CoCo-80X/90X User Manual

Dynamic Signal Analyzer Mode

7/23/2018

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Introduction

This manual applies to both the CoCo-80X and CoCo-90X vibration analyzers. While the instructions will refer to the CoCo-80X, please note that the same operations can be performed on the CoCo-90X. The only difference will be the number of channels allowed, and whether the input range can be modified (only adjustable on the CoCo-90X).

The CoCo-80X is a new generation of handheld data recorder, dynamic signal analyzer and vibration data collector from Crystal Instruments. It is ideal for a wide range of industries including petrochemical, paper, steel and other metals, automotive, aviation, aerospace, electronics and military. These industries demand quick, easy, and accurate data recording in addition to real-time processing in the field. The CoCo-80X is a perfect machine condition monitoring solution. It is a rugged, lightweight, battery powered handheld system with unparalleled performance and accuracy. The intuitive user interface is specifically designed for easy operation while still providing a wide variety of analysis functions.

Building on the success of the original CoCo-80, the newCoCo-80X boasts improved speed, a bigger screen, and more connection options. A significantly more powerful processor frees DSP resources for faster, more reliable, and more complex processing in real-time. The handheld system is equipped with a bright 7.0-inch color LCD display with multi-point touch functionality as well as a physical keypad. Flexible connections via a USB 2.0 port, 100Base-T Ethernet port, 802.11 b/g/n Wi-Fi connection, SD card interface, HDMI interface, CAN-bus/serial port, stereo headphone and microphone jack, and GPS. Connect the CoCo-80X to a PC to download files, remotely control operations, or upgrade the software through several means of network connections.

The CoCo-80X is equipped with 8 software-enabled input channels. Every CoCo-80X ships with 8 fully populated and functionally tested input channels. Embedded firmware contains a key enabling those channels for which software has been purchased. This means a unit initially purchased as a 2 channel CoCo-80X can be remotely upgrade to 4, 6, or 8 channels via purchased upgrade. Each analog input is serviced by two 24-bit ADCs and a DSP implementing the cross-path calibration technology of US Patent number 7,302,354 B2 to achieve better than 150 dBFS dynamic range (simultaneously measuring signals as small as 600 nV and as large as ±20 V). Measured time histories are stored in 32-bit single precision floating point format (per IEEE 754-2008) and all subsequent signal processing is performed using floating-point arithmetic. 54 sample rates from 0.48 Hz to 102.4 kHz are provided with better than 150 dB of alias-free data from DC to 45% of any selected sample rate protected by steep 160 dB/Octave anti-aliasing filters. The eight channels are amplitude matched within 0.1 dB and phase matched within 1 degree.

The (ISO 11898-1&2) CAN-bus digital input allows simultaneous measurement of an automobile's speed, engine RPM and/or any of the hundreds of performance variables tracked by its Controlled Area Network (CAN). Simply plug into the vehicle's SAE J1962 compliant On-Board Diagnostic (OBD-II) connector to add these additional time signals to your measurement.

The CoCo-80X accurately measures and records both dynamic and static signals. The SD card storage simultaneously records 8 channels of data at up to 102.4 kHz while performing real-time frequency and time domain calculations. An embedded signal source channel provides several standard waveforms that are synchronized with the input sampling rate. A tachometer channel can be enabled to measure the rotating speed during data acquisition. The source and tachometer share a common LEMO connector.

The CoCo-80X hardware platform supports two different software working modes Dynamic Signal Analyzer (DSA), and Vibration Data Collector (VDC). Each working mode has its own user interface and navigation structure. DSA mode is designed for structure analysis and mechanical testing. It is useful for electrical measurement, acoustic analysis, and a wide range of other applications. VDC mode is dedicated to route-based machine condition monitoring, vibration data collection, and trending. CRT mode allows the instrument to be operated as a bench-top testing device where commands are executed and data is displayed in real-time on an accompanying PC.

The CoCo-80X supports multiple languages that can be switched dynamically. It comes with English, Chinese, Japanese, French, and Spanish.

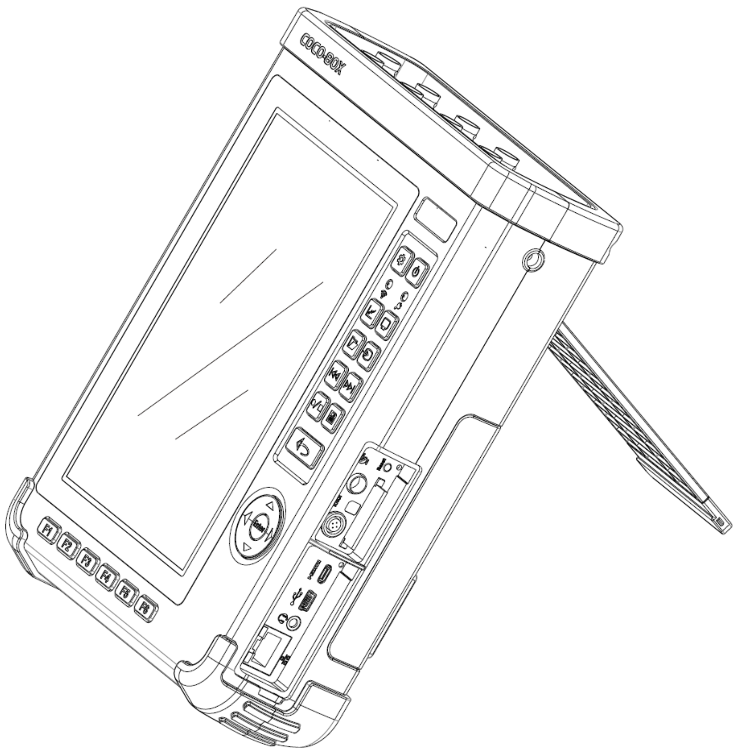


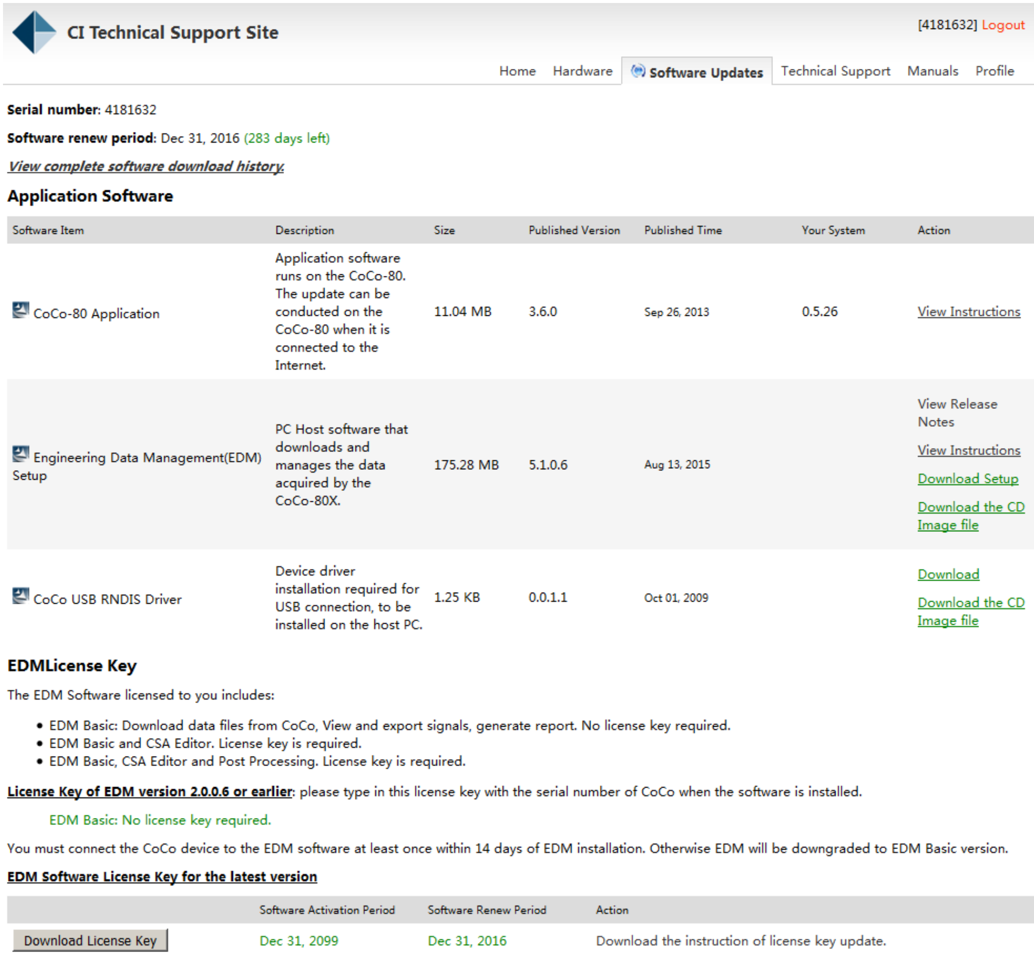
Figure 1: CoCo Hardware

Online Support

To access product information about your CoCo-80X, go to the product page of CI website at: http://www.go-ci.com/support.asp, log in with the serial number of the CoCo-80X and the password included in your shipping documents. After you log-in, you will be able to review and download the latest information which is restricted to CoCo-80X users, including:

- Product Information
- New CSA projects
- User's Manual
- Shipping and Repair History
- User Forum
- Technical Support
- Software Updates
- Technical Issues

A typical CI Technical Support webpage is shown below.



CI Technical Support Site

[4181632] Logout

Home Hardware Software Updates Technical Support Manuals Profile

Serial number: 4181632

Software renew period: Dec 31, 2016 (283 days left)

View complete software download history

Application Software

Software Item	Description	Size	Published Version	Published Time	Your System	Action
CoCo-80 Application	Application software runs on the CoCo-80. The update can be conducted on the CoCo-80 when it is connected to the Internet.	11.04 MB	3.6.0	Sep 26, 2013	0.5.26	View Instructions
Engineering Data Management(EDM) Setup	PC Host software that downloads and manages the data acquired by the CoCo-80X.	175.28 MB	5.1.0.6	Aug 13, 2015		View Release Notes View Instructions Download Setup Download the CD Image file
CoCo USB RNDIS Driver	Device driver installation required for USB connection, to be installed on the host PC.	1.25 KB	0.0.1.1	Oct 01, 2009		Download Download the CD Image file

EDMLicense Key

The EDM Software licensed to you includes:

- EDM Basic: Download data files from CoCo, View and export signals, generate report. No license key required.
- EDM Basic and CSA Editor. License key is required.
- EDM Basic, CSA Editor and Post Processing. License key is required.

License Key of EDM version 2.0.0.6 or earlier: please type in this license key with the serial number of CoCo when the software is installed.

EDM Basic: No license key required.

You must connect the CoCo device to the EDM software at least once within 14 days of EDM installation. Otherwise EDM will be downgraded to EDM Basic version.

EDM Software License Key for the latest version

	Software Activation Period	Software Renew Period	Action
Download License Key	Dec 31, 2099	Dec 31, 2016	Download the instruction of license key update.

Figure 2: Crystal Instruments CoCo Support Site

The latest CoCo-80X application software, device drivers or CSA projects can be downloaded while the CoCo-80X subscription is maintained.

Limited Warranty & Limitation of Liability

Each CI product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year for the CoCo-80X hardware and its accessories. The warranty period begins on the date of shipment. Parts, product repairs and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a CI authorized reseller, and does not apply to fuses, disposable batteries or to any product which, in CI's opinion, has been misused, altered, neglected or damaged by accident or abnormal conditions of operation or handling. CI warrants that software will operate substantially in accordance with its functional specifications for one year and that it has been properly recorded on non-defective media. CI does not warrant that software will be error free or operate without interruption.

CI authorized resellers shall extend this warranty on new and unused products to end user customers only but have no authority to extend a greater or different warranty on behalf of CI. Warranty support is available if the product is purchased through a CI authorized sales outlet or the Buyer has paid the applicable international price. CI reserves the right to invoice the Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

CI's warranty obligation is limited, at CI's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a CI authorized service center within the warranty period.

To obtain warranty service, contact your nearest CI authorized service center or send the product, with a description of the difficulty, postage and insurance prepaid (FOB Destination), to the nearest CI authorized service center. CI assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If CI determines that the failure was caused by misuse, alteration, accident or abnormal condition of operation or handling, CI will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges.

This warranty is the buyer's sole and exclusive remedy and is in lieu of all other warranties, express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose. CI shall not be liable for any special, indirect, incidental or consequential damages or losses, including loss of data, whether arising from breach of warranty or based on contract, tort, reliance or any other theory.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

Crystal Instruments Corporation, http://www.crystalinstruments.com/

Safety Information: Read First

The CI CoCo-80X Handheld Data Acquisition System complies with:

EN 61326:1997+A1:1998+A2:2001

EN61000-3-2: 2000 & EN61000-3-3: 1995+A1:2001

Use the CoCo-80X and its accessories only as specified in this User's Manual.

Condensation may form on the circuit boards when the device is moved from a cold environment to a warm one. In these situations, always wait until the device warms up to room temperature and is completely dry before turning it on. This acclimatization period should take about 2 hours.

For the most accurate measurements a warm-up phase of 20 min is recommended.

The devices have been designed for use in clean and dry environments. It is not to be operated in 1) exceedingly dusty and/ or wet environments; 2) in environments where danger of explosion exists; or 3) in environments containing aggressive chemical agents.

Always lay cables in a manner to avoid tripping hazards.

A Warning identifies conditions and actions that pose hazard(s) to the user. A Caution identifies conditions and actions that may damage the Instrument.

To avoid electrical shock or fire:

- The CoCo is only to be used as a low voltage measurement instrument.
- Do not apply input voltages above the rating of the Instrument. You should never apply a voltage that potentially exceeds ±40V to the instrument.
- Review the entire manual before use of the instrument and its accessories.
- Do not operate the instrument around explosive gas or vapor.
- Before use, inspect the instrument, BNC connectors, and accessories for mechanical damage and replace when damaged. Look for cracks or missing plastic. Pay special attention to the insulation surrounding the connectors.
- Remove cables and accessories when not in use.
- Use the ground input only to ground the instrument. Never apply any voltage.
- Do not insert metal objects into the connectors.
- Use only the wall-mount power supply provided by Crystal Instruments.

AC Adapter Voltage Range

For external power source CoCo-80X uses a wall-mount AC Adapter. The AC Power range is 100Vac – 240Vac.

Maximum Measurement Input Voltage

Maximum Working Input Voltage: 20 V peak. Voltage ratings are given as "working voltage". They should be read as V peak for dynamic applications and as V dc for DC applications.

Max. Input Range without damaging the hardware: 40Vpeak.

If Safety Features are Impaired

If the instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired. Before use, inspect the test leads for mechanical damage and replace damaged test leads. If the instrument or its accessories appear to be impaired or not functioning properly, do not use it and send it in for repair.

Quick Start

This Quick Start section is intended to give a brief introduction to the most basic use of the CoCo-80X system. By following the instructions you will learn how to do the following:

1. Install the EDM software to your host PC.
2. Record Time Streams with CoCo-80X.
3. Download and view the data on the host PC.

After completing the Quick Start tutorial, you should read the following sections for a more comprehensive description of the system.

Install Engineering Data management (EDM) software to PC

To install EDM and related software systems included on the CD, place the installation CD in the CD drive on your PC. The Welcome Screen will automatically open as shown below. If the Welcome Screen does not automatically open, run the Setup.exe file on the root level of the CD by selecting the physical drive with the CD, opening the EDM folder, and double-clicking on Setup.exe.

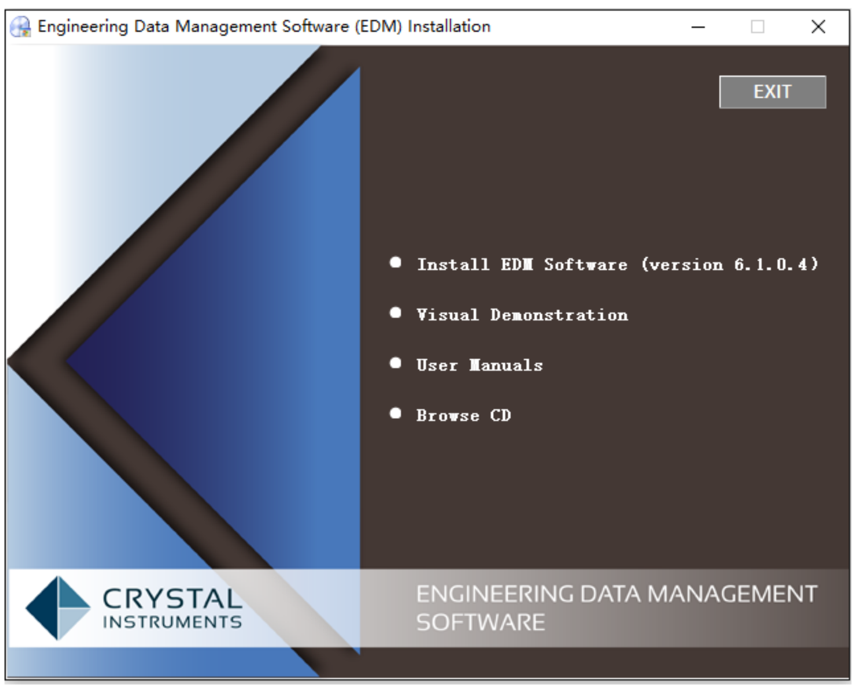


Figure 3: Welcome Screen for EDM Installation CD.

To launch the EDM installer click **Install EDM Software (version X.X.X.X)** from the EDM Installation screen to launch the Installation Wizard.

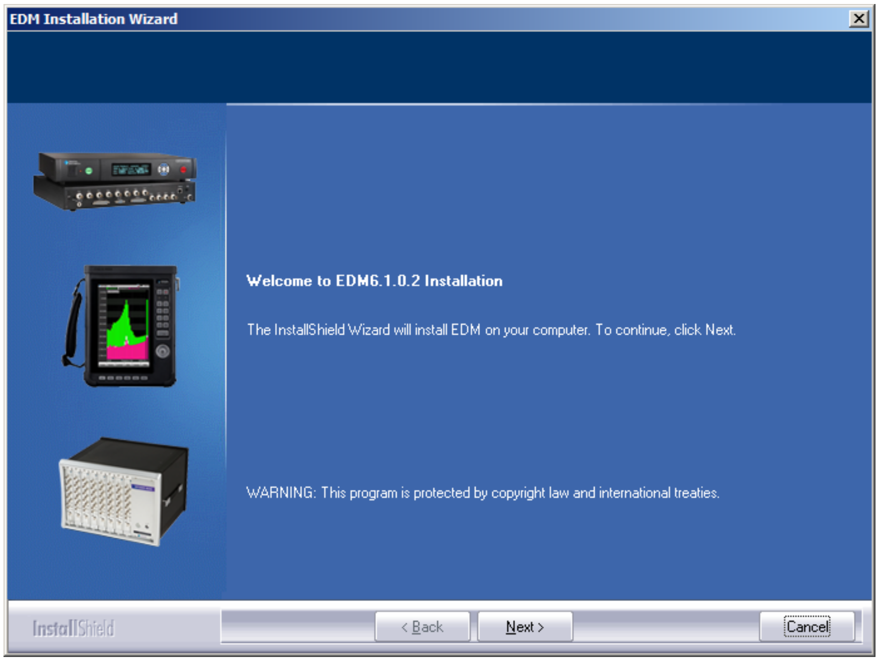


Figure 4: EDM Installation Wizard

Click **Next** to begin the installation process.

Review and accept the license agreement and click **Next**.

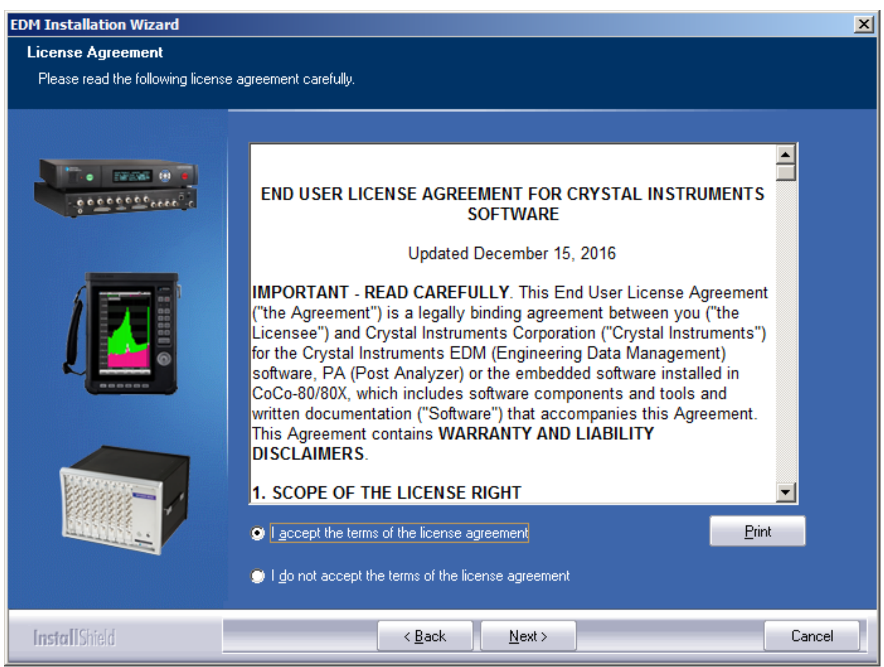


Figure 5: EDM License Agreement acceptance page

To install EDM a valid license key is required. If the default location does not contain your license key, browse for the correct folder. Once the license key has been specified, press **Next**.

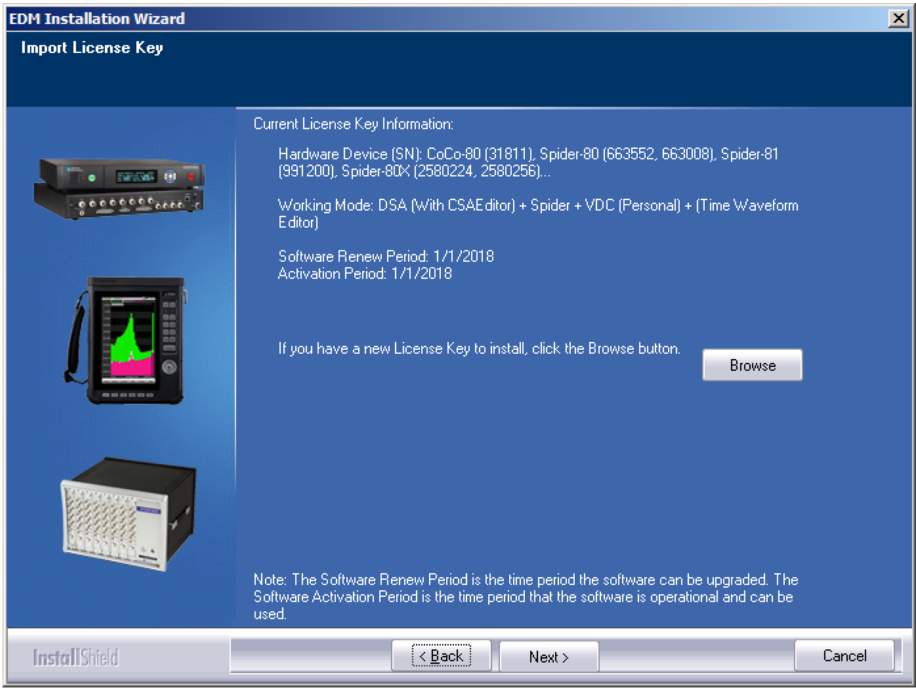


Figure 6: License Key directory page

> **Note**: If you do not know the location of your license key or do not have a license key, refer to the section of this manual titled **Where is My License Key**.

Specify the installation directory and press **Next**. The default directory is C:\Program Files\Crystal Instruments\EDM.

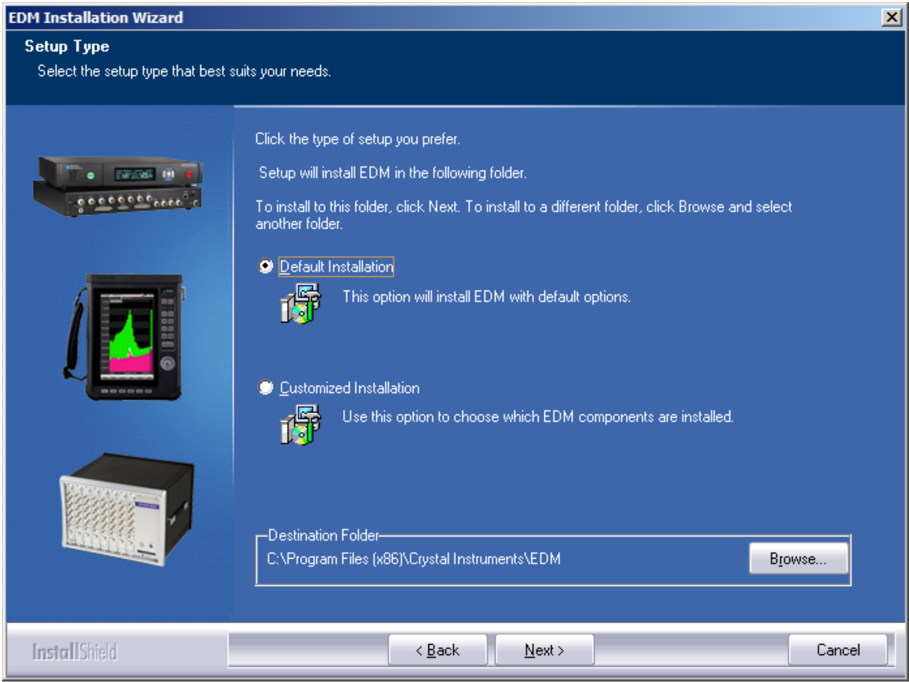


Figure 7: Installation Directory page

If desired, specify preferred location for Data Files, CSA Projects, Arbitrary Signal files, and Limit Collection files. Press **Next** to continue.

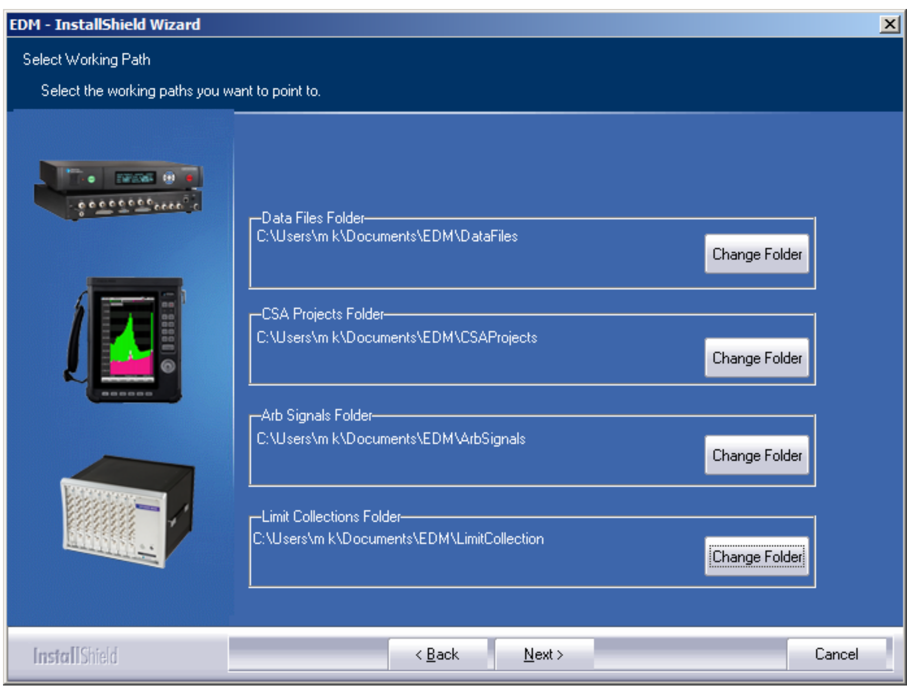


Figure 8: EDM Default Save location page

Specify Start Menu folder name and press **Next**.

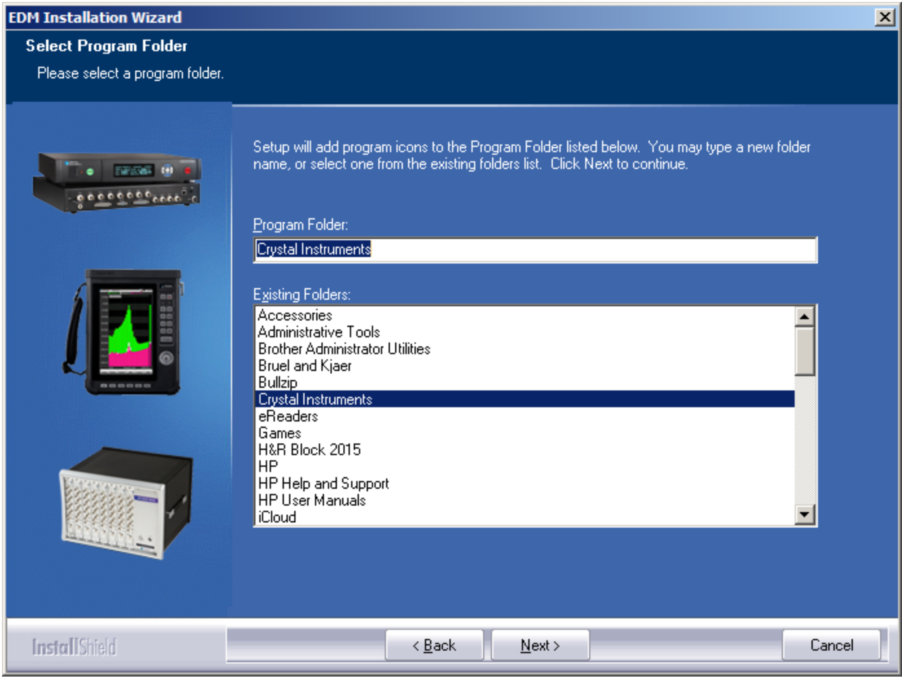


Figure 9: Programs folder title page

Select your preferences for Shortcuts, Default Units, Default Language, Paper Size, and Multiple Module support. These setting can be changed later in the EDM Settings menu. Press **Next**.

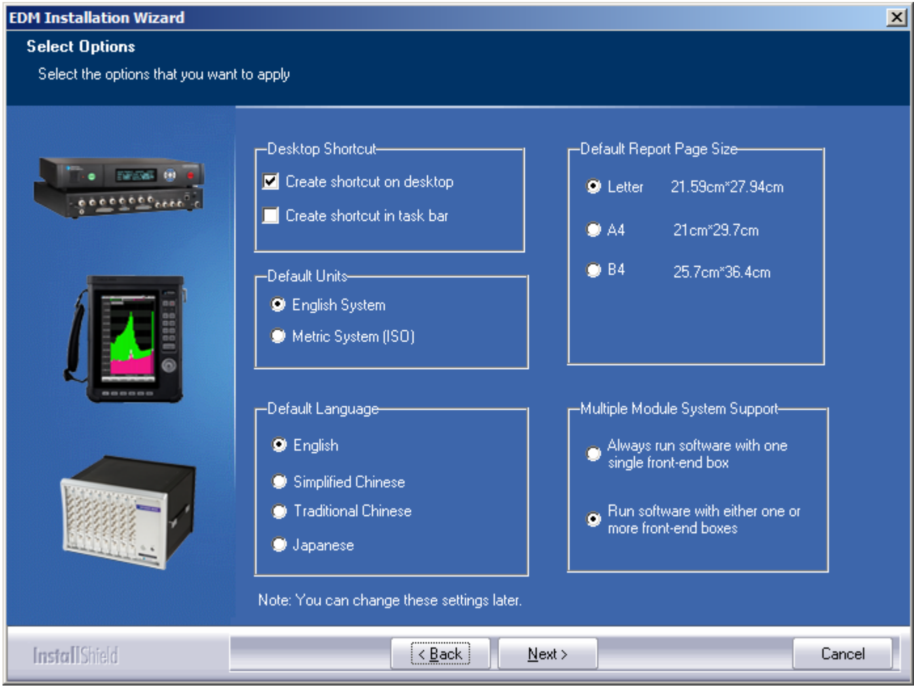


Figure 10: EDM Default settings

Review the installation setting. Click back if changes are necessary. Click **Next** if all settings are correct. The Installation Wizard will then set up EDM according to the settings.

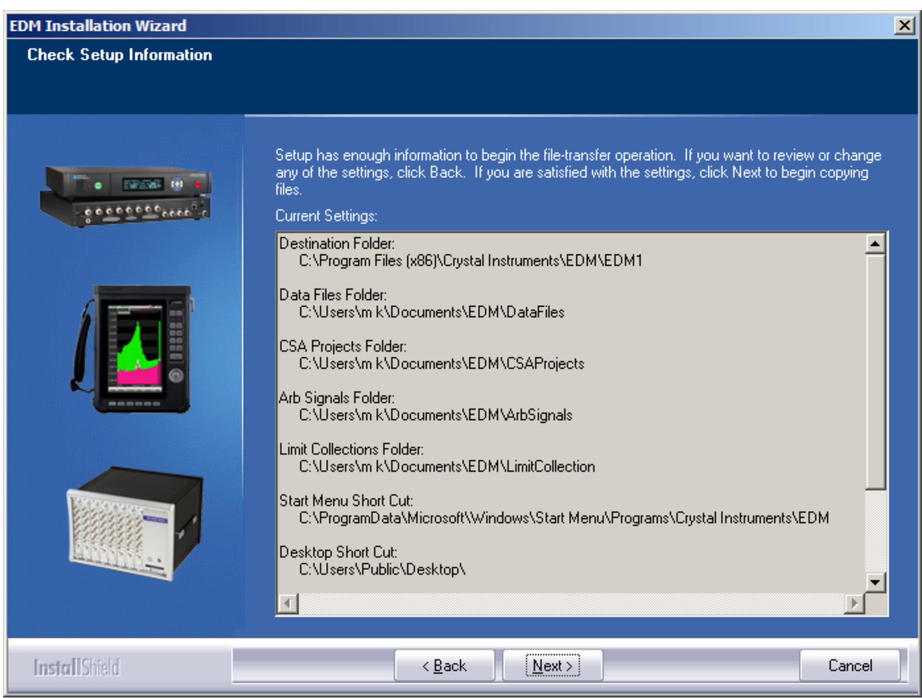


Figure 11: Installation summary page

Click **Finish** to exit the EDM installer.

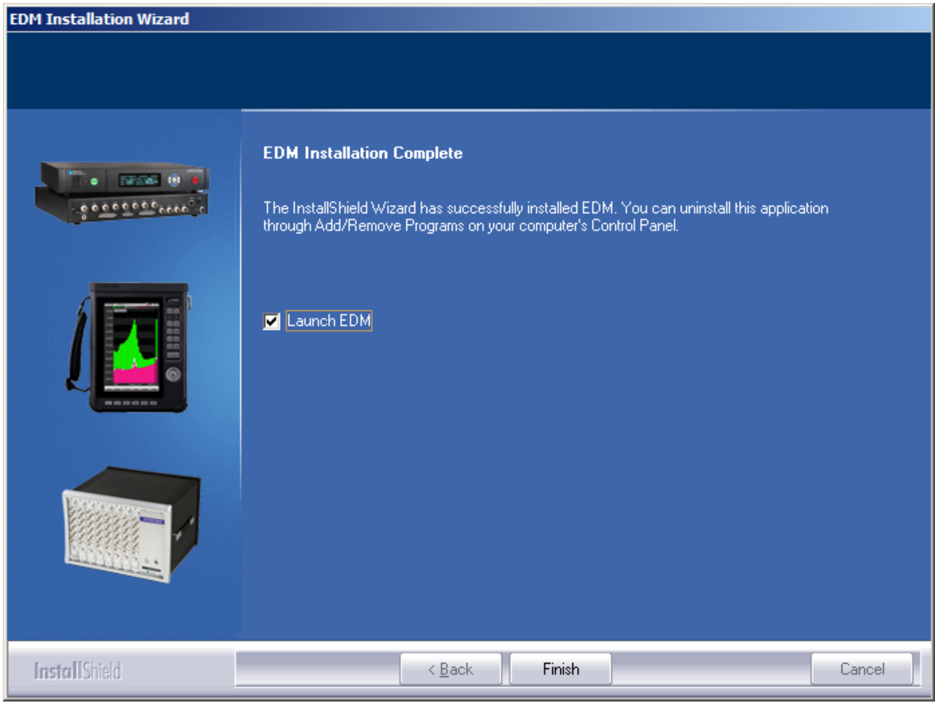


Figure 12: Completed installation page

Engineering Data Management (EDM) is PC software used for data management, post signal processing, viewing, reporting, and connecting Crystal Instruments hardware, the PC, and the data storage system. EDM provides connectivity to one or more CoCo or Spider devices. It provides data management tools to search through many tests and records, and view file properties or waveform characteristics. The analysis tools display data in a wide variety of formats and configurations to help identify important signal characteristics using cursors. The report tool documents the hardware configuration or data analysis results in a user formatted document.

EDM has two working modes for use with CoCo:

- **CoCo-80X DSA mode**: access CoCo-80X in its DSA mode, download, and view data files. CSA Editor, a tool for editing CoCo testing projects, will be included in this mode. This manual will cover information on the basic CoCo DSA functions.

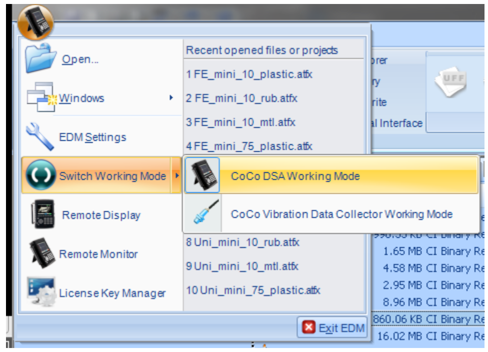


Figure 13: EDM DSA Working Mode

CoCo-80X VDC mode: creates a route data collection database, uploads settings to CoCo, downloads data to PC, and performs trending and alarm analysis. There are two versions of VDC modes: personal and enterprise. The personal version allows the user access the database on his local PC. The enterprise version allows multiple users access to the database over a LAN. For more information on VDC mode, check the CoCo VDC Manual.

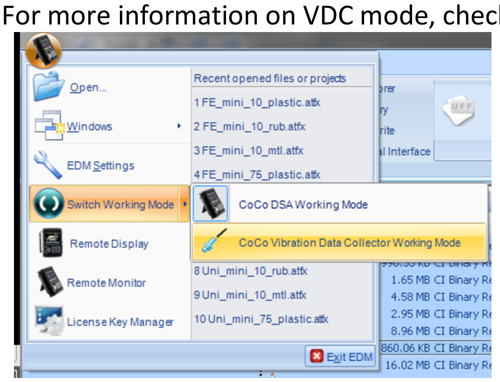


Figure 14: EDM VDC Working Mode

EDM software is registered to a CoCo device. To activate the EDM software, a valid License Key is required. EDM software uses a License Key file to enable or disable certain functions. License Key files are also used to control the Activation Period and Software Subscription Renew period. Multiple License Keys can be installed in one EDM installation. This allows one instance of EDM to run multiple Crystal Instruments devices.

A typical management page for license keys is shown below:

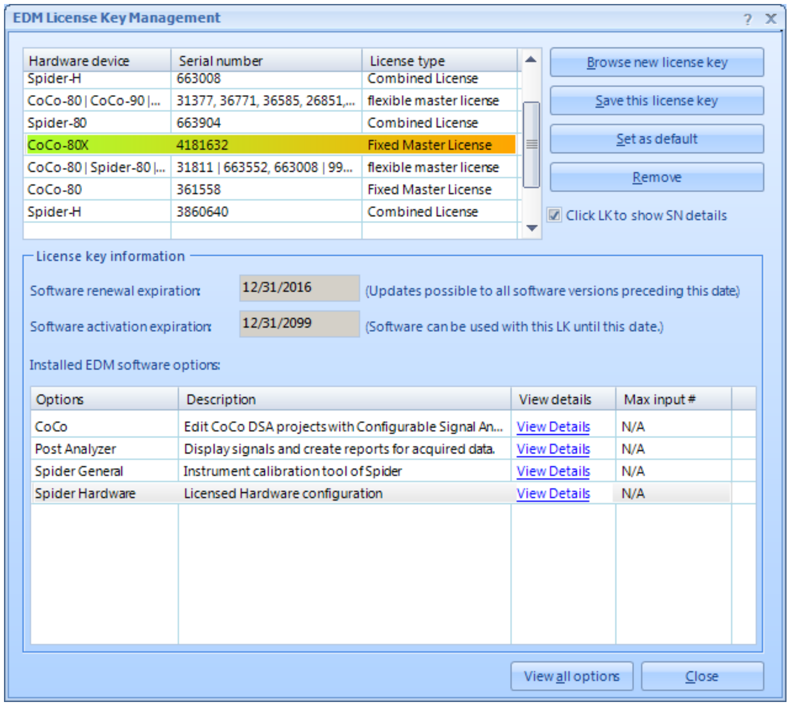


Figure 15: License Key Manager

Software Renewal Period: this is the time period that this EDM installation can be upgraded using the currently installed License Key. When the time expires, the EDM software will still be functional but cannot be updated.

Software Activation Period: this is the time period that this EDM installation can be used under this License Key.

Where is My License Key?

Your License Key is a file with extension of *.LIC. There are three ways to obtain your EDM software License Key:

(1) When your EDM Software and CoCo are shipped from Crystal Instruments, we will send out an automated email message providing shipping information, your License Key and the Serial Number of your instrument.

If you already have an evaluation copy of EDM software installed, you will use the License Key to obtain the additional features of EDM.

(2) If you have not received the automated email message, or do not have your License Key, retrieve the License Key by logging into the CI Technical SupportHYPERLINK "http://www.go-ci.com/support.asp"http://www.go-ci.com/support.asp using the CoCo serial number and the password provided

in the automated message mentioned above. and the password provided in the automated message mentioned above.

(3) Call Crystal Instruments Technical Support in the US at (408) 986-8880.

USB Device Connection

After the EDM installation is complete, the CoCo can be connected to the PC using any of the connection methods described below. Even if a USB cable is used as the connection, the USB driveris not required. .

Connect CoCo to the PC through the provided USB cable. This cable has a mini-USB connection to the CoCo and a standard USB 1.1/2.0 connection to the PC.

Other connection options such as Ethernet and Wi-Fi are available and are described in the following section of the manual.

EDM Software Update

After EDM has been installed, you should check for updates to the software that may be available. There are two ways to get update EDM:

- Log into the Technical Support Site via the Internet, download the EDM SETUP.EXE file to your computer, and install it manually.
- Request a new installation CD from CI.

Recording Time Streams with CoCo-80X

Push the power button on CoCo and wait for about 30 seconds until the Welcome screen is displayed. If the CoCo is not charged, connect the power supply to simultaneous power and charge the system.

Press Analysis button; use the **Up** or **Down** arrow buttons to select one of the CSA project files to run.

In the signal display screen, press **F2 (Param.)** and select **Time Stream Recording Setup** to define data streams for recording. To enable the recording for any signal, first use the up/down arrow navigation buttons to move to the signal, then press the Enter button to select or de-select.

Push the **Start/Stop Recording** button to record the signals. After a few seconds push the **Start/Stop Recording** button again to stop the recording.

Push the **File** button, then the **View File** soft button to review the recorded signals.

Download Data to the PC

Connect the CoCo to the PC using the USB cable, Ethernet cable provided, or the Wi-Fi. Note there are two USB ports on the CoCo-80X device. Connect the USB cable to the smaller USB-client connector shown below.

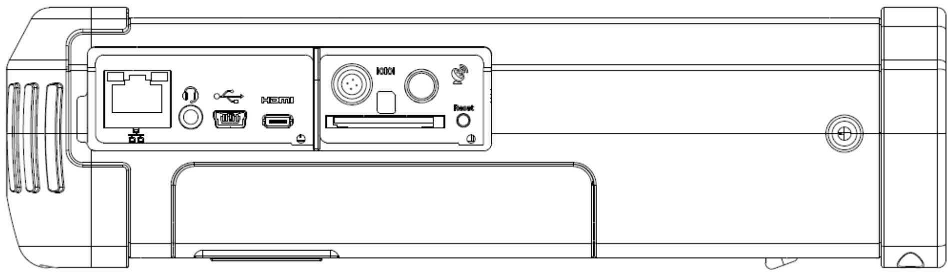


Figure 16: CoCo to PC USB Connection via USB Port on the Side of CoCo

Run the EDM software from the host PC.

Click **Search** in EDM to search for CoCo devices that are connected to the PC.

After the EDM finds the CoCo, click **Connect**.

Drag the data file from the CoCo (xxx.atfx) to a local folder.

Right-click on the signal file xxx.atfx in the local folder, and click **View** from the pop-up menu.

EDM will now switch to the View page. Drag the signal ch1 into the empty center area. The waveform that was just recorded will be displayed.

After completing this short Quick Start tutorial, refer to the following sections and review the complete User's Manual for a detailed description of the features and operating instructions.

Important Notice about the Concept of CSA

CSA stands for **C**onfigurable **S**ignal **A**nalysis. Each CSA is designed to capture a specific type of measurement. As a result, not all types of analysis are present in every CSA. For example, the CSA **Time(4)** only shows and records the time streams of the input channels and does not allow the use of a trigger, transient capture, or spectral analysis. Features for a specific CSA are defined using CSA Editor, a utility in EDM.

Basic CoCo Operation

This section provides a detailed description of the CoCo-80X device including the user interface, hardware, the Configurable Signal Analysis (CSA) projects, and peripherals.

CoCo User Interface

The CoCo-80X menu-driven user interface is easy to use and requires little training. Hard buttons on the front panel are used to enter function-specific menus. The buttons are divided into three areas: the *navigation buttons* are those arrow buttons and the Enter button; the *function buttons* include all hard buttons on the right panel; the six *soft buttons* located directly below the display change function depending on the current mode selection.

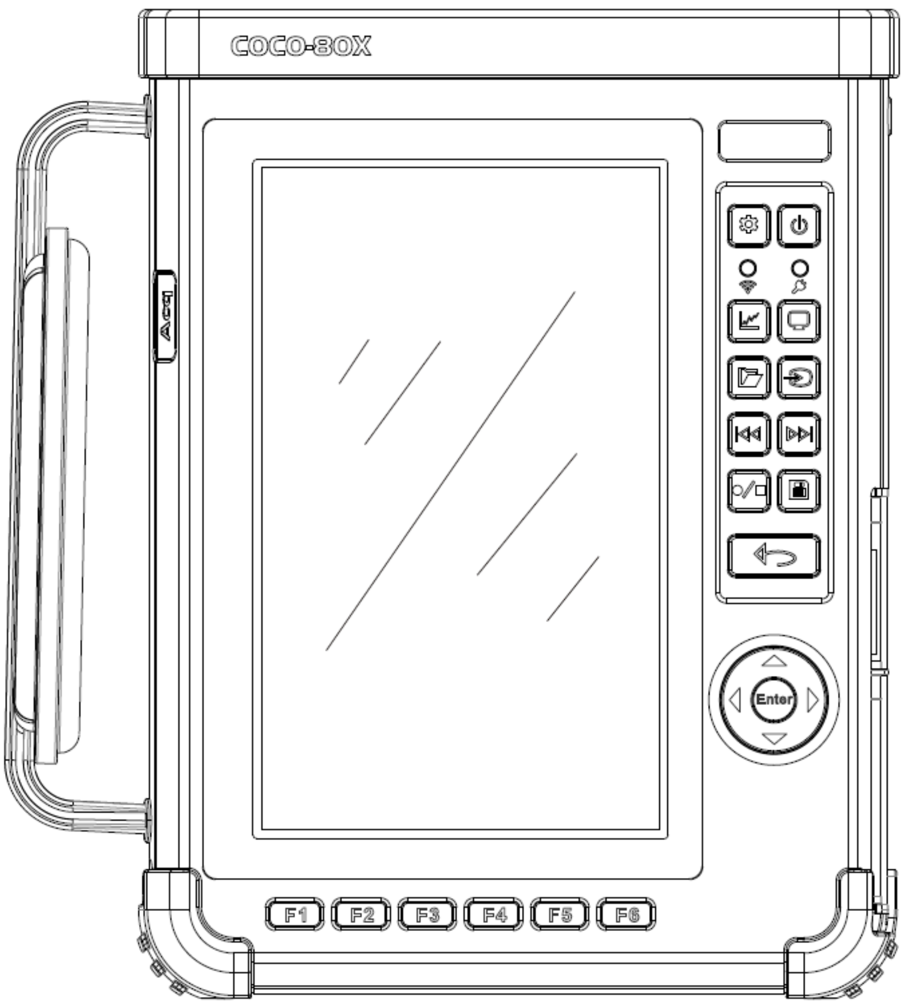
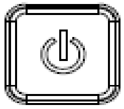
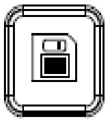
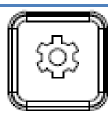
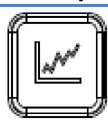
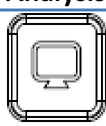
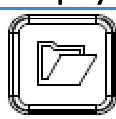
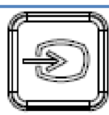
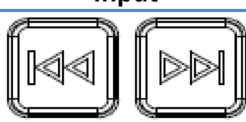
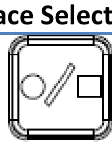


Figure 17. Button layout on the CoCo-80X front panel.

Summary of Buttons

The following table gives a brief description of the function of the buttons on the CoCo-80X.

