources, a port carries a single wavelength. For integrated optical sources, a port carries all the wavelengths. Table 2–4 defines the configurations for each optical source type.

Table 2–4 Output port configurations

Optical source type	Wavelengths	Number of Ports
Modular	8 + 1	8 + 1
	16 +1	16 + 1
	32 + 1	32 + 1
Integrated	8 + 1	AS
	16 + 1	
	32 + 1	

2.3 WAVELENGTH SPECIFICATIONS

Both integrated and modular optical sources shall meet the specifications in Table 2–5 and Table 2–56. Compliance for modular optical sources shall be measured at TP1, and for integrated optical sources at TP1a. All specifications are defined at the end of a fiber patch cord and compliance is based on measurement of the fiber output.

Table 2–5 Grid specifications[1]

Description	Wavelength span (nm)	Number of channels	Channel spacing (GHz)	Channel bandwidth (GHz)
Grid definition	9	8+1	200	100
		16+1	100	50
	18	8+1	400	200
		16+1	200	100
		32+1	100	50
	36	8+1	800	400
		16+1	400	200
		32+1	200	100

Notes:
[1] All parameters must be met across full temperature range with all ports active.

Table 2–6 Optical source specifications[1]

Description	Value	Unit
Nominal wavelength range, 9nm span [a]	1295.56 to 1304.58	nm
Nominal wavelength range, 18nm span [a]	1291.1 to 1309.14	nm
Nominal wavelength range, 36nm span [a]	1282.26 to 1318.35	nm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	AS	nm
Center wavelength variation range [b]	AS	nm
Side-mode suppression ratio (SMSR), (min)	AS	dB
Optical return loss tolerance (max) [c]	AS	dB
Relative intensity noise (per wavelength) [c]	AS	dB/Hz
Optical linewidth (max) [c]	AS	MHz
Optical port reflectance, each port (max) [d]	AS	dB
Launch power variation, each port (max)	AS	dB

Notes:
[1] All parameters must be met across full temperature range with all ports active.
[a] Nominal wavelength range and center wavelength offset range are specified at a fixed temperature to be agreed on between suppliers and integrators.
[b] Center wavelength variation range is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset.
[c] Relative intensity noise is specified with a reference receiver defined in section 3.4. Optical linewidth shall be measured using techniques described in section 3.7. Both linewidth and RIN specs shall be met across the full temperature range.
[d] Optical port reflectance is defined looking into TP1 or TP1a.

The maximum optical power levels for each of the wavelength grids are listed in Table 2–7. Three power classes, designated Type 1, Type 2 and Type 3 are shown. The optical power values for Type 1 are intended to comply with the eye safety limits outlined in Section 4 at the shortest wavelength for each grid. Type 2 limits are 6 dB below Type 1, and Type 3 limits are 6 dB higher than Type 1. Optical sources complying with Type 3 will need to have additional measures to ensure that eye safety limits are not exceeded when accessing the optical sources.

Table 2–7 Maximum output power classes [1]

Output power class [a]	9 nm span Maximum optical power	18 nm span Maximum optical power	36 nm span Maximum optical power	Units
Type 1	20	20	14	dBm
Type 2	14	14	8	dBm
Type 3	26	26	20	dBm

Notes:
[1] All parameters must be met simultaneously with all ports active.
[a] Output power is defined as the total of the optical power of all wavelengths within an optical fiber. Output power limits are for both integrated and modular optical sources.

3 DEFINITION OF OPTICAL PARAMETERS AND MEASUREMENT METHODS

All optical measurements shall be made by coupling light from the optical source to measurement setups described below. For measurements that require frequency dependent content, measurements should be performed with the appropriate levels of back reflection applied to TP1 or TP1a.

3.1 WAVELENGTH

The center wavelength shall be measured with all ports and all laser sources active. It is measured per TIA/EIA-455-127-A or IEC 61280-1-3 without any patterns applied.

3.2 OUTPUT POWER

The optical output power shall be measured using methods given in IEC 61280-1-1 without any patterns applied.

3.3 RELATIVE INTENSITY NOISE

A general description of the relative intensity noise measurement is given in IEEE Std. 802.3-2018 58.7.7. The following changes to the measurement method are required for CW-WDM:

1) The electrical receiver bandwidth should be AS GHz.
2) There is no modulation applied to the optical signal. In this case P_M is defined as the average optical power in the measurement.
3) An optical filter is required for integrated optical power supplies to isolate each individual wavelength and measure compliance. The bandwidth of this filter is AS.

