HDCA

User Guide

ARAGÓN PHOTONICS

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ÍNDICE

1. Safety Considerations

1.1. Safety Symbols

The following signs will be used in this guide and must be followed by the user to ensure safe operation and maintain the product in a safe condition.

The warning sign denotes a hazard. It calls attention to a procedure which, if not correctly performed, could result in injury or loss of life. Do not proceed beyond a caution or warning sign until the indicated conditions are fully understood and met.

The caution sign indicates a hazard. It calls attention to a procedure which, if not correctly performed, could result in damage to or destruction of the product. Do not proceed beyond a caution or warning sign until the indicated conditions are fully understood and met.

The instrument will be marked with the following symbols:

Power button of the unit.

It indicates that laser radiation may be output from the connector.

~

The AC symbol is used to indicate the required nature of the line module input power.

1.2. General Considerations

The HDCA is a Safety Class 1 instrument, that is, an instrument with a metal chassis directly connected to earth via power supply cable. The main plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.

Before operation, check the instrument and this manual for safety considerations. This section describes general safety precautions that must be observed during the operation of this instrument and to maintain the instrument in safe condition.

If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protections are intact) only.

No operator serviceable parts inside. Refer servicing to qualified service personnel. To prevent electrical shock do not remove covers.

Ventilation requirements: the device should be located so that the convection into and out of the product must not be restricted.

The instrument must not be positioned on its rear part; the connectors on the back panel could be damaged.

1.3. Specific Considerations for HDCA

The HDCA has an optical output connector whether for the internal or for an external laser source in the front panel indicated as "TLS Output".

Please pay attention to the following laser safety warnings:

Under no circumstances look into the end of an optical cable attached to the optical laser output when the device is operational. The laser radiation can seriously damage your eyesight.

Do not activate the laser output when there is no fiber attached to the optical output connector.

The laser output is enabled by pressing the "Switch On" button in the Component Analyzer application. The laser is on when the green LED on the front panel of the instrument is lit.

The use of other optical instruments with this product will increase the hazard to your eyes.

1.4. Initial Inspection

Inspect the shipping package for damage. If there is any damage to the container, please keep it until you have checked the contents of the shipment for completeness and verified the external aspect of the instrument. If there are no signs of damage, verify the instrument performance.

If there are any signs of damage to any part of the outer enclosure, do not perform any electrical testing. Please, contact to Aragon Photonics Labs service.

For repair and calibration the device must be returned to APL service.

1.5. Line Power Requirements and Connections

The instrument has a three wire power cable. This cable is connected directly in the appliance coupler located at the rear of the instrument and to the mains.

Do not remove instrument covers under any circumstances. Components replacement and internal adjustment must be made only by qualified service in APL.

Do not connect AC power until you have verified the line voltage above indicated. Damage to the equipment could result.

To operate with the instrument it is necessary to switch on the power button located in the front panel of the device. Then a green LED on the button is lit.

To switch off the instrument press the power button located in the front panel of the device. Then the green LED on the button will not light. Please, note that the power button on the front panel of the instrument does not stop the flow of power to the instrument.

If you need to turn off the power, unplug the instrument at the mains or remove the power cable connector from the appliance coupler at the rear of the device.

The instrument HDCA (complies with overvoltage category II) can operate from the single-phase AC power source that supplies between 100 V and 240 at a frequency range of 50 to 60Hz. The maximum power consumption is 180 W.

1.6. Operation Environment

The HDCA instrument has been designed for indoor use only.

The device should be protected from temperature extremes and changes in temperature that might cause condensation within it.

The specified operation temperature range for this device is +15ºC to 35ºC.

STOP To prevent potential fire or shock hazard do not expose the instrument to rain or other excessive moisture.

STOP To prevent electrical shock, disconnect the instrument from mains before cleaning. Use a dry cloth to clean the external case parts. Do not attempt to clean internally.

1.7. Input/Output Connectors

The electrical ports located in the rear of the instrument are showed in the figure 0.1. A brief description of each one is indicated.

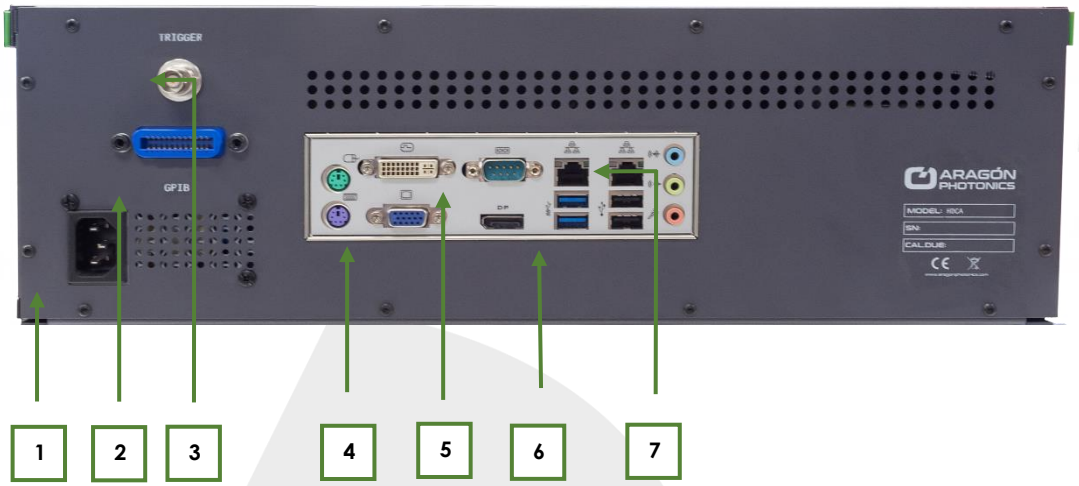


Fig. 1.1 HDCA rear panel.

1 Power Cable connector.
2 GPIB: Available for remote control with SCPI commands.
   a. HDCA 100 series: port used for communication with the external tunable laser source.
   b. On other options is available under request.
3 BNC TRIGGER.
   a. Trigger IN (HDCA 100 series): trigger synchronization with the external tunable laser.

b. Trigger OUT (HDCA 400 series): output trigger for the internal tunable laser (for trigger configuration please refer to section 4 "Tunable Laser Source Application)

4 VGA connector (VGA OUT).

5 Serial Port.

6 USB out ports: a memory stick can be used to export data.

Controller devices are not recommended to be connected to these USB ports.

7 RJ 45 connector (Ethernet port): connector 10/100 base-T. Available port for remote control.

The optical connectors located in the front panel are showed in figure 0.2. They may change depending on the HDCA option. Unless requested otherwise, all the optical connectors are FC/APC

Fig. 1.2 HDCA front panel.

Following the optical connectors located in the front panel are listed.

1 *TLS IN (HDCA 100 SERIES):* optical input for the external tunable laser.

2 *TLS OUT:* optical output for the tunable laser. It's the return loss (RL) port. A green LED is activated when there is power being output through this connector.

Invisible laser radiation. Do not view directly with optical instruments. Class 1 laser product. Refer to section 0.3 for specific considerations.

3 *PORTS 1-4:* optical inputs for component analyzer application.

The maximum optical power of the device under test must not exceed the value of +20 dBm.

2. What is a HDCA?

The HDCA is a high definition component analyzer which measures in real time the Insertion and Return Loss of optical passive devices. The interface can display the maximum and minimum transmission values across the required spectral width with the main following characteristics:

- Very high resolution: <1MHz.
- High Sensitivity: -85dBm
- Spurious-free dynamic range: >90 dB..
- Real time measurement, fast speed.

2.1. Applications

In real time, and keeping at the same time high resolution and high dynamic range, it is possible to quickly and easily measure optical spectra of:

- Photonic integrated circuits (PIC)
- Ring resonators
- Arrayed waveguide grating (AWG)
- WDM components
- Fiber Bragg Gratings
- Patchcords

Where it is possible:

- Measure band pass and band rejected
- Q factor
- TE/TM spectra characterization
- Polarization dependent losses (PDL)
- Identify dynamic effects on Devices Under Test.
- Identify lindewidth

The HDCA has a built-in Macro Tool function that allows you to automate measurements process. Alternatively, the HDCA can be remotely controlled over both GPIB bus and the communication network through the Ethernet interface.

3. Setting up the HDCA

3.1. Items Included in the shipment

The following items are included in the HDCA shipment:

1 HDCA

The default configuration includes angled FC/APC connectors.

2 Power Cord
3 GPIB or USB Cable (HDCA 100 series)
4 BNC Cable (HDCA 100 series)
5 Polarization Maintaining Fiber patch cord (HDCA 100 series)
6 USB stick with User Guide and Programming Guide

3.2. Connecting the HDCA

When operating, the HDCA should be located whith a clearance of at least 75 mm in each side and at the rear of the instrument.

Follow the steps described below to properly start up the unit.

1 Connect an external monitor to the computer VGA or DVI connector. Connect it to the electric line using the proper power cord or adaptor of your country.
2 Connect the HDCA to the electric line using the supplied power cord.
3 Turn on the HDCA pressing the power button located in the front panel.

Fig. 3.1 HDCA setup.

3.2.1. Connecting an external tunable laser (HDCA 100 series)

HDCA 100 series requires the following additional steps in order to properly connect an external tunable laser to the HDCA. Check section 14 in this manual for a list of compatible external tunable lasers.

- **GPIB Laser**

  If the external tunable laser uses the GPIB bus to communicate with the HDCA please follow the next connection procedure:

  1. Turn off the HDCA and use the GPIB cable to connect the HDCA unit to the external laser source.
  2. Use the BNC cable included in the shipment to connect the "Trigger Input" connector on the rear panel of the HDCA to the "Trigger Output" connector on the laser.
  3. Use the polarization maintaining fiber included in the shipment to connect the external laser optical output to the "TLS Input" on the front panel of the HDCA.
  4. Turn on the HDCA.

- **Other lasers may use:**

  1. USB Port
  2. Serial Port

3.3. Turning on the HDCA

When the HDCA unit starts an OS based in Windows 7 is launched. After a few seconds a User Account selector screen appears with two options:

- **APL Support**: password protected account for remote support and administration purposes. Not accessible by the user.
- **User**: password protected account for the use of the HDCA application. By default the password is APL04, it can be changed afterwards in the application selector screen, see section 2.4.

3.4. Application selector screen

Once the HDCA unit is started an application selector screen appears. It is possible to select between several applications depending on the HDCA option.

Fig. 3.2 *Application Selector Screen.*

1 Tunable laser: runs the internal tunable laser application (see section 4).

Invisible laser radiation. Do not view directly with optical instruments. Class 1 laser product. Refer to section 0.3 for specific considerations.

2 Component analyzer: runs the Component Analyzer application (see section 5).

Invisible laser radiation. Do not view directly with optical instruments. Class 1 laser product. Refer to section 0.3 for specific considerations.

The application selector screen is always accessible from any of the applications through the Exit to App Selector button located in the System menu.

3.4.1. Application by default

It is possible to configure a specific application to automatically run on HDCA start up. The "Configure" dialog box is accessible through the set up menu.

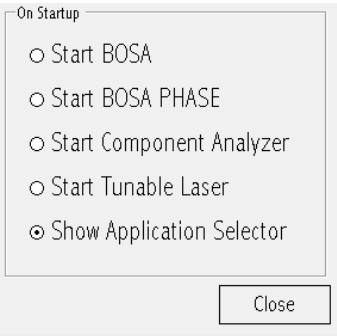


Fig. 3.3 Configure default application dialog box.

3.4.2. Change user password

It is possible to change the default User account password in the HDCA. Click in *SetUp->Change User Password* and introduce the required information.

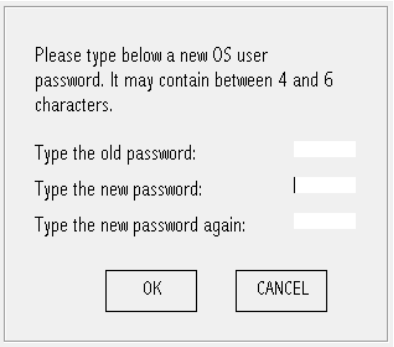


Fig. 3.4. Change or set the password of the User account.

3.4.3. Updates and Installation

See section 7.5.

4. HDCA: High Definition Component Analyzer

4.1. Graphical User Interface

In this chapter, the user interface of the HDCA is presented. All menu options and user keys are summarized. Next, a brief description of each feature is made for the ease of understanding.

4.1.1. Interface Keys Overview

The interface is composed of two main areas, as shown in Figure 3.1. These are: *Button Bar* and *Measurement Area*. The measurement area includes the measurement representation, context menu, current measurement settings and markers information.

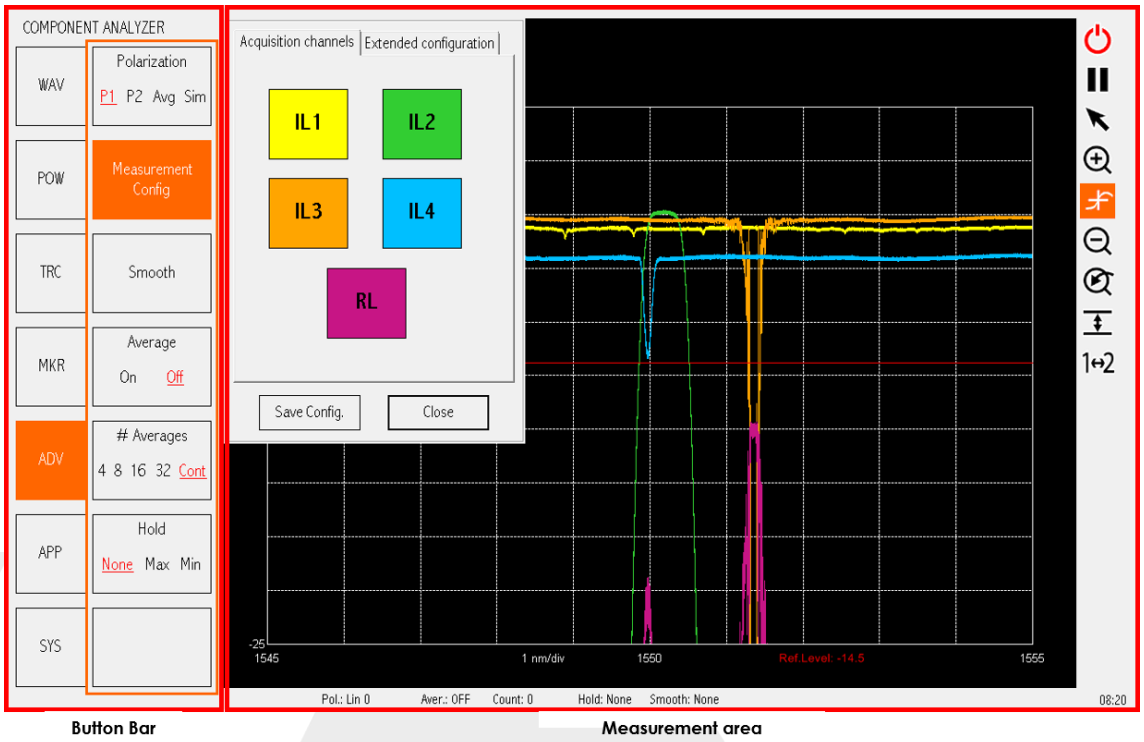


Fig. 4.1 HDCA user interface.

