Anritsu

MS9710B/MS9710C Optical Spectrum Analyzers

DWDM Measurement Solutions

Application Note

January 2002

Contents

1. Introduction

As the DWDM market grows, channel numbers are rapidly increasing. Now, channel density is over 100 channels in a single fiber. With this increase in quantity and density it is critical to accurately measure these DWDM signals. The Anritsu OSA (Optical Spectrum Analyzer) has excellent wavelength and level specifications that fully meet these DWDM requirements. This application note will describe how to perform DWDM signal analysis using Anritsu OSAs.

2. Anritsu OSA Line-up

Anritsu has three models of OSAs: the MS9710B, MS9710C, and MS9710C-15.
The MS9710B is for general use and is priced very low. The MS9710C has greater function capability and higher performance. An example is higher resolution bandwidth (RBW) and better wavelength accuracy. The MS9710C-15 is the highest performance model, especially in the L-band. The main differences are given in Table 1. Refer to the datasheets for details.

	MS9710B	MS9710C	MS9710C-15
Main features	C-band Up to 100 GHz channel spacing	C+L Band Up to 50 GHz channel spacing	
Measurement range	600-1750 nm		
λ accuracy	50pm(1530～1570nm)	20pm(1530～1570nm) 50pm(1520～1600nm)	20pm (1520～1620nm)
MAX. RBW	70 pm	50 pm	
RBW accuracy (0.2 nm)	<3% (1530～1570nm)	<3% (1530～1570nm)	<3% (1520～1620nm)
Level flatness	+/-0.1dB (1530～1570nm)	+/-0.1dB (1530～1570nm) +/-0.3dB (1520～1620nm)	+/-0.1dB (1520～1620nm)
PDL	+/- 0.05dB (C-band)	+/- 0.05dB (C +L band)	
Level linearity	+/- 0.05dB (C-band)	+/- 0.05dB (C +L band)	

Table 1

3. *Measurement Example of DWDM Signals*

The Anritsu OSA can measure and analyze wavelength, level, and SNR for up to 300 WDM-signal channels simultaneously. Accurate SNR measurements can be made with errors less than 0.2 dB. This is due to excellent high-resolution accuracy and level linearity of the OSA. In addition, the noise level is standardized per nm by dividing it by the selected RBW (MS9710C/C15).
Figure 1 shows an example of 12 channels of WDM signals with 100 GHz (0.8 nm) channel spacing.

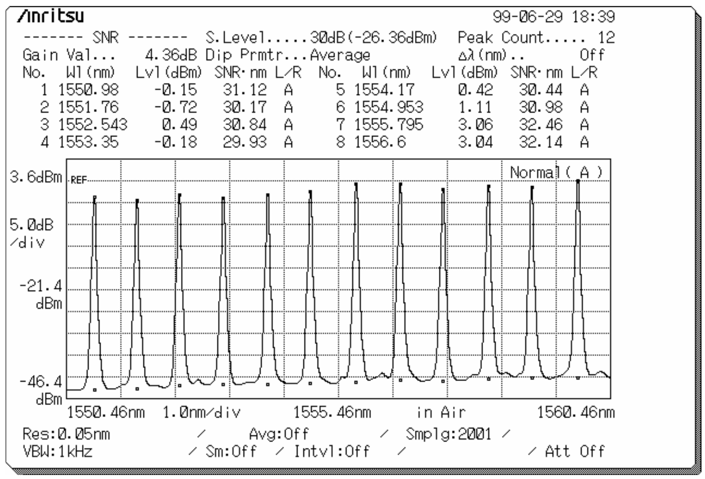
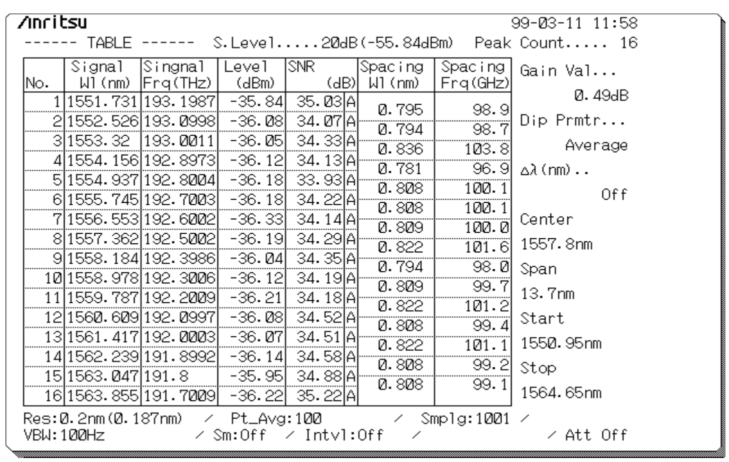