For integrated optical source configurations, RIN is measured on each output port for each wavelength at TP1a. An optical filter (filter bandwidth AS) is used to measure each wavelength individually for all ports.

3.4 SIDE MODE SUPPRESSION RATIO (SMSR)

SMSR is defined as the ratio of the average optical power in the dominant longitudinal mode to the optical power of the most significant side mode in the presence of worst-case reflections. For optical sources that have multiple output wavelengths there is an additional SMSR requirement that refers to the power that exists outside the grid.

3.5 GRID DEFINITIONS

In Figure 3.1 below, the 8+1 grid is used to illustrate several key definitions from Table 2–5 and Table 2–5. Under nominal conditions, a compliant optical source must meet the grid spacing and channel bandwidth in Tables 2-1, 2-2, and 2-3. However, to allow for laser fabrication variation as well as a range of nominal operating conditions the entire wavelength grid can be shifted by up to +/- center wavelength offset range as described by the offset grid. Movement of the grid

over environmental conditions is also allowed and is described by the center wavelength variation range.

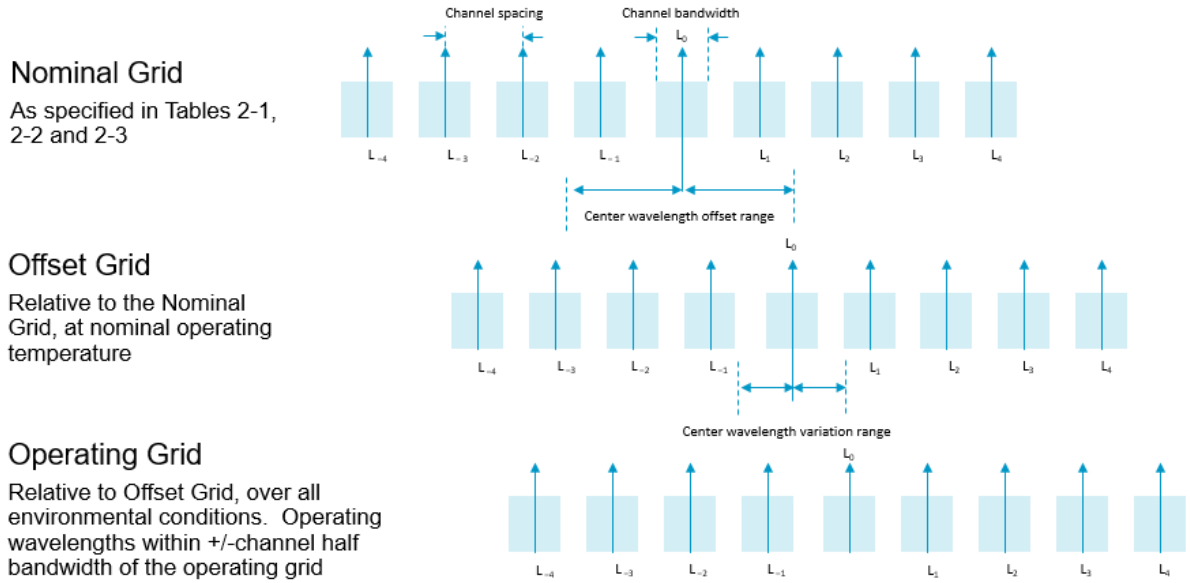

Figure 3-1 8 + 1 Wavelength Grid Set: Nominal Conditions

3.6 LINEWIDTH

The linewidth specified is the Lorentzian component of the optical noise spectrum and is related to the white phase noise component of the optical field. It is defined as the -3 dB full width of a self-heterodyne (3.5 µs delay) measurement. Typically, one arm of the interferometer is shifted in frequency (OIF-ITLA-MSA-01.3). Similar to RIN, linewidth for integrated power supplies shall be measured at TP1a and is to be measured for each line with an optical filter applied (filter bandwidth AS).

4 SAFETY REQUIREMENTS

Eye safety specifications should follow IEC 60825-1 2014 (3rd ed).

5 OPTICAL FIBER CABLE

The specifications are compatible with both standard single mode fiber and polarization maintaining fiber. Standard APC and PC connections can be used.