4.1.1.1. The measurement area

The *measurement area* shows the optical spectrum of the current Devices Under Test (DUT). Results are offered via traces and numerical data. In Figure 3.2 the trace plotting area is represented.

The *measurement area* can be further divided into a *graphical representation area*, *data collection area*, *operation parameters area* and quick function bar.

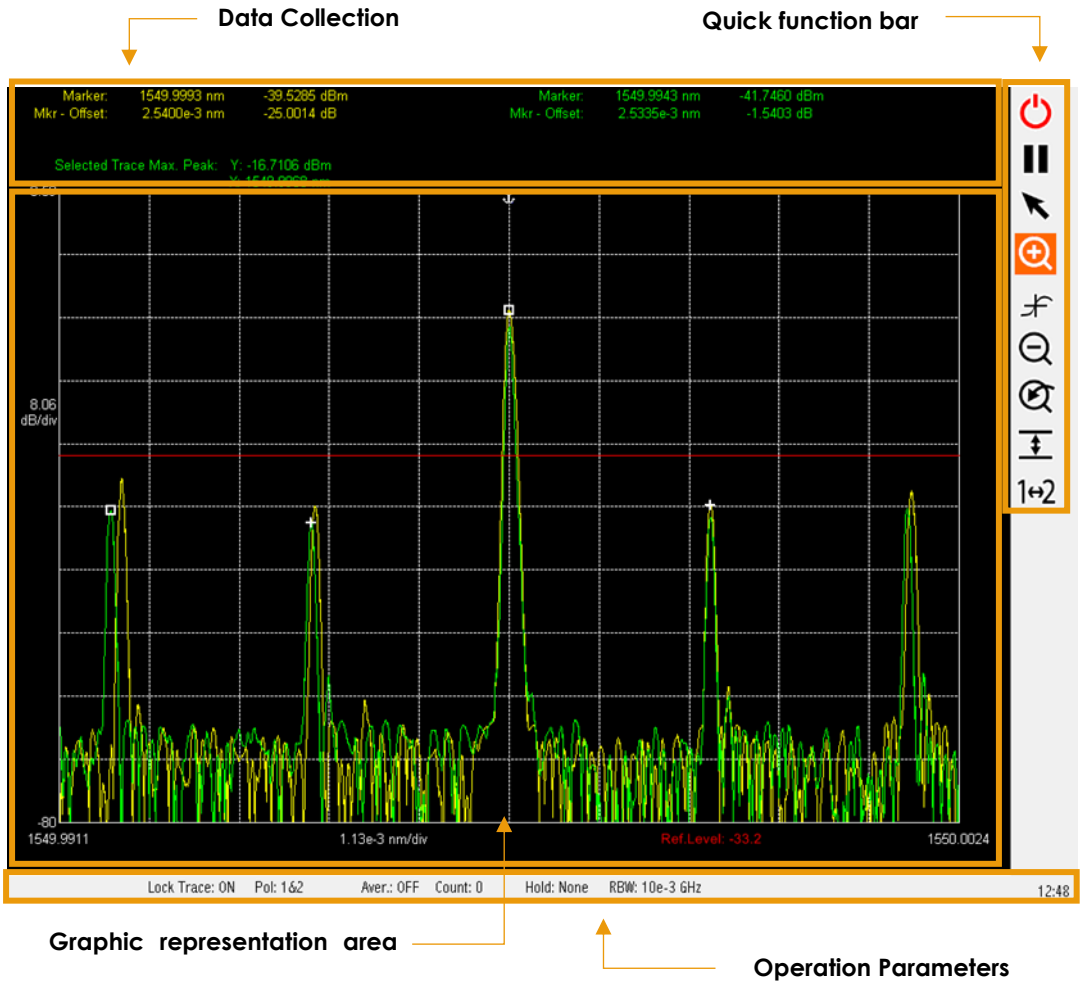


Fig. 4.2 HDCA Measurement area.

- **Graphical representation area** where the current DUT spectrum is plotted. Attached to the graph the following measurement conditions are indicated:
  1. Reference Level information.
  2. Scales per division for both power and wavelength.
  3. Traces. It is possible to view several traces simultaneously, up to five live traces at both polarization states and loaded traces identified as *Trace M1 to Trace M4*.

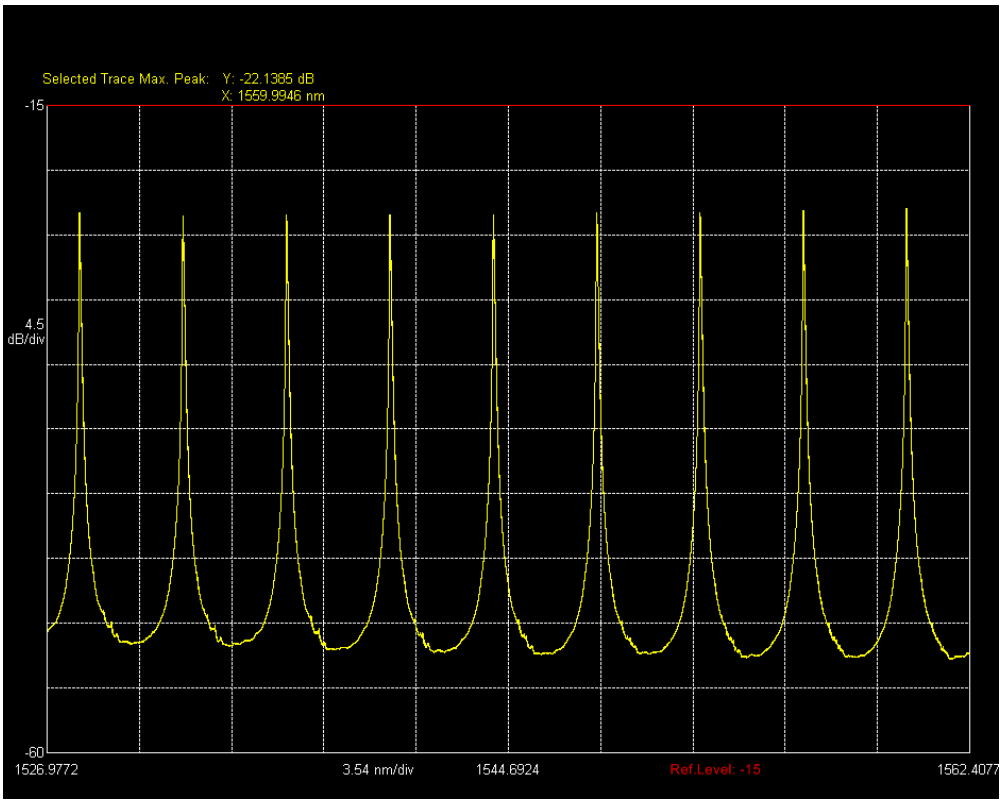


Fig. 4.3 HDCA Graphic representation area.

- **Data collection area** in the top side of the *measurement area* shows markers information (optical power and wavelength) for traces.
- **Operation parameters area** at the lower part of the measurement area shows information about the operation conditions of the system such as:
    1. Polarization control.
    2. Average, hold function and smooth.
    3. Device status (i.e. starting, calibrating,...). Any internal error will be output at the right in this area (please refer to *13.2 Error Messages* for details).
    4. Time.
- **Quick function bar** at the top right of the *measurement area* which allows the user to perform commonly used actions in an easy way.

Quick bar description

	Allows the user to start or stop the current measurement at any time. Even when stopped, the configuration parameters of the HDCA can be modified; if the measurement is later initialized, the new parameter values will be used.
	Freezes the current measurement on the screen. The unit is fully working in second plane but the data is not displayed.
	No mode is selected
	Sets the zoom-in mode. The representation area on a chart can be amplified by a click and drag operation.
	Places a marker on the trace.
	Extends the wavelength representation range by a factor of two.
	Undoes zooming actions.
	Fits the vertical axis to the displayed data.
	Switches among active traces in the chart.

4.1.1.2. The button bar

The *Button Bar* encompass user keys related to Wavelength, Optical Power, Markers, Traces, Advanced and System menus, respectively. Following figures show the button tree diagram of the HDCA.

Button Bar description

The button bar contains all user keys related to the measurement options. From the main bar the user can set all the operation parameters of the HDCA by means of the touch sensitive screen or using a mouse.

Those options which require data to be typed in, display an emerging keyboard. This allows the use of the system without the need of an external keyboard. Changes can be confirmed with the "*Apply*" button, or dismissed by clicking "*Cancel*" button or clicking outside the keyboard. Note that it is always possible to type the data using an external keyboard.

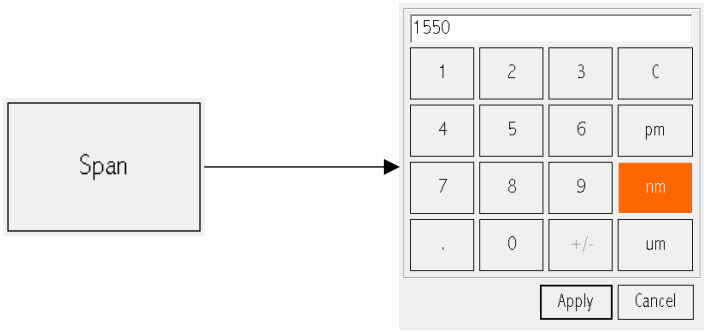


Fig. 4.4 Keyboard.

Some buttons allow the user to choose between different options. By pressing the button, all the options are consecutively activated. These are called *Option Buttons*.

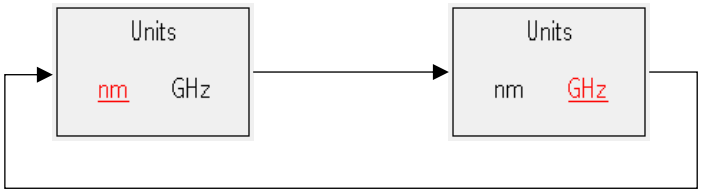


Fig. 4.5 Example of option button.

4.1.1.2.1. Wavelength button

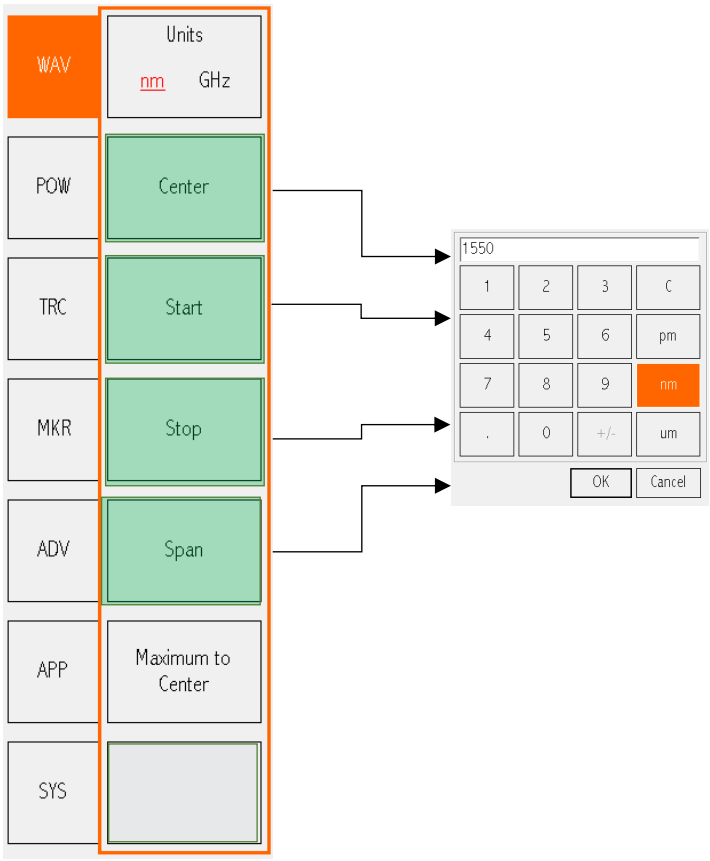
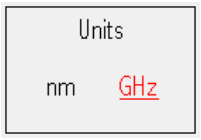


Fig. 4.6 HDCA *Wavelength* button bar tree diagram.

Wavelength submenu

	This is an option button. Changes the units of the horizontal axis from nm to GHz or vice versa. All the information in the *button bar* or *data collection area* related to the horizontal axis is properly switched to the current scale units.
	Sets the central value for the wavelength or frequency to be represented.
	Sets the initial wavelength or frequency value for the measurement range**.**
	Sets the final wavelength or frequency value for the measurement range.
	Sets the total measurement range.
	Shifts the wavelength or frequency range in order to represent the maximum power peak of the current trace at the center of the plotting area.

