Application Note

Fast and Easy CWDM Network Assessment,

Using ITU-T G.695 application codes

MU909020A

Network Master Optical Channel Analyzer

Introduction

Although Coarse wavelength-division multiplexing (CWDM) technology was first deployed in the early 1980s, it has only gained significant interests among service providers since a few years, as a cost alternative to Dense wavelength-division multiplexing (DWDM) for metro core and metro access, the main bottleneck of today's networks.
The main assets of CWDM technology is to allow to increase bandwidth on existing fiber architectures, with flexibility and scalability, with a total transparency to protocols, and with a cost saving of 30% to 50%, in comparison with the DWDM alternative. Therefore, it is becoming the preferred choice for large and medium-sized carriers, but also for cable TV companies and for enterprise network operators to carry higher bandwidth services to the residential market and to interconnect Storage-Area-Network.
To ensure vendors interoperability, the International Telecommunication Union (ITU) issued in 2003 a dedicated recommendation for CWDM application, providing optical parameter values for physical layer interfaces. This ITU-T G.695 standard complements the previous ITU-T G.694.2 recommendation, defining a wavelength grid with 20 nm channel spacing which includes 18 wavelengths between 1271 nm and 1611 nm.
This application note presents the main items of the ITU-T G.695 standard, and explains how the network conformity to the recommendation can be easily checked with the Anritsu MU909020A Optical Channel Analyzer.

ITU-T G.695 recommendation summary

The ITU-T G.695 recommendation aims to enable multi-vendor interfaces compatibility, defining and providing values for optical interface parameters of physical point-to-point and ring CWDM system applications.
Applications are defined using two different methods, one using multichannel interface parameters, in a "black-box" approach, and the other using single-channel interface parameters, in a "black-link" approach, both in unidirectional and bidirectional applications, with up to 16 channels and up to 2.5 Gbit/s modulation rate.
Figure 1 represents a scheme of the "black-box" approach for bidirectional applications, with the reference measurement points to assess the CWDM link.

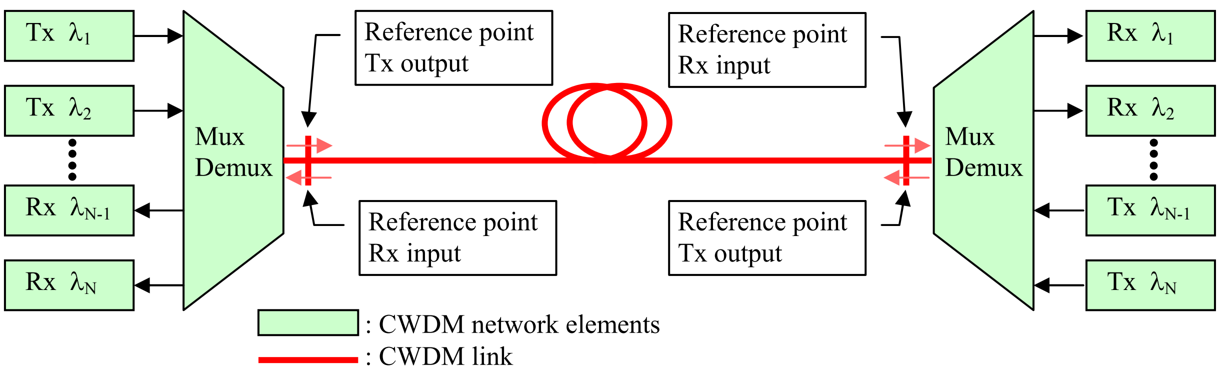

*Figure 1. **"Black-box" approach for bidirectional applications**.*

Figure 2 represents a scheme of the linear “black-link” approach for bidirectional applications, which may include one or several Optical Add-Drop Multiplexers (OADMs), with the reference measurement points to assess the CWDM link.

