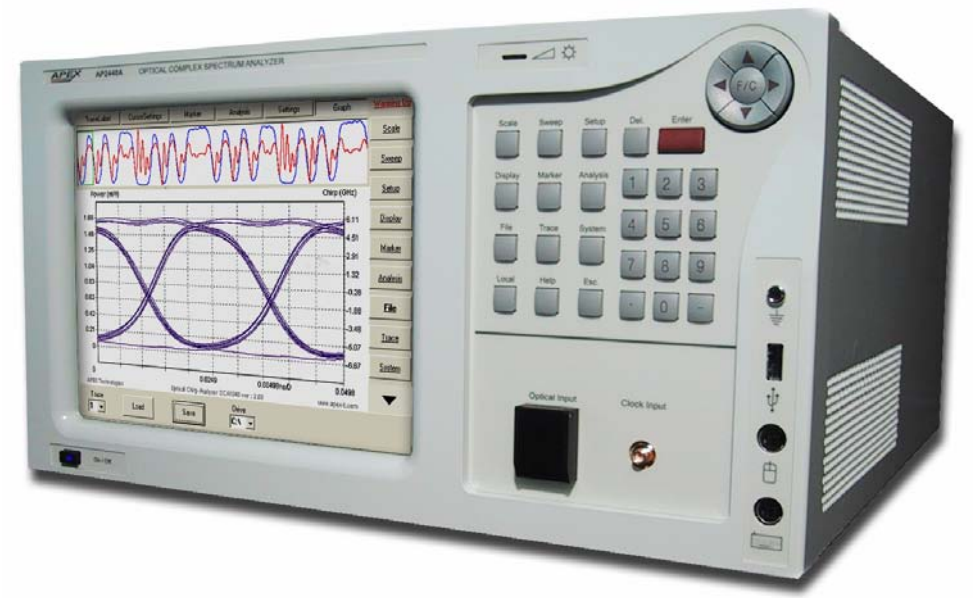
Quick Measurement Procedure
for the AP2440A
Optical Complex Spectrum Analyzer



1. CONNECT THE OCSA TO THE MAINS

2. TURN THE MAIN ON/OFF switch on the back of the instrument to the “ON” position.

3. SWITCH ON THE AP2440A VIA the front panel ON/OFF button. The blue LED inside the switch should light up, confirming “ON” status. After one minute the LCD screen will light up.

4. **CONNECT A CLOCK** signal to the AP2440A. The front panel clock accepts frequencies from 9.5Ghz up to 12.5GHz with a power between 0 and +10dBm.
   The back panel clock connection accepts frequencies between 2.3GHz and 3.12GHz with a power between 0 and +10dBm. Either one of this two clock ports can be utilized.

5. **CONNECT THE SIGNAL UNDER TEST** to the AP2440A optical input on the front panel (FC/PC connectors only!).

6. The signal under test requires a particular pattern length :

	Pattern frequency	
	Fr1 (**SHORT Pattern**) (Between 2.38GHz and 3.12GHz)	Fr2 (**LONG Pattern**) (Between 594MHz and 781MHz)
Bit rate	**Pattern length**	
2.5Gb/s (between 2.38 and 3.12Gb/s)	1bit	4bits
5Gb/s (between 4.76 and 6.24Gb/s)	2bits	8bits
10Gb/s (between 9.5 and 12.5Gb/s)	4bits	16bits
20Gb/s (between 19 and 25Gb/s)	8bits	32bits
40Gb/s (between 38 and 50Gb/s)	16bits	64bits
80Gb/s (Between 76 and 100Gb/s)	32bits	128bits
160Gb/s (between 152 and 200Gb/s)	64bits	256bits

7. Switch to the '**Spectrum'** mode by pressing the 'Spectrum' button in the main menu screen, at first we are going to verify the quality of the signal under test by means of the OSA :

    8. In the '**SWEEP'** menu (Vertical Menu), press the '**AUTO'** button (Horizontal Menu). The AP2440A is now calibrating and will select the best parameters settings for this particular signal under test.

    9. After the signal is displayed, Zoom-in on the spectrum to verify the spacing between each spectral component (peak). They should be either spaced by 2.5GHz (from 2.3GHz up to 3.12GHz) or 625MHz (from 594MHz up to 781MHz). Sub-harmonics of these frequencies are not accepted and will definitely cause measurement errors. It is therefore mandatory to have a clean spectrum for accurate OCSA measurements.
    ** If the 'AUTO' function didn't adjust the span correctly(Span too wide) refer to 'Appendix 2.1'*

    10. Press the '**SWEEP'** button in the vertical menu, and press the '**REPEAT'** button in the horizontal menu to **verify the stability** of power and wavelength of the signal under test. If some spectral lines are moving more than 3dB than averaging is required (refer to appendix 3). If they are moving more than 6dB, try to stabilize the signal under test.

    11. If the frequency spacing is good and the stability is OK, press the '**MAIN'** button located at the lowest part of the vertical menu.

    12. Press the '**CHIRP'** button in the 'MAIN' menu.

13. **SETUP** of the OCSA measurement :

Press the '**SETUP**' button in the vertical menu and the menu below will be displayed horizontally :

- Select the 'Clock Input' : **10GHz** if the clock is connected to the front panel clock input, or **2.5GHz** if the clock is connected to the 2.5GHz clock input at the back of the AP2440A.

- Set the '**Clock frequency**' selection to '**AUTO'** mode if no sub-frequencies are generated in the spectrum under test.

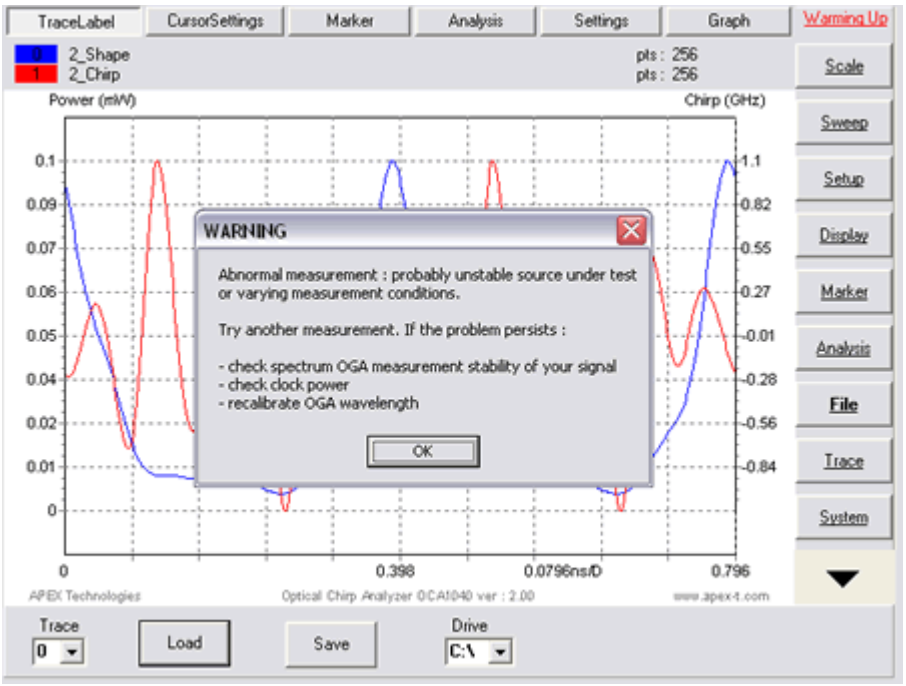
14. **MEASUREMENT** of the optical complex spectrum :

Press the '**SWEEP'** button in the vertical menu and press the '**AUTO'** button (Horizontal Menu). The AP2440A will adjust the center wavelength and span automatically. After the measurement, verify that the 'SPAN' and the 'CENTER' wavelength have been adjusted correctly. If not refer to 'appendix 2.1'.

15. The measurement results are now displayed; the Pulse & Chirp parameters by default. Other parameters can be selected by at first pushing the '**DISPLAY'** button in the vertical menu following selecting the desired parameters in the horizontal menu.

Appendix 1 : Measurement errors

If the measurement conditions were not good the following screen will be displayed :



In this case verify :

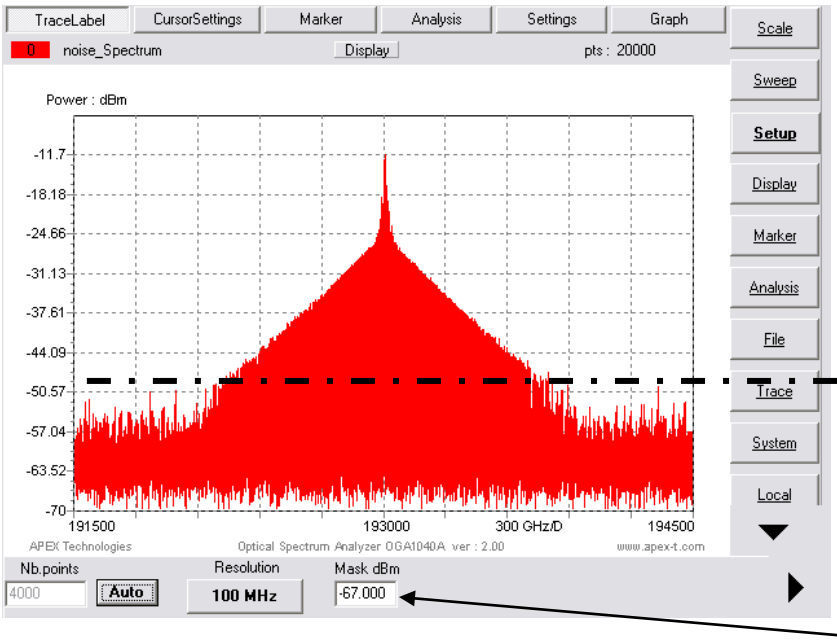
- If the optical signal under test is active.
- If the clock is connected and within the correct frequency and power range.
- With the optical spectrum analyzer, if the spectral components are spaced by the required frequency (if not change the pattern applied to the device under test)
- If the spectrum under test is stable in power and wavelength.

Appendix 2 : Particular cases

2.1 Noise floor adjustment :

In some cases the signal under test is generating a higher noise floor that the noise floor of the OSA (ASE noise of an EDFA for example). In this case the 'AUTO' sweep function of the OSA and the OCSA will select an incorrect center frequency and span. As a result, an incorrect setting of the noise floor will induce measurement errors on the optical complex spectrum analysis.

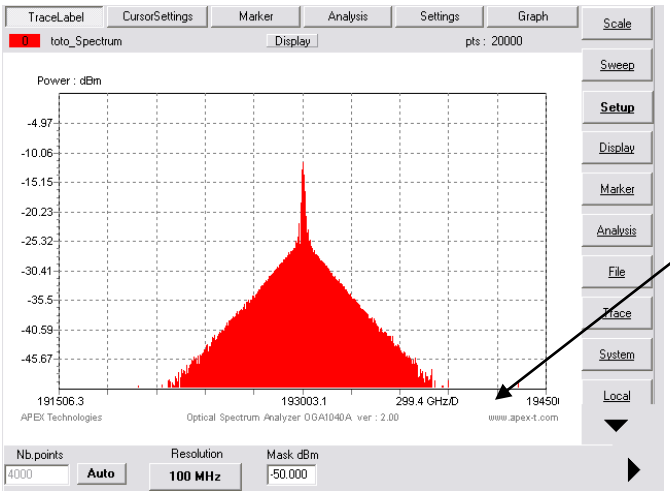
In this case, go to the '**SPECTRUM'** mode, measure the signal under test (with the '**AUTO'** function of the '**SWEEP'** menu) and measure the intensity value of the noise floor :



The noise floor of the signal under test in this case is -50dBm. If an 'Auto' sweep is launched it will fail and the optical complex spectrum analysis will be wrong.

Noise floor setting

Press the '**SETUP'** button in the vertical menu and enter the noise floor value of the signal under test in the **'Mask dBm'** box in the horizontal menu. Press the '**SWEEP'** button (Vertical Menu) and press the '**AUTO'** button (horizontal Menu) to measure the signal again with this new noise floor setting. (this value will be used for the optical complex spectrum measurement) :

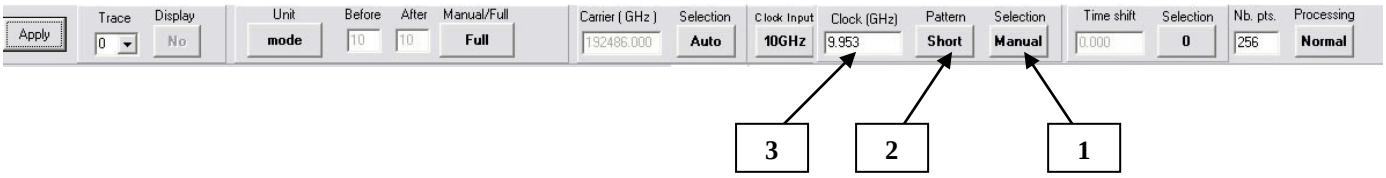


Same spectrum with a -50dBm noise mask setting. In this case a correct optical complex spectrum measurement can be made.

2.2 Manual setup of the clock frequency and pattern length :

When is a manual setup required ?

- For an accurate time display, the clock frequency can be entered manually
- If one of these error messages are displayed :
    - Pattern or Clock frequency out of range
    - Pattern or clock frequency may be different from Setup value



To manually set the clock, press the **'SETUP'** button in the vertical menu and press clock '**SELECTION'** button ('1') (Horizontal menu) to display '**MANUAL'**.

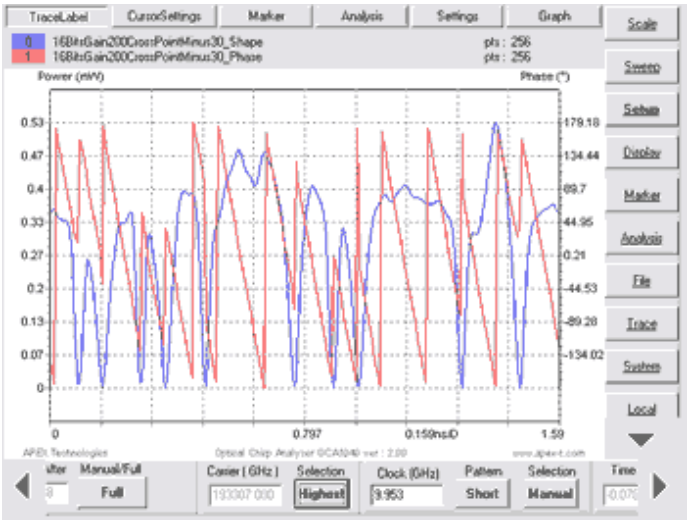
Enter the exact clock value in **'CLOCK GHz'** ('2') edit box.

Select the pattern length with the '**PATTERN'** button ('3'):

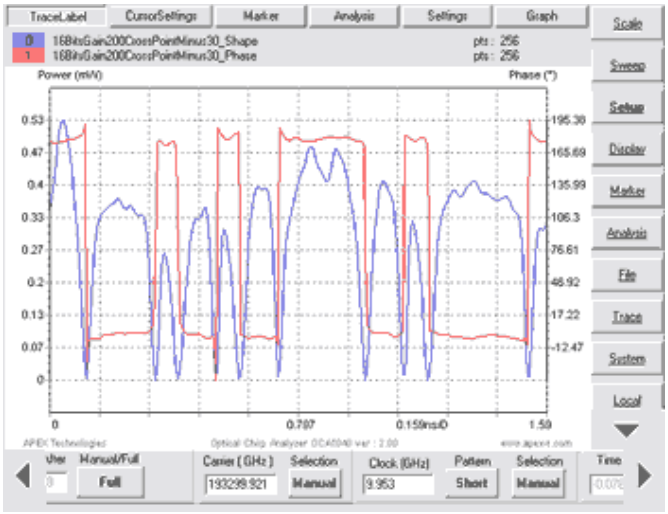
- **SHORT** : 2.5GHz repeat frequency
- **LONG** : 625MHz repeat frequency

2.3 Manual carrier selection for phase modulated signal :

For DPSK, QPSK and other phase modulations it is necessary to select the 'real' carrier in order to display the phase correctly, this is the procedure :



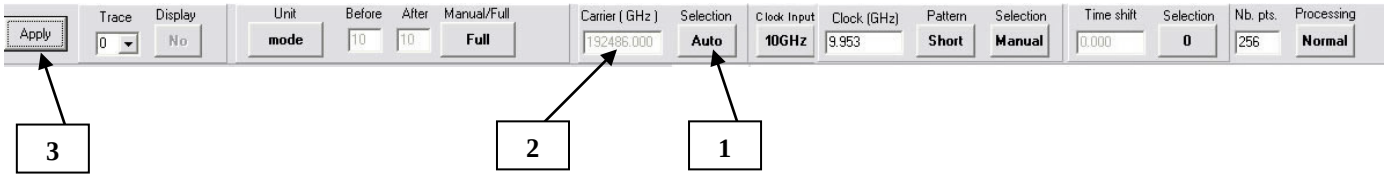
DPSK with an incorrect carrier selection



DPSK with a correct carrier selection

How to indentify the real carrier ? Turn OFF your modulation, measure the spectrum of the laser and measure its frequency (or wavelength) accurately.

How to enter the carrier manually ? If the frequency of the carrier is known, switch to the '**Chirp'** mode and enter this carrier frequency in the '**SETUP'** menu in the vertical panel as shown below.

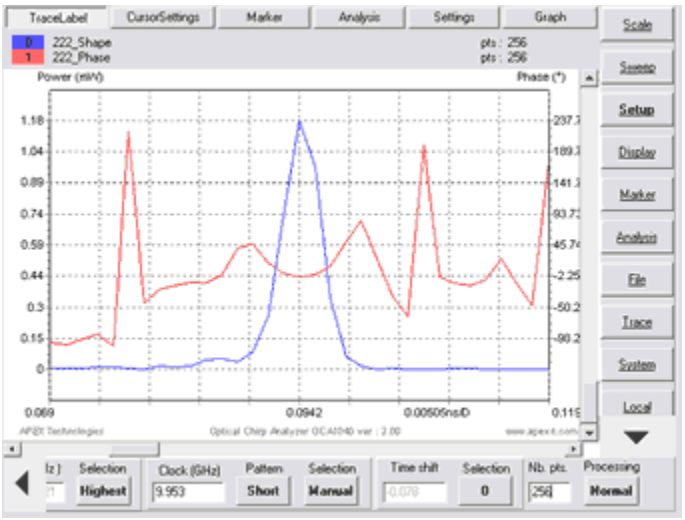


In the horizontal menu, press the carrier '**SELECTION'** button ('1') and select '**MANUAL'**, then enter the exact carrier value in the '**CARRIER'** edit box and press '**APPLY'** ('3'). The signal is now calculated based on this new carrier setting.

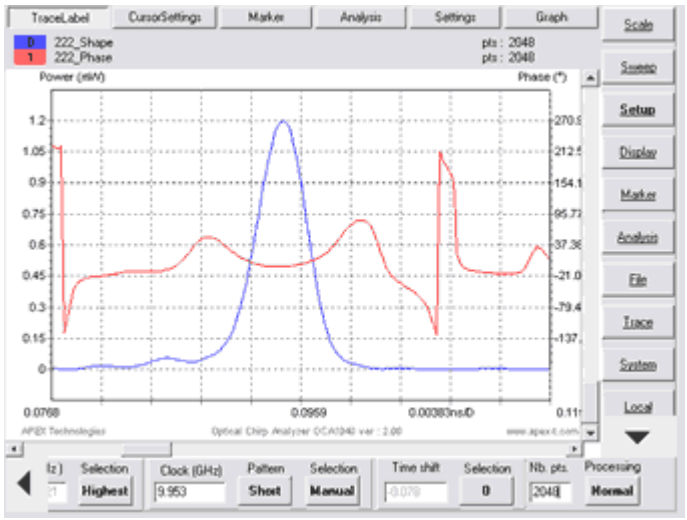
2.4 Increase of the number of display points :

By default after each measurement the AP2440A calculates the FFT with 256pts. The number of points can be changed in the '**SETUP'** menu.

Enter a 2^n number of points in the '**NB PTS**' edit box (not more than 4096pts otherwise the calculation will take very long) and press the '**APPLY'** button.



256pts display of a 2ps pulse

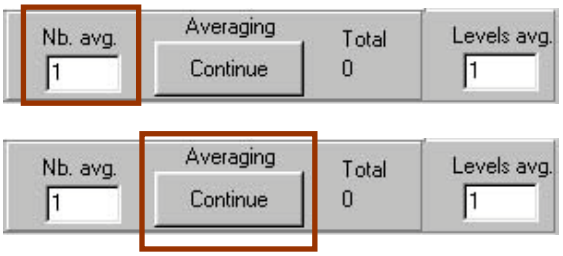


2048pts display of the same signal

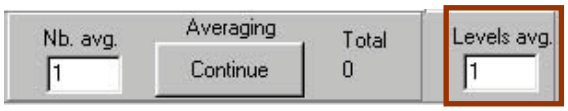
Appendix 3 : AVERAGING FUNCTIONS

Averaging functions are located in the 'SWEEP' menu.

Two kind of averaging functions are available :



- **Standard averaging :** When you would like to increase accuracy and repeatability, use this function.
  Enter the number of desired averages in the 'Nb.avg' box and press "SINGLE" to start the measurement. If you would like to continue at the end of the averaging process, press "Continue" and the averaging process will continue.



- **Levels averaging :** If the stability of the signal under test is not stable enough to measure pulse and chirp accurately, use this function.
  Enter the number of averaging desired in the 'Levels avg.' box and press "SINGLE" to start the measurement.

These two kind of averaging types can be used simultaneously, if desired.

Note: measurement inaccuracies are mostly caused by power repeatability issues of the spectrum under test. This can be improved by utilizing the averaging function.

If you have any questions or problems about the use of the AP2440A OCSA, or if you would like to know more about how to measure chirp, do not hesitate to contact us directly:

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AP244XB series

OPTICAL COMPLEX SPECTRUM ANALYZER

Instruction Manual

(Version 2.25)

APEX Technologies

9bis, rue Angiboust, 91460 Marcoussis, France

Printed in France **January 2009**

WARRANTY

Our products are tested and verified before the shipping. In case of failure due to manufacturing fault or an accident during transportation occurs, please contact our head office or your nearest distributor.

The term of warranty is one year after the date of delivery. We are making repairs free of charge on failures that occur within this term. However, a failure due to the user's misoperation or modification or change or opening of the instrument, or a failure or damage due to a natural disaster is excepted from the said free repair service even if it occurs within the term.

The information contained in this document is subject to change without notice.

General Safety Considerations

- **Before using this equipment, be sure to read through the "General Safety Considerations" and operation manual to ensure its correct operation and to maintain the instrument in a safe condition**.

- **After reading these documents, keep them handy so that anyone can read them at any time.**

- **Do not try to install any software in this equipment.**

- Be careful in that no water mixes in this equipment to be free from getting wet. Otherwise, it can cause a fire, electric shock or fault.

- This instrument is provided with a protective earthing ground incorporated in the power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.

- No operator serviceable parts inside. To prevent electrical shock, do not remove covers.

- Before switching ON this instrument, make sure that the line voltage selector switch is set to the voltage of the power supply and the correct fuse is installed.(refer to §1.1.2 & § 1.1.3).

- The power cord is connected to internal capacitors that may remain live for several seconds after disconnecting the plug from its power supply.

- For continued protection against fire hazard, replace line fuse only with the same type and rating. The use of other fuses or material is prohibited.

- If this instrument is used in a manner not specified by APEX Technologies, the protection provided by the instrument may be impaired.

- Do not put this equipment in an unstable place such as a shaky table or inclined location to avoid it falling down or bringing down. If it does, it can cause a physical injury.

- Do not put this equipment at a place where is subject to vibration or shock.

- Do not insert or drop a metal piece, etc…, into the equipment interior from its opening section. If does, it can cause a fire, electric shock or fault.

- Do not place this equipment at a place where is exposed to the direct sunlight or where is high in temperature.

- When moving this instrument, first pull out the power plug from its socket, and after making sure that its external connecting cords have been all removed, move the equipment.

- Do not block the air hole of this equipment.

- Do not put any container filled with water, etc…, or a small metal piece on or near this equipment.

- When this equipment is not used for a long period of time, be sure to keep the plug socket removed.

- When this equipment is used under any abnormal conditions giving out smoke or offensive smell, it can cause a fire, electric shock or fault. In such a case, turn its power switch OFF immediately and pull out the power plug from its socket, and after making sure that no smoke is given out any more, contact our agent to repair the equipment.

- Infrared light is output from the tunable laser source output located in the back panel and covered by a black safety cover.

- Never look at the light output unit or the tip of the optical fiber connected to the light output unit.

- The unit output infrared light from the tunable laser source output with this specification :

Laser type	Tunable laser source
Laser class	Class 1
Max. Output power	0.9mw
Beam diameter	9μm
NA	7.5degree
Wavelength	AP2440A : 1520nm to 1567nm AP2441A : 1520nm to 1607nm

Summary

Contents of figure

1 General

1.1 Preparations before use

1.1.1 Mechanical checks

Check the appearance, switch operations and connectors of the instrument to see if it have not been damaged or had any fault during transportation.

1.1.2 Power supply

Use a power supply of AC 100V or AC110V or AC 230V with a power supply frequency of 50Hz to 60Hz.

1.1.3 Fuse replacement

Use two 250V/T2.5A fuses for a 230V input voltage.

Use two 250V/T5A fuses for a 110V input voltage.

The fuses are already installed in the standard equipment.

In case a fuse must be replaced because of a failure, clear up the cause of the failure and remove it before.

Turn OFF the instrument and unplug the power supply cord.

Open the fuse receptacle with a screwdriver.(Fig.1)

Remove old fuses and insert the two new fuses as shown on Fig. 2. Pull down and push the fuses receptacle.

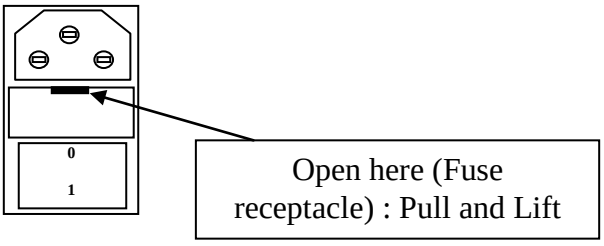


Fig 1 : Power panel

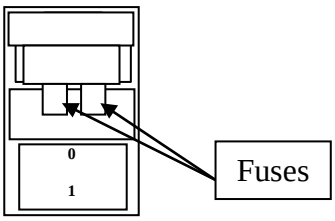


Fig. 2 : Opened Fuse receptacle

1.2 Precautions on handling

This instrument is sensitive to shock and vibrations. It is necessary to take precautions for the transportation of the instrument. Always use the hard case delivered with the instrument for the transportation of it.

1.3 Environmental conditions

This instrument have to be use only on the horizontal way and never upside down. A bad position can damage the instrument.

Storage temperature : -10°C to +50°C

Operating temperature range : +10°C to +35°C

1.4 Specifications

	AP2441B	AP2443B
Optical spectrum analyzer specifications		
Wavelength measurement range	1525nm to 1607nm	1520nm to 1630nm
Wavelength span range	80pm to 82nm	80pm to 110nm
Wavelength absolute accuracy [a b c]	+/-3pm	
Wavelength resolution(@3dB) [d]	20MHz (0.16pm) and 100MHz (0.8pm)	
Measurement level range [a e]	-70dBm (monochromatic) to +10dBm	
Absolute level accuracy [a b e]	+/- 0.3dB	
Level repeatability [a b d e]	+/- 0.2dB	
Close-in dynamic range [a b e]	>40 dB @ +/- 1pm >60dB @ +/- 3pm	
Spurious free dynamic [d]	55dB Typical (50dBmin)	
Sweep time [d e]	5s for 55nm	8s for 110nm
Optical input	FC/PC for SM fiber	
Tunable laser output	>-7dBm	
Internal absolute WL calibrator	Yes	
Display capabilities		
X scale	Wavelength in nm or frequency in GHz	
Y scale	Optical power in mW or dBm	
Optical complex spectrum analyzer specifications		
Wavelength measurement range	1525nm to 1607nm	1520nm to 1630nm
Clock frequency	Fclk1 = 9.92GHz to 12.5GHz or Fclk2 = 2.47 to 3.13GHz	
Clock frequency (option OCSA03)	Fclk1 = 6GHz to 12.5GHz or Fclk2 = 1.5GHz to 3.13GHz	
Clock power	0 to +10dBm	
Pattern frequency	Fr1 = 2.48GHz to 3.12GHz and Fr2 = 620MHz to 781MHz (see pattern table bellow)	
Pattern frequency (option OCSA03)	Fr1 = 1.5GHz to 3.12GHz and Fr2 = 375MHz to 781MHz (see pattern table below)	
Measurement level range [h]	-55dBm to + 10dBm	
Maximum temporal resolution [f]	95fs	75fs
Chirp accuracy [g]	+/- 60MHz	
Measurement time [g]	5s	7s
Display capabilities		
X scale	Time in ps or Wavelength in nm or Frequency in GHz	
Y scale	Intensity in mW or dBm, chirp in GHz, phase in degree, alfa parameter	
Options		
OSA01	Continuous and step by step Optical Tunable laser source	
OSA02	Optical tracking generator for transmission measurements	
OCSA03	No bit rate limitation option (see pattern table below)	
OCSA04	Group delay and chromatic dispersion analysis	

Optical complex spectrum analyzer pattern length

The bit rate of the signal under test divided by the pattern length must be included in the pattern frequency range[i]

Bit rate	2.48Gb/s to 3.12Gb/s	4.96Gb/s to 6.24Gb/s	9.92Gb/s to 12.5Gb/s	19.84Gb/s to 25Gb/s	39.68Gb/s to 50Gb/s	79.36Gb/s to 100Gb/s	158.72Gb/s to 200Gb/s	317,44Gb/s to 400Gb/s	634,88Gb/s to 800Gb/s
Bit rate (OCSA03)	1.5Gb/s to 3.12Gb/s	3Gb/s to 6.24Gb/s	6Gb/s to 12.5Gb/s	12Gb/s to 25Gb/s	24Gb/s to 50Gb/s	48Gb/s to 100Gb/s	96Gb/s to 200Gb/s	192Gb/s to 400Gb/s	384Gb/s to 800Gb/s
Pattern length for Fr1	1bit	2 bits	4 bits	8 bits	16 bits	32 bits	64 bits	128 bits	256 bits
Pattern length for Fr2	4 bits	8 bits	16 bits	32 bits	64 bits	128 bits	256 bits	512 bits	1024 bits

Turn ON the instrument

Push the power supply switch of the real panel (Refer to Fig.3, n°1). Then press the On/Off button of the front panel (Refer to Fig.4, n°6) The software is running under windows and it takes around 1 minute to start the program. Do not push any button before the start menu is displayed.

A warm-up of 30 minutes is necessary for temperature stabilization. During this time, 'Warm-up' is written on the 'Start' menu and on the top of the vertical menu of the spectrum analyzer software. If 'SINGLE' or 'AUTO' of the 'SWEEP' menu is pressed, a wavelength calibration is automatically started. If the laser warming up is not finished a message will be displayed on the screen and the measurement will not be done.

After 30 minutes, 'WARM-UP' is deleted on the start menu. Then a wavelength calibration of the spectrum analyzer have to be made (Even if a wavelength calibration have been made during the 'Warm-up'). If 'SINGLE' or 'AUTO' of the 'SWEEP' menu is pressed, a wavelength calibration is automatically started. Otherwise, it is possible to calibrate the spectrum analyzer by pushing the 'RUN CAL' button of the 'SETUP' menu (Refer to §7.4.3 for 'SETUP' menu). When calibration succeed, a message is displayed : 'CALIBRATION SUCCEED'.

Specifications are guaranteed after a 1 hour warm-up and after a wavelength calibration.

1.5 Turn OFF the instrument

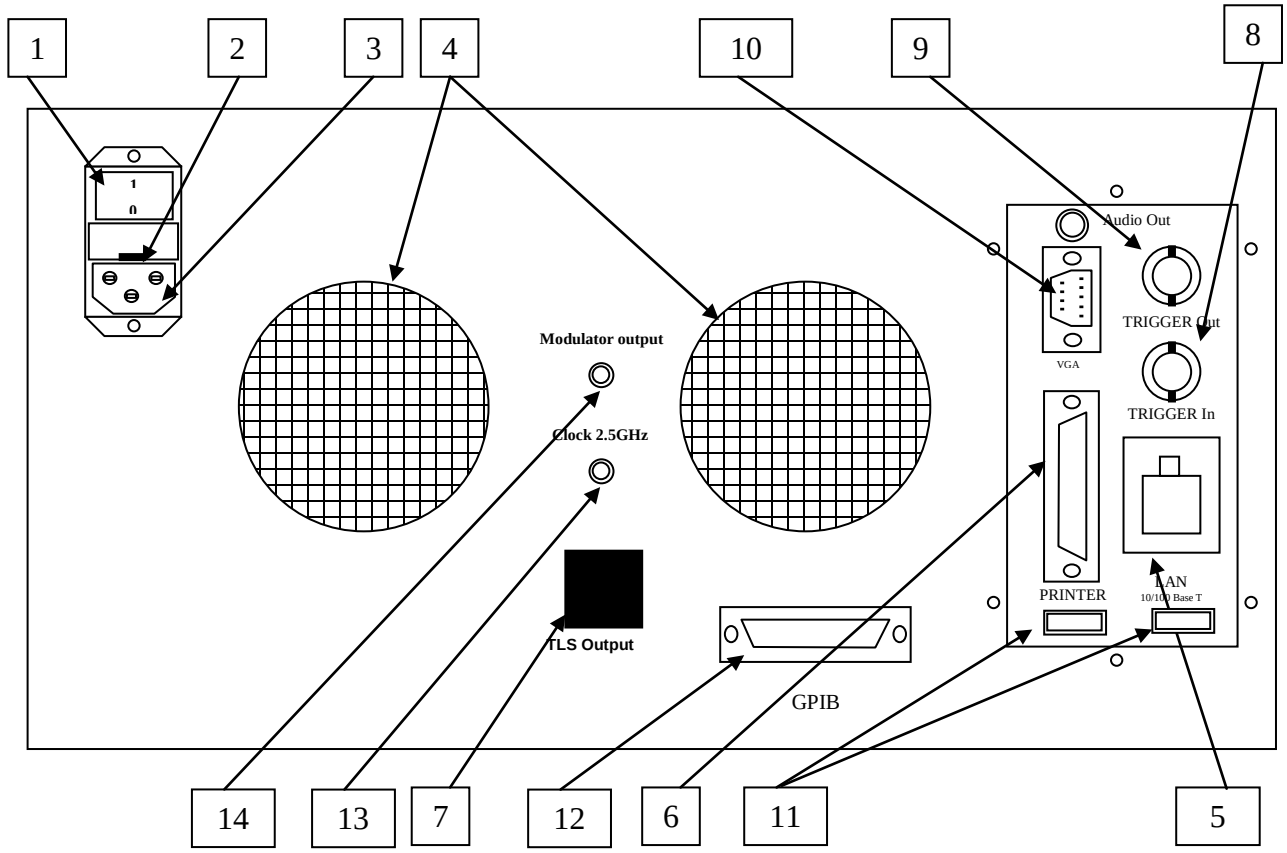
To turn OFF the instrument, push the ‘On/Off’ switch of the front panel (Refer to Fig.4, n°6) and wait few seconds for the shutting down of the software and the computer.