4.1.1.2.2. Power button

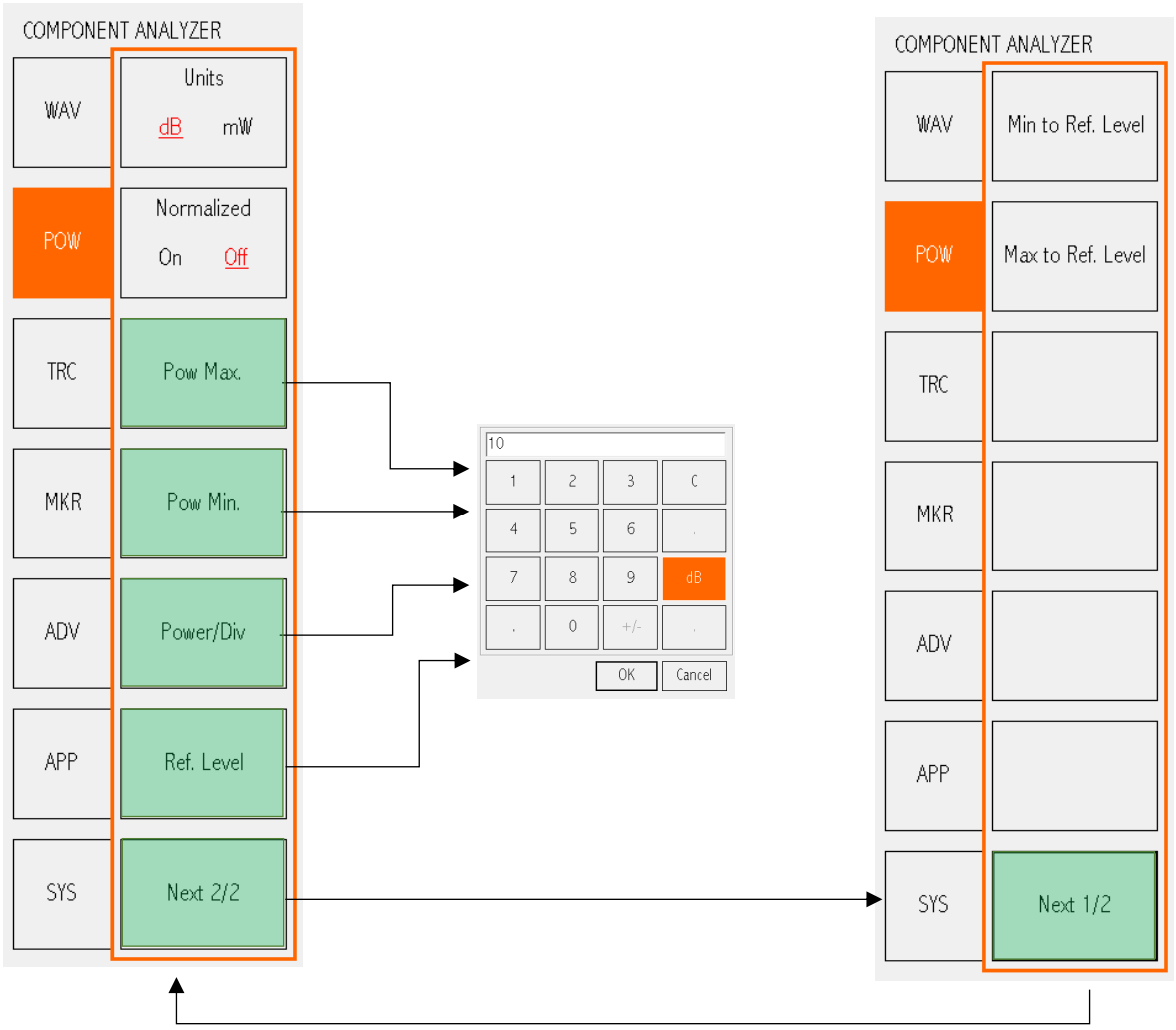
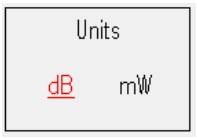
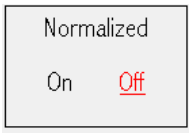
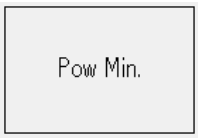
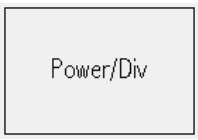


Fig. 4.7 HDCA *Power* button bar tree diagram.

Optical Power submenu

	It changes the units of the vertical axis from dB to mW or vice versa.
	This is an *option button*. It allows the user to normalize the losses from 0dB.
	"Pow Max" sets the maximum value of the power axis.
	"Pow Min" sets the minimum value of the power axis.
	Sets the scale factor of the vertical axis. Power axis is rescaled with the indicated power per division.
	Sets the power value of the reference level (red line).
	Makes the minimum vertical axis value equal to the reference level.
	Makes the maximum vertical axis value equal to the reference level.

4.1.1.2.3. Traces button

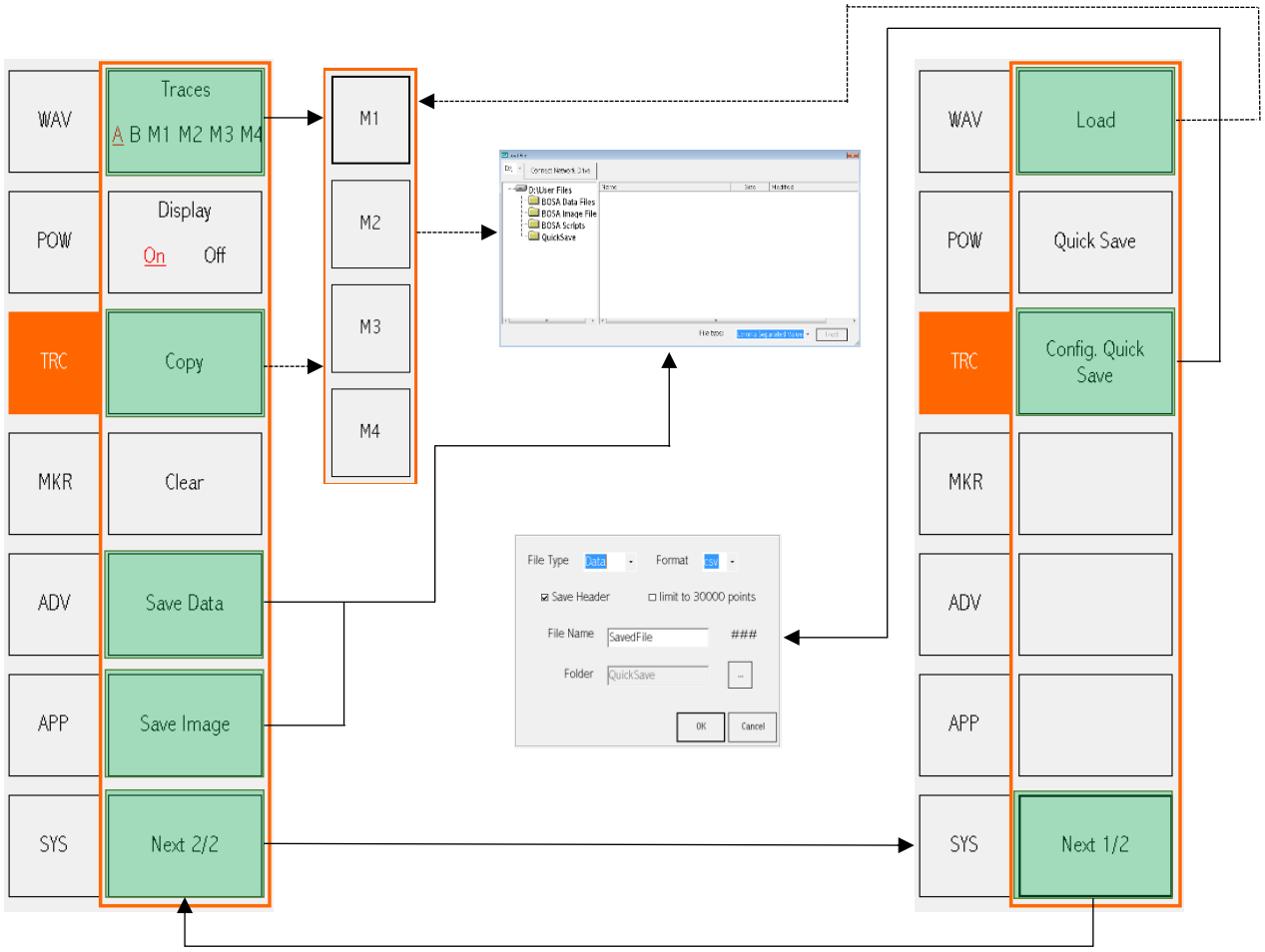
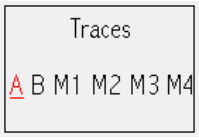
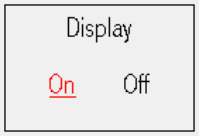
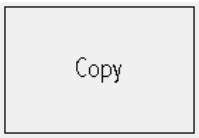


Fig. 4.8 HDCA *Traces* button bar tree diagram.

Traces submenu

The spectra of the current measured SUT will be displayed in yellow.

	Changes the active trace among the measured traces, A and B, and the stored memories, M1 M2 M3 M4 when used. The application reserves the trace A and B for the polarization
	Enables or disables the display of the current memory trace.
	Performs a copy of the active trace A or B to the trace selected through the displayed menu.
	Loads a data file, previously saved by the user (in local or external disc), in the trace selected through the displayed menu.
	Clears the active trace.
	Opens a new windows form to save the active trace. Available formats are: .bdf, .txt, csv. More information in section 3.2.4.
	Opens a new windows form to save the image displayed in the measurement area. Available formats are jpeg, bitmap, gif or tiff image formats.
	Performs a Quick Save operation in one click in the conditions set in Config. Quick Save button.
	Displays a dialog box to set the way in which the Quick Save operation is performed: File type, format, name, folder.

4.1.1.2.4. Markers button

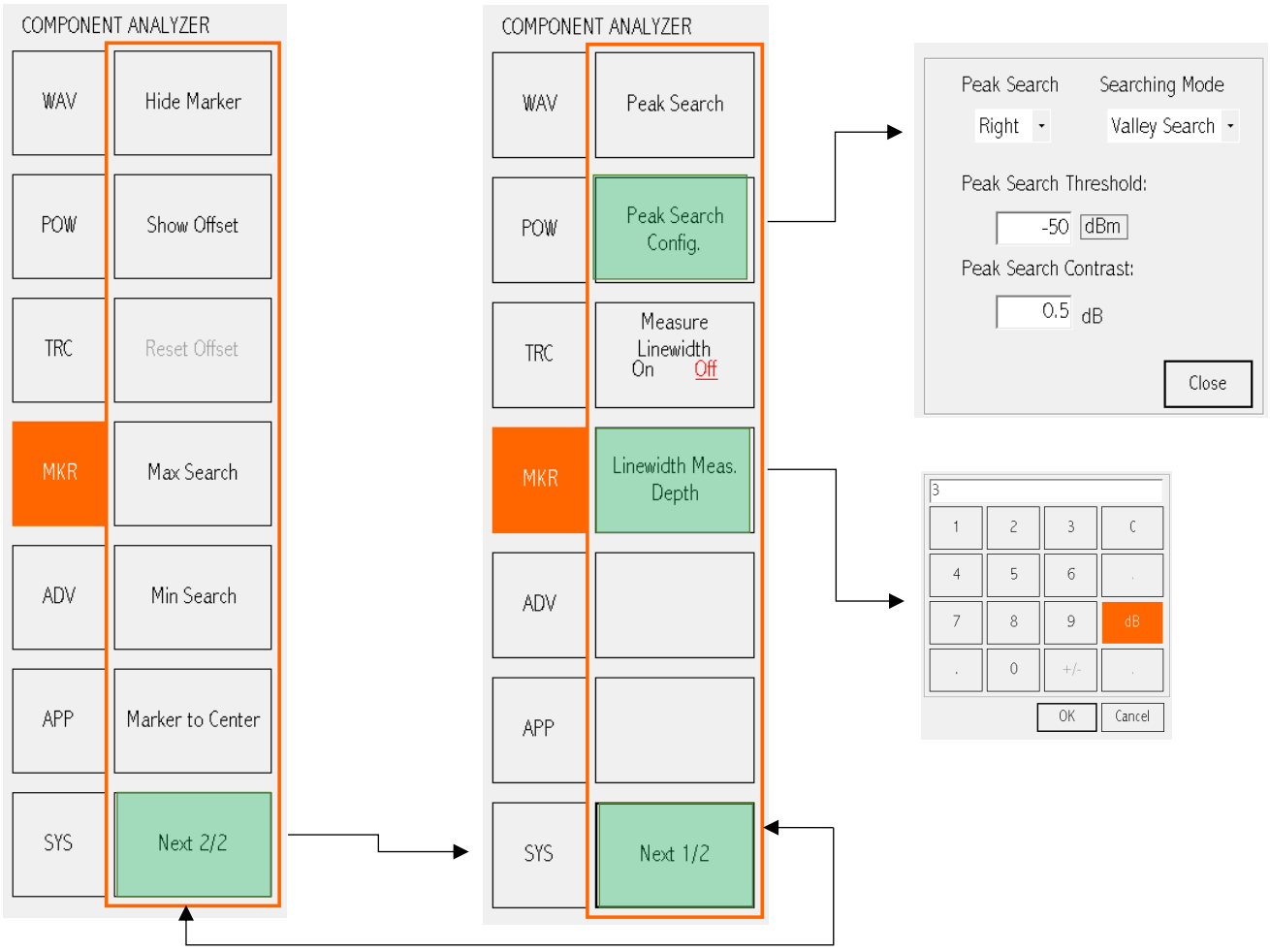


Fig. 4.9 HDCA *Markers* button bar tree diagram.

Markers submenu

One marker and its offset can be placed on any of the two traces.