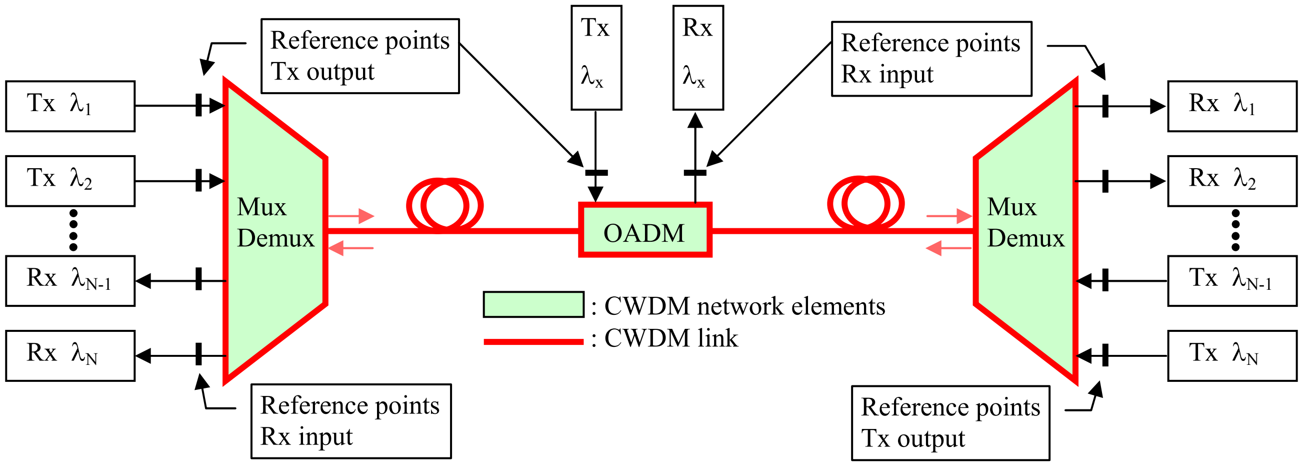

*Figure 2. Linear**"Black-link" approach for bidirectional applications**.*

Figure 3 represents a scheme of the ring “black-link” approach for bidirectional applications, with the reference measurement points to assess the CWDM link.

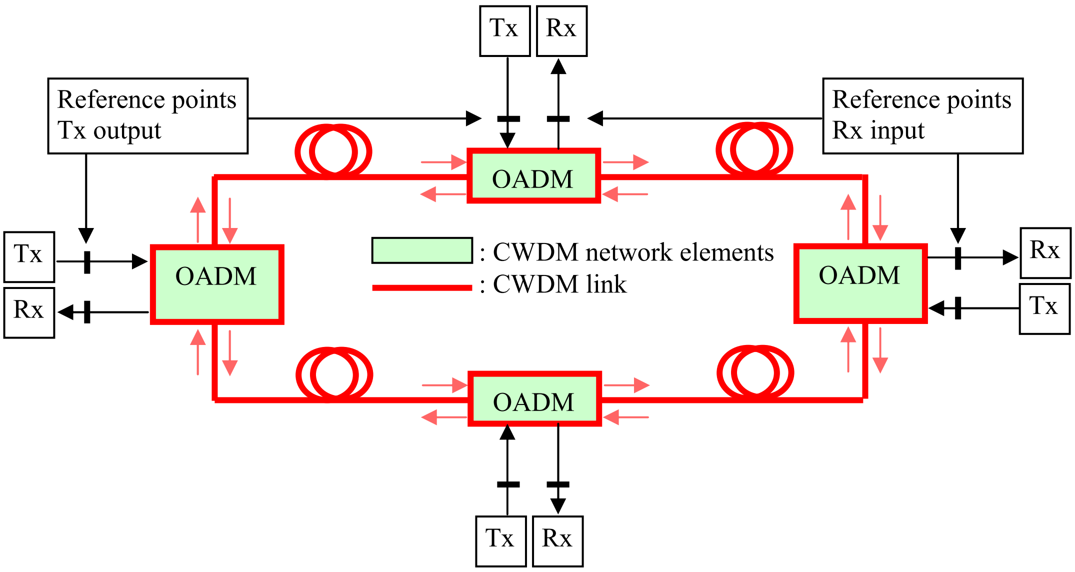

*Figure 3. Ring**"Black-link" approach for bidirectional applications**.*

Based on these representations, the ITU-T G.695 recommendation defines application codes to identify the network, its implementation and architectural characteristics. The application code notation is constructed as follows:

CnWx-ytz ,

where:

- **C** is the indicator of CWDM applications
- **n** is the maximum number of channels supported by the application code (4, 8, 12 or 16)
- **W** is a letter indicating the span distance such as:
  - **S** indicating short-haul (with a typical target distance up to 37 km)
  - **L** indicating long-haul. (with a typical target distance from 38 km to 90 km)
- **x** is the maximum number of spans allowed within the application code (x = 1 in this recommendation)
- **y** indicates the highest class of optical tributary signal supported:
  - **0** indicating up to NRZ 1.25G
  - **1** indicating up to NRZ 2.5G
- **t** is a placeholder letter indicating the configuration supported by the application code. In the current version of this recommendation, the only value used is **D** indicating that the application does not contain any optical amplifiers.

- **z** indicates the fiber types, as follows:
  - **2** indicating G.652 fiber
  - **3** indicating G.653 fiber
  - **5** indicating G.655 fiber

A bidirectional system is indicated by the addition of the letter **B** at the front of the application code: B-CnWx-ytz.
A system using the "black-link" approach is indicated by the addition of the letter **S** at the front of the application code: S-CnWx-ytz.

The following tables list the application code supported by ITU-T G.695 recommendation, and the associated parameters and values for CWDM applications. In table 1 are indicated the target distance, the maximum number of channels, the supported bit rate, the wavelength range and the maximum and minimum channel output power at Tx reference points, for each application code. In table 2 are indicated the maximum and minimum attenuation of the link, the maximum tolerated optical path penalty, the wavelength range and the maximum and minimum channel input power at Rx reference points, for each application code.

Class	Target distance (km)	Maximum number of channels	Bit rate	Maximum mean channel output power dBm	Minimum mean channel output power dBm	Central wavelength nm
C4S1–1D2	37	4	2.5	4.5	–3	1531–1591
C4S1–1D3	37	4	2.5	4.5	–3	1531–1591
C4S1–1D5	37	4	2.5	4.5	–3	1531–1591
C4L1–1D2	69	4	2.5	4.5	–3	1531–1591
C4L1–1D3	72	4	2.5	4.5	–3	1531–1591
C4L1–1D5	72	4	2.5	4.5	–3	1531–1591
B–C4L1–0D2	90	4	1.25	5	0	1531–1591
B–C4L1–0D3	90	4	1.25	5	0	1531–1591
B–C4L1–1D2	80	4	2.5	5	0	1531–1591
B–C4L1–1D3	83	4	2.5	5	0	1531–1591
B–C8L1–0D2	64	8	1.25	4	–3.5	1471–1611
B–C8L1–0D3	64	8	1.25	4	–3.5	1471–1611
B–C8L1–1D2	55	8	2.5	4	–3.5	1471–1611
B–C8L1–1D3	58	8	2.5	4	–3.5	1471–1611
C8L1–1D2	55	8	2.5	4	–3.5	1471–1611
C8S1–1D2	27	8	2.5	4	–3.5	1471–1611
B–C8S1–1D2	27	8	2.5	4	–3.5	1471–1611
B–C12L1–0D2	42	12	1.25	3.5	–4	1291–1351
				1.5	–6	1471–1611
B–C12L1–1D2	38	12	2.5	3.5	–4	1291–1351
				1.5	–6	1471–1611
C16S1–1D2	20	16	2.5	3.5	–4	1311–1371
				2.5	–5	1391–1451
				1	–6.5	1471–1611
B–C16S1–1D2	20	16	2.5	3.5	–4	1311–1371
				2	–5	1391–1451
				1	–6.5	1471–1611
C16L1–1D2	42	16	2.5	3.5	–4	1311–1371
				1.5	–6	1391–1451
				–0.5	–8	1471–1611
B–C16L1–1D2	42	16	2.5	3.5	–4	1311–1371
				1.5	–6	1391–1451
				–0.5	–8	1471–1611
S–C8S1–1D2		8	2.5	5	0	1471–1611
S–C8S1–1D3		8	2.5	5	0	1471–1611
S–C8S1–1D5		8	2.5	5	0	1471–1611
S–C8L1–1D2		8	2.5	5	0	1471–1611
S–C8L1–1D3		8	2.5	5	0	1471–1611
S–C8L1–1D5		8	2.5	5	0	1471–1611