Then push the power supply switch to 0 (refer to Fig.3, n°1).

2 Rear and Front panel description

2.1 Rear Panel

Fig. 3 : Rear panel



1 : Power supply switch

2 : Fuse receptacle

3 : AC power connector

4 : Fans

5 : 10/100 Base-T Ethernet port

6 : Printer parallel port

7 : Tunable laser source output
(CAUTION : FC/APC connector)

8 : Trigger IN (not connected)

9 : Trigger OUT (not connected)

10 : VGA connector (for external screen)

11 : USB 2.0 connectors for external devices

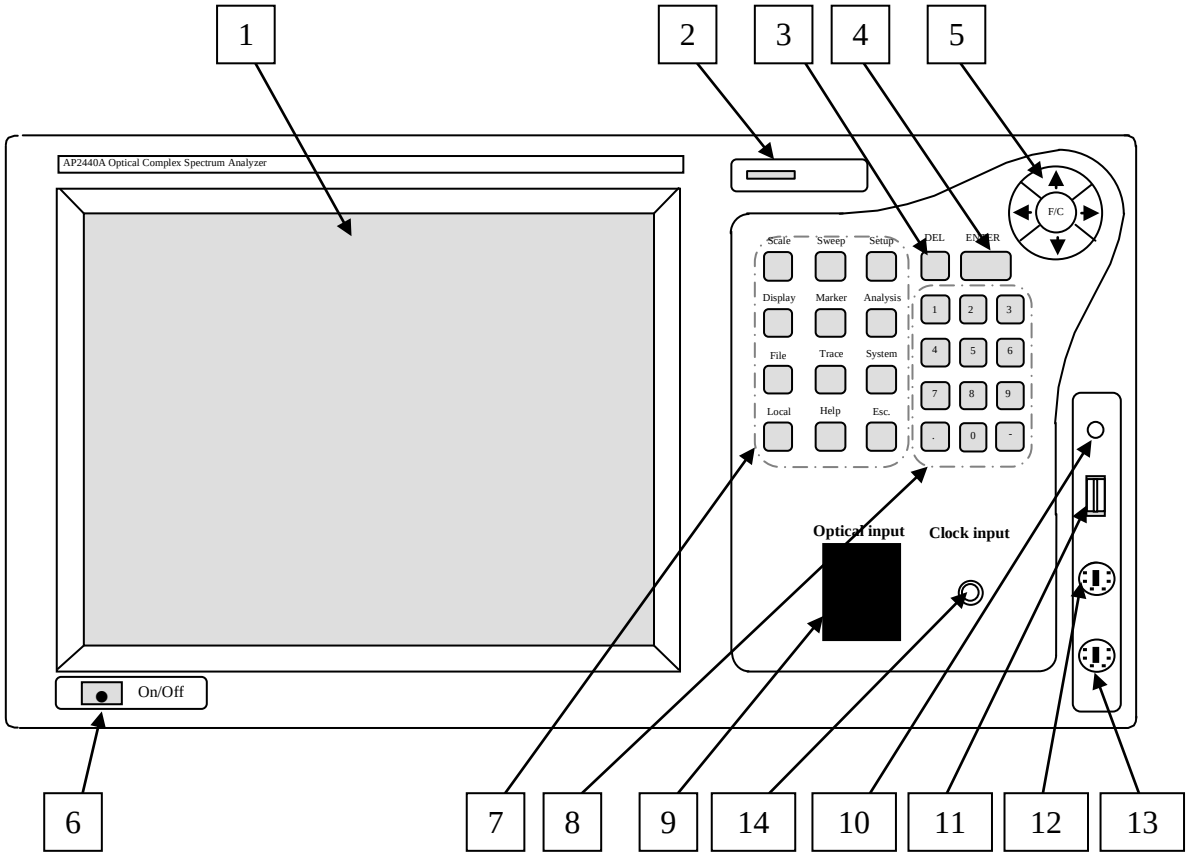
12 : GPIB connector

13 : SMA 2.5GHz clock input

14 : (optional) SMA +14dBm output for modulator connection

2.2 Front panel

Fig. 4 : Front panel



1 : 10.4’’ touch sensitive TFT screen

2 : Screen contrast adjustment screw

3 : Delete button

4 : Enter button

5 : Directions and Fine/Coarse button

6 : On/Off switch

7 : Function selection keyboard

8 : Numerical keyboard

9 : FC/PC Optical input (SM 9/125µm fiber)

10 : Ground connection

11 : Front panel USB connector

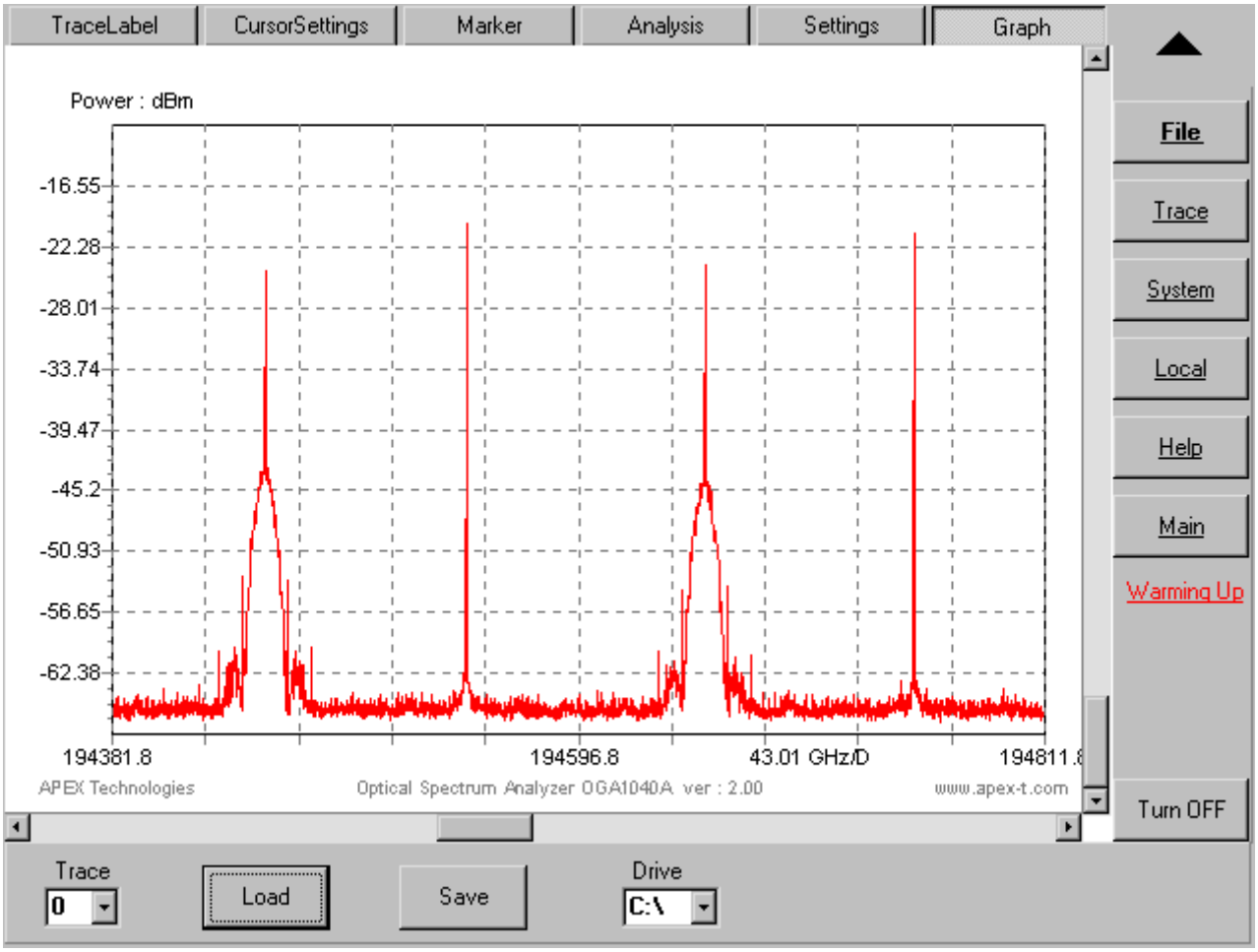
12 : Keyboard connector (PS2)

13 : Mouse connector (PS2)

14 : SMA 10GHz clock input

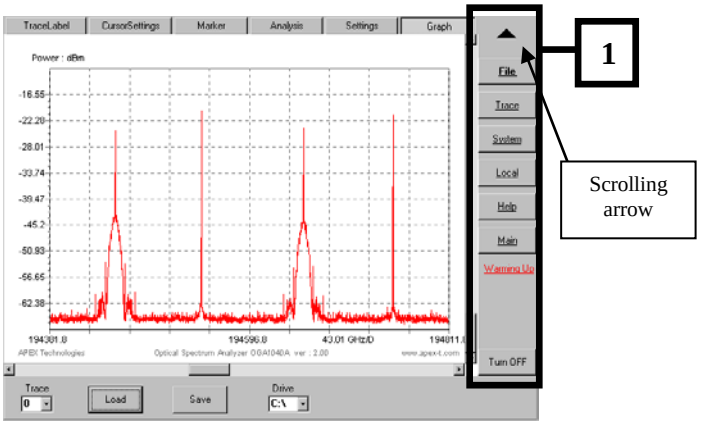
3 SCREEN configuration

Fig. 5 : Screen configuration



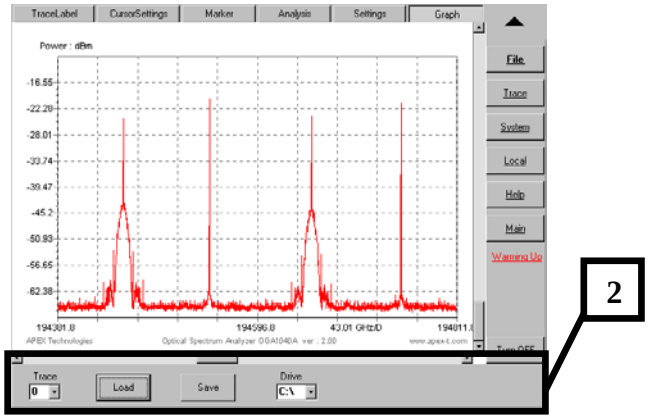
1 : Vertical panel

Use this panel to select a Menu. If an Up or Down arrow is displayed it is possible to scroll this panel up or down. The selected menu is in bold character and is displayed on the horizontal panel (2).



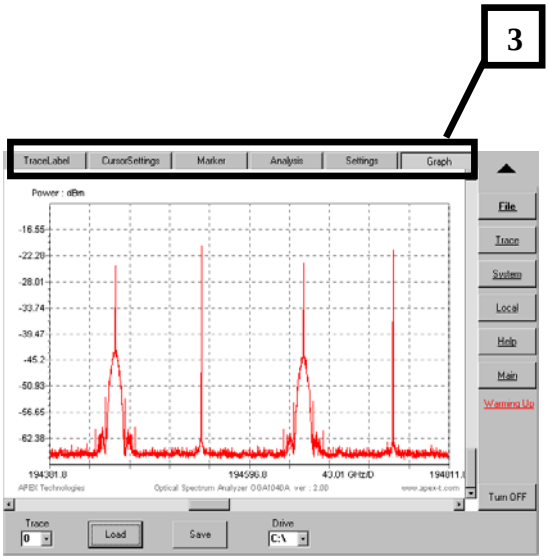
2 : Horizontal panel :

Use this panel to select a function. . If a Right or Left arrow is displayed it is possible to scroll this panel right or left.



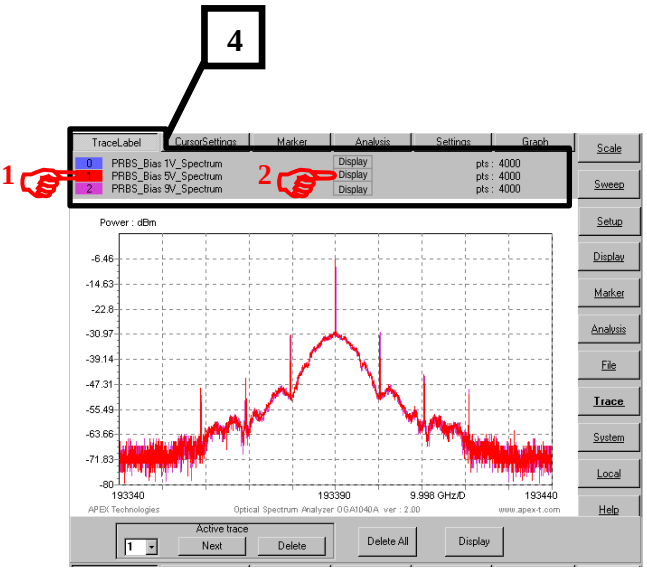
3 : Thumb-index panel :

Click in one of the thumb-index to display measurement and analysis information. Click again to reduce it.



Details of thumb-index panel :

4 : Trace label

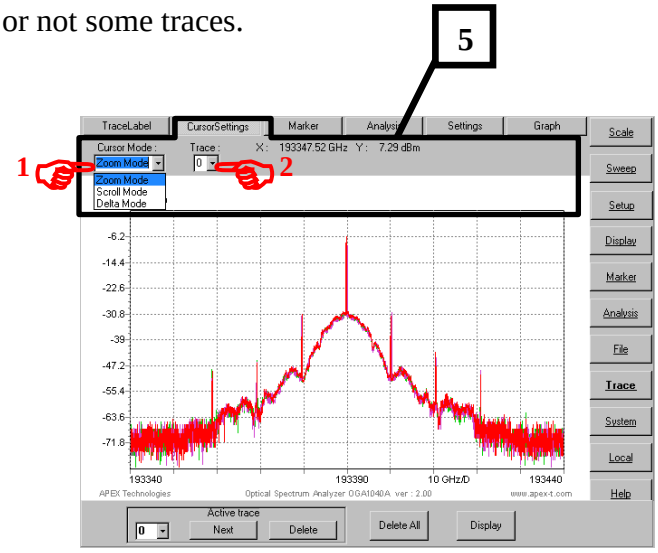


Trace label thumb-index inform about the number of traces measured or loaded, their names, their colors, the number of points and their states (Blank or Display).

1 ☞ : Click on the trace number to select the active trace.

2 ☞ : Click on the Display/Blank box to display or not some traces.

5 : Cursor settings



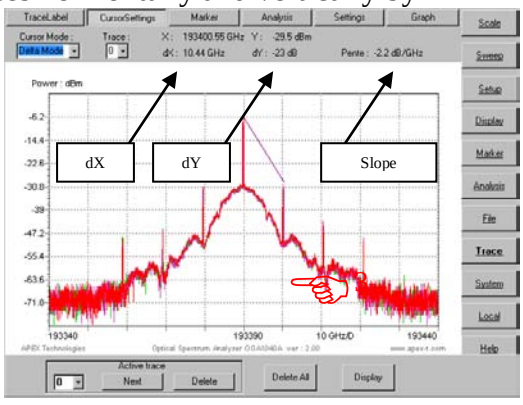
Cursor settings thumb-index permits to select the cursor mode, the active trace and inform about position of the cursor.

For any cursor mode, the position of the cursor is displayed. The unit used for the cursor position is the unit of the active trace.
X : Frequency in GHz or Wavelength in nm or time in ns
Y : Power in mW or dBm, chirp in GHz, phase in degree and alfa chirp parameter (no unit)

1 ☞ **: Cursor mode selection**

- Zoom mode : In zoom mode, zoom the active trace (and all other traces using this unit) by drawing a rectangle from the top/left corner to the bottom/right corner. To un-zoom draw a rectangle from the bottom/right to the top/left corner.

- Scroll mode : In scroll mode, translate the traces horizontally and vertically by clicking on the graph.



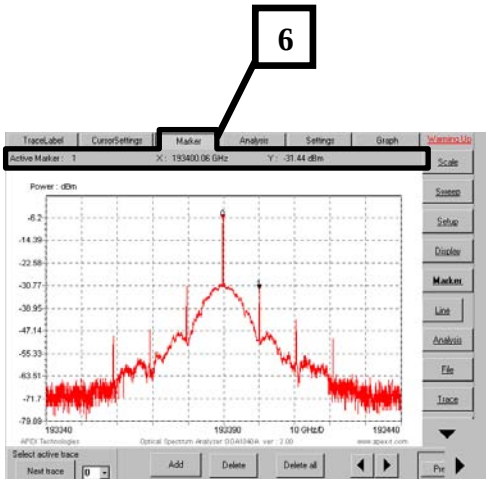
- Delta mode : In delta mode, measure the difference between two points of the active trace. Trace a line between two points (☞3), and read information written on the cursor settings thumb-index. (dX : horizontal scale difference of the active trace; dY : vertical scale difference of the active trace; slope : slope of the line drawn

2 ☞ **: Active trace selection**

Select the active trace in this scrolling box.

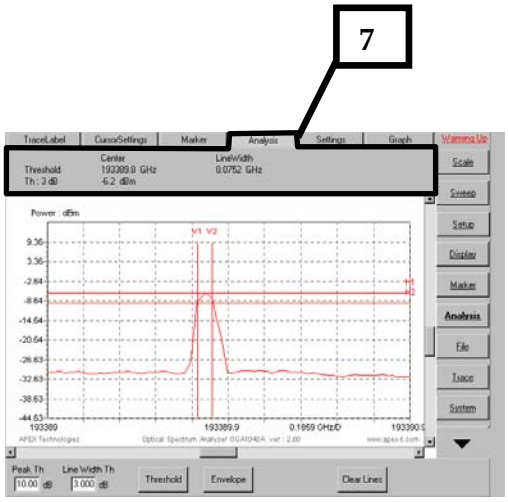
6 : Marker

Marker thumb-index gives information about the active marker (X scale and Y scale) and the vertical and horizontal lines.



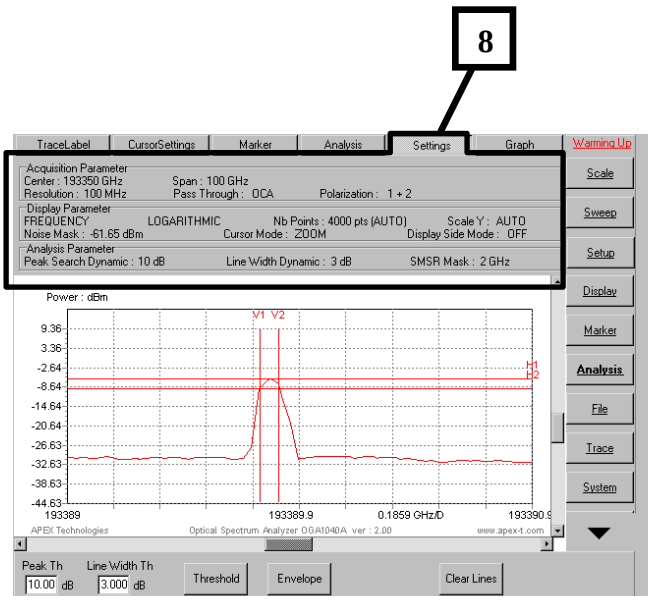
7 : Analysis

Analysis thumb-index gives results of an analysis function (Threshold, SMSR,…)



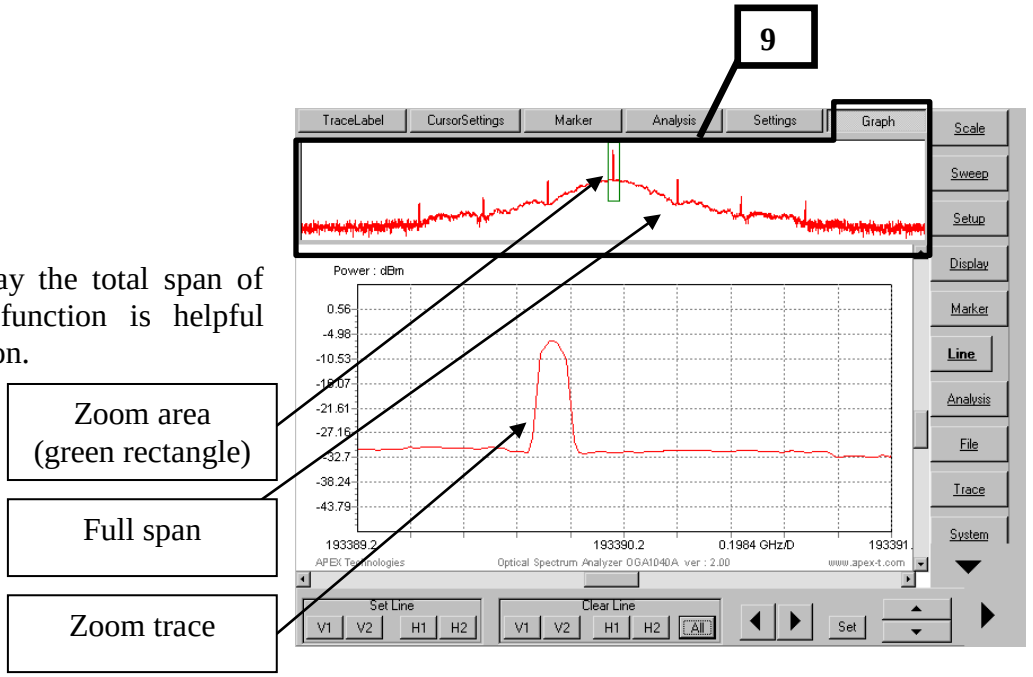
8 : Setup

Setup thumb-index inform about the measurement, display and analysis setup of the last measurement.



9 : Graph

Graph thumb-index display the total span of the measurement. This function is helpful when using a zoom function.



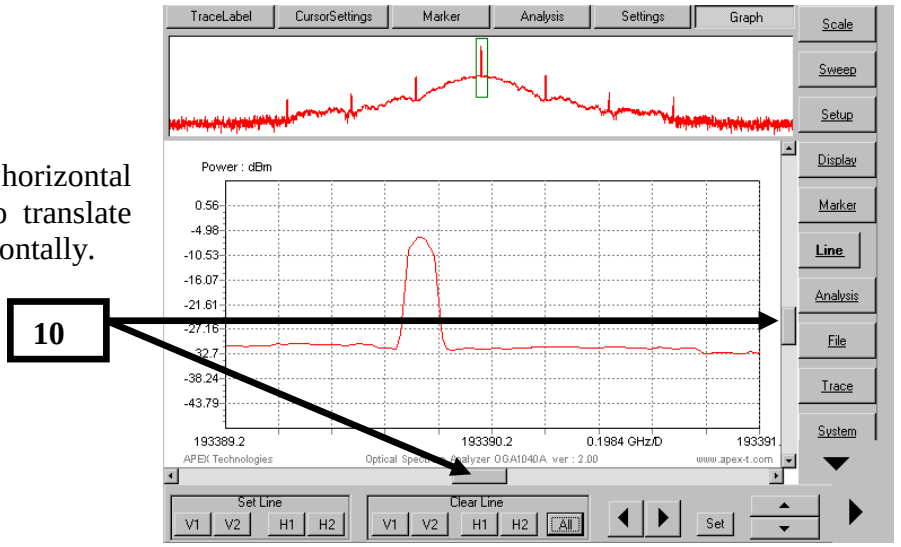
Zoom area (green rectangle)

Full span

Zoom trace

10 : Scrolling bars

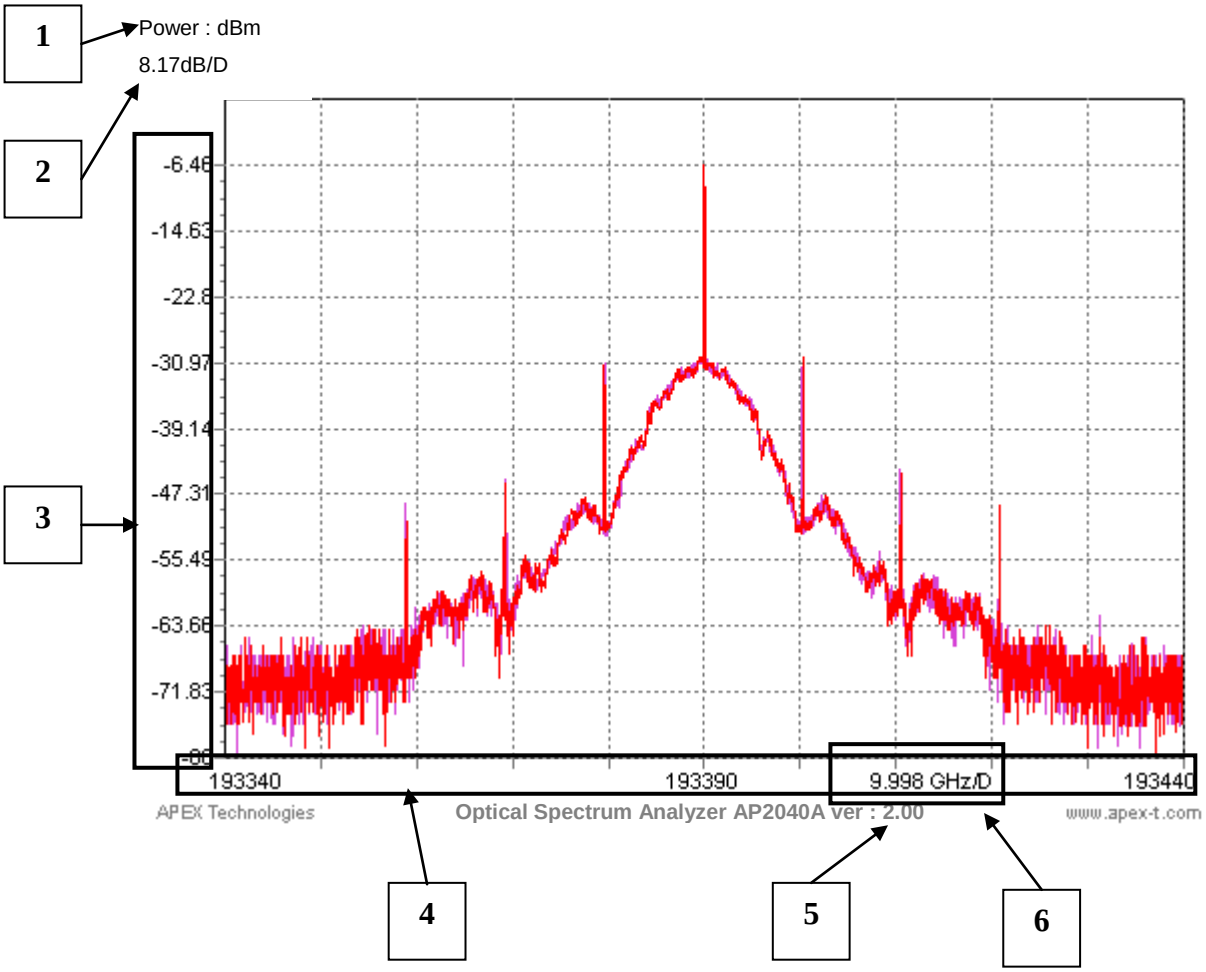
After a zoom, vertical and horizontal scrolling.bars appears. Use them to translate the zoom area vertically and/or horizontally.



4 GRAPH configuration

4.1 For the optical spectrum analyzer :

Fig. 6 : Graph configuration



1 : Y scale unit

2 : Y scale by division

3 : Y scale

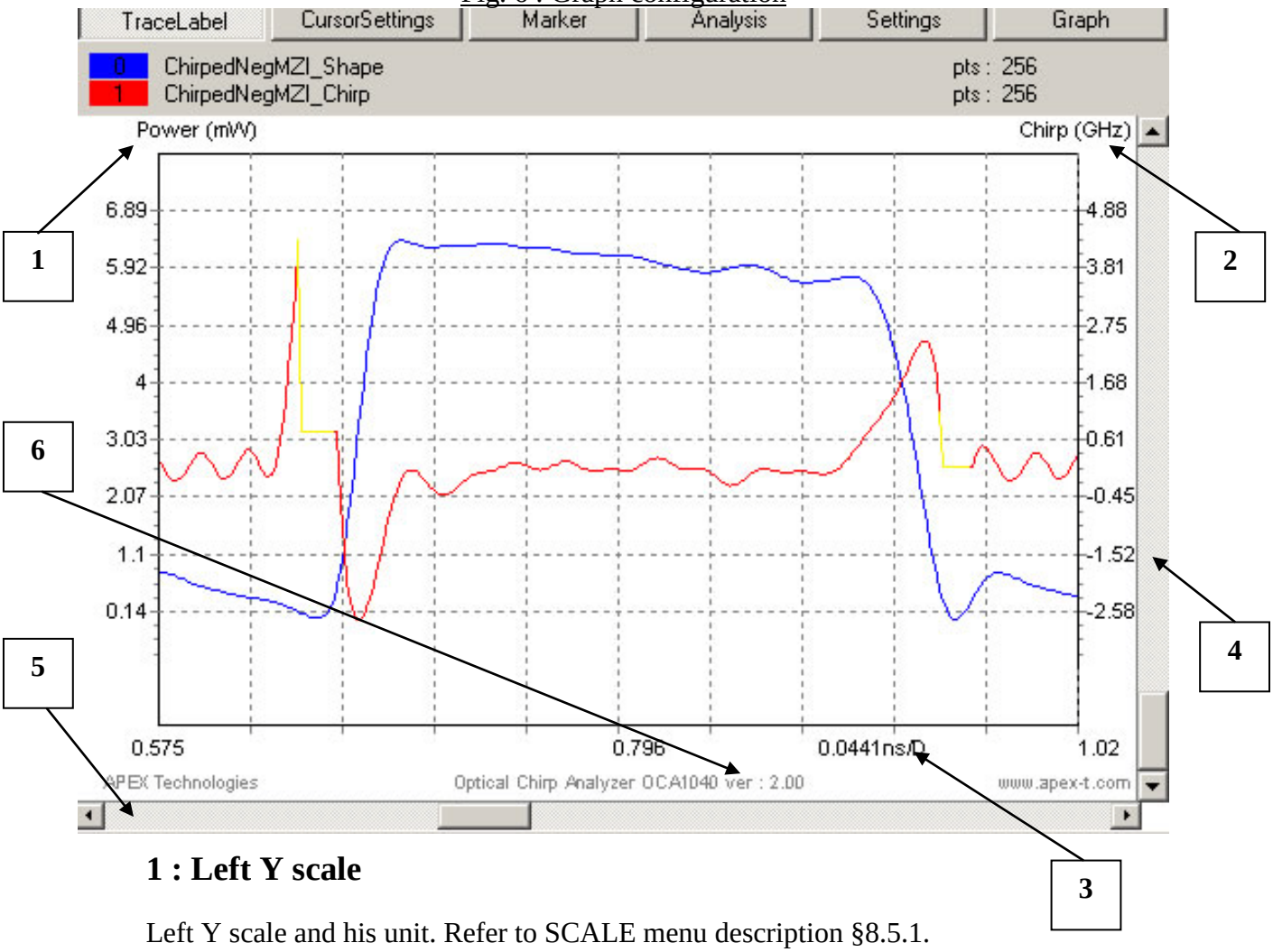
4 : X scale

5 : Software version

6 : X scale by division

4.2 For the optical complex Spectrum Analyzer :

Fig. 6 : Graph configuration



1 : Left Y scale

Left Y scale and his unit. Refer to SCALE menu description §8.5.1.

2 : Right Y scale

Right Y scale and his unit, refer to §8.5.1.

3 : X scale

X scale and his unit. It can be changed in the X SCALE menu.

4 & 5 : Scrolling bar

This two scrolling bar (vertical and horizontal) can be used after the use of the ZOOM IN function in the SCALE menu. It is thus possible to translate vertically or horizontally the zoomed trace.

6 : Software version

Note this number before contacting us for assistance or repair.

5 Key rules

Every keys can be selected by three different ways :

- Front panel keyboard

- Mouse

- Touch-sensitive screen.

5.1 Touch-sensitive screen

The AP2440A is equipped with a touch-sensitive screen. Use the touch-sensitive pen delivered with the instrument in order to protect the screen from scratch or finger-prints.

The touch sensitive screen is used for function selection, zoom function and lines function.

5.2 Mouse

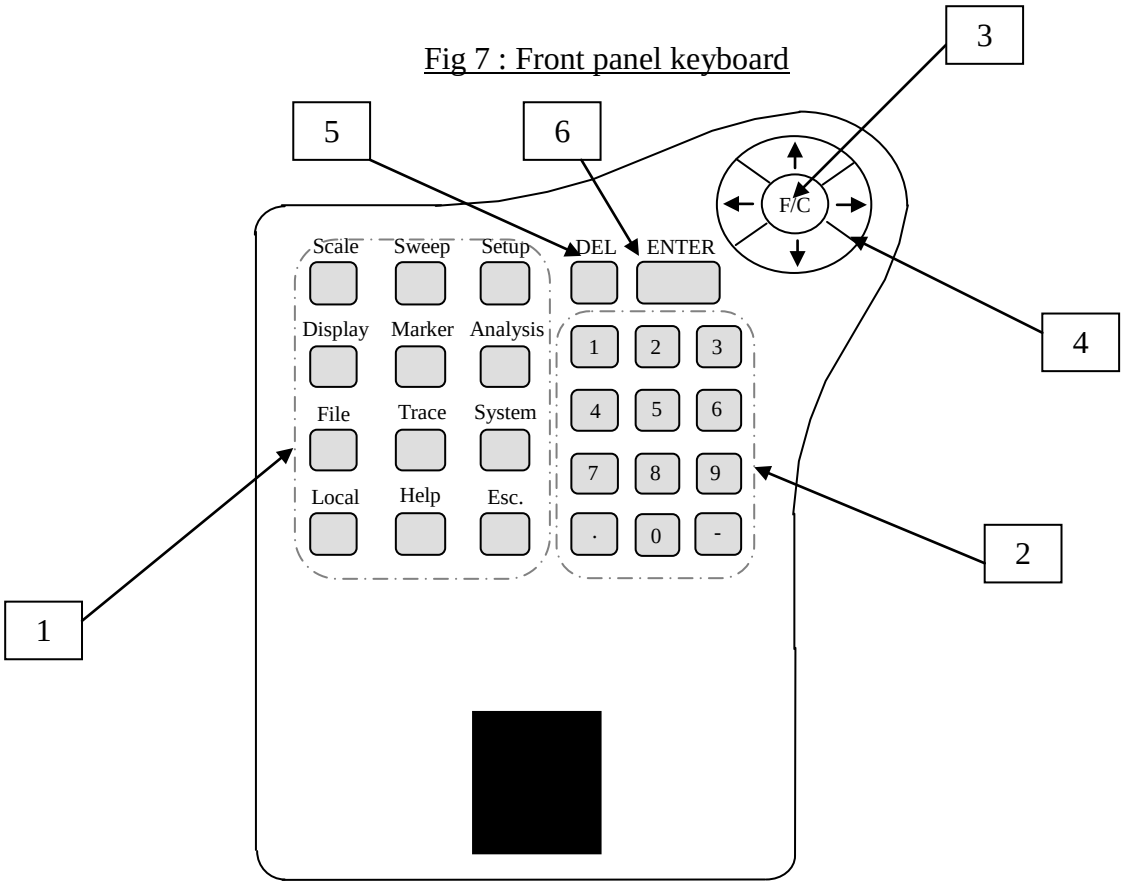
A mouse can be used also with the AP2440A.