Show Marker	***Shows or hides a marker on the active trace. It is represented on the chart with a cross.*** Automatically the data appears on the data section on top of chart.
Show Offset	Shows or hides the offset of a marker. It is represented on the chart with a square. Data appears on the data section on top of chart together with marker–offset information.
Reset Offset	Sets the offset to cero and the square is placed at the same position of the marker
Max Search	Sets the marker to the maximum point in the active trace.
Min Search	Sets the marker to the minimum point in the active trace.
Marker to Center	Moves the center of the screen to the position of the active marker.
Peak Search	Moves the active marker to the next peak. The criteria of peak searching are defined through *Peak Search Configuration* button.
Peak search Conf.	Opens a new window that allows user to configure the peak searching criteria. Detailed description available at 3.3.1.4.
Measure Linewidth Off On	This is an *option button*. When ON, the linewidth of the marker peak selected is displayed above the measurement area after a "LW XdB:" label, where X is the value configured with the "linewidth measurement depth" window.

Linewidth Meas. Depth	Opens a new window that allows configuration of the depth level at which linewidth value is calculated.

4.1.1.2.5. Advanced button

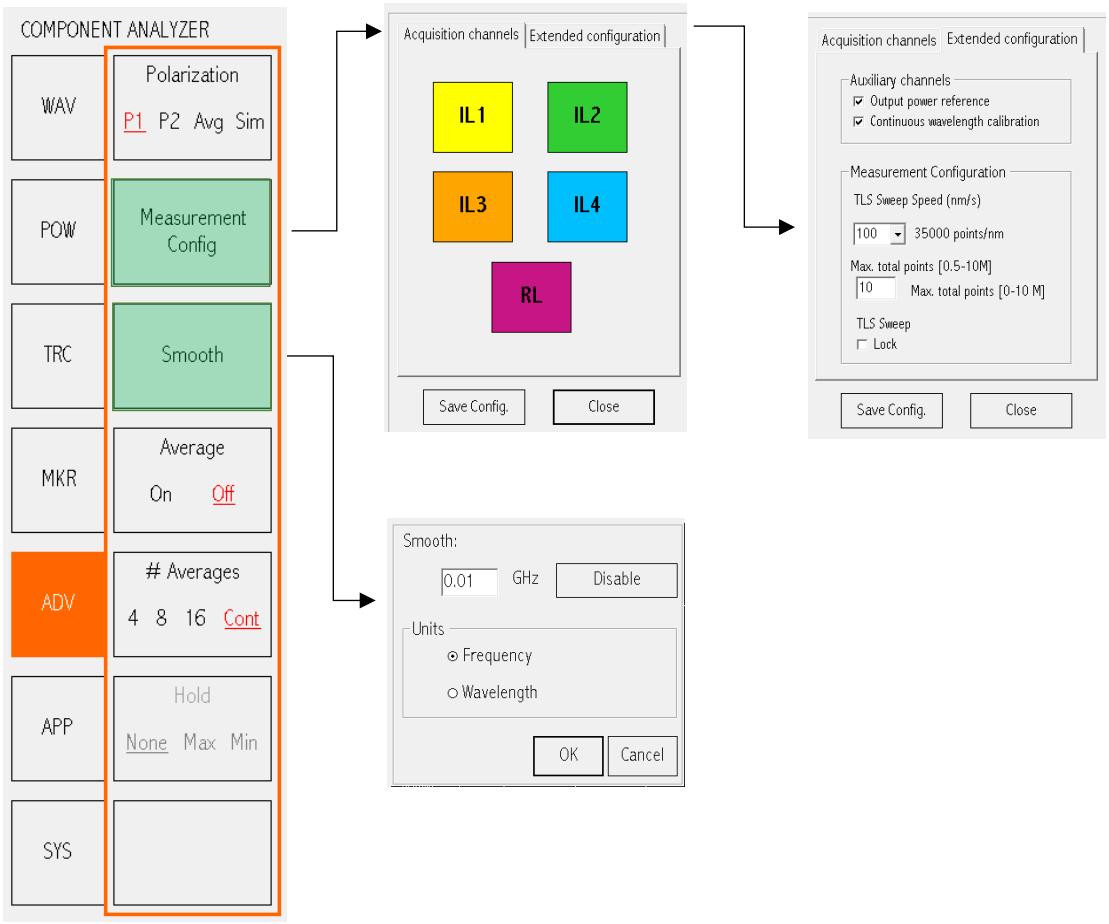
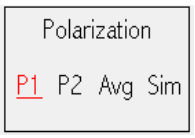
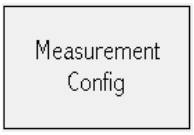
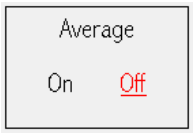
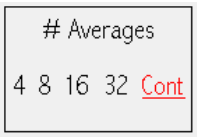
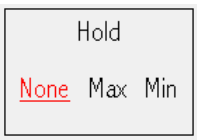


Fig. 4.10 HDCA *Advanced* button bar tree diagram.

Advanced submenu

	This is an *option button*. It selects between two orthogonal polarization measurement, average of both or simultaneous.
	***This button changes open the main configuration menu of the component analyzer including acquisition channels and extended configuration such as scanning speed and auxiliary channels.***
	This button allows the smooth of the active trace for noise cleaning.
	This is an *option button*. It performs trace averaging for noise reduction purposes.
	This is an *option button*. Five averaging modes are available: 4, 8, 16, 32 traces averaging and continuous averaging.
	This is an option button. It compares consecutive sweeps and shows the maximum or minimum for each point of the trace.

4.1.1.2.6. Applications button

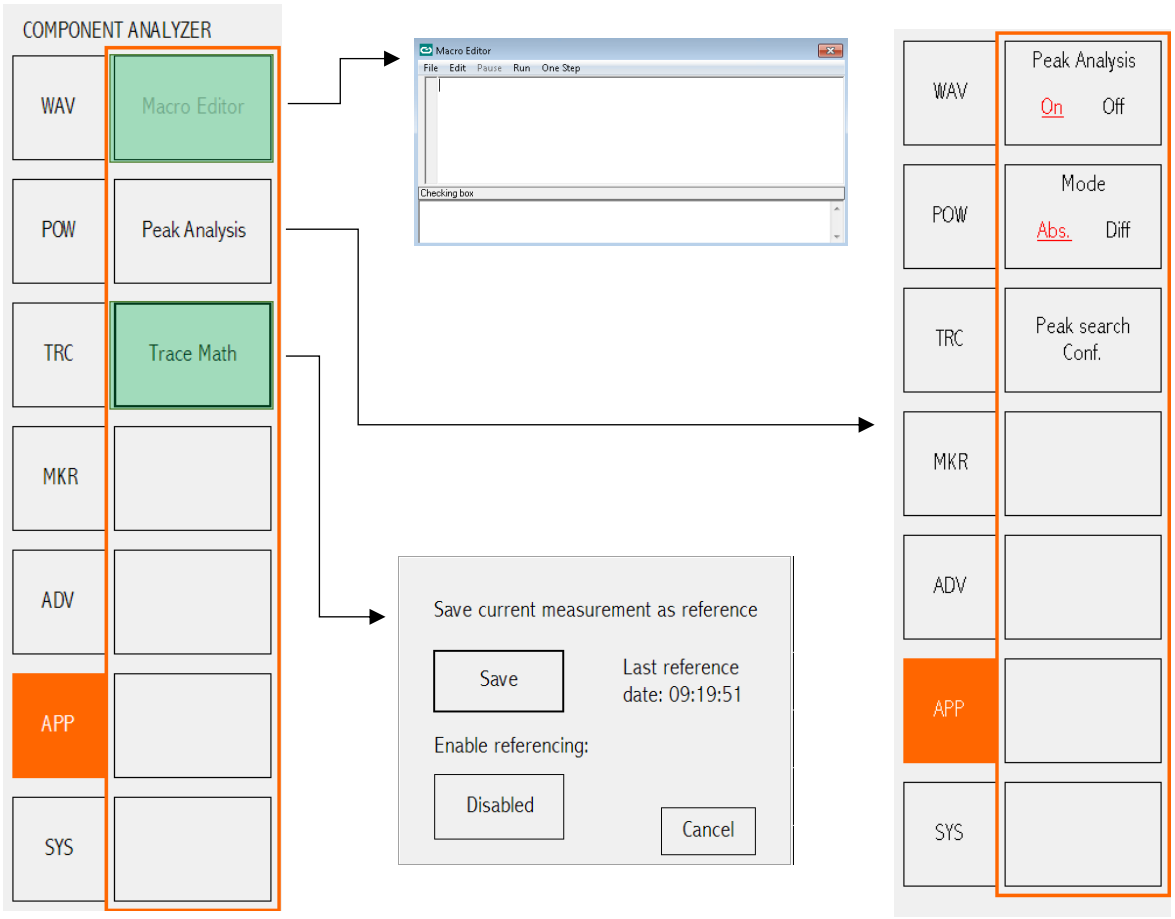
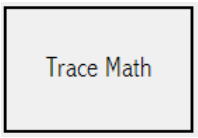


Fig. 4.11 HDCA *Applications* button bar tree diagram.

Applications submenu

	This application allows the user to perform automatic measurements and procedures in the HDCA. Moreover, the unit can control other external devices through GPIB protocol. Please, refer to section 8.1 of this guide and "HDCA Programming Guide" for more details.
	Displays the Peak Analysis application for the identification and analysis of multiple peaks in the active measurement. Detail description in section 3.3.1.
	Trace math menu enables the user to save the current channel measurement in order to use it as a reference to avoid the power uncertainty from the front optical connectors. By enabling this option, the current channel measurement is divided by the saved reference. This option is enabled only when just one channel is being measured, otherwise remains disabled.

4.1.1.2.7. System button

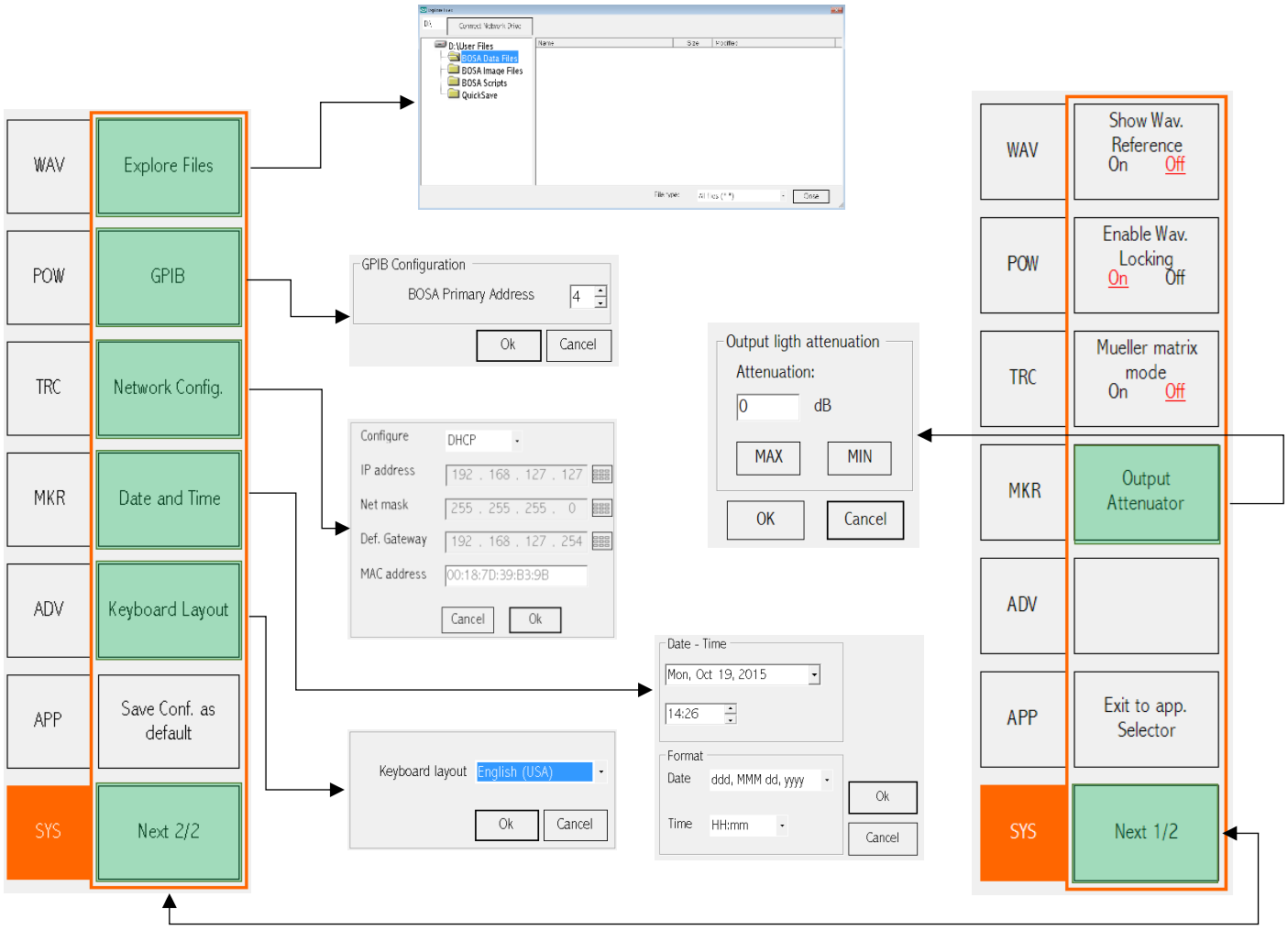
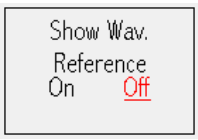
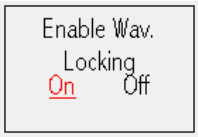
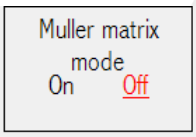
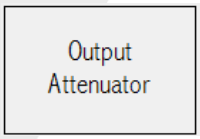


Fig. 4.12 HDCA *System* button bar tree diagram.

System submenu

	Manages the user files. Allows user to delete files, create new folders, rename files or move them to USB stick. It also allows to connect to a network drive (see section XXX)
	Pops up a dialog box to configure the GPIB properties.
	Displays a dialog box to configure the network allowing remote access to the HDCA.
	Shows data and time information.
	Allows the user to select the keyboard layout.
	Saves the current measurement configuration (X axis, Y axis) to be set up the next time the HDCA is started.
	Displays the absorption spectrum of the internal gas cell. See Appendix I for details.
	Enables continuous wavelength correction based on the internal gas cell. For small spans, less than absorption lines separation, this function may not work properly. See Appendix I for details.
	This is an *option button*. It allows the user to disable the standard Polarization (in Advanced submenu) measurement. Then the following Polarization button is displayed:
	Allows the user to attenuate the output light from the HDCA TLS OUT port. Attenuation can variate from 0 to 30 dB.