The fiber optic cable requirements are satisfied by PM cables, cables containing IEC 60793-2-50 type B1.1 (dispersion un-shifted single-mode), type B1.3 (low water peak single-mode), or type B6_a (bend insensitive) fibers.

6 IDENTIFICATION/COLOR CODING

Optical sources are identified by packaging color coding. This color code or other visible feature is visible when installed in a system. The color code scheme is specified in Table 6–1.

Table 6–1 Color Coding

Color Code	Application
Red	Modular optical source
Blue	Integrated optical source

7 APPENDIX

Example use cases of the specification are shown. They are informative and not part of the normative specification. An additional wavelength grid is shown. It is informative and not part of the normative specification.

7.1 EXAMPLE APPLICATION: FLEXIBLE WAVELENGTH LINKS

An example application allows for wide variation in center wavelength which includes laser wavelength drift over temperature. Example specifications for modular optical source are listed in Table 7–1.

Table 7–1 Informative modular optical source specifications[1]

Description	Value	Unit
Grid spacing and channel bandwidth (18nm span)	400 ± 100 (8 +1 set) 200 ± 50 (16 + 1 set) 100 ± 25 (32 + 1 set)	GHz
Nominal wavelength range (18nm span) [a]	1291.1 to 1309.14	nm
Launch power, each wavelength (max, 18nm span) [b]	14	dBm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	±5	nm
Launch power variation, each wavelength (max)	±1	dB
Side-mode suppression ratio (SMSR), (min)	30	dB
Relative intensity noise (per wavelength) [c]	–135	dB/Hz
Optical linewidth (max) [c]	20	MHz
Optical return loss tolerance (max)	–20	dB
Center wavelength variation range [d]	±4	nm

Notes:

[1] All parameters must be met across the full temperature range with all ports active.

[a] Nominal wavelength range and center wavelength offset range are specified at a fixed temperature to be agreed on between suppliers and users.

[b] Output power is defined in an optical fiber for power class Type 2. Types 1 and 3 are 6 dB and 12 dB higher, respectively.

[c] Relative intensity noise is specified with a reference receiver defined in section 3.3. Optical linewidth shall be measured using techniques described in section 3.6. Both linewidth and RIN specs shall be met across the full temperature range.

[d] Center wavelength variation range is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset range.

For integrated optical sources, the allowed port configurations are listed in Table 7–2.

Table 7–2 Informative output port configurations

Optical power supply type	Wavelengths	Number of Ports
Modular	8	8
	16	16
	32	32
Integrated	8	≥8
	16	≥16
	32	≥32

The specifications for integrated optical sources are given in Table 7–3.

Table 7–3 Informative integrated optical source specifications [1]

Description	Value	Unit
Grid spacing and channel bandwidth (18nm span)	400 ± 100 (8 +1 set) 200 ± 50 (16 + 1 set) 100 ± 25 (32 + 1 set)	GHz
Nominal wavelength range (18nm span) [a]	1291.1 to 1309.14	nm
Launch power, each port (max, 18nm span) [b]	$14 - 10\times\log_{10}(N/N\lambda)$	dBm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	±5	nm
Launch power variation, each port, each wavelength (max)	±1	dB
Side-mode suppression ratio (SMSR), (min) [c]	30	dB
Outside mode suppression ratio (min) [d]	AS	dB
Relative intensity noise (per lane) [e]	–135	dB/Hz
Optical linewidth (max) [e]	20	MHz
Optical return loss tolerance (max)	–20	dB
Center wavelength variation range [f]	±4	nm

Notes:

[1] All parameters must be met simultaneously with all ports active.

[a] Nominal wavelength range and center wavelength offset range are specified at a fixed temperature to be agreed on between suppliers and users.

[b] Output power is defined in an optical fiber. N refers to the number of output ports carrying all wavelengths of a given grid. N_λ refers to the number of grid wavelengths.

[c] Side mode suppression ratio for integrated optical source is defined as the ratio between the power in any defined channel to the power at any point between channels.

[d] Outside mode suppression ratio refers to the power in wavelengths outside the nominal wavelength range + center wavelength offset in Table 2–1, Table 2–2, or Table 2–3.

[e] Relative intensity noise is specified with a reference receiver defined in section 3.3. Optical linewidth shall be measured using techniques described in section 3.6. Both linewidth and RIN specs shall be met across all operating conditions.