The mouse is used for function selection, zoom function and lines function.

5.3 Front Panel keyboard

The front panel keyboard can be used for function selection, numerical keyboard and to move markers and lines.

Fig 7 : Front panel keyboard



5.3.1 Numerical keyboard

(fig.7; n°2) Use this keyboard to enter numerical values (for scale X or scale Y for example). To delete values, use the “Del.” button (Fig.7; n°5). When values are entered, push “Enter” button (Fig.7; n°6).

5.3.2 Function selection with front panel keyboard

(fig.7; n°2) For function selection, push the function key and then the corresponding horizontal panel is displayed.

To enter in an edit box (box with numbers inside), select the edit box and press enter. Then it is possible to enter the number or to select a digit to change with righ and left arrows, this digit can be increased with the up and down arrows.

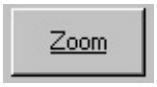
5.3.3 Front panel arrows

(fig.7; n°4) Front panel arrows, can be used to move markers and lines.

F/C button (Fig.7; n°3) can be use to switch to the Main menu. Then it is possible to select the application : Optical spectrum analyzer or Optical complex spectrum analyzer

5.3.4 Button and boxes appearance

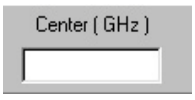
In the vertical and horizontal panels, there is different kind of button and boxes :



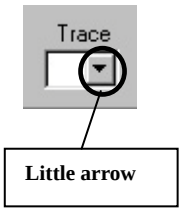
- **Underlined button :** The underlined buttons permit to reach a submenu.
  By pushing this button, the Zoom menu will appear

- **Bold character button :** When buttons have bold characters inside, it means that the information written on the button can be changed by pushing the button. Bold characters show the selected parameter.
  By pushing this button, unlocked will be written on the button and the unlock function will be active.

- **Normal button :** For normal button, push the button to start the function.
  By pushing this button, the 'Accuracy' analysis will start.



- **Edit box :** When this white box is displayed, values can be entered in it with front panel keyboard or external keyboard. To enter numbers in this edit box, click in the box with the mouse or with touch sensitive screen or use the 'next' key of the front panel keyboard.



- **Roll box :** With this boxes, it is possible to select settings in a list by clicking on the little arrow (see figure) with the mouse or the touch sensitive screen. Then a list of settings appears. Select with the mouse or the touch sensitive screen the necessary setting.
  With the 'Next' key of the front panel keyboard, it is possible to select the roll box. Then, use the up & down front panels arrows to select the setting.

When characters of one of those buttons or boxes are written in gray color, it means that the state of this box or button can not be changed.

6 AP2440A applications

The AP2440A can be use for 2 main applications :

- **Optical spectral analysis :** Measuring the power in function of the wavelength or the frequency.
- **Complex spectral analysis :** Measuring the power and the phase in function of the wavelength (or the frequency) and therefore the chirp, the pulse shape, the phase and the Alfa parameter by calculation.

In this instruction manual the two applications are separated.

6.1 Application selection

When the instrument is turned ON, a 'Start Menu' is displayed :

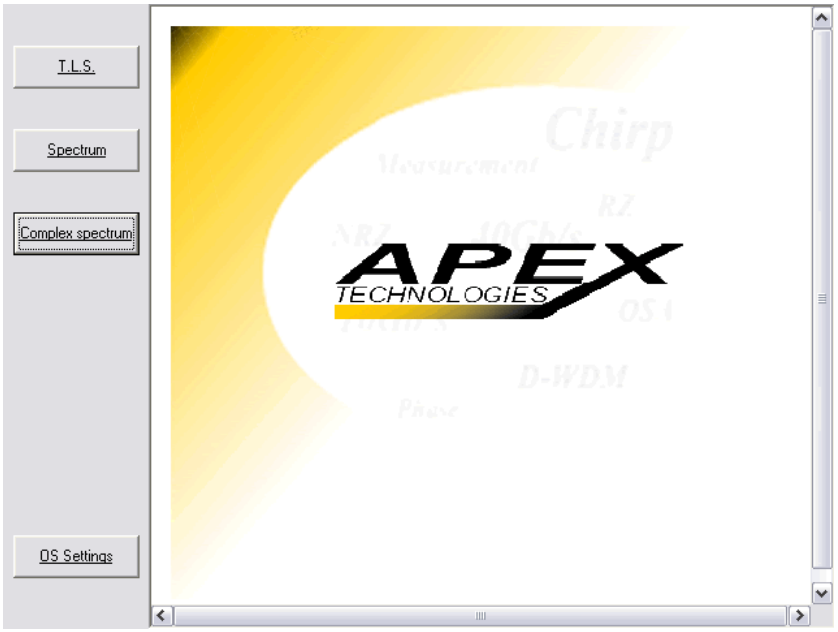


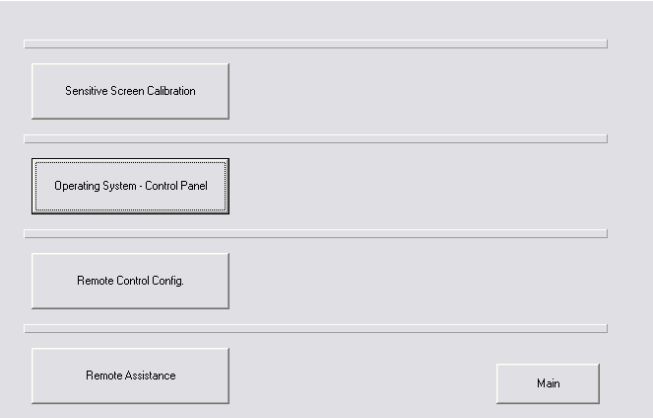
Fig. 8 : Start menu

The 'Spectrum' button start the Optical Spectrum Analyzer software and the 'Complex Spectrum' button start the Optical Complex Spectrum Analyzer software. The “T.L.S.” button is an optional button to open the optional tunable laser source software.

During the 30 minutes Warm-up, 'Warm-up' is displayed in red in this menu.

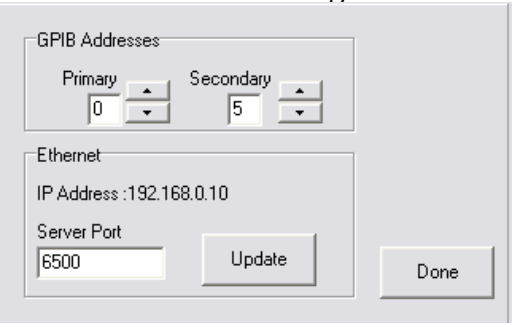
6.2 Operating system settings

In the start menu, after pressing the “OS Settings” button a new screen is displayed as follow :

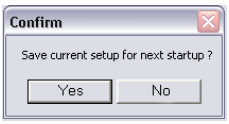


6.2.1 Remote control config

Press “Remote control config” to enter in the menu below :



For GPIB control, the equipment need a primary and a secondary address. Select their value in this edit box and press “Done” button to go back to the “OS settings” panel.
For Ethernet control, the server port can be changed by entering the port value in the edit box and press “Update” button.
A new panel is displayed :



- Press ‘Yes’ to apply the new setting now and keep this value for the next startup
- Press ‘No’ to apply the new setting but for the next startup the port will stay as the previous value.

For GPIB and Ethernet controls, refer to end of the instruction manual.

6.2.2 Sensitive screen calibration

Press “sensitive screen calibration” if you noticed a bad calibration of the touch sensitive screen.
And process the calibration of the touch sensitive screen in the “calibration” thumb index. We advice a 5 points calibration.

6.2.3 Operating system - control panel

For operating system (windows 2000) settings,refer to the “adminsitrator report” document delivered with the equipment.

6.2.4 Remote assistance (refer to remote assistance addendum)

6.3 Connections

6.3.1 Optical connection

The applicable fibers for AP2440A input is SMF fibers (9/125)

The AP2440A input (front panel) **accept only FC/PC** connectors.

The AP2440A TLS output (back panel) **accept only FC/APC** connectors. :

Damage due to non-suitable connectors is not subject to any warranty issue.

We advice to connect a FC/PC pigtail every time on your instrument and use only this pigtail to connect your signal under test.

6.3.2 RF connection

Keep connectors clean.

Do not use a damaged connector.

Connect your arm to the front panel ground connector with a bracelet to avoid electrostatic discharge.

Use dynamometric key for every connection.

Max. Input power +10dBm. An higher power can seriously damage the AP2440A. Damage due to a too high power is not subject to any warranty issue.

Damage due to static discharge is not subject to any warranty issue.

Caution : The optional “modulator output” of the back panel (refer to §2.1 #14) have to be charged continously when not used (50Ohm).

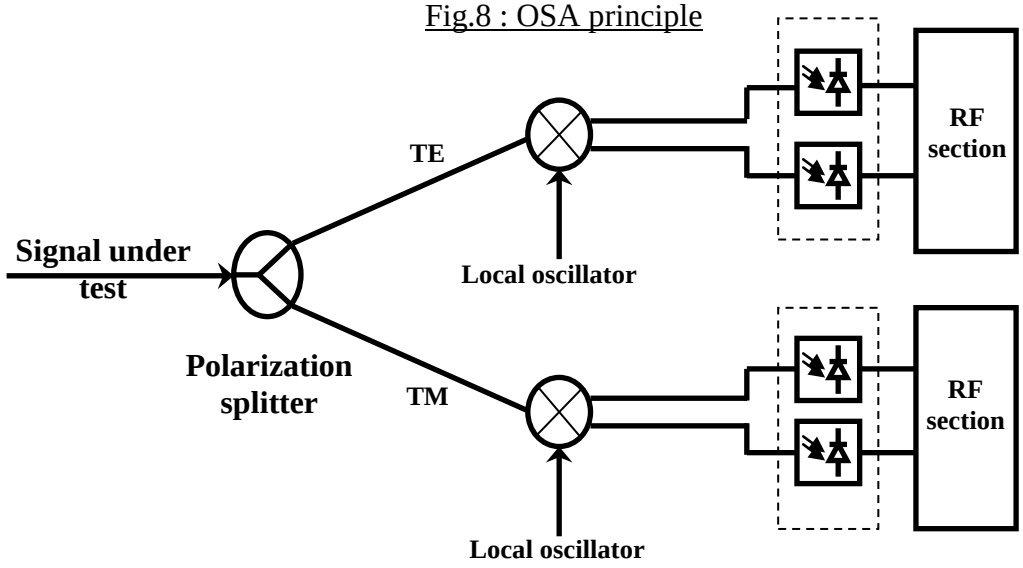
Caution : High output power for the optional “modulator output” (refer to §2.1 #14) connector : +14dBm

7 Optical Spectrum Analyzer

7.1 Measurement principle

In AP2040A we are using an interferometric method for optical spectrum measurement.

Fig.8 : OSA principle



The local oscillator (tunable laser source) interfere with the signal under test giving beatings on the receiver section. Then these beatings are filtered with the RF section.

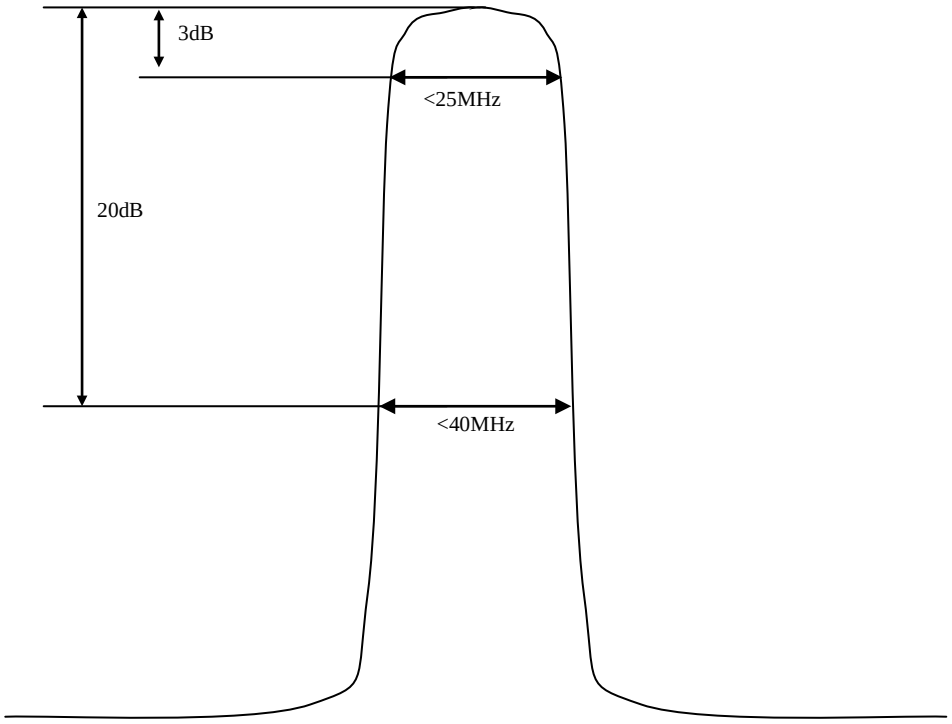
Polarization independence is realized by splitting the signal under test into two orthogonal polarization states. Then this two signals are analyzed separately and are combined by software to give a polarization independent spectrum analysis.

A wavelength calibrator is integrated in the AP2440A giving an absolute wavelength accuracy of +/-3pm after calibration. Refer to §7.1.5 for more details on wavelength calibration.

7.1.1 Resolution

By using an interferometric method, the AP2440A is giving an high 3dB resolution and also an high 20dB resolution as shown below. Two resolution settings are available (20MHz or 100MHz):

Fig. 14 : OSA resolution for high resolution



High Resolution :
Wavelength resolution @ 3dB : <25MHz
Wavelength resolution @ 20dB : <40MHz
Low resolution : This resolution offers the best power accuracy and repeatability
Wavelength resolution @ 3dB : <100MHz
Wavelength resolution @ 20dB : <150MHz

7.1.2 Dynamic and noise floor of the measurement

The noise floor of the spectrum measurement is guaranty under -67dBm at 1550nm and at 20MHz resolution.

The maximum input power is +20dBm to the AP2440A input connector. An higher input power can seriously damage the instrument.

With this spectrum analysis principle, side modes of the local oscillator can be seen. They are located at ~13GHz from a peak and are ~65dB lower than the main peak. So, when a peak power is higher than -2dBm, side modes of the local oscillator can be seen ~13GHz away from the peak and 65dB lower. (refer to §7.1.6 for more details)

7.1.3 Sampling point

The number of measured points during an acquisition (measuring points) is set automatically by the instrument depending on the measured span.

With AP2440A, it is possible to change, in the Setup menu, the number of 'displayed points'. When the number of "displayed points" is higher than the number of "measuring points", the software automatically interpolate the "displayed points" between two "measuring points".

To have a good resolution for markers setting, the number of "displayed points" can be increased. The step of the markers is fixed by the number of "displayed points".

When the number of "displayed points" increase, the display time increase.

A maximum of 20,000pts display is possible.

7.1.4 Measurement time

The standard measurement time is (resolution : 100MHz)

- 5s for 55nm.
- 1s for 5nm
- 1s for 1nm

7.1.5 Internal calibrator

The AP2040A integrate a wavelength calibrator giving an absolute accuracy of +/-3pm after calibration.

During the Warm-up, it is possible to calibrate the instrument, but we do not guarantee any specifications. If 'Single' or 'Auto' of the 'Sweep' menu is pressed, a wavelength precalibration is automatically started.

The initial calibration of the equipment have to be made after 30 minutes warm-up, even if a calibration have been made during the warm-up. The first time after the 30 minutes warm-up 'Single' or 'Auto' of the 'Sweep' menu is pressed, a wavelength calibration is automatically started. Otherwise, it is possible to calibrate the AP2440A by pushing the WL cal' button of the 'Setup' menu (Refer to §7.4.3 for 'Setup' menu). When, calibration succeed, a message is displayed : 'Calibration succeed'.

The wavelength calibration quality is dependent on external temperature variations, so we advice to verify the calibration every 30minutes. (Refer to §7.4.3). With the 'Auto' edit box of the 'Setup' menu, it is possible to select the time between two 'calibration warning' messages. This 'Calibration warning' message inform about the last calibration made. (see below). Calibration warning messages do not work during the 30 minutes warm-up.

Push OK to delete this message on the screen. . The user can choose or not to calibrate the wavelength of the AP2440A. Push the 'Run cal' button of the 'Setup' menu to calibrate.

For every measurement, the wavelengths measured are automatically corrected by the internal calibrator.

The 'Run cal' button run a verification of the absolute wavelength calibration. If the instrument is under measurement, the calibration can not be made.

7.1.6 Spectrum special feature

With our interferometric method, spectrums measured with the AP2440A can have particular features.

7.1.6.1 Spurious responses

The local oscillator used in the AP2440 series have side modes and they can be seen on the displayed spectrum.

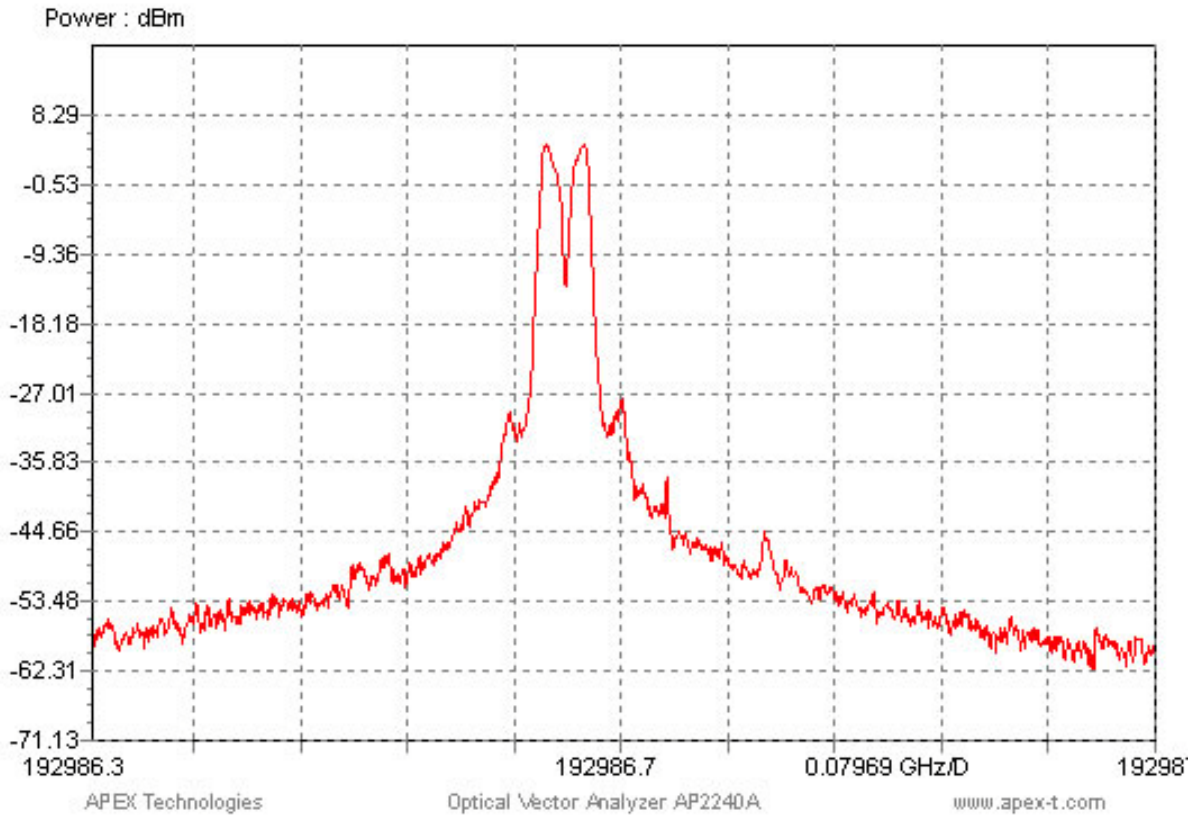
Side modes location and power depend on the local oscillator.

AP2440A & AP2441A : Side bands are located at ~13GHz from the main peak and ~60dB lower.

AP2443A : Side bands are located at ~5GHz from the main peak and ~45dB lower.

7.1.6.2 Hetherodyne filter shape

The principle used with AP2440A for spectrum characterization induce, a particular filter shape as shown below :



The ‘hole’ in the center of the peak represent the center wavelength. The dynamic of this ‘hole’ can vary depending on the number of points and signal under test.

7.2 Measurement procedure

7.2.1 Spectrum measurement

- Turn ON the instrument (refer to §1.5)
- A 30 minutes warmup is necessary to get the absolute wavelength calibrated.
- Connect the fibers as explained in §6
- Select the trace to use for the measurement with the 'TRACE' roll box of the 'SWEEP' menu and push 'SINGLE' in the 'sweep' menu to start the measurement.

The measurement is done.

7.2.2 Polarization requirements

The AP2440A is polarization independent thanks to its polarization diversity configuration (refer to Fig.8 and §7.1 for measurement principle details).

7.2.2.1 Polarization state of the measured signal

The signal under test do not need to have a fixed polarization state if 'Polarization 1+2' is selected in the 'SYSTEM' menu.

7.2.2.2 Polarization diversity capability

In the AP2440A, we are using a polarization diversity principle, and we are analyzing separately two orthogonal polarization states. Then 3 kinds of measurement can be displayed (these 3 options can be selected on the "SYSTEM" menu, before the measurement) :

Polarization 1+2 :
By software we are combining the two orthogonal polarization states. The measurement displayed is polarization independent.

Polarization 1 :
Only one the two polarization states is displayed (perpendicular to polarization 2). In this configuration the measurement is polarization sensitive.

Polarization 2 :
Only one the two polarization states is displayed (perpendicular to polarization 1). In this configuration the measurement is polarization sensitive.

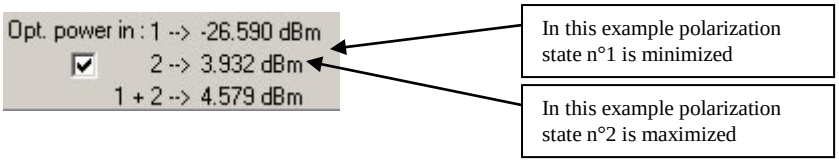
Polarization 1&2 :
The two polarization states are displayed on two different traces. In this configuration the measurement is polarization dependent.

Caution : The input fiber of the AP2440A is an SM fiber, so the two orthogonal polarization states displayed by the AP2440A are not necessarily the slow and fast axis of a PM fiber if a PM fiber is used at the input of the equipment.

Trick : For the signal under test, in order to align the TE and TM axis of a PM fiber with the two polarization states of the equipment :

- *Use a polarized source aligned in the TE or TM axis*
- *Connect a polarization controller between the PM fiber of the signal under test and our instrument and fix all the SM fibers.*
- *In the "SYSTEM" menu, tick the "Opt. Power IN" box*

- *Adjust the polarization controller in order to maximize the power in one of the two polarization state (see example below)*



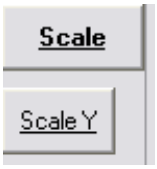
- *Polarization is now aligned and polarization state n°1 and n°2 correspond to the TE and TM polarization state of the PM fiber.*

7.3 SPECTRUM menu description

- **SCALE :** This menu is used to change X scales and Y scales, to display linear or logarithm curves and to Zoom.
- **SWEEP :** This menu is used to run the sweeping, to set the span and the center frequency (Or Start and Stop Frequency) and to set the number of averaging.
- **SETUP :** This menu is used to set the number of 'displayed points' and to set the calibrator functions.
- **DISPLAY :** This menu is used to choose the information displayed on the screen.
- **MARKER :** This menu is used to set horizontal and vertical lines and markers.
- **ANALYSIS :** This menu is used to run analysis modes like peak search function.
- **FILE :** This menu is used to save or to load from floppy disk drive or from hard-drive.
- **TRACE :** This menu is used to select the active trace and to delete traces.
- **SYSTEM :** This menu is used for polarization control, initialization and calibration of the touch sensitive screen.
- **LOCAL :** This menu is used to switch from REMOTE mode (GPIB control) to LOCAL mode.
- **HELP :** This menu is not used for the moment.
- **MAIN :** This menu is used to come back to the first page. In this page you can choose to use the spectrum analyzer alone or with the chirp measurement.

7.4 Menu by menu description

7.4.1 SCALE menu



By pushing in the vertical panel, the SCALE button, a new button will then appear in this vertical panel : SCALE Y.

You can use this new button as a standard Underlined Buttons (refer to §5.3.4 for button description)

An horizontal menu will be also displayed after pushing the SCALE Button:

- Push this button to select the displayed unit for the X scale. The spectrum can be display in Wavelength or in Frequency. The selected parameter is written on the button. The displayed wavelength is the vacuum wavelength.

- This box is used to select the active trace. Six traces are available, and the active trace is used to set scales and markers. The color of the active trace is red by default. 'Next trace' button select another active trace in chronological way of the trace number. The active trace number is then written in the roll box close by. The active trace can be selected also with the roll box by selecting directly the trace number.

- This button is used to select the power display in LINEAR or in LOGARITHM. The selected parameter is written on the button.

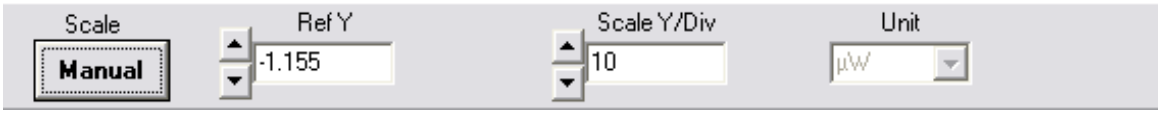
- When this button is pressed the center wavelength is set to the wavelength of the last spectrum having a maximum power.

- When this button is pressed, ON is written on the button. In this case the center wavelength is set to the wavelength of the last spectrum having a maximum power for every new sweeping. Press again this button to stop this function.

7.4.1.1 SCALE X menu

X scale is determined by the Start and Stop sweeping setup (refer to menu SWEEP).

7.4.1.2 SCALE Y menu



To enter in this menu, press 'SCALE Y' of the vertical menu.
By default, Y scale is adjusted automatically. To adjust the scale manually, push the 'SCALE' button to display "Manual". Then it is possible to adjust scale/Div and Ref level.

7.4.2 SWEEP menu

This horizontal menu appear when the 'SWEEP' button in the vertical menu is pressed.

- Push the Start/Span button to select Start/Stop or Center&Span configuration. The selected option is written on bold characters on the 'Start/Span' button.

  If Start/Stop is chosen, enter the Start and the Stop wavelength or frequency value required for the sweeping in the 'Start' and 'Stop' edit boxes. To switch from Wavelength to Frequency or vice-versa, refer to §7.4.1

  If Center&Span is chosen, the Start and Stop edit boxes are changed in Center and Span edit boxes. Then enter the required value for the sweeping in those edit boxes. To switch from Wavelength to Frequency or vice-versa, refer to §7.4.1

  Span width is limited depending on the resolution :

  - 100MHz resolution : Span Min = 40GHz

  - 20MHz resolution : Span Min = 10GHz

- Push this button to transfer the X scale settings (after a zoom for example) into the Start and the Stop value of this sweep menu.

- Choose the trace for the sweeping with this roll box. If the chosen trace is already used by another measurement, this old measurement will be automatically deleted and replaced by the new measurement.

- Push the 'Single' button to start the sweeping.

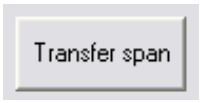
- Push the 'Auto' button to start the sweeping on the whole wavelength range. Then the software find automatically the signal, adjust automatically the start and the Stop wavelength values. A signal is automatically detected when its dynamic is higher than the ‘Peak treshold’ value.’Peak tresholod’ can be set in the ‘Analysis’ menu, and ‘Peak Search’ function.

- Push this button to sweep continuously the spectrum analyzer. Press the “Stop” button to stop the sweeping.

- Enter the delay between two sweeping in this edit box in seconds. When 0 is entered, the lowest delay is used.

- Press this button to stop the sweeping.

- When this button is pressed, the sweeping is in “Repeat” mode but the spectrum on the screen displays only the maximum power points of every sweeping. This function can be stop by pushing the “Stop” button. If “Single” or “Repeat” or “Max Hold” is pressed after a MaxHold function, the MaxHold spectrum is deleted and a new spectrum is displayed.



- Press this button to transfer the Span/Center or Start/Stop wavelength settings of the Spectrum Analyzer software to the Complex Spectrum Analyzer software.

7.4.3 SETUP menu

This horizontal menu appear when the 'SETUP' button in the vertical menu is pressed.

- Press the ‘Auto’ button to display ‘Manual’ and enter the number of displayed points in the Nb Points Edit Box. Refer to §7.1.3 for more information on sampling and displayed points.

- Two resolution are available. Choose the resolution you need by pushing this button. The sweeping time is 4 times longer at the highest resolution.

- It is possible to enter an horizontal mask with the “mask dBm” edit box. Enter a value in dBm and then every measurement below this value will not be displayed.

7.4.4 DISPLAY menu

The “Display” horizontal menu appear when the 'DISPLAY' button in the vertical menu is pressed.

- Push the “color” button to select every colors of the display : fonts, traces, …

- Push the “full screen” button to display the graph on the full screen. Press the “Exit” button to go back to the standard display.

- Tick the “Screen keyboard” edit box, to display or not the touch sensitive keyboard when numbers or letters have to be written.

7.4.5 MARKER and LINE menu

7.4.5.1 MARKER menu

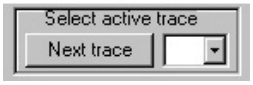
This menu appear when the 'MARKER' button in the vertical menu is pressed.

This menu is used to set, add or delete markers on the active trace.

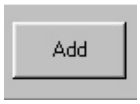
The step between two positions of markers depend on the number of displayed points. Refer to §7.1.3 for more information on sampling and displayed points.

Use this menu to set Markers on the active trace.

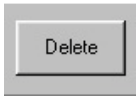
By pushing 'Marker' button on the vertical panel, the 'line' button is displayed on the vertical panel.



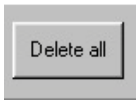
- Select the Active Trace by pushing on the 'Next Trace' button or by clicking on the 'trace' roll box. The active trace is in Red color. Markers can only be set on the active trace.



➢ Push the 'add' button to add a new marker on the active trace. After pushing the 'add' button, the marker is set on the middle of the screen and the new marker is the Active Marker.



➢ Push the 'delete' button to delete the Active Marker.



➢ Push the 'delete all' button to delete every markers of the active trace.

➢ Push the right and the left arrow to move the active marker on the active trace. To move markers, the front panel arrows can be used also.

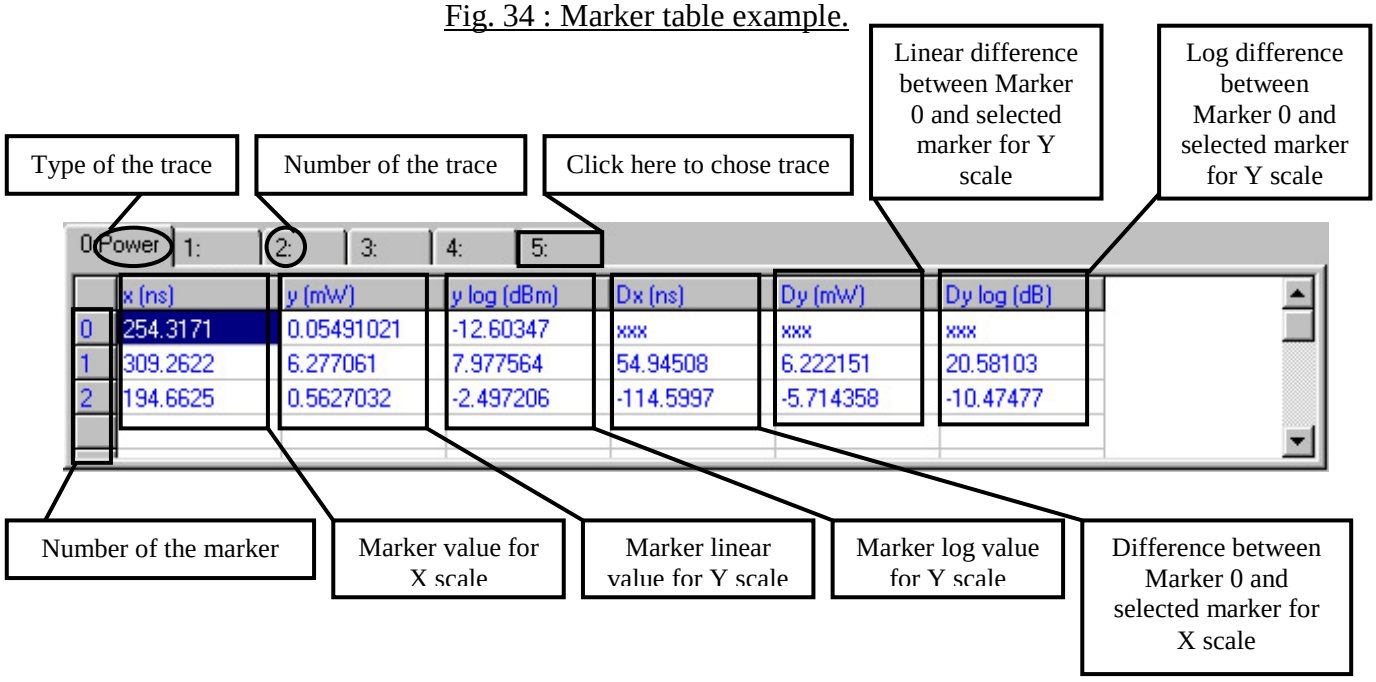
➢ Select the active marker with this panel.
The active marker is in Black color and his number is written in the 'n°' edit box.
Push the 'Previous' button to select the previous marker as the active marker.
Push the 'Next' button to select the next marker as the active marker.
The active marker position is displayed on the 'Scale/Div' panel. (Refer to §3 for Scale/Div panel description)

➢ Push this button to display the 'Marker table'. When the 'Marker table' is displayed, push again this button to actualize data.