Exits to the application selector screen.

4.1.1.3. The Context Menu

The *Context Menu* appears when right-clicking on the graphical representation area, and comprises some important user keys related to the representation itself and is only accessible when using an external mouse.

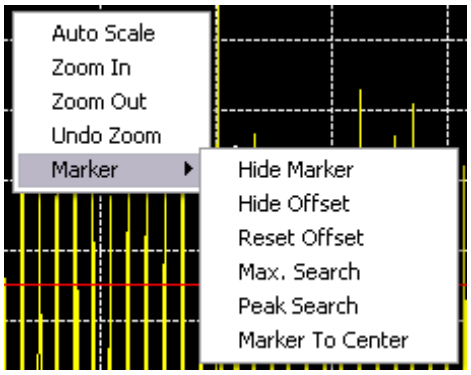


Fig. 4.13 HDCA *Context Menu.*

Context menu description

The context menu contains interface keys related to the graphical representation itself.

Auto Scale	Performs an auto scale operation in the vertical axis of the chart
Zoom In	Enables the zoom mode to perform a zoom-in operation
Zoom Out	Performs a zoom-out operation on the chart
Undo Zoom	Retrieves the previous axis configuration on the chart
Marker-> Show Marker	Shows or hides a marker on the active trace
Marker-> Show Offset	Shows a marker offset to obtain relative measurements
Marker-> Reset Offset	Sets the offset to cero and moves the square symbol of the offset to the marker position

Marker-> Max Search	Moves the marker to the maximum value of the display data
Marker-> Peak Search	Moves the marker to the position of the next peak
Marker-> Marker to Center	Changes the horizontal axis configuration to set the marker in the center of the representation area

4.1.1.4. Interface shortcuts

Some of the configuration parameters can be easily changed through the active zones of the graphical interface. By double clicking in these zones, marked in Fig.4.14, the application opens the corresponding menu to set the value of the related parameter.

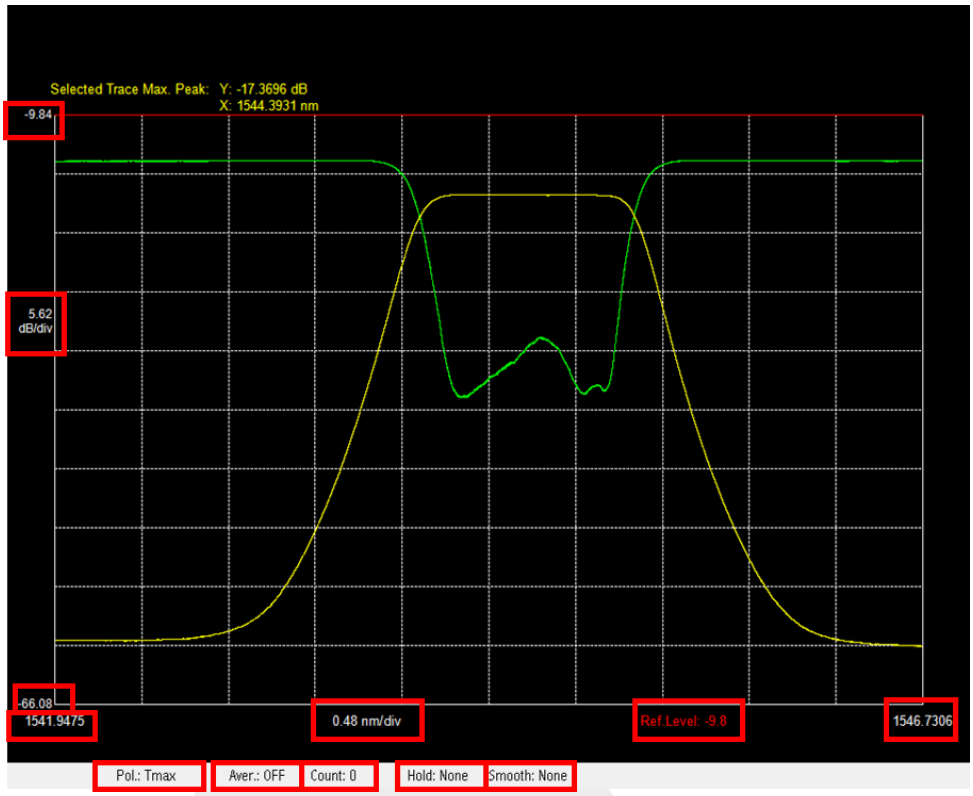


Fig. 4.14 HDCA Graphical Interface shortcuts

4.2. Taking measurements

4.2.1. Hooking up the Device Under Test (DUT)

Using a single mode fiber, connect an optical patchcord from the AUX Output port on the front panel of the HDCA to the input fiber of the device under test. Connect then the output fiber of the device under test to the desired Input port on the front panel of the HDCA. Now the HDCA is ready to start measuring the DUT.

Fig. 4.15. Diagram of the connections for the component analyzer measurement.

Check the connector type for DUT before connect it.

Invisible laser radiation. Do not view directly with optical instruments. Class 1 laser product. Refer to section 0.3 for specific considerations.

4.2.2. Viewing the DUT Trace

Prepare the instrument to make measurements as explained in section 2 "Setting up the HDCA". Measurements require to press the Run button placed on the top right corner to start.

If the optical spectrum is not viewed set the start and stop wavelength accordingly in the wavelength tab.

NOTE: The current measurement can be stopped at any time by pressing the *OFF* button, which is located at the right top corner of the screen. Later, the measurement can be continued by pressing the *ON* button.

4.2.3. Configure the measurement

The Measurement Config. Menu grants the user a deeper control of the acquisition parameters of the High-Definition Component Analyzer. This button has been included in the ADV tab.

This menu is divided into two tabs:

1 **Acquisition channels.** High-Definition Component Analyzer allows to capture one to five simultaneous channels choosing from AUX IN 1-4 (or Insertion Loss port 1-4) and RL (Return Loss) by selecting the appropriate button. This selection can be done while the equipment is running.

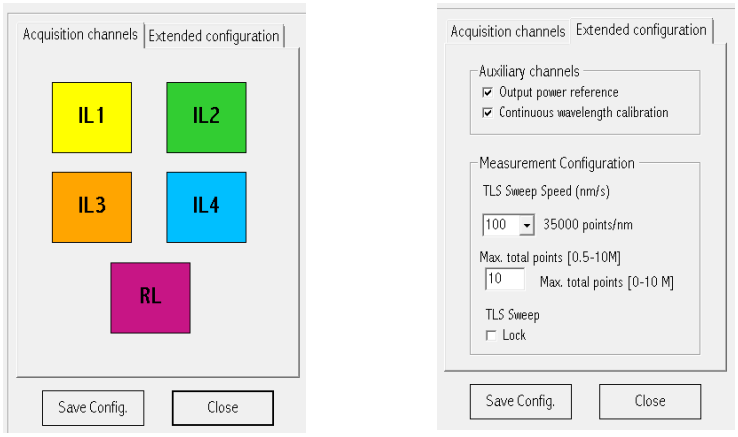


Fig. 4.16. Measurement configuration tabs.

2 **Extended configuration.** This menu allows the user a higher grade of control of the measurement. The measurement options changes must be done when the measurement is stopped, otherwise, options are disabled.

a. **Auxiliary channels.** This section allows you to enable/disable some auxiliary channels in order to have a higher point count on the measurement channel.

i. **Output Power Reference.** By default, the HDCA takes a measurement of the power that is coming out of the TLS OUT port and divides any measurement by it, so that they are effective insertion or return losses. If this auxiliary channel is not acquired, then the traces only reflect a power level and can have some ripple and lack of flatness coming from the non-constant power emitted by the tunable laser.

ii. **Continuous wavelength calibration.** The HDCA takes a measurement of an internal interferometer in each sweep in order to achieve the maximum wavelength repeatability. If

this auxiliary channel is not acquired, wavelength repeatability won't be maximized.

b. **TLS Sweep Speed (nm/s).** The tuning speed at which the external Tunable Laser Source scans the device spectral response. Five different speeds are available. At the right side of the value box, the maximum number of points per nm that will be acquired is displayed. This number is calculated dividing the Acquisition Card rate (3.5 MS/s) by the speed.

c. **Max. total points (Millions).** The total number of points (all channels) that the Acquisition Card can capture for each laser scan is limited by this number. At the right side of this box, the maximum number of points per channel is displayed for reference.

d. **TLS Sweep:** By enabling this option the sweep parameters, such as speed and span, remain fixed and any zoom in or out in the graph don't imply any reconfiguration/calibration of the laser status.

4.2.4. Making measurements with Averaging function

It is possible to reduce the noise in the spectrum using the *Averaging* function.

1. Select the ***Advanced*** submenu.
2. Choose the average count (4, 8, 16, 32 or Continuous) pressing *#Averages* button.
3. Activate the average process pressing *Average* button.

4.2.5. Saving and loading measurements

4.2.5.1. Save

1. Select ***Traces submenu and press Save button***.
2. Select ***Save Data or Image button***.
3. Choose the format you wish to use for saving the measurement.
4. Enter a filename and choose the destination for the saved measurement.
5. Press ***OK*** button.

Save data:

Opens a new windows form to save the active trace. Available formats are:

- .bdf : it is the HDCA Data File format (binary format). Only a HDCA can open this type of file.
- .txt: it is a text file which can be opened by any text editor.
- .csv: comma separated values file. Wavelength and power values are saved in each row separated by a comma.

The total number of points in the current view will be saved. Note that some widely used applications present limitations on the number of points to be managed. A downsampling to 44000 points can be set in the Save window.

Save image:

Opens a new windows form to save the image displayed in the *measurement area.* Available formats are jpeg, bitmap, gif or tiff image formats. Please take into account that jpeg format will not preserve the level of quality displayed in the screen.

4.2.5.2. Quick save

Before performing a quick save, it is possible to configure it.

1. Select the *Configure Quick Save* option.
2. Select the ***File Type*** *and* ***Format***.
3. Write the ***File name.***
4. Select the ***Folder.***
5. Press *OK* button.

To perform a Quick Save, proceed as below:

1. *Select* **Traces submenu**.
2. Select the ***Quick Save*** option.

The measurement is automatically saved with the configuration defined in *Configure Quick Save*.

4.2.5.3. Load

In order to load data, follow the next steps:

1. Select ***Traces*** in the main button bar.
2. Select the ***Load*** option.
3. Select the drive.
4. Select the file you wish to load and press *OK* button.

4.3. Applications

4.3.1. Peak Analysis

The peak analysis application provides fast and dynamic measurement of multiple peaks in a live signal. Based on the threshold level set by the user, the system locates all the peaks in the span and displays their information.

4.3.1.1. Interface Description

The application presents all the identified peaks by setting individual markers in all of them. In the right side of the display, all the information is sorted and presented in a table according to the units set by the user.

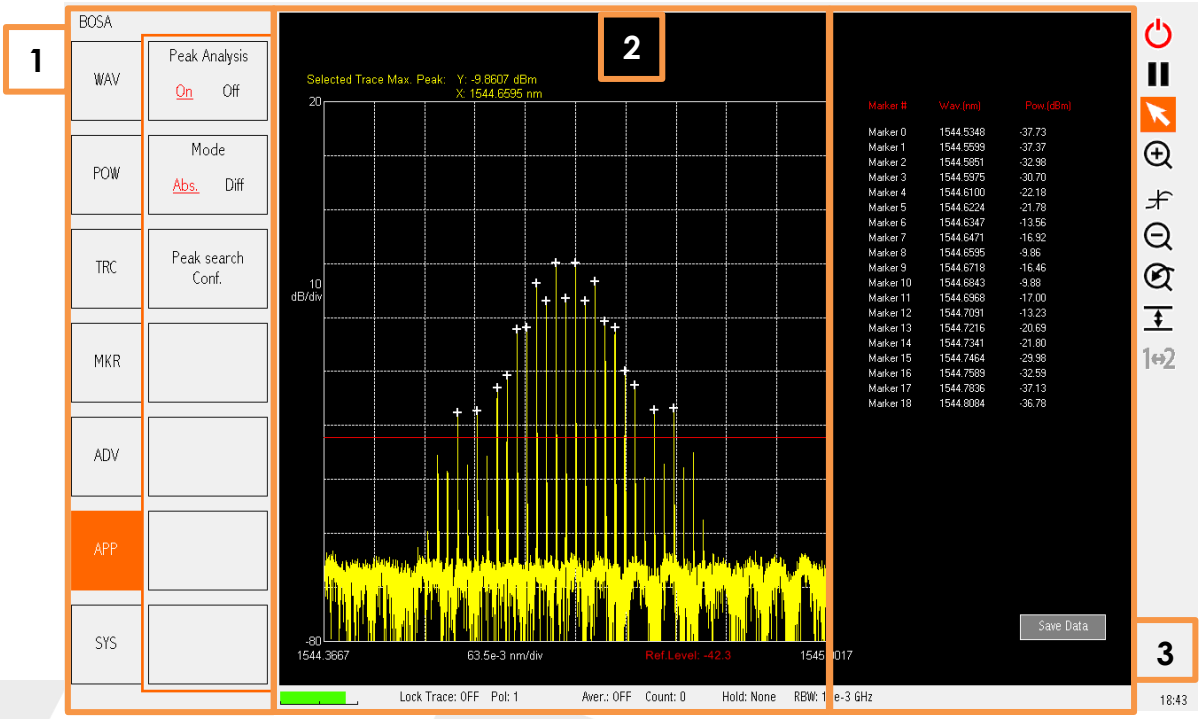
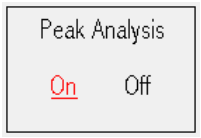
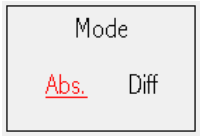


Fig. 4.17 Peak Analysis application graphical user interface.