Table 1. Application codes, physical layer parameters and values at Tx reference points

Class	Central wavelength nm	Maximum attenuation dB	Minimum attenuation dB	Maximum mean channel input power dBm	Minimum mean channel input power dBm	Maximum optical path penalty dB
C4S1–1D2	1531–1591	10.5	4	0.5	–13.5	1.5
C4S1–1D3	1531–1591	10.5	4	0.5	–13.5	1.5
C4S1–1D5	1531–1591	10.5	4	0.5	–13.5	1.5
C4L1–1D2	1531–1591	19.5	13	–8.5	–22.5	2.5
C4L1–1D3	1531–1591	20.5	13	–8.5	–23.5	1.5
C4L1–1D5	1531–1591	20.5	13	–8.5	–23.5	1.5
B–C4L1–0D2	1531–1591	25.5	12	–7	–25.5	1.5
B–C4L1–0D3	1531–1591	25.5	12	–7	–25.5	1.5
B–C4L1–1D2	1531–1591	22.5	12	–7	–22.5	2.5
B–C4L1–1D3	1531–1591	23.5	12	–7	–23.5	1.5
B–C8L1–0D2	1471–1611	21	12	–8	–24.5	1.5
B–C8L1–0D3	1471–1611	21	12	–8	–24.5	1.5
B–C8L1–1D2	1471–1611	18	19	–8	–21.5	2.5
B–C8L1–1D3	1471–1611	12	12	–8	–22.5	1.5
C8L1–1D2	1471–1611	18	12	–8	–21.5	2.5
C8S1–1D2	1471–1611	9	3	1	–12.5	1.5
B–C8S1–1D2	1471–1611	9	3	1	–12.5	1.5
B–C12L1–0D2	1291–1351	20	11	–7.5	–24	1
B–C12L1–0D2	1471–1611	14.7	7	–5.5	–20.7	1
B–C12L1–1D2	1291–1351	18	13.3	–7.5	–22	1
B–C12L1–1D2	1471–1611	11	7	–5.5	–19.3	1.5
C16S1–1D2	1311–1371	8.5	3.5	0	–12.5	1
C16S1–1D2	1391–1451	7.5	2.5	0	–12.5	1
C16S1–1D2	1471–1611	6.5	0.5	0.5	–13	1
B–C16S1–1D2	1311–1371	8.5	3.5	0	–12.5	1
B–C16S1–1D2	1391–1451	7.5	2.5	–0.5	–12.5	1
B–C16S1–1D2	1471–1611	6.3	0.5	0.5	–122.8	1
C16L1–1D2	1311–1371	18	11	–7.5	–22	1
C16L1–1D2	1391–1451	15.8	9	–7.5	–21.8	1.5
C16L1–1D2	1471–1611	13.3	7	–7.5	–21.3	2
B–C16L1–1D2	1311–1371	18	11	–7.5	–22	1
B–C16L1–1D2	1391–1451	15.8	9	–7.5	–21.8	1.5
B–C16L1–1D2	1471–1611	13.3	7	–7.5	–21.3	2
S–C8S1–1D2	1471–1611	16.5	5	0	–18	1.5
S–C8S1–1D3	1471–1611	16.5	5	0	–18	1.5
S–C8S1–1D5	1471–1611	16.5	5	0	–18	1.5
S–C8L1–1D2	1471–1611	25.5	14	–9	–28	2.5
S–C8L1–1D3	1471–1611	25.5	14	–9	–28	2.5
S–C8L1–1D5	1471–1611	25.5	14	–9	–28	2.5

Table 2. Application codes, physical layer parameters and values at Rx reference points

Checking these parameters and associated values enable to ensure compatibility of interfaces having the same application code and supplied by different vendors. It also defines the rules for the joint engineering necessary to interconnect aggregate interfaces with different application codes, taking a particular care with the critical parameters such as the Tx output power and the Rx input power, the central channel wavelengths, and bit rate coding.