7.4.5.2 Marker table

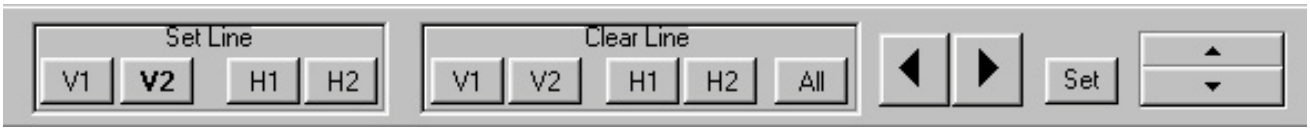
This is an example of display of the marker table :

Fig. 34 : Marker table example.



7.4.5.3 LINE menu

The line menu is accessible after pushing the 'marker' button on the vertical menu. Push the 'LINE' button to display the 'Line' menu in the horizontal panel.



For Lines settings, choose the lines in the 'Set line' panel (the selected lines are in bold characters in the Set line panel), move them on the screen with the touch sensitive screen, the front panel arrows or the arrows of the Line menu, and then push the 'Set' button to fix them.
Do not forget to set the line, otherwise the line not set will move every time the touch sensitive screen or the mouse is used.

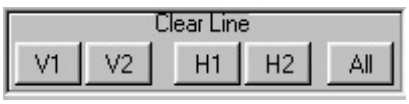
- This 'set line' panel is used to select the vertical or horizontal lines. Every selected lines are displayed in bold on the panel. It is possible to select up to 4 lines.

  Push the 'V1' button to select the first vertical line and display it in the center of the screen.

  Push the 'V2' button to select the second vertical line and display it in the center of the screen.

  Push the 'H1' button to select the first horizontal line and display it in the center of the screen.

  Push the 'H2' button to select the second horizontal line and display it in the center of the screen.



- This 'Clear line' panel is used to delete horizontal and vertical lines.

  Push the 'V1' button to delete the first vertical line.

  Push the 'V2' button to delete the second vertical line.

  Push the 'H1' button to delete the first horizontal line.

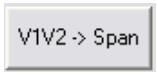
  Push the 'H2' button to delete the second horizontal line.

  Push the 'All' button to delete all the lines.

➢ Move the vertical selected lines by using the 'right' and 'left' arrow. It is possible also to move the selected lines with the touch sensitive screen or the front panel arrows.

➢ Move the horizontal selected lines by using the 'Up' and 'Down' arrow. It is possible also to move the selected lines with the touch sensitive screen or the front panel arrows.

➢ Push the 'set' button to fix the selected lines. After pushing the 'set' button, every lines are fixed and unselected.



➢ When vertical lines are set on the screen, press this button to transfer their values in the “Start” and “Stop” value of the “Sweep” menu.

7.4.6 ANALYSIS menu

This menu appear when the 'Analysis' button of the vertical menu is pressed.

7.4.6.1 Peak search

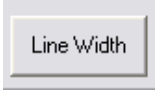
➢ Press 'Peak Search' button to display the setting panel of this function :

With this function, the software automatically search peaks with a dynamic higher than the “Peak Th.” Setting (Peak threshold). Enter the peak threshold value in the “Peak Th.” edit box and push the 'find peaks' button to run the peak search function.

To display marker value, press the “display table” button. Then the marker table is display below the graph. Push again this button to remove this display.

Push the “Clear” button to delete all markers.

7.4.6.2 Linewidth

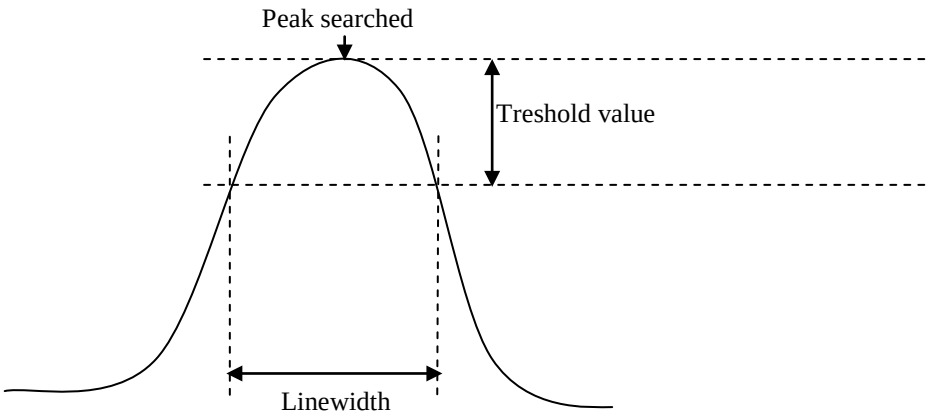


➢ Push the linewidth button to display the setting panel of this function.

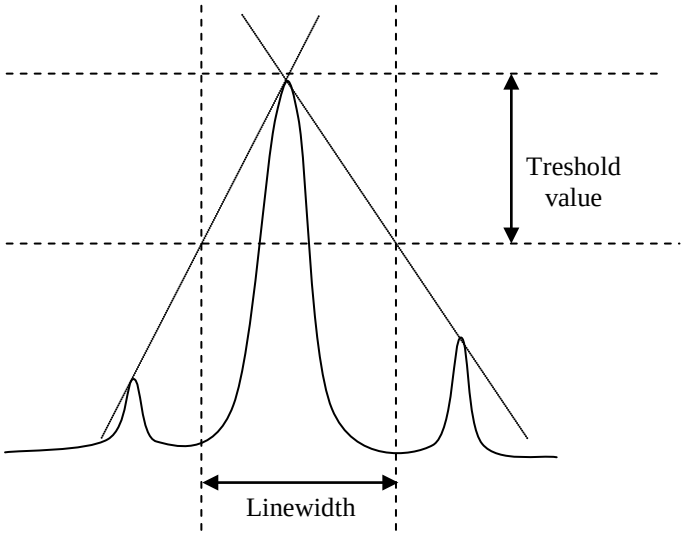
Peak Th : Enter in this box the specifications for peak search function. If a linewidth analysis function is pressed and if there is no peak higher than this threshold value, then no analysis will be done. If there is several peaks, the analysis will be done on the highest power peak.

Line width Th : Enter the threshold value for the 'Threshold' linewidth analysis. If 3dB is entered in this box, when "Threshold" analysis function is pressed, the analysis result will be the linewidth of the peak at 3dB from the top.

Threshold : Push this button to run the "threshold" analysis function. Results of this analysis are written on the "Analysis" thumb index.

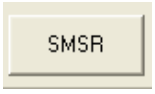


Envelope : Push this button to run the 'Envelope' linewidth function. Results of this analysis are written on the "Analysis" thumb index. Envelope function can not be used when only one peak is present.



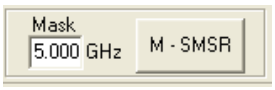
Clear lines : Push this button to delete every horizontal and vertical lines on the screen.

7.4.6.3 SMSR

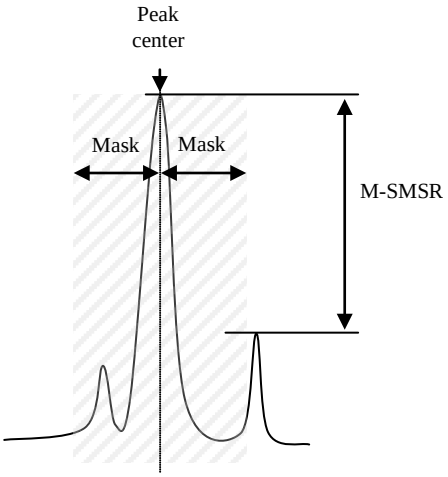


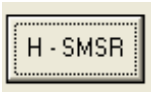
- Push the SMSR (side mode suppression ratio) button to display the setting panel of this function.

Peak Th : Enter in this box the specifications for peak search function. If a SMSR analysis function is pressed and if there is no peak and no side modes higher than this threshold value, then no analysis will be done. If there is several peaks, the analysis will be done on the highest power main peak.

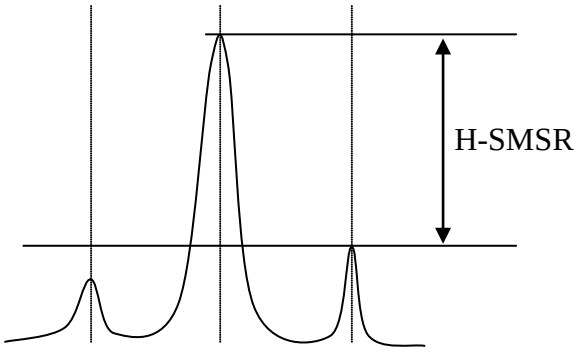


- M-SMSR function analyze side mode supression ratio of a laser source by setting a mask area. No side modes are analyzed inside the mask area. Then the closest side mode outside this area is used for SMSR analysis.





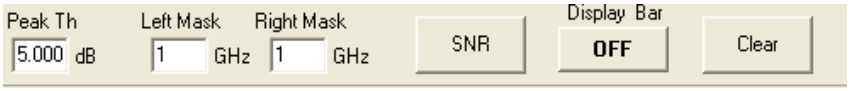
- H-SMSR function analyzes side mode supression ratio of a laser source by measuring the power difference between the main peak and the closest and highest side mode.



Clear lines : Push this button to delete every horizontal and vertical lines on the screen.

7.4.6.4 SNR

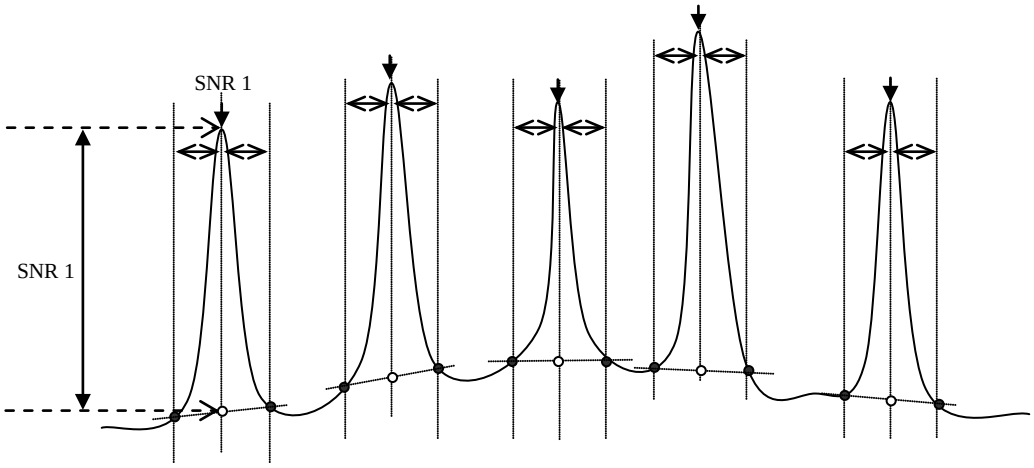
- Push the SNR (signal to noise ratio) button to display the setting panel of this function.



Peak Th : Enter in this box the specifications for peak search function. If a SNR analysis function is pressed and if there is no peak and peaks higher than this threshold value, then no analysis will be done. If there is several peaks, the analysis will be done on all the peaks.

Left & right mask : These edit boxes determine where the noise will be measured for the signal to noise ratio analysis. The noise value used for the SNR calculation is the average noise between the left and the right noise.

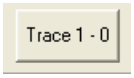
SNR : Push this button to start the signal to noise ratio analysis on all the peaks higher than the peak threshold. SNR value is written on every peaks analyzed.



Display bar : Push this button to display a bar graph representation of all the SNR peaks analyzed.

Clear : Push this button to delete every markers and SNR values on the screen.

7.4.6.5 Trace 1 - 0



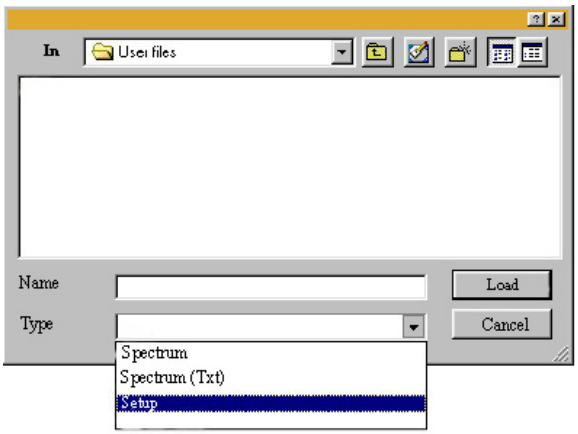
- Push the trace 1 – 0 button to calculate in dB, the power difference between trace number 1 and trace number 0. The power difference display is using trace number 2. To remove the power difference display, go to “TRACE” menu and “Delete” trace number 2.

7.4.7 FILE menu

This menu is used to save or load measurements, setups and marker tables on the hard disk drive or the floppy disk drive. This menu appear when the 'File' button of the vertical menu is pressed.

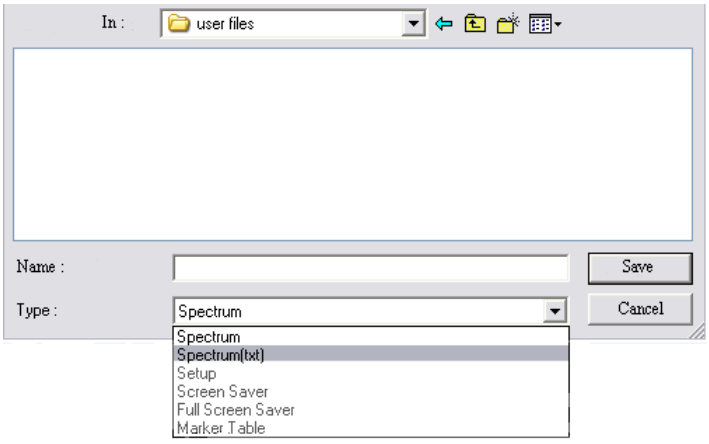
- Choose the trace to Save or select the trace for the loading with this roll box.

➢ Push the 'Load' button to load a file on the trace selected in the 'Trace' roll box. After pushing the LOAD button, a new panel is displayed.



- Select the type of data to load (For detail about the type refer to § 7.4.7.1 to § 7.4.7.4) in the 'Type' roll box.
- Enter or select in the list, the name of the file to load.
- Push the Load button.

➢ Push the 'Save' button to save a file. If a measurement is saved, the trace saved is the trace specified in the 'Trace' roll box of the File menu. After pushing the Save button, a new panel is displayed :



- Select the type of data to save (For detail about the type refer to § 7.4.7.1 to § 7.4.7.4) in the 'Type' roll box.
- Enter the name of the file to save.
- Push the Save button.

7.4.7.1 SPECTRUM format

This format can be read only by the instrument (*.dat). The size of a 'Spectrum' file is lower than a 'Spectrum (txt)' file.

When a measurement is saved in 'Spectrum' format, its name is : name_spectrum.dat.

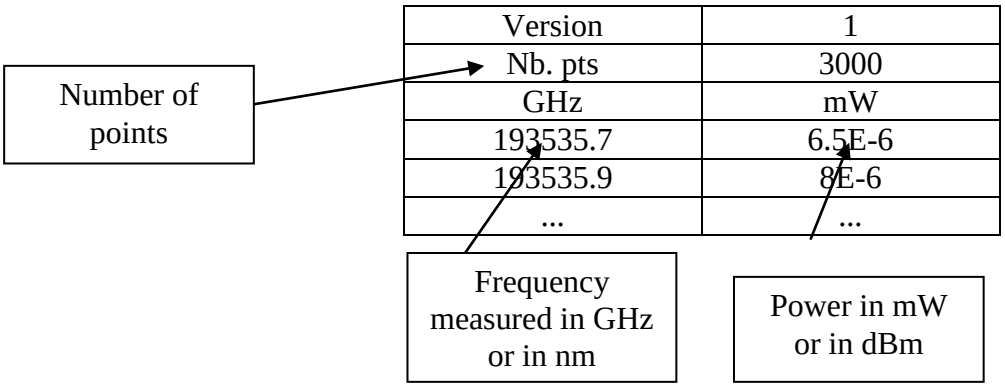
Use this format if the data have only to be use with the instrument.

7.4.7.2 SPECTRUM (Txt) format

This format can be read with every software able to read *.Txt files. The size of a 'Spectrum (txt)' file is higher than a 'Spectrum' file. Files saved in 'Spectrum (txt)' format can be loaded also with the instrument.

When a measurement is saved in 'Spectrum (Txt)' format, its name is : name_spectrum.txt

This is an example of a 'Spectrum (Txt)' file :

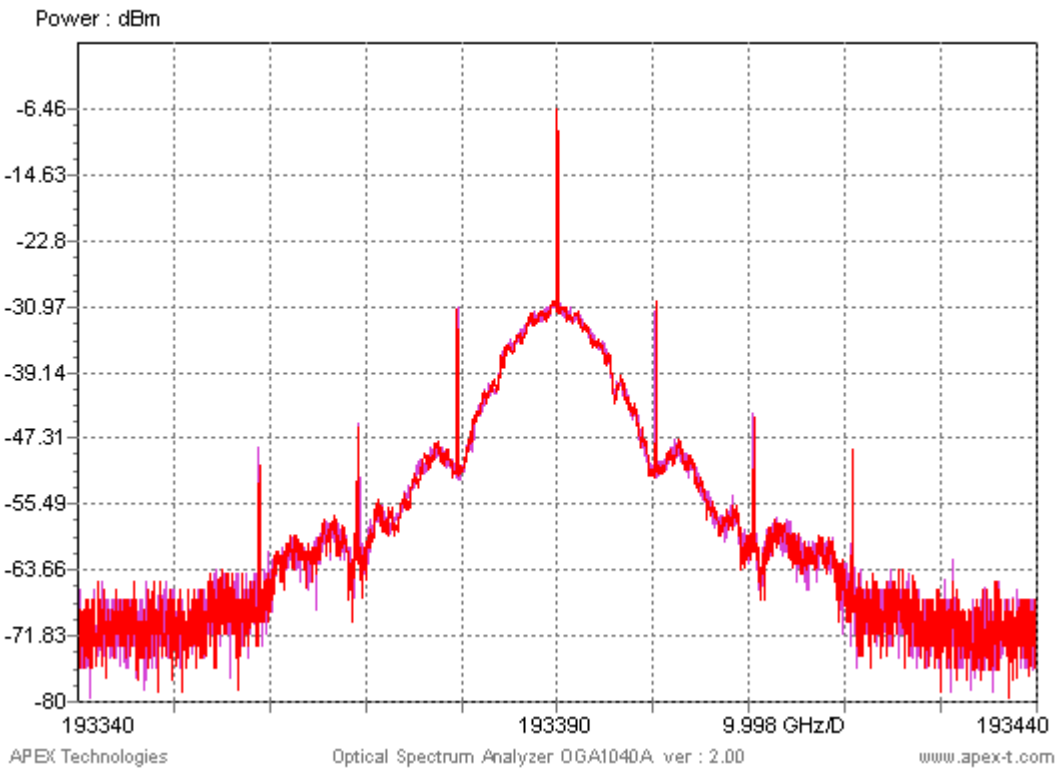


7.4.7.3 SCREEN SAVER format

If a file is Saved in 'Screen saver' format, its name is : name.bmp. This file is a copy of the measurement and its size is around 900Ko. Those files can be read with an external computer.

This is an example of the screen copy of a spectrum :

Fig. 16 : Screen copy



Screen copies can be saved also in "full screen saver" mode. In this case the complete screen is copied (with buttons, thumb-index...).

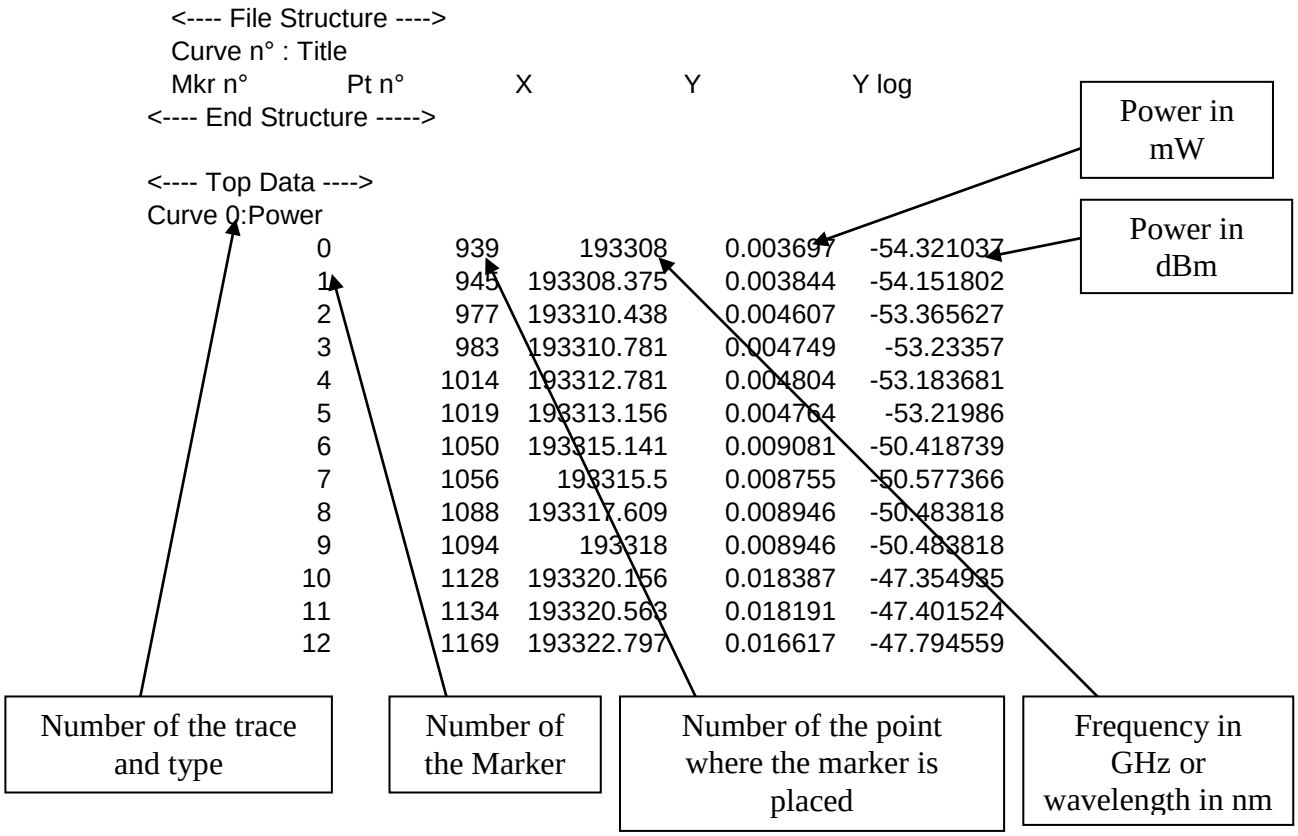
7.4.7.4 MARKER TABLE format

Use this format to save the marker table. This file format can not be loaded.

This format can be read with every software able to read *.Txt files.

When a file is saved in this format its name is : name_MarkerTable.txt.

This is an example of a file saved in MarkerTable format :



If there is two traces with markers, then all the markers are listed on the 'MarkerTable' file and the markers from two different traces are separated by the number of the trace and its type in the first column (Example : 'Curve 0 : Power').

7.4.7.5 SETUP menu

With this menu, it is possible to store your current setup as the new setup for the startup, or to load the default setup of the equipment.

Press “Default” to load the default setup of the equipment.

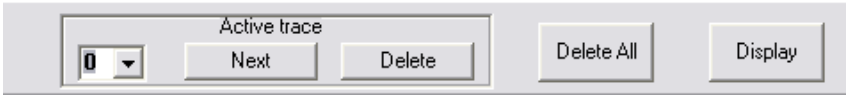
Press “Startup” to save the current setup as the new startup setup.

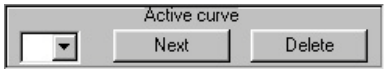
7.4.7.6 Remove USB device

Use the USB device box to remove properly a USB stick plugged on the equipment. Choose the device and press “remove”.

7.4.8 TRACE menu

This menu is used to select or delete the active traces.

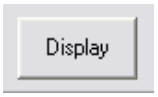




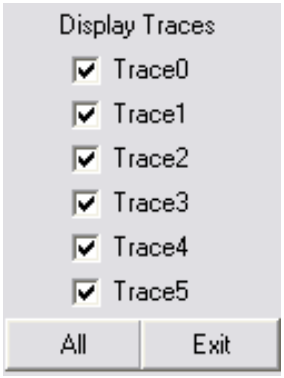
- The number of the active Curve is written in the roll box. To change the active trace, choose it in the roll box or push the 'NEXT' button.

- To delete one trace, push the 'DELETE' button. Only the active trace is deleted with the 'DELETE' button.

- Push the 'DELETE ALL' button to delete every traces.



- Push the “display” button to select traces to display on the screen. A trace not displayed is not deleted from the memory and at any time it is possible to display it. It is possible to check displayed traces and blank traces on the traces thumb index (refer to §3, n°4).



- This is the panel displayed when ‘Display’ button is pressed. Tick in the corresponding boxes, to display or not traces.
- Press ‘All’, to display all traces.
- Presse ‘Exit’ to close this panel

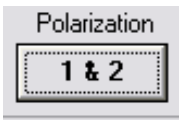
7.4.9 SYSTEM menu

This menu is used for Input power control, for polarization settings, wavelength calibration and for calibration of the touch sensitive screen.

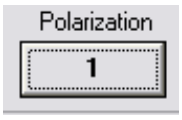
- Opt. Power IN : Tick this box to display the total input power (1+2) in dBm and the power of the two orthogonal plarization states (1 or 2) (refer to OSA principle§7.1 and §7.2.2.2 for polarization diversity configuration).

➢ Polarization : With this button it is possible to choose the polarization state to display on the screen.

- 1 + 2 : In this state, the measurement displayed on the screen is the polarization independent spectrum. The two orthogonal polarization states are measured and the software calculates the combination of the two polarization and display one trace.

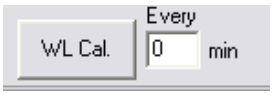


- 1 & 2 : The two orthogonal polarization states are measured, and two traces will be display on the screen after a measurement.



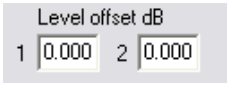
- 1 : One polarization state is display in this case

- 2 : One polarization state is display in this case (orthogonal polarization state versus 1)



➢ Push the ‘WL Cal.' button to start the wavelength calibration.

The calibration can not be done before 30 minutes of use. We recommend 30 minutes between two calibration. The time between calibration can be set in the ‘every’ edit box. Then a message will appear on the screen when the calibration have to be done.



➢ Enter an offset in dB for each polarization channel in the “Level offset dB” box.

8 Optical Complex Spectrum Analyzer

8.1 Measurement principle

AP2440A is using an unique and patented method for Pulse Shape, Chirp, phase and Alfa parameter measurements.

AP2440A is able to measure the power and the phase of each spectral component of a modulated signal.

By knowing the power and the phase of each spectral component, we can calculate different characteristics :

- Pulse shape
- Chirp
- Phase
- Alfa parameter

So, for each complex spectral analysis, 3 steps can be distinguish :

- **First step** : Power measurement
- **Second step** : Phase measurement
- **Third step** : Calculation of the different characteristics

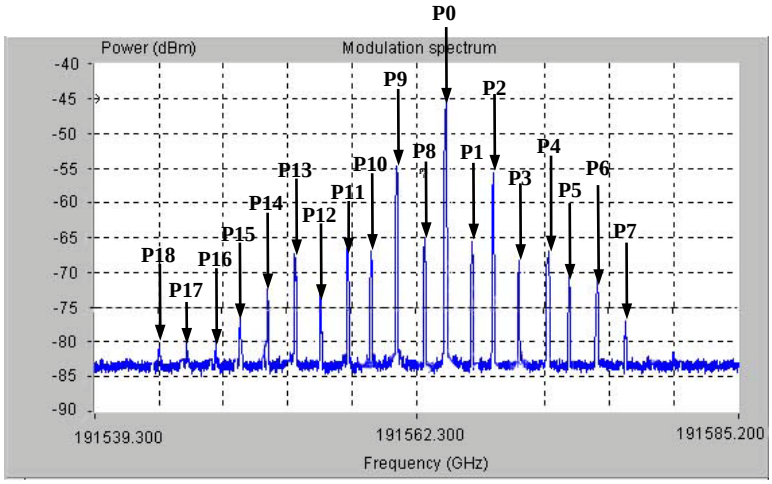
8.1.1 Modulated signal particularity

For a complex spectral analysis, the optical modulated signal under test need to have a repeat frequency (Fr1) of 2.5GHz or (fr2) of 625MHz in order to have each spectral components of the modulated signal spaced by 2.5GHz or 625MHz. For more information about the repeat frequency, refer to §8.2.2. With AP2440A, clock signal can be set from 9.92GHz to 12.5GHz (front panel clock) or from 2.48GHz to 3.125GHz (back panel clock), so the repeat frequency can be set from 2.48GHz to 3.125GHz(fr1) or from 620MHz to 781MHz (fr2)

8.1.2 Power measurement of a modulated signal

The power measurement of each spectral component of the modulated signal under test is realized by the Optical Spectrum analyzer by using a peak search function. (Refer to §7.1 for measurement principle of the spectrum analyzer)

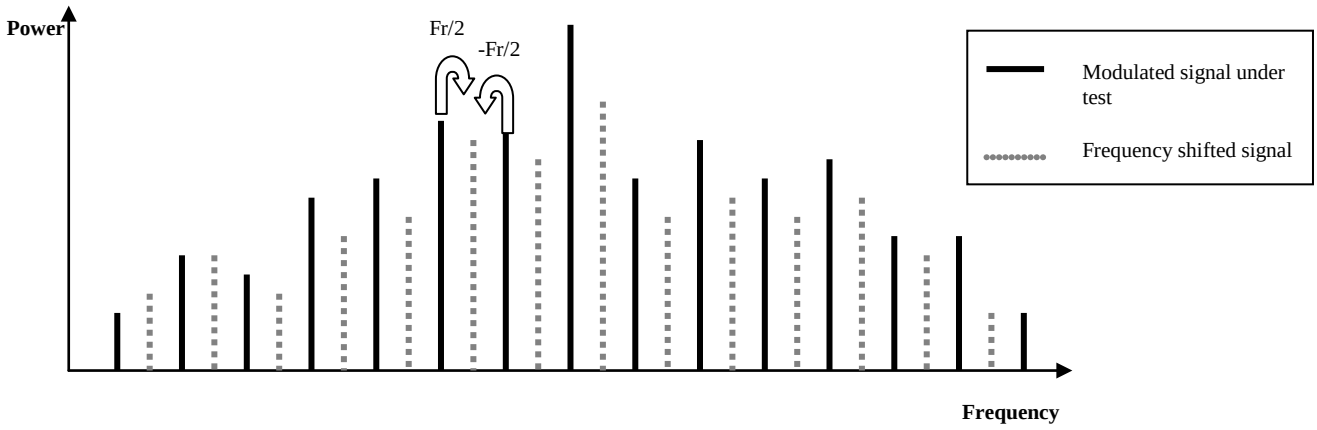
Fig. 17 : Power measurement of a modulated signal



8.1.3 Phase measurement of a modulated signal

For the phase measurement, a frequency shifting of +/-Fr/2 of the modulated signal under test is realized for each spectral components by using the clock signal :

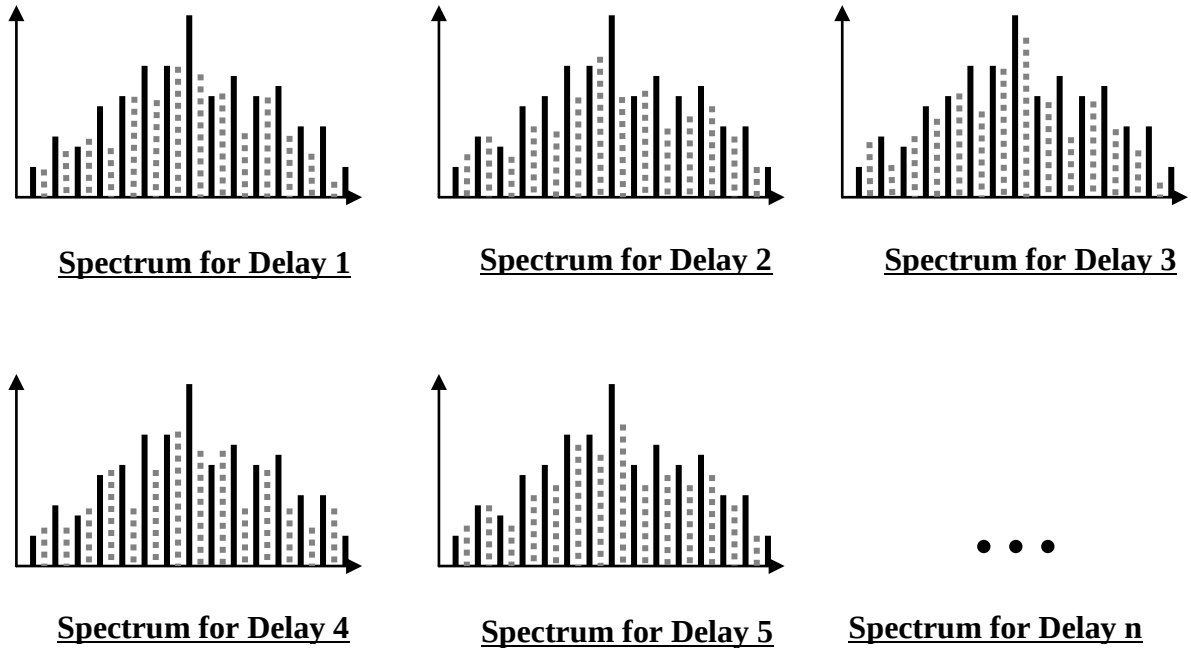
Fig. 18 : Modulated signal under test and frequency shifted signal for phase measurement



With this frequency shifting, two consecutive spectral components of the signal under test will interfere together as shown above.

Then, the clock signal is delayed several times (with different particular delays) and the resulting spectrums are measured :

Fig. 19 : Phase measurement principle



So, by knowing the exact delay applied and by analyzing the resulting power of the frequency shifted signal as a function of the delay, it is possible to deduct the relative optical phase of two consecutive spectral components.

8.1.4 Calculation by Fast Fourier Transform (FFT)

An electromagnetic field of an optical wave can be expressed in the complex form as :

$$E = A\exp[i2\pi f_0 t] = |A|\exp[i2\pi f_0 t + \varphi]$$

where A is the complex envelop, $i = \sqrt{-1}$, t is the time, f_0 is the frequency and φ is the phase of the optical wave.

The « chirp » designates the transient deviation of the instantaneous frequency f from the value f_0, caused by a temporal variation of the phase φ.