Button Name	Functions
 Power	Power on/off the CoCo-80X or lock keypad
 Save	Save the signals designated by the CSA project
 Setup	Go to the main setup page
 Analysis	Open the "Analysis Groups" page to choose a CSA project
 Display	Switch to the current CSA project signal display (must have an active project running)
 File	View existing record files stored on CoCo memory.
 Input	Enter the input channel setup page
 Trace Selection	Go to previous or next trace window
 Recording	Start/Stop recording time stream(s)
	Save signal(s)

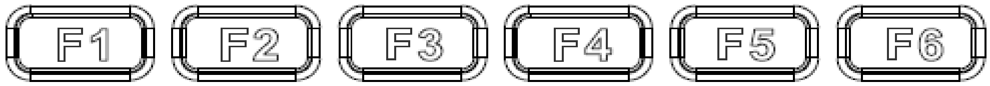
Save	
	
F1-F6 function buttons	Context-dependent function soft buttons

Table 1: CoCo buttons and common functions

Startup

Press the **Power** button to power on the unit. The initialization screen shows the startup progress. When the startup sequence is complete the Welcome Screen is shown.

Power off

To power off the unit, press the **Power** button and then select **Turn Power Off** and press **OK**. The Cancel soft button returns to the previous menu without powering off the unit. Lock keypad function can be selected instead of Power Off.

Arrow Buttons

The arrow buttons move the display focus between adjacent fields. Use the arrow buttons to select different fields, enter parameters, select other screens, and enter text. Arrow buttons can also be used for zooming, panning around a trace, or moving enabled cursor positions. In the trigger setup window, the arrow buttons can be used to move the threshold and trigger delay.

Enter Button

The **Enter** button is used to accept an entry or select an item on the display. To select an item, use the arrow buttons to move the focus to the item and then press the **Enter** button.

Soft Buttons

The **F1** – **F6** soft key functions depend on the active. Some soft buttons open new screens that include additional soft buttons.

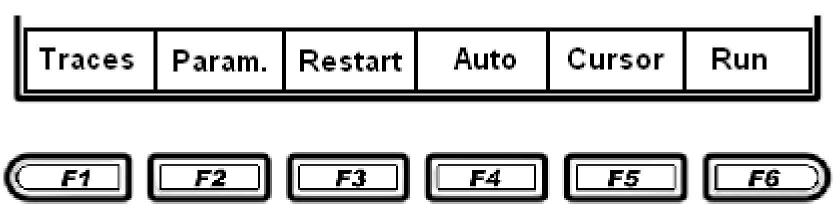


Figure 18: CoCo soft keys

Status Bar

The Status Bar indicates the status of the system.

Figure 19: CoCo-80X display Status Bar.

- Dynamic Signal Analyzer Main Setup Navigation indicates the name of the screen or provides information about the analysis such as sampling rate.
- Volume indicates the volume level for the internal speaker.
- Power indicates battery or line power.
- Battery status indicates the state of charge.
- Indicates whether a connection between the CoCo and a computer exists. A green check, as show, indicates a physical connection, a red x indicates connection problems.
- 12:39 System time displays the time (defined in the Setup screen).

Other statuses, such as sampling rate, number of averaged frames in spectral processing, and number of frames acquired will be displayed according to the running CSA.

Welcome Screen

The Welcome Screen is shown after the system has completed the startup sequence. It lists the five most recent CSA projects, as well as favorited projects and other functions (ex: date/time, network connection settings, etc.)

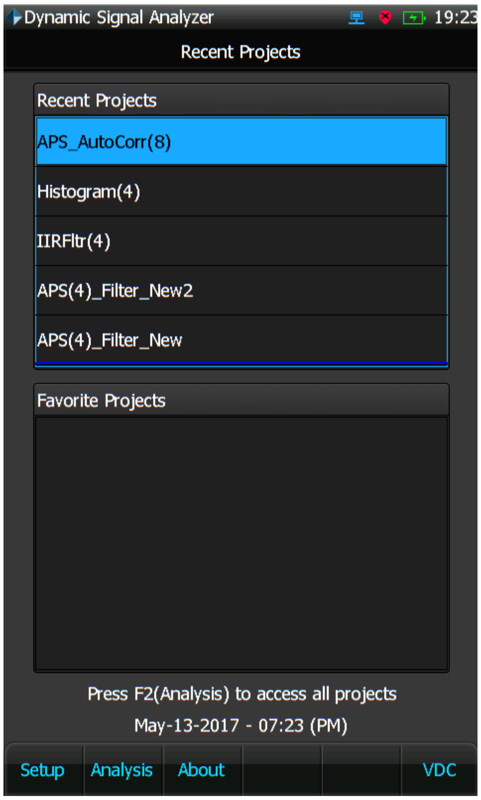


Figure 20: Welcome screen shown on startup.

Analysis Button

The Analysis Button brings up the Configurable Signal Analysis (CSA) groups.

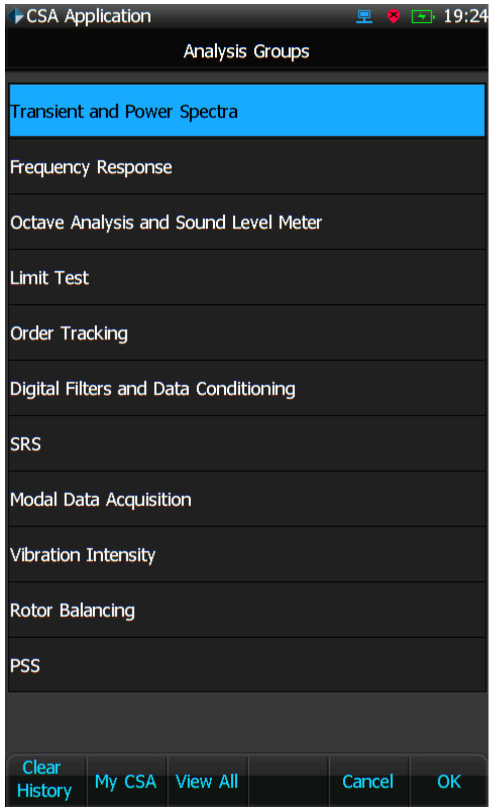


Figure 21: CSA Application Group

This screen shows several categories of applications. These categories mostly match the template that the CSA uses when it is created with a few exceptions: octave analysis and sound level meter applications are grouped in Acoustic Analysis group, and any CSA with limiting test are grouped in Limit Test group.

After entering one of the application groups, a list of the CSA projects is displayed in a menu on the left, with information about each project to the right. Use the **Up** and **Down** arrow buttons to select a project and read the description, maximum sampling rate, time last modified, and publisher information on the right. When additional CSA projects are loaded from a PC to the CoCo-80X, they will appear on the menu. After selecting one CSA project from the menu press the **F6 (Run)** soft button to load and run the CSA project.

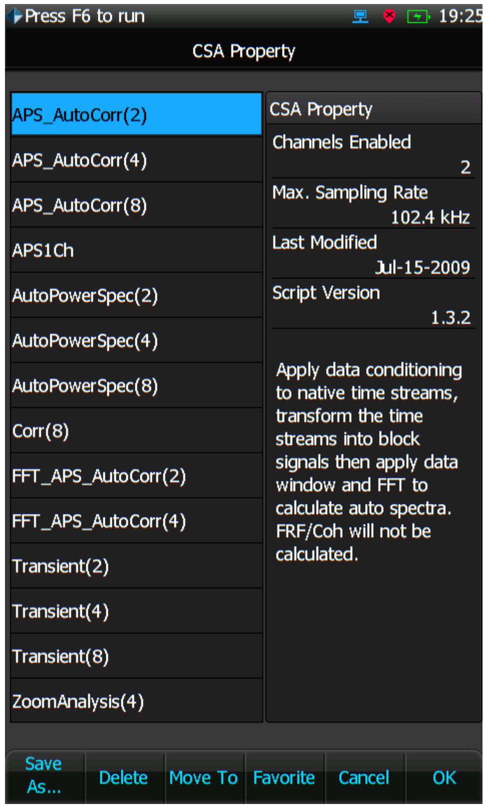


Figure 22: Analysis screen is used to select a CSA.

Save As... saves the current CSA project with a different name. This can be used to change project parameters and save the new project without overwriting the original project.

Delete removes the CSA project from the CoCo-80X flash memory. The CSA project can be reloaded from the PC if it is accidentally deleted.

Move to lets you move the CSA project file to another group.

Favorite gives the option of adding this CSA as favorite.

Cancel returns to the previous screen

OK loads the selected project and starts the display. The Enter button also loads and starts the selected project.

Display Button

The Display Button brings up the main Signal Display window. Pressing the Display button and Enter will always lead to displaying the current active window. This is the most frequently used window in this instrument.

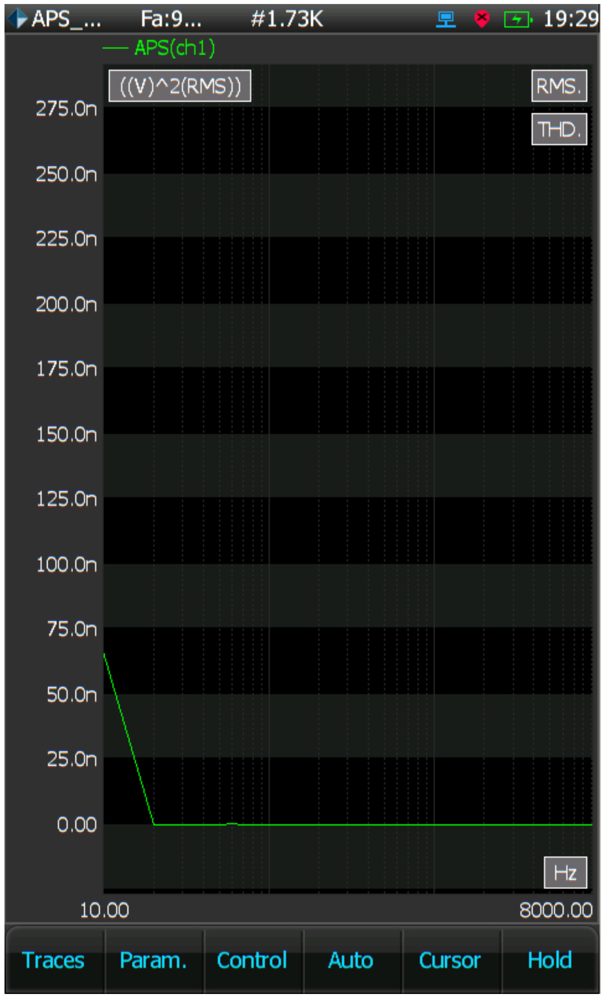


Figure 23: Display screen showing a window with one trace.

A signal display window can have either one or two traces. The software allows three types of signal display windows: a window with one trace, a window with top and bottom traces, and a window with a 3D waterfall trace. Some CSAs also have other displays available, such as bar graphs and color spectrographs. The picture below shows a window with two traces.

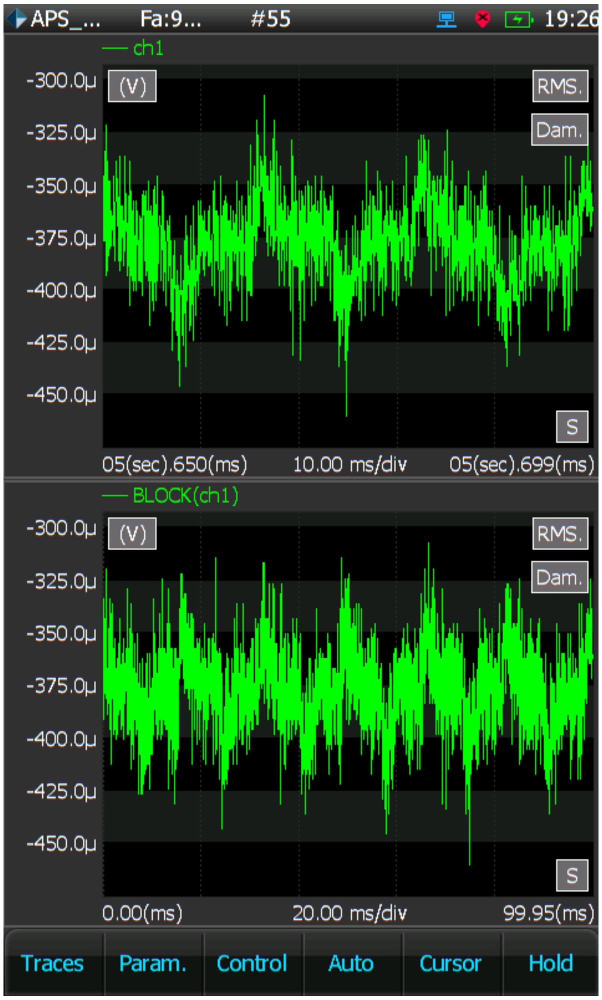


Figure 24: Two trace window.

A trace is defined as a display area with an axis that can show multiple signals of the same dimension such as time or frequency. Only the signals with the same engineering units in X and Y axis can be overlaid.

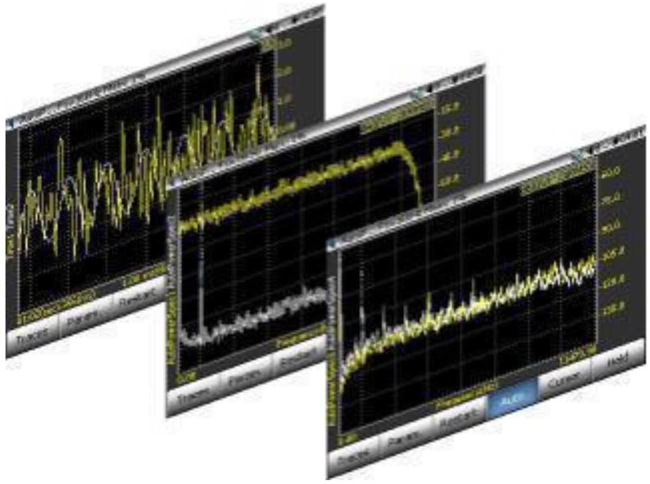


Figure 25. Multiple traces can be defined and multiple signals can be displayed in each trace.

The traces are periodically updated when the Display is in Run mode. To stop the trace updating, press the **F6 (Hold)** soft button. Note that the trace display updates independently from the Record operation. In other words, while traces are updated on the display, they are not recorded to memory until the Rec./Stop button is pressed.

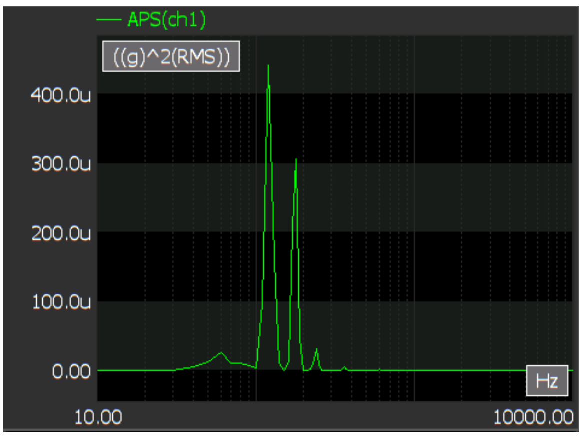


Figure 26: A single trace within a window

A trace typically consists of five objects:

1. The signal label on the top-left (displayed as APS(ch1) in this example)
2. The center display area (the area highlighted in red)
3. The view mode (displayed as ((g)^2(RMS)) in this example)
4. The vertical Y-scale range on the right
5. The horizontal X-Scale on the bottom

Pressing **Display** again while viewing a live signal window will bring up a menu to access to several trace functions.

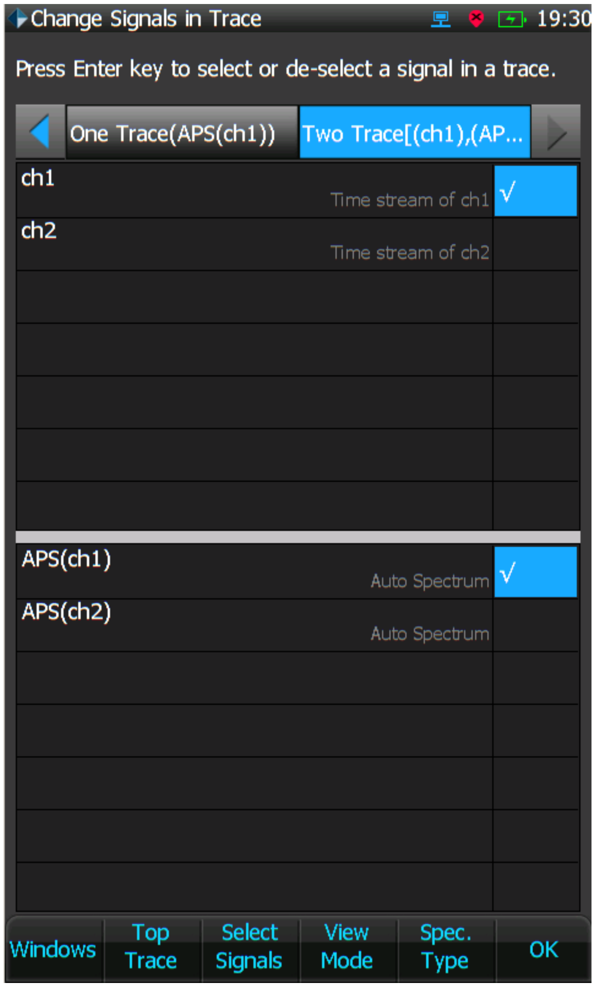


Figure 27. Window and Trace Settings

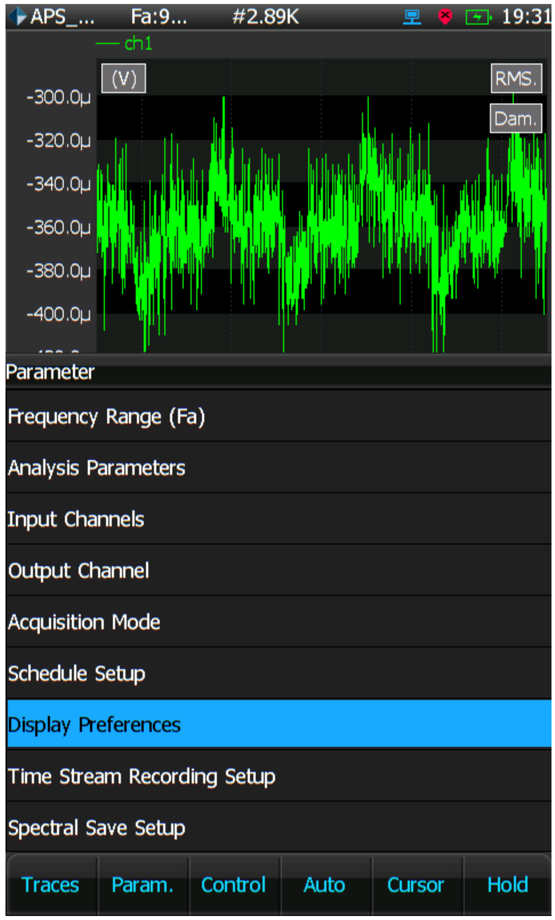


Figure 28: Display Settings

Display Preferences (under **Param.**) contains the settings for trace defaults, shown below. When the blue focus is on each item, press **Enter** to choose display preferences options from the dropdown menu. Finally, press **Apply** to save the changes and go back to the previous screen, or press **Cancel** to go back to the previous screen without saving any changes.

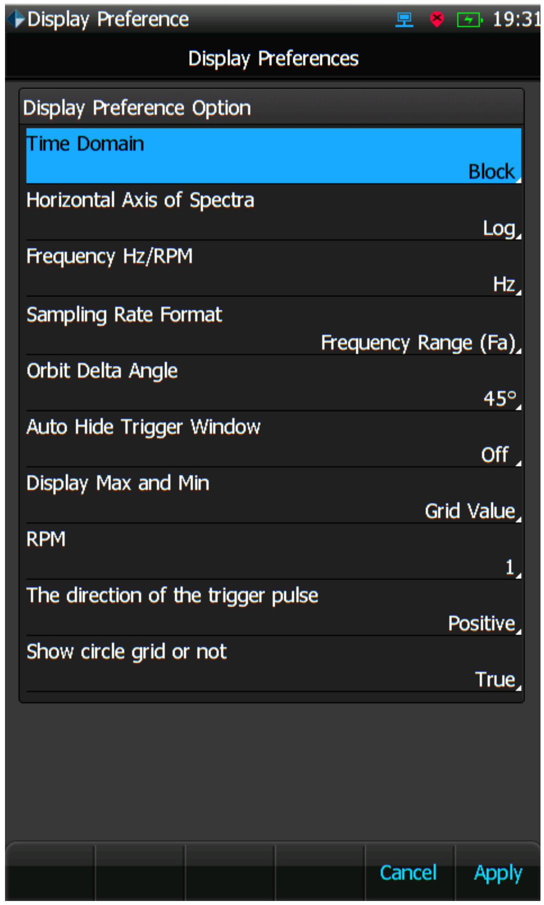


Figure 29: Display Preferences

~~**Auto Scale X-Axis** returns to auto scale status on the X-axis.~~

~~**Set Exact X-Axis** range allows CoCo to display the specific ranges on the X-axis.~~

~~**Set Exact Y-Axis** range allows CoCo to display the specific ranges on the Y-axis.~~

Signal Display Soft Buttons

Traces (F1)

Pressing **F1 (Traces)** opens the **Window and Trace Menu**. This menu lists the names of the existing windows in the display and is used to change the windows and signals in the display. The menu lists the defined windows at the top of the menu. The display can be changed from one window to another by selecting a different window from the menu and pressing **Enter**. Multiple windows can be created to provide a flexible display format.

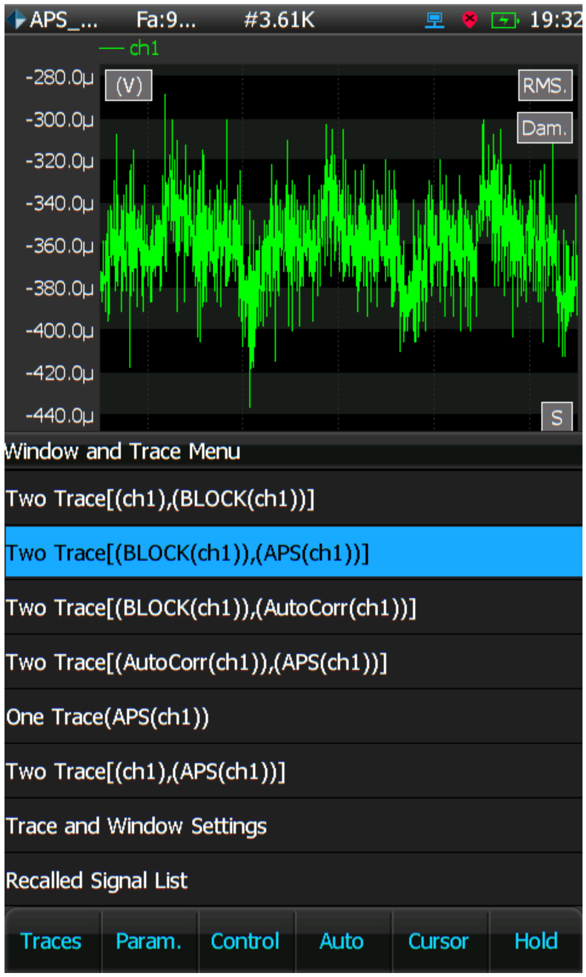


Figure 30. Window and Trace Menu.

Selecting **Window and Trace Menu** opens settings screen to add new windows and define which signals will be included in each trace.

To create a new window, select **Trace and Window Settings**, and press **F1 (Add Window)** to choose from a variety of window options (one trace, two traces, color map window, etc.)

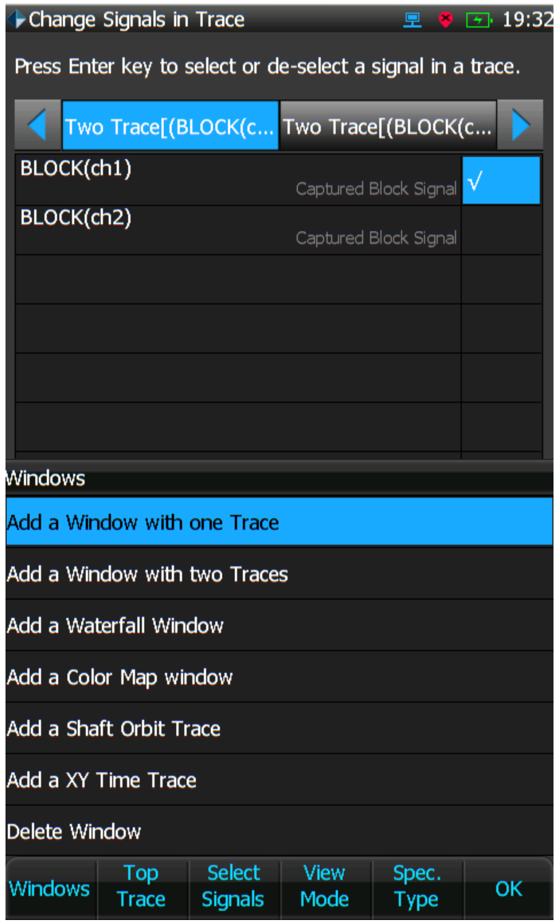


Figure 31: Options for types of new windows

After selecting the window type, enable the signal to be displayed in this window by pressing the **Enter** button. To simplify the user interface and optimize performance, only signals that are defined in the CSA as display candidates will be visible and available to be added to the trace. If a signal is not available for display then the CSA must be edited before it can be added.

After the first signal is selected, only signals of the same type will show in the list. Additional signals of the same type can be selected to overlay on a single trace.

To set up a window with two traces, first select **Add a Window with two Traces.** The following screen will be displayed:

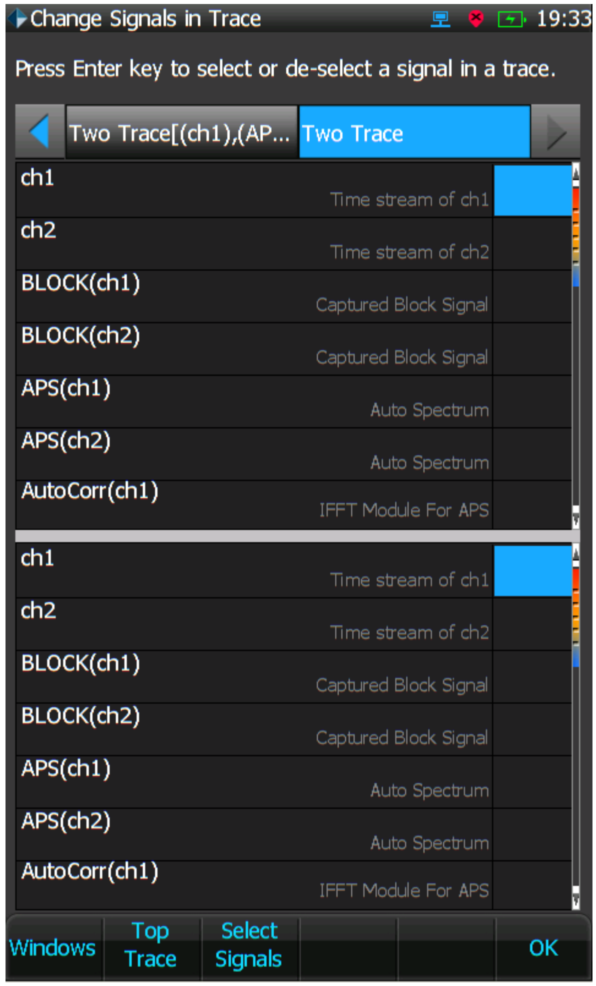


Figure 32. Edit window screen is used to add/delete window and add signals to each trace.

In this screen, the top and bottom trace can be defined by selecting appropriate signals in the same way as you set up the one trace window. To switch between top and bottom traces within the window, press **F2**.

View Mode changes the mode of the current display when it is the frequency domain data. The signals can be displayed in a graphic plot or as a text value. The text value can display different quantities such as RMS, Peak, and Average value of the signal. For graphic plots, the view mode also selects the ordinate scale type (linear, sarithmic, or dB). Depending on the type of plot (time stream, APS, etc), different selections will be available. The view mode can also be changed in the Display window, by pressing the **F1 (Traces)** soft button and selecting **Select View Mode for Current Trace.**

Other soft buttons under the Trace and Window settings control the windows in the current display. **Add Window** creates a new window in the Window List. Windows are named sequentially as Window1, Window2, etc. **Delete Window** removes the highlighted window from the Window List. **Clear Signals** removes all signals from the highlighted trace. **Select All Signals** adds all signals to the highlighted trace. **Cancel** returns to the previous screen without changing the trace definitions. **OK** saves the changes to the trace definitions and returns to the previous screen.

Param (F2)

Param opens the Parameter Settings Menu. This menu sets parameters for the sampling rate, input and output channels, triggering, spectral saving, and time stream recording.

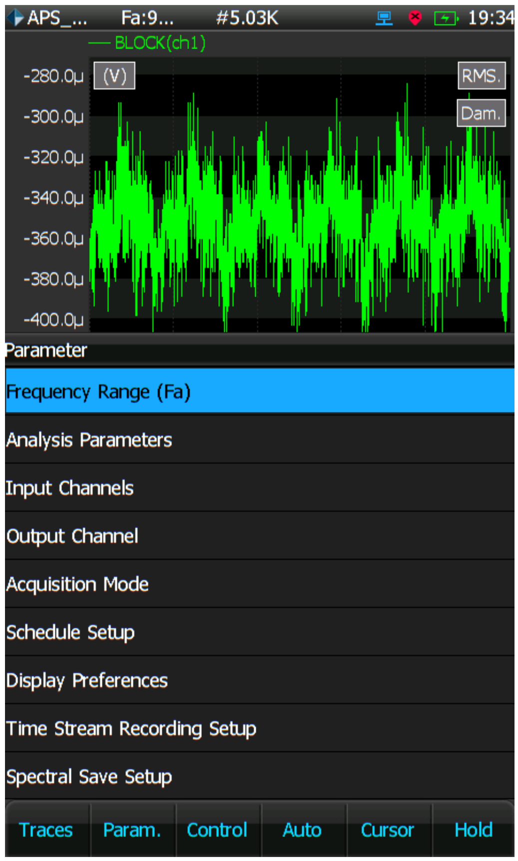


Figure 33. Parameter Settings menu.

Param -> Sampling Rate (fs)/Freq. Range(fa) is used to set the sampling rate or frequency range for data acquisition. Sampling rate and frequency are related: the frequency range is approximately 46% of the sampling rate. Use the **Up** and **Down** arrow buttons to select from the scroll menu and press **Enter** to accept the setting. Frequency range is a global setting that applies any loaded CSA.

Param -> Analysis Parameters is used to change parameters that are defined in the CSA project. These parameters depend on the selected CSA project but may include block size/line, window type, average mode, average number, weighting type, etc. Refer to the CSA project description in Section 4 for more details.

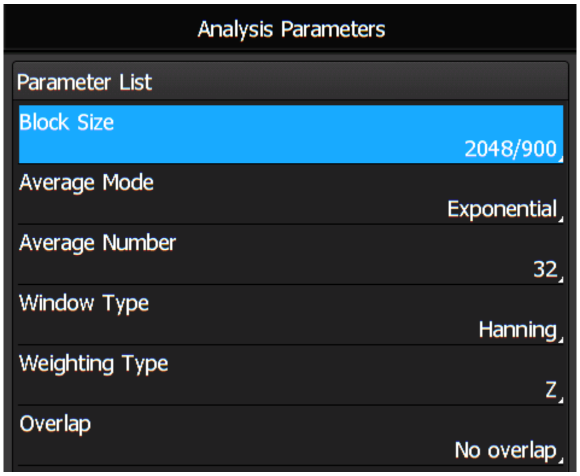


Figure 34. Analysis Parameters Setup Screen for A CSA Project.

Param -> Input Channels brings up the **Sensor and Channel Setting** window. It displays the peak magnitude of each channel over a small averaging time period. The vertical scaling of the bars is logarithmic, which helps the user see both large and small signals.

As long as the signals are within the full range, the measurement will be accurate (thanks to the high-dynamic technology implemented in the CoCo). However, if the signals are above the full range, overload will occur and the instrument will flash to warn the user.

Figure 35: Input channel setup table

The input channel table is used to set the sensitivity, input mode, and label for the hardware input channels. To edit these parameters, use the **Arrow** buttons to select or tap the parameter and press **Enter**. Input channel settings are global settings that apply any loaded CSA.

Input Channel Table Settings

Sensitivity is used to set the physical quantity, units, and sensitivity of the input channel. Use the arrow buttons to select the parameters and press **Enter** to select it. The parameters can be applied to all channels using the soft button **Apply to all Ch**.

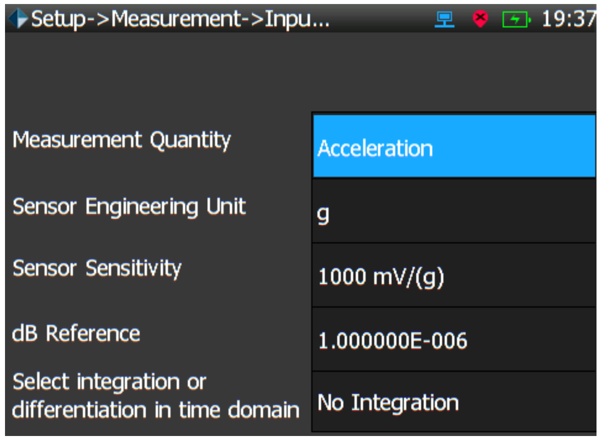
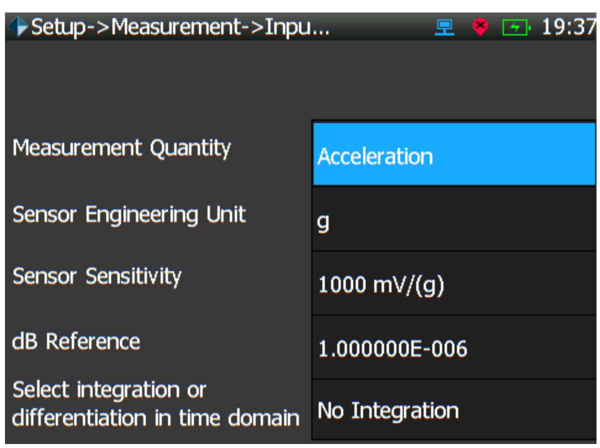


Figure 36: The sensor parameter menu

- **Measurement Quantity** defines the quantity such as acceleration, velocity, displacement, force, voltage, etc.
- **Sensor Engineering Units** defines the engineering units such as m/s^2, cm/s^2, g, etc. for the input channel.
- **Sensor Sensitivity** defines the sensitivity in **millivolts/engineering unit** defined in the unit menu.
- **dB Reference** defines the dB reference value for certain measurement quantities.
- **Select Integration/Differentiation** gives the options of No Integration/Differentiation, Integration/Differentiation, or Double Integration/Differentiation when the measurement quantity is acceleration, velocity, or displacement.

When the Measurement Quantity is set as Acceleration, a built-in integration or double-integration module may be used to generate readings in velocity or displacement. When the Physical Quantity is selected as Velocity, integration to displacement or differentiate to acceleration modules can be enabled. Note that the algorithms for integration are implemented in the digital domain and include a high-pass filter and DC removal routines.



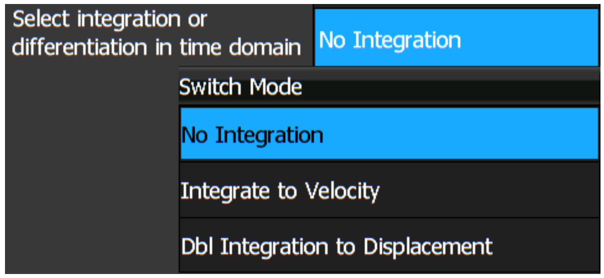


Figure 37. Apply built-in digital integration or double integration.

Input Mode is used to set the type of sensor being connected. The choices are AC-Differential, AC-Single Ended, DC-Differential, DC-Single Ended, and IEPE. For more details about these modes, refer to the later chapter Hardware->CoCo-80X Input Connections.

High-Pass Filter is used to define the cutoff frequency of a high-pass filter. The range is from 0.1 Hz to current frequency range.

Label is used to change the name of the signal. Use the alphanumeric keypad to enter a label name and press the OK soft button to accept it.

Param -> Output Channels is used to define the waveform for the output channel. Use the Up/Down arrow buttons to select from Sine, Triangle, Square, White Noise, Pink Noise, DC, Chirp, Swept Sine or Arbitrary Wave. When a signal type has been selected, pressing Right will shift the selection cursor to set the parameters for that type of output.

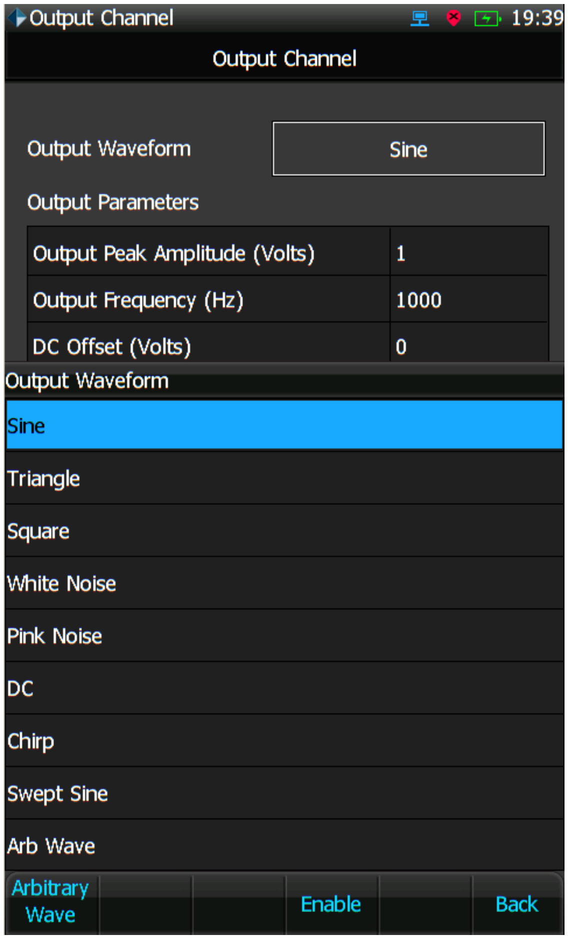


Figure 38. Output Channel screen.

For each waveform the parameter settings must also be entered such as range, frequency and amplitude. Output Channel is a global setting that applies to any loaded CSA. Once the parameters have been set, the output must be turned on by pressing **F4 (Enable)**. The output can be turned off by pressing **F4 (Disable)**.

When the **Arb waveform** is selected, an arbitrary waveform file must be selected to output. This file must be uploaded to the CoCo-80X through EDM before it can be used.

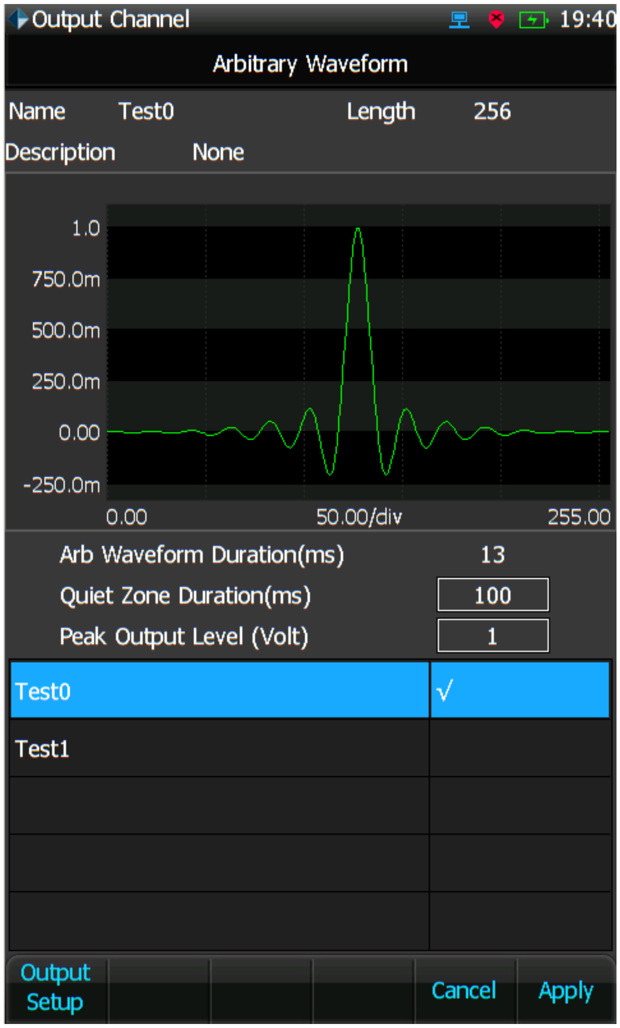


Figure 39. Arbitrary waveform setup.

In the arbitrary waveform setup, the duration is fixed by the number of points in the arbitrary data file and the sampling rate in use. The Quiet Zone is the time with "zero" output between two arbitrary waveform pulses. The Peak Output Level is the normalized maximum volt for the output waveform. Regardless of the value in the arbitrary file, it is always normalized to this peak level volt.

Param -> Trigger is used to enter Acquisition Mode and configurs the trigger, determining how data blocks are captured from the conditioned time streams into the signal analyzer phase. Use the F1-F6 keys to configure the Trigger Parametrs. The following trigger modes (press F1 to see the list) are supported:

- Free Run
- Continuous after Trigger
- Single Shot without Trigger

- Single Shot with Trigger
- Manual-arm Trigger
- Auto-arm Trigger

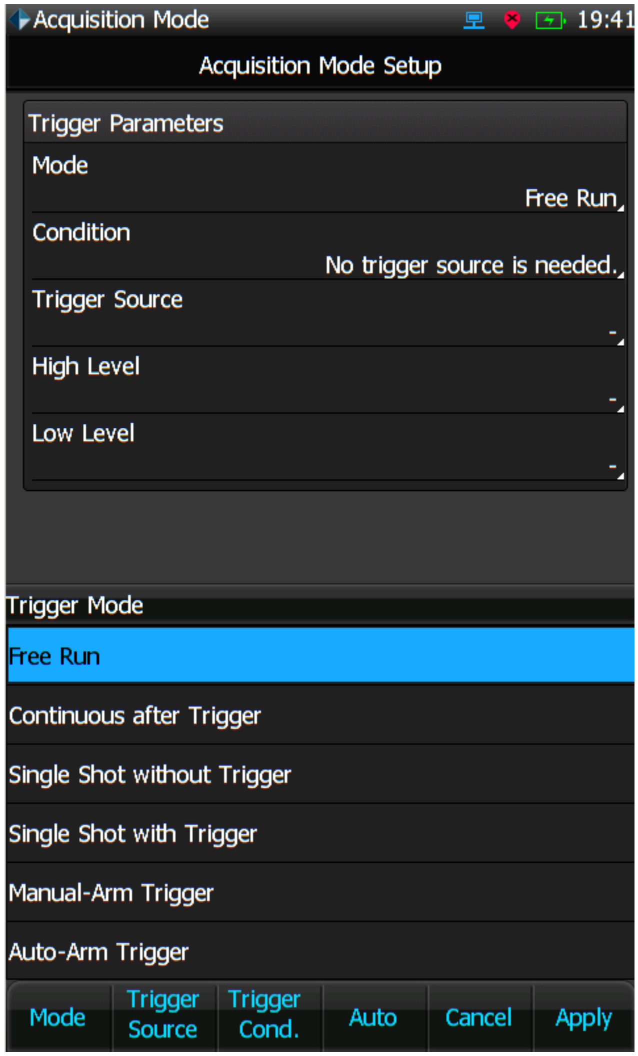


Figure 40. Acquisition Mode

It is important to note that the Acquisition Mode is designed for signal analysis functions only, such as spectrum measurements. The data conditioning process is not affected by the Acquisition Mode. For example, data recording will continue uninterrupted regardless of the Acquisition Mode. Acquisition Mode setting is dependent on the selected CSA.

Param -> Schedule Setup is used to configure automated test schedules.

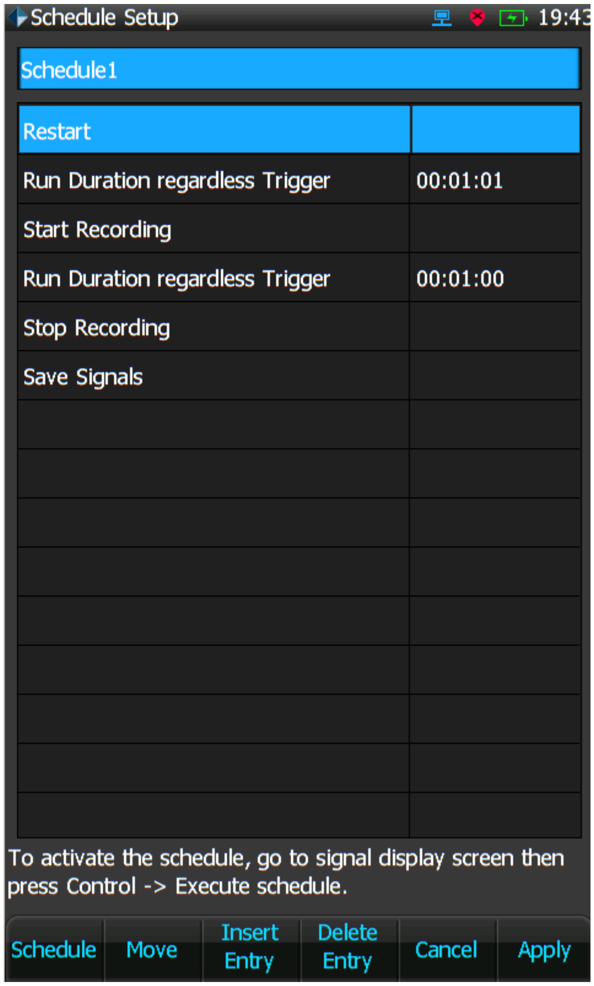


Figure 41. Schedule Setup.

The test schedule automatically controls the test duration and imitates human operation. Multiple testing schedules can be developed and one is executed at a time. A testing schedule event can include the following events: Loop/End-Loop, Run Duration, Hold, Limit Check on, Limit Check off, Start Recording, Stop Recording, Save Signals, Turn Signal Source On, Turn Signal Source Off, Reset Average, Set All Input Mode, Activate/Deactivate Timer to Save/Stop Saving, and Wait for One Time.

Use the F1-F6 keys to set the schedule setup: press **Schedule** (F1) to add or remove the selected schedule, and press **Insert Entry** (F3) or **Delete Entry** (F4) to modify the currently selected schedule. Use **Move / Fix** (F2) and the arrow keys to change the order of entries within a schedule. Press **Apply** (F6) to save the schedule setup.

Activating the testing schedule requires an extra step. This is designed to ensure the test schedule does not start inadvertently. To activate the testing schedule, go to the main signal display window and press the **Display** button for 3 seconds, then release. This will activate the test schedule. After the test schedule is activated, all the buttons, except the power button, F5 and F6, will be deactivated because the test is in the automatic mode.

To exit the automated schedule, press **Exit** (F6). To redo the schedule, press **Redo** (F5).

Figure 42: Restart or Exit a schedule

Using the testing schedule allows the instrument to divide the total measurement into multiple files, making it easier to retrieve and analyze. The picture above shows a typical schedule with loop/end loop functions. It allows the instrument to run on standby for 1 minute, record for 1 min, then save the spectral data. This is repeated 10 times.

When the schedule is activated, the schedule status will be displayed during run time.

Use the following formula to calculate the total time duration that you can record:

$$Total\ Installed\ Flash\ Memory\ in\ Bytes = (Channels\ Enabled) * (Recording\ Time\ in\ Seconds) * (Sampling\ Rate) * (8\ bytes) * (1.2)$$

Or

$$Recording\ Time\ in\ Seconds = \frac{Total\ Memory\ in\ Bytes}{(Channels\ Enabled) * (Sampling\ Rate) * (8\ bytes) * (1.2)}$$

For example, if 6 channels are enabled and the sampling rate is 100 Hz with 4GB memory installed:

*Recording Time in Seconds = 4GB/(6*100*8*1.2) = 4*1024*1024*1024/(6*100*8*1.2) = 745654 sec (= 207 hours)*

Param -> Display Preferences allows changes to display preferences. When the blue focus is on each item, press **Enter** to choose display preferences options from the dropdown menu. Finally, press **Apply** to save the changes and go back to the previous screen, or press **Cancel** to go back to the previous screen without saving any changes.

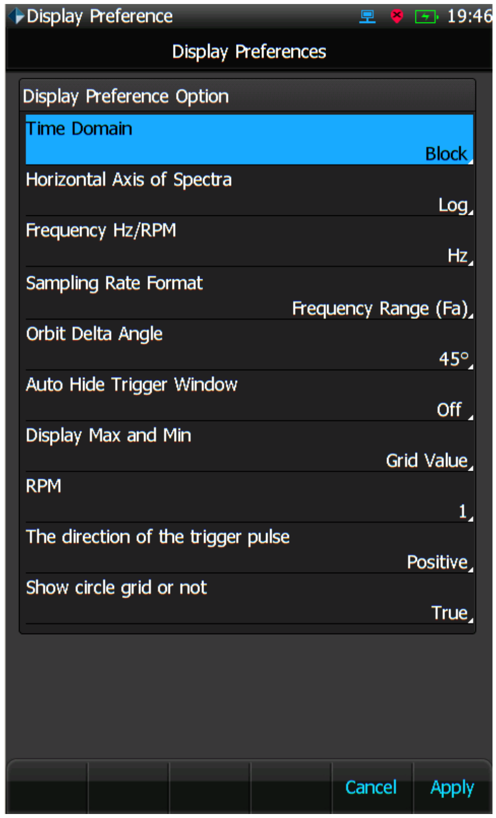


Figure 43: Display Preferences window

Param -> Time Stream Recording Setup defines which time streams will be recorded to memory when the **Rec./Stop** button is pressed. To add a stream to the record list, select it in the Signal List using the **Up** and **Down** buttons and press **Enter**. Note that adding more signals to the record list increases the file size of the recording and reduces the recording duration. Only streams that are of interest should be recorded to conserve memory and maximize recording time. **Time Stream Recording Setup** is dependent on the selected CSA. Note that only signals that are identified as **Record Candidates** in the CSA file will be visible and can be recorded. This feature is designed to simplify the CoCo-80X user interface and optimize device computation resources.