As to the central channel wavelengths, the grid is defined in ITU-T G.694.2 recommendation, with 18 channels from 1271 nm to 1611 nm, with a 20 nm channel spacing. In addition to the parameters and values summarized in tables 1 and 2, ITU-T G.695 standard recommends a maximum central wavelength deviation of ± 6.5 nm with regard to G.694.2 grid. As low-cost uncooled distributed-feedback (DFB) lasers are deployed in CWDM networks, with large centering tolerances at nominal temperature and big thermal drift on operating temperature range, the measurement of channels wavelength deviation with temperature is highly recommended to prevent network breakdown issues.

Fast and easy assessment of CWDM networks

To facilitate the verification of CWDM network compliancy with ITU-T G.695 recommendation, Anritsu has developed a dedicated CWDM test instrument, called Network Master Optical Channel Analyzer (OCA). The Network Master OCA is a field modular device designed to measure power and wavelength over the 18 CWDM channels, and to monitor their drift over time. Coming in a small, light and rugged handheld format, this easy to use instrument is particularly well adapted to help field technicians for installation, maintenance and troubleshooting of CWDM access networks.

Figure 3. Network Master Optical Channel Analyzer

Providing a global vision of all the CWDM channels displayed in a graph or a table window on the large screen of the instrument, complemented with several drift functions to allow a long-term characterization of the channels, the Network Master OCA enables fast and reliable measurement of CWDM network parameters in every environment. The software interface has been carefully developed to ease the qualification of CWDM links, and will require quite no training to characterize a CWDM network at a glance.
In particular, alarm thresholds for all configurations defined in ITU-T G.695 recommendations are stored in the OCA for an easy Go / No Go testing. Figure 4 shows the interface of the [Settings / Alarms] menu, where can be activated the appropriate alarm thresholds at the CWDM network reference measurement point.

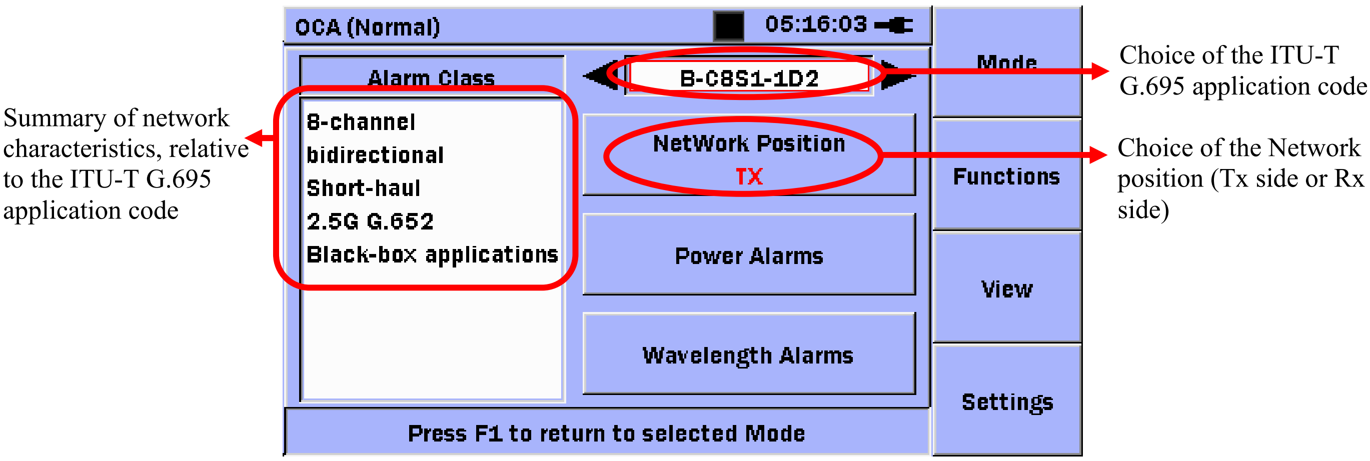

Figure 4. [Settings / Alarms] menu on Network Master OCA

The application code of the network under test can be selected in the [Settings / Alarms] menu of the OCA. Red indicators will be then displayed in every graph and table displays, in accordance with the power and wavelength boundary values recommended by ITU-T G.695, as we can see on figure 5 hereafter.