The instantaneous frequency is given by :

$$f(t) = f_0 + \frac{1}{2\pi}\frac{d\varphi}{dt}$$

and the chirp is :

$$C(t) = f(t) - f_0 = \frac{1}{2\pi}\frac{d\varphi}{dt}$$

This method is adapted to periodic modulation signals only (refer to §8.1.1). Let T be the period, Fr = 1/T the fundamental frequency of the modulation signal $M(t)$. Then the complex envelop of the optical field has the same period and thus the Fourier expansion of the complex field can be written as :

$$\mathrm{E(t) = A(t)\exp[i2\pi f_0 t] = \sum_k A_k \exp\{i[2\pi(f_0 + kFr)t + \Phi_k]\}}$$

The corresponding spectrum is composed of discrete and regularly spaced lines. One is located at the carrier frequency f_0, surrounded by modulation lines located at $f_0 + kFr$. A_k is the amplitude and Φ_k is the phase of the line k.

The amplitude values are given by the power levels of the spectral lines (refer to §8.1.2).

The measurement of the phase values is done as explain in §8.1.3.

Knowing A_k and Φ_k, an FFT algorithm calculates:

$$A(t) = \sum_k A_k \exp\{i[2\pi kFt + \Phi_k]\} = |A(t)|\exp[i\varphi(t)]$$

which leads to the **temporal profile of the intensity** (the pulse shape of the optical signal) :

$$I(t) = |A(t)|^2 / 2$$

and the **temporal profile of the chirp :**

$$\mathrm{C(t) = \frac{1}{2\pi}\frac{d\varphi}{dt}}$$

and the **Alpha parameter** is :

$$\mathrm{\alpha(t) = 2I \times \frac{d\varphi/dt}{dI/dt}}$$

These profiles are calculated over a time window equal to T and with a time resolution $\Delta t = T/N$, where N is the number of lines analyzed in the original spectrum.

8.2 Measurement configuration

8.2.1 AP2440A requirements

For the complex spectral analysis of an optical modulated signal, the AP2440A require a particular configuration :

- The optical modulated signal under test need to have a repeat frequency of fr1 or fr2 (refer 8.1.1) in order to have each spectral components of the modulated signal spaced by one of these frequency range. If not, it is impossible to measure the complex spectrum therefore the pulse shape and other associated measurements (Chirp, Alfa...)

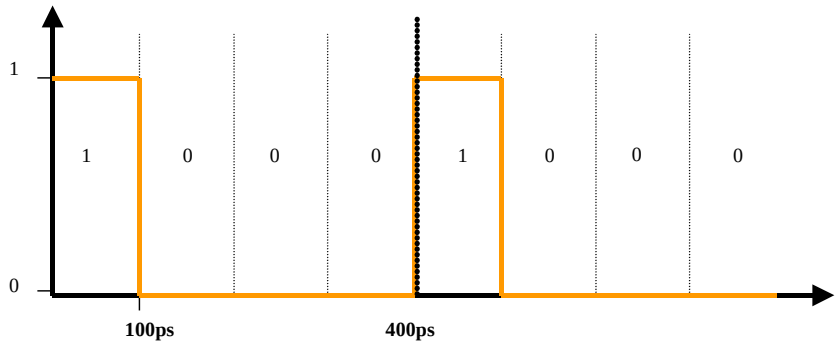
- The AP2440A need a clock synchronized with the modulated signal under test and with a frequency between 9.92GHz and 12.5GHz (front panel clock) or between 2.48GHz and 3.125GHz (back panel clock).

8.2.2 How to get 2.5GHz repeat frequency?

- For 10Gb/s measurements :

- At 10Gb/s NRZ (period of 100ps), to have a repeat frequency of 2.5GHz (400ps), it is necessary to generate a 4 bits pattern.

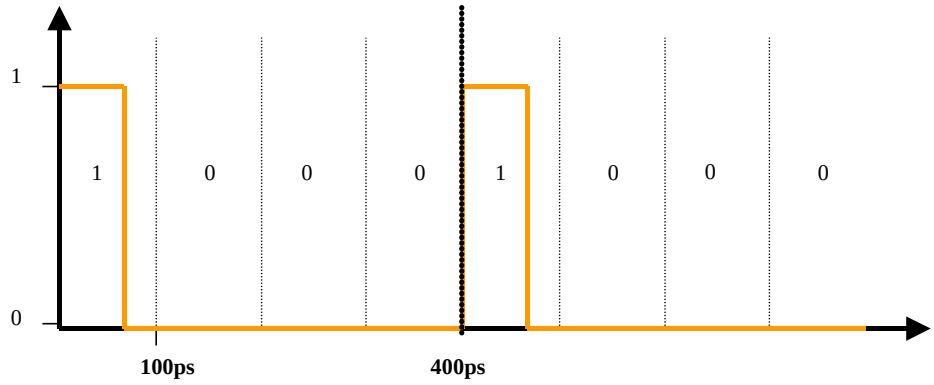
Fig. 20 : 10Gb/s NRZ example



Different patterns are possible :
1 0 0 0 (and 0100 ; 0010 ; 0001)
1 1 1 0 (and 0111)
1 1 0 0 (and 0110 ; 0011)

- At 10Gb/s RZ the same patterns as NRZ can be used.

Fig. 21 : 10Gb/s RZ example



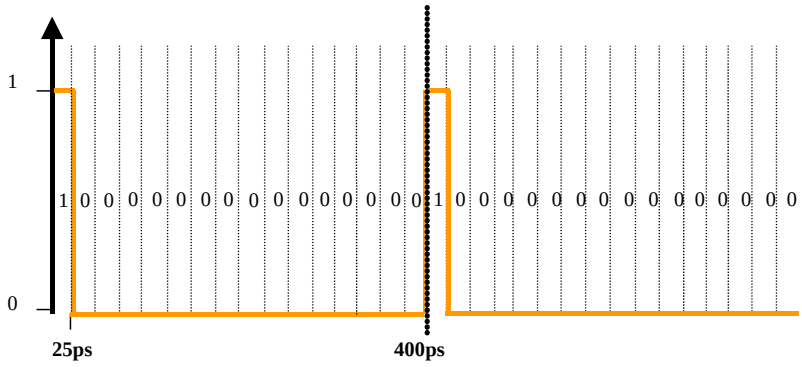
So, for any measurement at 10Gb/s (RZ or NRZ), it is necessary to generate a 4 bits pattern to have a repeat frequency of 2.5GHz.

Trick : To verify that the pattern used have a repeat frequency of 2.5GHz, it is just necessary to verify that the two first bits of the pattern are different from the two last bits.

- For 40Gb/s measurements :

  - At 40Gb/s NRZ (period of 25ps), to have a repeat frequency of 2.5GHz (400ps), it is necessary to generate a 16 bits pattern.

Fig. 22 : 40Gb/s NRZ example

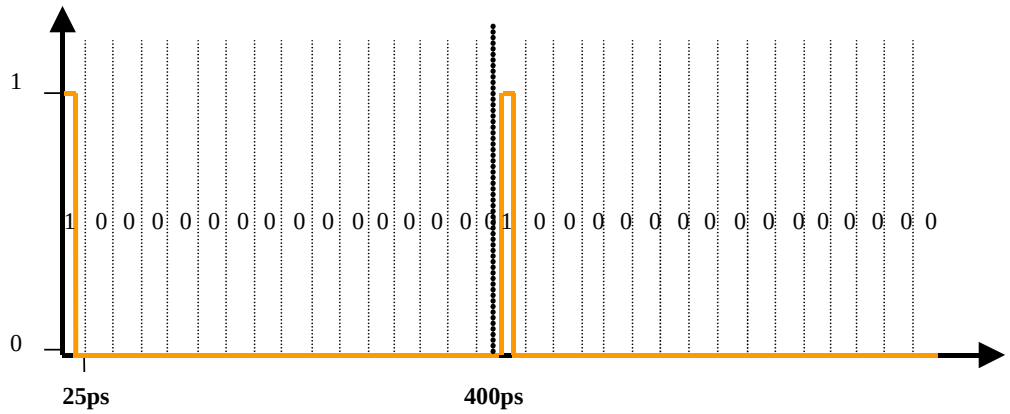


At 40Gb/s NRZ, a lot of different patterns are possible :

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0
1 0 1 1 0 0 0 1 1 1 1 0 1 0 1 1
etc…

- At 40Gb/s RZ the same patterns as NRZ can be used.

Fig. 23 : 40Gb/s RZ example



So, for any measurement at 40Gb/s (RZ or NRZ), it is necessary to generate a 16 bits pattern to have a repeat frequency of 2.5GHz.

Trick : To verify that the pattern used have a repeat frequency of 2.5GHz, it is just necessary to verify that the eight first bits of the pattern are different from the eight last bits.

For example 1111000011110000 is not possible to measure because there is a repeat frequency of 5GHz.

- For others bit rate :

It is possible to measure complex spectrums by using other bit rates than 10Gb/s or 40Gb/s. The only constraint for any bit rate is to provide an optical modulated signal with a repeat frequency of 2.5GHz and a clock signal synchronized with the modulated signal and with a frequency between 9.95GHz and 10GHz.

For example, to measure a 20Gb/s signal, it is necessary to generate a 8 bits pattern (20Gb / 8bits = 2.5GHz).

At a bit rate of 2.5Gb/s it is possible to measure the complex spectrum if the signal is on RZ format. Then we can analyze 1 bit.

8.2.3 How to get 625MHz repeat frequency?

The pattern length is 4 time longer than the pattern used for 2.5GHz repeat frequency.

For example at 10Gb/s, a 16bits pattern can be used.

8.2.4 Clock requirements

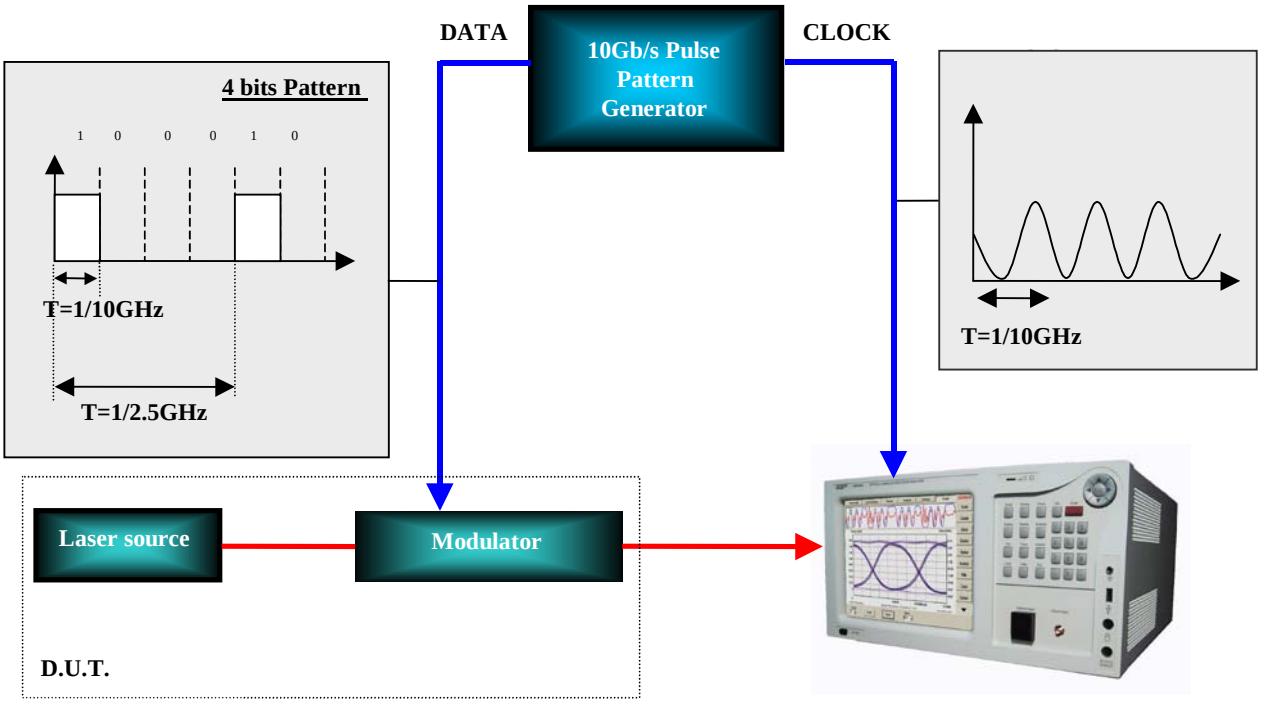
For any bit rates, to measure the complex spectrum, we need a 10GHz clock (front panel clock input) or 2.5Ghz clock (back panel clock input)

The clock frequency can be tuned from 9.95GHz to 10GHz or from 2.48GHz to 3.125GHz

The minimum power required for the clock is -10dBm and the maximum is +10dBm.

8.2.5 10Gb/s measurement configuration

Fig. 24 : 10Gb/s configuration



8.3 Measurement procedure

8.3.1 For a standard complex spectrum measurement

- Turn ON the instrument with the front panel switch (N°6 fig.4)
- Wait 30 minutes before any measurement and a 1 hour warm-up is recommended.
- Push 'Auto' in the 'sweep' menu to start the measurement. A standard measurement without averaging last around 10s.

8.3.2 Spectral width

By using the 'Auto' button of the 'Sweep' menu, the spectral width is automatically set depending on the signal under test. Caution, in case of a signal using optical amplifiers the automatic span search can be wrong due to the spontaneous emission generated by the optical amplifier. In this case a manual setting of the center wavelength and the span is necessary.

Caution : If the spectral width is not wide enough for the signal under test, then every spectral components can not be measured. So, the measurement will be wrong.(Refer to §8.3.3 for influence of the spectral width)

8.3.3 Problems by reducing the spectral width :

This is an example of the same measurement with two different spectral width :

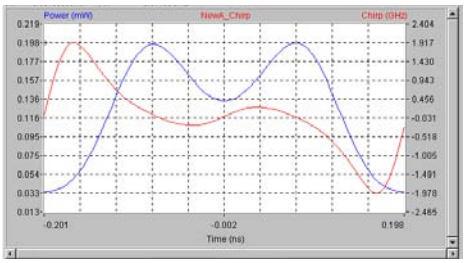


Fig. 26 : Chirp and pulse shape measurement with a 5GHz spectral width (2/16 modes before carrier and 2/16 modes after carrier)

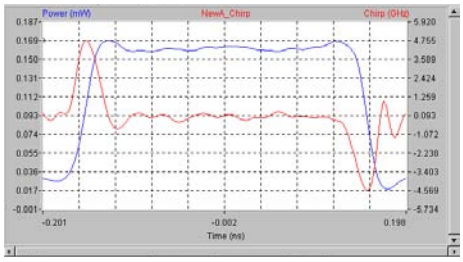


Fig. 27 : Chirp and pulse shape measurement with a 40GHz spectral width (16/16 modes before carrier and 16/16 modes after carrier)

In this example, we can see that the spectral width limitation induce a distortion in the calculated parameters. So, the bandwidth selection function have to be used with precautions.

8.3.4 Basics of bandwidth selection :

For a standard measurement ('Full' mode in the 'Setup' menu), the complex spectral analysis gives the power and the phase of every spectral components measured by the instrument. The calculation of the Chirp, pulse shape, phase and Alfa parameter will then use every spectral components measured during this complex spectral analysis.

But, it is also possible to select manually the spectral width for the FFT calculation by using the 'Manual' function in the 'Setup' menu. With this function, it is possible to select the number of spectral components or the spectral width in GHz before and after the carrier. (Refer to §8.5.3).

8.3.5 Polarization requirements

AP2440A is polarization independent.

8.3.6 Carrier selection

For a complex spectral analysis, it is necessary to locate the carrier of the modulated signal. With AP2440A, there is 3 different mode for the carrier selection :

- Auto mode : The carrier is selected in order to have a chirp centered in 0
- Highest mode : The carrier is selected as the highest spectral component power.
- Manual mode : The carrier is selected manually.

8.3.6.1 What is the influence of the carrier selection?

Influence for pulse shape measurement :

There is no difference in pulse shape by changing the carrier position.

Influence for chirp measurement :

We know that the Chirp formula is :

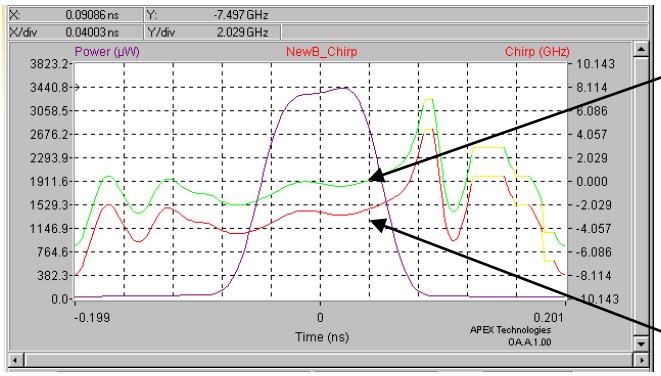
$$C(t) = f(t) - f_0$$

Instantaneous optical frequency

Carrier

If, instead of taking the real carrier, an adjacent mode is taken (at 2.5GHz from the carrier for example), then C(t) is translated by 2.5GHz. See our example next page.

Fig. 28 : Carrier influence on chirp



Chirp calculated with the real carrier.

Chirp calculated with the carrier 2.5GHz away from the real carrier.

Influence for Phase measurement :

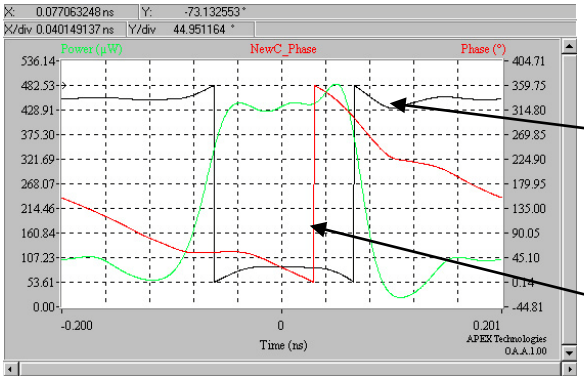
We know that the phase formula is :

$$\varphi(t) = 2\pi \int_0^t C(t).dt$$

Therefore, if the carrier is moved :

$$\varphi'(t) = \varphi(t) + Ft$$

Fig. 29 : Carrier influence on phase



Phase measured with the real carrier.

Phase measured with the carrier 2.5GHz away from the real carrier.

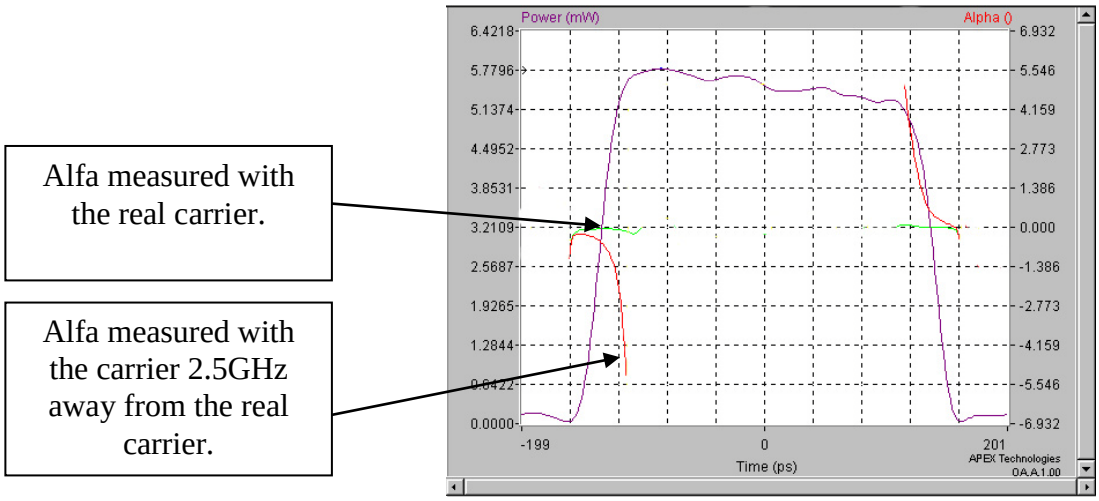
In this example, we can see that the phase measurement, can be totally different with two different carrier selection.

Trick : For phase modulated signals (DPSK, QPSK,...) it is important to select the good carrier otherwise the phase display will not show the real phase modulation.

Influence for Alfa measurement :

If the Alfa parameter is calculated with a bad carrier, its value will be wrong. See our example below.

Fig. 30 : Carrier influence on Alfa



Conclusion on the influence of the carrier :

The carrier selection is important for Chirp, phase and Alfa measurement.
In most of the cases, in 'Auto' mode, the software find the real carrier and then calculate the real chirp and the real phase. But, in some special cases, when the chirp is non symmetric for example, the software can not determine the real carrier. So, it is important to verify if the carrier used is the real carrier.

8.3.6.2 How to know the real carrier?

Follow this procedure to know the real carrier and to calculate every parameters with the real carrier :

- Turn off the modulation applied on the DUT (not necessary to turn off the clock)
- Push 'Single' to start a measurement
- Choose the trace measured in the 'Trace' roll box of the 'Setup' menu
- Press the 'Display' button in the 'Setup' menu to display 'Yes'
- Push the carrier selection button to display 'Manual'. The carrier written in the 'Carrier' edit box is now fixed manually to the real carrier value and every new measure will use this value.
- Turn on the modulation applied on the DUT
- Push 'Single' to start a new measurement with the new carrier.

Caution : This procedure is working if the DUT wavelength does not change when there is or not a modulation applied to it.
Trick : Constellation display can help to find the good carrier (refer to Analysis menu §8.5.6.4)

8.3.7 Sampling points and displayed points

For a complex spectral analysis, the number of 'measured points' is determined by the number of spectral components and is automatically set internally.

Then it is possible to set the number of point for the FFT calculation ('displayed points'). It is possible to change the number of 'displayed point' for the calculation in the 'SETUP' menu (refer to §8.5.3 for Setup menu description). The number of 'Displayed points' have to be higher than the number of 'measured points'.

The increase of the number of displayed point permit to smooth the traces calculated by FFT. We advice a minimum of 256 points.

To have a good resolution for markers setting, the number of displayed 'points' can be increased. The step of the markers is fixed by the number of 'displayed points'.

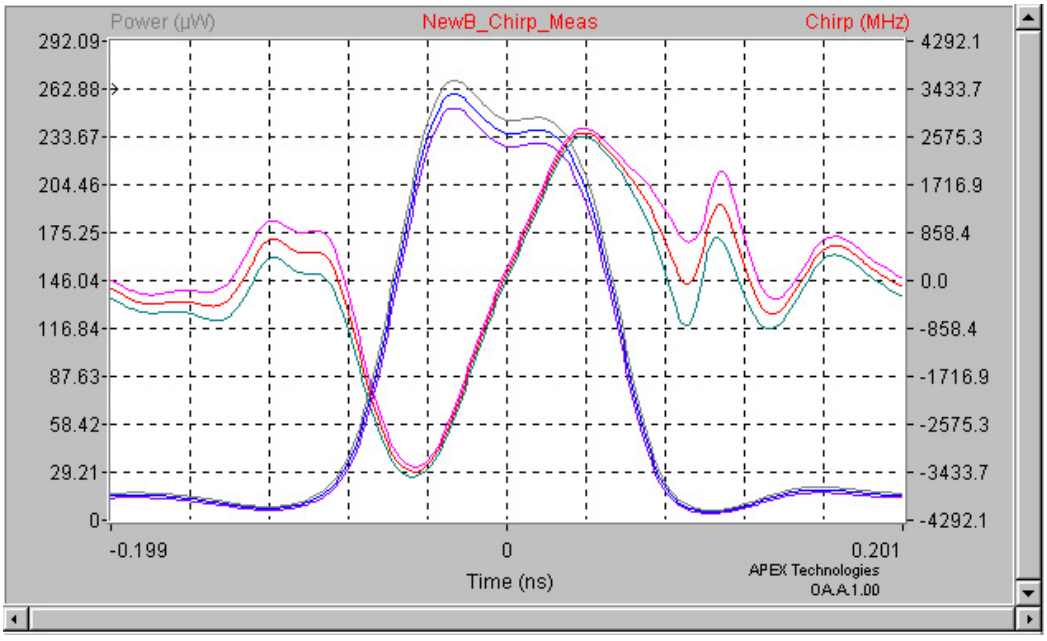
The number of points is in a 2^n format (256pts, 512pts,.1024pts...) If a value is entered, the software correct it to the closest 2^n value.

8.3.8 Accuracy function

Because the measurement accuracy is dependent on the signal measured, an accuracy function is available. This function calculate the Minimum and the maximum value for each point of a trace. Two new traces will be displayed : Up trace and Low trace.

In the following example a pulse shape measurement and a chirp measurement are displayed with their accuracy traces.

Fig. 31 : Acuracy traces



Two accuracy functions can be calculated :

Typical : If typical accuracy is selected, the minimum and maximum values are calculated upon the absolute accuracy of the power measurement of each spectral components (Signal under test spectral components and frequency shifted spectral components used for phase measurement) (refer to§8.1 for measurement principle).

Estimated : If estimated accuracy is selected, the minimum and maximum values are calculated upon the absolute power accuracy of the reference spectrum and the estimated phase accuracy (estimation upon the evaluation of the phase measurement reliability of the signal under test).
If the measurement is averaged, the power and the phase accuracy is calculated upon the averaging results. The minimum and maximum values are calculated upon those accuracy. Use this function when the signal measured is not stable. The displayed accuracy can give information on the reliability of a measurement.

When “Fast” calculation (refer to “setup” menu) is used, the accuracy is calculated only in the zoomed display (if a zoom is used).

8.3.9 Internal calibrator

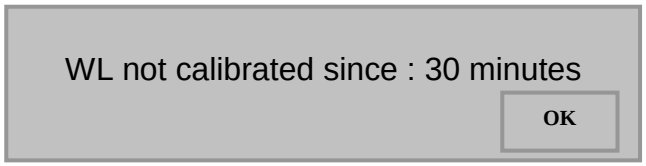
The AP2440A integrate a wavelength calibrator giving an accuracy of +/-3pm after calibration.

During the Warm-up, it is possible to calibrate the module, but we do not guarantee any specifications. If 'Single' or 'Auto' of the 'Sweep' menu is pressed, a wavelength calibration is automatically started.

The initial calibration of the module have to be made after 30 minutes warm-up, even if a calibration have been made during the warm-up.

The first time (after the 30 minutes warm-up) 'Single' or 'Auto' of the 'Sweep' menu is pressed, a wavelength calibration is automatically started. Otherwise, it is possible to calibrate the the wavelength by pushing the 'Run cal' button of the 'Setup' menu of the 'Spectrum' application(Refer to §7.4.3 for 'Setup' menu of the 'Spectrum' application). When, calibration succeed, a message is displayed : 'Calibration succeed'.

The wavelength calibration quality is dependent on external temperature variations, so we advice to verify the calibration every 30minutes. (Refer to §7.4.3). With the 'Auto' edit box of the 'Setup' menu of the 'Spectrum' application, it is possible to select the time between two 'calibration warning' messages. This 'Calibration warning' message inform about the last calibration made. (see below). Calibration warning messages do not work during the 30 minutes warm-up.



Push OK to delete this message on the screen. The user can choose or not to calibrate the wavelength of the OGA module. To calibrate the module push the 'Run cal' button of the 'Setup' menu of the 'Spectrum' application.

For every measurement, the wavelengths measured are automatically corrected by the internal calibrator.

The 'Run cal' button run a verification of the absolute wavelength calibration. If the instrument is under measurement, the calibration can not be made.

8.3.10 Undefined points (Yellow traces)

By using FFT calculation, when the power of the pulse is close from 0 for certain points, then the chirp for this points can not be calculated. The software automatically find this 'Undefined points' and display them in 'Yellow color'. Auto scale functions will never use this points for the auto scale calculation.

For Alfa calculation, the same phenomenon appear when there is no pulse variations (refer to §8.1.4 for details on Alfa calculation). These undefined points are also displayed in yellow color and are not used for Auto scale functions.

8.4 CHIRP menu description

- **SCALE :** This menu is used to change X scales and Y scales, to display linear or logarithm curves, to lock curves together and to Zoom.
- **SWEEP :** This menu is used to run the sweeping and to set the span and the carrier frequency.
- **SETUP :** This menu is used to set the measurement conditions.
- **DISPLAY :** This menu is used to select the unit of measurement and the type of measurement to display (temporal variation or frequency spectrum).
- **MARKER :** This menu is used to set horizontal and vertical lines and markers.
- **ANALYSIS :** This menu is used to run analysis modes like accuracy mode.
- **FILE :** This menu is used to save or to load from floppy disk drive or from hard-drive.
- **TRACE :** This menu is used to select the active curve and to fix or to delete curves.
- **SYSTEM :** This menu is used for polarization control, initialization and calibration of the touch sensitive screen.
- **LOCAL :** This menu is not used for the moment.
- **HELP :** This menu is not used for the moment.
- **MAIN :** This menu is used to come back to the first page. In this page you can choose to use the spectrum analyzer alone or with the chirp measurement.

8.5 Menu by menu description

8.5.1 SCALE menu

By pushing in the vertical panel, the SCALE button, 3 new button will then appear in this vertical panel : SCALE X, SCALE Y.

You can use this 3 new button as some standard Underlined Buttons.

An horizontal menu will be also displayed after pushing the SCALE Button:

- Push this button to select the displayed unit for the X scale when the spectrum mode is selected (Spectrum mode is selected in the display menu. Refer to §8.5.4 for more information). The spectrum can be display in Wavelength or in Frequency. The selected parameter is written on the button. The displayed wavelength is the vacuum wavelength.

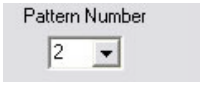
- This box is used to select the active trace. Six traces are available, and the active trace is used to set scales and markers. The color of the active trace is red by default. 'Next trace' button select another active trace in chronological way of the trace number. The active trace number is then written in the roll box close by. The active trace can be selected also with the roll box by selecting directly the trace number.

- Choose the axis for scale settings. Changing the "axis" will change the active trace as well.

- This button is used to select the power display in LINEAR or in LOGARITHM. The selected parameter is written on the button.

- Push this button to select the scale mode for the X scale. The selected parameter is written on the button (Auto or Manual). If Auto is selected the X scale of the active trace is adjusted automatically. If Manual is selected the scale will keep the actual settings whatever the active trace. When 'Auto' is selected, every new measurement or loading will use the Auto scale function.

- Push this button to select the scale mode for the Y scale. The selected parameter is written on the button (Auto or Manual). If Auto is selected the Y scale of the active trace is adjusted automatically. If Manual is selected the scale will keep the actual settings whatever the active trace. When 'Auto' is selected, every new measurement or loading will use the Auto scale function. This setting is only apply to the Axis selected in the “Axis” box.



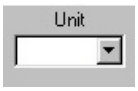
- Select the number of patterns display on the screen in this roll box.

8.5.1.1 SCALE X menu

- In this menu, every values (MIN X, MAX X, ScaleX/DIV, CENTER X and SPAN X) can be changed with touch sensitive screen, front panel or external keyboard.

- One value have to be fixed by pushing the FIX button. The fixed value is written in gray color and can not be changed. Every change in other values will never affect a fixed value.

  You can fix, for example, CENTER X at 193THz and then change MIN X, MAX X, Scale X/DIV or SPAN X. Then, every display will be centered at 193THz, whatever the others values are.



- The unit can be selected with the roll box 'Unit' if 'Manual' is selected in the 'Unit' button of the 'Scale' main menu (refer to §8.5.1). If 'Auto' is selected in the 'Unit' button of the 'Scale' main menu (refer to §8.5.1), the unit is displayed in Grey and can not be changed.

8.5.1.2 SCALE Y menu

- In this menu, every values (MIN Y, MAX Y, ScaleY/DIV, CENTER Y and REF Y) can be changed with touch sensitive screen, front panel or external keyboard.

- The displayed values are the scale values of the active trace.

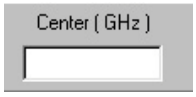
- One value have to be fixed by pushing the FIX button. The fixed value is written in grey color and can not be changed. Every change in other values will never affect a fixed value.

  You can fix, for example, CENTER Y at 0 and then change MIN Y, MAX Y, Scale Y/DIV or REF Y. Then, every chirp display will be centered at 0, whatever the others values are.

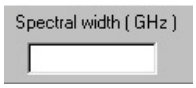
- The unit can be selected with the roll box 'Unit' if 'Manual' is selected in the 'Unit' button of the 'Scale' main menu (refer to §8.5.1). If 'Auto' is selected in the 'Unit' button of the 'Scale' main menu (refer to §8.5.1), the unit is displayed in Grey and can not be changed.

8.5.2 SWEEP menu

This horizontal menu appear when the 'SWEEP' button in the vertical menu is pressed.



- This panel define the center wavelength/frequency to be use for a single sweep. Enter the center wavelength/Frequency with the front panel keyboard.



- This panel define the spectral width to be use for a single sweep. Enter the spectral width with the front panel keyboard.

- Push this button to run the automatic sweep function. This function research automatically the center wavelength and the spectral width upon the whole wavelength range.
  The Span is determined by searching every spectral components with a dynamic higher than 3dB. The software is searching the far Left and the far Right spectral component and determine the Spectral width. The Center frequency is placed in the middle of the far Left and the far Right spectral component.

- Push this button to run a single sweep.

- Push this button to sweep continuously the complex spectrum analyzer. Press the “Stop” button to stop the sweeping.

- Press this button to stop the measurement. If the sweeping is stopped, no measurement will be displayed.

- This panel is used to set the phase averaging function. Enter the number of averaging required in the 'Number' box and push 'Single' to start the measurement.

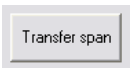
To continue the averaging after the end of one averaged measurement, press the 'CONTINUE' button. The averaging will then continue by keeping the first averaged measurement results. If 'Single' is pressed at the end of an averaging, a new averaged measurement is done. In this case, the results of the first averaged measurement are not used.

This 'CONTINUE.' function can be used when the first averaging is not sufficient. During an averaging, the measurement time can be long. So, it is necessary to verify that the measurement conditions do not change during the averaging.

➢ This panel is used to set the levels averaging function. Enter the number of averaging required in the 'Number' box and push 'Single' to start the measurement

Levels and phase averaging can be combined. In this case the measurement time will be : Meas.Time = SingleMeasTime x Nphase avg x NlevelAvg

➢ Tolerance dB box define the maximum power variations acceptable for an averaging function. If the signal under test is varying more than this value, the averaging is stopped and an error message is diplayed.



➢ Press this button to transfer the Span/Center or Start/Stop wavelength settings of the Complex Spectrum Analyzer software to the Spectrum Analyzer software.

8.5.3 SETUP menu

This menu is used to set the calculation conditions before a measurement or to change this conditions on an existing measurement.

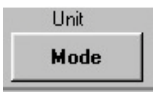
➢ Push this button to execute the calculation with the displayed Setup on the trace specified in the 'trace' roll box.