4.3.1.2. GUI Area Description

1	Specific buttons for the peak analysis application are located here. See below interface keys description for more details.
2	Spectrum measurement area. All the identified peaks will be marked in this area based on the threshold level set by the user. All HDCA tabs and functionalities can be used to set the most suitable spectrum measurement for peak analysis.
3	Data display area. It presents all the information of each of the detected peaks according to the selected mode and units.

4.3.1.3. Interface Keys description

	Activate or deactivate the Peak Analysis application.
	Switch between the two modes for the peak analysis. The "*Abs.*" mode shows the absolute value for the parameters, while the "Diff" mode shows the values relative to a spectral component defined by the marker.
	It is used to define the configuration parameters for the peak identification.

4.3.1.4. Peak Search Configuration

This menu allows to select between Peaks or Valleys for maximum or minimum values of spectral lines measurement.

When searching values it allows next right, next left, next up or next down values measurement.

In order to change the threshold level for the peak identification the user has two options. The first one is to manually change the reference level by dragging the red line with the mouse in the arrow cursor mode. The second option is to manually set the level by clicking in the "*Peak Search Conf*" menu and type the desired level in the emerged menu. In this menu the user can also define the contrast level for the peak identification.

4.3.1.5. Display Mode

The application also compares the power and wavelength/frequency with respect to any desired point of the spectrum. For that purpose, the user can place the marker in any point of the spectra, including any of the already identified peaks, and select the "*Differential Mode*". In this mode the table shows the absolute information of the marked point in the spectra, and its difference with each of the identified peaks.

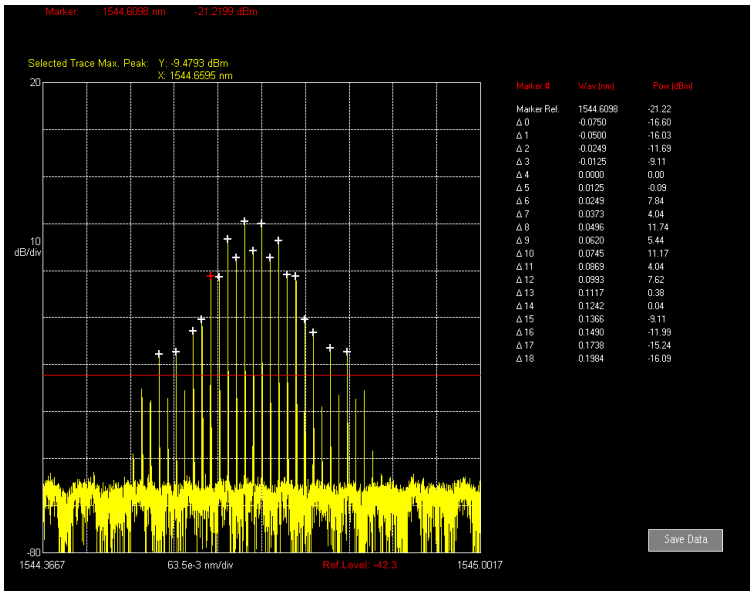


Fig. 4.18 Peak Analysis graphical user interface in differential mode.

4.3.1.6. Save and Export

All the displayed information in the table can be saved at any time by clicking the "Save Data" in the lower part of the data display area. Data can be saved in both modes along with an optional header with all the measurement configuration parameters.

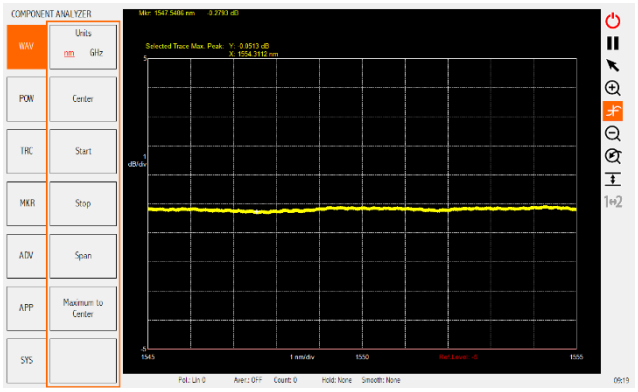
4.3.2. Trace Math

Trace math menu ables the user to save the current channel measurement in order to use it as a reference to avoid the power uncertainty from the front optical connectors. By enabling this option, the actual channel measurement is divided by the saved reference. This option is enabled when only one channel is being measured, otherwise remains disabled.

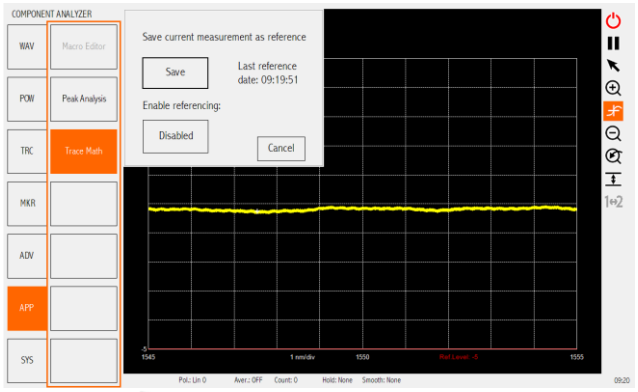
How to use:

1. Connect an optical patch cord between the TLS output port and the PORT 1-4 desired as the figure details.

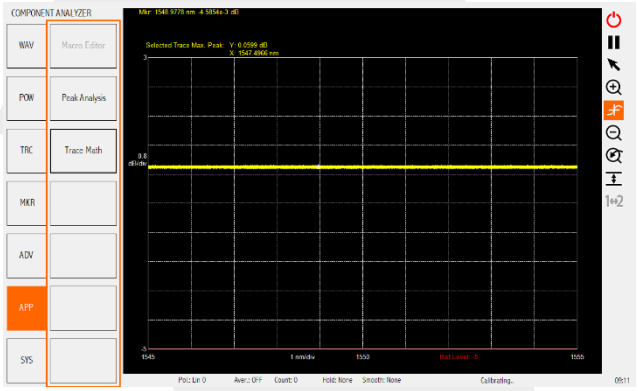
The user should see the loss profile of due to the optical connectors in the displayed span as the next figure depicts.



2 Save the current measure as the reference. Every time the user saves the current measure, the date of the last reference storage will appear. The enabling button will show as disabled by default.

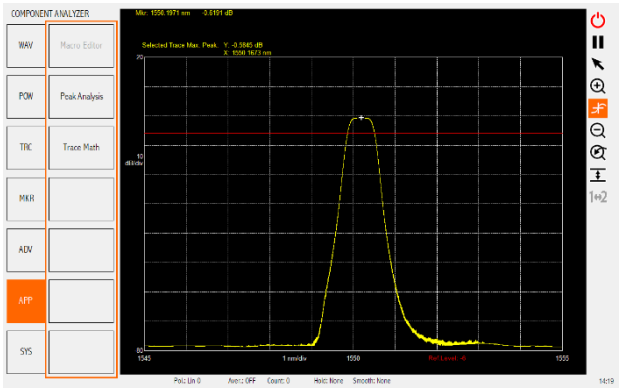


3 Enable the option. The displayed power profile should now stay by 0 dBm.



4 Turn off the application through the ON/OFF button so there is no light coming out from the TLS output port. Connect the device under test through the patch cord just measured to the desired PORT 1-4 as is depicted in the next figure:

5 Turn on the application through de ON/FF button. The insertion losses of the device under test are measured.



5. Tunable laser source (400 series) OPTION

5.1. Description

The HDCA 400 series allows the user to access the internal tunable laser and use it as a standalone laser. The optical output connector is located in the front panel. There is a green LED placed close to the optical connector which is lit any time there is optical power being output.

Invisible laser radiation. Do not view directly with optical instruments. Class 1 laser product. Refer to section 0.3 for specific considerations.

5.2. Graphical User Interface

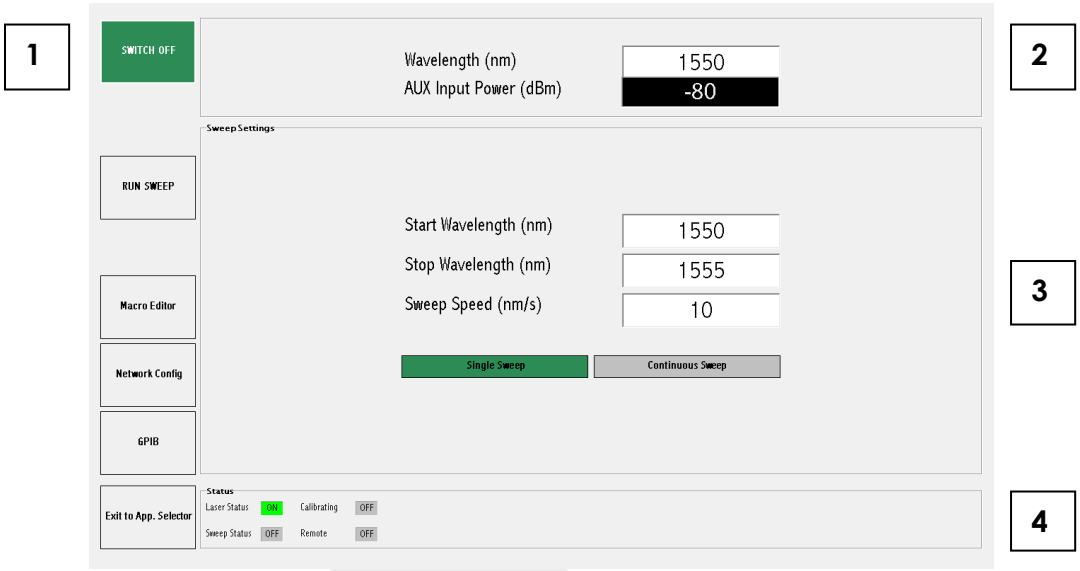


Fig. 5.1 TLS application interface.

1 General configuration

- SWICTH ON/OFF: the laser is switched on and off. The laser needs to be switch on before any other parameter is available.
- RUN SWEEP: the laser performs a sweep under the conditions configured in the "Sweep Settings" box.
- MACRO EDITOR: shows the macro editor tool to perform automatic measurements and procedures with the TLS (section 8)

- NETWORK CONFIG: a dialog box is displayed to configure an Ethernet remote communication.
- GPIB: a dialog box is displayed to configure a remote GPIB communication.

2 Static laser configuration

- WAVELENGTH: current laser wavelength in nm.
- AUX INPUT POWER: current optical input power in of the Aux Input in dBm.

3 Dynamic laser configuration

- START WAVELENGTH: starting wavelength for the sweep in nm.
- STOP WAVELENGTH: stopping wavelength for the sweep in nm.
- SWEEP SPEED: speed for the sweep.
- SINGLE/CONTINUOUS SWEEP: *single sweep* performs just one scan while *continuous sweep* maintains the laser sweeping until the user stops it.

4 Status Area. Actual status of the laser is indicated here as well as any error in the configuration parameters.

6. Remote control

There are several ways to automate measurement processes in the system.

The build in *Macro Editor Tool* allows the user to automate measurements as well as remotely control other devices through simple code scripts written directly in the unit. The HDCA can also be controlled remotely by using both the GPIB (if available) and Ethernet interface (all options).

6.1. Using the Macro Editor Tool

The Macro Editor Tool is a built-in function which allows control and program the HDCA, Tunable Laser and Component Analyzer apps. In each operation the instrument can also remotely control other instruments through GPIB interface (if available). These applications require the use of an external keyboard connected to the HDCA.

In case you need to control external devices, a standard GPIB cable (if interface available) must be used to connect the instrument and any other laboratory unit. The device addresses should be assigned from the programming language (see the Programming Guide).

- **To operate the HDCA through the built-in Macro editor function:**

1. Select *Applications* in the main button bar.
2. Press *Macro Editor* button. The interface of the *Macro Editor* will appear (fig 8.1)
3. You can choose between creating a new macro or load one previously saved.

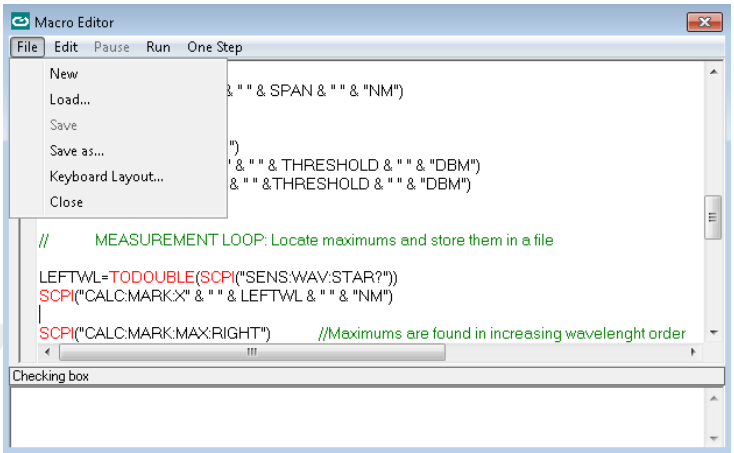


Fig. 6.1 Macro Editor.

- **To operate the Tunable Laser application through the built-in Macro editor function, click on the Macro Editor button.**

Create a Macro:

1. Choose the *New* option on *File* menu.
2. Click on the *Keyboard Layout* option to select one.
3. Refer to Programming Guide for more information about commands to create the macro.
4. Click on Run to start the macro. Information of the stage of the macro will appear in the Checking box section.
5. Click on One step if you wish to check the performance of each order of the program, Information will be shown in the Checking box.

Load a Macro:

1. Choose the *Load* option in *File* menu and load the desired macro.
2. Click on Run to start the macro. Information of the stage of the macro will appear in the Checking box section.
3. Click on One step if you wish to check the performance of each order of the program, Information will be shown in the Checking box.

6.2. Using the GPIB Interface (if available)

The GPIB (General Purpose Interface Bus) is an interface used for communication between personal computers and laboratory instruments, such as the HDCA. The IEEE-488 connector on the back of the unit allows for remote operation through a standard GPIB cable. The connector is a standard female 24-pin IEEE-488 connector to use with a standard shielded IEEE-488 cable.