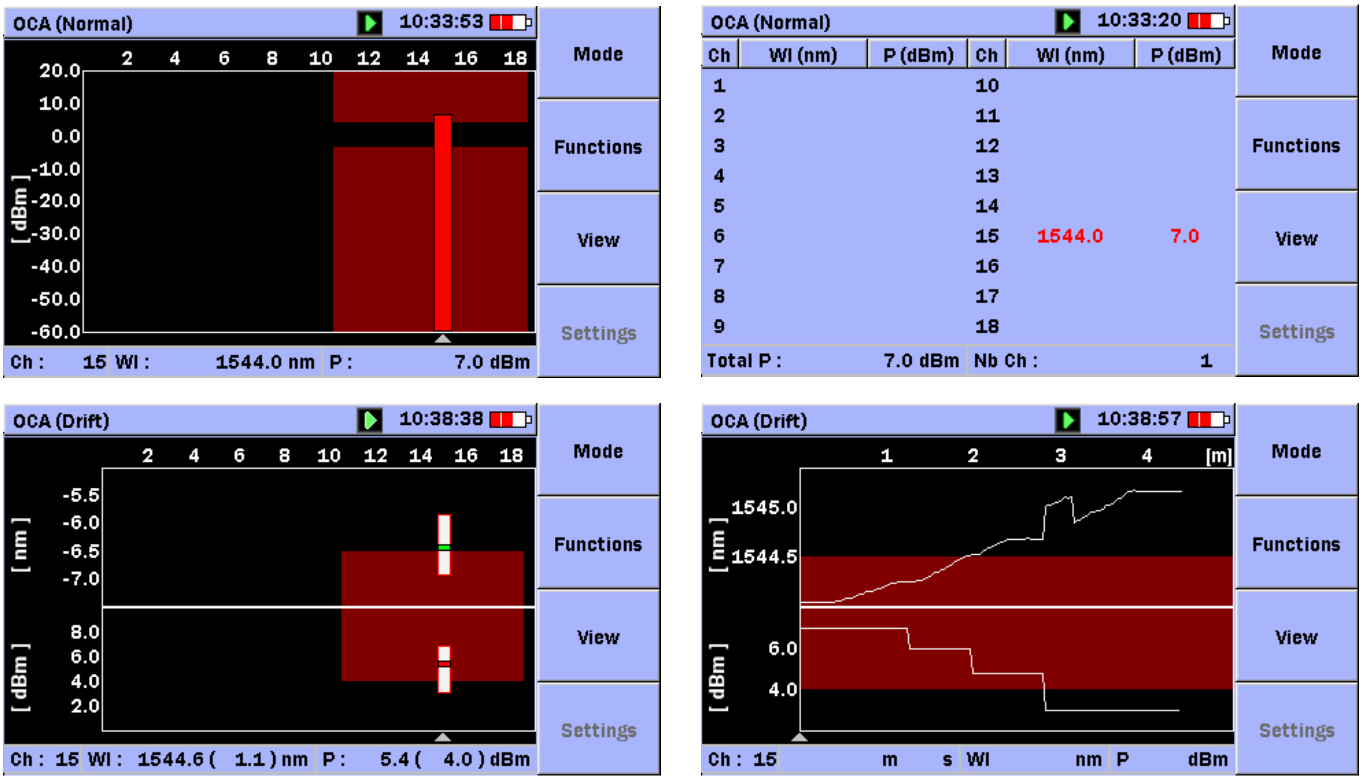

Figure 5. Alarms indicators in the different OCA displays:
[top, left]: normal graph display
[top, right]: normal table display
[bottom, left]: drift graph display
[bottom, right]: 1-channel drift plot display

On the above figure, one channel was simulated out of the target values, according to B-C8S1-1D2 application code, at the beginning of the test, with an excessive power of +7 dBm on a central wavelength of 1544.0 nm, out of the authorized band for the 1551nm CWDM channel. The detected channel power and wavelength values both appear in red on OCA graph and table displays. They are also displayed in alarm at the beginning of the drift test, and we can see on the OCA drift displays that the channel is going out of the alarm areas after a period, due to environmental changes for example. With these clear displays, the OCA can give the full picture of a CWDM network, both instantaneously and versus time, to facilitate the commissioning and the troubleshooting of the link.
All the alarms boundaries for the whole ITU-T G.695 application codes can be seen in the [Settings / Alarms] menu of the OCA, by selecting "Power Alarms" or "Wavelength Alarms" button. The maximum and minimum tolerated values are displayed in a table format, as we can see on figure 6. Operators can choose to change these alarms limits, to be more or less restrictive than the ITU-T standard. This can be done directly in the tables shown on figure 6.