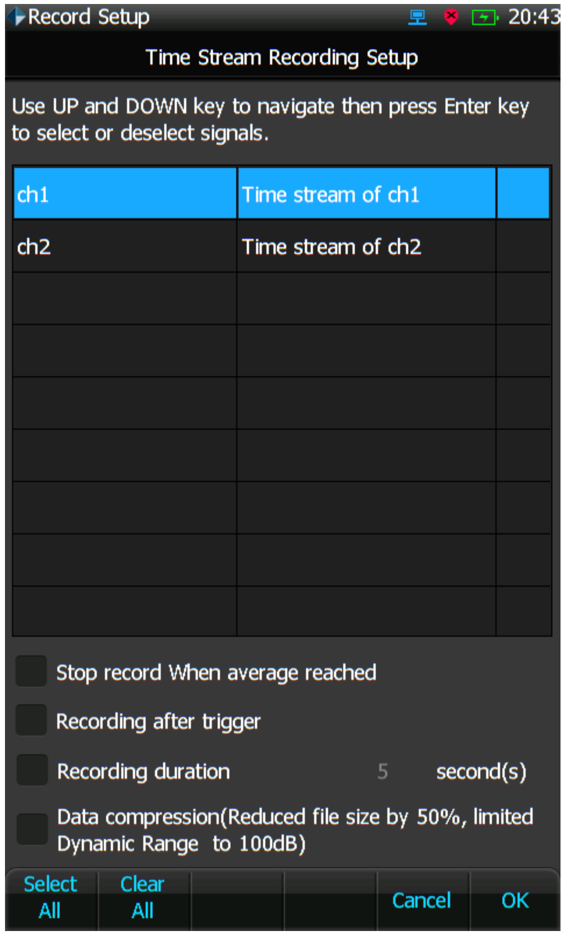


Figure 44: Select Time Stream channels for recording

Param -> Spectral Save Setup defines which signals will be recorded to memory when the **Save** button is pressed. To add a signal to the record list, select it in the Signal List using the Up and Down buttons and press **Enter**. **Spectral Save Setup** is dependent on the selected CSA. Note that only signals that are identified as **Save Candidates** in the CSA file will be visible and can be saved. This feature is designed to simplify the CoCo-80X user interface and optimize device computation resources.

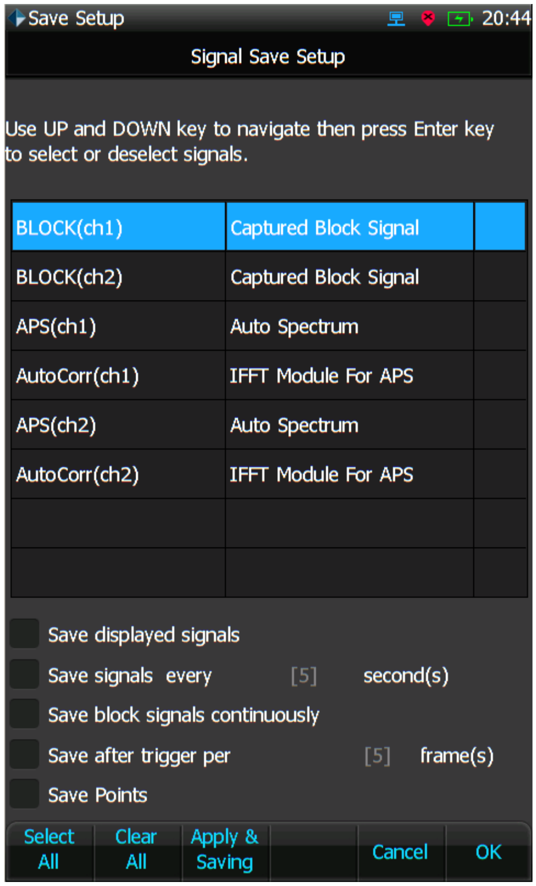


Figure 45: Select Spectral data to be saved

Control (F3)

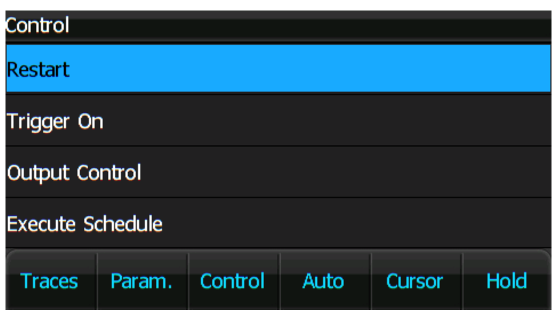


Figure 46: Control menu

Control -> Restart is used to reset the relative time base of the time streams and also reset the averaging and triggering if these features are used in the current CSA project. In some CSAs, where Restart is the only control option, F4 will display Restart rather than Control. Restart is used to control the running status without re-initializing the project and test.

Control -> Trigger On is used to setup trigger or turn on the preset trigger.

Control -> Output Control is used to setup the output channel including waveform type, amplitude, frequency, and so on. This allows user quickly editing the output parameters. Output must be turned on before the output control button can be used.

Control -> Scanner is used to activate the barcode scanner function. The user info and device info contained in a barcode can be read into the CoCo.

Control -> Execute Schedule is used to run the current schedule immediately. User will need to configure the schedule under the **Param -> Schedule Setup**.

Auto/Zoom/Move (F4)

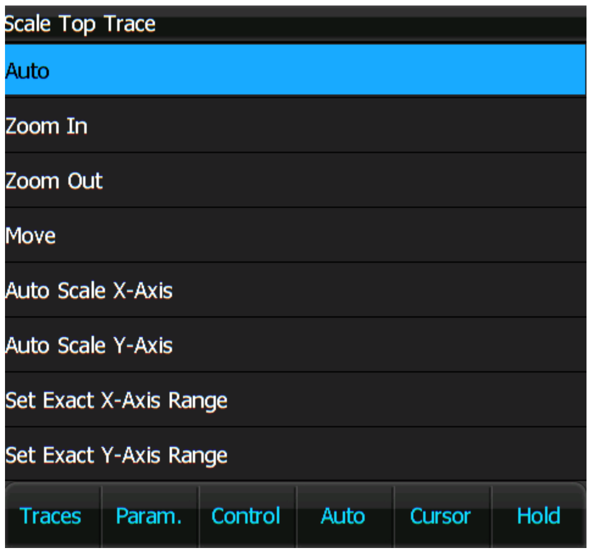


Figure 47: Auto-scale/Zoom/Move menu

Auto-Scale/Zoom/Move controls the vertical and horizontal scaling of the trace. When there are two traces, user must choose top trace or bottom trace before any actions. Auto applies an automatic vertical scale which continuously adjusts the axis to keep the signal near full scale.

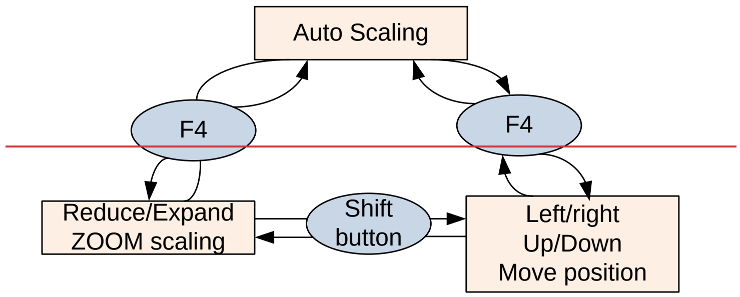
Zoom scale turns off the automatic scaling and uses the current scale regardless of the magnitude of the signals. When in the Zoom scaling mode, the four arrow buttons are used for the purpose of reducing or expanding.

When in the **Move** mode causes , the four arrow buttons are used for the purpose of to repositioning the window. The following diagram further explains the changes in the three different mode of using the navigation buttons:

Auto Scale X-Axis returns to auto scale status on the X-axis.

Set Exact X-Axis range allows CoCo to display the specific ranges on the X-axis.

Set Exact Y-Axis range allows CoCo to display the specific ranges on the Y-axis.



~~Figure 48. Trace navigation buttons.~~

Cursor (F5)

Cursor adds a vertical cursor to the trace. Use the **Right** and **Left** arrow keys to move the cursor. The signal values are listed to the right for all signals in a trace. Press the **Cursor** button again to remove the cursor from the trace. Tap and hold the cursor and drag it on the screen to move the cursor location.

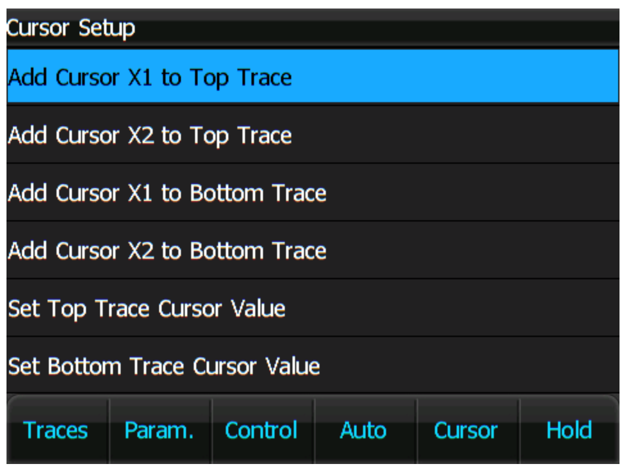


Figure 48. Cursors can be added to a trace.

Run/Hold (F6)

Run/Hold controls the display update and the signal analysis process. When the device is in **Run** mode the display updates the traces with the signals as fast as possible. When the device is in **Hold** mode the display stops updating. Note that **Run/Hold** is independent of **Record/Stop**. This means that when in **Run** mode signals are not recorded to memory until the **Rec./Stop** button is pressed. The record status is indicated by the red record icon blinking at the top of the screen during recording. It is important for you to understand the difference between **Run/Hold** and **Record/Stop** so that operator errors are not made when recording signals.

When in **Hold** mode, the signal analyzer will be held. Processing such as spectral analysis will be frozen.

Setup Button

The **Setup** button changes the screen to the Main Setup screen. Main setup includes both measurement settings and system settings. Use the arrow buttons to select one of the setting icons and press the Enter button to select it. Some systems settings are under **Other**. The system settings are described below.

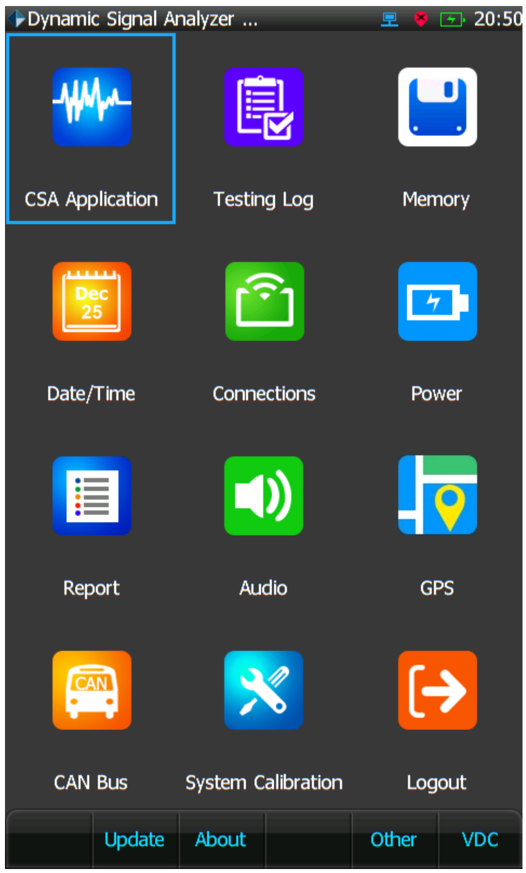


Figure 49: Main Setup Page

CSA Application is the equivalent to pressing Analysis button.

Testing Log records activities related to the tests. A sample of the testing log is show below.

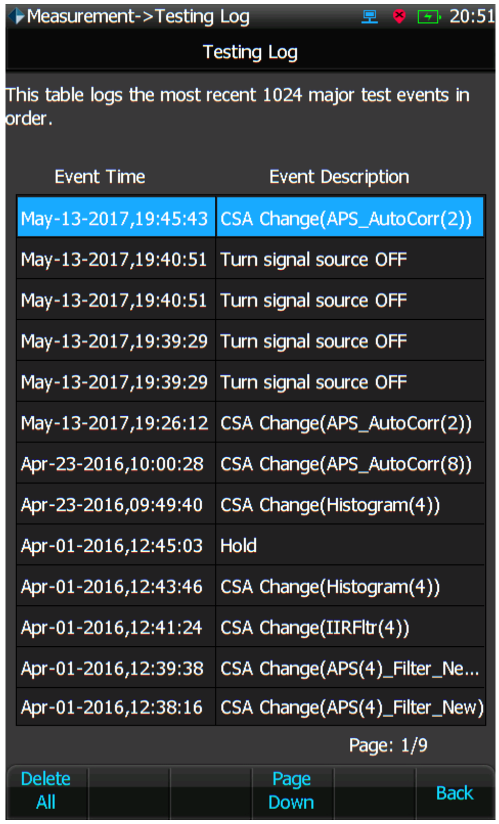


Figure 50: Test Log View.

Memory displays the status of the CoCo-80X memory. This includes local memory used by the CoCo-80X software and the flash memory used to store recorded data. This display can be used to monitor the remaining flash memory during field operations. When the flash memory is full the data must be downloaded to the PC and removed from the CoCo-80X before more data can be recorded.

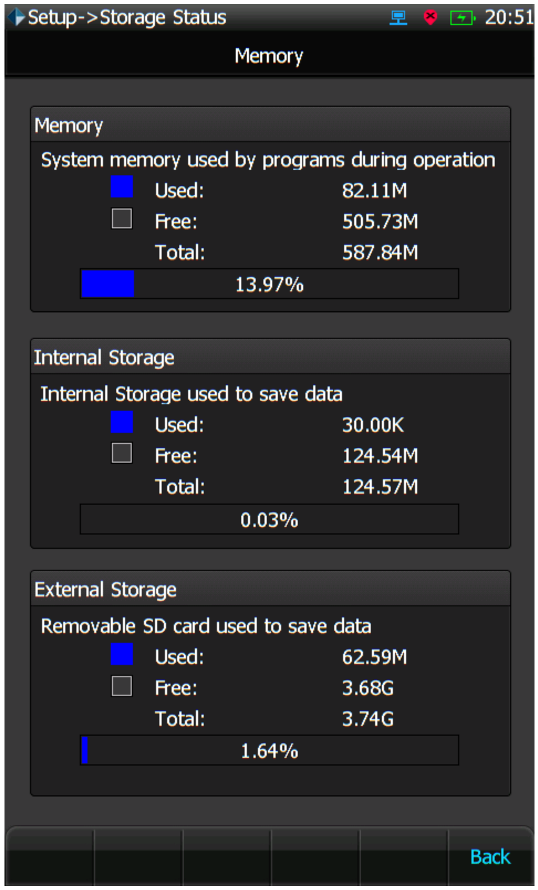


Figure 51: Memory and DSP CPU usage.

Date/Time sets the current date and time so a timestamp can be included as a file attribute with the data files.

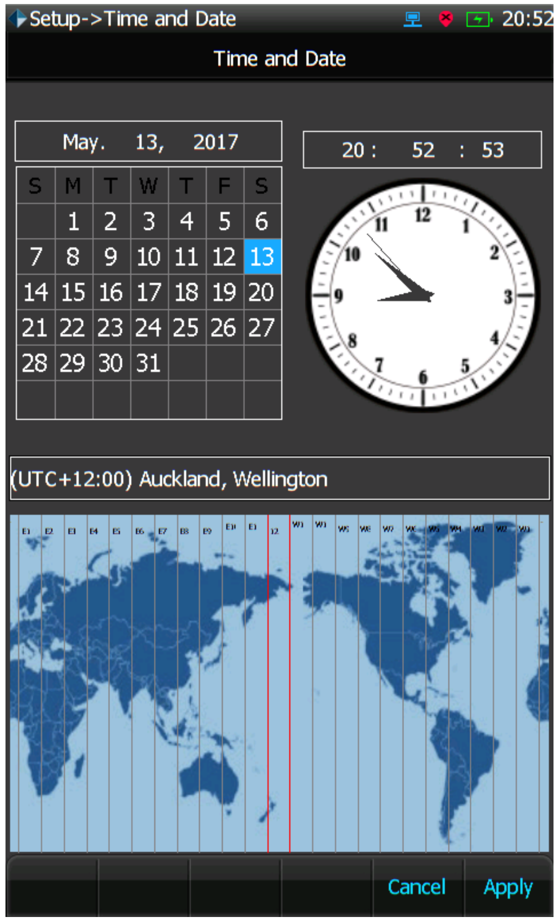


Figure 52: Date and Time Settings

Connections displays the status of the current IP address and MAC address of the CoCo. It also displays the connection status to the EDM, Internet, and CI Server. CoCo can use a static IP address or a dynamic IP address (DHCP) to establish the network connection. When the Wi-Fi feature is enabled, the CoCo will act as a DHCP server with an SSID named with its serial number and the CoCo name. The host PC can actively connect to the CoCo network via its wireless adapter.

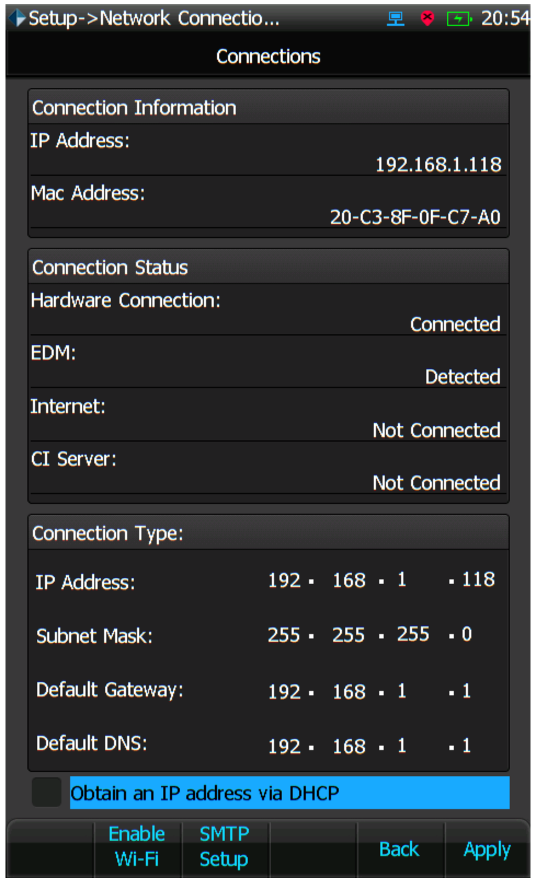


Figure 53: CoCo Connection Configuration

Power indicates the status of the power options and the power statistics including the remaining capacity of the battery and charging status of the battery. The Reset Value resets the total time on battery.

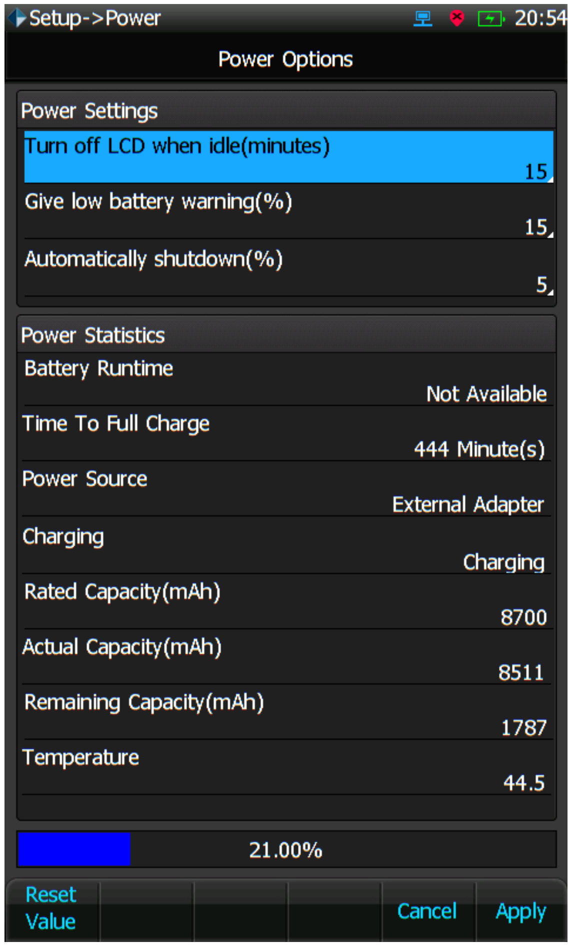


Figure 54. Power Status Screen.

F2 (Update) allows the CoCo to check for new software components on the Crystal Instruments server and conduct online software updates. The CoCo must be connected to the Internet using Ethernet when an on-line update is performed.

Reports contains all the testing reports from your tests. The schedule setup allows for testing reports to be automatically generated. This report includes basic information about the device, as well as input channel settings, parameter settings, trigger settings, and a screenshot.

F3 (About) displays hardware and software version information, software subscription period, and calibration status.

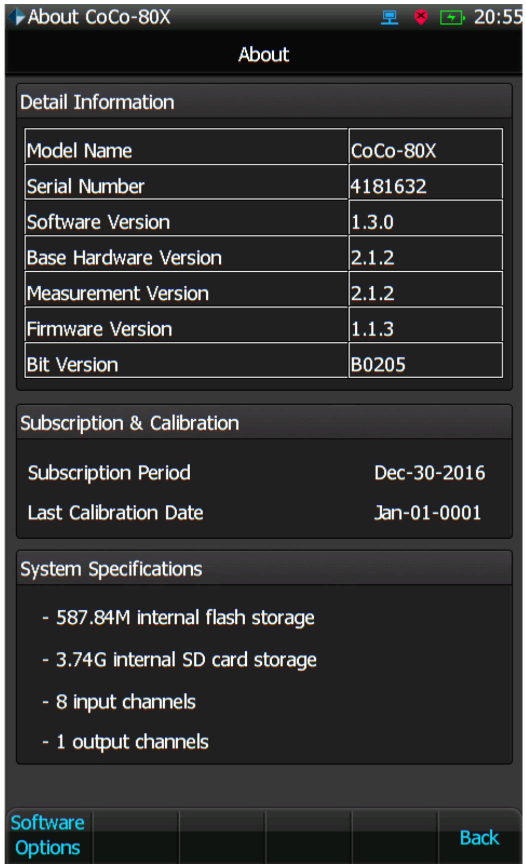
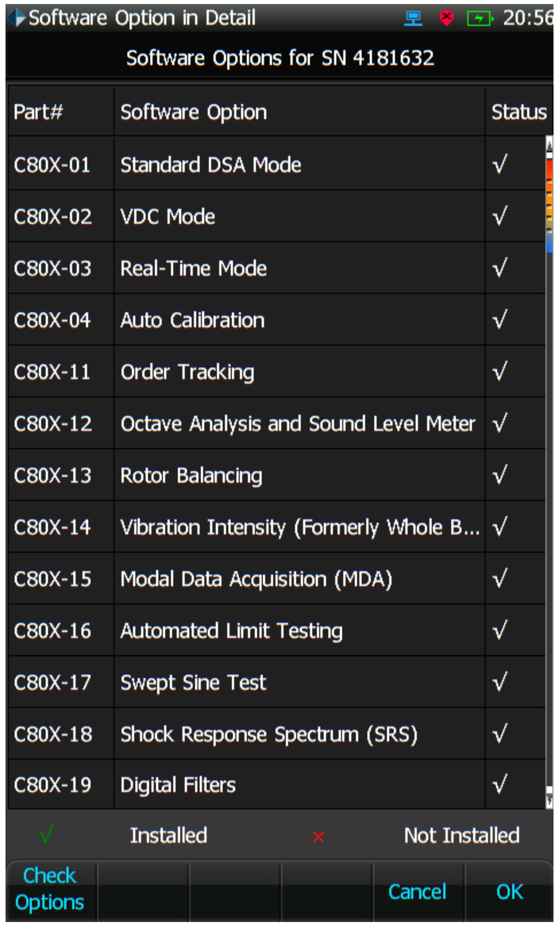


Figure 55. CoCo Hardware and Software Information

The **F1 (Software Options)** button will display all CoCo options and indicate which are installed.

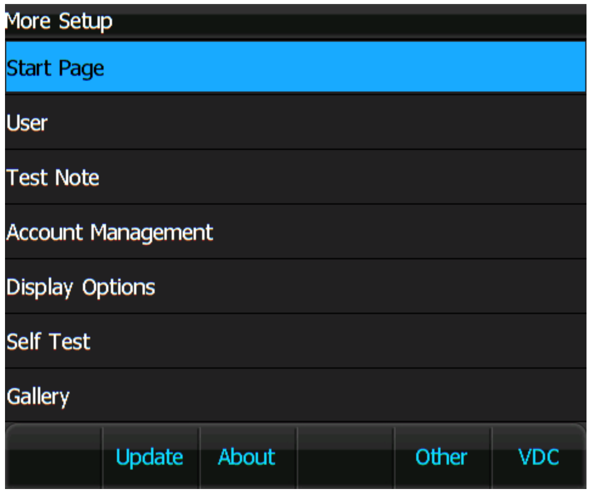


Part#	Software Option	Status
C80X-01	Standard DSA Mode	√
C80X-02	VDC Mode	√
C80X-03	Real-Time Mode	√
C80X-04	Auto Calibration	√
C80X-11	Order Tracking	√
C80X-12	Octave Analysis and Sound Level Meter	√
C80X-13	Rotor Balancing	√
C80X-14	Vibration Intensity (Formerly Whole B...	√
C80X-15	Modal Data Acquisition (MDA)	√
C80X-16	Automated Limit Testing	√
C80X-17	Swept Sine Test	√
C80X-18	Shock Response Spectrum (SRS)	√
C80X-19	Digital Filters	√

Figure 56. Software Options.

The **F1 (Check Options)** button will check the CI Server for available software options that can be installed.

F5 (Other) has five more options to setup.



F5 (Other) -> User shows the information recorded for the user of the hardware including Name, company, address, telephone and email and appends the information as an attribute to all data files. This information can be edited by selecting it with the **Arrow** buttons or tapping it, and pressing **Enter**.

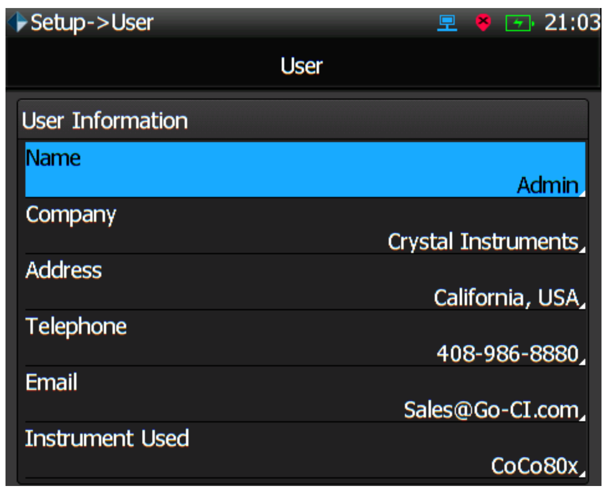
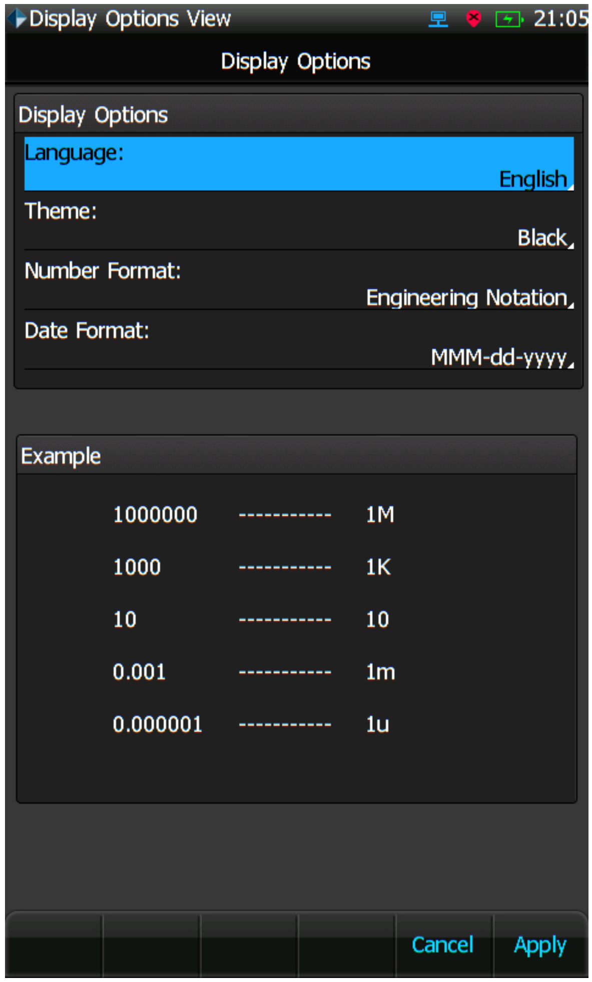


Figure 57. CoCo User Information

F5 (Other) -> Test Note allows use adding the test note to a test.

F5 (Other) -> Account Management creates users' accounts with various privileges. An account name and password can be created to protect the device from unauthorized use. Each account has an option list. All or part of options listed can be enable or disabled for specific accounts. Refer to the Account Management section for more details.

F5 (Other) -> Display Options has the option to set language to English, Chinese, Japanese, French, and Spanish. Two background theme colors, black and white, are available for use. Three number formats: floating point, scientific notation, and engineering notation are available, for displaying numbers. The different data formats are customized depending on the country.



File Button

The File button displays a list of all the data files saved and recorded to CoCo memory. The files are listed with creation time and total size. The overall capacity, used space, and free space are shown at the top of the window.

Use the **Up** and **Down** arrow keys to scroll through the list. Use the **Left** and **Right** arrow keys to move between pages. One or multiple files can be selected by highlighting them and pressing **Enter**. Some of the file operations, available through the soft keys on the bottom of the display, will work on all the selected files at once.

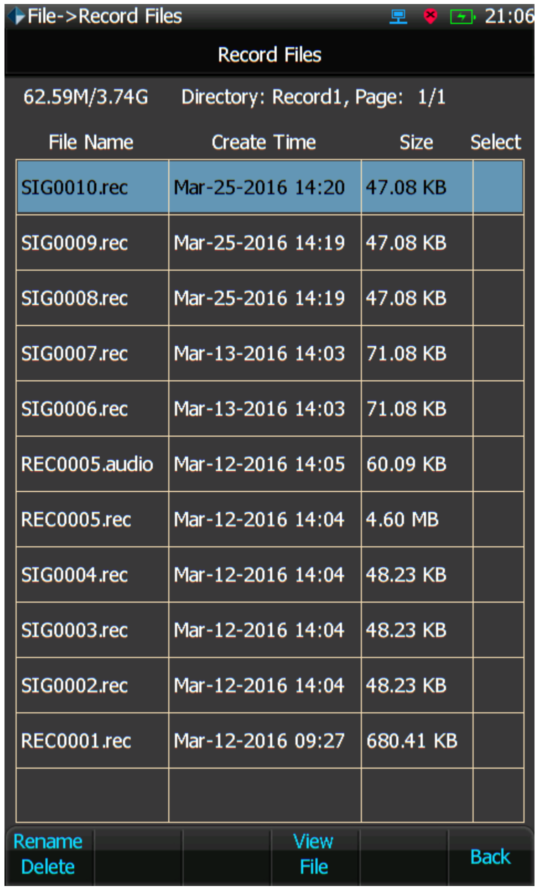


Figure 58. File display

Rename/Delete -> Rename changes the name of the selected file

Rename/Delete -> Delete Selected deletes the currently selected file

Rename/Delete -> Delete All deletes all files from the flash memory at once.

View File shows a summary of the currently highlighted data file. The **Text/Plot** soft button toggles between a text summary of the signal and a simple graphic preview.

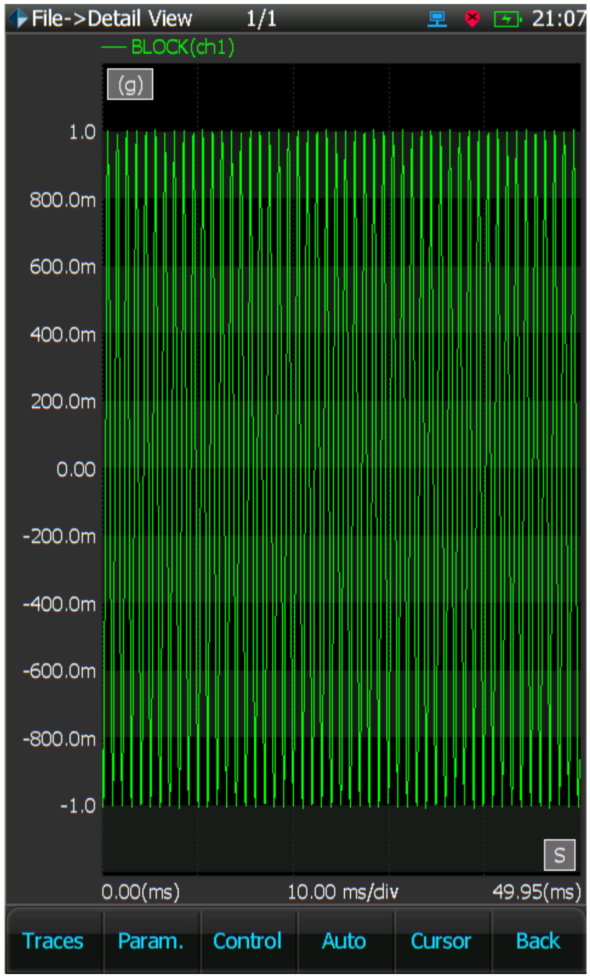


Figure 59. View the file content per signal.

Another way to view the full signal is to **Recall** it, which adds it to any of the currently defined live signal display windows. To recall a signal, press the **F4 (Recall)** button:

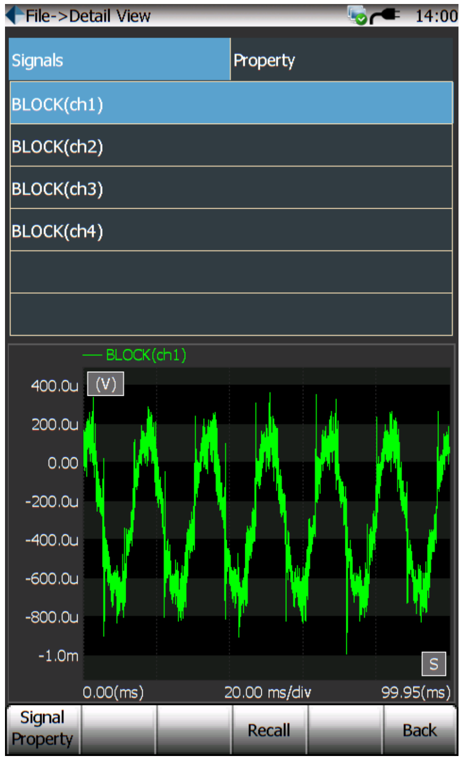


Figure 60: Recalling data files

A signal can be recalled into an existing trace or a new trace. Recalling into an existing trace will plot this signal over the other signals in that trace.

The signal can also be played back through the output channel of the CoCo. To do this, press **F5 (More Operations->Playback)**, and then press **F1 (Start Output)**. All annotations attached to this signal will also be displayed in this view.

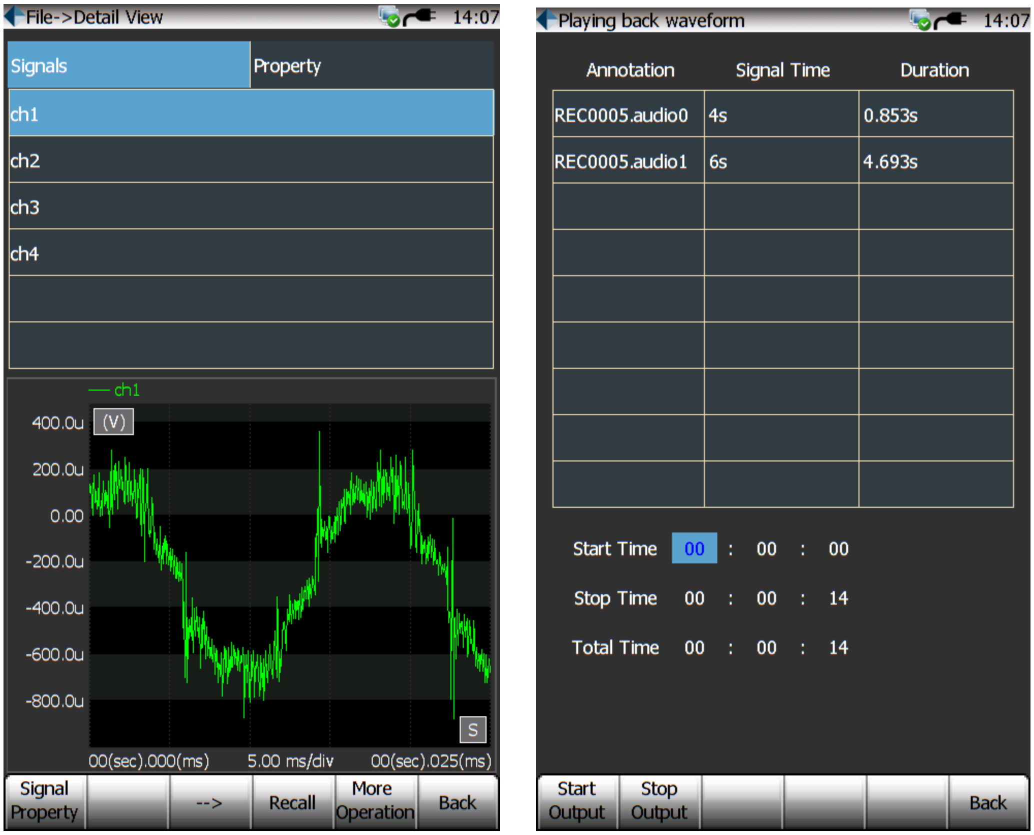


Figure 61: Playback recorded signals

Rec./Stop Button

Pressing **Rec./Stop** will start or end a time stream recording. The CoCo will function similarly to a tape recorder, recording all data from the selected inputs continuously until **Rec./Stop** is pressed again or there is no remaining memory. Recording files are named RECxxxx.

Time Stream Recording Setup from the **F2 (Param.)** menu specifies which channels are recorded and where they are saved.

Time stream data can be uploaded to a PC with EDM for further viewing and analysis of the recordings.

Save Button

The **Save** button is used to save block signals to memory. These include transient time signals and spectra signals, which, unlike time stream data, are a snapshot of a single block of data at the time the **Save** button is pressed. This can be used to capture averaged spectra or transient events at any time. Block and spectral data are saved by default as SIGxxxx.

The **Spectral Save Setup** menu in **F2 (Param.)** contains settings for which blocks are saved and where they are saved.

When the CoCo-80X is connected to a PC, the saved block signals can be downloaded using the EDM software.

Previous/Next Trace Button

The Previous/Next Trace button is used to switch to the next trace if multiple traces are available during the test. For example, the current test has the first trace displaying the time signal, the second trace displaying the block signal, and the third trace displaying the spectral signal. If the CoCo is displaying the time signal, pressing Previous/Next Trace will display the block signal. Pressing Previous/Next Trace again display the spectral signal.

View Mode Button

The **View Mode** button is used to switch among various view modes. Current available view modes include signal plot, current value, peak value, peak-peak value, maximum value, minimum value, averaged value. This function is only effective when signals are displayed.

(User) Button

The **(User)** button can be set as a shortcut to a specific CSA. When CoCo is conducting a test, press and hold this button for 3 seconds to enable it. When in a different CSA, pressing **(User)** will switch directly to the preset CSA.

Recall Button

The Record button is used to recall signals. The saved signal can be recalled to a new window or a current window with the same type of signals.

Input Button

The **Input** button displays the input channel table and allows further editing. This can also be accessed from **F2 (Param.) -> Input Channels** settings.

The input channels table is used to set the sensitivity, input mode, and label for the hardware input channels. To edit these parameters, use the arrow buttons to select the parameter and press **Enter**. When the **Input Channels** menu item is selected, the channel status screen will be shown. It displays the peak magnitude of each channel over a certain period of time. The vertical scaling of the bars is logarithmic. The log scaling allows for viewing both large and small signals.

Thanks to the high-dynamic technology implemented in the CoCo, as long as the signals are within the full range, the measurement will be accurate. However, if the signals are above the full range, overload will occur and the instrument will flash to warn the user.

The sensor table is used to set the physical quantity, units, and sensitivity of the input channel. Use the arrow buttons to select the parameter and press **Enter** to select it. The parameters can be applied to all channels pressing **F1 (Apply All)**. The input channel sensors and sensitivity all can be set up in either EDM or in the CoCo.

Figure 62: VDC Analysis Input Channel Sensor Setup

Sensitivity is defined in *millivolts per engineering unit*. The **Engineering Unit** is dependent on the **Measurement Quantity** selected. This selection opens a numeric keypad to enter the sensitivity value. Press **F6 (OK)** to accept the value.

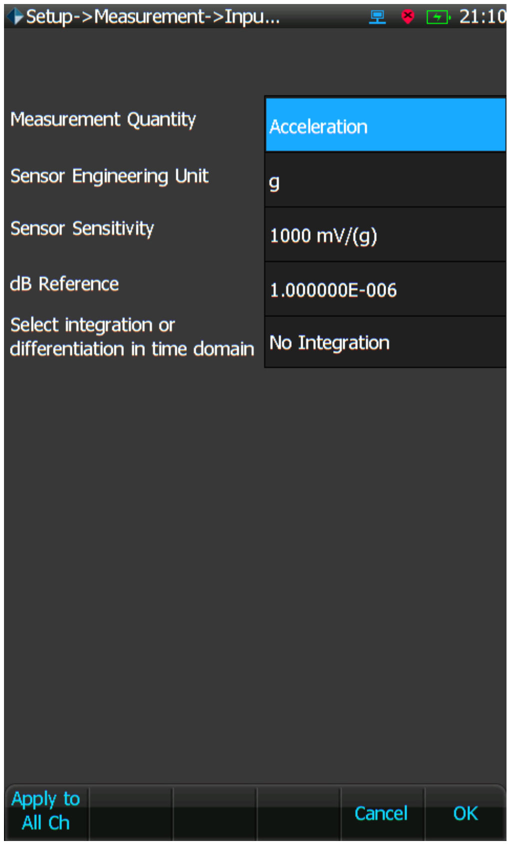


Figure 63: Input Channel & Sensor Setup, adjusting sensitivity in CoCo

When the Physical Quantity is set to Acceleration, a built-in integration or double-integration module can be applied to generate readings in velocity or displacement, respectively. When the Physical Quantity is selected as Velocity, **Integration to Displacement** and **Differentiate to Acceleration** are available. Notice that the algorithms for integration are implemented in the digital domain. They also included a high-pass filter and DC removal routines.

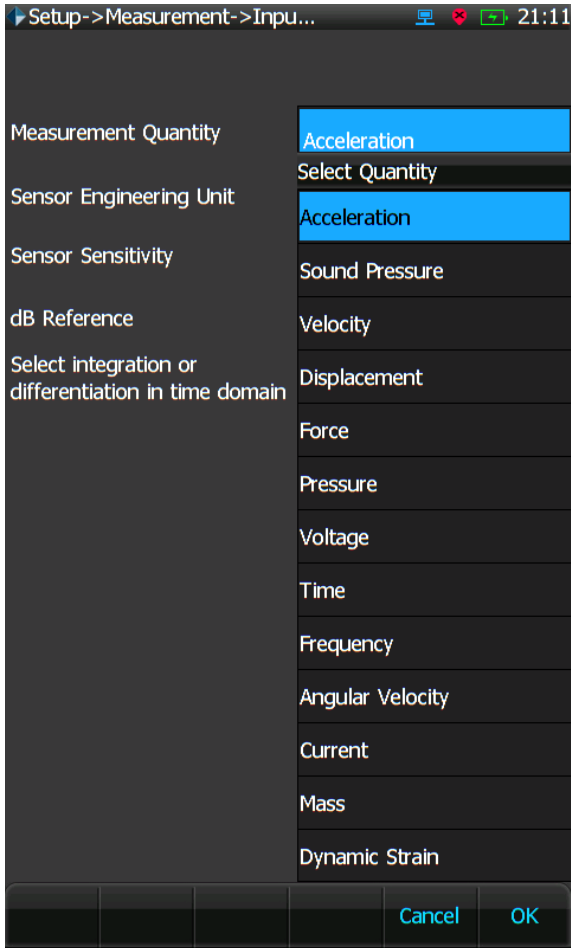


Figure 64: Select measurement quantity for a channel

HP Fltr (High-Pass Filter) sets the cutoff frequency of high-pass filter for each individual channel. This is a very important parameter especially when accelerometer is used at the front-end and velocity or displacement is set as measurement quantities.

Input Mode

Label is used to change the name of the signal. Use the alphanumeric keypad to enter a label name and press the OK soft button to accept it.

CoCo-80X Startup and Shutdown

This section describes powering the CoCo on and off, locking the keypad, and resetting the CoCo-80X.

Power on and off the CoCo-80X

The **Power** button is located in the top-right corner of the CoCo. For the very first time the CoCo-80X is used, it is necessary to set the clock time. All the data acquired and stored will include the time it was recorded as a file attribute with a clock time accuracy of seconds.

There are two LEDs on the front panel. The left LED is an indicator for the system power. When the system is turned on, it will be red. The LED on the right is the indicator for external power charging. When the CoCo is being charged, it will be lit in red. When the system is fully charged and still connected to the external DC power, it will be lit in green.

System Reset

In the rare event of a system lock up, the **Power** button may not respond. To restore the unit, you can reset the system in one of two ways.

Reset the system using the Power Button

The system can be reset by pressing the power button for more than 4 seconds which will force the system to shut down. After the system is shut down, it can be rebooted by pressing the power button again.

Reset the system by Pushing the Reset Pin

The system can also be reset using the recessed **Reset** button inserting a pin or paper clip through the reset hole. The **Reset** pin hole is shown below.

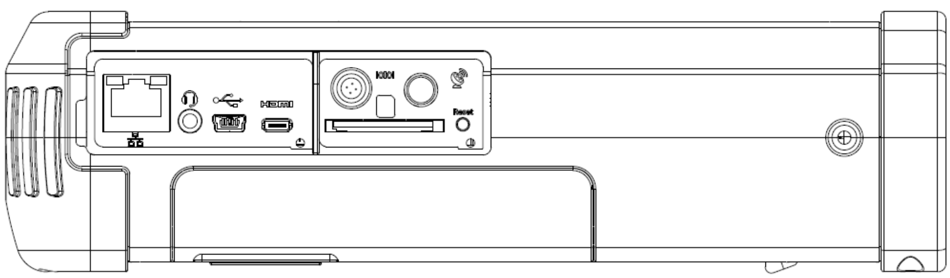


Figure 65: CoCo side panel where the Reset button is located

CoCo-80X Software Disaster Recovery through EDM

In the event that the CoCo-80X application software programs are completely corrupted due to an unknown reason, EDM can be used to restore the CoCo-80X back to its original state when via USB.

To perform a full recovery, open Global Settings through the CoCo menu and select CoCo Recovery. Follow the instructions there to complete the restore process.

Important: This method should be used as a last resort. All custom CSA's and any data stored on the CoCo will be lost.

Keypad Lock

To avoid unintentional operations the keypad can be locked by pressing the **Power** button and selecting **Lock Keypad** from the menu.

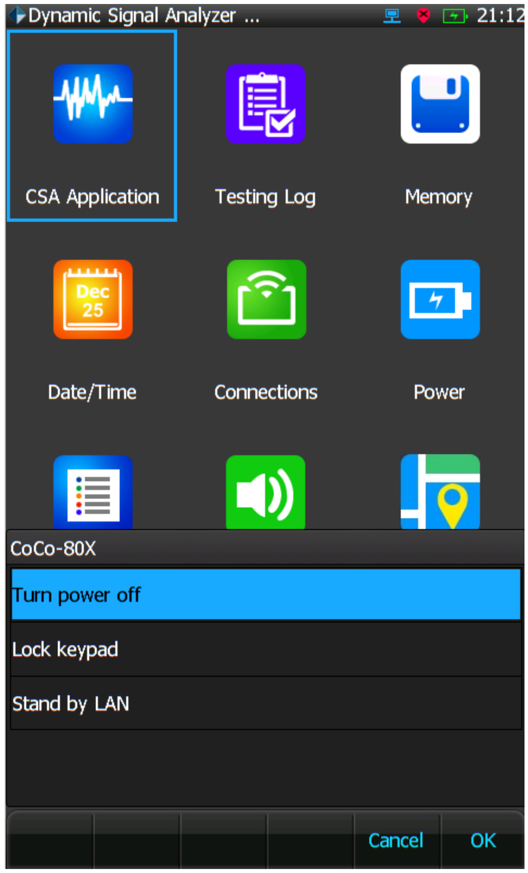


Figure 66. Select to Lock Keypad

Account Management

Account Management sets the privilege of each CoCo user. New user's account can be created at this step by clicking Create Account. The Edit Account button allows to change the user name and password, and to view current options enabled on this account. When an account name is highlighted, press Delete Account to remove it from the account list. View Options allows to what options are enabled for current user. Disable Login button functions to remove all user account management from the CoCo. End user will have full access to the CoCo.