Figure 1

The measurement results can be switched to a table display that can be saved and recalled in text format (MS9710C/C-15). Both the wavelength and frequency are shown in the table (Figure 2).


Anritsu 99-03-11 11:58
------ TABLE ------ S.Level.....20dB(-55.84dBm) Peak Count..... 16

No.	Signal Wl(nm)	Singnal Frq(THz)	Level (dBm)	SNR (dB)		Spacing Wl(nm)	Spacing Frq(GHz)
1	1551.731	193.1987	-35.84	35.03	A	0.795	98.9
2	1552.526	193.0998	-36.08	34.07	A	0.794	98.7
3	1553.32	193.0011	-36.05	34.33	A	0.836	103.8
4	1554.156	192.8973	-36.12	34.13	A	0.781	96.9
5	1554.937	192.8004	-36.18	33.93	A	0.808	100.1
6	1555.745	192.7003	-36.18	34.22	A	0.808	100.1
7	1556.553	192.6002	-36.33	34.14	A	0.809	100.0
8	1557.362	192.5002	-36.19	34.29	A	0.822	101.6
9	1558.184	192.3986	-36.04	34.35	A	0.794	98.0
10	1558.978	192.3006	-36.12	34.19	A	0.809	99.7
11	1559.787	192.2009	-36.21	34.18	A	0.822	101.2
12	1560.609	192.0997	-36.08	34.52	A	0.808	99.4
13	1561.417	192.0003	-36.07	34.51	A	0.822	101.1
14	1562.239	191.8992	-36.14	34.58	A	0.808	99.2
15	1563.047	191.8	-35.95	34.88	A	0.808	99.1
16	1563.855	191.7009	-36.22	35.22	A		

Gain Val... 0.49dB
Dip Prmtr... Average
Δλ(nm).. Off
Center 1557.8nm
Span 13.7nm
Start 1550.95nm
Stop 1564.65nm

Res:0.2nm(0.187nm) / Pt_Avg:100 / Smplg:1001 /
VBW:100Hz / Sm:Off / Intvl:Off / / Att Off

Figure 2

4. Measurement Procedure for DWDM Signals

4.1 Calibration:

To insure accuracy, the OSA should be calibrated before making any measurements. The OSA calibration procedure is described in appendix A and the operation manual. It is highly recommended that a re-calibration be performed in the event of a 10^{o} C change in room temperature or when the instrument is relocated.

4.2 Parameter settings for accurate measurements:

For making accurate measurements it is necessary to set the OSA parameters correctly. A description of those settings follows:

- ***RBW***

RBW is defined at the FWHM (Full Width at Half maximum: 3 dB width) of the OSA's internal optical filter. Max. RBW is 50 pm for the MS9710C/C-15 and 70 pm for the MS9710B. When measuring a light source (ex. DFB laser), with a linewidth less (narrower) than the RBW setting on the OSA, the observed profile will be the OSA filter shape and not the source linewidth. The dynamic range specification also represents the filter shape. The dynamic range of MS9710C is typically 45 dB at 0.2 nm from the signal peak, with a 50 pm RBW setting. This means that optical levels 0.2 nm away from the signal peak and 45 dB below the signal peak will be detected as OSA noise. This is really the parasite error inherent to the OSA due to the limitations of the optical filter. The dynamic range at 0.4 nm away from the peak is almost 60 dB and is sufficient for most WDM applications. When the RBW is set at 0.1 nm or greater, the MS9710 has very good stability, repeatability and polarization dependent loss (PDL less than 0.05 dB). When a 0.1 nm RBW setting is selected, the dynamic range at 50 GHz (0.4 nm) is more than 50 dB. This means that when measuring DWDM signals with 100 GHz channel spacing, the best RBW setting is 0.1 nm. The measurement errors of 30 dB OSNR is less than 1 % when measuring the OSNR noise level at 0.4 nm from the peak. This is because the noise of the OSA itself is 50 dB below the signal level. (When the OSNR is 30 dB, the difference between the noise level of OSNR and the noise of OSA itself (parasite noise referred to above) is 20 dB and the measurement error will be 1%). The 0.05 nm RBW is sufficient for 50 GHz channel spacing since the dynamic range at 0.2 nm from the peak is 45 dB.