Before you can operate HDCA through GPIB interface you must assign a device address that is unique from the other equipment attached to the bus.

- **Setting the Device Address in HDCA and Component Analyzer:**

1. Under the System menu, select GPIB. The GPIB Configuration window appears.
2. Select a GPIB primary address for the HDCA different from the controller computer or the other instruments' addresses.

- **Setting the Device Address in Tunable Laser:**

1. Click GPIB button. GPIB Configuration window appears.

2 Select a GPIB primary address for the HDCA different from the controller computer or the other instruments' addresses.

The default GPIB address of the HDCA is 4.

- **Returning to Local Control:**

When the HDCA or Component Analyzer application is in remote control, the Stop/Run button in the main screen will change to Local and all the main interface of the will be disabled. Press Local button if you wish to return the instrument to local control.

NOTE: When the Laser application is in remote mode all the buttons in the main window are disabled. Press EXIT REMOTE MODE button if you wish to return the instrument to local control.

6.3. Using the Ethernet Interface

In order to use the Ethernet interface in the HDCA, it must be connected to a LAN through its 10/100/1000 base-T connector, located on the back of the instrument, and a standard network cable. To operate the instrument remotely through Ethernet interface, see the Programming Guide.

Before you can operate the HDCA through the Ethernet interface you might need to configure it. The IP address of the instrument is set by default using DHCP (Dynamic Host Configuration Protocol). If your network does not support DHCP, a manual configuration will be required. Use the following steps to configure the Ethernet interface.

- **Automated configuration:**

1 Open system/configuration screen:
   - In HDCA or Component Analyzer:
     - Select the *System* option on the Menu bar.
     - Choose the *Network Configuration* option. A dialog box will appear on the screen (fig.7.2)
   - In Tunable Laser app:
     - Click Network Config. button.

2 Choose DHCP in the Configure combo box

3 Press *OK* button to automatically configure the IP address.

4 It is necessary to wait a few seconds until the new configuration takes effect.

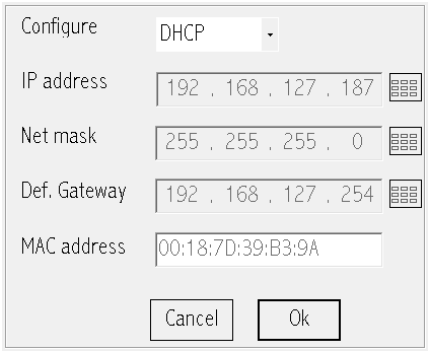


Fig. 6.2 Automated Network Configuration.

- **Manual configuration:**

1 Same as above.

2 Same as above.

3 Choose Manual in Configure combo box.

4 IP Address, subnet mask and the default gateway will be enabled. The MAC address of the device is displayed at the bottom. Press the button at the right of the IP address and the keypad appears. See figure 7.3

5 Enter the IP address, the subnet mask and the default gateway using the keypad

6 Press *OK* button on the message box IP Address

7 Press *OK* button on the message box Network configuration to finish.

8 It is necessary to wait a few second until the new configuration take effect.

Now the HDCA is ready to be operated through Ethernet interface. See Programming Guide for more information.

Upon receiving a command over the Ethernet interface, the instrument will set in remote mode and the functions on the screen are locked out. To return the system to local, press the *LOCAL* button located in the right top corner on the screen.

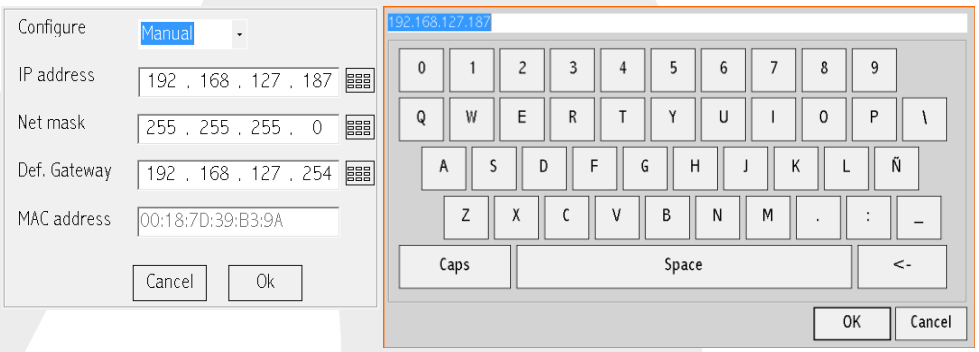


Fig. 5.3 Manual Network Configuration.

7. Maintenance

For the maintenance of the device, please follow the safety considerations described in 'Safety considerations' at the beginning of this guide (section 0) and the cleaning information provided in the following points. These cleaning instructions mainly concern both optical connectors located at the front of the equipment and the external optical connectors that are being inserted.

7.1. Cleaning Optical Connections. General Considerations

It is important that every fiber connector and adapter is inspected and cleaned prior to mating.

Cleaning the fiber optic connections is one of the most basic and important procedures for maintaining fiber optic systems.

Any contamination in the fiber connection can cause failure of the component or failure of the whole system. A particle that partially or completely blocks the core generates strong back reflections, which can cause instability in the laser system.

In addition to dust, other types of contamination must also be cleaned off the endface. Such materials include:

- Oils (frequently from human hands)
- Film residues (condensed from vapors in the air)
- Powdery coatings (left after water or other solvents evaporate away)

These contaminants can also cause damage to the equipment if not removed.

When cleaning fiber connections, always follow the procedures carefully. The aim is to eliminate any dust or contamination and to provide a clean environment for the fiber- optic connection. Remember that inspection, cleaning and re-inspection are critical steps which must be done before making any fiber-optic connection.

Before inspecting and cleaning your fiber-optic connections, review the following reminders:

- Always turn off any laser sources before you inspect fiber connectors or bulkheads.

Laser light can damage your eyes.

- Always inspect the connectors or adapters before you clean.

- Always inspect and clean the connectors before you make a connection.
- Always use the connector housing to plug or unplug a fiber.
- Always keep a protective cap on unplugged fiber connectors.
- Never clean bulkheads or receptacle devices without a way to inspecting them.
- Never touch the end face of the fiber connectors.
- Never allow cleaning alcohol to evaporate slowly off the ferrule.

Wet cleaning is not recommended for mounted bulkheads and receptacles. Damage to equipment can occur.

7.2. Clean Bulkheads

The fiber optic bulkheads of HDCA equipment are designed to be easily disassembled and cleaned.

Swabs for the cleaning of bulkheads is not always very effective even for experienced operators.

Wet cleaning is not recommended for mounted bulkheads and receptacles. Damage to equipment can occur.

Any bulkhead placed in the front panel of the HDCA is formed by one adapter and one APC polished connector and is designed to be disassembled with facility before being cleaned.

The **disassembling procedure** is as follows:

1. Make sure that the lasers are turned off before beginning the inspection.

Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2. Remove the protective end cap from the adapter.
3. Remove the optical adapter pushing upwards the horizontal metal bar below the connector. With special care pull out the adapter to extract it from the front panel. Please, refer to figure 8.1

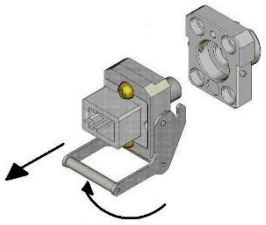


Fig. 7.1 Removable Front Adapter (connector type might be different).

4 The internal connector ferrule is now accessible to be cleaned (see following chapters).

5 Reinsert the adapter applying horizontal soft pressure.

6 Push downwards the horizontal metal bar. A "click" sound confirms that the adapter is in its proper position.

7.3. Connector Cleaning Procedure

1 Inspect the fiber connector, component, or bulkhead with a fiberscope. If the connector is dirty, clean it with a dry-cleaning technique.

2 Inspect the connector.

3 If the connector is still dirty, repeat the dry-cleaning technique.

4 Inspect the fiber connector.

5 If the connector is still dirty, clean it with a wet cleaning technique followed immediately with a dry clean to ensure no residue is left on the endface.

6 Inspect the connector again.

7 If the contaminate still cannot be removed, repeat the cleaning procedure until the end face is clean.

CAUTION Wet cleaning is not recommended for mounted bulkheads and receptacles. Damage to equipment can occur.

CAUTION Never use wet cleaning without to ensuring that it does not leave residue on the end face. It can cause equipment damage.

7.3.1. Dry Cleaning Technique

This section describes dry cleaning techniques using lint-free wipes.

1 Make sure that the lasers are turned off before beginning the inspection.

Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2 Remove the protective endcap and store it in a small resealable container.

3 Inspect the connector with a fiberscope.

4 If the connector is dirty, clean it with a lint-free wipe.

5 Fold the wipe into a square (about 4 to 8 layers thick).

Be careful not to contaminate the cleaning area of the wipe with your hands or on a surface during folding.

6 Fold the wipe into a square (about 4 to 8 layers thick).

Do not scrub the fiber against the wipe; doing so could cause more contamination.

7 Fold the wipe into a square (about 4 to 8 layers thick) using another clean section of the wipe.

8 Properly dispose of the wipe and lightly wipe the ferrule tip with the central portion of the wipe.

9 Inspect the connector again with the fiberscope.

10 Repeat this process if necessary.

7.3.2. Wet Cleaning Technique

If a 'dry' cleaning procedure does not remove the dirt from the fiber endface, then try the wet cleaning method.

Improper cleaning can cause damage to the equipment. The primary concern with using isopropyl alcohol is that it be removed completely from the connector or adapter. Residual liquid alcohol will act as a transport mechanism for loose dirt on the endface. If the alcohol is allowed to evaporate slowly off the ferrule, it can leave residual material on the cladding and fiber core. This is extremely difficult to clean off without another wet cleaning and usually more difficult to remove than

the original contaminant. Liquid alcohol can also remain in small crevices or cavities where it can re-emerge during fiber connection.

1. Make sure that the lasers are turned off before beginning the inspection.

Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments.

2. Remove the protective endcap and store it in a small resealable container.
3. Inspect the connector with a fiberscope.
4. Fold two wipes into a square (about 4 to 8 layers thick).
5. Moisten one of the wipes with one drop of 99% alcohol. Be sure the other wipe remains dry.
6. Lightly wipe the ferrule tip in the alcohol moistened wipe.
7. Immediately repeat the action on the dry wipe to remove any residual alcohol.
8. Inspect the connector again with a fiberscope.
9. Repeat the process as necessary.

7.4. Adapters Cleaning Procedure

Dry cleaning techniques are recommended for adapters using lint-free swabs. Please, apply the following steps:

1. Remove the protective endcap and store it in a small resealable container.
2. Inspect the adapter.
3. If the adapter is dirty, clean it with a lint-free swab.
4. Turn the swab to clean the sleeve face.
5. Inspect the adapter again.
6. Repeat this process as necessary.

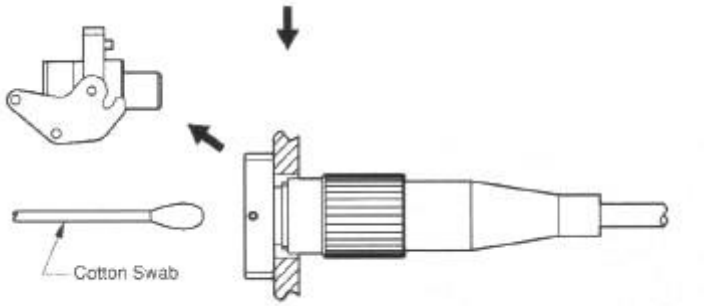


Fig. 6.2 Adapter Cleaning.

8. Technical Service

8.1. Aragón Photonics Labs Services and Sales Office

Any repair, maintenance or adjustment of this instrument must be performed by qualified personnel. Before returning an instrument for service, please contact our assistant engineer at APL support office by internet, phone or fax.

Phone number +34 976 359972
Fax number: +34 976 402022
Email address: support@aragonphotonics.com
Internet: www.aragonphotonics.com
Box mail: Prado 5, local. 50009. Zaragoza. Spain

Also, if you need assistance with your test and measurement needs, we will be very pleased to support you.

8.2. Warranty

The HDCA instrument is warranted against defects in material under normal use conditions for a period of one year from the date of shipment. For warranty service the product must be returned to APL Office. Contact support@aragonphotonics.com for any question on warranty.

8.3. Calibration

The calibration of the instrument affects to the optical power and wavelength scales and this should be done in APL offices. A two-year calibration period is recommended unless indicated otherwise in your Calibration Certificate.

8.4. Returning the Device for Service

If the initial inspection of the device fails, the instrument does not meet the specifications or the device is not working correctly, notify the APL service office. If the instrument is to be shipped to APL service, APL will send the document 'Return Material Agreement request form' to be completed by you. This document should be attached to the device.

The original carton and packaging material must be used when shipping the HDCA to APL Service. Mark with FRAGILE labels the outer side of the packaging to encourage careful handling.

8.5. Firmware updates

You may need to upgrade the firmware of the instrument to enhance the usability and functionality of your instrument. New features may be available with new firmware revisions.

APL will provide the latest firmware versions. Load the corresponding file on a USB memory stick. Once the USB stick is connected to your HDCA you may carry out the firmware update directly through the *Help* Menu, selecting the *Software Update* option.

9. Specifications

The following table show the HDCA technical specifications:

HDCA High-Definition Component Analyzer	
Mainframe	
Operating Temperature	+15°C to +35°C
Power Requirement	100/110/220 V, 50/60 Hz
Power consumption	Máx. 180W.
Dimmensions & Mass	Type A: 445 x 470 x 140 (mm). Type B: 540 x 470 x 180 (mm). Max. 10.5Kg. for 100 series Max. 20Kg for 400 series
Model Parameters	
Wavelength Range	Type A: 1510-1620 nm HDCA 400 series Type B1: 1520-1630 nm HDCA 400 series Type B2: 1480–1630 nm HDCA 400 series Depends on TLS model 100 series
Max Resolution	0.0024 pm (0.3 MHz)
Max Wavelength Accuracy	±0.5 pm
Max Wavelength Repeatability	±0.15 pm
Calibrated Input Power Range	IL: +10 to -90 dBm RL: +10 to -55 dBm
Optical ports	1x TLS IN (PM) 100 series 1x TLS OUT (RL port) 1x DUT IN (IL ports) 3x EXTRA DUT IN as option
Power accuracy	±0.1 dB
TLS output	0 dBm typ.
Polarization Measurement	Two orthogonal polarization channels. Average Option 30: Mueller matrix. PDL measurement
Tunning speed	100 nm/s Typ. 8 - 600 nm/s for Type A 400 series Depends on TLS for 100 series
Data handling	
Acquisition rate	3.5 Ms/s per channel
Max Data points	10 Million
Communication Interface	
Optical connectors	FC/APC
Interfaces Available	USB. Ethernet. GPIB.