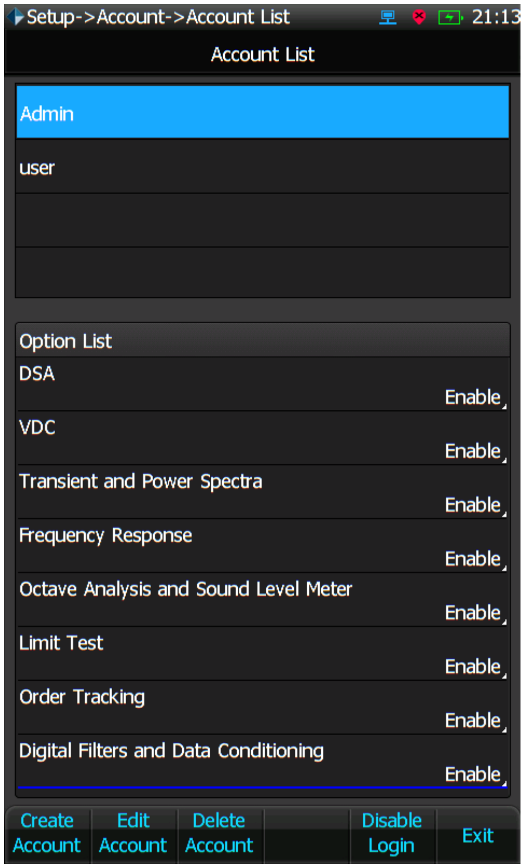


Figure 67. Account Management

Hardware

CoCo-80X Input Connections

This section describes the CoCo-80X input connections and the related circuit design including a description of AC/DC-Single End, AC/DC-Differential, and IEPE input modes.

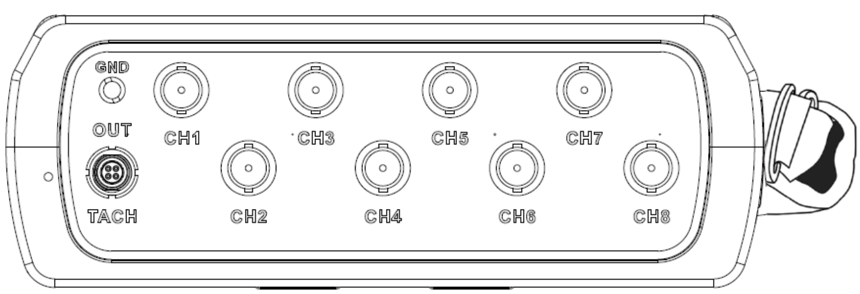


Figure 68: CoCo-80X IO connection panel

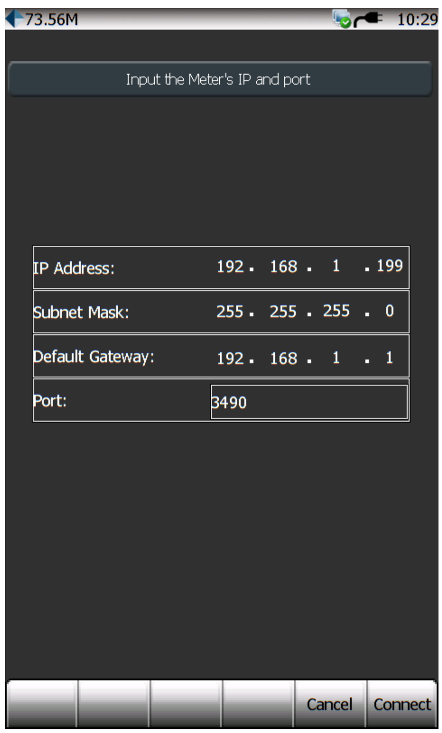
System Calibration

The CoCo loads factory calibration data during start-up, eliminating the need for daily calibration checks. Although the CoCo does not require daily field calibration, CI recommends an annual calibration and performance verification by local CI service centers.

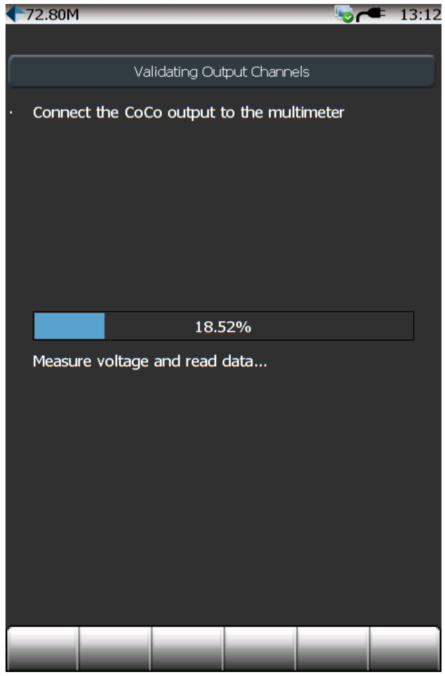
To execute the System Calibration, first press the **Setup** hard button, then select **System Calibration** icon and press **Enter**.

- Connect multi-meter LAN port to the LAN;
- Connect CoCo-80x output to the multi-meter;
- Connect CoCo-80x LAN port to the LAN;
- Set the multi-meter IP and port number.

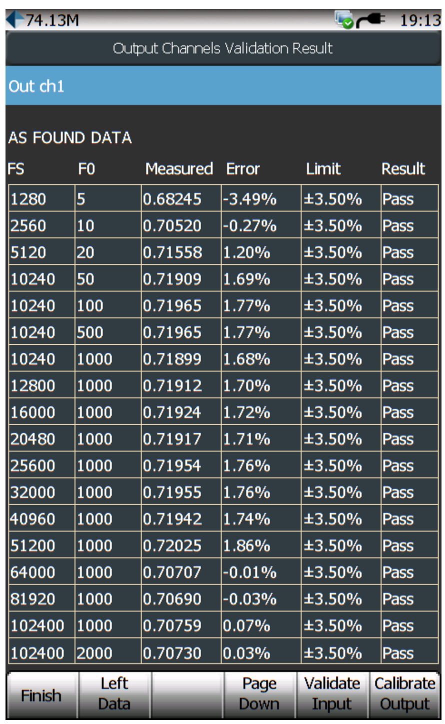
Enter the IP address and port number of the network multi-meter to the CoCo calibration setup page.



Press Connect button to establish connection between the multi-meter and the CoCo.

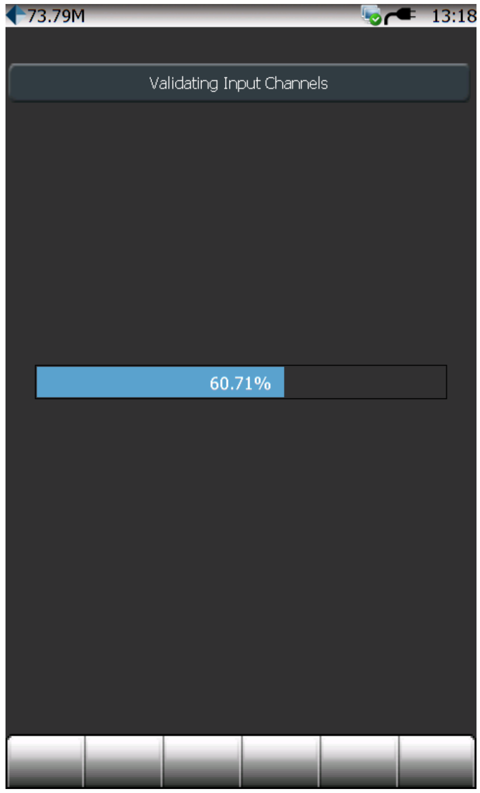


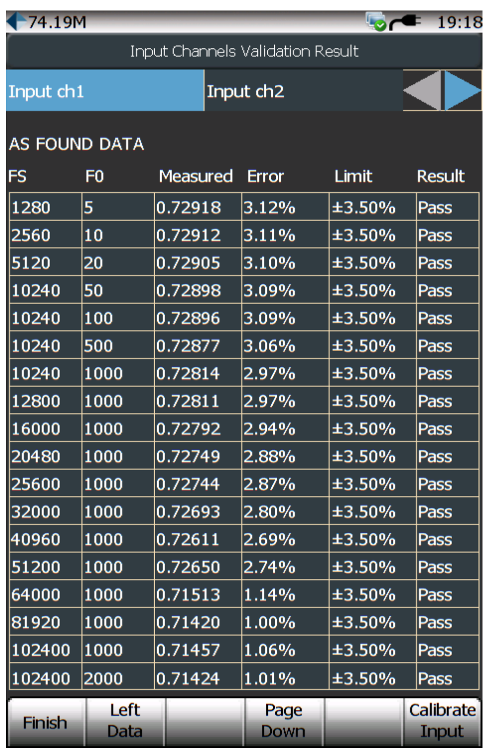
After the voltage measurement and data transfer are done, the output channel validation result will be displayed.



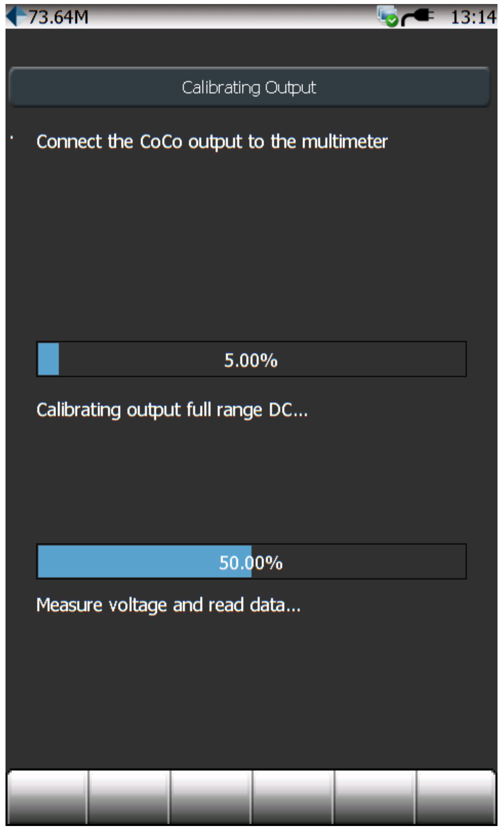
FS	F0	Measured	Error	Limit	Result
1280	5	0.68245	-3.49%	±3.50%	Pass
2560	10	0.70520	-0.27%	±3.50%	Pass
5120	20	0.71558	1.20%	±3.50%	Pass
10240	50	0.71909	1.69%	±3.50%	Pass
10240	100	0.71965	1.77%	±3.50%	Pass
10240	500	0.71965	1.77%	±3.50%	Pass
10240	1000	0.71899	1.68%	±3.50%	Pass
12800	1000	0.71912	1.70%	±3.50%	Pass
16000	1000	0.71924	1.72%	±3.50%	Pass
20480	1000	0.71917	1.71%	±3.50%	Pass
25600	1000	0.71954	1.76%	±3.50%	Pass
32000	1000	0.71955	1.76%	±3.50%	Pass
40960	1000	0.71942	1.74%	±3.50%	Pass
51200	1000	0.72025	1.86%	±3.50%	Pass
64000	1000	0.70707	-0.01%	±3.50%	Pass
81920	1000	0.70690	-0.03%	±3.50%	Pass
102400	1000	0.70759	0.07%	±3.50%	Pass
102400	2000	0.70730	0.03%	±3.50%	Pass

Press Validate Input button to continue to calibrate the input channels.





Press Validate Output button to continue to calibrate the output channels. When finished, the calibration result will be displayed.


73.64M
13:14
Calibrating Output
Connect the CoCo output to the multimeter
5.00%
Calibrating output full range DC...
50.00%
Measure voltage and read data...

Input Modes

This section describes the CoCo input connections and the related circuit design including a description of single ended versus double ended AC versus DC coupling and IEPE.

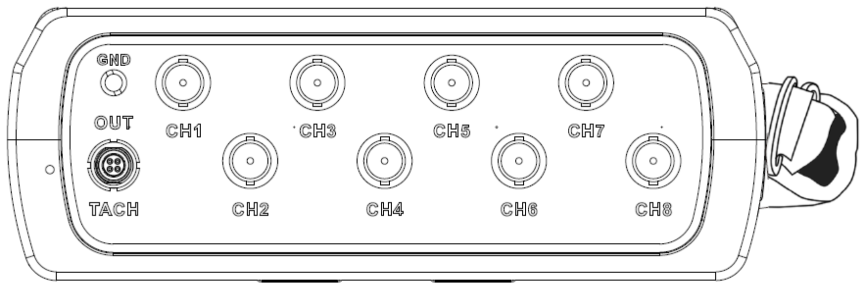


Figure 69: BNC input connectors, output and ground connector.

DC-Differential

DC-Differential measures signals with a DC component. It uses a differential input mode to ignore the DC component and just measure the fluctuations (AC component) of the signal.

Differential mode is recommended when measuring signals with a common mode voltage (CMV). CMV is an in-phase signal that appears simultaneously on multiple input channels. If the sum of the signal and the CMV do not saturate the input and cause clipping, the measurement will be accurate. If the signal and CMV exceed the input range then the signal will be clipped and produce erroneous results. If the signal and CMV are very high and exceeds the maximum over-voltage rating of the instrument front end then the data will be erroneous and the hardware can be damaged. This must be avoided to protect the hardware from permanent damage.

DC-Single End

DC-Single End allows measurement of signals with a DC component and uses single ended input mode. Single ended mode is recommended for most cases and when no CMV exists. This is the case when measuring the output of sensor amplifiers. A CMV will produce noise in single ended mode.

AC-Differential

AC-Differential applies a high-pass filter with a low cutoff frequency to the input, filtering the DC component of the signal. The result is a zero mean signal. This is most commonly used for dynamic signals with CMV.

AC-Single End

AC-Single End mode combines the AC high-pass filter with single ended mode. This is most commonly used for dynamic signals with no CMV such as measuring the output of an amplifier.

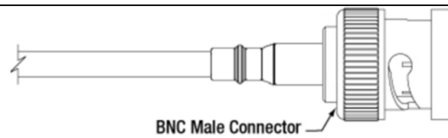
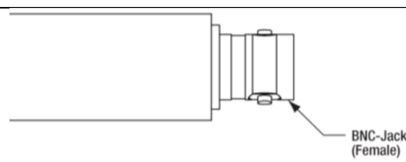
IEPE (ICP)

The CoCo supports IEPE constant current output type for its input channels. The built-in circuit is powered by a 4mA constant current source at roughly 21 Volts. IEPE refers to a type of transducer that is packaged with a built-in current source. IEPE is an acronym for *Integral Electronic Piezoelectric*. IEPE requires an AC filter so DC measurements are not possible when IEPE is enabled. CoCo has a cut-off frequency of 0.3Hz@-3dB for the IEPE input mode.

CoCo can automatically detect the IEPE sensor connection when the IEPE input mode is enabled.

Signal Source and Tachometer Connectors

The signal source and tachometer channels share a common LEMO connector. The CoCo-80X can only use one of these functions at a time, and this can be configured in the software. The connector cables for these functions look nearly identical, but they are not interchangeable. The tachometer cable has a female BNC connector, whereas the signal source cable has a male BNC connector. Users must pay attention to use the correct cable.

Function	Part Number (Connector)	Example
Signal Source	C80X-A10 LEMO-to-BNC (male)	
Tachometer	C80X-A11 LEMO-to-BNC (female)	

CoCo-80X Output Connections

The CoCo-80X includes one output channel that can act as a function generator to provide a variety of waveforms synchronized with the input channel sampling rate. The output channel is a SMB mini-jack. A SMB-to-BNC adaptor is provided with the unit. For each waveform the parameters such as amplitude and frequency can be specified with the **Output Parameters** screen menu located in the **F2 (Param.)** menu. The output waveforms include: Sine, Triangle, Square, White Noise, Pink Noise, DC, Chirp, Swept Sine, and (optional) Arbitrary Waveform.

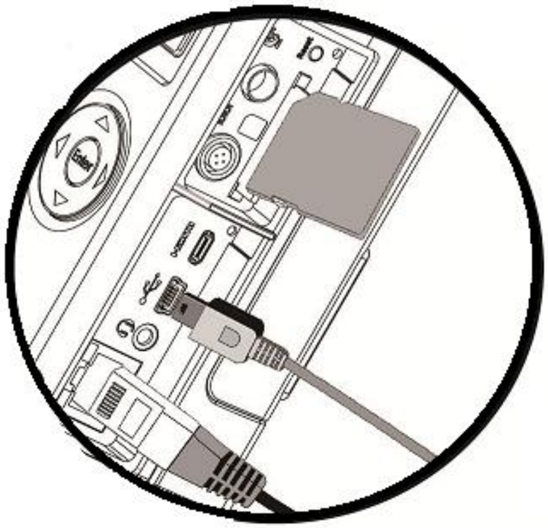
CoCo-80X Peripherals and Accessories

This section describes the peripherals and accessories available on the CoCo-80X including SD Card, audio devices, Ethernet, USB, HDMI, audio and battery. The CoCo-80X includes interfaces to many peripheral devices. These can be connected to the hardware via the connectors shown below.

Item Descriptions:	
	CoCo-80X Handheld Data Acquisition System
	Suitcase with foam inside
	Hang Strap
	USB cable
	Regular Ethernet cable
	BNC cable
	CD for EDM, the host software, User's Manual in PDF
	Cable for Output (Signal Source)
	Main Battery (installed)
	Cross-Over Ethernet Cable
	AC/DC Power Adapter
	Power Cable to AC Outlet

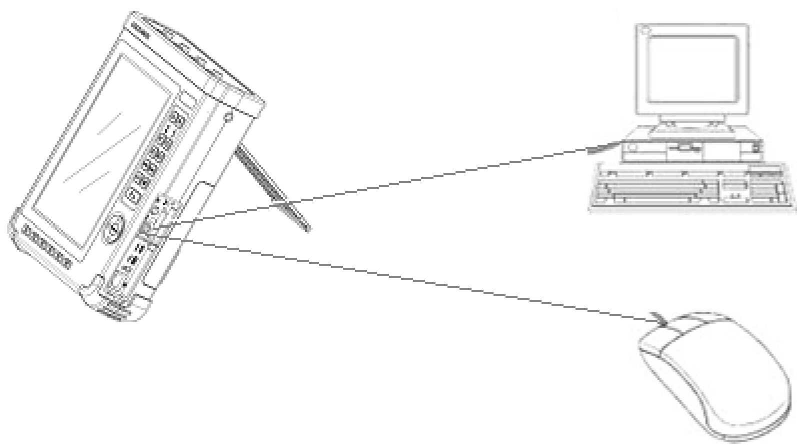
Ethernet

CoCo is equipped with an RJ-45 100-BaseT Ethernet jack to connect to a local area network or directly to a PC. A cross-over Ethernet cable must be used to connect the CoCo-80X to a PC **directly**. If CoCo is connected to a network hub, router or a switch, then a regular Ethernet cable (not a crossover cable) should be used.



USB Ports

The CoCo-80X has one USB-client (mini-USB) port and one USB-host port. Physically they are one port on the right side of CoCo. Client and host share a single port, only one mode is supported at a time. The USB-host requires a OTG cable. It is fully compliant with USB 2.0 full speed specification and backward compatible with USB 1.1. The shapes of the USB port is as shown below:



The USB-client port is used to establish communication between the CoCo-80X and a PC. When the USB-client port is used, CoCo-80X device acts as a slave unit.

The USB-host port is used to establish communication between the CoCo-80X and other USB-based peripherals, such as a USB-mouse, or a USB memory stick. In this case, the CoCo-80X acts as a USB master device.

Mouse Support

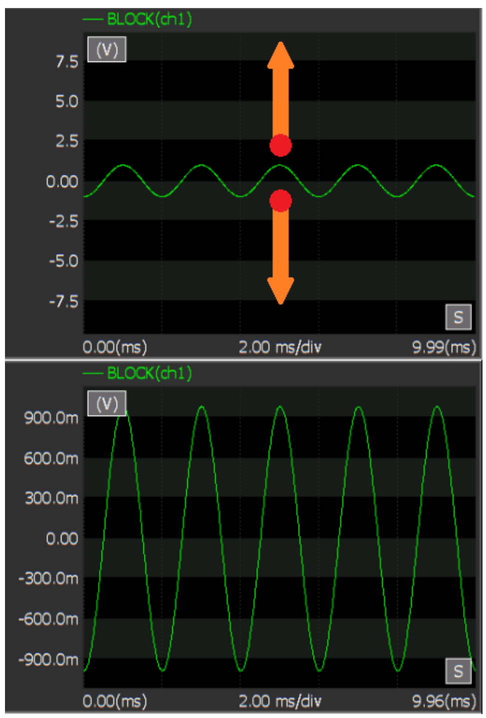
USB Mouse is supported with following operations: F1~F6 function buttons, two virtual keypads, scrolling and make selections in any combo box, ZOOM-in scaling, ZOOM-out scaling the graph.

To ZOOM-in on the graph, hold the left button of the mouse and drag to the area that you intent, then release the left butt

To ZOOM-out the graph to the previous scaling stage, double-click on the graph.

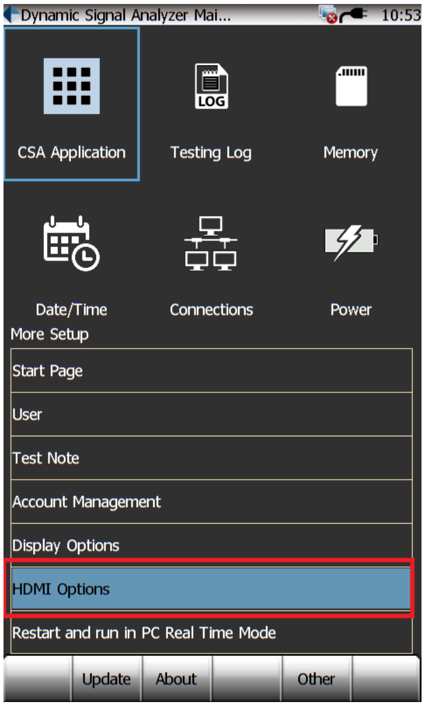
Touch Screen

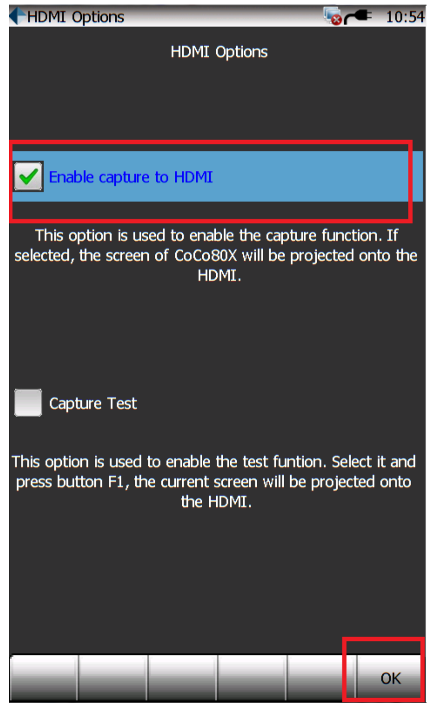
CoCo-80X supports touch screen which means user can tap the CoCo-80X screen to complete certain control. This touch screen features single point touch control and two-point touch control. The single point touch is usually used to tap icons or entries to enter it. The two-point touch control is usually used to zoom in/out signals.

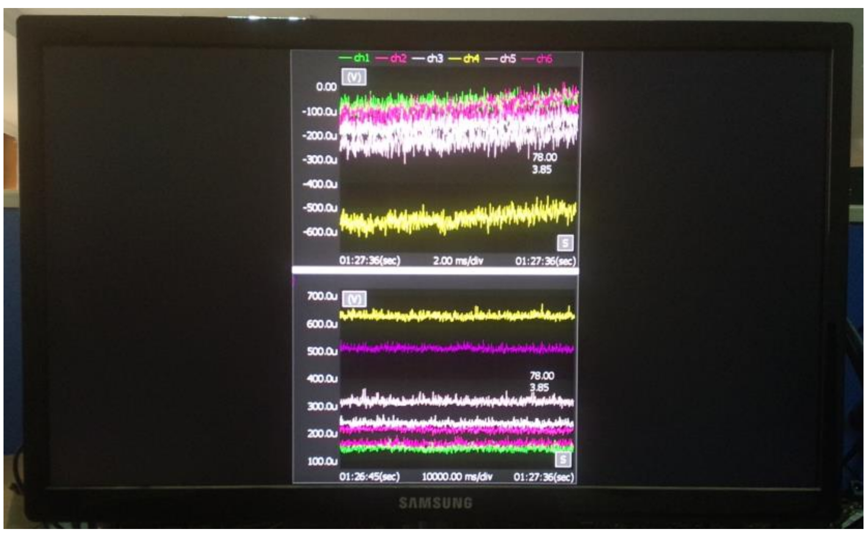


High Resolution Display

By connecting CoCo-80X and high-resolution monitor using the HDMI cable, user can display the signals on the CoCo-80X on a high-resolution monitor or TV. The HDMI function is automatically enabled. Simply connect the cable to your TV or monitor, and it will automatically output to the display.~~Under the Setup page, click F5 to choose HDMI options; check the Enable capture to HDMI; then press OK to finish the setup. Turn on the monitor to view the CoCo-80X screen on the monitor.~~

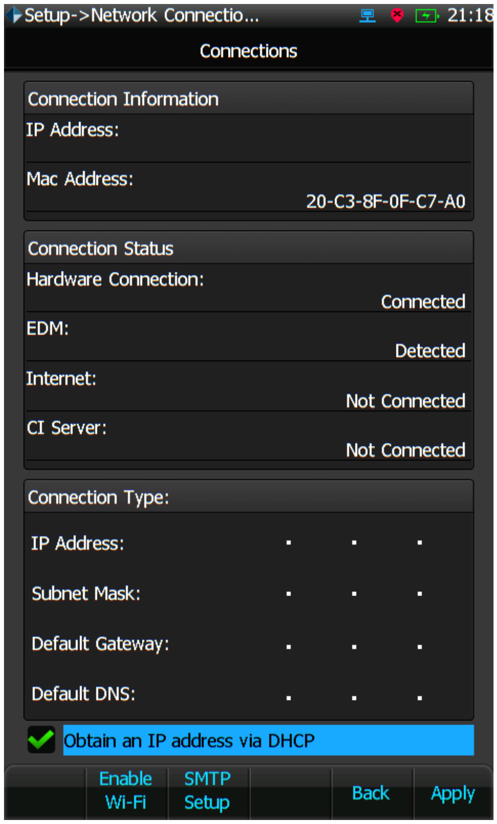


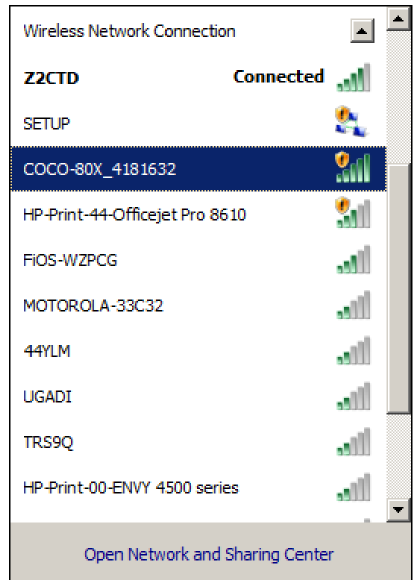




Wi-Fi

CoCo-80X is wireless equipped. It can connect to the LAN or Internet via Wi-Fi to transfer the data or control signals. To change the Wi-Fi setting, click or tap the Connections icon under the Setup page; click F2 Enable Wi-Fi to activate the wireless feature. When the Wi-Fi is active, the CoCo-80X will broadcast its SSID with its name and serial number. The PC running EDM software can connect to this SSID via its wireless adapter. After the connection is established, EDM can detect and connect to CoCo-80X.





SD Card Interface

The MMC/SD-Card interface is designed to be used for multiple purposes, mainly the high-density memory card. The official information about the MMC/SD-card can be found on the official site: http://www.sdcard.org/

The user can copy the recorded signal files from the internal flash memory to SD memory card or directly record the time stream data to SD memory card.

Audio Devices

CoCo-80X has the following built-in audio devices:

- 3.5mm stereo jack connector for an earphone
- Built-in speaker
- Built-in microphone

The earphone and speaker are used to generate status sounds that provide audio feedback to the use such as:

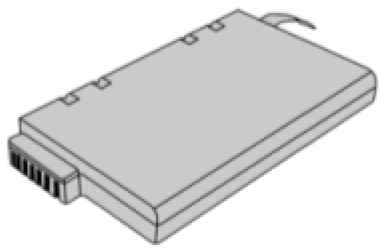
- AC adapter is connected
- AC adapter power was disconnected

- System boot-up successful
- System boot-up failure

Battery

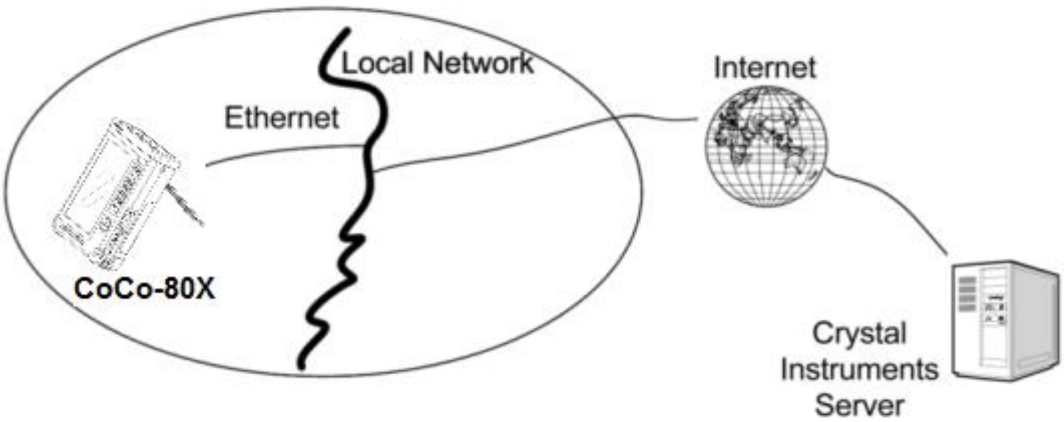
There are two batteries inside the CoCo-80X device, the clock battery and the main battery. The clock battery is only used maintain power to the internal clock. It is located inside the hardware and should be replaced when necessary by an authorized CI service center and should not be replaced by the user. The main battery is used to power the instrument. The main battery is a Lithium-Ion type cell with a capacity of up to 6600 milliamp-hours. The main battery is located inside the enclosure and can be replaced by opening the lid on the back of the CoCo-80X.

To recharge the main battery, simply connect the AC adaptor between the CoCo-80X and the AC power source. The power source must be in the range of 100 - 250 VAC. When the CoCo-80X is turned on, a battery capacity symbol is shown on the status bar that indicates the state of charge of the battery.



CoCo-80X Online Updates

The CoCo-80X application software has the capability to check for software updates from the CI web server when you connect the CoCo-80X device to the Internet. You first connect the CoCo-80X to a local network using regular Ethernet. After you connect it, press Setup button and click the Update icon. The CoCo-80X will first check the connection status, and then a connection will be established.



After communication is established, the CoCo-80X will check with the server to verify if the software subscription is valid. If the CoCo-80X is in the valid software subscription period, it will then check the latest software components available on the server and download them to the CoCo-80X after the user's approval.

Two types of software components can be updated:

- CoCo-80X application software
- CSA projects

The CoCo-80X user interface will always ask the user's confirmation before the software is downloaded. When the new CoCo-80X application software is downloaded, you will be asked to confirm to overwrite the old version with the new version. Then the older version will be overwritten.

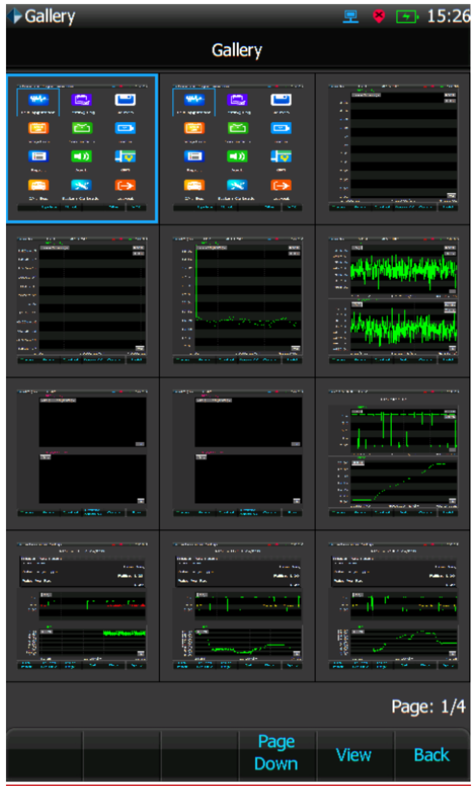
When new CSA projects are downloaded, if the new CSA files take the same file name as the old ones, the old CSA files will be renamed to the CSA files with sequence number added. This approach will prevent overwriting the old CSA files that may have been changed by the user.

If the connection to the Internet could not be established, press the Setup button and click on the Connections icon. This will lead you to the Ethernet network setup. The most common problem is caused by inappropriate IP address setting. Most often, your LAN requires you set up the IP as "Dynamically obtain an IP via DHCP". Refer to section "Configuring the CoCo-80X Network Settings" in this manual for more details.

Screenshots with the CoCo-80X

Screenshots can be taken at any moment with a simple command on the touchscreen. Double-tap on the top Status bar to capture a screenshot. It will briefly display the name of the screenshot that was acquired.

To view your screenshots, this can be done on the PC or directly on the CoCo-80X. From the Setup screen, press Other (F5), and then select ‘Gallery’. The gallery displays all the stored screenshots from the SD card.



Screenshots are automatically stored in the ‘Picture folder’ on the SD card.

Name	Date modified	Type
Balance Data	6/20/2017 1:44 PM	File folder
CoCo-80	5/5/2017 3:40 PM	File folder
Picture folder	5/3/2017 12:57 PM	File folder
Record1	5/6/2017 8:52 AM	File folder
Record2	5/6/2017 8:52 AM	File folder
Record3	5/6/2017 8:52 AM	File folder
Record4	5/6/2017 8:52 AM	File folder
Record5	5/6/2017 8:52 AM	File folder
Report	5/11/2017 2:57 PM	File folder

CANBUS

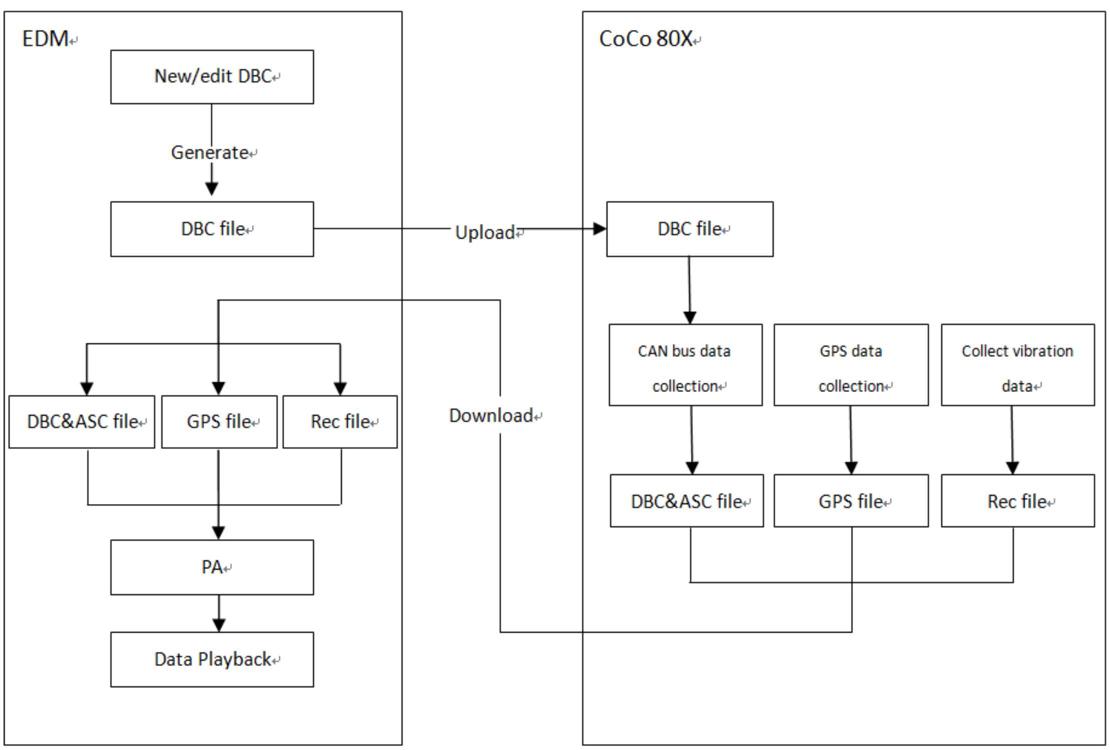
CANbus is the abbreviation for the Controller Area Network Bus which is a communication protocol allowing peer to peer (usaully the microcontrollers and devices) communication without the host control.

CANbus was initially designed in 1990 and ISO released the standard in 1993. Then the CANbus has widely been used in the industries of vehicle, aviation, and factory automation.

CANbus on the CoCo conform with ISO 11898-1 (Bosch CAN protocol 2.0 part A, B) Standard (11-bit) and Extended (29-bit) identifiers (Extended by default). It uses a 4-pin LEMO connector to secure on the CoCo end. The transmission bit rate is up to 1 Mbps.

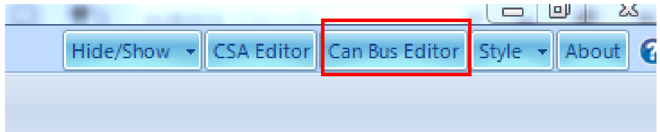
System Block Diagram

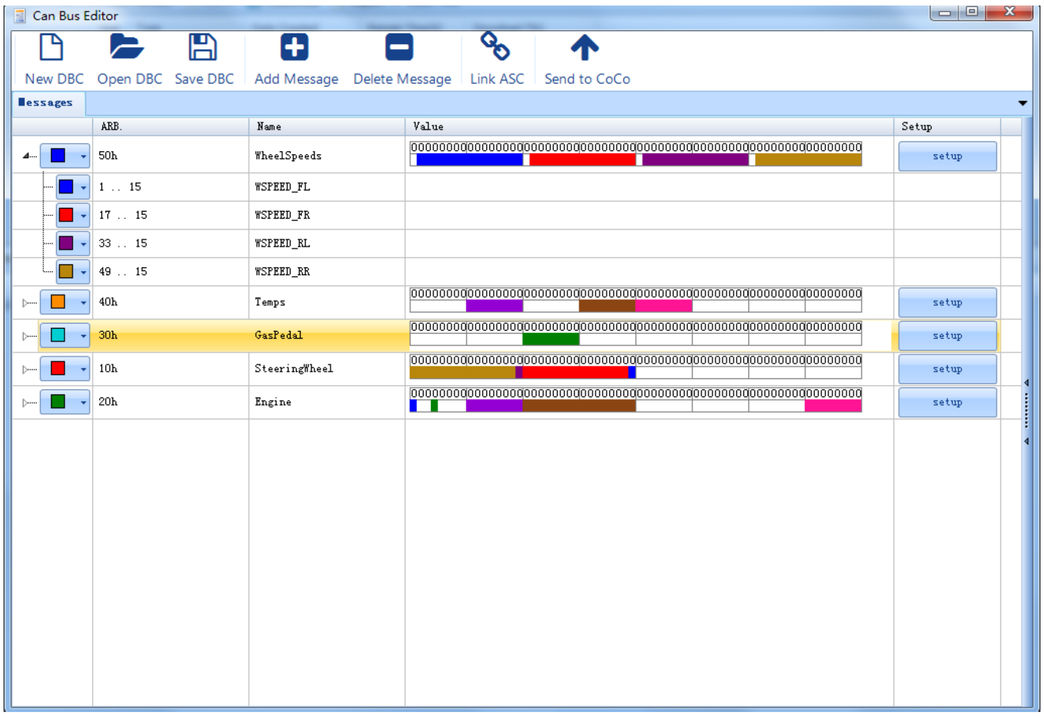
The following diagram illustrates how the CANbus work with CoCo-80X. Users need to configure the CANbus profile on the EDM, upload the profile to the CoCo-80X, and operation the CANbus on the CoCo-80X.



CAN Bus Editor

Open EDM, select "CoCo-DSA mode", click on the upper right corner "Can Bus editor" button to enter DBC editing interface.





New DBC: Create a DBF file.

Open DBC: Open a DBC file.

Save DBC: Save the current editor of DBC file as a disk file.

Add Message: Add a message for the DBC file.

Delete Message: Delete the currently selected message definitions.

Link ASC: Connect an ASC file, and through the current DBC resolution.

Send to COCO: Select a DBC file is uploaded to CoCo.

Messages tab within the current DBC file contains all message definitions and signal definitions.

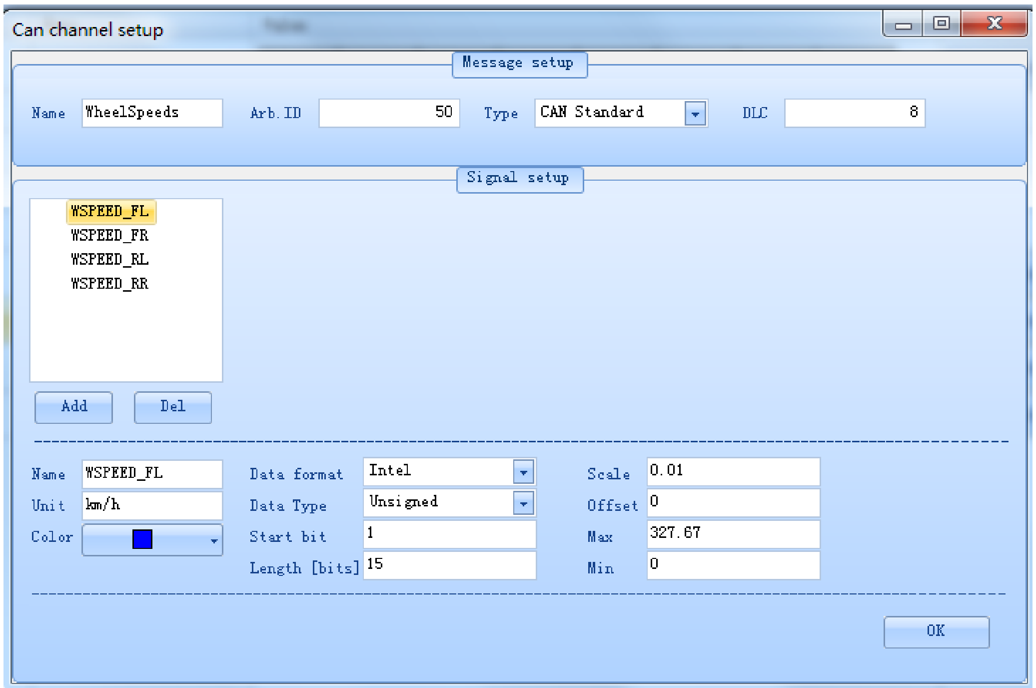
ARB: MessageID or Signal range (56 ... 8: It represents from 56, length 8)

Name: Message name or Signal name.

Value: The message contains the signal distribution (Distinguished by different colors) (Unfinished).

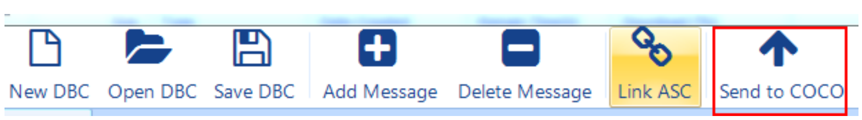
Setup: Message and signal settings.

Click the Setup button to set specific parameters for each message.



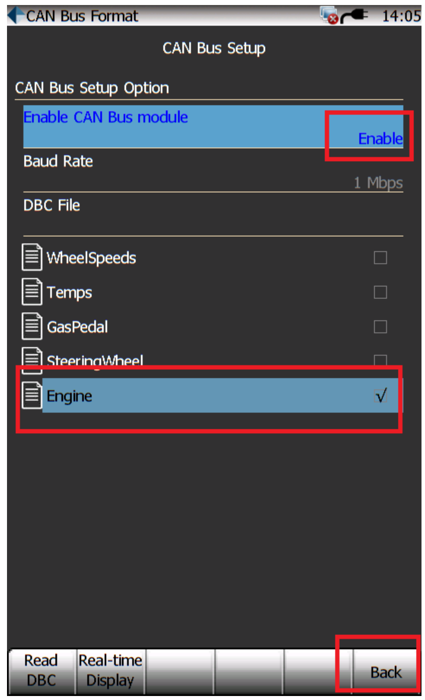
Upload DBC file

Click "Send to COCO" button, select the DBC file, uploaded to the CoCo connected.

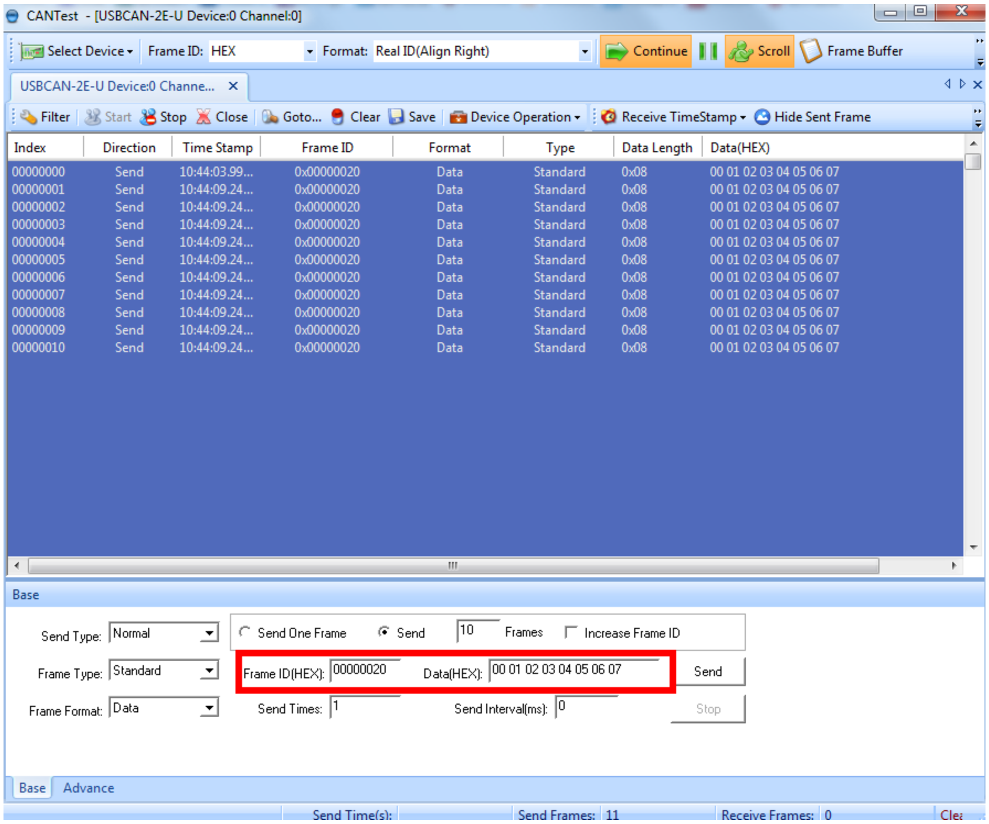


Operations on CoCo-80X

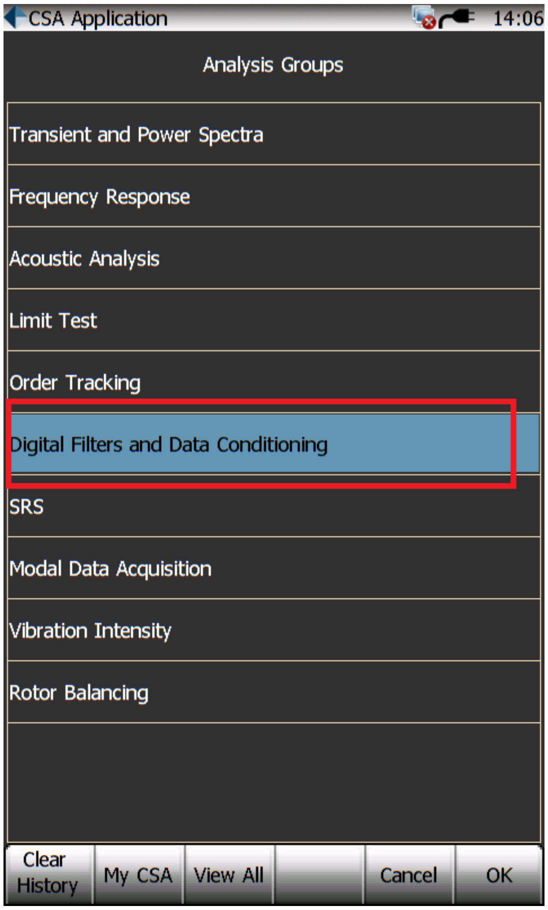
CANbus icon can be found under the Setup menu. Enable the CAN Bus module, set the Baud Rate, Read the DBC file and select at least one message. Click “Back” to go back to DSA analysis.

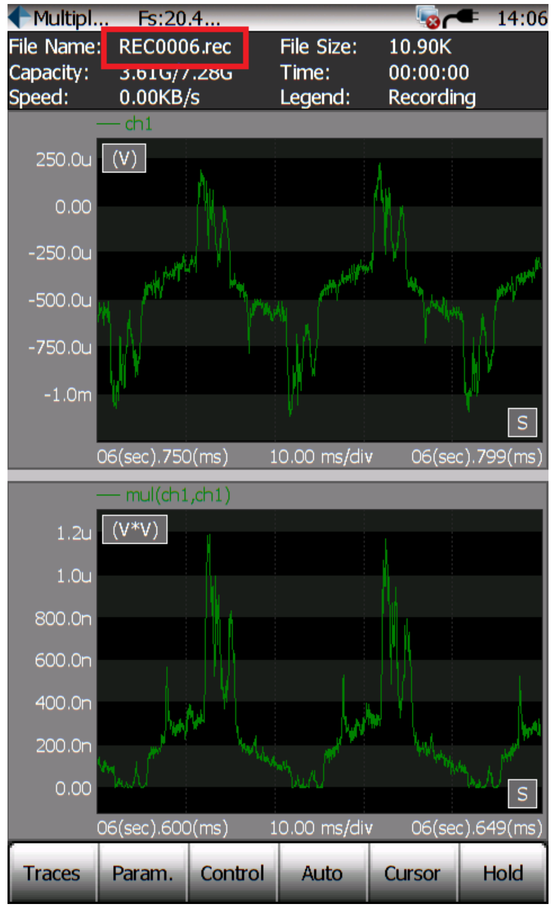


Send some CAN data through the CANalyst-II to CoCo80X.