➢ Choose the trace by clicking in the 'trace' roll box.

If YES is written on the 'Display' button, the settings of the selected trace are displayed on the 'Setup' menu (Bandwidth and Carrier values). Use this button to know the measurement set up of one trace.

If NO is written, the displayed setup (Bandwidth and Carrier values) do not correspond to the trace specified in the 'trace' roll box.

➢ This panel is used to set or to show the spectral bandwidth used for the FFT calculation (refer to §8.1 for measurement principle). For a better understanding of the bandwidth selection, please refer to §8.3.3.



➢ The spectral bandwidth could be set with two different units : GHz or Mode. The displayed bold character show the unit selected. Push this button to change the unit.

- GHz unit : If GHz is selected, the bandwidth is expressed in Frequency (GHz).

- Mode unit : If Mode is selected, the bandwidth is expressed in number of spectral components (modes).

Every spectral components are spaced by 'Fr' (Fr = Repeat Frequency. Refer to §8.1.1). If the number of modes is 20, for example, the bandwidth used for the calculation is 20'Fr'*

- The value display in the Edit Box 'Before' correspond to the number of modes (or the spectral width in GHz) used before the carrier for the FFT calculation.

- The value display in the Edit Box 'After' correspond to the number of modes (or the spectral width in GHz) used after the carrier for the FFT calculation.

Comment : If the bandwidth is expressed in GHz, following our measurement principle, the effective bandwidth is a multiple of 'Fr' (refer to §8.1.1) because every spectral components are spaced by 'Fr'. If the bandwidth value entered is not a multiple of 'Fr', the software will automatically change this value to a value multiple of 'Fr'.

- Push this button to select the 'Bandwidth selection' function. The displayed bold character show the function selected. Push this button to change the function :

- Manual :. If 'Manual' is selected, it is possible to change the bandwidth by entering values in the edit box 'Before' and 'After'. Press 'Calculate' to display the result. Refer to §8.3.3 for a better understanding of the bandwidth selection.

- Full : With 'Full' function, every modes measured are used for the calculation. To visualize the number of modes used, set YES on the 'display' button. Refer to §8.3.3 for a better understanding of the bandwidth selection.

- This panel determine the carrier selection option and the carrier value. There is 3 different options for the carrier selection : Manual, Highest, Auto. For a better understanding of the carrier selection influence , refer to §8.3.7.

The displayed bold character show the option selected. Push this button to change the option.

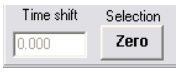
- Manual : If manual is selected, enter manually the carrier value in the 'Carrier' box. If manual is pressed, every new measurement or loading will use this carrier value.

- Highest : If highest is selected, the software will automatically search the highest spectral component and will set this spectral component as the carrier.

- Auto : If auto is selected, the software is automatically searching the carrier in order to have the averaged chirp in one period T (Refer to §8.1.4 for T definition) centered in O.

- This panel is used to set the input clock frequency. If the front panel clock is used, pushed the 'clock input' button to display 10GHz. If the back panel clock is used, pushed the 'clock input' button to display 2.5GHz.

- The clock frequency and the pattern length can be evaluated by the spectrum analyzer with an accuracy around 300MHz. If 'Selection' is in 'Auto' mode, the AP2440A is determining automatically the clock frequency and the pattern length. The time scale accuracy is determined by the clock frequency accuracy. So, if there is a need of an accurate time scale, enter manually the clock value in the 'Clock (GHz)' edit box after pushing the 'Selection' button to 'Manual'. If 'Manual' is selected, it is necessary to select also the 'Pattern' length manually. 'Short' means a repeat frequency between 2.48GHz and 3.12GHz (fr1) and 'Long' means a repeat frequency between 621MHz and 781MHz (fr2).

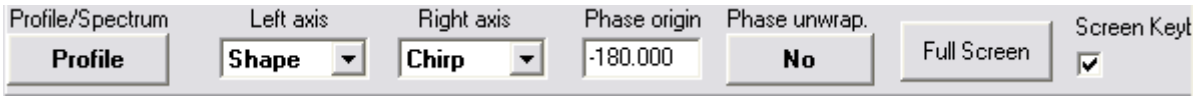


- By default select 'Zero' in this settings. In 'Manual' mode the signal can be shifted temporarly. A 1,000 time shift correspond to one complete pattern shift. This function can be used for an easy comparison between two signals having two different time reference.

- Enter the number of points used to display the calculation results. Refer to §8.3.8.
  If processing is set to Fast, the calculation time will be faster but no accuracy is realized (No Yellow trace (refer to 8.3.11)) .

8.5.4 DISPLAY menu

This menu is used to select the different characteristics and information displayed on the screen.



Two main display type can be done with this instrument.

Profile : In the 'profile' mode, the X scale is expressed in time. An FFT as explained in §8.1.4 is performed to display profile traces. In this mode it is possible to measure :

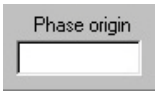
- Pulse Shape in dBm or mW
- Chirp in GHz
- Phase in degree
- Alfa parameter

Spectrum : In the 'Spectrum' mode, the X scale is expressed in frequency (or in wavelength). The direct measurement of the complex spectral analysis are used (Refer to §8.1.4) without any FFT calculation. In this mode it is possible to display :

- Power in dBm or mW
- Phase in degree

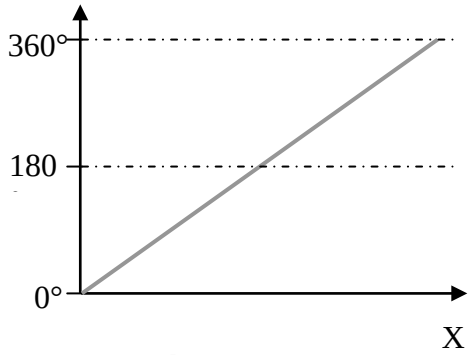
➢ Push the 'Profile/Spectrum' button to select the display mode.

➢ Choose the parameter to display either on the right or on the left axis, on the roll boxes 'Left axis' and 'right axis'. The curve is automatically displayed after the choice in the list.

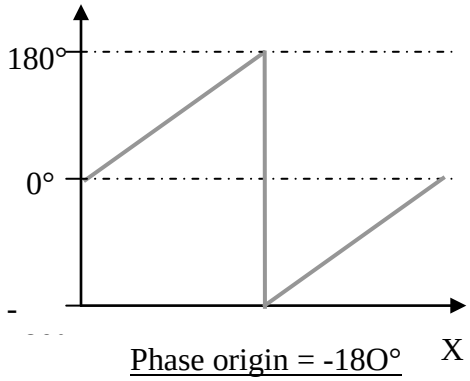


➢ The phase is always displayed by default (Phase unwrap = No) with a maximum dynamic of 360°(in Profile or in Spectrum mode). With 'Phase origin' button, it is possible to select the lowest phase value display on the screen. The phase is then displayed between the 'Phase origin' value and the 'Phase Origin' value + 360° as shown below :

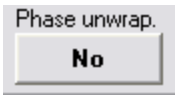
Fig. 32 : Phase display of the same measurement with two different Phase Origin



Phase origin = O°

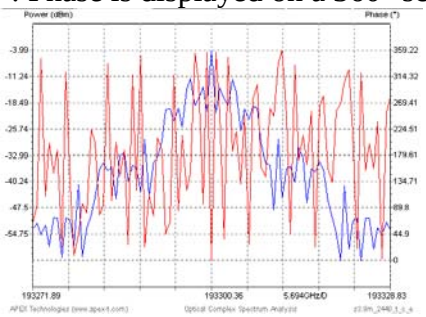


Phase origin = -18O°

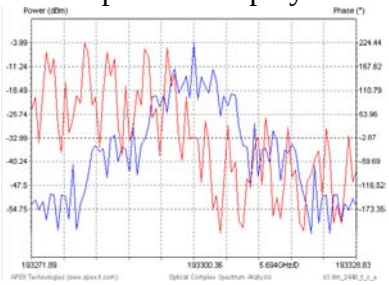


➢ As explained above, the phase is displayed by default on a 360° scale. Press the “phase unwrap.” button to display the phase without the 360° scale limitation. 3 options can be set to display the phase :

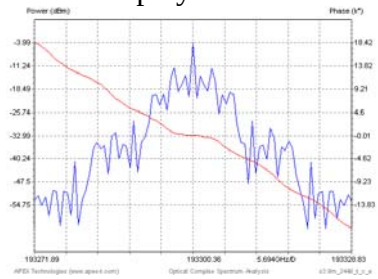
➢ NO : Phase is displayed on a 360° scale



➢ BASIC : The phase is displayed in order to display every consecutive phase values with its closest value. In this case the phase is displayed in thousands of degrees (k°)



➢ LINEAR : The phase is displayed in order to have the minimum phase slope variations. In this case the phase is displayed in thousands of degrees (k°).



➢ Push this button to display the measurement on the Full Screen. Push 'EXIT' (in the bottom right corner) to exit from this mode.

8.5.5 MARKER and LINE menu

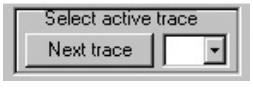
This menu is used for markers and lines settings.

8.5.5.1 Marker menu

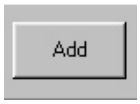
Use this menu to set Markers on the active trace.

The step between two positions of markers depend on the number of displayed points. Refer to §8.5.3 for number of points setting.

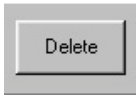
By pushing 'Marker' button on the vertical panel, the 'line' button is displayed on the vertical panel.



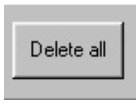
➢ Select the Active Trace by pushing on the 'Next Trace' button or by clicking on the 'trace' roll box . The active trace is in Red color. Markers can only be set on the active trace.



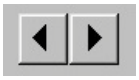
- Push the 'add' button to add a new marker on the active trace. After pushing the 'add' button, the marker is set on the middle of the screen and the new marker is the Active Marker.



- Push the 'delete' button to delete the Active Marker.



- Push the 'delete all' button to delete every markers of the active trace.



- Push the right and the left arrow to move the active marker on the active trace. To move markers, the front panel arrows can be used also.

- Select the active marker with this panel.

  The active marker is in Black color and his number is written in the 'n°' edit box.

  Push the 'Previous' button to select the previous marker as the active marker.

  Push the 'Next' button to select the next marker as the active marker.

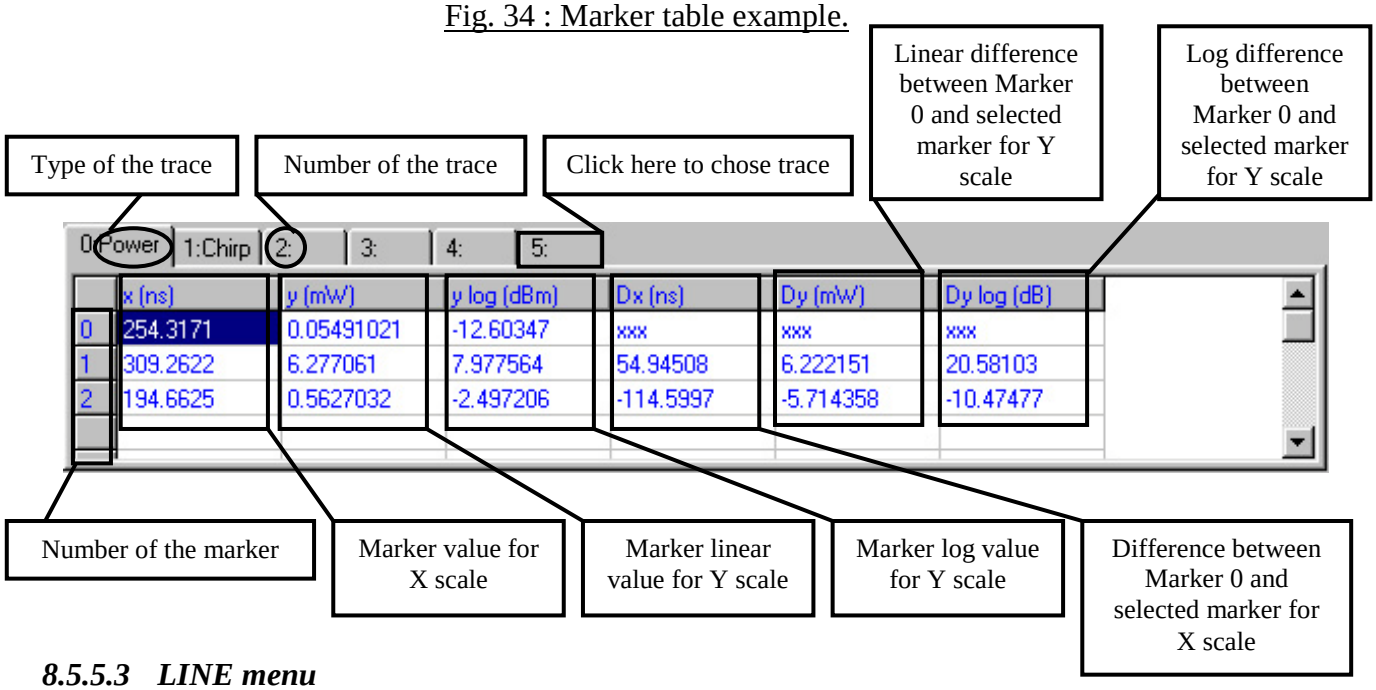
  The active marker position is displayed on the 'Scale/Div

- Push this button to display the 'Marker table'. When the 'Marker table' is displayed, push again this button to actualize data.

8.5.5.2 Marker table

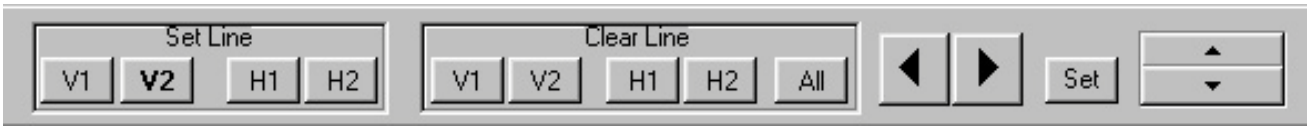
This is an example of display of the marker table :

Fig. 34 : Marker table example.



8.5.5.3 LINE menu

The line menu is accessible after pushing the 'marker' button on the vertical menu. Push the 'LINE' button to display the 'Line' menu in the horizontal panel.



For Lines settings, choose the lines in the 'Set line' panel (the selected lines are in bold characters in the Set line panel), move them on the screen with the touch sensitive screen, the front panel arrows or the arrows of the Line menu, and then push the 'Set' button to fix them. The lines position are displayed on the 'Lines' panels (refer to §3 for screen configuration)

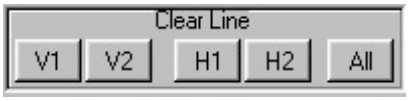
- This 'set line' panel is used to select the vertical or horizontal lines. Every selected lines are displayed in bold on the panel. It is possible to select up to 4 lines.

  Push the 'V1' button to select the first vertical line and display it in the center of the screen.

  Push the 'V2' button to select the second vertical line and display it in the center of the screen.

Push the 'H1' button to select the first horizontal line and display it in the center of the screen.

Push the 'H2' button to select the second horizontal line and display it in the center of the screen.



- This 'Clear line' panel is used to delete horizontal and vertical lines.

Push the 'V1' button to delete the first vertical line.

Push the 'V2' button to delete the second vertical line.

Push the 'H1' button to delete the first horizontal line.

Push the 'H2' button to delete the second horizontal line.

Push the 'All' button to delete all the lines.

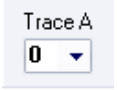
- Move the vertical selected lines by using the 'right' and 'left' arrow. It is possible also to move the selected lines with the touch sensitive screen or the front panel arrows.

- Move the horizontal selected lines by using the 'Up' and 'Down' arrow. It is possible also to move the selected lines with the touch sensitive screen or the front panel arrows.

- Push the 'set' button to fix the selected lines. After pushing the 'set' button, every lines are fixed and unselected.

8.5.6 ANALYSIS menu

This menu is used for analysis function.



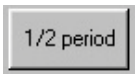
- Choose the trace used for the analysis functions in the 'trace A' roll box. This trace can be different from the active trace.

8.5.6.1 Accuracy function

- Push the 'accuracy' button to calculate the accuracy of the trace selected in the 'trace' roll box.

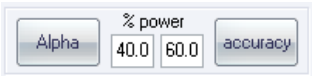
We advise to fix traces before using accuracy function. If traces are not fixed, the accuracy curves can use traces already used for other measurements. (Refer to §8.5.8 for more information about 'fix trace' function).

➢ Choose the accuracy function (typical or estimated) by ticking in the appropriate box. (Refer to §8.3.9 for details on accuracy functions)



➢ Push this button to display traces with a translation of 200ps on X scale.

8.5.6.2 Alfa parameter calculation



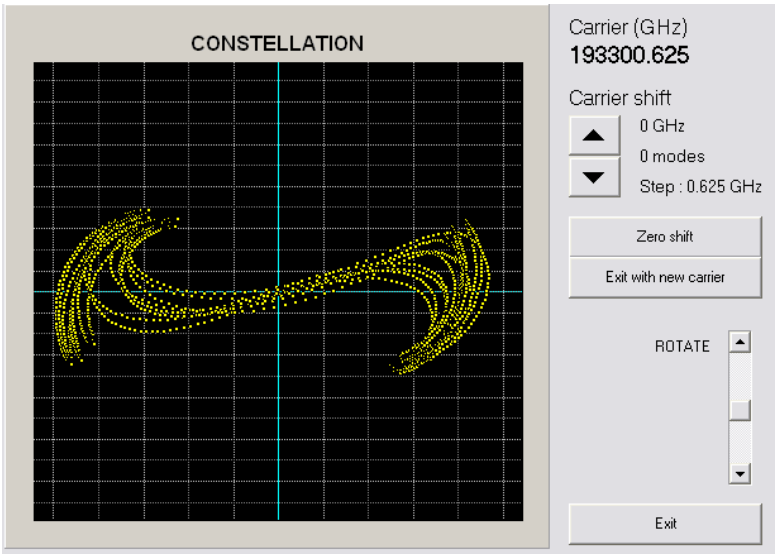
➢ Push the 'Alfa' button to calculate the averaged Alfa parameter on every pulses and measured between the % of power of the pulse defined on the edit box. In this example, Alfa will be determined between 40% of the pulse and 60% of the pulse power. Push the 'accuracy' button to calculate the accuracy of this measure.

8.5.6.3 Eye diagram display

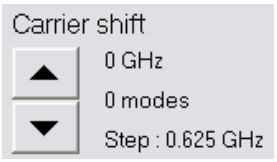
➢ To display the intensity or phase eye diagram, first select the pattern length of the measurement under test. Then enter the number of points for the eye diagram display in the 'Nb Pts' edit box. Then press 'Eye'. To delete the eye diagram press 'Clear eye'.

8.5.6.4 Constellation display

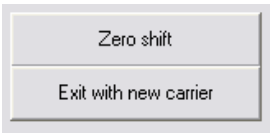
➢ To display the constellation display of the signal press the "constellation" button. A constellation display represent the Imaginary and real axis. A new screen is display after pressing this button :



In the constellation display the carrier settings can be change in order to find the ‘real’ carrier (refer to §8.3.6. for carrier information).



- Push the up or down arrow to shift the carrier selection. One pressure in the Up arrow will shift increasingly (in frequency) the carrier selection from 1 spectral component and one pressure in the down arrow will shift decreasingly.



- Push the “Zero shift” button to come back to the initial carrier posistion.
- Push the “Exit with new carrier” to display the time domain measurement with this new carrier setting.
- The constellation can be rotated at your display convenience with the “rotate” arrows. Rotating the constellation do not have any influence on the time domain measurement.

8.5.6.5 Amplitude display

- Push the “amplitude” button on to display the peak-to-peak amplitude (the measure of the change between peak and trough).

8.5.6.6 B-A display

- Choose the trace B used for the analysis functions “B-A” in the 'trace B' roll box. Push the “B-A” button to display the difference curve between the trace B and A.

8.5.7 FILE menu

This menu is used to save or load measurements, setups and marker tables on the hard disk drive or on the floppy disk.

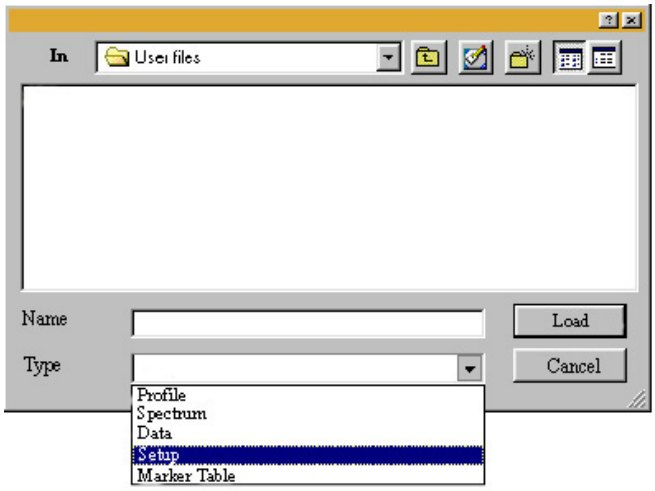
- Choose the drive to load or save measurements.

Two choices are possible :

C: (Hard disk drive)

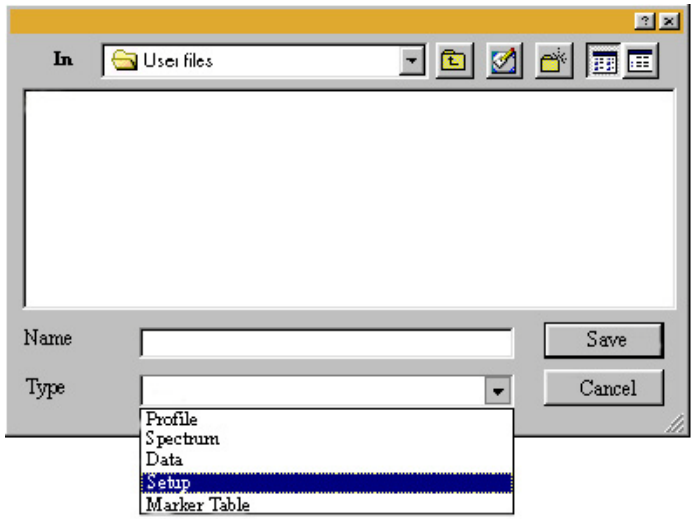
A: (Floppy disk drive)

➢ Push the 'Load' button to load a file. After pushing the LOAD button, a new panel is displayed. *The loaded file will use the first free trace(not fixed trace). To display existing traces and loaded traces at the same time, we advice to fix the existing traces before loading any trace.*



- Select the type of data to load (For detail about the type refer to § 8.5.7.1 to § 8.5.7.6) in the 'Type' roll box. Caution, when Profile & Spectrum file type are loaded, it is impossible to use Calculation functions. It is necessary to load the data in 'Data' type to use calculation functions.
- Enter or select in the list, the name of the file to load.
- Push the Load button.

➢ Push the 'Save' button to save a file. If a measurement is saved (Profile or Spectrum or Data type), the trace saved is the trace specified in the 'Trace' roll box of the File menu. After pushing the Save button, a new panel is displayed :



- Select the type of data to save (For detail about the type refer to § 8.5.7.1 to § 8.5.7.6)) in the 'Type' roll box.
- Enter the name of the file to save.
- Push the Save button.

➢ This roll box is used to select the trace to save.

8.5.7.1 PROFILE format

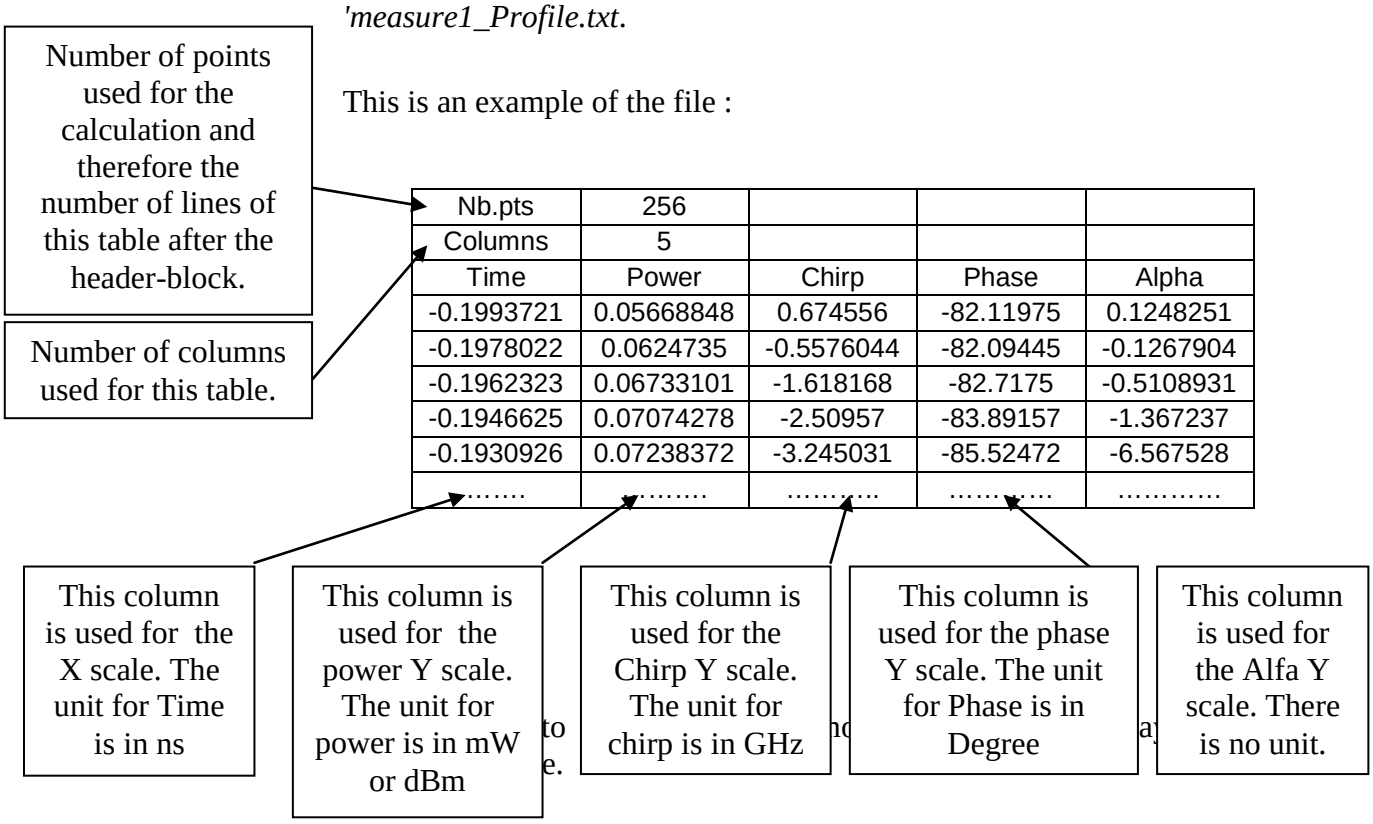
This format can be used with an external PC.

Saving in 'PROFILE' format :

This file can be use with an external PC. Its file name will be 'NAME_Profile.TXT'

If, for example, the file name entered in the Edit Box is 'measure1', the name of the file saved in 'PROFILE' format will be 'measure1_Profile.txt.

This is an example of the file :



Loading in 'PROFILE' format :

With this format, it is impossible to change the Setup and to use analysis functions.It is only possible to display the trace and use markers and lines functions.

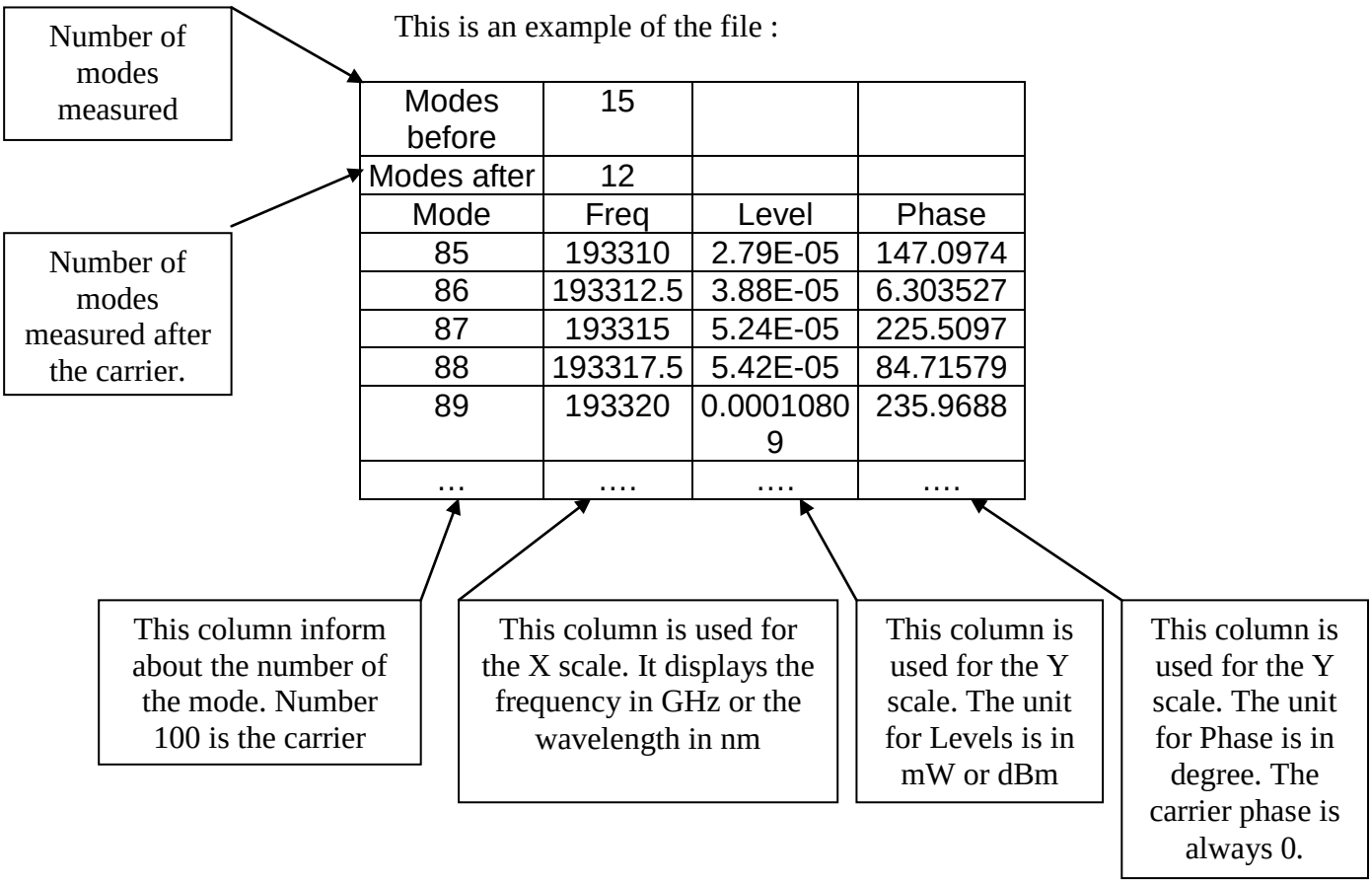
It is possible to load a 'Profile' file even if the display is in 'Spectrum' mode

8.5.7.2 SPECTRUM format

Saving in 'SPECTRUM' format :

This file can be use with an external PC. Its file name will be 'NAME_ComplexSpectrum.TXT'

If, for example, the file name entered in the Edit Box is 'measure1', the name of the file saved in 'SPECTRUM' *format will be 'measure1_ComplexSpectrum.txt*.



This is an example of the file :

Modes before	15		
Modes after	12		
Mode	Freq	Level	Phase
85	193310	2.79E-05	147.0974
86	193312.5	3.88E-05	6.303527
87	193315	5.24E-05	225.5097
88	193317.5	5.42E-05	84.71579
89	193320	0.00010809	235.9688
…	….	….	….

It is possible to save in 'Spectrum' mode even if the display is in 'Profile' mode

Loading in 'SPECTRUM' format :

With this format, it is impossible to change the Setup and to use analysis functions.It is only possible to display the trace and use markers and lines functions.

It is possible to load a 'Spectrum' file even if the display is in 'Profile' mode.

8.5.7.3 DATAS format

This format can not be used with an external PC(only with AP2440A)

This format is used when it is necessary to use analysis functions or to change or use setup functions.
Saving in 'DATAS' format :

Its file name will be 'NAME_Data.DAT'.

By saving in 'DATAS' format, every measurement data are stored : Carrier frequency, number of averaging, measurement accuracy…

Loading in 'DATAS' format :

It is possible to use it as a new measurement.

8.5.7.4 BMP format

Use this format to save a screen copy in Bitmap format. ('NAME.bmp'). The size of those files is around 900Ko. Those files can not be loaded.

8.5.7.5 MARKER TABLE format

Use this format to save the Marker Table. This format can be use with an external PC.

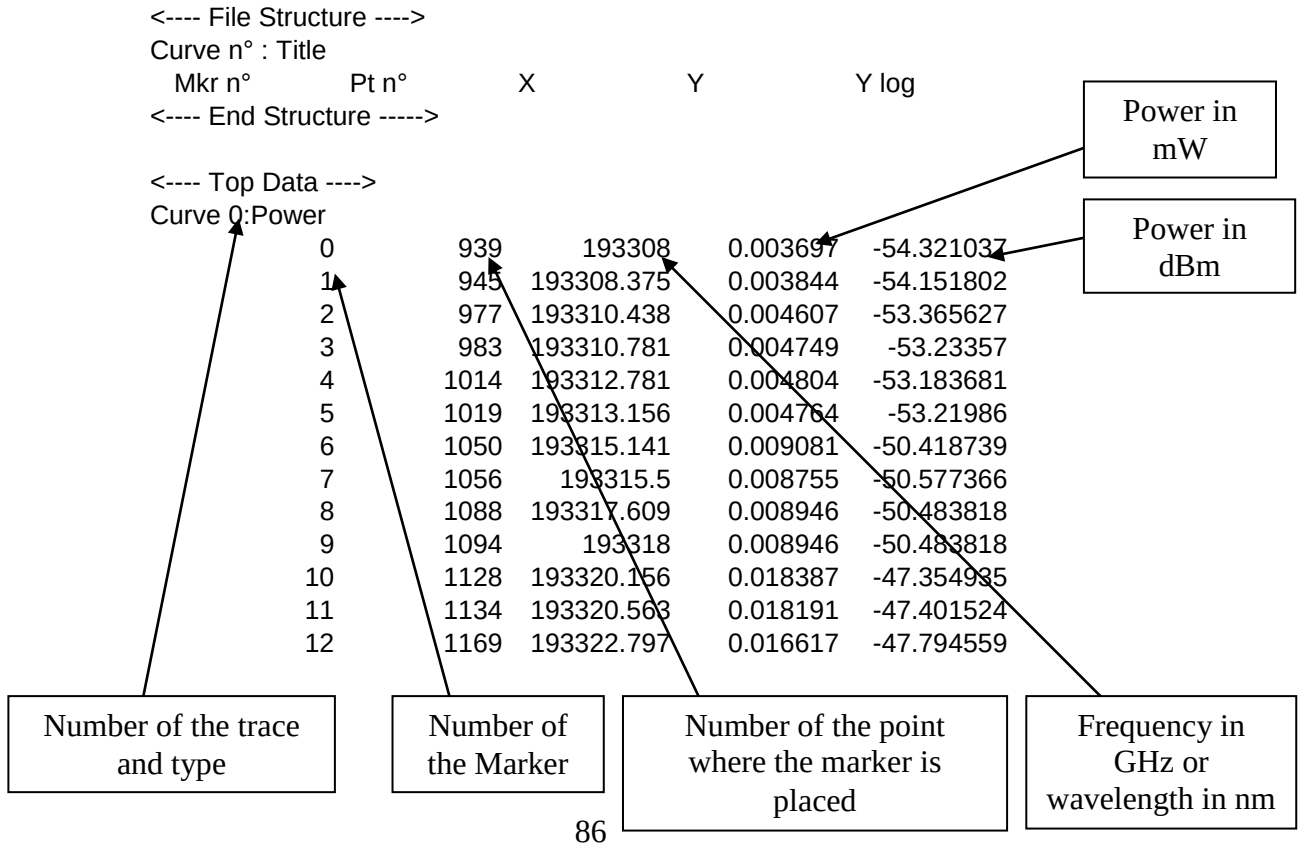
If a file is saved in 'Marker Table' format :

Its file name is 'NAME_MarkerTable.TXT'.