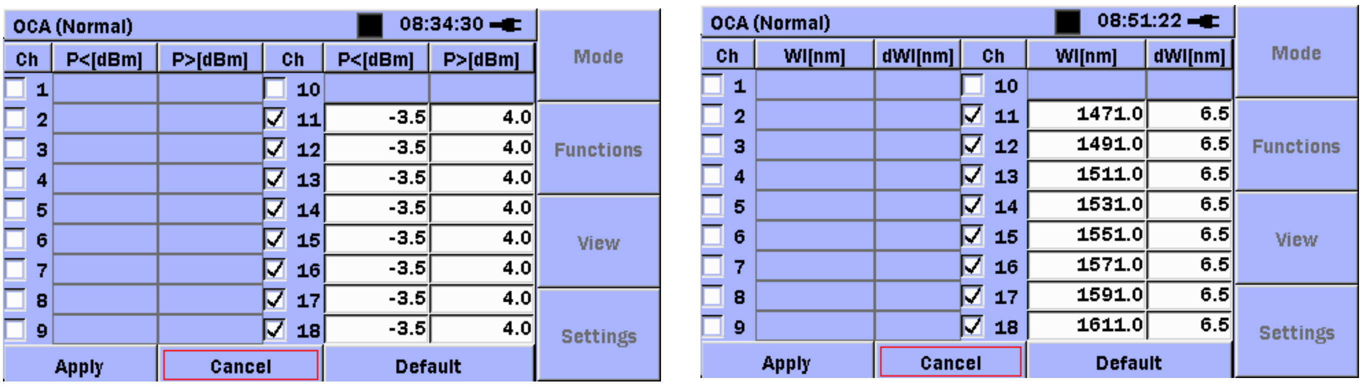

Figure 6. Power and wavelength alarms values relative to B-C8S1-1D2 application code, Tx side

Thanks to these alarms menu, operators can choose to compare their CWDM network performance with the target values defined in ITU-T recommendations, or to define their own criteria, depending on their architecture and objective.

Conclusion

Because of its flexibility, scalability, protocol transparency and cost effectiveness, CWDM is the preferred technology to increase bandwidth in metro and access networks. In 2003, the International Telecommunication Union set up a framework to ensure interoperability of CWDM systems from the different vendors on this market, with the ITU-T G.694.2 and ITU-T G.695 recommendations. To ease the installation, the commissioning, the troubleshooting of CWDM networks in the field, Anritsu released a new field tester, the Network Master Optical Channel Analyzer. This handheld instrument provides fast and accurate measurements of the wavelength and power of the 18 CWDM channels, and monitors their drift over time. With stored alarm threshold values, in accordance with the application codes defined in the ITU-T G.695 recommendation, the Network Master OCA can characterize any CWDM network at a glance with an easy Go / No Go testing.

Anritsu Corporation
5-1-1 Onna, Atsugi-shi, Kanagawa, 243-8555 Japan
Phone: +81-46-223-1111
Fax: +81-46-296-1264

• **U.S.A.**
Anritsu Company
1155 East Collins Blvd., Suite 100, Richardson,
TX 75081, U.S.A.
Toll Free: 1-800-267-4878
Phone: +1-972-644-1777
Fax: +1-972-671-1877

• **Canada**
Anritsu Electronics Ltd.
700 Silver Seven Road, Suite 120, Kanata,
Ontario K2V 1C3, Canada
Phone: +1-613-591-2003
Fax: +1-613-591-1006

• **Brazil**
Anritsu Eletrônica Ltda.
Praca Amadeu Amaral, 27 - 1 Andar
01327-010-Paraiso-São Paulo-Brazil
Phone: +55-11-3283-2511
Fax: +55-11-3288-6940

• **Mexico**
Anritsu Company, S.A. de C.V.
Av. Ejército Nacional No. 579 Piso 9, Col. Granada
11520 México, D.F., México
Phone: +52-55-1101-2370
Fax: +52-55-5254-3147