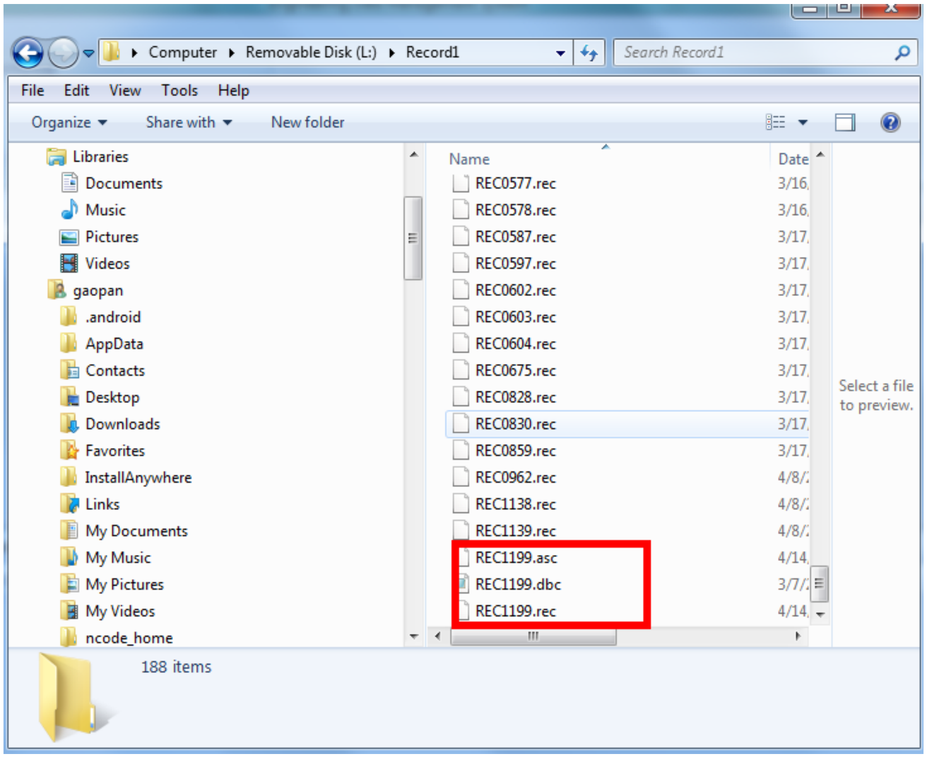


3, Run a csa file in Data Conditioning group, and record.



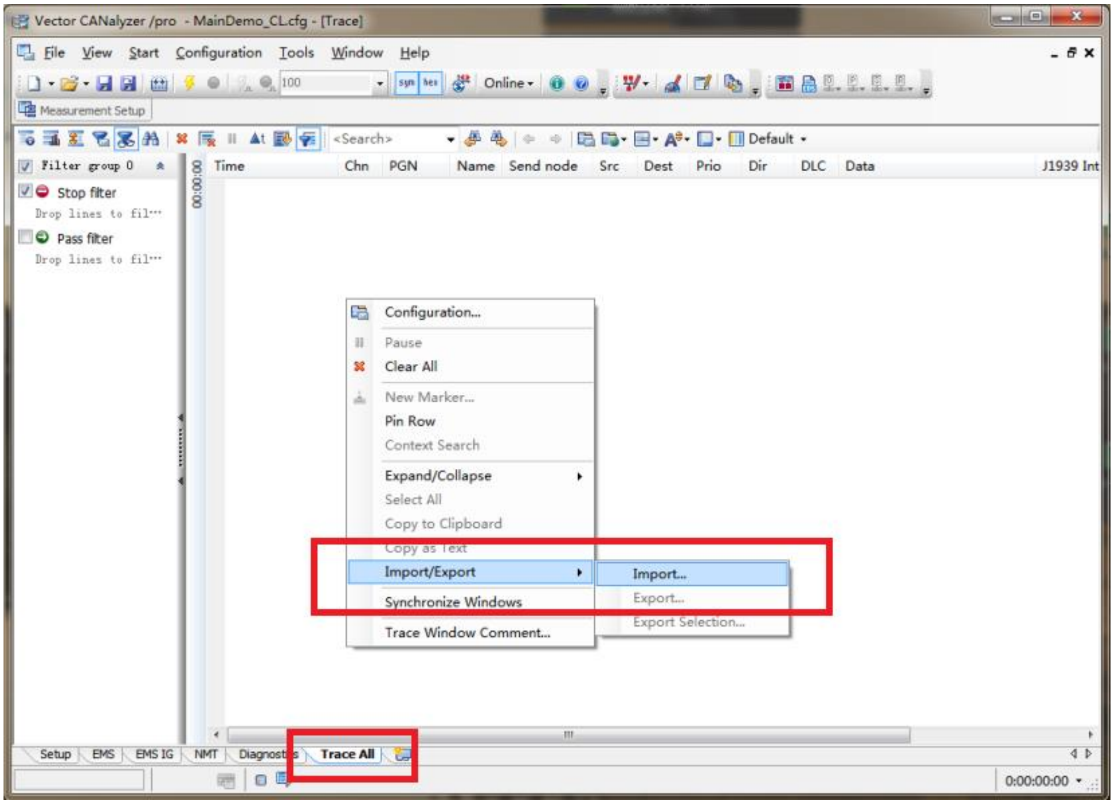


4, When the recording finished, three files will be generated.

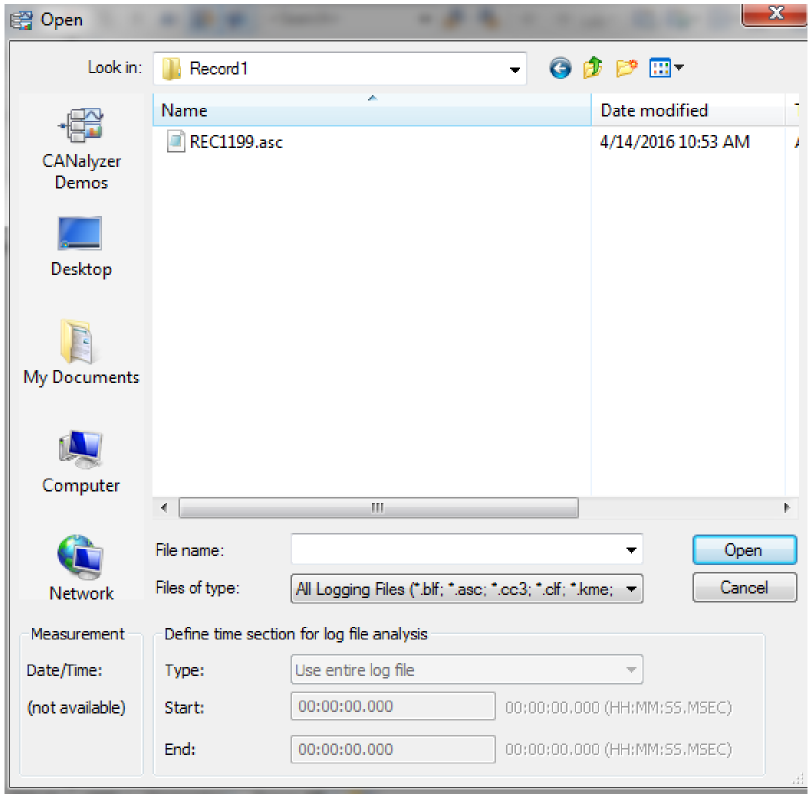


Users can import the “asc” file in the Vector CANalyzer or download to EDM.

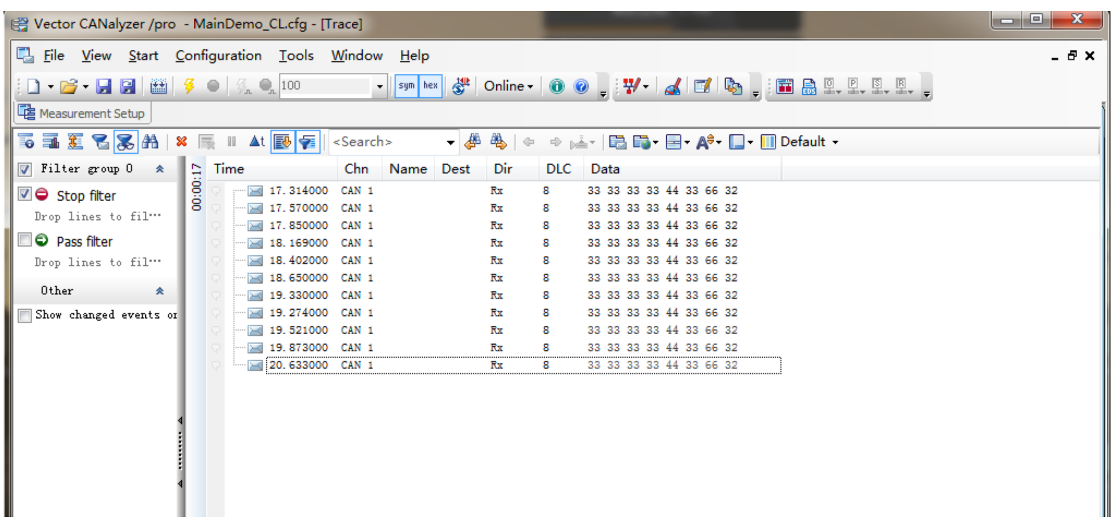
Open the software “Vector CANalyzer”; select “Trace All”; and right click the window; select “Import”.



Choose “All logging files”, and select an “asc” file.



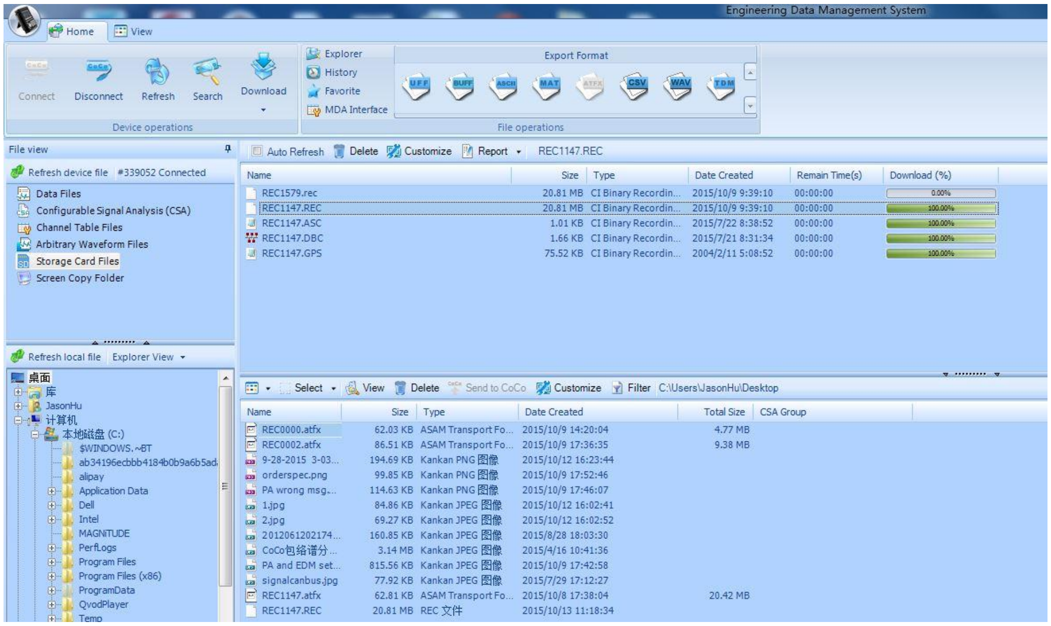
The data can be displayed in this window:



Download file

In EDM DSA mode, when connected to CoCo, refresh the file list, you can see available for download vibration rec and Canbus files.

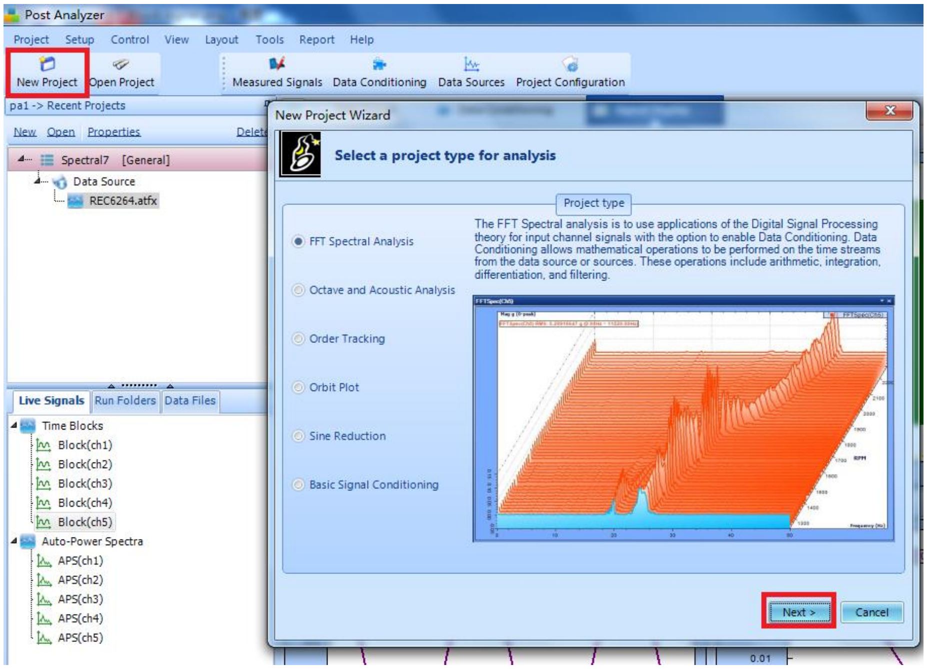
Select a "asc" file, click download, EDM will download the current asc file corresponding dbc files and gps file, and the file name will automatically match the vibration signal file downloaded; if you select a vibration signal file to download, EDM will automatically match asc, dbc and gps file batch download.

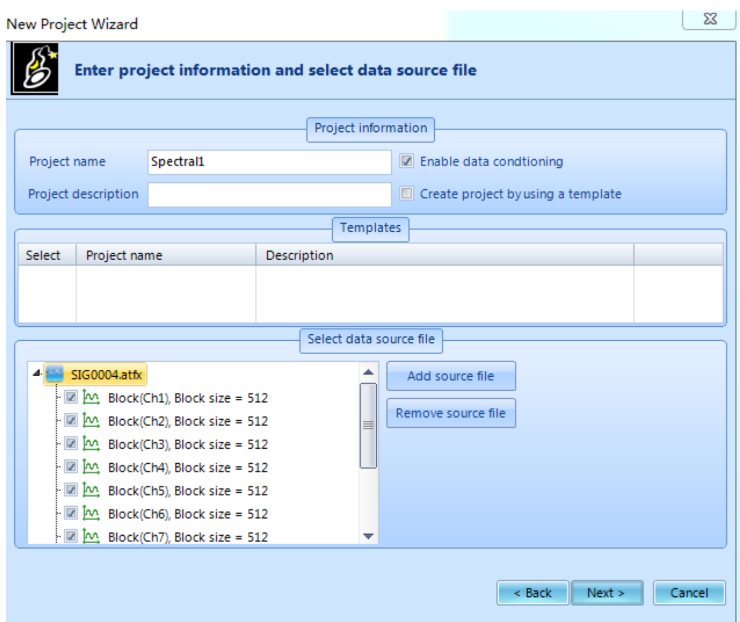


Data Playback

A. New Project

Open PA, New Project:

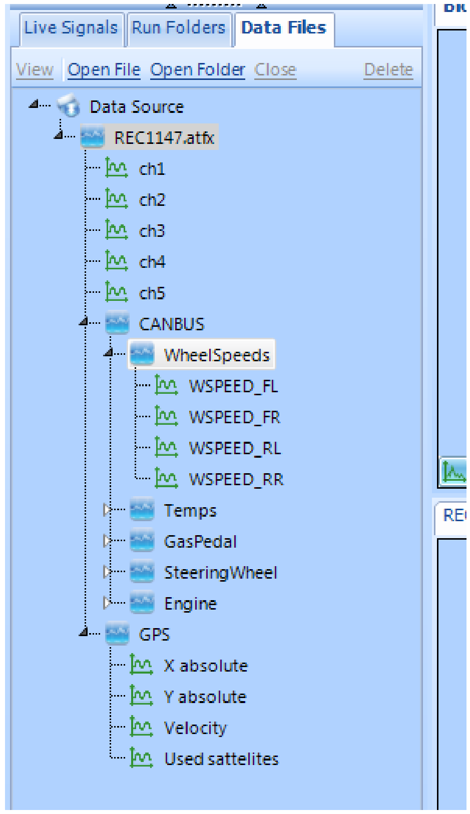




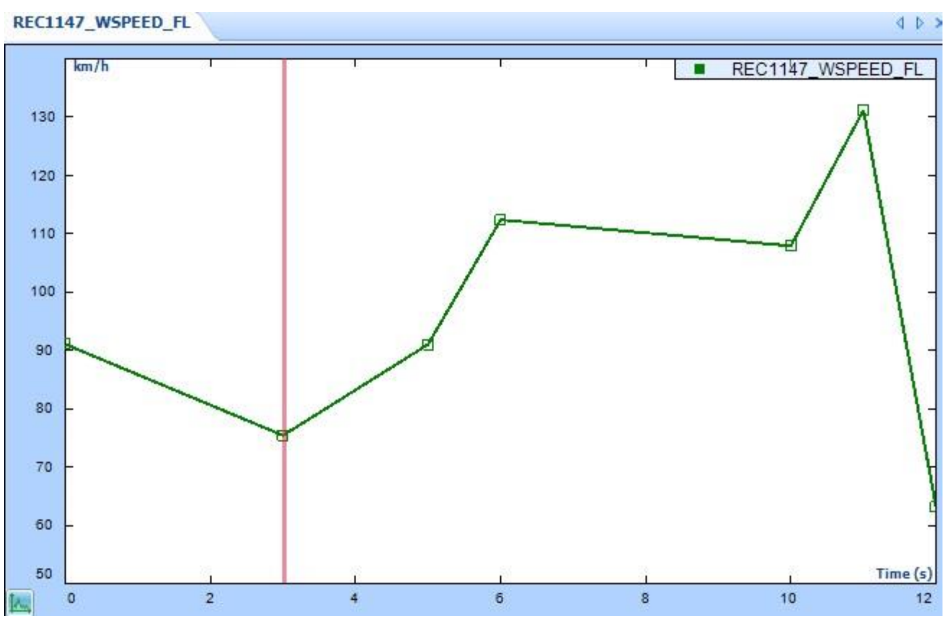
Click on "Add Source file" add signal file, if there is the same directory on the same file name DBC, ASC or GPS file is automatically loaded.

B. Signal display

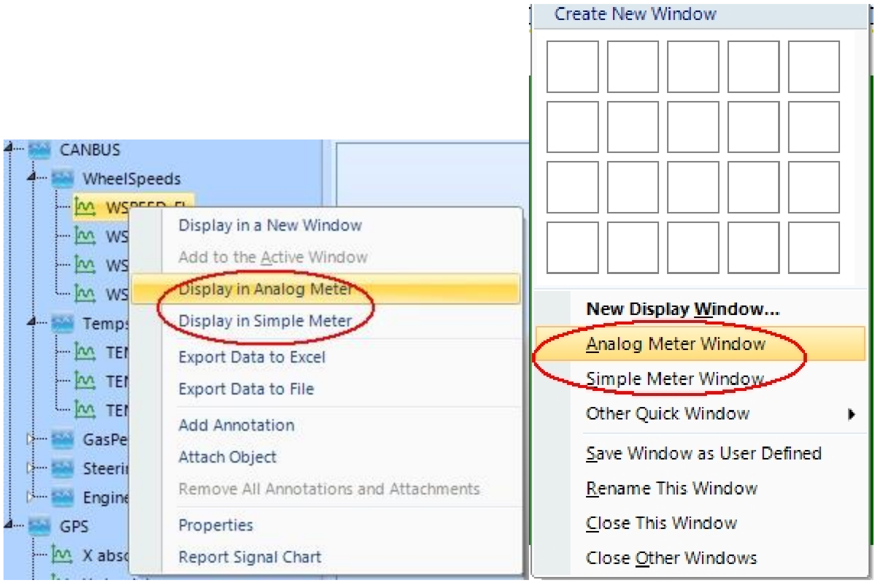
After the project is created, click on the Data Files tab, you can see a list of CANBUS and the GPS signal.



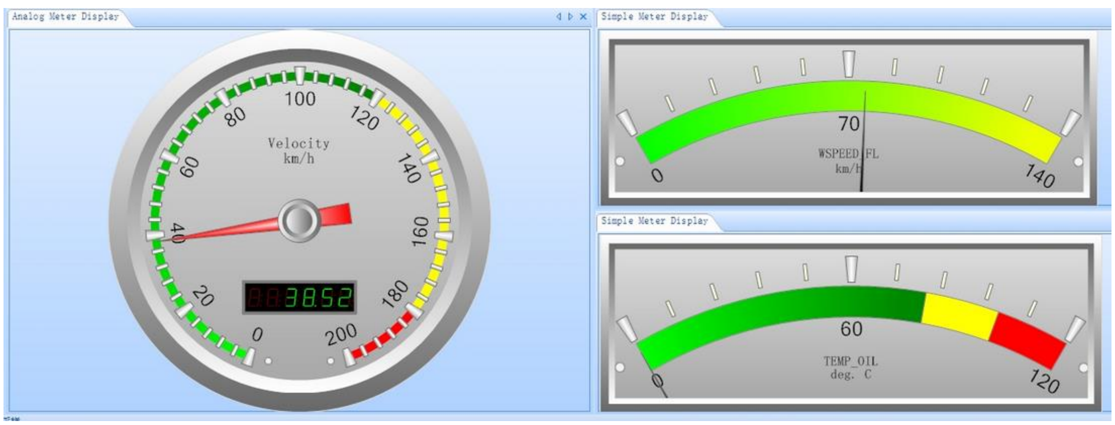
If you double click the signal or select the menu item "Display in a New Window", the default waveform window is displayed.



You can also choose the instrument display, select the menu:



Analog meter and Simple Meter display:

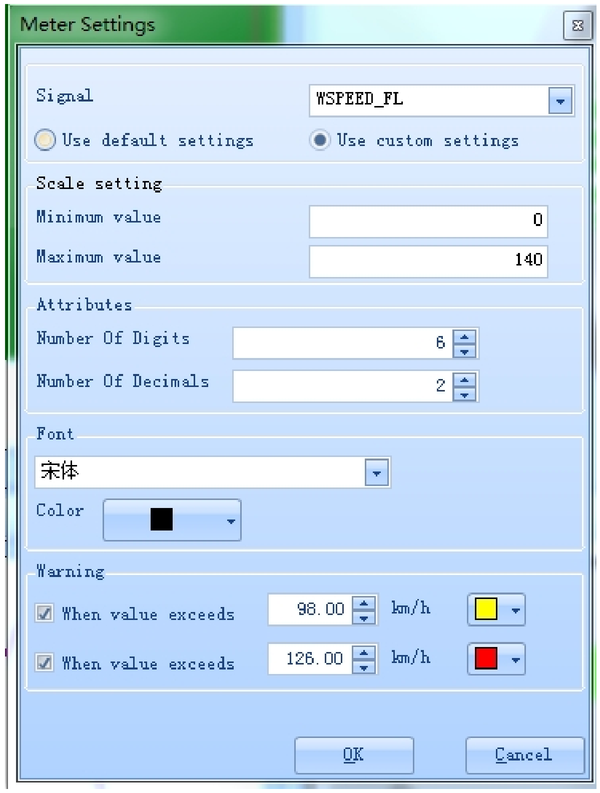


The overall effect:

C. Meter Settings

Click the right mouse button over a control, select "Properties" menu item, and then pop "Meter Settings" form.

If you select "Use default settings", the following settings will be unavailable, the controls will automatically be set relatively appropriate maximum, minimum, and other parameters. If you select "Use curstom settings", the instrument controls are displayed in the user's settings.



Parameter Description:

Signal: The meter display source data.

Minimum value: Dashboard scale minimum.

Maximum value: Dashboard scale maximum.

Number of digits: Numeric Indicator of digits.

Number of decimals: Numeric Indicator of decimals.

Font: Set the font and font color.

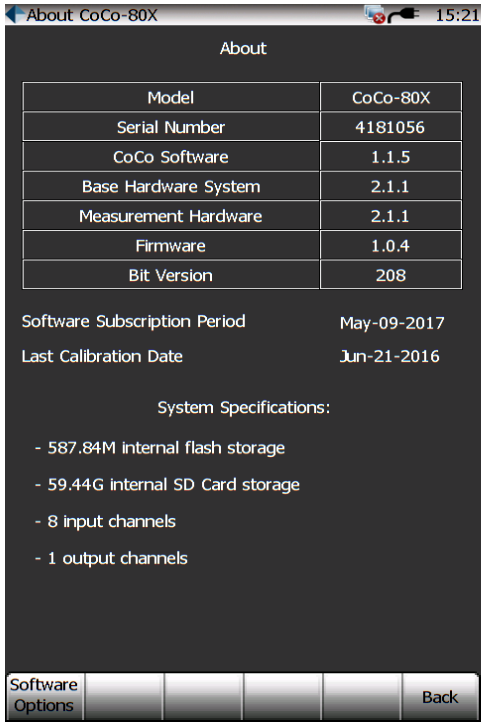
Warning: Set the alarm value.

CANbus and GPS Configuration on CoCo-80X

Currently the CANbus and GPS features require the hardware firmware version 1.0.4 or above. For user who has a lower version hardware, the hardware upgrade is necessary through Crystal Instruments or its authorize channels.

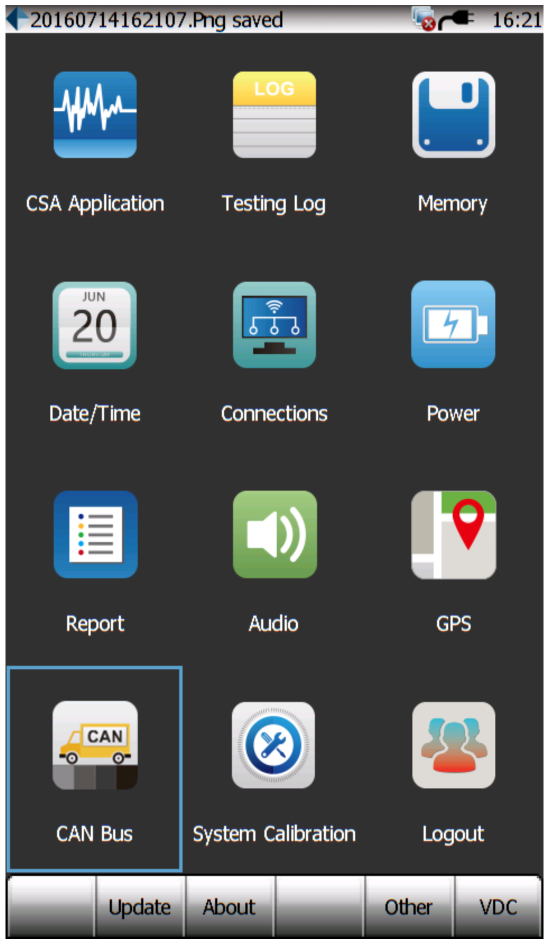
The CoCo software version must be on 1.1.5 or above which can be upgraded by proper license key.

Click the About icon on the Setup page to view the version numbers.

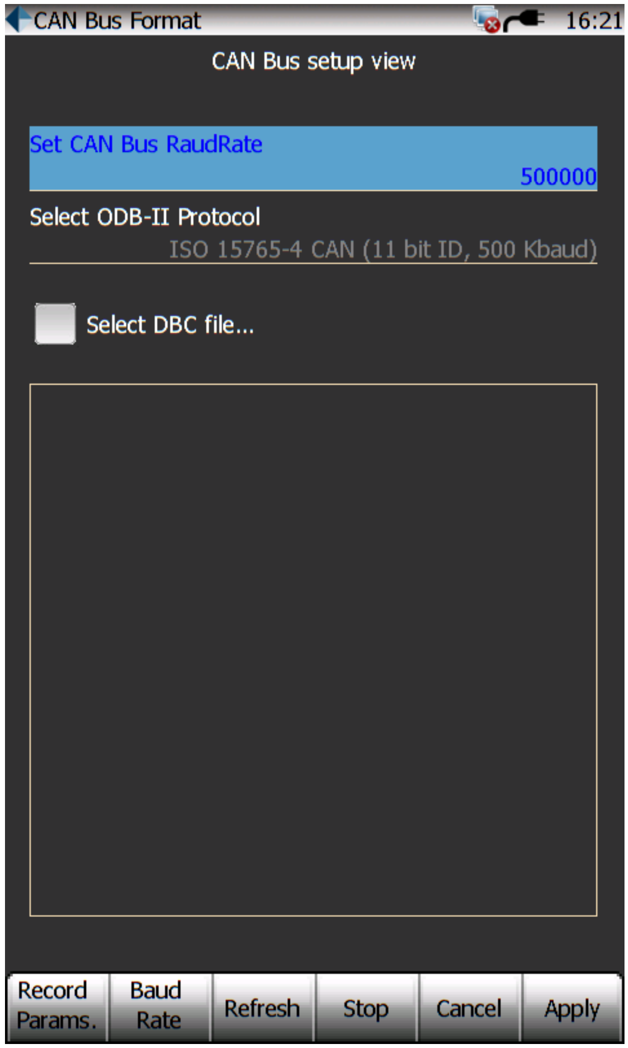

About CoCo-80X
15:21
About
Model
CoCo-80X
Serial Number
4181056
CoCo Software
1.1.5
Base Hardware System
2.1.1
Measurement Hardware
2.1.1
Firmware
1.0.4
Bit Version
208
Software Subscription Period
May-09-2017
Last Calibration Date
Jun-21-2016
System Specifications:
- 587.84M internal flash storage
- 59.44G internal SD Card storage
- 8 input channels
- 1 output channels
Software Options
Back

A. CANbus Configuration

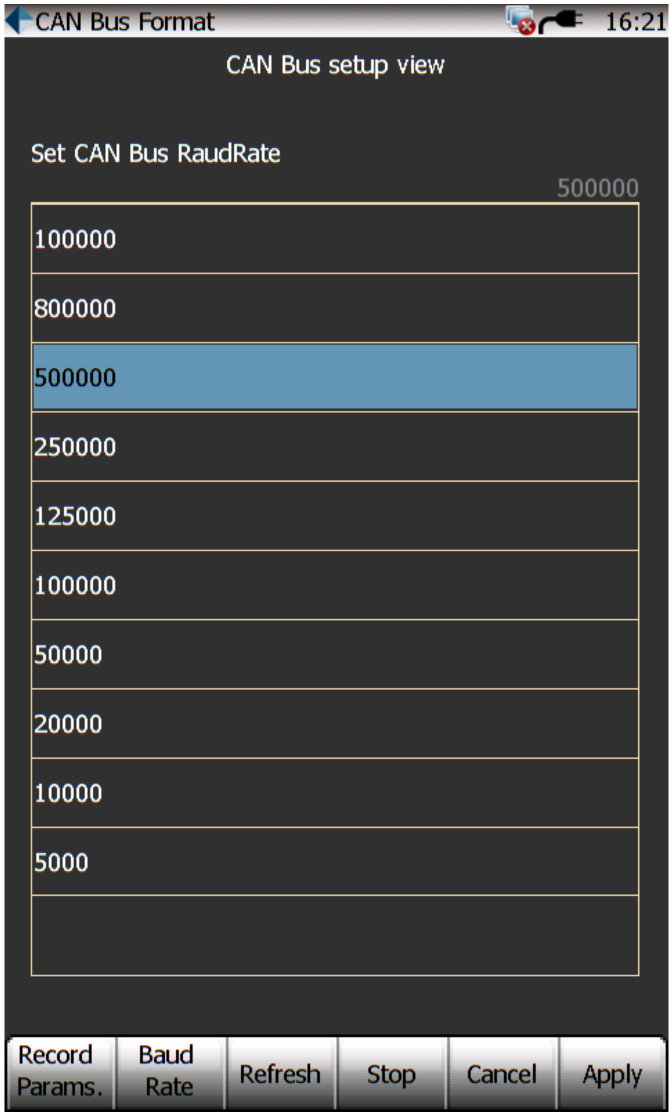
Click CANbus icon on the Setup page to enter the CANbus configuration page. CANBus must be configured from this CANbus menu.



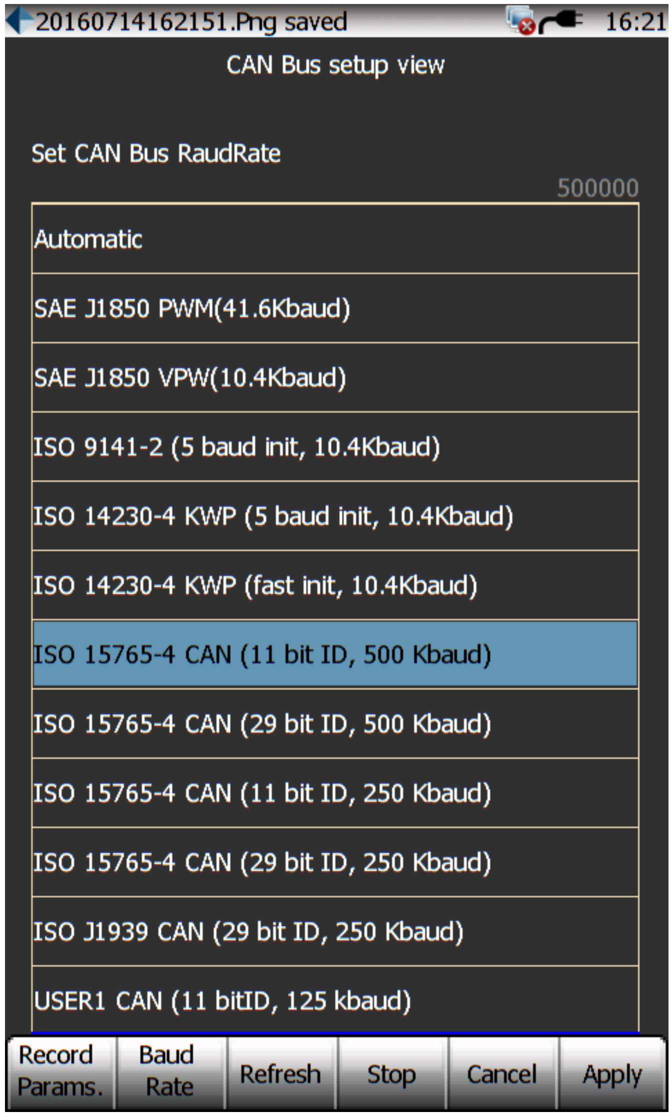
Set CANbus RaudRate and ODB-II protocal. Click on each option to view the dropdown menu to make selections.



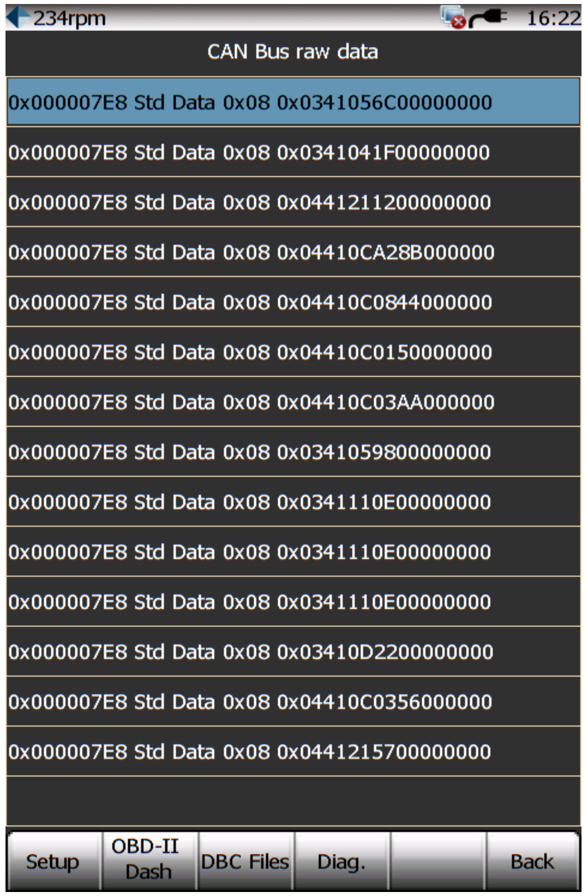
This is the list of available baud rate.



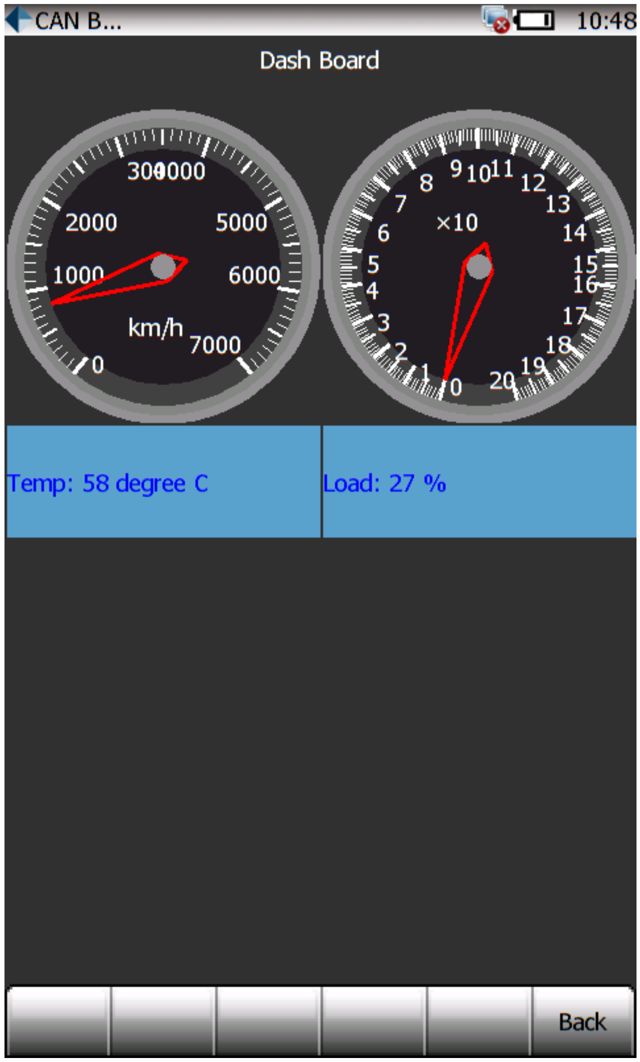
This is the list of the protocols.



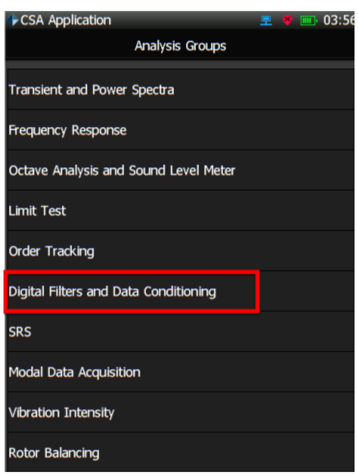
View the CANbus raw data at the next step.



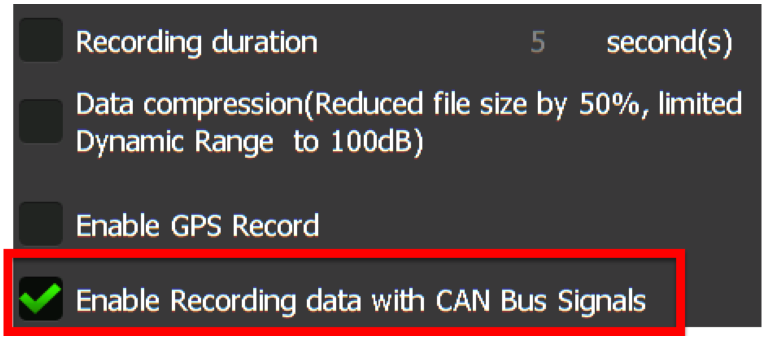
View the dashboard of the temperature and the load percentage.



CANbus must be enabled for recording in the *Time Stream Recording Setup*. First choose a CSA that supports CANbus recording – this is currently only supported in the *Digital Filters and Data Conditioning* CSA groups.

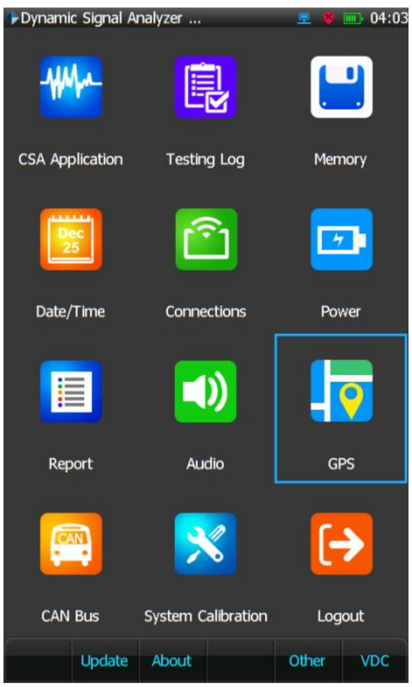


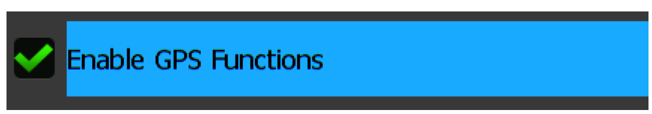
Go to the *Time Stream Recording Setup*, which can be found in the *Parameters* (F2) Menu. Here you can choose which channels/signals to enable for recording. Select the box to '*Enable Recording data with CAN Bus Signals*'.



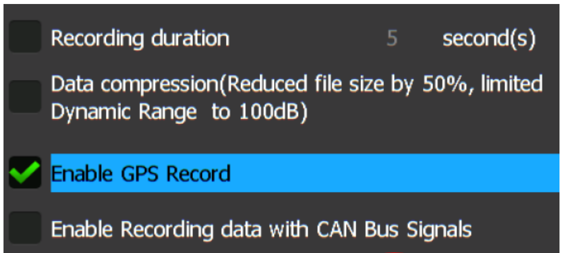
B. GPS Configuration

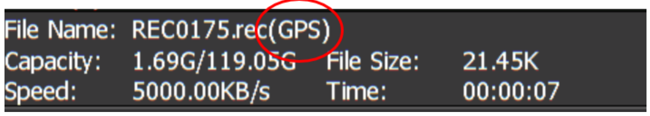
The GPS function must first be enabled from the Setup screen.





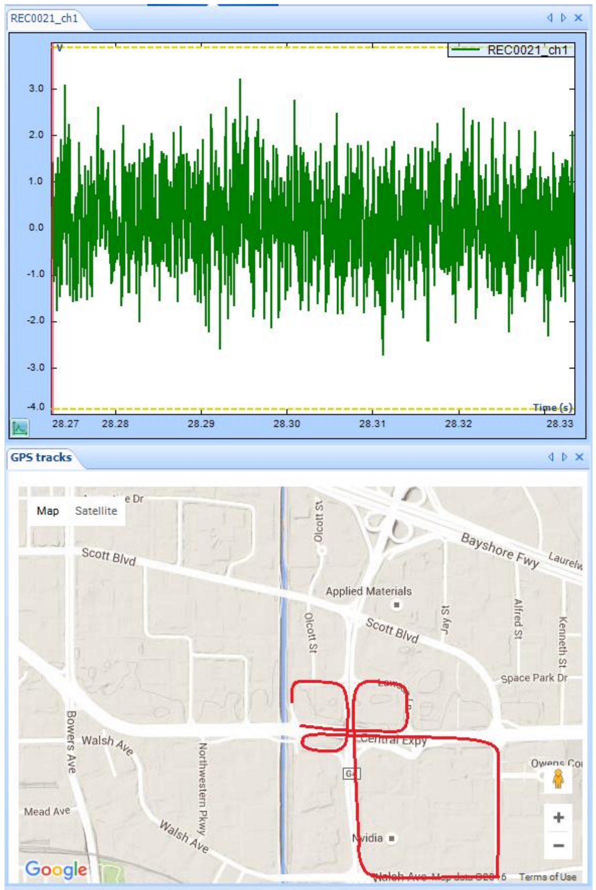
The GPS signal must also be enabled for recording. First, you must be in the appropriate CSA. Select any CSA from *Digital Filters and Data Conditioning*. Then open the *Time Stream Recording Setup*, and select the box for '*Enable GPS Record*'.

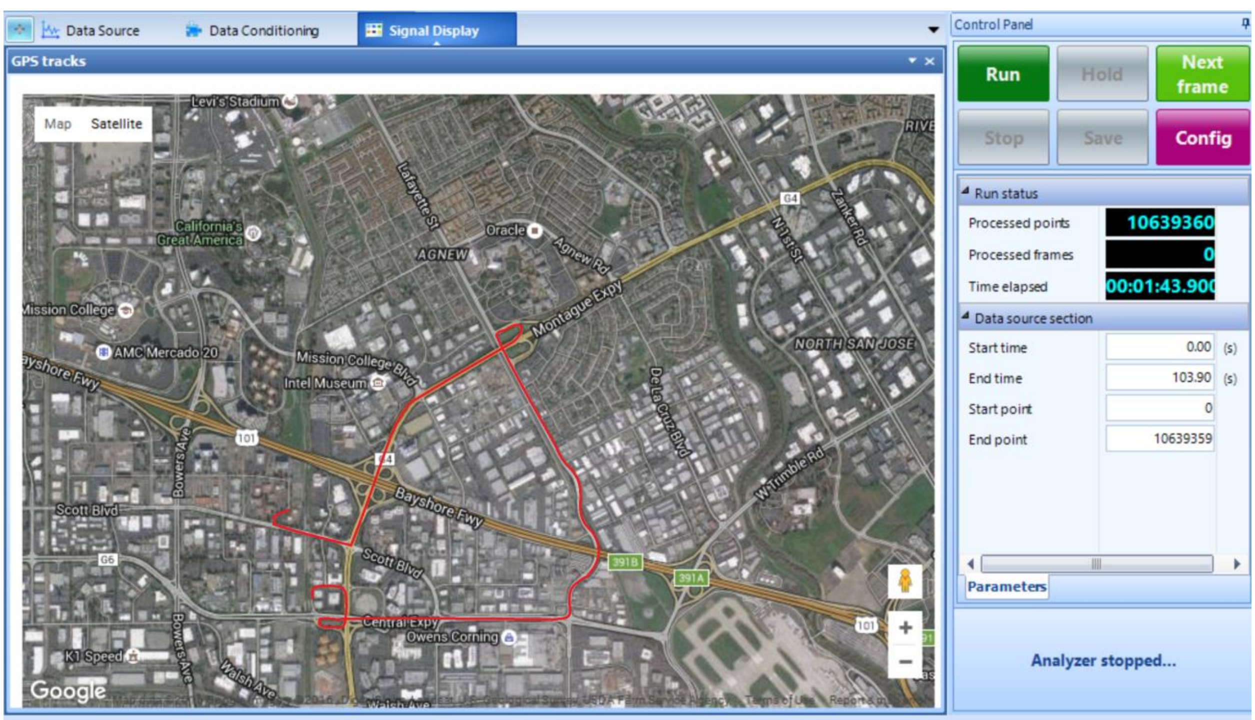




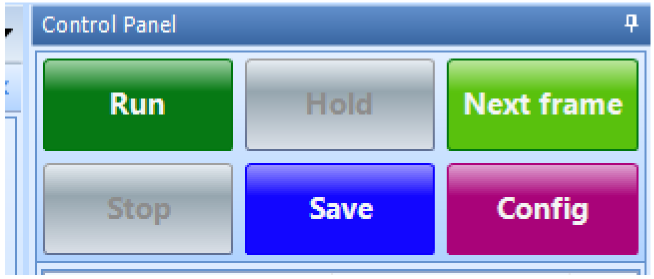
C. GPS track display

GPS tracks with other semaphore operations differ, click on "GPS tracks" signal, according to longitude and latitude to draw up GPS trajectory. The cursor is in the initial position. The left mouse button drag to move trajectories.Scroll the mouse wheel to enlarge or reduce the display scale.


REC0021_ch1
REC0021_ch1
Time (s)
GPS tracks
Map
Satellite
Scott Blvd
Bayshore Fwy
Applied Materials
Central Expy
Walsh Ave
Bowers Ave
Mead Ave
Northwestern Pkwy
Space Park Dr
Nvidia
Google


Data Source
Data Conditioning
Signal Display
GPS tracks
Map
Satellite
Control Panel
Run
Hold
Next frame
Stop
Save
Config
Run status
Processed points
10639360
Processed frames
0
Time elapsed
00:01:43.900
Data source section
Start time
0.00
(s)
End time
103.90
(s)
Start point
0
End point
10639359
Parameters
Analyzer stopped...