By saving in 'Marker Table' format, every markers of every traces are saved

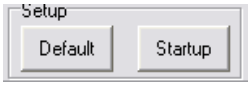
It is impossible to load files with 'Marker Table' format.

This is an example of a file saved in MarkerTable format :



If there is two traces with markers, then all the markers are listed on the 'MarkerTable' file and the markers from two different traces are separated by the number of the trace and its type in the first column (Example : 'Curve 0 : Power').

8.5.7.6 SETUP menu



With this menu, it is possible to store your current setup as the new setup for the startup, or to load the default setup of the equipment.

Press “Default” to load the default setup of the equipment.

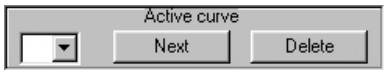
Press “Startup” to save the current setup as the new startup setup.

8.5.7.7 Remove USB device

Use the USB device box to remove properly a USB stick plugged on the equipment. Choose the device and press “remove”.

8.5.8 TRACE menu

Use this menu to set the active trace, delete traces and Fix traces.



- The number of the active Curve is written in the roll box. To change the active trace, choose it in the roll box or push the 'NEXT' button.

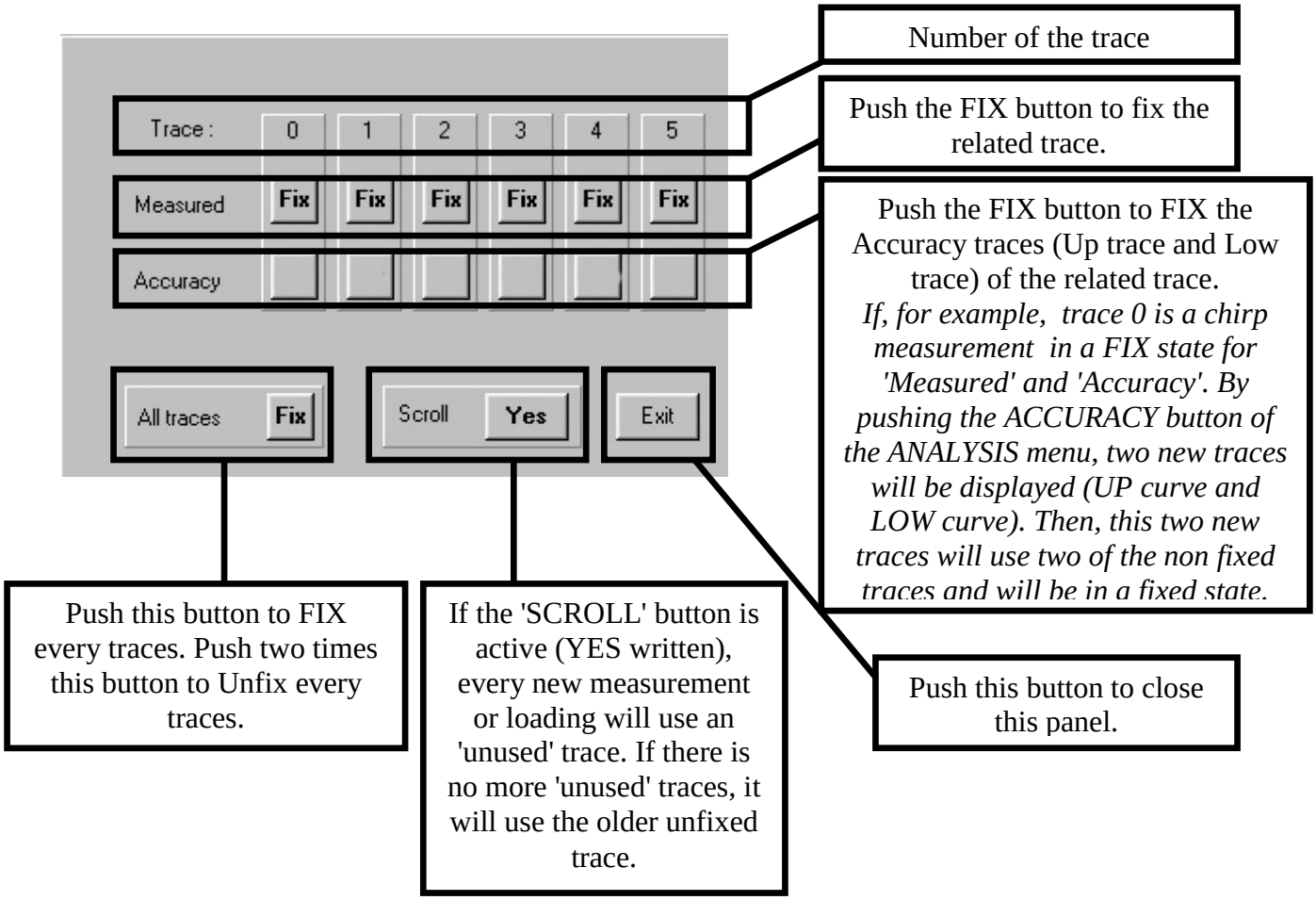
- To delete one trace, push the 'DELETE' button. Only the active trace is deleted with the 'DELETE' button.

- Push the 'DELETE ALL' button to delete every traces.

- Push the 'Fix..' button to display the FIX Panel.

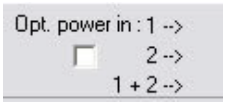
- FIX Panel : This panel is used to fix traces. If a trace is Fixed, it is impossible to use it for a measurement or for a loading. If there is no data in a fixed trace, the trace will be used like an Unfixed trace.

Fig. 35 : Fix trace panel



8.5.9 SYSTEM menu

This menu is used for the screen copy print, polarization control, the initialization before a measurement and setup of the Touch sensitive screen.

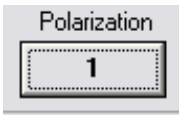


- Tick with the mouse or the touch sensitive screen in the white box to display the total optical input power in dBm of the OCA1040 module. When 'HIGH' is written, the total power is too high and if 'LOW' is written the total optical input power is too low for a measurement.

- Polarization : With this button it is possible to choose the polarization state to display on the screen.

- 1 + 2 : In this state, the measurement displayed on the screen is the polarization independent measurement. The two orthogonal polarization states are measured and the software calculates the combination of the two polarization and display one trace.

- 1 & 2 : The two orthogonal polarization states are measured, and two traces will be display on the screen after a measurement.



- 1 : One polarization state is display in this case

- 2 : One polarization state is display in this case (orthogonal polarization state versus 1)

- The AP2440A includes optical modulators. When instrument is turned ON, the Min bias and Maximum Bias value are measured and stored in the equipment. It is possible to verify these settings by pushing ‘Ajust OCA’ button. In the ‘Every’ edit box, enter the period of every adjustment in Minutes. By default, O min. Is entered.

Tick the box “Never” in order not to automatically adjust the Bias values. In this case the typical value for the bias are restored.

Caution : The OCA adjustment have to be made with an optical input signal. An OCA adjustment realized with no optical signal at the input can cause some complex spectrum measurement errors.

AP2440A series

OPTICAL COMPLEX SPECTRUM ANALYZER

Instruction Manual Addendum 1

(Transfer function, group delay, chromatic dispersion and 9 spectrum saving)

(Version 1.00)

APEX Technologies

9bis, rue Angiboust, 91460 Marcoussis, France

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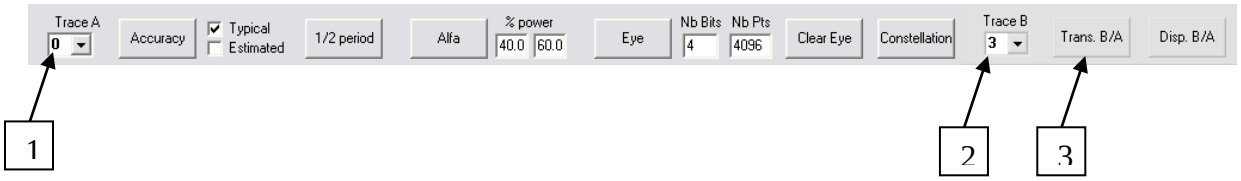
Summary

1 Spectral transfer function :

On the 'ANALYSIS' menu, the difference between two complex spectra can be calculated (in phase and in power) thanks to the 'Trans. B/A' function (refer §2.7.1)



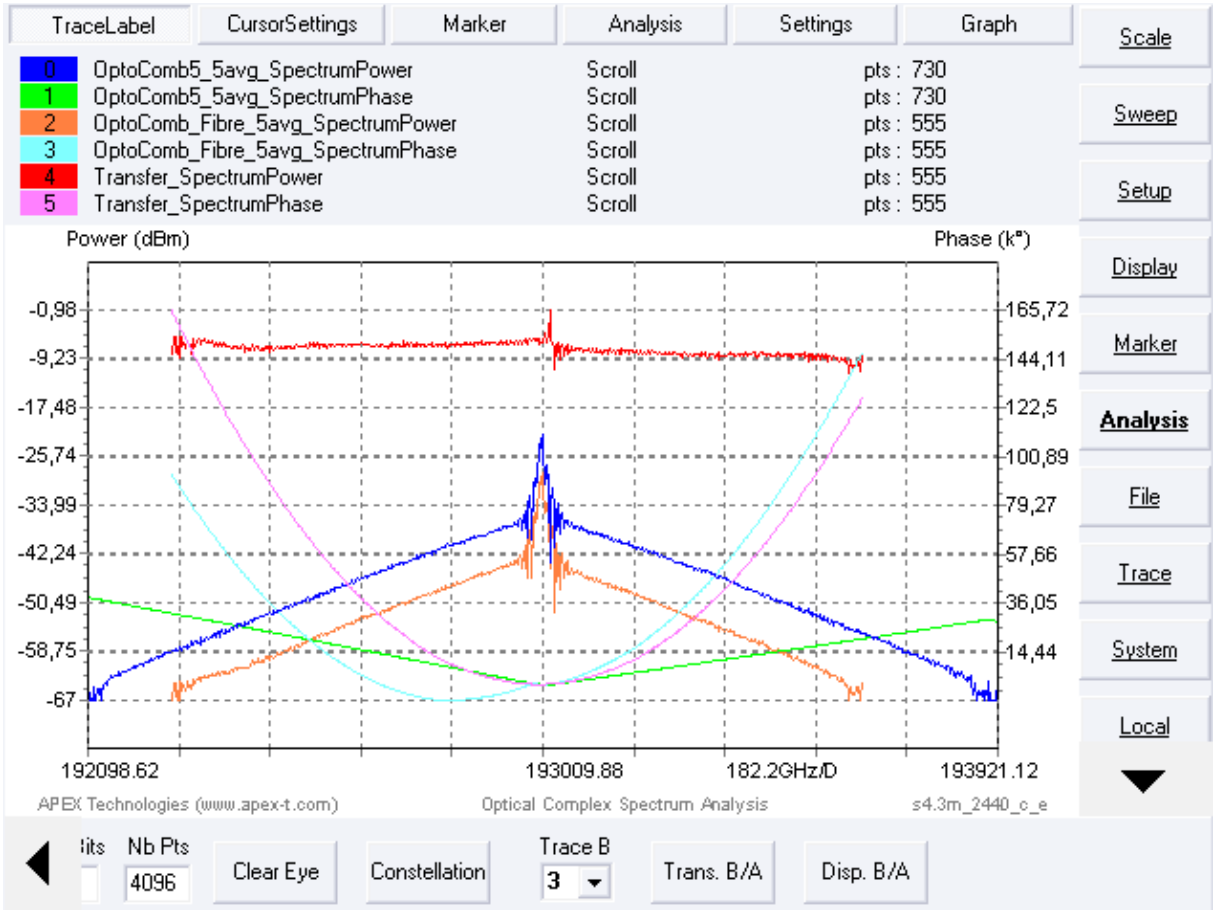
1 Select the trace number for the trace A in this edit box

2 Select the trace number for the trace B in this edit box

3 Press this button to calculate the transfer function between trace A and trace B

This is an example of the use of this function :

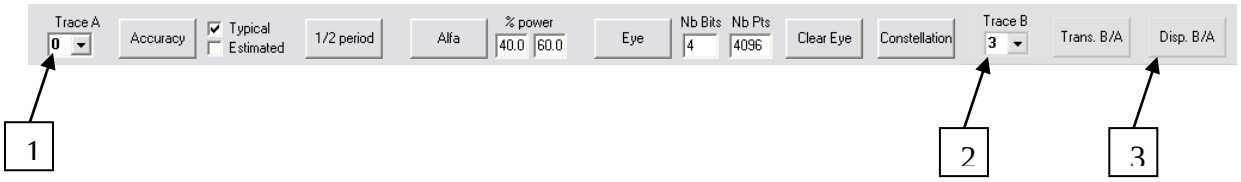
The blue (intensity) and green (Phase) trace (trace O and trace 1) are used as trace A
The orange (intensity) and sky blue (Phase) trace (trace 2 and trace 3) are used as trace B
Trans. B/A : The transfer function of the intensity between blue and orange trace is displayed in red (trace 4)
Trans. B/A : The transfer function of the phase between green and sky blue trace is displayed in pink (trace 4)



Caution : Do not forget in the TRACE menu, to select the 'Scroll' mode (refer to §8.5.8 of the standard instruction manual) otherwise after pressing 'Trans. B/A' function, the original traces will be deleted and only the result of the transfer function will be displayed.

2 Group delay and chromatic dispersion testing

On the 'ANALYSIS' menu, the group delay between two signals and the chromatic dispersion can be calculated thanks to the 'Disp. B/A' function (refer to §2.7).



1 Select the trace number for the trace A in this edit box

2 Select the trace number for the trace B in this edit box

3 Press this button to calculate the group delay (refer to §2.7.2) and the chromatic dispersion (refer to §2.7.3) between trace A and trace B

Caution : To calculate the dispersion between two traces, it is necessary to compare signals with the same time reference. For this purpose, it is necessary to set the 'Time shift' of the SETUP menu in 'Manual' mode with a 0 value for both traces (refer to §8.5.3 (of the standard instruction manual)for time shift information).

2.1 Chromatic dispersion display

After pressing the 'Disp. B/A' button, this is the new display :

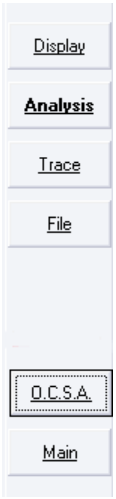
The blue squares represent the group delay between trace A and trace B and the blue lines is the calculated group delay uncertainty. The group delay scale is the left scale and is in ps.

The grey trace is the linear fit of the group delay (used for CD calculation)(Refer to §2.7.3)

The red lozenge is the calculated chromatic dispersion (Refer to§ 2.7.3) and the red line is the calculated uncertainty of the chromatic dispersion. The chromatic dispersion scale is the left scale and is in ps/nm.

This is the details of this software functionality :

2.2 Vertical Menu



DISPLAY menu used to select the different parameters displayed on the screen

ANALYSIS menu used for the analysis of the results

TRACE menu used to delete traces or select section

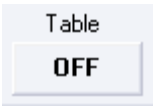
FILE menu used to save or load traces

OCSA button is used to go back to the Optical Complex Spectrum Software

MAIN button is used to go back to the AP2440A main menu

2.3 DISPLAY menu

Press this button to display the horizontal scale in frequency (GHz) or in wavelength (nm).



Press this button to display or not the following table :

Wavelength (nm)	Group Delay (ps)	Wavelength (nm)	Mean Gr. Delay (ps)	Dispersion (ps/nm)
1557.26358	440.3	1553.98541	-256.3	211.7
1557.22314	424.8			
1557.16247	410.7			
1557.14225	403.9			
1557.12203	406.9			

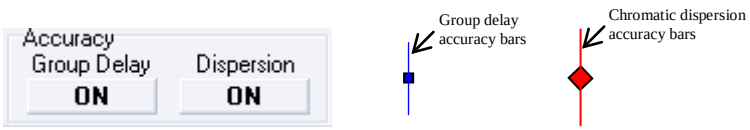
This table list :

- The Group Delay values calculated with their related wavelength (column 1 and 2)
- The mean wavelength calculated (column 3) (Refer to §2.7.3)
- The mean group delay (column 4) (refer to §2.7.3)
- The dispersion calculated (column 5) (refer to §2.7.3)

Press this button to display or not the group delay on the screen (blue squares)

Press this button to display or not the chromatic dispersion (red lozenge)

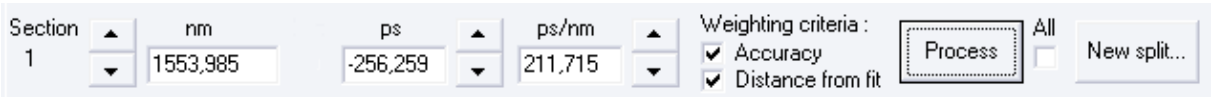
Press this button to display or not the dispersion fit



Press this button to display or not the group delay accuracy bars and the chromatic dispersion accuracy bars

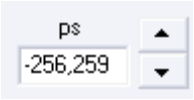
Display the active section in yellow (if ON is selected) in the case of a multi-section measurement

2.4 ANALYSIS Menu

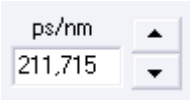


Use these arrows to change the active section (in case of a multi-section)

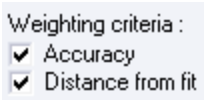
By default, the mean wavelength of the active section is displayed on this box. (Refer to §2.7.3) A wavelength value can be entered in this box and then by clicking on the 'Group delay' box, the relative group delay value is displayed for this particular wavelength.



By default, the group delay of the mean wavelength of the active section is displayed on this box. A group delay value can be entered in this box and then by clicking on the 'Process' button a new group delay value is calculated in order to find the closest group delay value (group delay is known modulo the period of the signal under test)(Refer to §2.7.4).

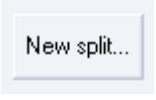


In this box the chromatic dispersion is written in ps/nm. Use the arrows to display the different possible values. (Refer to §2.7.4)

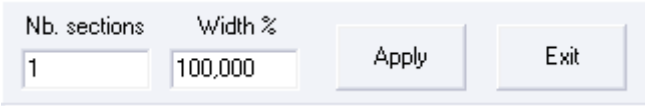


When the 'Accuracy' box is ticked, only the group delay points having a sufficient accuracy are displayed and used for the chromatic dispersion calculation. Press the 'Process' button to apply the setting. (refer to §2.7.3) When the 'Distance from fit' box is ticked, only the group delay points sufficiently close from the dispersion fit are displayed and used for the chromatic dispersion calculation. Press the 'Process' button to apply the setting.(Refer to §2.7.3)

Press the 'Process' button to apply any of the setting of the ANALYSIS menu. When the 'All' box is ticked, the settings are applied to every sections.



The 'New split' button can be use to share a complete measurement in different sections or to combine different measurement in one section. After pressing this button a new panel is displayed :

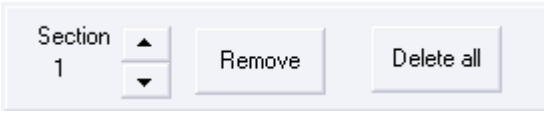


Enter the number of section in the 'Nb. Sections' edit box. This edit box can be use to combine several section or to split one section in several section. The 'Width %' edit box determine the percentage of the screen for every section. For example, if the measurement displayed on the screen is covering 5nm in one section and if you enter 20% (for 1 section), then the section will cover only 1nm. (other points are removed in this case).

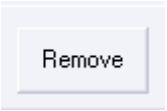
Press the 'Apply' button to apply the new section definition. Press the 'Exit' button to come back to the ANALYSIS menu.

2.5 TRACE menu

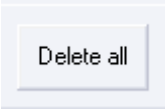
This menu is used for section management



Choose the active section with the Up and Down arrows



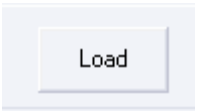
Press the 'Remove' button to delete the active section



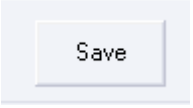
Press the 'Delete All' button to delete all the sections

2.6 FILE menu

This menu is used for saving or loading measurements.



Push the 'LOAD' button to load group delay and dispersion data saved on the HDD or in a USB stick.



Push the 'SAVE' button to save all the sections displayed on the screen. Data are saved in TXT and can be use with other software.

In the following page, an example of a 5 section measurement in TXT format :

Chromatic dispersion and group delay TXT file example:

```
Version    0
Nb.sections        5
_____________________________________________________
Section    1
Period     400     ps
Nb.pts.    111

Col. 1 : optical frequency
Col. 2 : group delay
Col. 3 : group delay accuracy

GHz                ps                  +/- ps
192269.868164063   -6398.0546875       163.299545288086
192272.368164063   -6452.26806640625   163.299224853516
192277.368164063   ...
_____________________________________________________
Section    2
Period     400     ps
Nb.pts.    111

Col. 1 : optical frequency
Col. 2 : group delay
Col. 3 : group delay accuracy

GHz                ps                  +/- ps
192544.868164063   -6907.30908203125   8.51952362060547
192552.368164063   ...
_____________________________________________________
Section    3
Period     400     ps
Nb.pts.    110

Col. 1 : optical frequency
Col. 2 : group delay
Col. 3 : group delay accuracy

GHz                ps                  +/- ps
192822.368164063   -7399.5986328125    8.96201705932617
192829.868164063   ...
_____________________________________________________
Section    4
Period     400     ps
Nb.pts.    111

Col. 1 : optical frequency
Col. 2 : group delay
Col. 3 : group delay accuracy

GHz                ps                  +/- ps
193097.368164063   -7850.388671875     5.9904842376709
193104.868164063   ...
_____________________________________________________
Section    5
Period     400     ps
Nb.pts.    111

Col. 1 : optical frequency
Col. 2 : group delay
Col. 3 : group delay accuracy

GHz                ps                  +/- ps
193374.868164063   -8313.134765625     8.56315517425537
193377.368164063   ...
_____________________________________________________
Dispersion fit :
Col. 1 : section number
Col. 2 : mean optical frequency
Col. 3 : mean group delay
Col. 4 : first order dispersion (estimated slope group delay vs. wavelength)
Col. 5 : first order dispersion accuracy

Section  GHz                ps       ps/nm    +/- ps/nm
1        192404.874023438   -6667    212.16   1.23284
2        192682.374023438   -7140.85 217.65   1.01339
3        192958.624023438   -7620.85 198.90   1.59341
4        193234.874023438   -8079.25 215.03   1.10944
5        193512.374023438   -8540.20 199.32   1.97790
```

Total number of sections

Section number

Period of the measured section

Number of group delay points measured

Definition of the columns

Group delay measured for this section

Section n°2

Section n°3

Section n°4

Section n°5

Definition of the columns

Chromatic dispersion, mean wavelength and accuracy calculated for every section

2.7 Principle and details of the measurement

Spectral transfer function, chromatic group delay variations and dispersion can be analyzed by comparing the complex spectra of a periodical optical signal (test signal) measured before and after passing through the device under test (DUT), that is to say at the input and at the output of the DUT.

The optical field propagating through the DUT can be written as :

$$E(z,t) = \sum_n A_n(z) \exp[i(\omega_n t + \Phi_n - \beta(\omega_n)z]$$

where *z* is the position along the propagation direction, *t* is the time,
$A_n(0)$, ω_n and Φ_n are the amplitude, angular frequency (*) and phase of the n^{th} mode in the spectrum of the test signal at the input of the DUT, β is the propagation constant inside the medium of the DUT (supposed here undependent of *z* for simplification, but the results would be the same with a non uniform medium).

[(*) True optical frequencies ν, displayed by the software, are related to angular frequencies by $\omega = 2\pi\ \nu$. In this paragraph, only angular frequencies are mentioned, even as « optical frequencies »]

The power and phase of the n^{th} mode at the input (*in*) and at the output (*out*) of the DUT (with length *L*) are :

$$I_n^{in} \propto |A_n(0)|^2$$
$$I_n^{out} \propto |A_n(L)|^2$$
$$\Phi_n^{in} = \Phi_n$$
$$\Phi_n^{out} = \Phi_n - \beta(\omega_n)L$$

2.7.1 Transfer function :

It is the spectral complex transmission response of the DUT.
At each mode *n*, the intensity and phase transmission are :

$$I_n^{tr} = I_n^{out} / I_n^{in}, \text{ or } I_n^{tr}(\text{dB}) = I_n^{out}(\text{dBm}) - I_n^{in}(\text{dBm})$$

$$\Phi_n^{tr} = \Phi_n^{out} - \Phi_n^{in}$$

2.7.2 Calculation of group delay points :

For a medium with known variations of propagation constant with respect to optical frequency $\beta(\omega)$, the propagation group velocity of a signal spectrally located around ω_c is given by : $v_g = \partial\omega / \partial\beta$ and the total group delay through the medium is :
$\tau_g = L / v_g = L(\partial\beta / \partial\omega)_{\omega=\omega_c}$

Thus it can be estimated between each pair of consecutive modes (*n*-1 ;*n*) by :

$$\tau_n \equiv \tau_g(\omega_n^c) \approx L\frac{\beta(\omega_n)-\beta(\omega_{n-1})}{\omega_n-\omega_{n-1}} = -\frac{\Phi_n^{tr}-\Phi_{n-1}^{tr}}{\omega_n-\omega_{n-1}}$$

at frequency $\omega_n^c \equiv (\omega_n + \omega_{n-1})/2$

For a test signal with time period *T*, $\omega_n - \omega_{n-1} = 2\pi/T$

The coordinates of each group delay point are calculated from the transfer function neighbouring modes by using these relations.

2.7.3 Chromatic dispersion fit :

The chromatic dispersion, expressed in ps/nm, corresponds to the slope of the group delay variations with respect to optical wavelength. It is estimated by a linear fit of the group delay points τ_n with respect to wavelengths $\lambda_n^c = 2\pi/\omega_n^c$

As these group delay values may be measured with more or less accuracy between points (e.g. depending on the differences between mode levels in the test signal, the lowest modes generally authorizing less accurate phase measurement), it is better on a statistical point of view to take these differences into account and to apply a weighted linear fit, the most accurate points having the most important weight in the fit, and the points whose accuracy is far poorer than the average accuracy being removed from the fit.

This correction is applied by checking the option « Weighting criteria : accuracy » in menu Analysis. The weight attached to each point is inversely proportional to the square of the standard deviation attributed to its measurement, estimated by complex spectrum measurement procedure and displayed as error bars on the graph. Otherwise, a uniform linear fit (i.e. with constant weights) is applied without favouring or removing any point.
By checking the other option « Weighting criteria : distance from fit », points located too far from line fit (relatively to the weighted r.m.s. distance of the whole points), considered as abnormal, are removed.
After removal of unaccurate or abnormal points from preliminary fit, a second fit is applied and displayed as a straight line passing through the group delay points.

The chromatic dispersion value *D*, constant by hypothesis in this single section fit, corresponds to the line slope. The optical frequency where the dispersion measurement is assumed to be done is the weighted mean ω_m of the whole point frequencies, with the same weights as defined previously. Optical frequency $\nu_m = \omega_m/2\pi$ (or corresponding wavelength λ_m) and dispersion *D* are the values displayed in menu Analysis just after processing (in the wavelength/frequency box « nm »/« GHz », and the dispersion box « ps/nm »), and the coordinates of the corresponding dispersion point on the graph.
The accuracy of the dispersion value is estimated as a function of the weighted r.m.s. distance of the whole points from line fit, and displayed as an error bar on this point.

An interpolation or extrapolation of the group delay along this line fit can be calculated and displayed in the group delay box « ps », at any frequency value entered in the wavelength/frequency box.

2.7.4 Additional adjustment of group delay and dispersion values after measurement :

Refering to above equations : $\tau_n = -\frac{\Phi_n^{tr} - \Phi_{n-1}^{tr}}{\omega_n - \omega_{n-1}} = -T\frac{\Phi_n^{tr} - \Phi_{n-1}^{tr}}{2\pi}$

as the phase difference $\Phi_n^{tr} - \Phi_{n-1}^{tr}$ is known modulo 2π, each group delay value τ_n is known modulo *T*.

Also, as the dispersion D = Δτ/Δλ is calculated from group delay points at wavelengths spaced by $\Delta\lambda \approx \lambda_m^{\,2}/cT$ (c = speed of light),

with Δτ known modulo T, D is known modulo $\Delta D \approx cT^2/\lambda_m^{\,2}$.

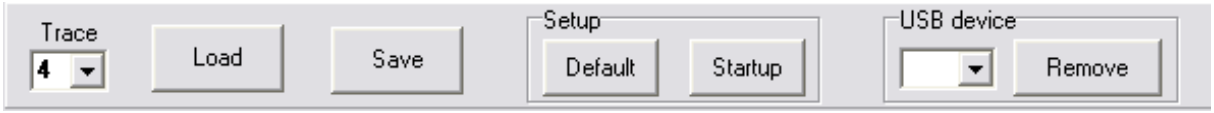
This is why it is possible to adjust the measured group delay among values spaced by the time period *T*, and to adjust the measured dispersion among values spaced by Δ*D* (double arrows near the group delay box and the dispersion box in menu Analysis).

3 /9 Spectra saving and loading

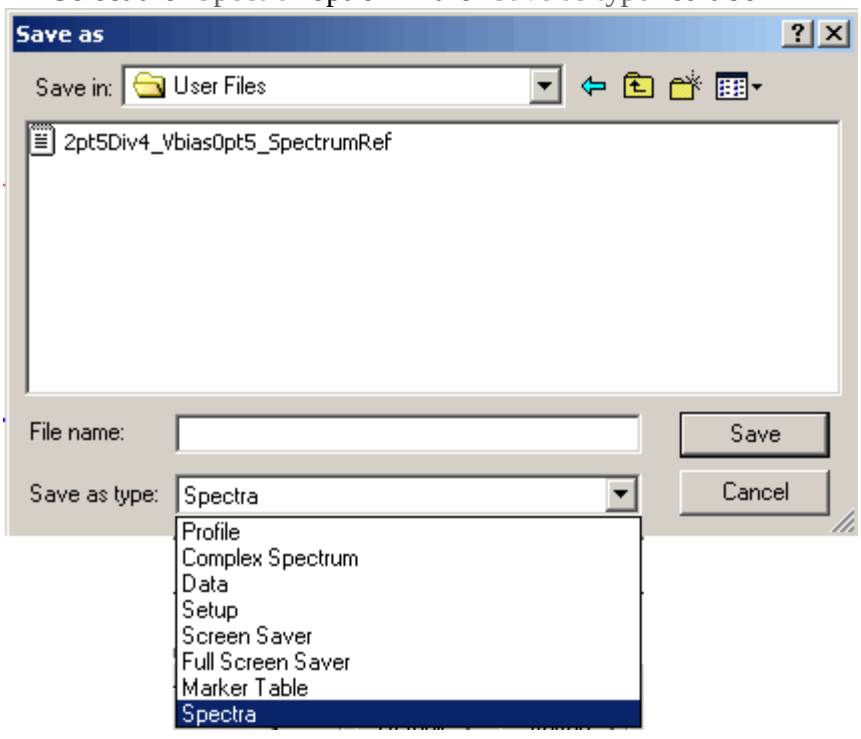
In the OCSA software it is now possible to save the 9 spectra used for the spectral intensity and phase measurement (refer to §8.1.3(of the standard instruction manual) for OCSA principle details) .

3.1 Saving procedure :

- Press the FILE button of the vertical menu
- Press the 'Save' button of the horizontal menu



- Select the 'Spectra' option in the 'Save as type' edit box



- Select the location for the saving in the 'Save In' box
- Enter the file name in the 'File Name' box
- Press the 'Save' button

The 9 spectra are now saved with the following name and extension :

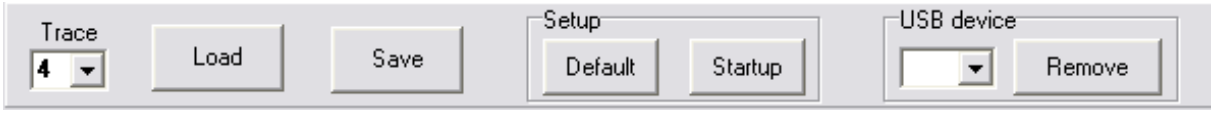
*Name*_SpectrumRef.txt ------► Reference Spectrum used for intensity data
*Name*_SpetrumPhase0.txt ------► Spectrum 1 used for phase measurement
*Name*_SpetrumPhase1.txt ------► Spectrum 2 used for phase measurement
*Name*_SpetrumPhase2.txt ------► Spectrum 3 used for phase measurement
*Name*_SpetrumPhase3.txt ------► Spectrum 4 used for phase measurement
*Name*_SpetrumPhase4.txt ------► Spectrum 5 used for phase measurement
*Name*_SpetrumPhase5.txt ------► Spectrum 6 used for phase measurement
*Name*_SpetrumPhase6.txt ------► Spectrum 7 used for phase measurement
*Name*_SpetrumPhase7.txt ------► Spectrum 8 used for phase measurement

Caution : Saving in 'Spectra' mode is only possible after a measurement (not after a loading of a file in 'Profile' mode or in 'Data' mode)

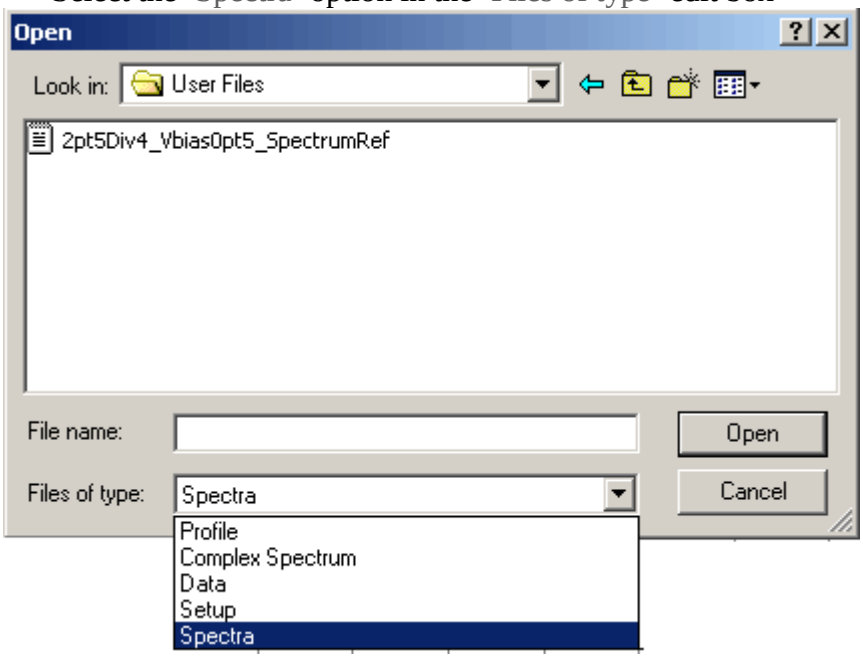
3.2 Loading procedure

Spectra saved in 'Spectra' mode, can be loaded with OSA software as a standard txt spectrum.
The 9 spectra can be also reloaded with the OCSA software. In this case follow this procedure.