[f] Center wavelength variation range is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset range.

7.2 INFORMATIVE 72-nm SPAN O-BAND GRID DEFINITION

The CW-WDM MSA normative specifications are for grid spacings less than 5nm. However, the MSA recognizes that currently there exists a gap in optical industry specifications between 5 nm and 20 nm grid spacings.

An 8-wavelength, 10 nm grid spacing CWDM grid is listed in Table 7–4 for consideration for development of specifications for uncooled applications over a restricted temperature range, for example 30 °C. The CW-WDM MSA currently has no plans to develop normative specifications for this grid spacing.

Table 7–4 Informative 72 nm span CWDM lane assignments

Lane	Center Wavelength	Unit
L_0	1271	nm
L_1	1281	nm
L_2	1291	nm
L_3	1301	nm
L_4	1311	nm
L_5	1321	nm
L_6	1331	nm
L_7	1341	nm

7.3 EXAMPLE APPLICATION: FIXED WAVELENGTH LINKS

This example application allows for narrow variation in center wavelength which includes laser wavelength drift over temperature. Example specifications for a modular optical source are listed in Table 7–5.

Table 7–5 Informative modular optical source specifications[1]

Description	Value	Unit
Grid spacing and channel bandwidth (18nm span)	400 ± 100 (8 +1 set) 200 ± 50 (16 + 1 set) 100 ± 25 (32 + 1 set)	GHz
Nominal wavelength range (18nm span) [a]	1291.1 to 1309.14	nm
Launch power, each wavelength (max, 18nm span) [b]	14	dBm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	±0.5	nm
Launch power variation, each wavelength (max)	±1	dB
Side-mode suppression ratio (SMSR), (min)	30	dB
Relative intensity noise (per wavelength) [c]	−135	dB/Hz
Optical linewidth (max) [c]	20	MHz
Optical return loss tolerance (max)	−20	dB
Center wavelength variation range [d]	±0.5	nm

Notes:

[1] All parameters must be met across the full temperature range with all ports active.

[a] Nominal wavelength range and center wavelength offset range are specified at a fixed temperature to be agreed on between suppliers and users.

[b] Output power is defined in an optical fiber.

[c] Relative intensity noise is specified with a reference receiver defined in section 3.3. Optical linewidth shall be measured using techniques described in section 3.6. Both linewidth and RIN specs shall be met across the full temperature range.

[d] Center wavelength variation range is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset range.

For integrated optical sources, the allowed port configurations are listed in Table 7–6.

Table 7–6 Informative output port configurations

Optical power supply type	Wavelengths	Number of Ports
Modular	8	8
	16	16
	32	32
Integrated	8	≥8
	16	≥16
	32	≥32

The specifications for integrated optical sources are given in Table 7–7.

Table 7–7 Informative integrated optical source specifications [1]

Description	Value	Unit
Grid spacing and channel bandwidth (18nm span)	400 ± 100 (8 +1 set) 200 ± 50 (16 + 1 set) 100 ± 25 (32 + 1 set)	GHz
Nominal wavelength range (18nm span) [a]	1291.1 – 1309.14	nm
Launch power, each port (max, 18nm span) [b]	$14 - 10\times\log_{10}(N/N\lambda)$	dBm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	±0.5	nm
Launch power variation, each port, each wavelength (max)	±1	dB
Side-mode suppression ratio (SMSR), (min) [c]	30	dB
Outside mode suppression ratio (min) [d]	AS	dB
Relative intensity noise (per lane) [e]	−135	dB/Hz
Optical linewidth (max) [e]	20	MHz
Optical return loss tolerance (max)	−20	dB
Center wavelength variation range [f]	±0.5	nm

Notes:

[1] All parameters must be met simultaneously with all ports active.

[a] Nominal wavelength range and center wavelength offset range are specified at a fixed temperature to be agreed on between suppliers and users.

[b] Output power is defined in an optical fiber. N refers to the number of output ports carrying all wavelengths of a given grid. $N\lambda$ refers to the number of grid wavelengths.

[c] Side mode suppression ratio for an integrated optical source is defined as the ratio between the power in any defined channel to the power at any point between channels.

[d] Outside mode suppression ratio refers to the power in wavelengths outside the nominal wavelength range + center wavelength offset in Table 2–1, Table 2–2, or Table 2–3.