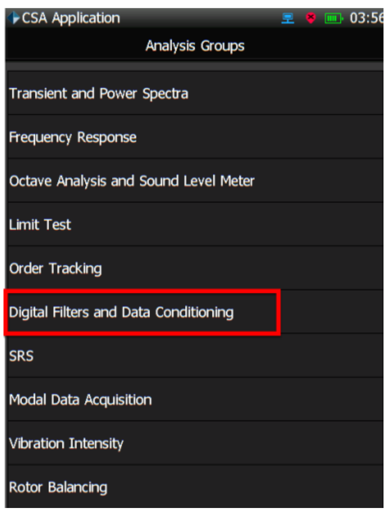
D. Analysis process



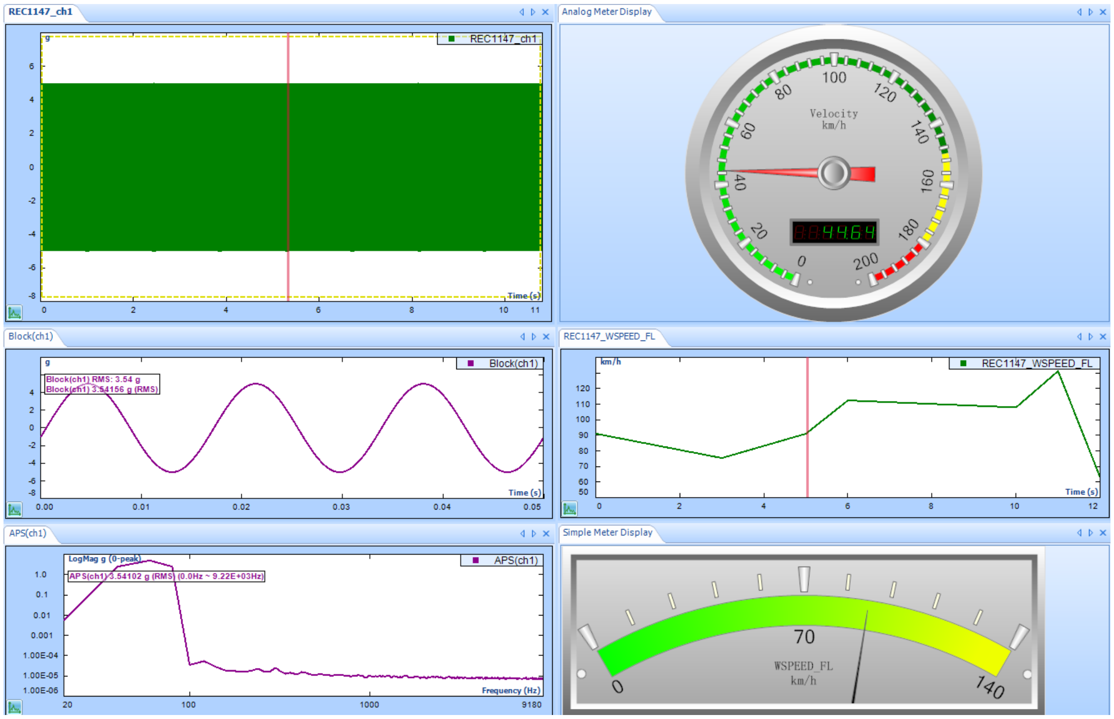
Click the Run button to start playback of data, meter control pointer and numeric indicator display real-time display, GPS trajectories over time to move the cursor.

CANbus and GPS Data Acquisition

To begin acquiring GPS or CANbus data, open the *Digital Filters and Data Conditioning* CSA group. These special measurement types are only available in this particular CSA group.



A. Configure CANBus for Recording



CSA — Configurable Signal Analysis

This section describes the Configurable Signal Analysis concept that is the basis for the CoCo-80X functionality and allows advanced users to customize the analysis features to suit individual needs. This section gives a brief description that is intended for the basic user. It does not describe writing projects for advanced users. For more on writing CoCo-80X analysis functions refer to the manual about CSA Editor that comes with EDM host software.

When the CoCo-80X powers up, the Welcome screen is shown. From this screen the user must select one of the CSA projects loaded on the CoCo-80X. When a CSA project is selected, the project defines the settings and analysis functions that are computed by the CoCo-80X. These settings include the following:

1. Parameters used by the data conditioning functions such as Add, Subtract, Multiply, Divide, Square, Square Root, RMS, Scale, Offset, Decimate
2. Parameters used by the signal analyzer functions such as FFT, Auto Power Spec, Coherence, FRF
3. Time Stream Data Recording Settings
4. Block Data Save Settings

5. Trace Settings

The CSA is designed to control how the data is processed, not how the data is acquired. When the CSA is changed, the processing functions are changed according to the new CSA, but the data acquisition parameters do not change. For this reason, the following settings have global effect and are not part of the CSA project:

1. Sampling Rate
2. Input Channels: sensitivity, coupling, channel labels
3. Output Channel: output waveform settings

All pre-programmed CSA projects have predefined parameters that are loaded when the project is selected. You can modify the parameters on the CoCo-80X from the **Param** Soft Button in the Display screen. Modified CSA projects can be saved with a different name using the Save As soft button in the Analysis screen so that the original projects are not overwritten.

Most pre-programmed CSA projects carry a variable called *Maximum Sampling Rate.* This is the sampling rate that this CSA can safely execute without exceeding its computational resource limit. Maximum Sampling Rate is used to limit the selection of the sampling rates.

Preprogrammed CSA projects

The CoCo-80X is preprogrammed with a set of default CSA projects which provide a wide range of options that meet most users' needs. Additional CSA projects may be downloaded from the Crystal Instruments web site. In addition, by using CSA Editor the advanced users may edit or develop their own customized CSA projects to meet their specialized needs. Typical default CSA projects are given below.

CSA Group	CSAs used for 4-channel CoCo-80X	CSAs used for 8-channel CoCo-80X	Description
Data Conditioning	RMS(4).csa	RMS(8).csa	Calculate the RMS of each input channel. Overlap ratio and average time are changeable.
	Time(4).csa	Time(8).csa	Apply no data conditioning for any channel. Only show the native input channels.
	PkPk(4).csa	PkPk(8).csa	Calculate the peak-to-peak value for each channel.
	Subtract(4).csa	Subtract(8).csa	Channel 1 is subtracted from each other channel.
	Multiply(4).csa	Multiply(8).csa	Multiply each channel by channel 1.
	Add(4).csa	Add(8).csa	Add channel 1 to other channels.
	Integration(4).csa	Integration(8).csa	Digitally integrate each channel. Suitable for signals with higher frequency content.
	IntegrationLow(4).csa	IntegrationLow(8).csa	Digitally integrate each channel. Suitable for signals with low frequency content.
	OffsetScale(4).csa	OffsetScale(8).csa	Apply an offset and a multiplier to each channel. The offset and multiplier can be modified in Analysis Parameters.
Transient Capture	Transient(4).csa	Transient(8).csa	Time streams from each channel are captured into block signals by enabling Acquisition Mode.
	Capture1Ch(4).csa	Capture1Ch(8).csa	Block-capture the channel 1 with up to 64k buffer size
Linear and Power Spectra	AutoPowerSpec(4).csa	AutoPowerSpec(8).csa	Transform the time streams into block signals then apply data window and FFT to calculate auto power spectra. FRF/Coh will not be calculated.
	APS1Ch(4).csa	APS1Ch(8).csa	Only calculate the auto spectrum for 1 channel with up to 64K buffer size
	FFT(4).csa	FFT(8).csa	Transform the time streams into block signals then apply data window and FFT.

CSA Group	CSAs used for 4-channel CoCo-80X	CSAs used for 8-channel CoCo-80X	Description
Frequency Response	FRF(4).csa	FRF(8).csa	Calculate the frequency responses when channel 1 set as reference and the others as responses.
	CrossPowerSpec(4).csa	CrossPowerSpec(8).csa	Calculate the cross power spectra when channel 1 set as reference and the others as responses.
	FRF_COH(4).csa	FRF_COH(8).csa	Calculate the FRF and coherence when channel 1 set as reference and the others as responses.
	FRF_COH_CPS_APS(4).csa	FRF_COH_CPS_APS(5).csa	Calculate the FRF, cross-power, auto-spectra and coherence functions when channel 1 set as reference and the others as responses.
Real-time Digital Filter	DecimFltr(4).csa	DecimFltr(6).csa	Apply n stage of 2:1 decimation to each input channel to obtain the signals with lower sample rate.
	FIR(4).csa	FIR(8).csa	Apply FIR Low Pass, High Pass, Band Pass, and Band Stop filters with filter length 67.
	RemezFltr(4).csa	RemezFltr(8).csa	Apply Remez FIR Low Pass, High Pass, Band Pass, and Band Stop filters with filter length 67.
	IIRFltr(4).csa	IIRFltr(8).csa	Apply IIR Butterworth Low Pass, Butterworth High Pass, Chebyshev Band Pass, and Elliptic Band Stop filters with filter order 7.
Acoustic Analysis	OCT(4).csa	OCT(8).csa	Apply 1/1, 1/3, 1/6 or 1/12 octave filters to time streams and generate octave spectra and filter RMS time traces. It conforms to ANSI std. S1.11:2004 and IEC 61260-1995.
	OCT RPM(4).csa	OCT RPM(8).csa	Apply 1/1, 1/3, 1/6 or 1/12 octave filters to time streams and generate octave spectra and filter RPM traces. It conforms to ANSI std. S1.11:2004 and IEC 61260-1995.

CSA Group	CSAs used for 4-channel CoCo-80X	CSAs used for 8-channel CoCo-80X	Description
	SLM(4).csa	SLM(8).csa	Sound Level Meter (SLM) template provides various overall sound level readings, time and frequency weighting according to IEC 61672-2002.
	SLM RPM(4).csa	SLM RPM(8).csa	Sound Level Meter (SLM) template provides various overall sound level readings, time and frequency weighting according to IEC 61672-2002.
Order Tracking	ORDTRK(4).csa	ORDTRK(8).csa	Normalized Order Spectra and Order Tracks
	ORDTRK(4)_CFS.csa	ORDTRK(8)_CFS.csa	Constant Frequency Bands
	ORDTRK(4)_Phase.csa	ORDTRK(8)_Phase.csa	Order Tracks with Phase
LimitTest	TimeLimiting(4).csa	TimeLimiting(8).csa	Apply limit test to the time stream signal of each channel. Limits are edited in CSA Editor.
	APSLimiting(4).csa	APSLimiting(8).csa	Apply limit test to the auto power spectrum of each channel. Limits are edited in CSA Editor.
	Transient_Limit(4).csa	Transient_Limit(8).csa	Apply the limit test to transient captured signals. Limits are edited in CSA Editor.
My CSA	Histogram(4).csa	Histogram(8).csa	View Histogram and statistical analysis of each channel.

Table 2. Preprogrammed CSA project Descriptions. Yellow-highlighted are most often used

When a CSA project is running you can choose to display, record or save data streams or signals.

Change CSA projects from the CoCo-80X

A CSA project specifies the analysis settings and functions including: analysis parameters and functions, time stream recording, block data save and trace settings. After a CSA is selected it can be modified from the CoCo-80X to change these parameters using the *Traces* and *Param* soft buttons in the Display screen. The modified CSA can then be saved using the Save As soft button in the Analysis screen. This allows modified CSAs to be saved and used again later.

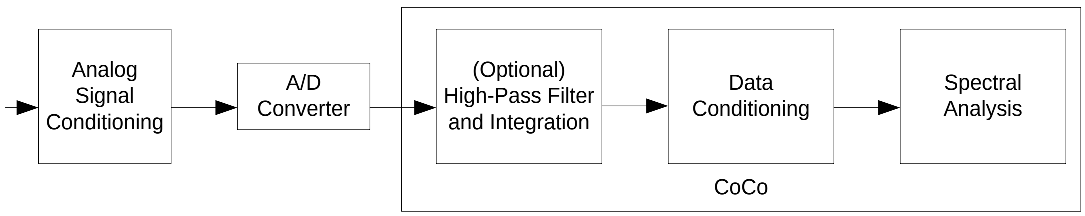
Editing CSA from the EDM Software

CSA files can also be edited or new CSA files can be created from scratch from the EDM software on a PC. This feature allows the advanced end user to create custom analysis functions to suit their special needs. This advanced topic is not covered in this manual. Refer to the CI Support web page for documentation about editing CSA from the EDM software.

To initiate the CSA Editor, click on the CSA Editor icon on the upper-left corner of EDM.

Signal Processing in the CoCo

In a global picture, the signals will go through the following stages in the analyzer:



First the analog signals will be processed by the analog signal conditioning circuitry. It usually includes input mode selection logic, the high-pass filter for AC coupling, and constant current source for IEPE. Then the analog signals will be digitized simultaneously by multiple A/D converters. The digital signals coming out of A/D converters, after a calibration process, will be fed into the DSP processor.

The CoCo may first turn on a pre-data conditioning algorithm. This pre-data conditioning algorithm may apply the high-pass filters so to reduce the DC drift, or convert the acceleration signals into velocity or displacement. It will also apply the appropriate engineering unit setting to the input signals.

Then the data streams will be fed into a user controlled Data Conditioning module, and then spectral analysis. This part will be explained in detail in the next section.

The Data Processing Flow of CoCo

CoCo-80X combines two instruments, a data recorder, and a signal analyzer into one system. It is important to understand the differences between these two functions. The following sections provide details of each.

The data conditioning and recording phase includes processing the data from native acquisition channels and data conditioning. Data conditioning operations include arithmetic operations such as adding or subtracting, filtering, integration, differentiation, calibration, and other operations that can be applied to the continuous time streams. All the signals in the data conditioning and recording stage are continuous time streams with a fixed sampling rate without any gaps. Time streams can be displayed or recorded.

The signal analyzer phase includes the Acquisition Mode and CSA based block-by-block processing. The acquisition mode controls how the continuous time streams are captured into fixed-sized blocks. The processing phase applies algorithms such as spectral analysis to the blocks.

The figure below shows how the input data is processed in the data conditioning and signal analyzer phases.

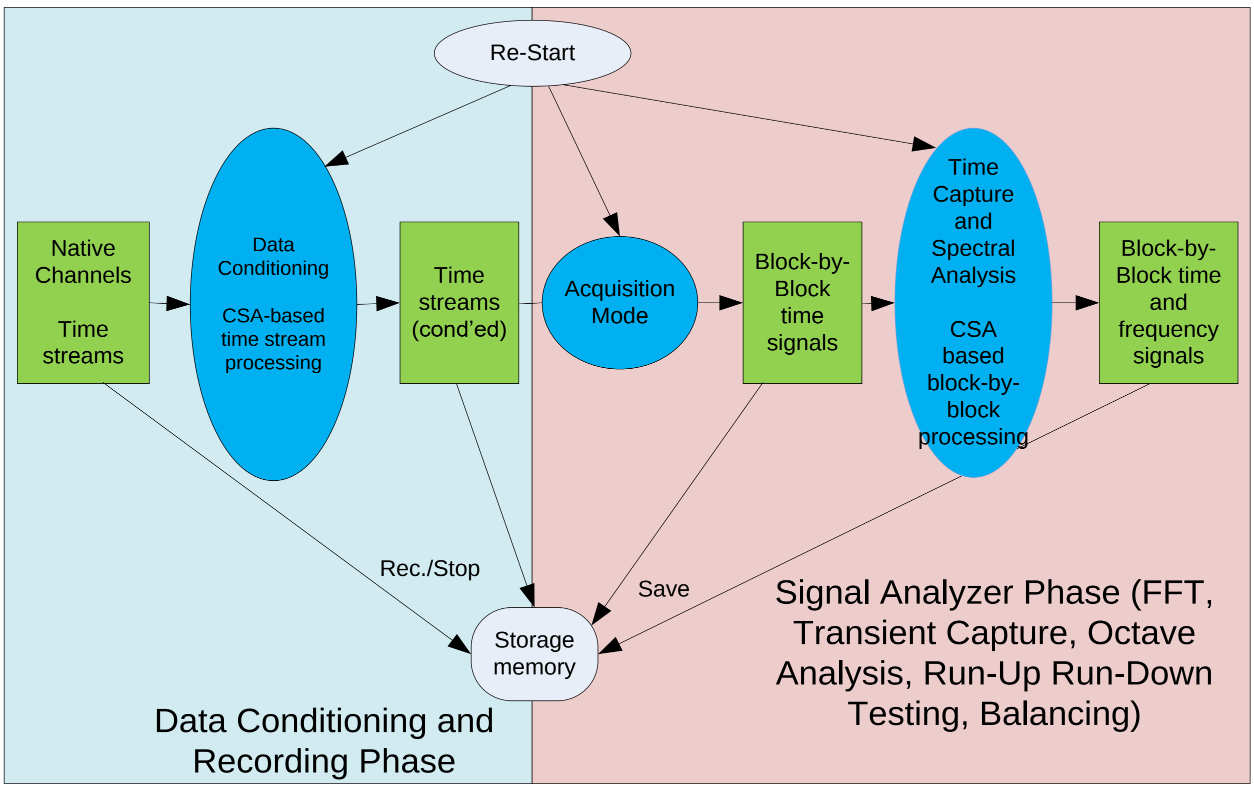


Figure 70. Data Process Flow Diagram.

The system has two dedicated buttons that control the data acquisition. **Rec./Stop** button only applies to the continuous time streams in the data conditioning phase while the **Save** button only applies to the captured time buffer and spectral signals in the signal analyzer phase. Recording and Save cannot be performed at the same time. In the other words, when the time stream is being recorded, the spectral analysis cannot be saved. To save a spectral analysis signal the time recording must first be stopped.

Re-Start soft button re-initializes the data conditioning, acquisition mode control and spectral analysis. It resets the timer of time streams, re-arms the trigger and resets the average number of spectral analysis.

Block Size governs the size of transient capture or FFT blocks in the signal analyzer phase. Block Size has no influence on the length of the time streams in the data conditioning phase.

Both time streams and block-by-block signals can be displayed with continuous update (Run mode) or frozen on the screen (Hold mode). In the signal display window the F6 soft button is assigned to the **Run/Hold** function. *Hold* means the display are frozen on the screen. **Hold** does not stop the data conditioning and recording process. If data is being recorded and the Hold button is pressed, the data will continue to be recorded until the Rec/Stop button is pressed again.

The **sampling rate** governs the rate at which samples of the signal are taken, to be converted into digital form. The CoCo-80X offers 54 stages of sampling rates, ranging from 0.48 Hz to 102.4 kHz.

The actual Data Conditioning and Signal Analysis function processing are defined by a special technology, CSA, as described in the following section.

Table 3: CoCo-80X Supported Sampling Rates

0.49 Hz	0.63 Hz	0.78 Hz
0.98 Hz	1.3 Hz	1.6 Hz
2.0 Hz	2.5 Hz	3.1 Hz
3.9 Hz	5 Hz	6.3 Hz
7.8 Hz	10 Hz	13 Hz
16 Hz	20 Hz	25 Hz
31 Hz	40 Hz	50 Hz
63 Hz	80 Hz	100 Hz
125 Hz	160 Hz	200 Hz
250 Hz	320 Hz	400 Hz
500 Hz	640 Hz	800 Hz
1.00 kHz	1.28 kHz	1.60 kHz
2.00 kHz	2.56 kHz	3.20 kHz
4.00 kHz	5.12 kHz	6.40 kHz
8.00 kHz	10.24 kHz	12.80 kHz
16.00 kHz	20.48 kHz	25.60 kHz
32.00 kHz	40.96 kHz	51.20 kHz
64.00 kHz	81.92 kHz	102.40 kHz

Acquisition Modes

This section describes the Acquisition Mode, which defines how the device captures block by block data from continuous time streams, usually in response to trigger events.

The instrument separates the data processing into three stages: data conditioning, acquisition mode, and signal analysis. Acquisition Mode controls how the continuous time stream data is captured for block-by-block processing. Acquisition Mode control is applied after data conditioning and before the signal analysis stage. If a CSA does not include a block capture function then Acquisition Mode will not be used.

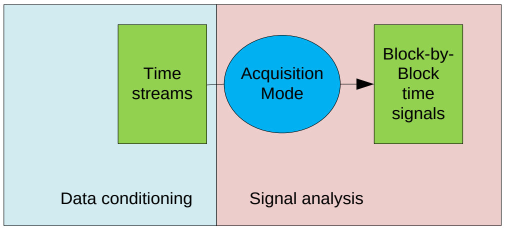


Figure 71. Data processing is separated into three stages.

Note: in the description below, sometimes when we say "capture a block of data", it really means that multiple blocks of data are captured from their own time streams. These blocks are all accurately time-synchronized.

Free Run displays block data acquired from the time stream as fast as possible or at the overlap rate set by the user. Free Run is commonly used to analyze random or irregular signals.

Continuous after Trigger waits until a trigger event is detected. After the first trigger event, averaging begins from zero and the system runs in Free Run mode.

Single Shot with Trigger waits until a trigger event is detected, then acquires one block of data and stops. This mode is the best if you want to observe the time signal block by block at a certain trigger event.

Single Shot without Trigger acquires one block every time the user presses the Run button. This mode is best for observing a time signal block by block at arbitrary times.

Auto-Arm Trigger acquires one block of data every time a trigger event is detected. This block is added to the current average based on the average mode settings under Analysis Parameters. If another trigger event is detected, a new block of data will be acquired. This process will continue indefinitely with no user interaction.

This mode can be used for time synchronous averaging with the average mode set to *Time Linear* or *Time Exponential*.

Manual-Arm Trigger works like Auto-Arm trigger but prompts the user to accept or reject each captured block. Only accepted blocks are added to the average. This mode is the best for applications such as impact hammer testing where you may not have confidence in the signal quality of some of the data blocks.

Trigger Source

Trigger Source defines what signal is used to determine a trigger event. Any time stream that is set as trigger source candidate in the CSA can be selected as trigger source on the CoCo-80X. If a signal is not identified as a trigger source candidate in the CSA file then the signal will not appear on the list. This feature is designed to simplify the user interface and optimize the CoCo-80X computational resources.

The candidates of Acquisition Mode selection and Trigger Source selection will be defined by the CSA editor. The CSA editor will assign some the data streams after the data conditioning as candidates of trigger sources. For example, in a CSA there are 8 channels, if you only select ch1 and ch2 time streams as candidates of trigger source and then this CSA will only show ch1 and ch2 on the trigger source selection menu.

You may also define time streams other than native channels as trigger source candidate. For example, if in the CSA an RMS measurement is derived from ch1, this RMS time stream can be used as a trigger source.

Trigger Condition

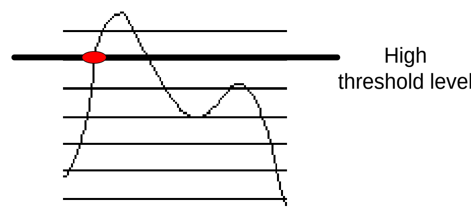
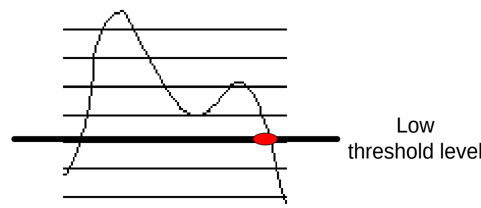
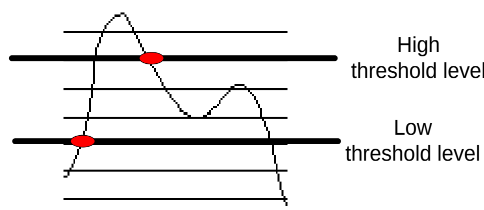
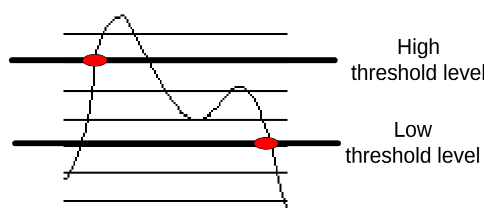
Trigger Condition defines when a trigger is detected based on the signal level and the slope. The four choices are:

- Trigger Source > High Level (rising edge)
- Trigger Source < Low Level (falling edge)
- Low Level < Trigger Source < High Level (level trigger)
- (Trigger Source > High Level) OR (Trigger Source < Low Level) (edge trigger)

There are two types of trigger detection, one is called edge detection; the second level detection. In the trigger conditions above, 1, 2 and 4 are edge detection and 3 the level detection. Edge detection compares at least two sample points against the threshold level. Level detection only detects one sample point.

When **Free Run** is selected, trigger source and level are not needed.

The table below visually explains when the trigger event will happen in these four conditions. The red mark shows the instant in time that the trigger event is detected:

Trigger Condition	Illustration
Trigger Source > High Level (rising edge)	
Trigger Source < Low Level (falling edge)	
Low Level < Trigger Source < High Level (level trigger)	
(Trigger Source > High Level) OR (Trigger Source < Low Level) (edge trigger)	

Trigger Delay

Trigger delay allows a captured signal to include some data before or after the trigger event. This is done by defining some number of points, or the percentage of the total Block Size, that the capture occurs after the trigger event. For example, if the Block Size is set to 1024 and the trigger delay is 10%, the data capture will happen 102 points after the trigger event.

A negative trigger delay is more common for transient data capture. Negative trigger delay means that the data capture will include data points before the trigger event. For example, a -10% trigger delay means that the data capture will include 102 data points before the trigger event with Block Size 1024. Some instruments call a negative trigger delay a **Pre-Trigger**. The following picture shows the concept of a negative trigger delay:

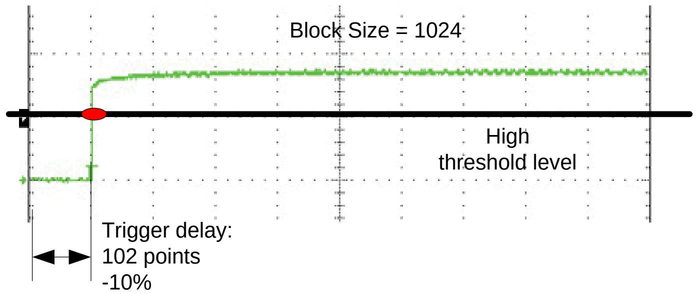


Figure 72. Pre-Trigger (negative delay) example.

Overlap

When overlap is enabled, consecutive data blocks have overlapped samples. This reduces the averaging time. Overlap is only used when the Acquisition Mode is set to **Free Run** or **Continuous after Trigger**. Otherwise it is not used. Continuous capture without further trigger can also use overlapping.

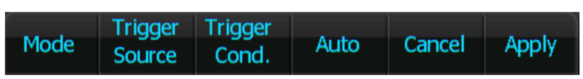
No Overlap – Overlap is not applied.

Automatic – System determines the best overlap rate

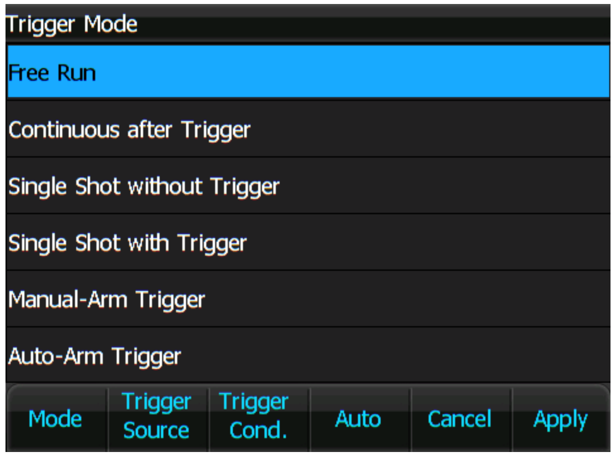
Acquisition Mode Setup

This section explains how to set up the acquisition mode and the trigger related parameters. First select the Acquisition Mode under the Param. Setting then the acquisition mode screen will be shown.

The soft buttons are assigned with different functions:

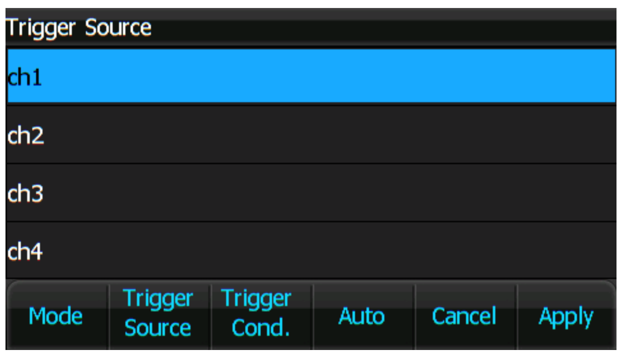


Press F1 to select one of the acquisition modes:

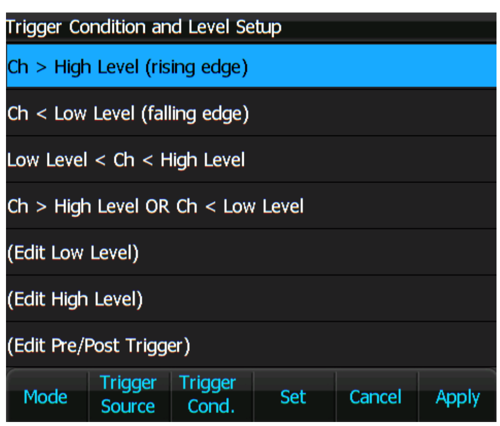


When the Acquisition Mode is not **Free Run**, the Trigger Source, Trigger Condition must be defined.

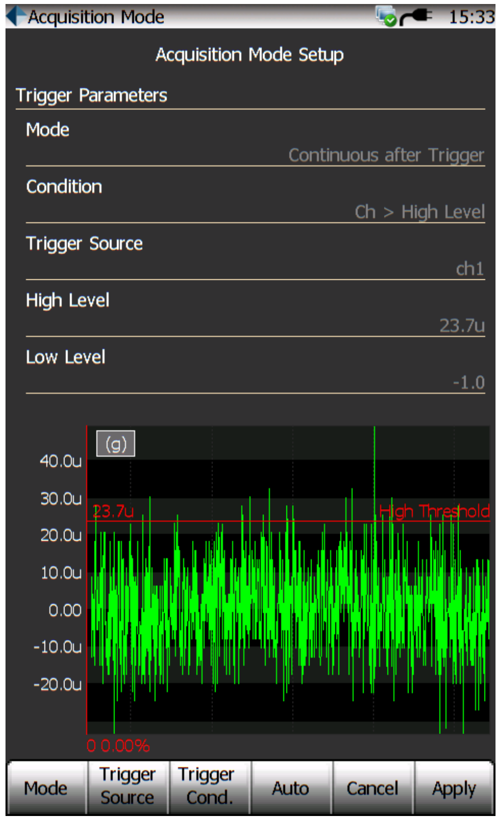
Press F2, Trigger Source, to select one of the time streams as the trigger source. These time streams are set as Trigger Source Candidates by the CSA Editor when this CSA project is created on the host PC.



Press F3, *Trigger Cond.*, to select one of the trigger conditions. You can also key in the trigger level(s) using Editing Level entry.



The arrow buttons can also be used to set the trigger level and delay settings.



Use the arrow buttons to change the trigger level and delay while the data stream from the trigger source is displayed.

Press F4 to activate one of four functions for the navigation arrow buttons:

- **Auto Scale Window**
- **Fixed Scale Window**: Arrow buttons used for expanding or reducing the scales
- **Move Window**: Arrow buttons used to shift the positions of the window
- **Set Trigger Level**: Arrow buttons are used to set the high threshold level, low threshold level, and trigger delay

The method 3 is a more convenient way to set the trigger threshold level instead of using the editing tool under F3. The editing tool allows you to set the trigger level to a precise value.

Press F5 to set the overlap rate. This factor will only have effect when the acquisition mode is set as **Free Run** or **Continuous after Trigger**.

After all trigger parameters are set, press F6 (OK) button then the system will exit to the main measurement display window.

Using a Trigger During Measurement

This section explains the trigger operation while making measurements. Manual-Arm Triggering is the most common mode and will be described first and in the most detail. The other types will be explained briefly afterwards.

Manual Arm Trigger

When the Acquisition mode is setup then a small popup window is displayed as shown below indicating that the system is waiting for a trigger event. No signals are displayed until a trigger event is detected.

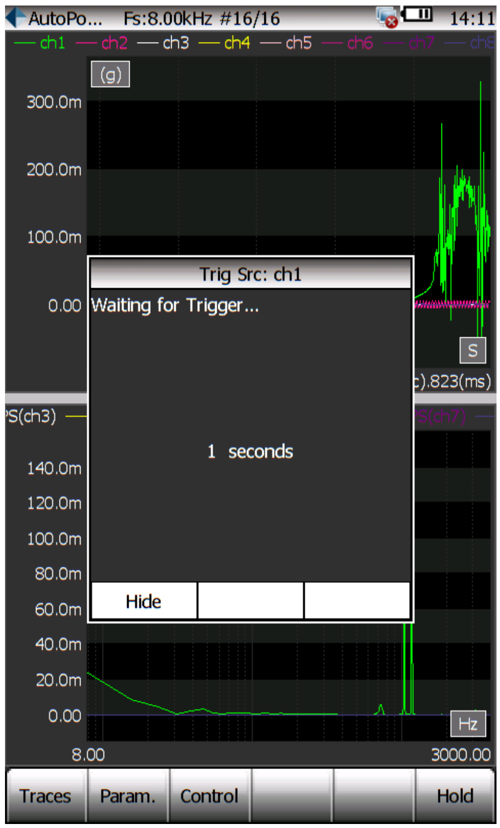


Figure 73. Waiting for trigger message.

You can change from waiting for trigger mode to Hold mode by pressing the F6 (Hold) button. The window will close and the system will change to Hold mode.

Press Restart (F3) or Run (F6) to reopen the window and return to the waiting for trigger mode.

When a trigger event occurs due to the Trigger Source signal meeting the trigger condition, the popup window will show a block of captured data from the trigger source signal.

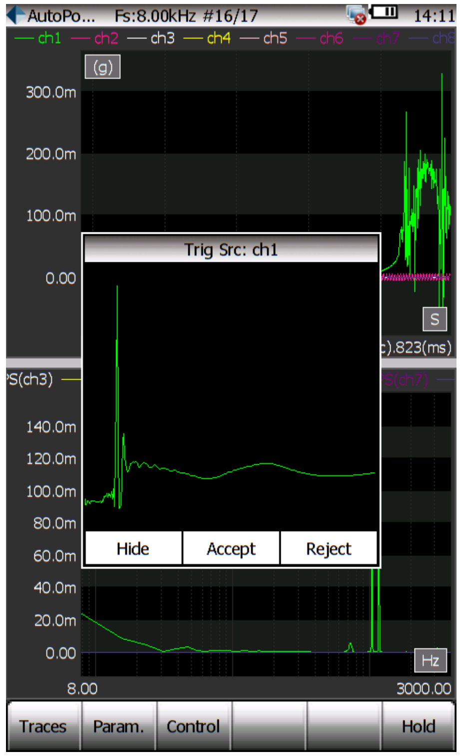


Figure 74. Trigger window with Accept or Reject options.

The display will depend on the type of signals in the pane.

If a time stream is displayed then the display will update continuously. You will not notice the difference before or after trigger event for the time stream.

If a block signal is displayed, the block signal(s) in the background window will be updated with the new content.

If a block signal in the frequency domain is displayed, it will not be updated because you have yet to "accept" the time signal.

Now you may do one of two things: **Accept** or **Reject**.

If you press the **Accept** button, the acquired block signals will be passed to the signal analysis stage, usually windowing, FFT and spectral analysis. Then you can continue to the **Next** frame of capture.

After you press the **Next** key, the system will go back to waiting in trigger mode.

If you press **Reject** then the captured time signals will be discarded and will not be sent to signal analysis stage. After the **Reject** action, the system goes back to waiting in trigger mode.

The number showed on the top status bar, #N, indicates the number of the frames of the time captures that have been accepted and averaged into the spectra.

After you press the **Hide** key, the small from window will disappear. Press **Enter** to show this window again.

During trigger operation, you can switch the main display window to any trace. This can be helpful to view the time stream selected as the trigger source to tune the level and slope settings.

Time-Synchronous Averaging

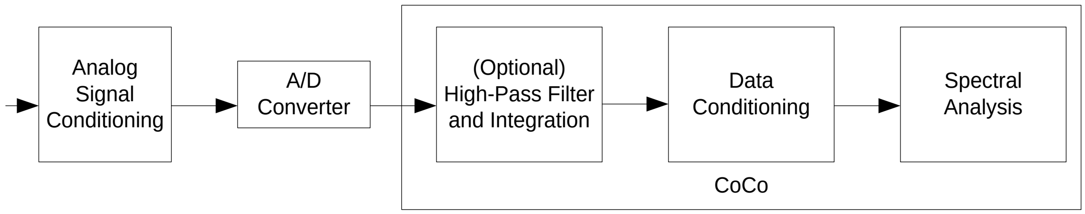
In some measurement situations, it is desirable to average together multiple periods of a periodic time signal. This will average out random noise, and leave only the periodic part of the signal. However, this relies on the ability of the averaging function to align each successive period. One method to do this involves synchronous triggering, where one signal marks each period of another signal. The averaging is then triggered by this second signal. The most common example of this is when the averaging is done on a signal from a sensor connected to a rotating machine, and a tachometer pulse signal is used for triggering.

Time-synchronous averaging can be done on the CoCo using the Auto-arm trigger mode and the Time Exponential or Time Linear average mode.

Built-In Digital Integration

Ideally a measurement is made using a sensor that directly measures the desired quantity. For example an accelerometer should be used to measure acceleration, a laser velocimeter or velocity pickup should be used to measure velocity and an LVDT should be used to measure position. However since position, velocity and acceleration are related by the time derivatives it should be possible to measure an acceleration signal and then compute the velocity and position by mathematical integration. Alternatively you can measure position and compute velocity and acceleration by differentiating. The integration can be performed at the analog hardware level or at the digital level.

The CoCo provides a means to digitally integrate or double integrate the incoming signals. The integration module fits into the very first stage after data is digitized, as shown below:



There are several issues to address in such implementation:

The integration and double integration algorithm has to be accurate enough and it must find a way to reduce the effects of a DC offset. A tiny initial value, offset in the measurement or temperature drift before the integration, may result in a huge value after single or double integration. This DC effect can be removed using a high-pass filter.

The initial digital signal must have a high signal-to-noise ratio and high dynamic range. The integration process in essence will reduce the high frequency energy and elevate the low frequency components. If the original signals do not have good signal-to-noise ratio and dynamic range, the signals after integration and double integration will have too much noise to use. The noise will corrupt the integrated signal.

The instrument must be able to set two different engineering units: one engineering unit for the input transducer and a second engineering unit after the integration. For example, first the instrument must provide a means to set the sensitivity of the sensor, say 100*mV/g*. After the double integration, the instrument must have the means to set the engineering unit to a unit that is compatible with the integration such as *mm*.

The CoCo instrument handles these three issues effectively so you can get reliable velocity or displacement signals from the acceleration measurement, or displacement signals from the velocity measurement. The CoCo hardware has a unique design to provide 130dB dynamic range in its front-end measurement. The signals with high dynamic range will create better results after digital integration.

Since such built-in integration is conducted in the time domain before any other data conditioning or spectral analysis, the time streams generated after the digital integration can be treated in the same way as other time streams. They can be analyzed or recorded.

CoCo also provides differentiation and double differentiation to calculate the acceleration or velocity from velocity or displacement transducers. Differentiation is not as common as integration.

It must be noticed that the displacement after double integration to the acceleration is not the same as that measured by a proximity probe. A proximity probe measures the relative displacement between a moving object to the fixed coordinates seated by the probe. The accelerometer and its integration value can only measure the movement of the moving object against the gravity field.

Sensor Consideration

Accelerometer signals that are non-dynamic, non-vibratory, static or quasi-static in nature (low acceleration of an automobile or flight path of a rocket) are typically integrated in the digital domain, downstream of the signal conditioner. Piezoelectric and IEPE accelerometers are commonly used to measure dynamic acceleration and, therefore, dynamic velocity and displacement. They should not be used to measure static or quasi-static accelerations, velocities, or displacements because the IEPE includes analog high pass filtering in the sensor conditioning that cuts out any low frequency signal. At frequencies approaching 0 Hz, piezoelectric and IEPE accelerometers cannot, with the accuracy required for integration, represent the low frequency accelerations of a test article.

When this slight inaccuracy is integrated in order to determine velocity and displacement, it becomes quite large. As a result, the velocity and displacement data are grossly inaccurate. A piezoresistive or variable-capacitance accelerometer is a better choice for low frequency signals and for integration. These types of sensors measure accelerations accurately at frequencies approaching 0 Hz. Therefore the integration calculation of velocity and position can be used to produce accurate results.

Calculation Errors in Digital Integration

Two types of calculation errors can be caused by digital integration: low sampling rate and DC offset.

The sampling rate of a signal must be high enough so that the digital signal can accurately depict the analog signal shape. Some people may think that according to the Nyquist sampling theorem as long as the sampling speed is more than twice of the frequency content of the signals before the integration, the integration results should be acceptable. This is not true. Satisfying the Nyquist frequency only ensures an accurate estimate of the frequency of a measurement. Integration error can still occur of a signal is not sampled at more than twice the signal frequency. The figure below shows a 1 kHz sine wave sampled at 8 kHz and 5.12 kHz.

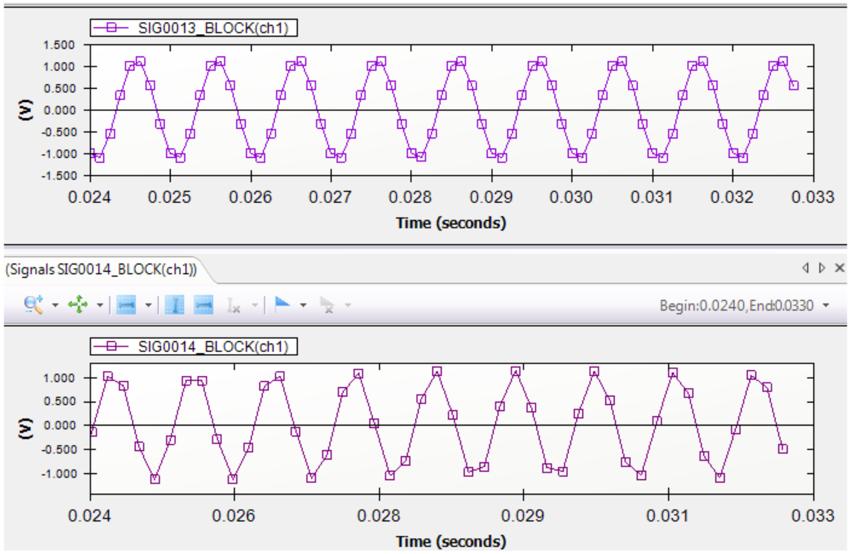


Figure 75. A 1 kHz sine wave sampled at 8 kHz (top) and also sampled at 5.12 kHz (bottom).

It is clear that the higher the sampling frequency, the closer this digitized signal is to the true analog waveform. When the sampling rate is low, the digital integration will have significant calculation error. For example, the 5.12 kHz sampled signal is not symmetric about 0 volts so the integration will drift and a double integration may grow with accumulated error very fast.

In general, you should use a sampling rate 10 times higher than the frequency content of interest in the signal when you apply numerical integration.

DC offset is the second type of digital integration error and can be more severe. It is caused by any measurement error before integration and may result in huge amplitude errors after the integration. Figure 76 shows how a small measurement error in acceleration will create a constant DC offset in the acceleration integrated to compute velocity and result in a drift and eventually an infinitely large magnitude of displacement after double integration.

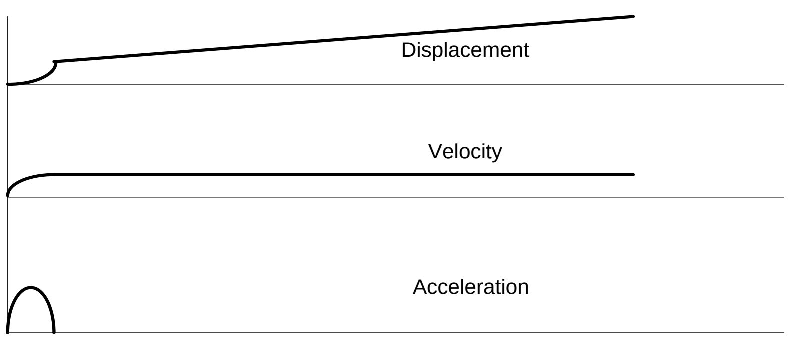


Figure 76. A small error in acceleration results in a DC offset in velocity and a huge drift in displacement.

Of course, the computed velocity and displacement signals are unrealistic. They are artifacts of the integration errors. To remove such a problem caused by inaccurate measurement and digital integration, a high pass filter can be applied before or after the integration. It should be noted that the high-pass filter will distort the waveform shape to some extent because it alters the low frequency content of the signal. However, this effect must be tolerated if numerical integration is used.

Digital High-Pass Filter

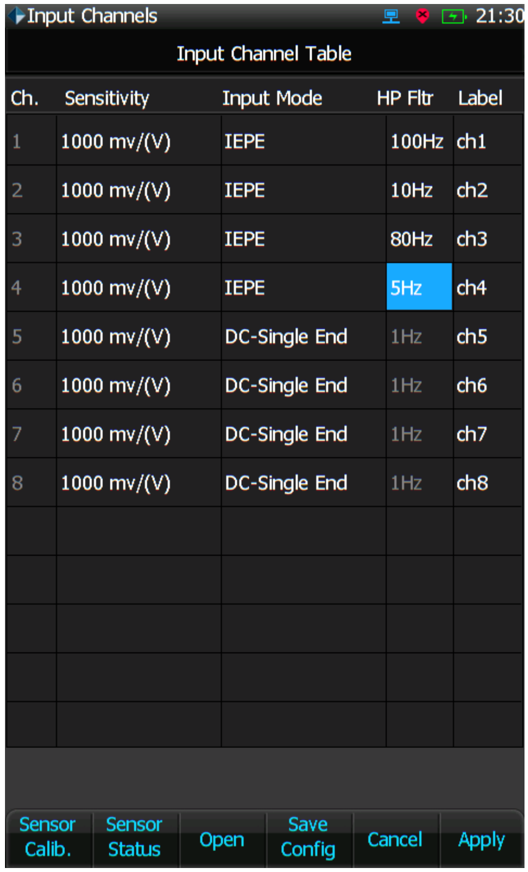
The most effective way to remove the DC drift effect as described above is to apply a high pass digital filter to the continuous time streams. In CoCo, a unique algorithm is realized so that even though the data is sampled at high rate, the high pass filter can still achieve very low cutoff frequency.

The filter cutoff frequency is specified at -3dB attenuation.

To remove unwanted signals at or near DC, set up the cutoff frequency of the digital high-pass filter as high as possible as long as it won't chop off useful frequency content of your interest.

To give an example, if you are not interested in any frequency less than 20Hz, then you can set the cutoff frequency to approximately 10Hz. With this setting, the amplitude attenuation at 20Hz will be less than 1dB.

The following picture shows that ch1 sets the high-pass filter at 100 Hz and ch2 at 10Hz.



Using Integration

Integration can be enabled in the Input Channel table. In CoCo, to set up the built-in integration or double integration, you must set two engineering units. The first one is for sensor sensitivity, the second for the engineering unit after the integration or differentiation. For example, you can choose either *g* or *m/s²* as the engineering unit used for the accelerometers. After the double integration, you can choose one from the list of *meter*, *cm*, *mm* or other displacement units for displacement presentation.

Example

First select Acceleration or Velocity in the input channel table:

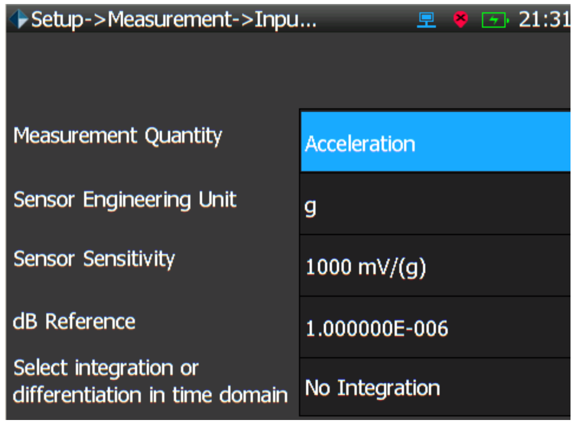


Figure 77. Sensor sensitivity without integration.

Then select the engineering unit of the sensor to be used and set its sensitivity.

Under the item of Selection integration or differentiation, select appropriate item. The example shows *Double Integration to Displacement* is selected

Select the appropriate engineering units for displacement. This example shows displacement units of millimeters.

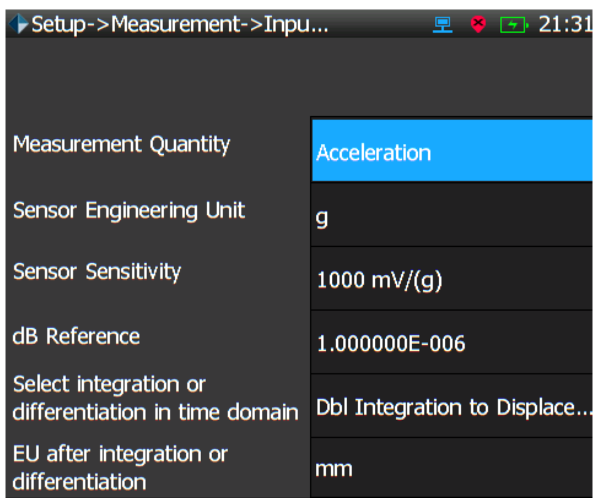
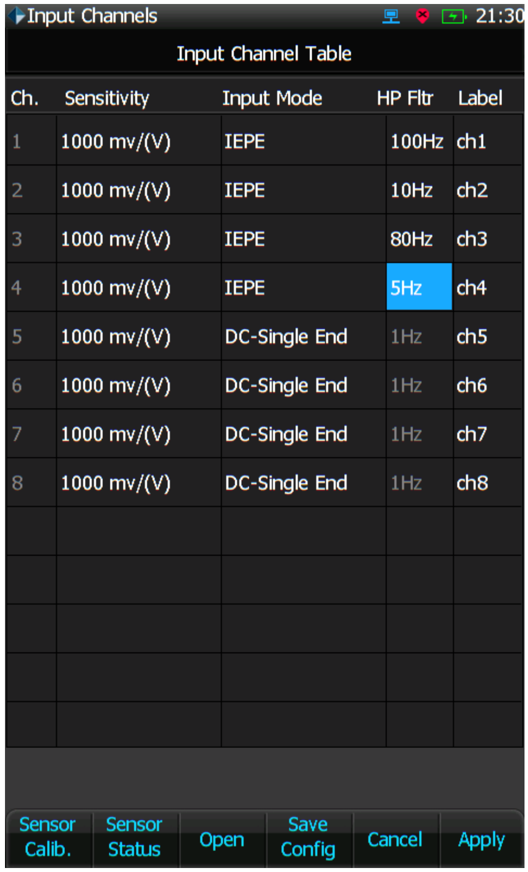


Figure 78. Sensor sensitivity window with double integration and units.