- Press the 'FILE' button of the vertical menu
- Press the 'Load' button of the horizontal menu



- Select the 'Spectra' option in the 'Files of type' edit box



- Then only the reference spectrum will be display in the window. Select the reference spectrum and press 'Open'
- Then, the 9 spectra are used for the intensity and phase calculation

OPTICAL SPECTRUM ANALYZER REMOTE FUNCTIONS

	Function	Control Command	Explanation	Talker output data
Scale	Scale X Unit	SPXUNT*	Switch X axis Display Wavelength or Frequency For Frequency : * = 0 For Wavelength : * = 1	 SP_FREQUENCY SP_WAVELENGTH
	Scale Y Unit	SPLINSC*	Switch Y axis Display Linear or Log For Linear : * = 0 For Log : * = 1	 SP_LIN SP_LOG
	Next Trace	SPNXTTR	Active Next trace	SP_TRACE_* (* = Active Trace)
	Trace number	SPTR*	Active Trace Number *	SP_TRACE_* (* = Active Trace)
	Peak Center	SPPKCTR*	Peak Center Selection Manual, Auto or OFF For OFF : * = 0 For Auto : * = 1 For Manual : * = 2	 SP_PEAKAUTOCENTER_OFF SP_PEAKAUTOCENTER_ON SP_PEAKCENTER
Scale Y	Ref Y	SPREFY*	For set Ref Y to value : * = Value For ask Ref Y : * = ?	 SP_REFY_* (* = Value)
	Y By Division	SPDIVY*	For set Div Y to value : * = Value For ask Div Y : * = ?	 SP_YPERDIV_* (* = Value)
	Unit Y	SPUNTY*	if Unit of Scale Y = Linear : for Unit Y in nW : * = 0 for Unit Y in µW : * = 1 for Unit Y in mW : * = 2 for Unit Y in W : * = 3 if Unit of Scale Y = Log : Unit Y = dBm	 SP_YUNT_* (* = Value)

	Function	Control Command	Explanation	Talker output data
Sweep	Start Sweep in Frequency	SPSTRTF*	For set Start Frequency : * = Value For ask Start Frequency : * = ?	SP_START_* (* = Value)
	Start Sweep in Wavelength	SPSTRTWL*	For set Start Wavelength : * = Value For ask Start Wavelength * = ?	
	Stop Sweep in Frequency	SPSTOPF *	For set Stop Frequency : * = Value Fo ask Stop Frequency : * = ?	SP_STOP_* (* = Value)
	Stop Sweep in Wavelength	SPSTOPWL*	For set Stop Wavelength : * = Value For ask Stop Wavelength : * = ?	
	Span Sweep in Frequency	SPSPANF*	For set Span Frequency : * = Value For ask Span Frequency : * = ?	SP_SPAN_* (* = Value)
	Span Sweep in Wavelength	SPSPANWL*	For set Span Wavelength : * = Value For ask Span Wavelength : * = ?	
	Center Sweep in Frequency	SPCTRF*	For set Center Frequency : * = Value For ask Center Frequency : * = ?	SP_CTR_* (* = Value)
	Center Sweep in Wavelength	SPCTRWL*	For set Center Wavelength : * = Value For ask Center Wavelength : * = ?	
	Scale X to Span	SPTRANSF	Transfert Scale X To Span	SP_SCALE_TO_SPAN
	Sweep Trace	SPTRACESWP*	Sweep Trace Number *	SP_SWEEP_TRACE_* (* = Sweep Trace)
	Start a Sweep	SPSWP*	Select Type and Start a Sweep Auto Sweep : * = 0 Single Sweep : * = 1	SP_AUTO_SWEEP SP_SINGLE_SWEEP
	Sweep Delay	SPSWPDELAY*	For set Delay : * = Value For ask Delay : * = ?	SP_DELAY_SWEEP_* (* = Value)
	Sweep Average Number	SPNBAVG*	For set Average Number :* = Value For ask Average Number : * = ?	SP_AVERAGING_NUMBER_* (* = Value)

	Function	Control Command	Explanation	Talker output data
Setup	Point Number	SPNBPTSWP*	For set Display Point Number : * = Value For ask Display Point Number : * = ?	SP_POINT_NUMBER_* (* = Value)
	Point Number Selection Auto/Manual	SPAUTONBPT*	Ask Point Number Selection : * = ? Manual Point Number : * = 0 Auto Point Number : * = 1	SP_POINT_NUMBER_MANUAL SP_POINT_NUMBER_AUTO
	Wavelength calibration	SPWLCALM	Start Wavelength Calibration	SP_WL_CALIBRATION
	Sweep Resolution	SPSWPRES*	For ask Resolution : * = ? For set 100MHz : * = 0 For set 20MHz : * = 1	SP_RESOLUTION_100MHz SP_RESOLUTION_20MHz
	Noise Mask	SPSWPMSK*	For ask Noise Mask : * = ? For set Noise Mask : * = Value	SP_NOISE_MASK_* (* = Value)
Display	Full Screen	SPFULLSCR*	Display in Full Screen OFF : * = 0 Display in Full Screen ON : * = 1	SP_FULLSCREEN_OFF SP_FULLSCREEN_ON
Marker	Add	SPMKRAD	Add New Marker	SP_MARKER_ADD
	Delete	SPMKRDEL	Delete Active Marker	SP_MARKER_DEL
	Delete All	SPMKRDELAL	Delete all Marker	SP_ALL_MARKER_DEL
	Left	SPMKRLEFT*	Move Left active Marker Slow : * = 0 Move Left active Marker : * = 1 Move Left active Marker Fast : * = 2	SP_MARKER_LEFT_0 SP_MARKER_LEFT_1 SP_MARKER_LEFT_2
	Right	SPMKRRIGHT*	Move Right active marker Slow : * = 0 Move Right active marker Slow : * = 1 Move Right active marker Slow : * = 2	SP_MARKER_RIGHT_0 SP_MARKER_RIGHT_1 SP_MARKER_RIGHT_2
	Previous	SPMKRPRV	Active Previous Marker	SP_PREVIOUS_MARKER
	Next	SPMKRNXT	Active Next Marker	SP_NEXT_MARKER
	Number	SPMKRNB	Active Marker Number	SP_MARKER_NUMBER_* (* = Value)
	Marker Table	SPMKRTBL*	Display Marker Table OFF : * = 0 Display Marker Table ON : * = 1	SP_MARKER_TABLE_OFF SP_MARKER_TABLE_ON

	Function	Control Command	Explanation	Talker output data
Line	Clear	SPLINDEL*	Del V1 : * = 1 Del V2 : * = 2 Del H1 : * = 3 Del H2 : * = 4 Del All Line : * = 5	SP_DEL_LINE_V1 SP_DEL_LINE_V2 SP_DEL_LINE_H1 SP_DEL_LINE_H2 SP_DEL_ALL_LINE
	Set	SPLINSET	Set All Lines	SP_SET_LINE
	Left	SPLINLEFT*	Move Left Vertical Line Slow : * = 0 Move Left Vertical Line : * = 1 Move Left Vertical Line Fast : * = 2	SP_MOVE_LINE_LEFT_0 SP_MOVE_LINE_LEFT_1 SP_MOVE_LINE_LEFT_2
	Right	SPLINRIGHT*	Move Right Vertical Line Slow : * = 0 Move Right Vertical Line : * = 1 Move Right Vertical Line Fast : * = 2	SP_MOVE_LINE_RIGHT_0 SP_MOVE_LINE_RIGHT_1 SP_MOVE_LINE_RIGHT_2
	Up	SPLINUP*	Move Up Horizontal Line Slow : * = 0 Move Up Horizontal Line : * = 1 Move Up Horizontal Line Fast : * = 2	SP_MOVE_LINE_UP_0 SP_MOVE_LINE_UP_1 SP_MOVE_LINE_UP_2
	Down	SPLINDOWN*	Move Down Horizontal Line Slow : * = 0 Move Down Horizontal Line : * = 1 Move Down Horizontal Line Fast : * = 2	SP_MOVE_LINE_DOWN_0 SP_MOVE_LINE_DOWN_1 SP_MOVE_LINE_DOWN_2
	V1V2 To Span	SPLINTOSPN	Delta Vertical Lines to Span	SP_DELTA_TO_SPAN
Analysis	Dynamic	SPPKDYN*	Ask the Peak dynamic Value : * = ? Set the Peak dynamic to *	SP_PEAK_DYN_* (* = Value)
	Find Peak	SPPKFIND	Search Peaks	SP_FIND_PEAK
	LineWidth Threshold	SPLINETH*	ask Line Width Threshold : * = ? set Line Width Threshold : * = Value	SP_LINEWIDTH_TH_* (* = Value)
	Calcul LineWidth	SPLINEWIDTH*	Calculate LineWidth : * = 0 Calculate LineWidth Envelope : * = 1	SP_LINEWIDTH_* (* = width in GHz or nm) SP_LINEWIDTH_ENV_* (* = width in GHz or nm)
	SMSR Mask	SPSMSRMSK*	Ask SMSR Mask : * = ? Set SMSR Mask : * = Value	SP_SMSR_MASK_* (* = Value)
	Calcul SMSR	SPSMSR*	Calculate M-SMSR : * = 0 Calculate H-SMSR : * = 1	SP_M_SMSR_*_** SP_H_SMSR_*_** (* = SMSR in dB, ** = spacing in GHz or nm)

	Function	Control Command	Explanation	Talker output data
Analysis	SNR Left Mask	SPSNRLEFT*	Ask SNR Left Mask : * = ? Set SNR Left Mask : * = Value	SP_SNR_LEFT_MASK_* (* = Value)
	SNR Right Mask	SPSNRRIGHT*	Ask SNR Right Mask : * = ? Set SNR Right Mask : * = Value	SP_SNR_RIGHT_MASK_* (* = Value)
	Calcul SNR	SPSNR	Calculate SNR	SP_SNR
	Display SNR Bar	SPSNRBAR*	Display SNR Bar OFF : * = 0 Display SNR Bar ON : * = 1	SP_SNR_BAR_OFF SP_SNR_BAR_ON
Trace	Delete	SPTRDEL	Delete Active Trace	SP_DEL_ACTIVE_TRACE
	Delete All	SPTRDELAL	Delete All Traces	SP_DEL_ALL_TRACE
	Display Trace	SPTRDISP*	Display trace N° : *	SP_DISPLAY_TRACE_* (* = Trace N°)
	Blank Trace	SPTRBLK*	Blank Trace N° : *	SP_BLANK_TRACE_* (* = Trace N°)
System	Polarization Channels	SPPOLAR*	Select measurement on polarization channel(s) 1 : * = 0 2 : * = 1 1 & 2 : * = 2 1 + 2 : * = 3	SP_POLAR_* * = 1 * = 2 * = 1&2 * = 1+2
	DC Optical Power Measurement (dBm)	SPMEASDETECTORDBM*	Gets averaged DC optical power (in dBm) on selected polarization channels, with * = nb. of averaged measurements	If polarization channels = 1, 2 or 1 + 2 : SP_DETECTOR_DBM_* * = measured value If polarization channels = 1 & 2 : SP_DETECTOR_DBM_*_** * = measured value on channel 1 ** = measured value on channel 2
File	Save in Spectrum	SPSAVEA*_filename	Save Trace * in "filename_Spectrum.dat"	SP_SAVE_SPECTRUM_DATA
	Save in Spectrum(TXT)	SPSAVEB*_filename	Save Trace * in "filename_Spectrum.txt"	SP_SAVE_SPECTRUM_TXT
	Save Screen Copy	SPSAVEC_filename	Save Screen in "filename.bmp"	SP_SAVE_SCREEN
	Save Marker Table	SPSAVED_filename	Save Marker in "filename_MarkerTable.txt"	SP_SAVE_MARKER
	Save Setup	SPSAVEE_filename	Save Setup in "filename_Spectrum.set"	SP_SAVE_SETUP
	Load in Data Type	SPLOADA*_name_Spectrum.dat	Load trace * from "name_Spectrum.dat"	SP_LOAD_SPECTRUM_DATA
	Load in Text Type	SPLOADB*_name_Spectrum.txt	Load trace * from "name_Spectrum.txt"	SP_LOAD_SPECTRUM_TXT
Data Transfer	Linear data Transfer	SPDATAL*	Transfer Trace Number * Data	
	Log data Transfer	SPDATAD*		
	Scale X Transfer in Wavelength	SPDATAWL*		
	Scale X Transfer in Frequency	SPDATAF*		
	Linear Marker Transfer	SPDATAMKRL*		
	Log Marker Transfer	SPDATAMKRD*		
	X Marker Transfer in Wavelength	SPDATAMKRWL*		
	X Marker Transfer in Frequency	SPDATAMKRF*		

*****' '**********E***' '.....' '**********E***'\n'

Number of data (1 to 20000) — Data (1.2E-38 to 3.4E+38) — (continues according to the number of data)

OPTICAL COMPLEX SPECTRUM ANALYZER REMOTE FUNCTIONS

	Function	Control Command	Explanation	Talker output data
Scale	Scale X Unit	CHXUNT*	For X axis in Frequency : * = 0 For X axis in Wavelength : * = 1	CH_FREQUENCY CH_WAVELENGTH
	Scale Y Unit	CHLINSC*	For Y axis in Linear : * = 0 For Y axis in Log : * = 1	CH_LIN CH_LOG
	Scale Y Selection Unit	CHYUNTTYP*	For Y Unit Auto : * = 0 For Y Unit Manual : * = 1	CH_YUNIT_AUTO CH_YUNIT_MANUAL
	Type Scale Choice	CHSCALTYP*	For Y Scale Auto : * = 0 For Y Scale Manual : * = 1	CH_SCALE_AUTO CH_SCALE_MANUAL
	Next Trace	CHNXTTR	Active Next Trace	CH_ACTIVETRACE_* (* = N° Active Trace)
	Trace number	CHTR*	Active Trace Number *	CH_ACTIVETRACE_* (* = N° Active Trace)
Scale X	Min X	CHMINX*	For set Min X to value : * = Value For ask Min X parameter : * = ? For fix Min X parameter : * = '.'	CH_MINX_* CH_MINX_* CH_MINX_FIX
	Max X	CHMAXX*	For set Max X to value : * = Value For ask Max X parameter : * = ? For fix Max X parameter : * = '.'	CH_MAXX_* CH_MAXX_* CH_MAXX_FIX
	X By Division	CHDIVX*	For set Div X to value : * = Value For ask Div X parameter : * = ? For fix Div X parameter : * = '.'	CH_DIVX_* CH_DIVX_* CH_DIVX_FIX
	Center X	CHCTRX*	For set Center X to value : * = Value For ask Center X parameter : * = ? For fix Center X parameter : * = '.'	CH_CTRX_* CH_CTRX_* CH_CTRX_FIX
	Span X	CHSPANX*	For set Span X to value : * = Value For ask Span X parameter : * = ? For fix Span X parameter : * = '.'	CH_SPANX_* CH_SPANX_*

	Function	Control Command	Explanation	Talker output data
Scale Y	Min Y	CHMINY*	For set Min Y to value : * = Value For ask Min Y to value : * = ? For fix Min Y parameter : * = '.'	CH_MINY_* CH_MINY_* CH_MINY_FIX
	Max Y	CHMAXY*	For set Max Y to value : * = Value For ask Max Y to value : * = ? For fix Max Y parameter : * = '.'	CH_MAXY_* CH_MAXY_* CH_MAXYFIX
	Y By Division	CHDIVY*	For set Div Y to value : * = Value For ask Div Y to value : * = ? For fix Div Y parameter : * = '.'	CH_DIVY_* CH_DIVY_* CH_DIVY_FIX
	Center Y	CHCTRY*	For set Center Y to value : * = Value For ask Center Y to value : * = ? For fix Center Y parameter : * = '.'	CH_CTRY_* CH_CTRY_* CH_CTRY_FIX
	Ref Y	CHREFY*	For set Span Y to value : * = Value For ask Span Y to value : * = ? For fix Span Y parameter : * = '.'	CH_REFY_* CH_REFY_* CH_REFY_FIX
	Unit Y (if Type Scale Choice is in Manual mode)	CHUNTY*	if Unit of Scale Y = Log : Unit Y = dBm if Unit of Scale Y = Power : for Unit Y in pW : * = 0 for Unit Y in nW : * = 1 for Unit Y in µW : * = 2 for Unit Y in mW : * = 3 for Unit Y in W : * = 4 if Unit of Scale Y = Frequency : for Unit Y in Hz : * = 0 for Unit Y in kHz : * = 1 for Unit Y in MHz : * = 2 for Unit Y in GHz : * = 3	if Active Trace Scale = Left : CH_UNITY_LEFT_* if Active Trace Scale = Right : CH_UNITY_RIGHT_*

	Function	Control Command	Explanation	Talker output data
Sweep	Center Sweep in Frequency	CHCTRF*	Set Center in Frequency : * = Value Ask Center in Frequency : * = ?	CH_CENTER_FREQ_*
	Center Sweep in Wavelength	CHCTRWL*	Set Center in Wavelength : * = Value Ask Center in Wavelength : * = ?	CH_CENTER_WL_*
	Span Sweep in Frequency	CHSPANF*	Set Span in Frequency : * = Value Ask Span in Frequency : * = ?	CH_SPAN_FREQUENCY_*
	Span Sweep in Wavelength	CHSPANWL*	Set Span in Wavelength : * = Value Ask Span in Wavelength : * = ?	CH_SPAN_WL_*
	Start a Sweep	CHSWP*	Select Type and Start a Sweep Stop Sweep : * = 0 Auto Sweep : * = 1 Single Sweep : * = 2 Average Sweep : * = 3	 CH_STOP_SWEEP CH_AUTO_SWEEP CH_SINGLE_SWEEP CH_AVERAGE_SWEEP
	Nb Average Sweep	CHNBAVG*	Set Number of Average : * = Value Ask Number of Average : * = ?	CH_AVERAGE_NB_*
		CHNBAVGL	Set Number of leve avg : * = Value Ask Number of leve avg : * = ?	CH_AVERAGE_LEVL_NB_*
	Total Measure Number	CHNBMES	Ask Total Number of measure	CH_AVERAGING_*
Setup	Calcul	CHCALCUL	Complex Spectrum Calcul	CH_APPLY_SETUP_PARAMETER
	Setup Trace	CHSETTR*	Setup Trace Number = *	CH_TRACE_SETUP_*
	Display Parameter	CHPARDIS*	For Display Parameter OFF : * = 0 For Display Parameter ON : * = 1	CH_DISPLAY_PARAMETER_OFF CH_DISPLAY_PARAMETER_ON
	Mode Unit	CHMODUNT*	For Mode Number : * = 0 For Mode in GHz : * = 1 For Mode in nm : * = 2 For ask Mode Unit : * = ?	CH_MODE_UNIT_NUMBER CH_MODE_UNIT_SPECTRAL CH_MODE_UNIT_SPECTRAL CH_MODE_UNIT_*
	Mode Before in Number	CHMODBENB*	Set Mode Before Number : * = Value Ask Mode Before Number : * = ?	CH_MODE_BEFORE_*
	Mode Before in GHz	CHMODBEF*	Set Mode Before in GHz : * = Value Ask Mode Before in GHz : * = ?	CH_FREQ_BEFORE_*
	Mode Before in nm	CHMODBEWL*	Set Mode Before in nm : * = Value Ask Mode Before in nm : * = ?	CH_WL_BEFORE_*
	Mode After in Number	CHMODAFNB*	Set Mode After Number : * = Value Ask Mode After Number : * = ?	CH_MODE_AFTER_*

	Function	Control Command	Explanation	Talker output data
	Mode After in GHz	CHMODAFF*	Set Mode After in GHz : * = Value Ask Mode After in GHz : * = ?	CH_FREQ_AFTER_*
	Mode After in nm	CHMODAFWL*	Set Mode After in nm : * = Value Ask Mode After in nm : * = ?	CH_WL_AFTER_*
		CHMODSEL*	Set Manual Mode Selection : * = 0 Set Full Mode Selection : * = 1 Ask Mode Selection : * = ?	CH_MODE_SELECTION_MANUAL CH_MODE_SELECTION_FULL CH_MODE_SELECTION_*
	Carrier Selection	CHCARSEL*	Set Manual Carrier Selection : * = 0 Set Auto Carrier Selection : * = 1 Set Highest Carrier Selection : * = 2 Ask Carrier Selection : * = ?	CH_CARRIER_SELECTION_MANUAL CH_CARRIER_SELECTION_AUTO CH_CARRIER_SELECTION_HIGHEST CH_CARRIER_SELECTION_*
	Carrier in Frequency	CHCARF*	Set Carrier Frequency : * = Value Ask Carrier Frequency : * = ?	CH_CARRIER_*
	Carrier in Wavelength	CHCARWL*	Set Carrier Wavelength : * = Value Ask Carrier Wavelength : * = ?	
	Clock Input Selection	CHCLOCKIN*	Set Clock Input to 2.5GHz : * = 0 Set Clock Input to 10GHz : * = 1 Ask Clock Input Selectiion : * = ?	CH_CLOCKINPUT_2.5GHz CH_CLOCKINPUT_10GHz CH_CLOCKINPUT_*
	Clock Input Value (Frequency)	CHCLOCKF*	Set Clock Value : * = Value Ask Clock Value : * = ?	CH_CLOCK_*
	Pattern Type (Short/Long)	CHPATTERN*	Set Short Pattern : * = 0 Set Long Pattern : * = 1 Ask Pattern : * = ?	CH_PATTERN_SHORT CH_PATTERN_LONG CH_PATTERN_*
	Pattern Selection Mode (Auto/Manual)	CHPATSEL*	Set Pattern Selection Auto :* = 0 Set Pattern Selection Manual :* = 1 Ask Pattern Selection :* = ?	CH_PATTERN_SEL_AUTO CH_PATTERN_SEL_MANUAL CH_PATTERN_SEL_*
	Time Shift Selection (0, T/2, Manual)	CHTSHISEL*	Set Time Shift to 0 : * = 0 Set Time Shift to T/2 : * = 1 Set time Shift Manual : * = 2 Ask Time Shift Selection : * = ?	CH_TIMESHIFT_SEL_ZERO CH_TIMESHIFT_SEL_T/2 CH_TIMESHIFT_SEL_MANUAL CH_TIMESHIFT_SEL_*
	Time Shift Value	CHTIMSHI*	Set Time Shift Value : * = Value Ask Time Shift Value : * = ?	CH_TIMESHIFT_*
	Processing Type (Normal / Fast)	CHPROCES*	Set Normal Processing : * = 0 Set Fast Processing : * = 1 Ask Processing : * = ?	CH_PROCESSING_NORMAL CH_PROCESSING_FAST CH_PROCESSING_*

	Function	Control Command	Explanation	Talker output data
Setup	Point Number	CHNBPT*	Set Point Number : * = Value Ask Point Number : * = ?	 CH_NBPOINT_
Display	Trace Display Type (Profile / Spectrum)	CHTYPTR*	Set Profile Traces : * = 0 Set Spectrum Traces : * = 1 Ask Display Type : * = ?	CH_TYPETRACE_PROFILE CH_TYPETRACE_SPECTRUM CH_TYPETRACE_*
	Left Trace Type Profile : Shape/Chirp/Phase/Alpha Spectrum : Power/Phase	CHLEFTTR*	Set Profile Shape Trace : * = 0 Set Profile Chirp Trace : * = 1 Set Profile Phase Trace : * = 2 Set Profile Alpha Trace : * = 3 Set Spectrum Power Trace : * = 4 Set Spectrum Phase Trace : * = 5 Ask Left Type Trace : * = ?	CH_LEFTTRACE_PROFILE_SHAPE CH_LEFTTRACE_PROFILE_CHIRP CH_LEFTTRACE_PROFILE_PHASE CH_LEFTTRACE_PROFILE_ALPHA CH_LEFTTRACE_SPECTRUM_POWER CH_LEFTTRACE_SPECTRUM_PHASE CH_LEFTTRACE_*
	Right Trace Type Profile : Shape/Chirp/Phase/Alpha Spectrum : Power/Phase	CHRIGHTTR*	Set None : * = 0 Set Profile Shape Trace: * = 1 Set Profile Chirp Trace : * = 2 Set Profile Phase Trace : * = 3 Set Profile Alpha Trace: * = 4 Set Spectrum Power Trace : * = 5 Set Spectrum Phase Trace : * = 6 Ask Right Type Trace : * = ?	CH_RIGHTTRACE_NONE CH_RIGHTTRACE_PROFILE_SHAPE CH_RIGHTTRACE_PROFILE_CHIRP CH_RIGHTTRACE_PROFILE_PHASE CH_RIGHTTRACE_PROFILE_ALPHA CH_RIGHTTRACE_SPECTRUM_POWER CH_RIGHTTRACE_SPECTRUM_PHASE CH_RIGHTTRACE_*
	Phase Origine	CHPHASOR*	Set Phase Origine : * = Value Ask Phase Origine : * = ?	 CH_PHASE_ORIGIN_*
	Full Screen	CHFULLSCR*	Display in Full Screen OFF : * = 0 Display in Full Screen ON : * = 1	CH_FULLSCREEN_OFF CH_FULLSCREEN_ON
Marker	Add	CHMKRAD	Add New Marker	CH_MARKER_ADD
	Delete	CHMKRDEL	Delete Actif Marker	CH_ACTIVE_MARKER_DEL
	Delete All	CHMKRDELAL	Delete all Marker	CH_ALL_MARKER_DEL
	Left	CHMKRLEFT*	Move Left Actif Marker Slow : * = 0 Move Left Actif Marker : * = 1 Move Left Actif Marker Fast : * = 2	CH_MARKER_LEFT_0 CH_MARKER_LEFT_1 CH_MARKER_LEFT_2
	Right	CHMKRRIGHT*	Move Right Actif Marker Slow : * = 0 Move Right Actif Marker : * = 1 Move Right Actif Marker Fast : * = 2	CH_MARKER_RIGHT_0 CH_MARKER_RIGHT_1 CH_MARKER_RIGHT_2
	Previous	CHMKRPRV	Active Previous Marker	CH_PREVIOUS_MARKER
	Next	CHMKRNXT	Active Next Marker	CH_NEXT_MARKER

	Function	Control Command	Explanation	Talker output data
Marker	Number	CHMKRNB?	Active Marker Number	CH_MARKER_NUMBER_*
	Marker Table	CHMKRTBL*	Display Marker Table OFF : * = 0 Display Marker Table ON : * = 1	CH_MARKER_TABLE_OFF CH_MARKER_TABLE_ON
Line	Add	CHLINAD*	For add V1 : * = 1 For add V2 : * = 2 For add H1 : * = 3 For add H2 : * = 4	CH_LINE_V1_ADD CH_LINE_V2_ADD CH_LINE_H1_ADD CH_LINE_H2_ADD
	Clear	CHLINDEL*	For del V1 : * = 1 For del V2 : * = 2 For del H1 : * = 3 For del H2 : * = 4 For del ALL : * = 5	CH_LINE_V1_DEL CH_LINE_V2_DEL CH_LINE_H1_DEL CH_LINE_H2_DEL CH_ALL_LINE_DEL
	Set	CHLINSET	Set All Lines	CH_LINE_SET
	Left	CHLINLEFT*	Move Left Vertical Line Slow : * = 0 Move Left Vertical Line : * = 1 Move Left Vertical Line Fast : * = 2	CH_LINE_LEFT_0 CH_LINE_LEFT_1 CH_LINE_LEFT_2
	Right	CHLINRIGHT	Move Right Vertical Line Slow : * = 0 Move Right Vertical Line : * = 1 Move Right Vertical Line Fast : * = 2	CH_LINE_RIGHT_0 CH_LINE_RIGHT_1 CH_LINE_RIGHT_2
	Up	CHLINUP	Move Up Horizontale Line Slow : * = 0 Move Up Horizontale Line : * = 1 Move Up Horizontale Line Fast : * = 2	CH_LINE_UP_0 CH_LINE_UP_1 CH_LINE_UP_2
	Down	CHLINDOWN	Move Down Horizontale Line Slow : * = 0 Move Down Horizontale Line : * = 1 Move Down Horizontale Line Fast : * = 2	CH_LINE_DOWN_0 CH_LINE_DOWN_1 CH_LINE_DOWN_2
Analysis	Analysis Trace	CHANALYSTR*	Set Analysis Trace : * = Value Ask Analysis Trace : * = ?	CH_ANALYSIS_TRACE_*
	Accuracy Calcul on Analysis Trace	CHACCURACY	Accuracy Calcul and Display	CH_ACCURACY
	Accuracy Type Typical / Estimated	CHTYPACCURACY*	Set Typical : * = 0 Set Estimated : * = 1 Ask Accuracy Type : * = ?	CH_ACCURACY_TYPICAL CH_ACCURACY_ESTIMATED CH_ACCURACY_*
	Half Periode Translation	CHALFPERIO	Half Periode Trace Translation	CH_TRANSLATION
	Alpha Calculation on Analysis Trace	CHALFA	Calculate Alpha mean and std. deviation on Analysis Trace sections defined	CH_ALFA_*_** * = mean value

			between Power Inf and Power Sup	** = standard deviation
	Function	**Control Command**	**Explanation**	**Talker output data**
Analysis	Power Inf for Alpha Calculation	CHPWALFAINF*	Set Power Inf : * = value (% of total power amplitude) Ask Power Inf : * = ?	CH_ALFA_INF_* * = value (% of total power amplitude)
	Power Sup for Alpha Calculation	CHPWALFASUP*	Set Power Sup : * = value (% of total power amplitude) Ask Power Sup : * = ?	CH_ALFA_SUP_* * = value (% of total power amplitude)
	Eye Bits Number	CHEYEBIT*	Set Eye Bits Number : * = Value Ask Eye Bits Number : * = ?	 CH_EYE_BIT_*
	Eye Points Number	CHEYEPTS*	Set Eye Points Number : * = Value Ask Eye Points Number : * = ?	 CH_EYE_PTS_*
	Eye Clear / Calcul on Analysis Trace (Power or Phase Vs Time)	CHEYE*	Clear Eye Diagram : * = 0 Calcul Eye Diagram : * = 1	CH_CLEAR_EYE CH_CALCUL_EYE
	Amplitude Calculation on Analysis Trace	CHAMPLITUDE	Calculate Amplitude of temporal trace	CH_AMPLITUDE_*_** * = value ** = units
File	Save Profile Save Spectrum Save Data Save Setup Save Screen Copy Save Marker Table	CHSAVPR*_name CHSAVSP*_name CHSAVDA*_name CHSAVSE*_name CHSAVSC*_name CHSAVMK*_name	Save Trace Number * in name	CH_SAVE_PROFILE CH_SAVE_SPECTRUM CH_SAVE_DATA CH_SAVE_SETUP CH_SAVE_SCREEN CH_SAVE_MARKERTABLE
	Load Profile Load Spectrum Load Data Load Setup	CHLODPR*_name CHLODSP*_name CHLODDA*_name CHLODSE*_name	Load Trace name * in Number	CH_LOAD_PROFILE CH_LOAD_SPECTRUM CH_LOAD_DATA CH_LOAD_SETUP
Trace	Del	CHTRDEL	Delete Active Trace	CH_DEL_ACTIVE_TRACE
	Del All	CHTRDELAL	Delete All Traces	CH_DEL_ALL_TRACE
	Scroll ON / OFF	CHSCROLL*	Set Scroll Trace OFF : * = 0 Set Scroll Trace ON : * = 1 Ask Scroll Trace ON/OFF : * = ?	CH_SCROLLTRACE_OFF CH_SCROLLTRACE_ON CH_SCROLLTRACE_*
	Fix All ON / OFF	CHFIXTRAL*	Set Fix All Trace OFF : * = 0 Set Fix All Trace ON : * = 1	CH_FIXALLTRACES_OFF CH_FIXALLTRACES_ON

			Ask Fix All Trace ON/OFF : * = ?	CH_FIXALLTRACES_*
	Fix Trace	CHFXMSTR*	Fix Trace Number *	CH_FIX_TRACE_*
	Unfix Trace	CHUNFXMSTR*	UnFix Trace Number *	CH_UNFIX_TRACE_*
	Fix Accuracy Trace	CHFXACTR*	Fix Accuracy Trace Number *	CH_FIX_ACCTRACE_*
	Unfix Accuracy Trace	CHUNFXACTR*	UnFix Accuracy Trace Number *	CH_UNFIX_ACCTRACE_*

	Function	Control Command	Explanation	Talker output data
Data Transfer	Scale X	CHDATATIM*	Transfer Trace Number * Data	
	Shape	CHDATAPUL*		
	Chirp	CHDATACH*		
	Phase	CHDATAPHA*		
	Alpha	CHDATAALF*		*****' '**********E***' '.....' '**********E***'\n'
	Truncated Chirp	CHDATACHC*		Number of data (1 to 10000) Data (1.2E-38 to 3.4E+38) (continues according to the number of data)
	Truncated Phase	CHDATAPHAC*		
	Truncated Alpha	CHDATAALFC*		
	Valid Chirp Measure	CHMESVCH*	Transfer Trace Number * Data	
	Valid Phase Measure	CHMESVPH*		data = 0 if measure not valide
	Valid Alpha Measure	CHMESVAL*		data = 1 if measure valide