[e] Relative intensity noise is specified with a reference receiver defined in section 3.3. Optical linewidth shall be measured using techniques described in section 3.6. Both linewidth and RIN specs shall be met across all operating conditions.

[f] Center wavelength variation range is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset range.

7.4 EXAMPLE APPLICATION: DUAL ELS 8+8 CHANNEL

This example application allows for two physically separate 8-wavelength external laser sources (ELS) to be combined to make a 16-wavelength source. In this application channel L0 of the 16+1 grid set is skipped to allow for differences in center wavelength offset and center wavelength variation between ELS1 and ELS2. Here the ELS should be mounted in the same chassis/rack to ensure that operating temperatures track closely. Figure 7.1 describes the dual ELS 8+8 channel example.

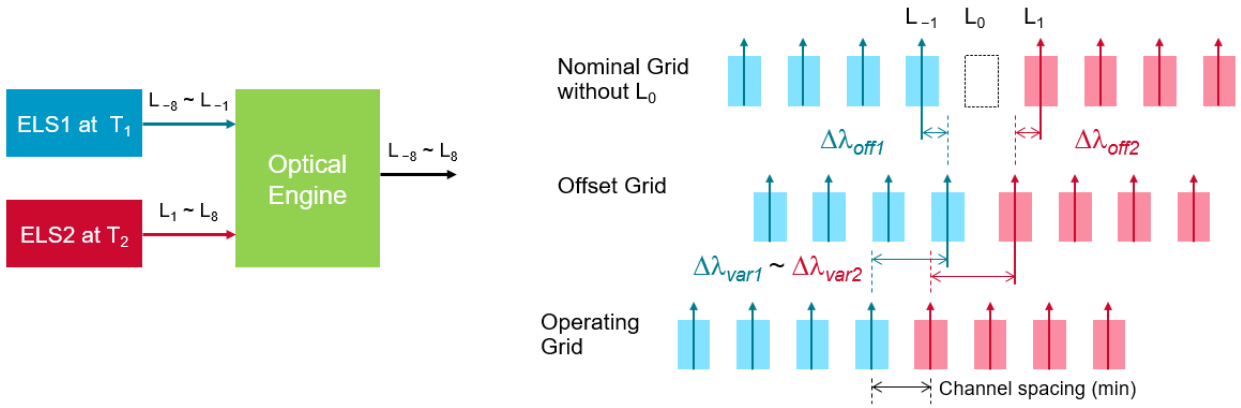

Figure 7-1 Dual ELS 8+8 channel example

Example specifications for a dual ELS 8+8 channel implementation are listed in Table 7–1. In this informative example, the ±4 nm center wavelength variation range allows for each ELS to operate uncooled over a ±40°C range, as long as the difference in temperatures between the two ELS is engineered to always remain less than 5°C.

Table 7–8 Informative Dual ELS 8+8 channel source specifications[1]

Description	Value	Unit
Grid spacing and channel bandwidth (36nm span)	400 ± 100 (16 + 1 set)	GHz
Nominal wavelength span (36nm span) [a]	1282.26 to 1318.35	nm
Launch power, each wavelength (max, 36nm span) [b]	14	dBm
Nominal center wavelength [a]	1300.05	nm
Center wavelength offset range [a]	±0.85	nm
Launch power variation, each wavelength (max)	±1	dB
Side-mode suppression ratio (SMSR), (min)	30	dB
Relative intensity noise (per wavelength) [c]	−135	dB/Hz
Optical linewidth (max) [c]	20	MHz
Optical return loss tolerance (max)	−20	dB
Center wavelength variation range [d]	±4	nm
Center wavelength variation difference [e]	0.5	nm

Notes:

[1] All parameters must be met across the full temperature range with all ports active and apply to each ELS independently.

[a] Nominal wavelength range and center wavelength offset are specified at a fixed temperature to be agreed on between suppliers and users.

[b] Output power is defined in an optical fiber.

[c] Relative intensity noise is specified with a reference receiver defined in section 3.3. Optical linewidth shall be measured using techniques described in section 3.6. Both linewidth and RIN specs shall be met across the full temperature range.

[d] Center wavelength variation is defined as the allowable shift in the grid over environmental conditions. It is defined in addition to center wavelength offset.

[e] Difference in center wavelength variation between the two modules must be less than this amount at any time over all environmental conditions.