• **U.K.**
Anritsu EMEA Ltd.
200 Capability Green, Luton, Bedfordshire, LU1 3LU, U.K.
Phone: +44-1582-433200
Fax: +44-1582-731303

• **France**
Anritsu S.A.
16/18 avenue du Québec-SILIC 720
91961 COURTABOEUF CEDEX, France
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

• **Germany**
Anritsu GmbH
Nemetschek Haus, Konrad-Zuse-Platz 1
81829 München, Germany
Phone: +49-89-442308-0
Fax: +49-89-442308-55

• **Italy**
Anritsu S.p.A.
Via Elio Vittorini 129, 00144 Roma, Italy
Phone: +39-6-509-9711
Fax: +39-6-502-2425

• **Sweden**
Anritsu AB
Borgafjordsgatan 13, 164 40 KISTA, Sweden
Phone: +46-8-534-707-00
Fax: +46-8-534-707-30

• **Finland**
Anritsu AB
Teknobulevardi 3-5, FI-01530 VANTAA, Finland
Phone: +358-20-741-8100
Fax: +358-20-741-8111

• **Denmark**
Anritsu A/S
Kirkebjerg Allé 90, DK-2605 Brøndby, Denmark
Phone: +45-72112200
Fax: +45-72112210

• **Spain**
Anritsu EMEA Ltd.
Oficina de Representación en España
Edificio Veganova
Avda de la Vega, n° 1 (edf 8, pl 1, of 8)
28108 ALCOBENDAS - Madrid, Spain
Phone: +34-914905761
Fax: +34-914905762

• **Russia**
Anritsu EMEA Ltd.
Representation Office in Russia
Tverskaya str. 16/2, bld. 1, 7th floor.
Russia, 125009, Moscow
Phone: +7-495-363-1694
Fax: +7-495-935-8962

• **United Arab Emirates**
Anritsu EMEA Ltd.
Dubai Liaison Office
P O Box 500413 - Dubai Internet City
Al Thuraya Building, Tower 1, Suit 701, 7th Floor
Dubai, United Arab Emirates
Phone: +971-4-3670352
Fax: +971-4-3688460

• **Singapore**
Anritsu Pte. Ltd.
60 Alexandra Terrace, #02-08, The Comtech (Lobby A)
Singapore 118502
Phone: +65-6282-2400
Fax: +65-6282-2533

• **India**
Anritsu Pte. Ltd.
India Branch Office
Unit No. S-3, Second Floor, Esteem Red Cross Bhavan,
No. 26, Race Course Road, Bangalore 560 001, India
Phone: +91-80-32944707
Fax: +91-80-22356648

• **P.R. China (Hong Kong)**
Anritsu Company Ltd.
Units 4 & 5, 28th Floor, Greenfield Tower, Concordia Plaza,
No. 1 Science Museum Road, Tsim Sha Tsui East,
Kowloon, Hong Kong
Phone: +852-2301-4980
Fax: +852-2301-3545

• **P.R. China (Beijing)**
Anritsu Company Ltd.
Beijing Representative Office
Room 1515, Beijing Fortune Building,
No. 5, Dong-San-Huan Bei Road,
Chao-Yang District, Beijing 10004, P.R. China
Phone: +86-10-6590-9230
Fax: +86-10-6590-9235

• **Korea**
Anritsu Corporation, Ltd.
8F Hyunjuk Building, 832-41, Yeoksam Dong,
Kangnam-ku, Seoul, 135-080, Korea
Phone: +82-2-553-6603
Fax: +82-2-553-6604

• **Australia**
Anritsu Pty. Ltd.
Unit 21/270 Ferntree Gully Road, Notting Hill,
Victoria 3168, Australia
Phone: +61-3-9558-8177
Fax: +61-3-9558-8255

• **Taiwan**
Anritsu Company Inc.
7F, No. 316, Sec. 1, Neihu Rd., Taipei 114, Taiwan
Phone: +886-2-8751-1816
Fax: +886-2-8751-1817

ISO 9001:2000 certified. Application Note: MBMU909020A-AN-01-0806-A4