- ***VBW***

The video bandwidth (VBW) is the cutoff frequency of the optical receiver (photo-detector/amplifier) of an OSA. The choice of VBW setting determines the system sensitivity. The relationship between the VBW and the sensitivity is as follows.

*The sensitivity values in Table 2 are with the OSA's optical attenuator set to OFF. When the attenuator is ON, 20 dB should be added to these values.

VBW	10 Hz	100 Hz	1 KHz	10 kHz	100 kHz	1 MHz
Sensitivity	-90 dBm	-80 dBm	-70 dBm	-60 dBm	-50 dBm	-40 dBm

Table 2

Measurement speed also depends on the VBW. The measurement speed decreases with a decrease in the VBW setting. A VBW setting of 1 kHz is the best for sensitivities of -70 dBm. The VBW of 10 kHz, 100 kHz and 1 MHz are for measuring pulsed light signals and are not suitable for WDM applications. VBW setting above 1 kHz do not improve measurement speed.

- ***Sampling points***

Once the measurement span is selected, the wavelength readout resolution is defined by Equation 1.

Wavelength readout resolution = Span / Sampling points

Equation 1

For example, when the wavelength span is set for 20 nm and the number of sampling points is set for 500, the readout resolution will be 40 pm (20 nm / 500 = 40 pm). If higher readout resolution of the wavelength is required, set the sapling points to 1000 or more. The measurement speed will decrease when increasing the number of sampling points.

- ***Attenuator***

The optical attenuator should be set to "ON" when the power per the RBW is more than 7 dBm. Select the 'level scale' (F2) function and set the attenuator to "ON" (f6). Setting the attenuator to "ON" will increase the noise floor by 20 dB. If the power does not exceed 7 dBm, the attenuator should be set to "OFF" to achieve better accuracy.

Recommended settings for RBW and Sampling Points

Measurement condition		Recommended OSA setting	
λ Span	Channel spacing	RBW	Sampling points
<10 nm	>100 GHz	0.1 nm	501
	50 GHz	0.05 nm	1001
10-20 nm	>100 GHz	0.1 nm	1001
	50 GHz	0.05 nm	2001
20-40nm	>100 GHz	0.1 nm	2001
	50 GHz	0.05 nm	5001
>40 nm	Any	0.05/0.1 nm	5001

Recommended setting for VBW and Attenuator

Measurement condition		Recommended setting		OSA Noise floor
Signal power/ RBW	Noise level of OSNR	VBW	Attenuator	
> + 7 dBm	> - 35 dBm/RBW	1 KHz	ON	-50 dBm
> + 7 dBm	-35 - -45 dBm/RBW	100 Hz	ON	-60 dBm
> + 7 dBm	< -45 dBm/RBW	10 Hz	ON	-70 dBm
<+ 7 dBm	> - 55 dBm/RBW	1 KHz	OFF	-70 dBm
< + 7 dBm	-55 - -65 dBm/RBW	100 Hz	OFF	-80 dBm
< + 7 dBm	< -65 dBm/RBW	10 Hz	OFF	-90 dBm

4.3 Measurement

(1) Set the wavelength range to measure. You can set the center wavelength and span using the direct keys “Center” and “Span” on the right, top side of the front panel. Alternatively, push the F1 key for ‘Wavelength” and input the start and stop wavelengths. If the measurement range is unknown, select ‘Auto-measurement” button on the right, bottom of the front panel. The measurement range will be determined automatically.

(2) Set the appropriate RBW, VBW, Sampling points, and attenuation. Refer to chapter 4-1 in the manual for accurate measurement settings.

(3) Select the “Application” key (F2) and select the “WDM” (f6).

(4) Push the “display mode” key (f3) and select according to the measurement purpose. Each of these modes measures different items. See the details below.