10. Troubleshooting

10.1. Error Messages

There is a list of possible system errors identified by an error code.

The Code Errors 100X, 200X, 440X, 800X and 900X are related to optical hardware errors and the Code errors 500X and 700X are related to communication hardware errors. All the error messages are shown above the operation parameters area. If any of the following error appears restart the system. If the error persists, please contact Aragon Photonics for further support.

Code Error	Error Message
7001 7002	'An internal module error has occurred, please take note on Error Code and contact Aragon Photonics for Technical Support. Error Code: 700x'
5001 5002 5005 5008 5009	'500x: Internal device communication error'
5004	'5004: Internal device read error'
5007	'5007: Internal device write error'
8001 8002 8003	'System error: 800X'
9001 9002 9003	'System error: 900X'

11. Compatible external TLS (HDCA 100 series)

HDCA 100 requires and external tunable laser to work. In order to offer the maximum measurement performance only few models are fully compatible with the HDCA.

11.1. Compatible lasers

The next list summarizes the TLS models and manufactures:

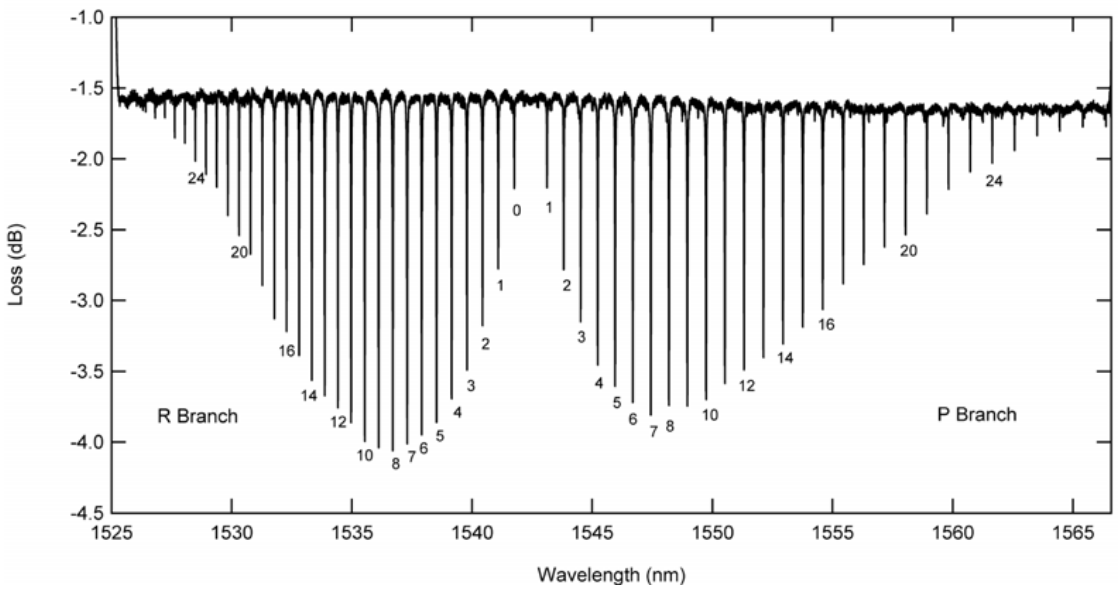
- Keysight (Agilent)
  - 81640A/B
  - 81680A/B
  - 81600B #200
- Newport (Newfocus)
  - TLB 6600 Venturi
  - TLM 8700
  - TLB 6700 Velocity
- EXFO (Yenista):
  - T100S- HP
- SANTEC
  - TSL-550
  - TSL-570
  - TSL-710
  - TSL-770

11.2. Laser requirements

- Wavelength range
  - T, O, S, C, L band.
- PMF output APC (FC preferred)
- Linewidth <1MHz
- Mode-hop free in the complete tuning range
- Continuous sweep
- Sweeping speed: 0.5 to 2000nm/s
- Trigger output at begin of sweep
- Output power of at least 0dBm across complete range
- GPIB, SERIAL or USB

APPENDIX I : Gas Cell Absorption Lines

C band model:

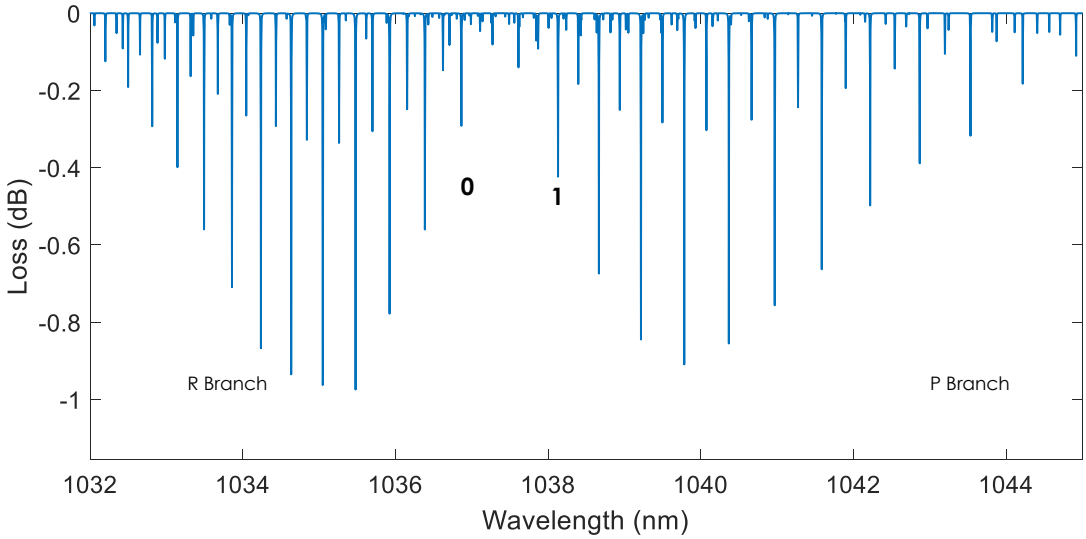


R Branch	Wavelength (nm)	P Branch	Wavelength (nm)
25	1528.0541	1	1543.1148
24	1528.4862	2	1543.8094
23	1528.9271	3	1544.5147
22	1529.3762	4	1545.2314
21	1529.8376	5	1545.9563
20	1530.3061	6	1546.6902
19	1530.7856	7	1547.4354
18	1531.2764	8	1548.1904
17	1531.7738	9	1548.9554
16	1532.2825	10	1549.7302
15	1532.8024	11	1550.5149
14	1533.3291	12	1551.3106
13	1533.8671	13	1552.1157
12	1534.4159	14	1552.9308
11	1534.9723	15	1553.7560
10	1535.5401	16	1554.5892
9	1536.1170	17	1555.4346
8	1536.7034	18	1556.2919
7	1537.2997	19	1557.1573
6	1537.9069	20	1558.0329
5	1538.5224	21	1558.9185
4	1539.1494	22	1559.8143
3	1539.7855	23	1560.7185
2	1540.4314	24	1561.6344
1	1541.0872	25	1562.5625

C+L band model:

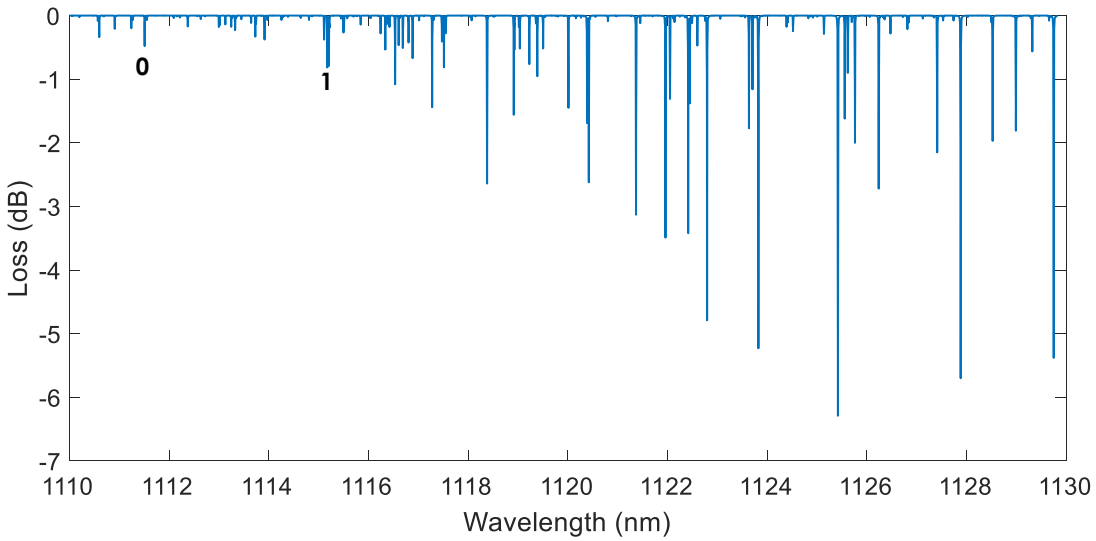
Band	C12 HCN	C12 CO	C13 CO
L26	1519.007585		
L25	1519.421573		
L24	1519.845905		
L23	1520.28055		
L22	1520.725527		
L21	1521.180877	1560.5025	1595.3772
L20	1521.646548	1560.868	1595.7554
L19	1522.122606	1561.26	1596.1595
L18	1522.609023	1561.6786	1596.5895
L17	1523.10582	1562.1237	1597.0454
L16	1523.613015	1562.5953	1597.5271
L15	1524.130607	1563.0935	1598.0349
L14	1524.658593	1563.6183	1598.5686
L13	1525.197017	1564.1697	1599.1284
L12	1525.745855	1564.7477	1599.7141
L11	1526.305129	1565.3523	1600.3258
L10	1526.874837	1565.9835	1600.9636
L9	1527.455003	1566.6414	1601.6274
L8	1528.045651	1567.3261	1602.3174
L7	1528.646756	1568.0375	1603.0334
L6	1529.258344	1568.7756	1603.7756
L5	1529.880439	1569.5405	1604.5439
L4	1530.513043	1570.3323	1605.3385
L3	1531.156133	1571.1509	1606.1593
L2	1531.809784	1571.9965	1607.0064
L1	1532.473951	1572.8691	1607.8799
L0	1533.148683	1573.7687	1608.7799
R1	1534.529837	1575.6498	1610.6596
R2	1535.23629	1576.6311	1611.6393
R3	1535.953327	1577.6397	1612.6457
R4	1536.680951	1578.6758	1613.6788
R5	1537.419216	1579.7392	1614.7388
R6	1538.168127	1580.83	1615.8255
R7	1538.927668	1581.9485	1616.9392
R8	1539.697845	1583.0945	1618.0797
R9	1540.478712	1584.2683	1619.2473
R10	1541.270255	1585.4698	1620.442
R11	1542.072479	1586.6993	1621.6641
R12	1542.885418	1587.9567	1622.9132
R13	1543.709081	1589.2422	1624.1898
R14	1544.543475	1590.5559	1625.494
R15	1545.388588	1591.8978	1626.8257
R16	1546.244477	1593.2681	1628.1851
R17	1547.111151	1594.6669	1629.5723
R18	1547.988599	1596.0942	1630.9873
R19	1548.87683	1597.5502	1632.4303
R20	1549.775904		
R21	1550.685785		
R22	1551.60651		
R23	1552.538091		
R24	1553.480541		
R25	1554.433873		
R26	1555.398101		
R27	1556.373239		

T band model (1030 – 1070 nm)



C2H2			
R branch	Wavelength (nm)	P branch	Wavelength (nm)
R20	1032.497955	P0	1036.864361
R19	1032.813578	P1	1038.130548
R18	1033.144437	P2	1038.395846
R17	1033.316892	P3	1038.665959
R16	1033.492878	P4	1038.939723
R15	1033.673558	P5	1039.217144
R14	1033.858936	P6	1039.498228
R13	1034.04554	P7	1039.784152
R12	1034.23801	P8	1040.074925
R11	1034.434031	P9	1040.368207
R10	1034.63477	P10	1040.666351
R9	1034.84023	P11	1040.969366
R8	1035.048095	P12	1041.274907
R7	1035.261853	P13	1041.585334
R6	1035.478024	P14	1041.899476
R5	1035.698938	P15	1042.219695
R4	1035.923436	P16	1042.541291
R3	1036.152687	P17	1042.86898
R2	1036.385533	P18	1043.534421
R1	1036.623144	P19	1044.218444

T band model (1070 - 1130 nm)



H2O			
Branch #	Wavelength (nm)	Branch #	Wavelength (nm)
0	1111.506696	22	1121.958958
1	1115.107676	23	1122.050278
2	1115.171208	24	1122.414725
3	1115.204189	25	1122.446171
4	1116.337169	26	1122.598512
5	1116.53307	27	1122.794404
6	1116.604545	28	1123.634296
7	1116.687944	29	1123.705206
8	1116.802972	30	1123.823654
9	1116.884211	31	1125.419849
10	1117.27671	32	1125.555952
11	1117.472697	33	1125.617963
12	1117.512877	34	1125.762022
13	1118.378784	35	1126.237951
14	1118.914401	36	1126.473963
15	1119.226736	37	1126.813559
16	1119.386756	38	1127.412061
17	1119.503807	39	1127.883185
18	1120.011638	40	1128.524794
19	1120.386511	41	1128.991132
20	1120.420291	42	1129.321056
21	1121.367946	43	1129.75022