With this setup, the accelerometer is set to measure *g* while the displacement uses *millimeter* as the output unit. The sensor sensitivity 50 mV/g transforms the input voltage into *g* appropriately.

To enable or set the high-pass filter, simply go to the channel table and highlight the column of *Hi-Pass Fltr*, and press Enter button. Each channel can have its independent cutoff filter values.


Input Channels
21:30
Input Channel Table
Ch.
Sensitivity
Input Mode
HP Fltr
Label
1 1000 mv/(V) IEPE 100Hz ch1
2 1000 mv/(V) IEPE 10Hz ch2
3 1000 mv/(V) IEPE 80Hz ch3
4 1000 mv/(V) IEPE 5Hz ch4
5 1000 mv/(V) DC-Single End 1Hz ch5
6 1000 mv/(V) DC-Single End 1Hz ch6
7 1000 mv/(V) DC-Single End 1Hz ch7
8 1000 mv/(V) DC-Single End 1Hz ch8
Sensor Calib.
Sensor Status
Open
Save Config
Cancel
Apply

CoCo Operation for Spectral Analysis

This section describes the operations of CoCo that are specifically related to FFT spectral analysis. For general operations of CoCo, refer to the previous chapters of this manual.

Select a CSA Project

To run a spectral analysis CSA, press the Analysis button and select either the *Linear and Power Spectra* or the *Frequency Response* Application group, then select one of the CSA spectral analysis projects.

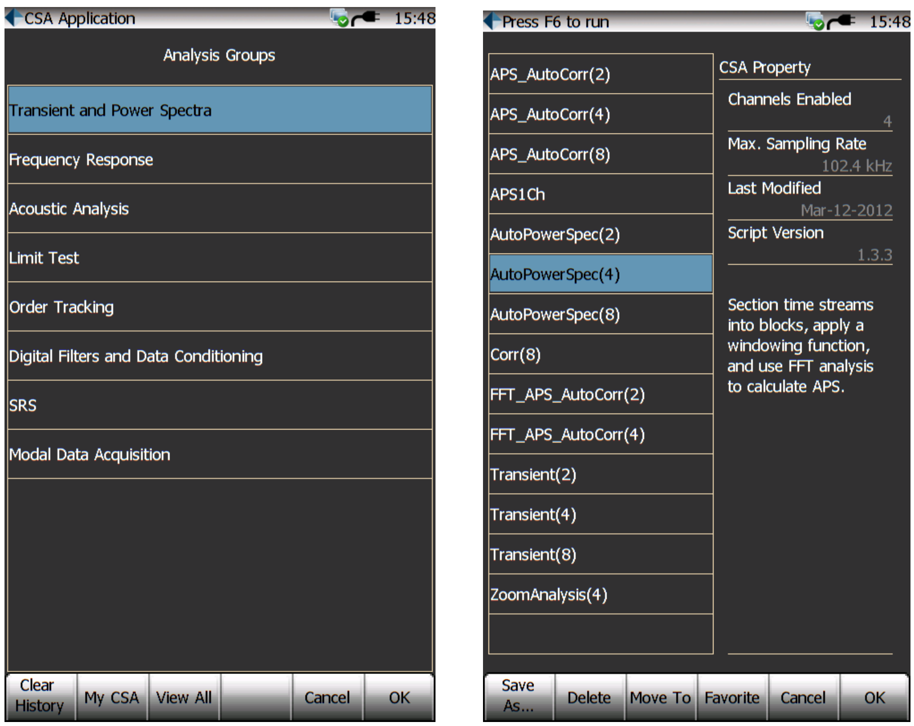


Figure 79. CoCo Select Analysis Function selection display.

Set Analysis Parameters for Spectral Analysis

To set the parameters for spectral analysis, press the Param. Button in the signal display window, select Analysis Parameters, then set the parameters.

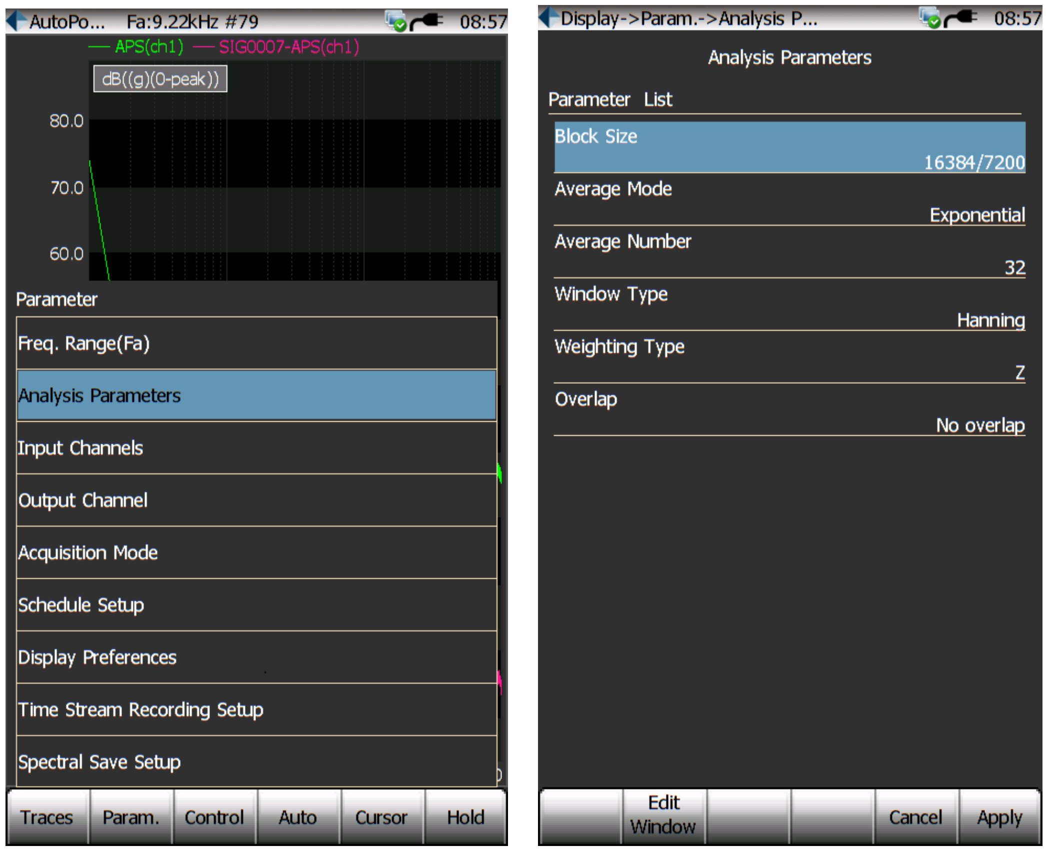


Figure 80. CoCo Analysis Parameters selection display.

Block Size: the block size of the time block signals.

Average Mode: Exponential, Linear or Peak Hold applied to frequency domain, power spectra averaging. Time Linear and Time Exponential applies to time domain averaging.

Average Number: the Average number of linear averages. When exponential average is selected as the average mode, 1/(Average Number) is used as the exponential factor.

Window Type: type of data window.

The selection candidates of these fields are defined in the CSA Editor. That is, the maximum sampling rate, maximum number of input channels, and so on, are defined when you create the CSA. For example if you select a Maximum Sampling Rate of 1 kHz in the CSA Editor, then higher sampling rates will not be available on the CoCo device. If a higher sampling rate is required, then you must modify the CSA and download it to the CoCo. Although this behavior may seem limiting, it should be noted that it allows the user to choose exactly the analysis functions and optimize the performance of the CoCo device to suit your specific needs and is one of the unique features of the CoCo system.

Weighting Type: CoCo offers Z, A, B, and C weighting.

Overlap Ratio: The overlap ratio setting has the options of %0, 25%, 50%, 75%, and As High As Possible.

Set the Spectrum Type

To set the Spectrum type, press F1 Trace->Trace and Window Settings->F5 Spec. Type; select the spectrum type from the following options; and press F6 OK.

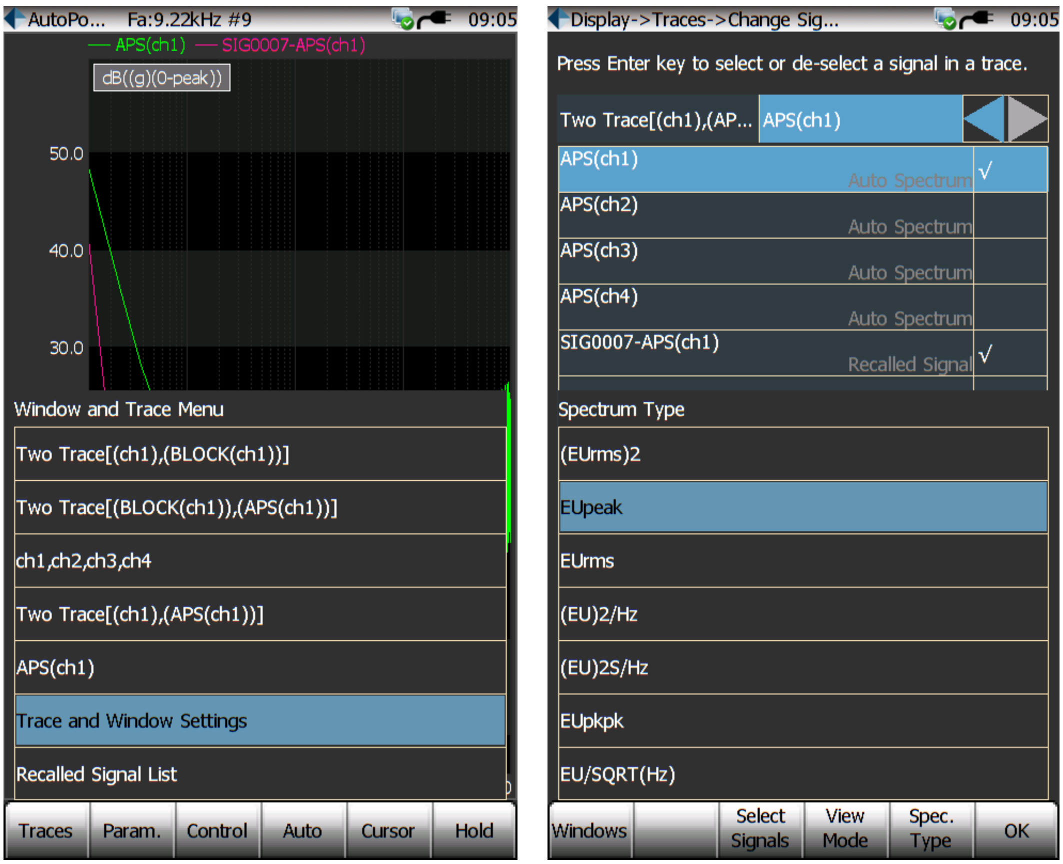


Figure 81. CoCo. Spectrum Type selection display.

Set the Output Channel Parameters

To enable the output channel as a function generator select Output Channel from the Param. Button. Next select the waveform. To set the amplitude and frequency and other parameters move the cursor to the parameter and press the Enter Button to edit the parameter.

To select an arbitrary waveform first select Arb Wave as the output type, then press the Arbitrary Wave Button to choose from all the wave files that are loaded on the CoCo.

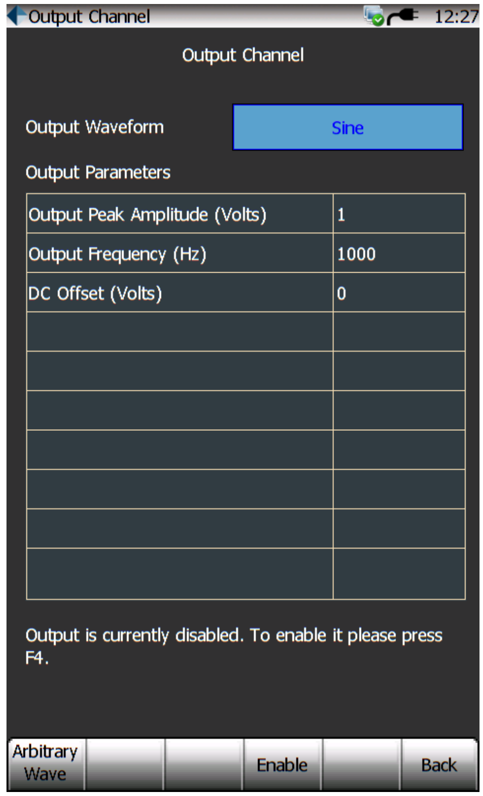


Figure 82. Output parameters.

Select the waveform from the list on the left and use the Arrow Buttons to move the cursor to the quiet zone, duration and peak output level settings on the right. Press the Enter Button to edit any of these parameters.

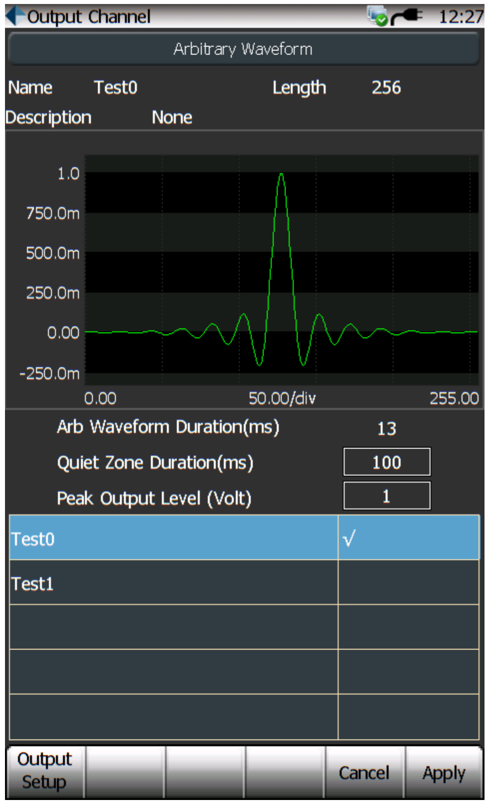


Figure 83. Arbitrary waveform settings.

To start the output channel press the Enable button.

Create Display Window and Set up the Trace

To create a display window select Trace and Window Setting under the Param. Button. Use the soft buttons to add or delete a window, clear the signals from the current window, select all signals or change the view mode to show a numerical value. Change the signals in each window by selecting a specific window tab with the left or right buttons then editing the window settings.

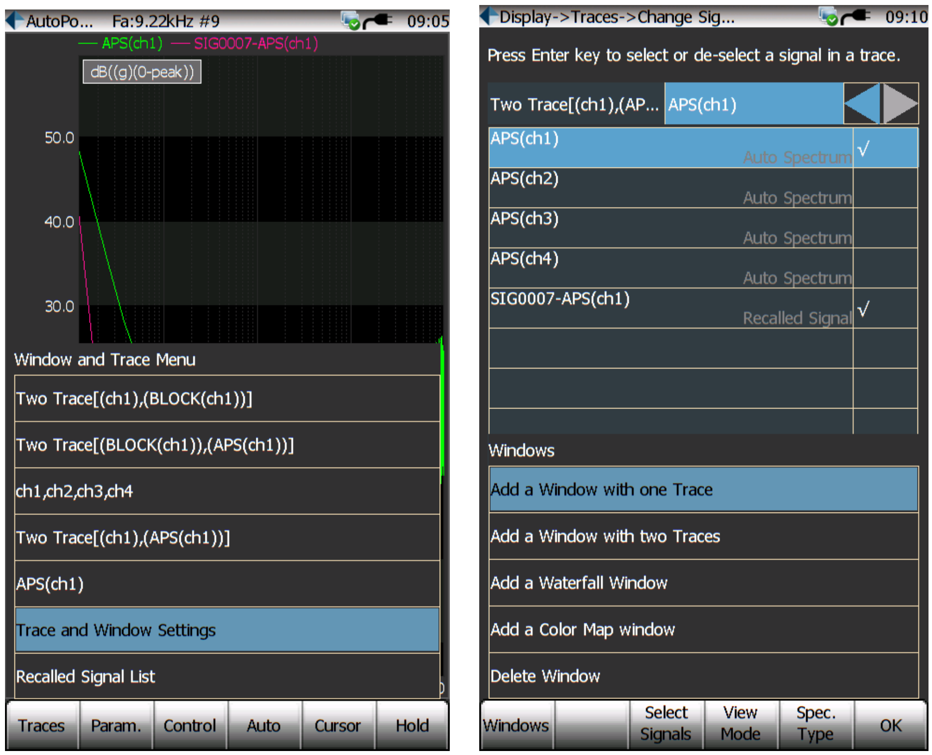


Figure 84. CoCo Add Window display.

dB and Linear Magnitude

Three view modes can be set from Trace->Trace and Window Settings->View Mode.

Most often, amplitude or power spectra are shown in the logarithmic unit decibels (dB). Using this unit of measure, it is easy to view wide dynamic ranges; that is, it is easy to see small signal components in the presence of large ones. The decibel is a unit of ratio and is computed as:

$$dB = 10\log_{10}(Power/P_{ref})$$

where Power is the measured power and P_{ref} is the reference power. For amplitude ratios, the formula is:

$$dB = 20\log_{10}(Ampl/A_{ref})$$

where Ampl is the measured amplitude and A_{ref} is the reference amplitude.

When using amplitude or power as the amplitude-squared of the same signal, the resulting decibel level is exactly the same. Multiplying the decibel ratio by two is equivalent to squaring the ratio. Therefore, you obtain the same decibel level and display regardless of whether you use the amplitude or power spectrum.

As shown in the preceding equations for power and amplitude, you must supply a reference for a measure in decibels. This reference then corresponds to the 0 dB level. Different conventions are used for different types of signals. A common convention is to use the reference 1 Vrms for amplitude or 1 Vrms squared for power, yielding a unit in dBV or dBVrms. In this case, 1 Vrms corresponds to 0 dB. Another common form of dB is dBm, which corresponds to a reference of 1 mW into a load of 50 Hz for radio frequencies where 0 dB is 0.22 Vrms, or 600 Hz for audio frequencies where 0 dB is 0.78 Vrms.

The picture below shows a sine wave with 1 V amplitude displayed in dB. Because the reference is 1 Vpk , it shows the peak value of this sine wave as 0 dB.

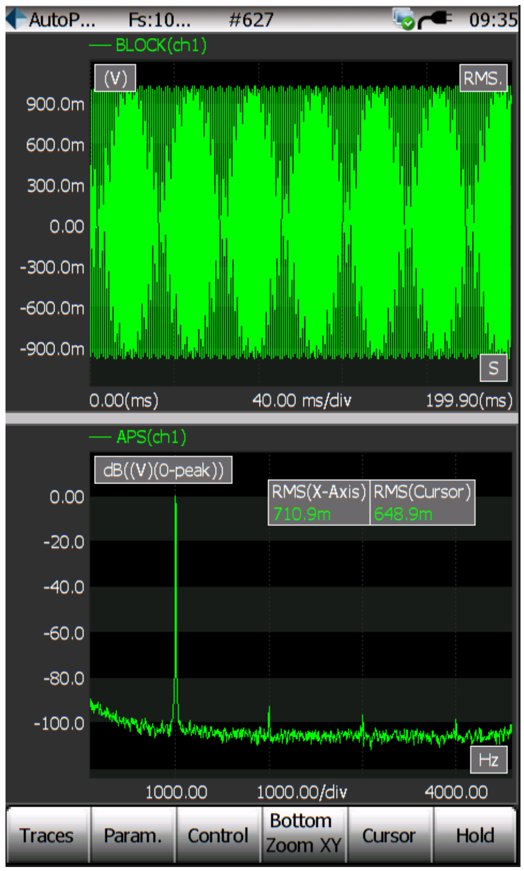


Figure 85. Show a 1Vpk sine signal in frequency domain with dB scaling.

Another display format is called Log, or LogMag. The Log display shows the signal scaled logarithmically with the grid values and cursor readings in actual engineering value. The picture below shows the same signal in LogMag.

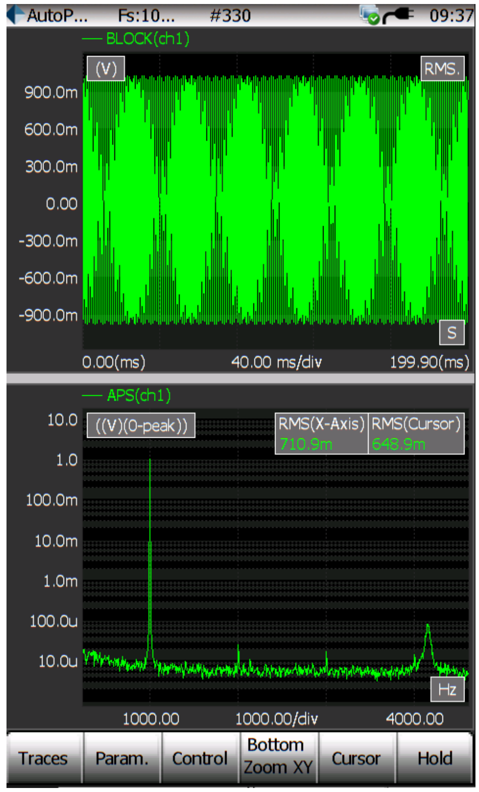


Figure 86. A 1Vpk sine signal in frequency domain with LogMag scaling.

When dB reference is not specified, the dB reference is 1.0 engineering units. In acoustics application, the dB reference for the sound pressure value is set to 20 µPa. The same input signal will result in different dB readings when dB reference is changed.

Set Acquisition Mode

The appropriate acquisition mode should be set to transform the time streams into blocks. The details of acquisition mode for transient capture are described in the next chapter, *Transient Capture and Hammer Test.*

For frequency analysis that use stable and continuous excitation signals, use either *Free-Run* or *Continuous after Trigger mode* in the Acquisition Mode selection.

For details about setting the acquisition mode, refer to the Basic Operation of CoCo-80X.

CoCo Operation for Transient Capture

Select a CSA Project

This section discusses the CoCo settings that are specifically related to transient capture applications. For a complete explanation of these settings refer to the Basic CoCo Operation section. To run a Transient Capture CSA press the Analysis button and select a CSA Application Group that includes transient capture option. These include: *Transient Capture*, *Linear and Power Spectrum*, and *Frequency Response*. Then, choose an Analysis Function from the CSA files on the CoCo to run.

Analysis Parameters: Window Type

First you must specify the Analysis Parameters under the Param. Button. Select the averaging mode, averaging number and data window type. Transient Capture commonly uses the *Force*, *Exponential* or combination *Force-Exponential* data window function. Press the Apply button to accept the settings.

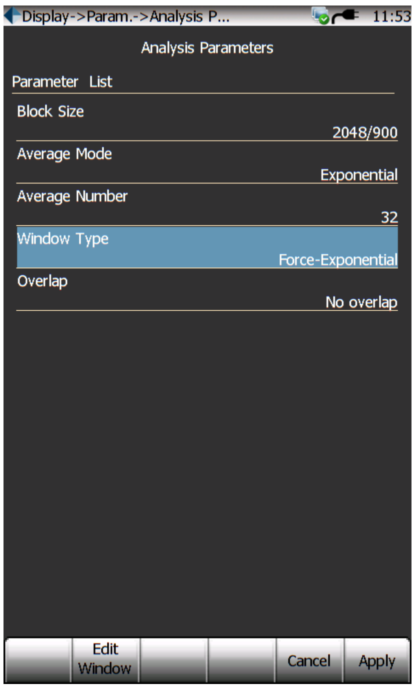


Figure 87. Select the data window type for transient capture.

Acquisition Mode

Next select Acquisition Mode under the Param. Acquisition Mode to control how the data is acquired and under what conditions. It includes setting the trigger mode, trigger source, level, conditions and overlap.

Select Trigger Mode using the Mode Button. Transient capture projects such as impact hammer tests typically use Manual-Arm Trigger or Auto-Arm Trigger.

Auto-Arm automatically accepts the data frame into the average and prepares the trigger for the next signal. Manual-Arm provides a graphical display of the data and allows you to accept or reject the frame into the average.

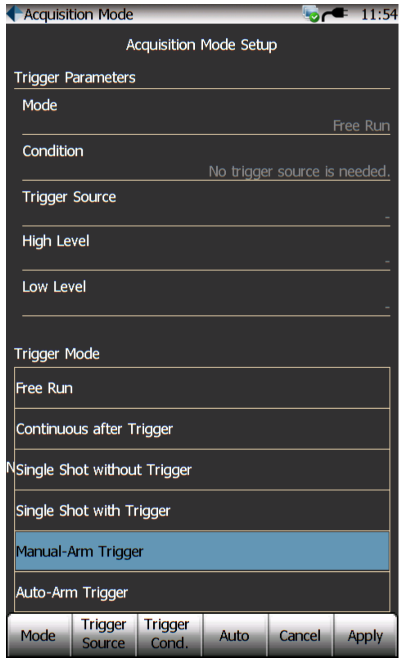


Figure 88. Trigger Modes for Transient Capture.

Trigger Source defines which signal to use as the trigger source. Only signals specified in the CSA script are available as trigger sources. If a signal is not available then it can be added as a trigger source by editing the CSA file and downloading it to the CoCo hardware.

The Trigger Condition and Level Setup define the conditions that will trigger the acquisition. You can also edit the high and low level and the trigger delay. Alternatively, you can change the level settings with the up and down arrow buttons.

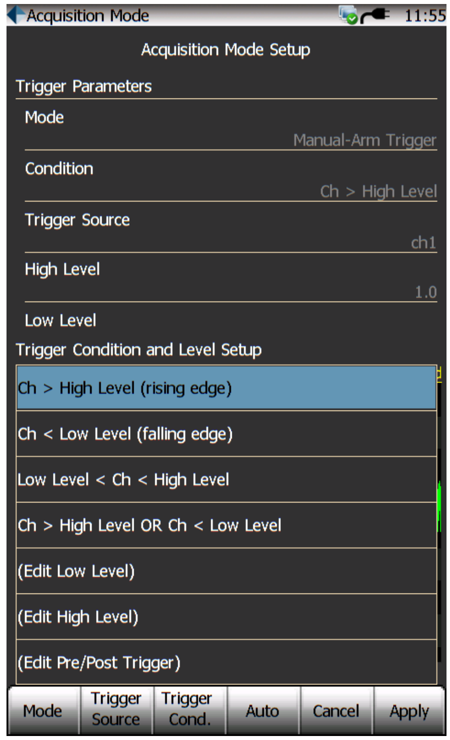


Figure 89. Trigger conditions and level setup for transient capture.

Overlap ratio found under the Analysis Parameters defines the amount of overlap between frames for averaging to reduce the time required to acquire a large number of averages.

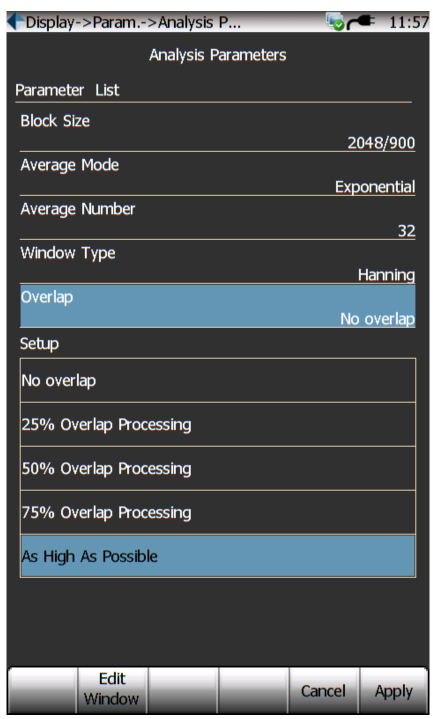


Figure 90. Overlap rate for transient capture.

After the Parameter Settings are specified the CoCo begins to wait for a trigger event. A window displays the time elapsed before a trigger event is detected.

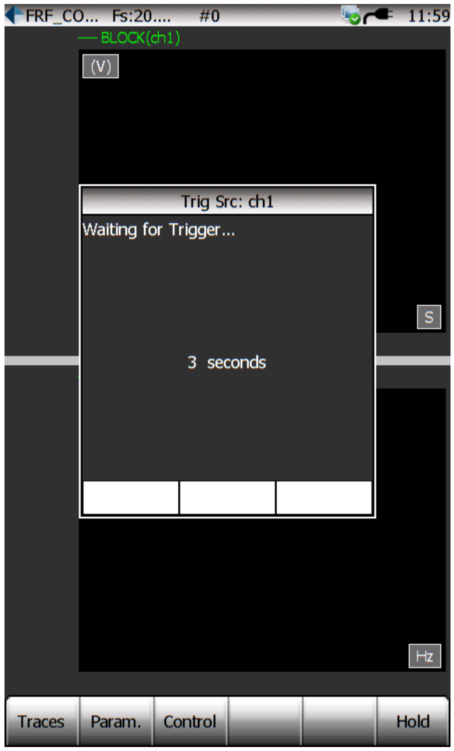


Figure 91. Waiting for trigger message.

When a trigger event is detected and Manual-Arm Trigger is selected, then a small window will show the data frame and give you the option to accept or reject the data. Accept will include the frame into the average and then ask you to proceed to the next trigger by pressing the Next button. Reject will discard the frame, not include it in the average, and return to the waiting for trigger mode. If Auto-Arm Trigger mode is selected then the system will automatically return to the wait mode after each trigger event with no user intervention.

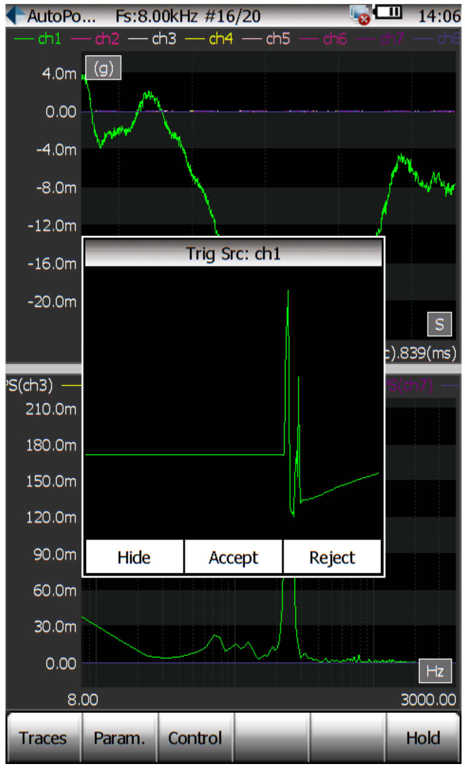


Figure 92. Accept/Reject display for transient capture.

The frame average number is displayed in the status bar to help you monitor how many averages have been recorded. When the averaging mode is set to linear and you have reached the averaging number, you are prompted to restart a new test by pressing the Run Button.

When the averaging mode is set to exponential then new frames will be acquired and included in the average until you press the Hold Button. The system does not stop when the average number reaches the averaging number. The averaging number only defines the behavior of the averaging function. Exponential averaging is intended for continuous averaging to help observe how a signal changes over time or converges to a mean.

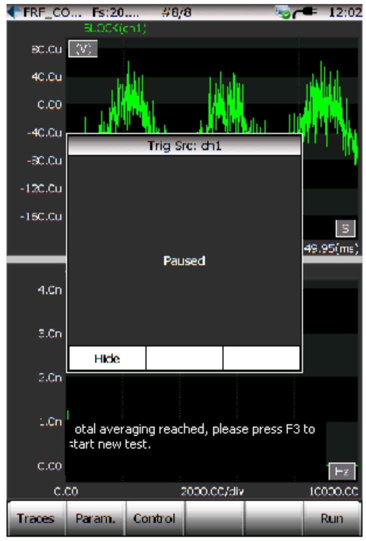


Figure 93. When averaging is complete you can restart a new test with the Run Button.

Save Averaged Data

Data can be saved at any time by pressing the Save Hardware Button. This opens a menu with several options. Press the Save Button again to save the signals in the save list. This can be done in the middle of an average or at the end.

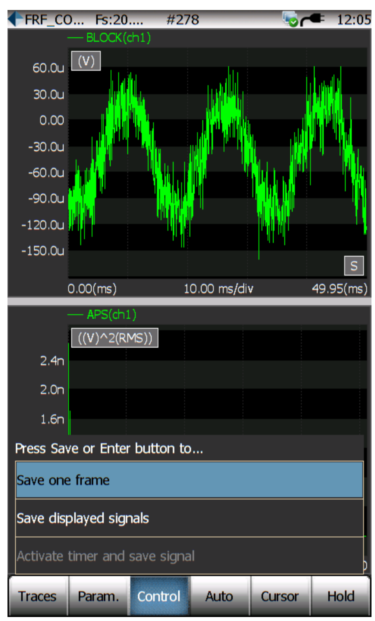


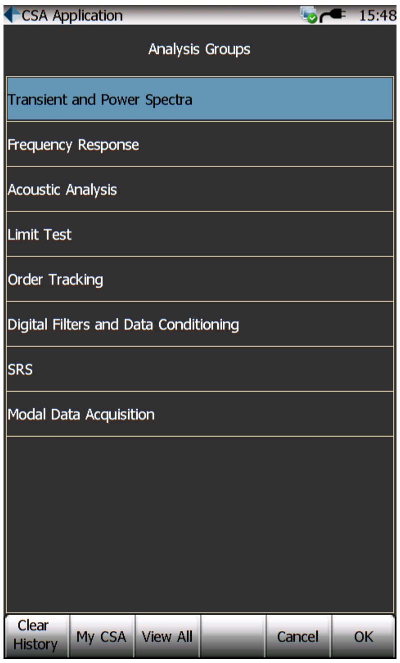
Figure 94. Save data by pressing the Save hardware button.

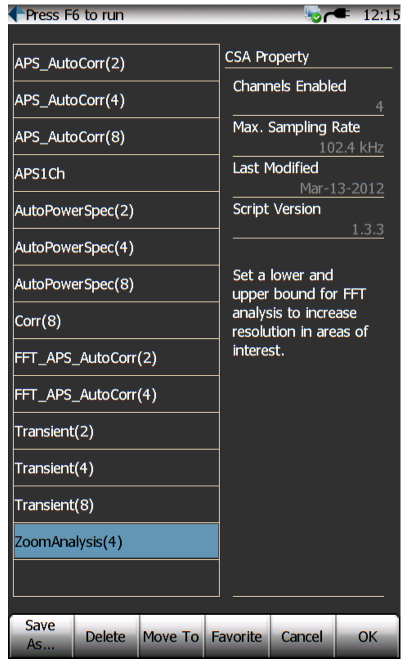
Select Define signals in the list to add or remove signals from the save list or setup automatic data save feature.

CoCo Operation for Zoom Analysis

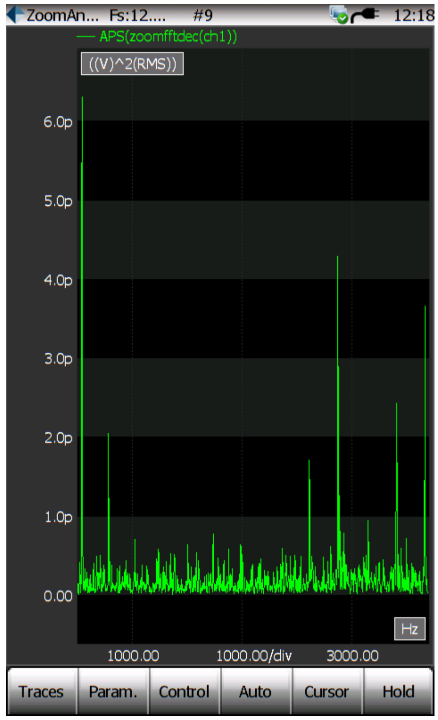
Select a CSA Project

This section discusses the CoCo settings that are specifically related to zoom analysis applications. For a complete explanation of these settings refer to the Basic CoCo Operation section. To run a Zoom Analysis, Press Analysis button to enter CSA Application Group.





Select Transient and Power Spectra item; select ZoomAnalysis(4) and press OK button to enter the display window of the current CSA.

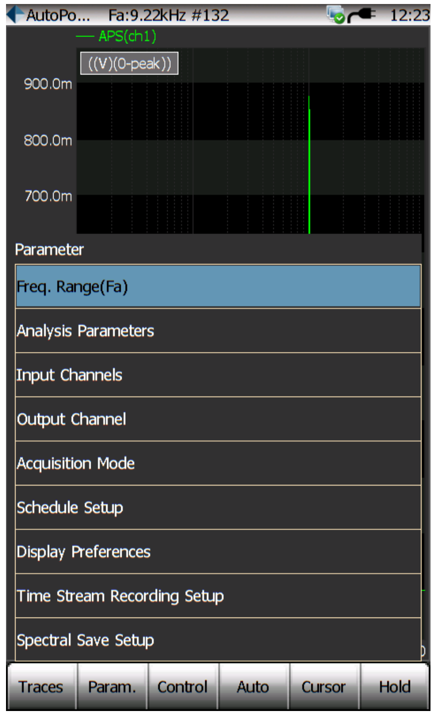


Traces

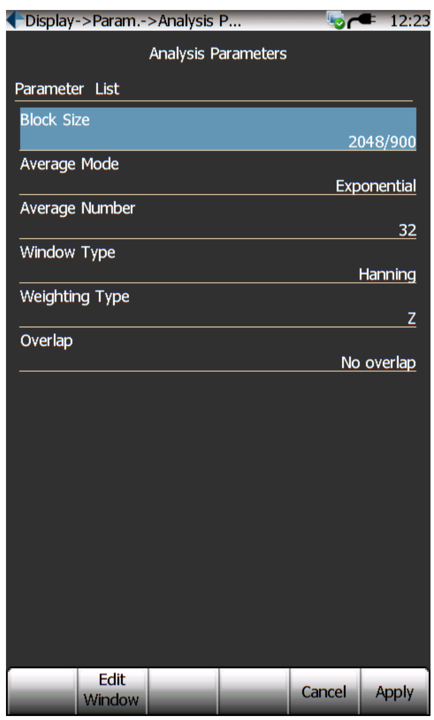
In the main window, press **Traces** button to change trace displays.

Param.

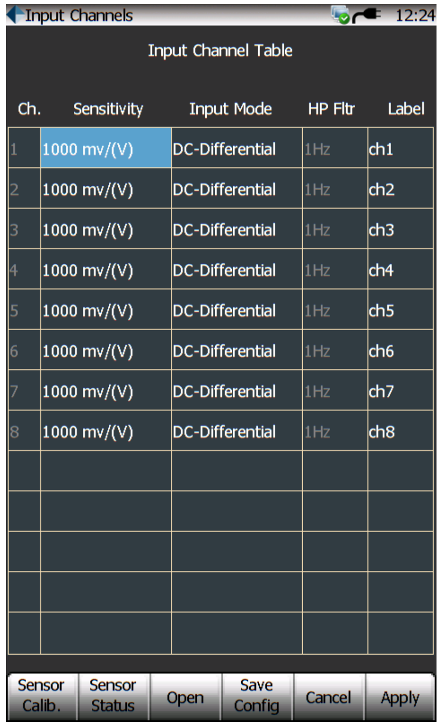
In the main window, press **Param.** button to set parameters.



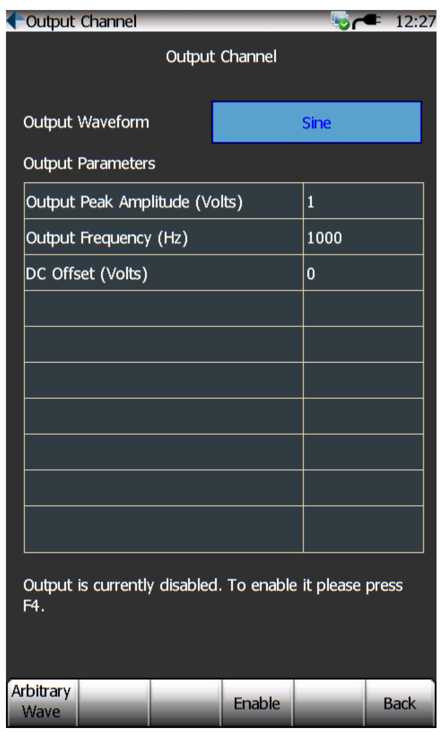
Select **Analysis Parameters** item to set parameters.



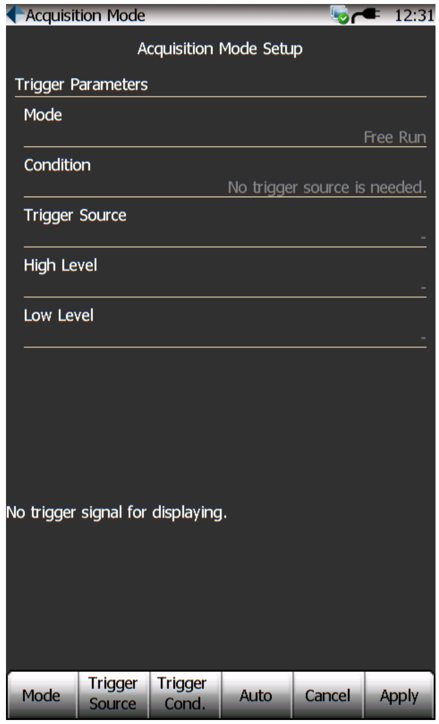
Select **Input Channels** item to set the input channel parameters such as sensitivity, input mode, high-pass filter, and labels



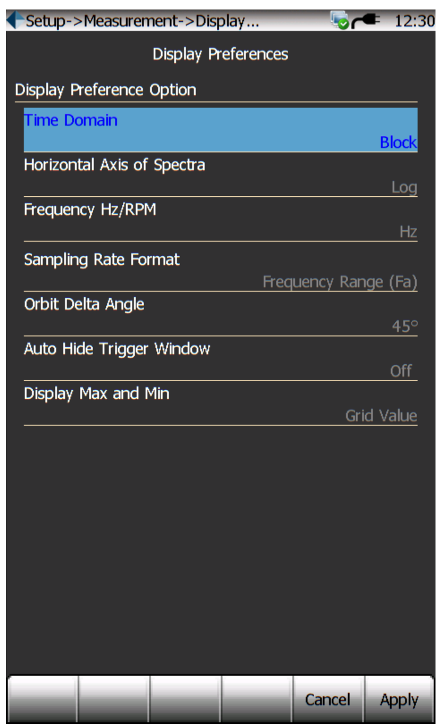
Select **Output channel** item to set the signal source, waveforms, output amplitude, frequency, and DC offset value.



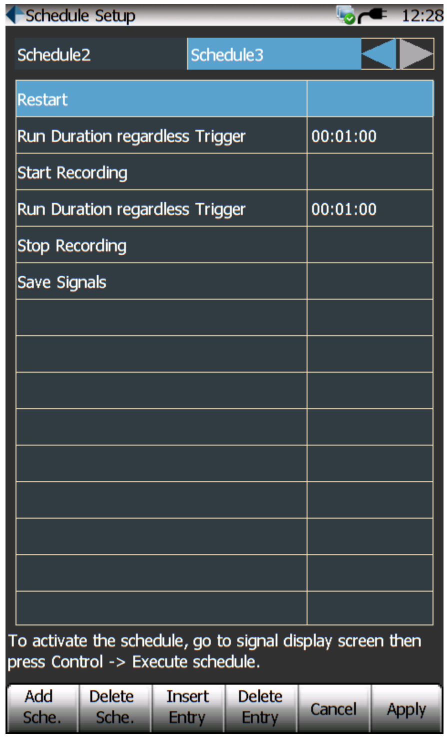
Select **Acquisition Mode** item to set Tachometer parameter.



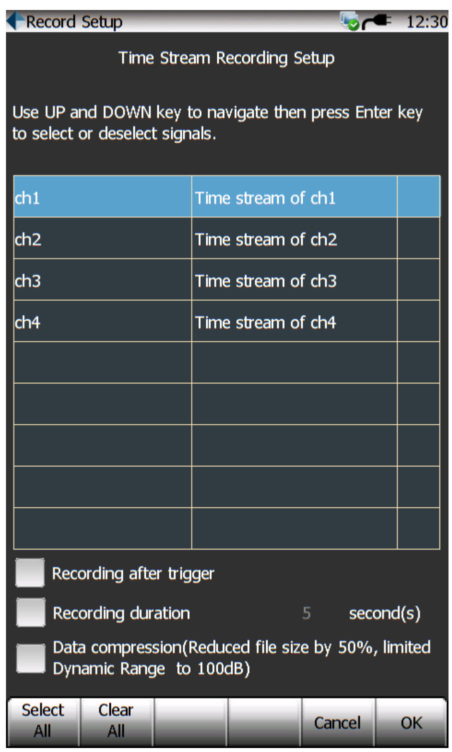
Select **Display Preferences** item to set display format.



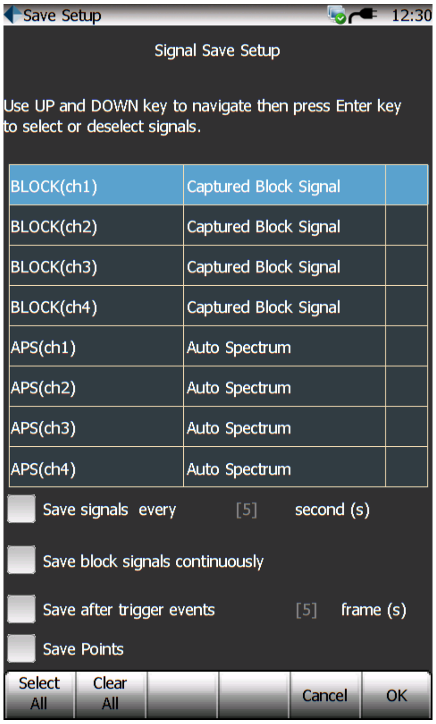
Select **Schedule Setup** item to set the test schedule.



Select **Time Stream Recording Setup** item to set record signal.

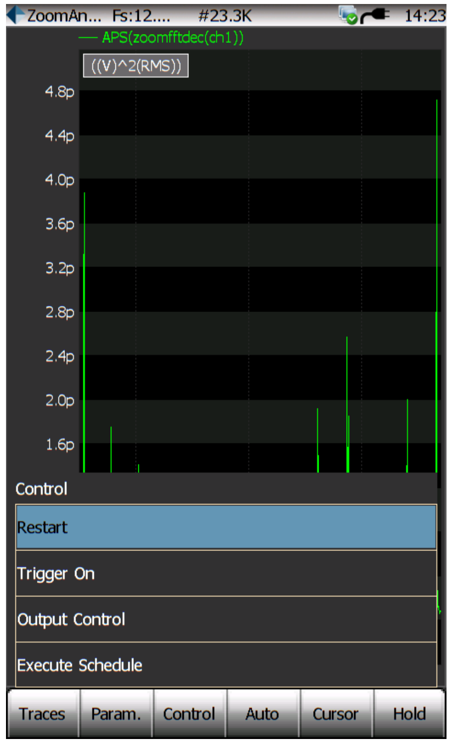


Select **Spectral Save Setup** item to set save signal.



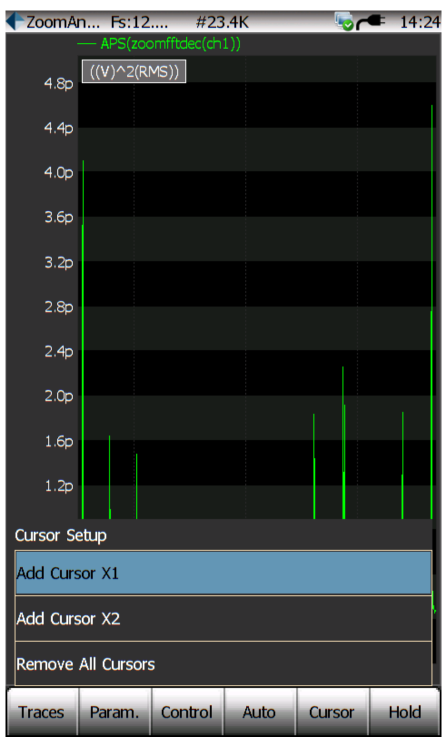
Control

In the main window, press **Control** button to control test process.



Cursor

In the main window, press **Cursor** button to add/remove cursor for selected signals.



Acoustic data acquisition: Octave Analysis

The Acoustics Data Acquisition software option includes Fractional Octave Filter Analysis, Sound Level Meters and Microphone Calibration functions.

The Fractional Octave Filter Analysis applies a bank of real-time octave filters to the input time streams and generates two types of signals at the same time: fractional frequency band signals, i.e., octave spectra, and the RMS time history of each filter band. The output of each real-time filter bank is in fact a 3D waterfall signal that is arranged in the x-axis as logarithmic frequency and z-axis as time. In the frequency direction, frequency weighting is applied. In the time axis, the time-weighting is applied.

The Sound Level Meter (SLM) is a similar application to octave filters in the acoustic data acquisition. This application is also referred to as an Overall Level Meter. The SLM applies ONE frequency weighting filter to the input signal and time weighting to the output. Various measures are then extracted from both the input and output signals of this frequency weighting filter.

Octave Filters

Acoustics Analysis provides 1/N octave analysis using true real-time digital filters that conform to Conforms to ANSI std. S1.11:2004, Order 3 Type 1-D and IEC 61260-1995 specifications. A, B and C weighting filters can be applied to the input data. Output results are weighted or un-weighted RMS values. The output can be normalized with a calibration value. The results can be plotted on log or linear axes and exact or preferred frequency values are supported.

The Acoustics Analysis provides 1/N octave analysis using true real-time digital filters that conform to ANSI S1.11 and IEC 61260 specifications. Each band filter is designed in accordance to ANSI S1.11 and IEC 61260 specifications by transforming the original analog transfer function to the digital domain by means of the bilinear transform. The filter order can be specified and the frequency ratio can be calculated using the binary or decimal system.