(f1) Multi peak: Measures the wavelength and level of each signal for up to 300 channels. Also, the total number of the channels is displayed.
(f2) SNR: In addition to the multi-peak measurement, the OSNR for each signal is measured. See the chapter 4.4-(2) for details.
(f3) Relative: In addition to multi-peak measurement capability, the OSA measures wavelength and level differences from the reference signal. Any signal can be set as a reference
(f4) Table: Wavelength, frequency, level, and channel spacing of each signal are displayed in a table. In addition, the total numbers of the channels and the gain variation (difference between the maximum signal power and the minimum signal power) are displayed.

(5) Select the “Single” or “Repeat” Sweep key at the bottom, right of the front panel and the OSA will begin the measurements. The “repeat sweep” makes continuous measurements and the display is refreshed after each individual sweep is completed.

4.4 Further useful information and functionalities

(1) Peak parameter:
The WDM signal includes several noise peaks. These peaks can be due to signal side modes or Four Wave mixing (FWM). To accommodate for this, the OSA has a function for setting the slice level. When the slice level is set, it automatically sets the detection threshold and the OSA will not detect any peak below this threshold level. For example, when the maximum peak power is 5 dBm and the slice level is set at 20 dB, the threshold level is -15 dBm.

(2) OSNR Measurement: The OSA has the capability for measuring the OSNR automatically. When performing OSNR measurements it is necessary to set the

Dip Parameter and the $\Delta\lambda$ Function. The Dip Parameter and the $\Delta\lambda$ function provide flexibility in setting the wavelength position of the noise level.

$\Delta\ \lambda$ Function: When making an ONSR measurement, the noise position can be set at some distance (in nanometers) from the peak. This is done by pushing the f6 key and setting the distance in nanometers from the numeric key pad. When the $\Delta\lambda$ function is off, the OSA sets the noise position automatically. The position is the minimum level between adjacent channels.

Dip Parameter: Each tone in a WDM signal has two noise positions. The Dip Parameter has four user selectable settings available. They are left (L), right (R), higher and average.
Left (L): The noise position is set on the left side of the signal (longer wavelength side).
Right (R): The noise position is set on the right side of the signal (shorter wavelength side).
Higher: The noise position is set on the higher level of right side (R) or left side (L).
Average: The noise position is set on both sides and the average noise value is used.

4.5 Data save/recall

Measurement results can be saved using the following methods.

- External printer: Push the "Print" button at the bottom, left on the front panel and the internal thermal printer prints the measurement results on the screen.
- Floppy Disk: Press the "save/recall" key (F4) and then the "Save" key (f3) to save the data on the FD. The results can be recalled on the OSA. The results can be saved in "bitmap" or "text" format for recall on a PC as an image or as text data.

Appendix

Calibration procedure

Optical Alignment: This procedure aligns the input port of the OSA to the detector inside the OSA to maximize light throughput.

1) Connect one or more laser tones (DFB or single mode) to the OSA input port.
2) On the main menu (below the display and characterized by capital F# keys) of the OSA select the “Cal” (F5) function key. This will display the calibration sub-menu (right side of display screen and characterized by small f keys).
3) Next choose the “Auto Align” (f6) function key from the sub-menu.
4) Press the “Execute” (f1) key to perform the optical alignment. On the top, right side of the screen “Execute Calibration” will be displayed. This indicates that the unit is performing the necessary calibration. When it is complete, this indicator will disappear. At this point the optical alignment is complete.

Wavelength Calibration: For the best results it is recommended that the calibration source on the back of the OSA be used. Using this source will insure that the OSA meets the manufacturer’s specification for wavelength accuracy.

1) Press the button at the top, right side of the OSA that indicates “Output”. This turns on the calibration source and requires a five minute stabilization period before proceeding.
2) Connect a fiber from the rear port labeled “Wavelength Reference Light Output” to the input port on the front of the OSA.
3) Enter the “Cal” sub-menu as mentioned above.
4) Press the “Wl Cal (Ref)” (f4).
5) Next select “Execute” (f1) to begin the calibration process. On the top, right side of the screen “Execute Calibration” will be displayed. This indicates that the unit is performing the necessary calibration. When it is complete, this indicator will disappear. At this point the wavelength calibration procedure is complete.

Specifications are subject to change without notice.

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