The RMS reading of each octave filter is usually represented by a “bar” in the spectrum plot. Keep in mind that the octave filters have “skirts” on both sides. They are not as straight as the bars depicts. The adjacent filters always overlap. Due to this reason, a sine tone at 1 kHz will not only excite the filter with center frequency at 1 kHz, but also all other filters. Figure 95 shows how the energy in each band is displayed on the octave spectrum plot using bars.

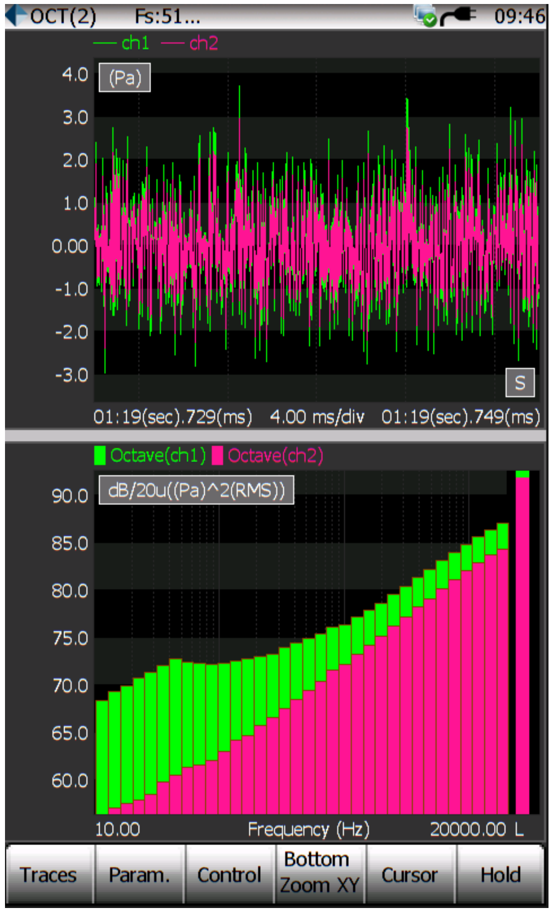


Figure 95. 1/3 octave filter banks.

Full Octave Filters

An octave is a doubling of frequency. For example, frequencies of 250 Hz and 500 Hz are one octave apart, as are frequencies of 1 kHz and 2 kHz.

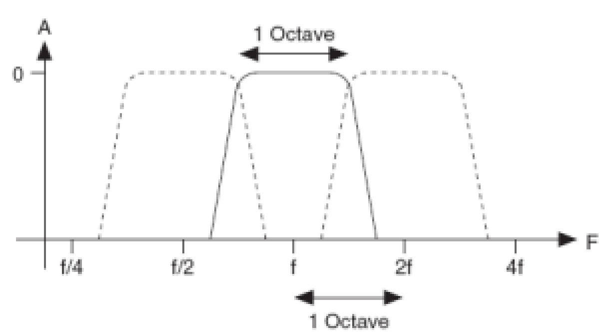


Figure 96. Full octave filter shape.

Full octave analysis, i.e., 1/1 octave, displays the frequency characteristics of a signal by passing the signal through a bank of band-pass filters where the center frequency of each filter is one octave apart. If the lower and upper cutoff frequencies of a band-pass filter are f_L and f_H, then the center frequency, f_c can be determined with:

$$f_c = \sqrt{(f_L * f_H)}$$

The nominal frequency ratio G is determined by:

$$G = f_H / f_L$$

Two systems are used in the industry, Base-two or Base-ten systems. For base-two systems, G = 2. For base-ten systems, G = $10^{3/10}$. Base-ten system is used in CoCo.

The proportional bandwidth property will divide the frequency information uniformly over a log scale. It is very useful in analyzing a variety of natural systems. For example, the human response to noise and vibration is very non-linear and many mechanical systems have a behavior that is best characterized by proportional bandwidth analysis.

Fractional Octave Filters

To gain finer frequency resolution, the frequency range can be divided into proportional bandwidths that are a fraction of an octave. For example, with 1/3 octave analysis, there are 3 band-pass filters per octave where each center frequency is $10^{1/10}$ the previous center frequency.

In general, for 1/N octave analysis, there are N band pass filters per octave such that:

$$\frac{f_H}{f_L} = \left(10^{3/10}\right)^{1/N}$$

$$f_{c\ j+1} = f_{c\ j} * \left(10^{3/10}\right)^{1/N}$$

where 1/N is called the fractional bandwidth resolution.

For CoCo the equation and table below define the center frequency of each fractional filter.

$$f_c = 10^{3X/10N}$$

For example for 1/1 Octave (N =1) the first center frequency (index X = 1) is computed as

$$f_c = 10^{\frac{3*(-3)}{10*1}} = 0.125 \text{ Hz}$$

	1/1-Octave	1/3-Octave	1/6-Octave	1/12-Octave
Standard	IEC 225-1966 DIN 45651 ANSI S1.11-2004 Order 7 Type 1-D	IEC 225-1966 DIN 45651 ANSI S1.11-2004 Order 3 Type 1-D	N/A	N/A
X (index)	-3 □ ~□ 14	-10 □ ~ □ 43	-20 □ ~ □ 86	-40 □ ~ □ 172
Total number of	18	54	107	213
f_c (Hz)	0.125 – 16k	0.1 – 20k	0.1 – 20k	0.1 – 20k

Table 4. Octave center frequencies.

Nominal center frequencies (midband frequencies)

Nominal center frequencies are "round" numbers that were inherited from the old analog octave filters. They are rounded midband frequencies for the designation of band pass filters. The nominal midband frequencies for 1/1-octave and 1/3-octave are listed in the ANSI S1.11-2004 Annex A. The standard also describes how to decide the nominal midband frequencies for other fractional octave bands.

The exact center frequency of the filter band is usually not the same as that of nominal frequency. For example, in a 1/3 octave, the exact center frequencies 794.33 Hz, 1000 Hz and 1258.9 Hz are used to correspond to the filters with nominal frequencies 800 Hz, 1000 Hz and 1250 Hz.

Band Edge Frequencies of Fractional Filters

The low and high edge frequencies of a filter can be calculated based on the frequency ratio, G and the fractional octave resolution N (=1, 3, 6, 12…)

$$Lower\ Edge\ Frequency \quad f_L = f_c * \left(10^{3/10}\right)^{-1/2N}$$

$$Upper\ Edge\ Frequency \quad f_H = f_c * \left(10^{3/10}\right)^{1/2N}$$

The bandwidth of the filter is: BW = $f_H - f_L$

When starting or resetting the filtering operation of the fractional-octave filters, a certain time is required before the measurements are valid. This time is called the settling time and is related to the bandwidth of any particular filter. The lowest frequency band has the smallest bandwidth and defines the settling time required before you can consider the complete fractional-octave measurement valid. A good rule of thumb is that the settling time is approximately five divided by the bandwidth.

$$Settling\ time = \frac{5}{BW} = \frac{5}{f_H - f_L}$$

Note the settling time depends on the bandwidth which changes with center frequency. A narrower filter and a lower frequency band requires a longer settling time.

Analysis Frequency Range

In CoCo, the user can decide the analysis range by changing the lowest and highest f_c as the Analysis Parameters:

Analysis Range	1/1 Octave	1/3 Octave	1/6 Octave	1/12 Octave
Lowest f_c (Hz)	0.125 1 8	0.1 1 10 100	0.1 1 10 100	0.1 1 10 100
Highest f_c (Hz)	1000 4000 16000	1000 2000 5000 10000 20000	1000 2000 5000 10000 20000	1000 2000 5000 10000 20000

Frequency Weighting

The human hearing system is more sensitive to some frequencies than others, and its frequency response varies with level. In general, low frequency and high frequency sounds appear to be less loud than mid-frequency sounds, and the effect is more pronounced at low pressure levels, with a flattening of response at high levels. Octave analysis and sound level meters therefore incorporate weighting filters, which reduce the contribution of low and high frequencies to produce a measurement that corresponds approximately to what we hear.

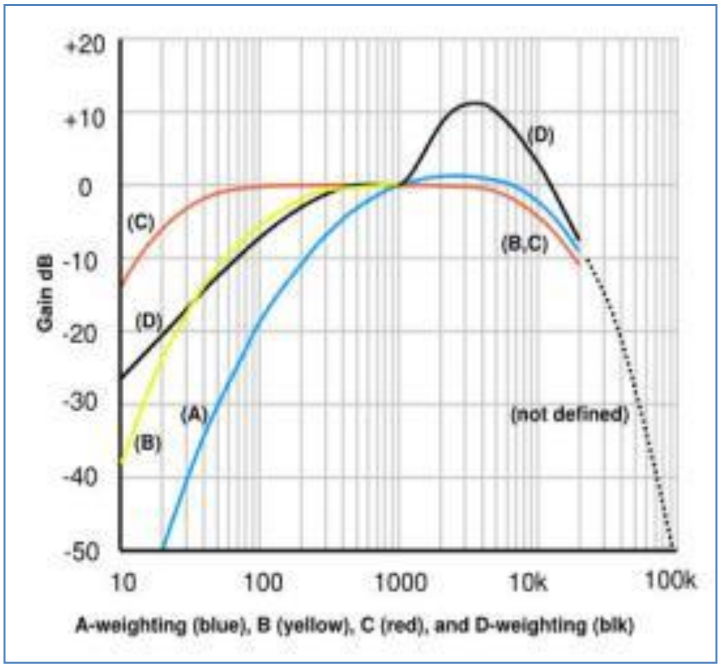


Figure 97. Frequency weighting filter shapes.

CoCo provides A, C, Z weightings conforming to IEC 61672-1 2002 and B weighting conforming to IEC 60651 in both of Octave analysis and Sound Level Meter. The Frequency weighting in the octave filters will affect the results of all filter bands.

Time or RPM based RMS Trace of the Octave Filters

The ANSI and IEC standard do not require storing the time history of the band pass filter output. However the user may be interested in viewing this information. On the CoCo the RMS history of all the band pass filters are stored, in the RMS quantity. Below is the description about how the RMSs. history is calculated.

The RMS history can be stored against one of two variables: Time or RPM.

Both the input and output of a digital filter are a series of data points. While it requires excessive memory to keep all the time data of all the filters, it is useful to keep the so called RMS history of each filter output. The RMS time history is computed after the time weighting averaging operation as shown in Figure 98.

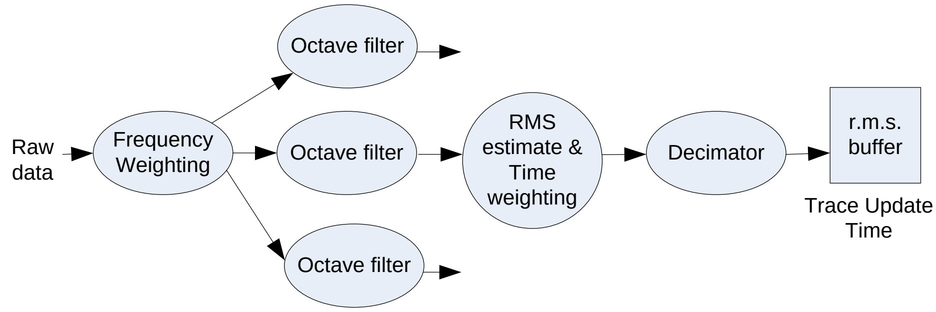


Figure 98. RMS time history calculation.

The Decimator is used so the user can choose the length of time to save the RMS data. For example, given a buffer length of 1024, a Trace Update Time of 5 ms will keep about 5 seconds of RMS history; if this update time is set to 5 seconds, it will record 1.4 hours of RMS history.

Figure 99 shows the 3D waterfall display of a 1/1 octave filter output. If a cut is made in the Z axis direction, the result will be an octave spectrum. If a cut is made in the X-axis, the result will be called a Time Trace.

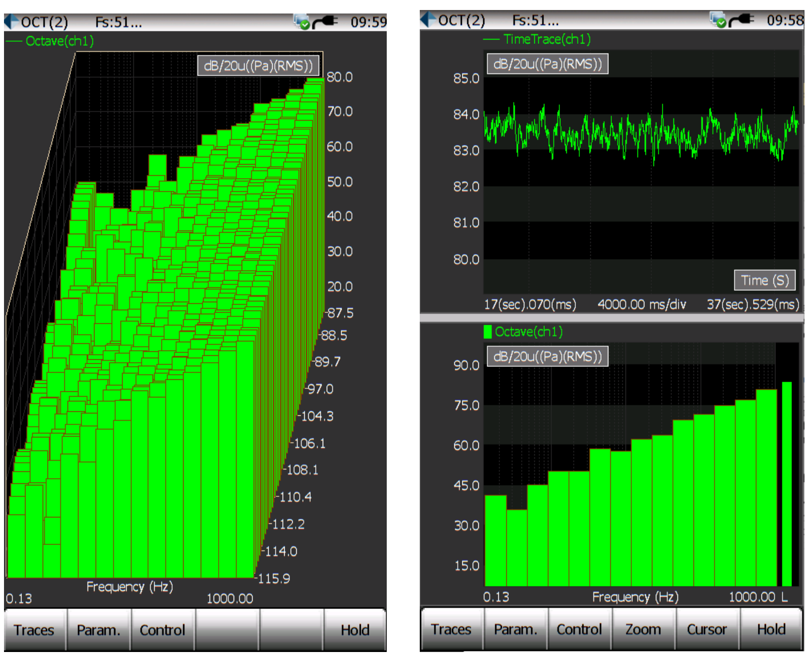


Figure 99. A cut of 3D Waterfall of octave filter output (left) maps to an RMS time trace (right)

The Time Trace stores the history of the RMS of each filter output. The spacing between two points of the Time Trace is called Trace Update Time, in seconds. On CoCo, one Time Trace is allocated for each channel for display. Keep in mind that this buffer of Time Trace is the output of a specific filter, the user can change the center frequency of the filter for the Time Trace during run time. In the other words, this time trace display buffer will change its content completely when the user switches the Time Trace Frequency from one to another.

Alternatively the RMS trace can be stored using RPM as a variable. This method is particularly useful in the automotive NVH applications. The picture below shows how one of the outputs of filters can be stored in RPM trace.

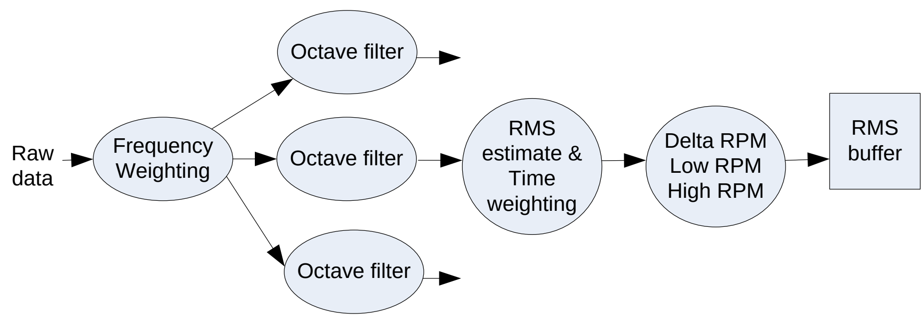


Figure 100. Store RPM based RMS traces.

Exponential and Linear Averaging

Linear average: The Linear average method uses a fixed time period to sum up the historical power value of each filter and then takes the square-root to calculate the averaged RMS value. In Linear average, the RMS trace update time is governed by the time period of the averaging. For each time period of averaging, one RMS value per frequency bin is produced.

Exponential average: Exponential average applies an exponential time constant to the historical power values of each filter and takes the square-root of the averaged power value. A time constant of 0.125 seconds is equivalent to “Fast” averaging and 1.0 second is equivalent to “Slow” averaging in the acoustics. In exponential average, the RMS trace update time is independent of the time constant.

Peak Hold: Peak Hold retains the maximum value in each frequency bin over the period of time since last “start” or “restart”.

As we discussed previously, each filter may have different settling time.

Measurements available to CoCo in Octave Analysis mode

The following measurement quantities are available on the CoCo in the octave measurement mode.

Time streams of input channels In CoCo, time domain data is always available in the form of long time history. The user can view and record the time signals. The limitation is that the sampling rate of the time signals cannot be arbitrarily changed. It is always set internally by the system based on analysis frequency range, i.e., the highest center frequency of the filter bands.

Octave Spectra Each input channel will have an octave spectrum.

RMS Trace Each input channel will have one RMS trace to display the RMS history. This RMS is the output of the filter for a specific band. The RMS trace is defined as the Time-RMS trace or RPM-RMS trace at the CSA Editor level. You cannot change between Time and RPM based for a specific CSA.

CSA Editor Operation

This section describes the operation of the CSA Editor related to octave analysis. For general operation of the CSA Editor refer to the CSA Users Manual.

CSA Editor Wizard

This section summarizes how to create a CSA project for octave analysis in the CSA Editor. We strongly recommend that you read the CSA Edit User's Manual to gain more detailed information before proceeding with this chapter.

To start, click on the CSA Editor icon in the upper-right corner in EDM and start the CSA Editor. The CSA Editor Wizard dialog box will be displayed. First select the CoCo type and number of channels of the CoCo that this CSA project will support. The number of channels must be equal to or less than the number of physical input channels on the CoCo hardware. Click on the Next Button.

Next select the Octave Analysis template and either time or RPM based mode. Time based octave analysis will compute the results based on time averages. This is the most common application. RPM based mode computes sound level versus the RPM measured by a tachometer for rotating equipment. Click on the Next Button.

Next select the number of input channels to compute the analysis functions. In general it is best to select the minimum number of channels to conserve computational resources for the CSA. This number can be less than or equal to the number of physical input channels on the CoCo hardware. Click on the Next Button.

Next enter the description of the CSA. This data will be saved with the CSA and be shown on the CoCo device when the CSA is opened. Click on the Next Button.

Select Signal Candidates

Next the Signal Analysis Display is shown. This display lets you select which signals will be display candidates, save candidates and which will be used to compute the octave analysis. Always select the minimum number of candidates required to conserve computational resources. Note that when a signal is selected as a candidate then it is available on the CoCo hardware, meaning that it can be displayed or save, etc. If the signal is not specified as a candidate in the CSA then it will not be available on the CoCo hardware.

Octave signal settings lets you specify the display, save and octave computation candidates for the input time streams.

Analysis output signal settings let you specify the display, record and save candidates for the computed octave data.

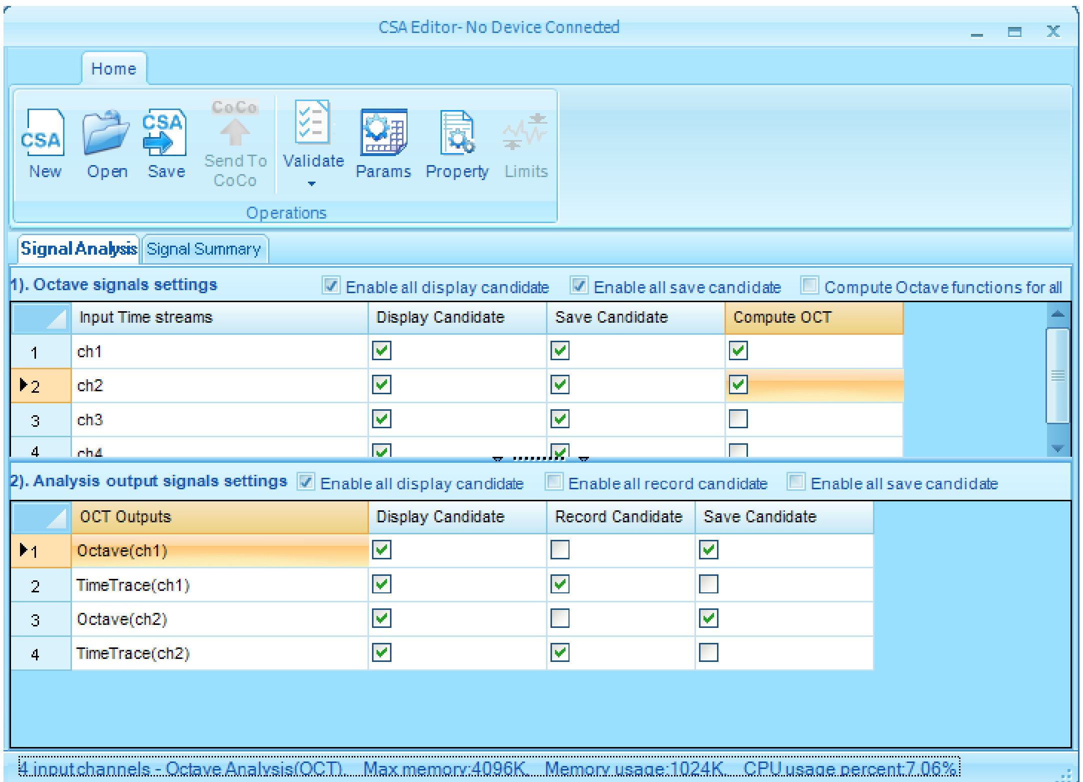
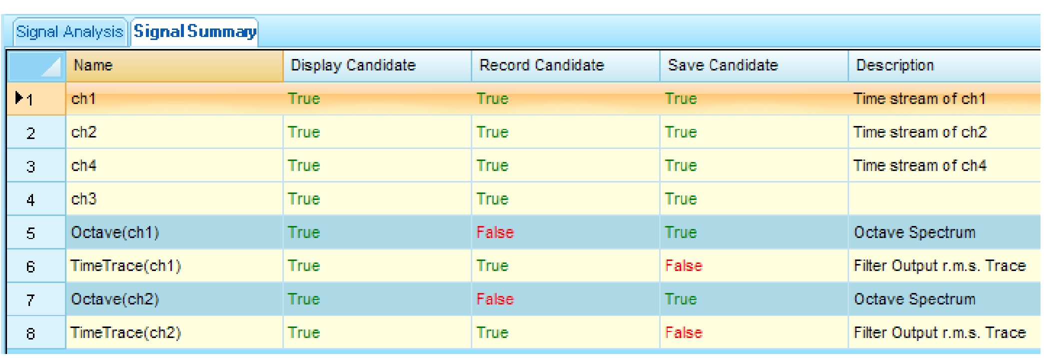


Figure 101. Signal Analysis tab in CSA Editor.

After all the candidate selections are made, a summary can be viewed by selecting the Signal Summary.



	Name	Display Candidate	Record Candidate	Save Candidate	Description
1	ch1	True	True	True	Time stream of ch1
2	ch2	True	True	True	Time stream of ch2
3	ch4	True	True	True	Time stream of ch4
4	ch3	True	True	True	
5	Octave(ch1)	True	False	True	Octave Spectrum
6	TimeTrace(ch1)	True	True	False	Filter Output r.m.s. Trace
7	Octave(ch2)	True	False	True	Octave Spectrum
8	TimeTrace(ch2)	True	True	False	Filter Output r.m.s. Trace

Figure 102. Signal Summary tab in CSA Editor.

Analysis Parameters

After the signals are selected the next step is to specify the Parameters by clicking on the Param icon in the CSA Editor Ribbon. The Parameters display lets you change the computation parameters such as octave resolution, low and high frequency, averaging type, etc. Click on the Edit Button next to each item to edit the parameter. Click on Ok to save the updated parameters.

Time Based Acquisition Analysis Parameters.

The parameters are different for time and RPM based acquisition. Figure 103 shows the parameters for time based acquisition. These parameters become the default values when the CSA is uploaded to the CoCo hardware. To change a parameter click on the Edit button.

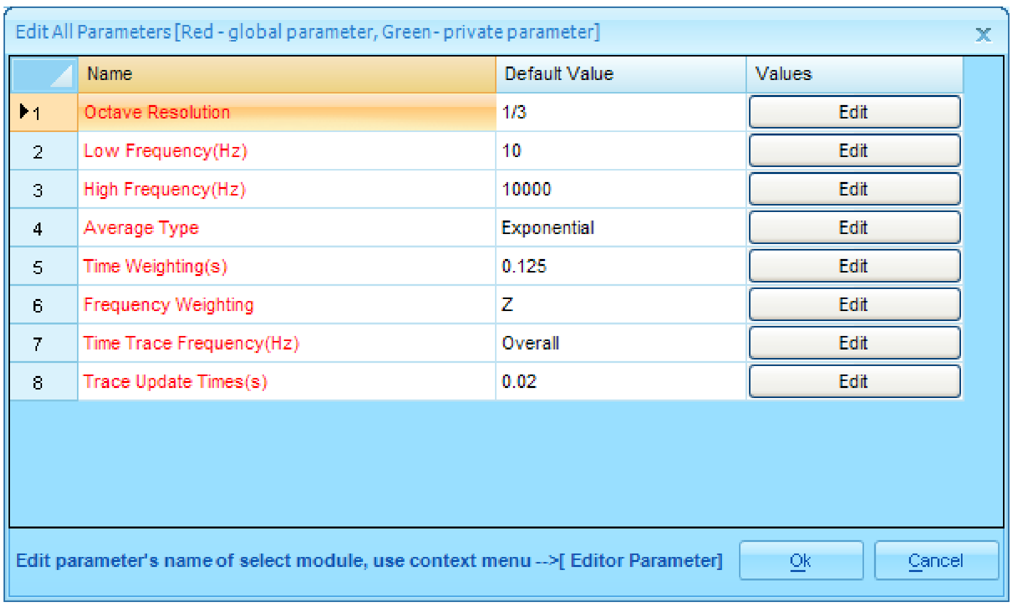


Figure 103. Edit Parameter window in CSA Editor for time based acquisition.

Octave Resolution – defines the octave resolution including: 1/1, 1/3, 1/6 and 1/12

Low/High Frequency (Hz) – defines the low and high frequency (span) of the measurement in Hz.

Average Type – defines the averaging type including: exponential, linear and peak hold.

Time Weighting – defines the time weighting for exponential averaging.

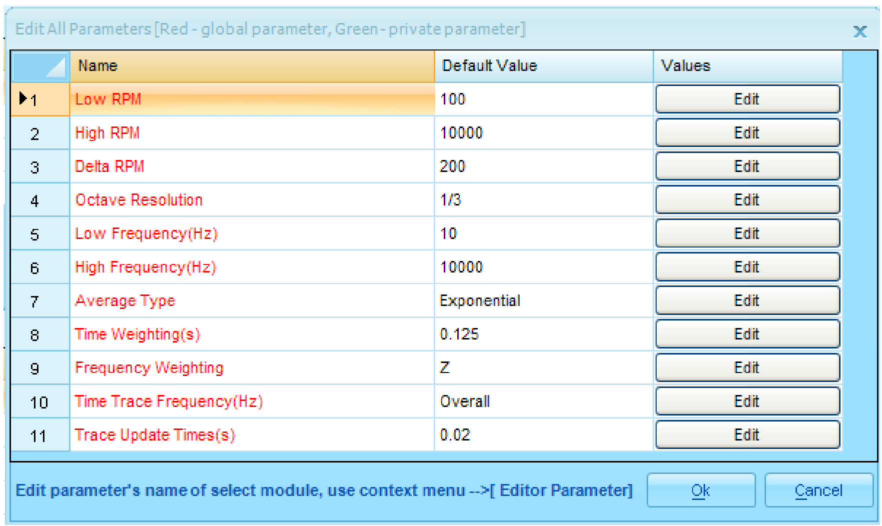
Frequency Weighting – defines the frequency weighting including: A, B, C or Z.

Time Trace Frequency (Hz) – defines which center band frequency or overall or frequency weighted band is used to plot time traces.

Trace Update Time – defines the time trace display duration. Select a larger update time to create a longer time trace display duration.

RPM Based Acquisition Analysis Parameters

Figure 104 shows the rpm based acquisition analysis parameters.


Edit All Parameters [Red - global parameter, Green - private parameter]

	Name	Default Value	Values
1	Low RPM	100	Edit
2	High RPM	10000	Edit
3	Delta RPM	200	Edit
4	Octave Resolution	1/3	Edit
5	Low Frequency(Hz)	10	Edit
6	High Frequency(Hz)	10000	Edit
7	Average Type	Exponential	Edit
8	Time Weighting(s)	0.125	Edit
9	Frequency Weighting	Z	Edit
10	Time Trace Frequency(Hz)	Overall	Edit
11	Trace Update Times(s)	0.02	Edit

Edit parameter's name of select module, use context menu -->[Editor Parameter] Ok Cancel

Figure 104. RPM based acquisition analysis parameters.

Low RPM – defines the low RPM level for display limits and also the limits for trigger mode.

High RPM – defines the high RPM level for display limits and also the limits for trigger mode.

Delta RPM – defines the resolution of RPM measurements. Note that a large RPM span and high resolution (small Delta RPM) require more computation resources.

The other parameters are the same as the time based acquisition parameters.

Validation, Save and Upload

After the CSA Wizard is complete and the CSA file is created, connect the host PC to the CoCo device and press the Validate icon to validate the CSA. It may take a few minutes to finish the validation.

Figure 105. Validate and Send to CoCo icons in the CSA Editor Ribbon.

The validation process analyzes the CSA file for internal consistency and estimates the required DSA resources required to run the CSA file on the CoCo device.

If the Validation passes, then press Send to CoCo command in the Validation dialog box to send the CSA project file to CoCo. Alternatively you can manually upload it to CoCo. The uploaded CSA will be classified into the Acoustic Analysis Application Group and can then be opened on the CoCo hardware.

CoCo-80 Operation

This section describes the operations of CoCo that are specifically related to octave analysis.

Select a CSA Project

After an Octave Analysis CSA is created from the CSA Editor and downloaded to the CoCo Hardware then it can be opened on the CoCo. Alternatively you can also open the default Octave Analysis CSA scripts on the CoCo Hardware. To open a CSA press the Analysis Button, then select the Acoustic Analysis Application Group. All Octave Analysis CSA files are automatically placed in this group to help organize the CSA files on the CoCo.

Next select an octave analysis CSA from the list. Octave analysis CSA files have the name OCT() by default.

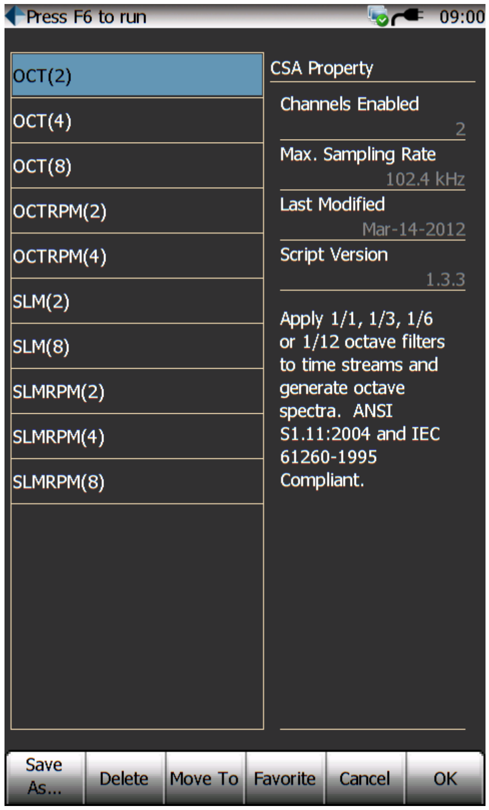


Figure 106. Select Analysis Function display.

Analysis Parameters for Octave Analysis

To set the parameters press the Param. Button in the signal display window.

Analysis Parameters lets you modify the settings for the data acquisition. The default parameters are set in the CSA Editor. To change a parameter move the cursor to the parameter using the Up and Down Buttons and press the Enter Button, then set the parameters.

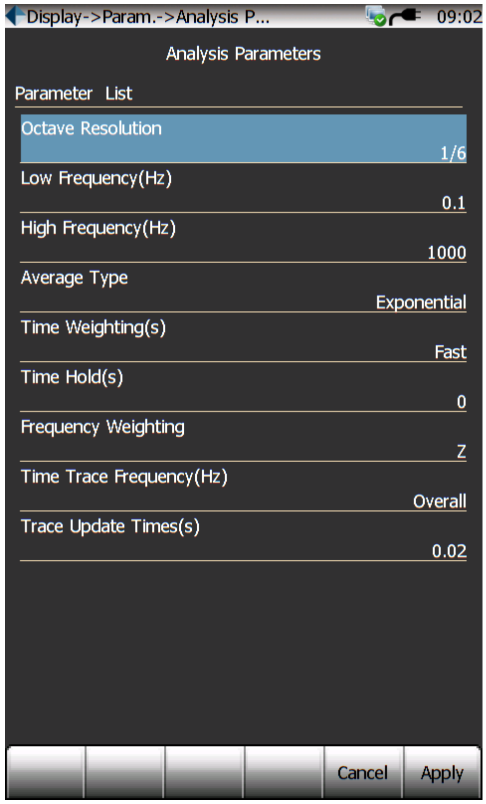


Figure 107. Analysis Parameters.

Octave Resolution: 1/1, 1/2, 1/6, or 1/12

Low Frequency (Hz): set the low frequency of the fist band.

High Frequency (Hz): set the high frequency of the last band.

Average Type: linear, exponential or peak hold

Time Weighting(s): 0.035 to 1000 seconds

Frequency Weighting: A, B, C or Z

Time Trace Frequency (Hz): overall, weighting, 0.125 to 16000 Hz.

Trace Update Time(s): 0.005 to 600 seconds. Conforms to weighting time when the averaging type is linear.

The time weighting parameter can be selected so it corresponds to “Fast” or “Slow” weighting mode. For “Fast” weighting mode, set the time weighting constant to 0.125 seconds; for “Slow” mode, set it to 1.0 seconds.

Acquisition Mode

Acquisition Mode controls the conditions under which the data is acquired. It can refer to triggered mode for time based acquisition or RPM mode for RPM based measurement. Refer to the CoCo Basic User Manual for trigger mode acquisition. Refer to the Order Tracking section which follows this section for a detailed description of the tachometer RPM setup.

Displays

This section describes the displays that are unique to the Octave Analysis template. Refer to the Basic User Manual for a description of displays that are common to the other templates.

Octave Display

The octave display shows the octave bands with the overall level indicated with 'L' and the frequency weighted level indicated with 'A, B, C or Z'.

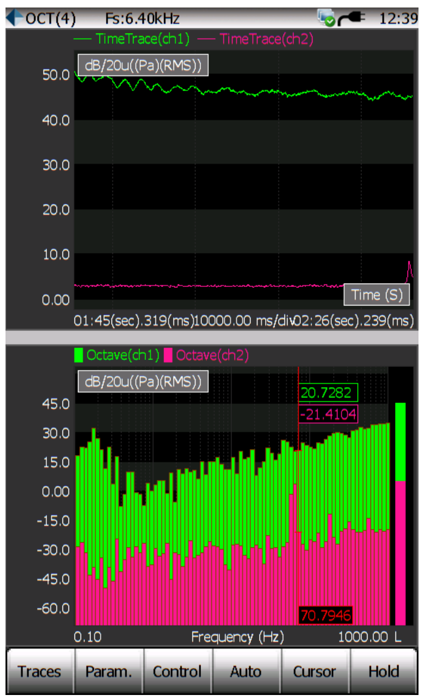


Figure 108. Octave display.

The vertical units can be change by selecting View Mode for Current Trace under the Trace and Window Settings button.

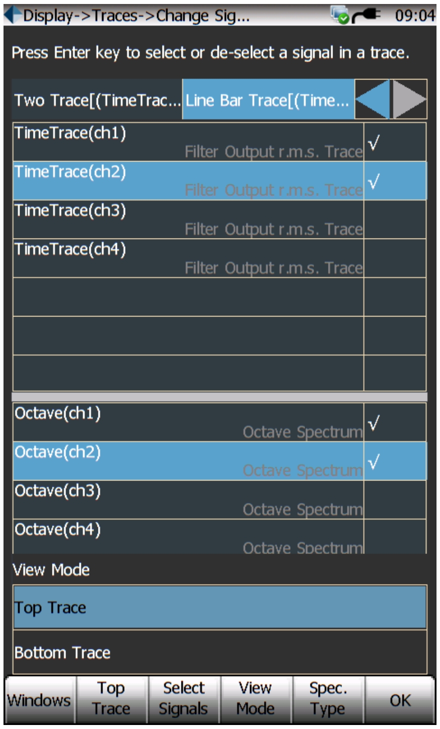


Figure 109. Trace View Mode.

The X and Y axes can be either scaled automatically or manually set to a user-defined range. To set the range manually, press the Display button and select *SetExact X-Axis* [or *Y-Axis*] *Range*.

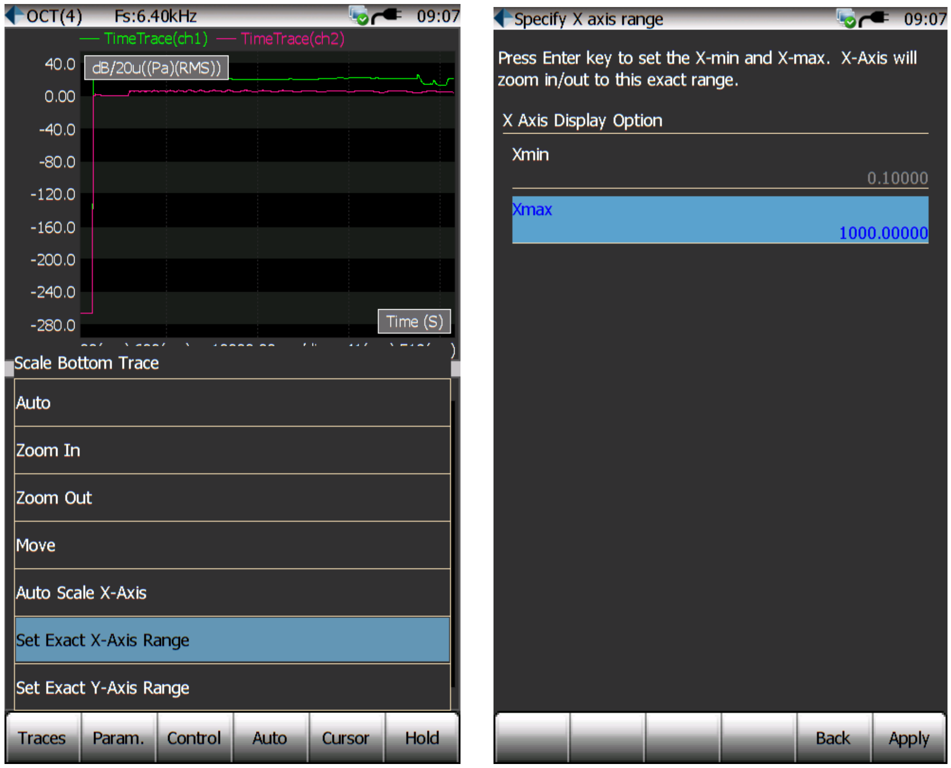


Figure 110. Axis manual range settings

There are a number of display preferences that can be changed under Param (F2) -> Display Preferences. Among those options is viewing the Octave chart as a solid bar graph, as bar outlines, or as a line graph.

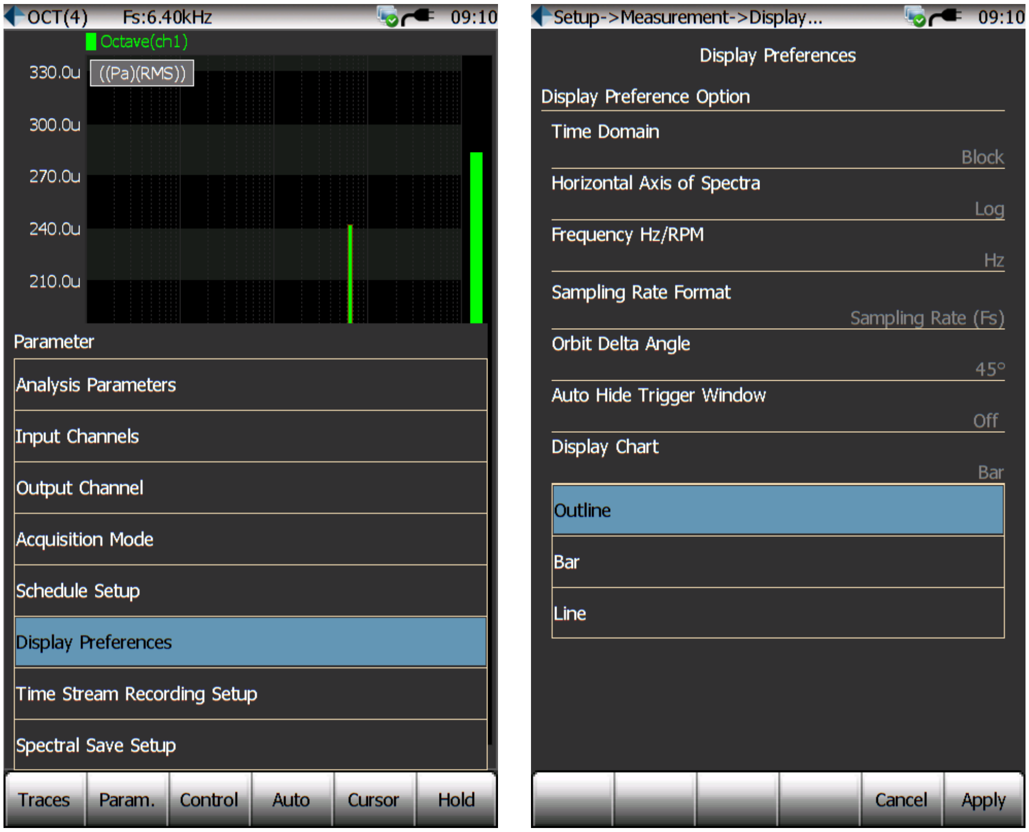


Figure 111. Octave display preferences

Time Trace Display

A time trace display shows the sound level of one of the octave bands including the overall or frequency weighted level vs. time. The trace update time can be changed under the Analysis Parameters to show a longer or shorter duration.

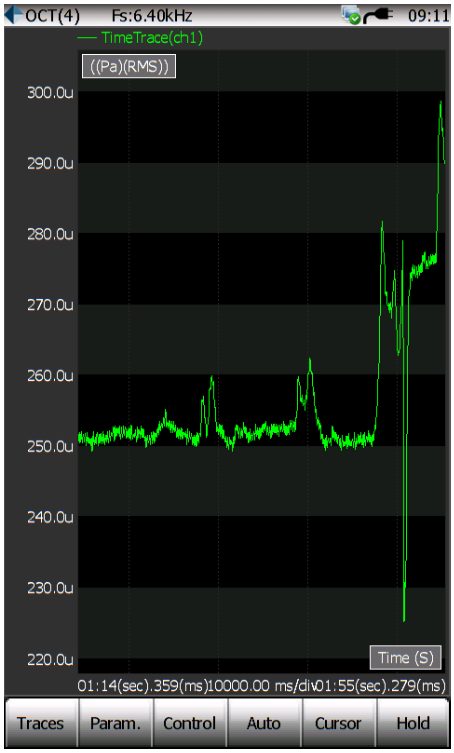


Figure 112. Time trace display.

The time trace frequency band can be changed by pressing the Control Button and selecting Change band frequency of time trace. Next chose the overall, weighted or any of the octave band center frequencies. The time trace will then display the selected band.

An RPM based level display can be added by selecting RPMTrace. It shows the level of one octave band or the overall or frequency weighted band vs. RPM. This trace type is only available for RPM based Acquisition Mode.

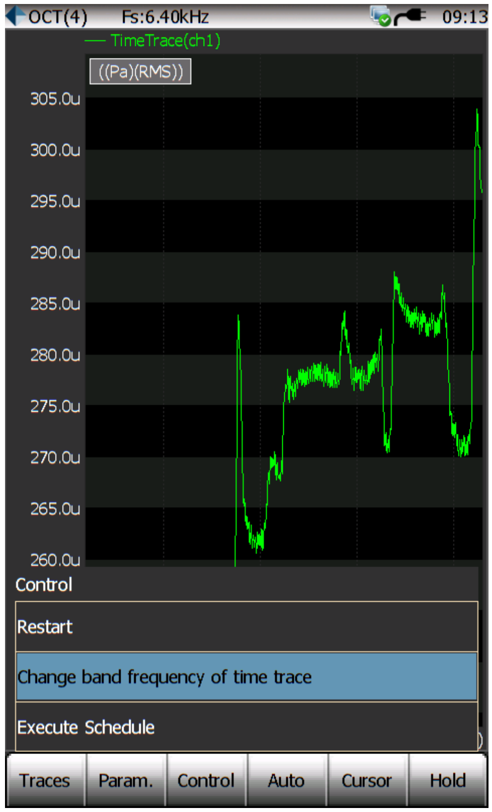


Figure 113. Change time trace frequency band.

Making Measurements

After the Analysis Parameters and displays are configured you are ready to make a measurement. Press the Run Button. To stop the display update press the Hold Button. To reset the averaging press the Control Button and select Restart.

You can use the Cursor Button to add cursors for analysis and use the Save Button to save the results. Refer to previous paragraph for more details about handling the cursors and data.

Acoustic data acquisition: Sound level meter

An analog sound level meter measures the sound pressure level. The standard sound level meter is more correctly called an exponentially averaging sound level meter as the AC signal from the microphone is converted to DC by a RMS circuit and thus it must have a time-constant of integration. This is referred to as time-weighting. Three of these time-weightings have been standardized, 'S' (1s) originally called Slow, 'F' (125 ms) originally called Fast and 'I' (35 ms) originally called Impulse. The output of the RMS circuit is linear in voltage and is passed through a logarithmic circuit to give a readout in decibels (dB). This is 20 times the base 10 logarithm of the ratio of a given root-mean-square sound pressure to the reference sound pressure. Root-mean-square (RMS) sound pressure is obtained with a standard frequency weighting and standard time weighting.

With the advent of digital technology and increasing accuracy of the electronic circuits, the sound level meter functions are more recently calculated in the digital domain. One of the important factors of such implementation is that the instrument must provide very high dynamic range so that both weak and strong signals can be calculated and observed. CoCo provides 130dB dynamic range. High dynamic range is one of the most important measures of the quality of an acoustic analyzer.

A traditional sound level meter only includes the 1/1 and 1/3 octave filters. In the CoCo system octave analysis is provided in addition to the other analysis functions providing more flexibility and computation power than a traditional sound level meter.

You should use Octave Analysis as the template to create a CSA projects when fractional octave analysis is needed. In both the Octave Analysis and Sound Level Meter templates the user can see the frequency weighted readings (such as dBA). But the reading results may be slightly different when comparing Octave Analysis and Sound Level Meter results. This is because the data processing flow in octave filter analysis and sound level meter is computed differently. In the octave analysis, the dBA, i.e., the A-weighted sound level is computed by applying the frequency weighting function to the output of each individual filter bank; while in SLM, the A-weighted sound level is created by applying the A-weight filter in the entire time domain. The SLM template should be used to obtain the dBA or similar overall readings for most sound studies that might be compared to results taken with a traditional sound level meter because the computation is more similar to that of a traditional sound level meter.

Terms and Definitions

In this section we will define the terminology used in the SLM software options.

Reference sound pressure is conventionally chosen as 20 µPa. This is the threshold of hearing of the average person and is used to compute the sound pressure level in the dB scale.

Sound pressure level (in dB) is defined as twenty times the logarithm to the base ten of the ratio of the RMS of a given sound pressure to the reference sound pressure. Sound pressure level is expressed in decibels (dB); symbol L_p.

Peak sound pressure is the greatest absolute instantaneous sound pressure during a stated time interval.

Peak sound level (in dB) is defined as twenty times the logarithm to the base ten of the ration of a peak sound pressure to the reference sound pressure, peak sound pressure being obtained with a standard frequency weighting. (example letter symbols are L_{peak}, L_{cpeak})

Frequency weighting is the difference between the level (dB) of the signal indicated on the display device and the corresponding level of a constant-amplitude steady-state sinusoidal input signal, specified in the IEC or ISO standards as a function of frequency. It accounts for A, B and Z frequency weighting discussed in the previous section.

Time weighting is an exponential function of time, of a specified time constant, that weights the square of the instantaneous sound pressure. This is the same as exponential averaging in the time domain to the instantaneous sound pressure.

It is a continuous averaging process that applies to the output of a frequency weighting filter or one of the fractional filters. The amount of weight given to past data as compared to current data depends on the exponential time constant. In exponential averaging, the averaging process continues indefinitely.

In a sound level meter the time weighting exponential averaging mode supports the following time constants:

- **Slow** uses a time constant of 1,000 ms. Slow averaging is useful for tracking the sound pressure levels of signals with sound pressure levels that vary slowly.
- **Fast** uses a time constant of 125 ms. Fast averaging is useful for tracking the sound pressure of signals with sound pressure levels that vary quickly.
- **Impulse** uses a time constant of 35 ms if the signal is rising and 1,500 ms if the signal is falling. Impulse averaging is useful for tracking sudden increases in the sound pressure level and recording the increases so that you have a record of the changes.
- **User Defined** allows you to specify a time constant suitable for your particular application.

Time-weighted sound level (in dB) is twenty times the logarithm to the base ten of the ratio of a given RMS sound pressure to the reference sound pressure, RMS sound pressure being obtained with a standard frequency weighting and standard time weighting. (example letter symbols are L_{AF}, L_{AS}, L_{CF}, L_{CS})

Maximum and minimum time-weighted sound level (in dB) is the greatest and lowest time-weighted sound level within a stated time interval. (example letter symbols are L_{AFmax}, L_{ASmax}, L_{CFmax}, L_{CSmax}, L_{AFmin}, L_{ASmin}, L_{CFmin}, L_{CSmin})

Time-average sound level (equivalent continuous sound level) (in dB) is twenty times the logarithm to the base ten of the ratio of a RMS sound pressure during a stated time interval to the reference sound pressure, sound pressure being obtained with a standard frequency weighting. (example letter symbols are L_{Aeq}, L_{Ceq})

Sound exposure is the time integral of the square of sound pressure over a stated time interval or event. Sound exposure is used to measure high-level, short duration noises and to study their effects on humans.

Sound exposure level (in dB) is the total sound energy of a single sound event and takes into account both its intensity and duration. Sound exposure level is the sound level you would experience if all of the sound energy of a sound event occurred in one second. This normalization to duration of one second allows the direct comparison of sounds of different durations.

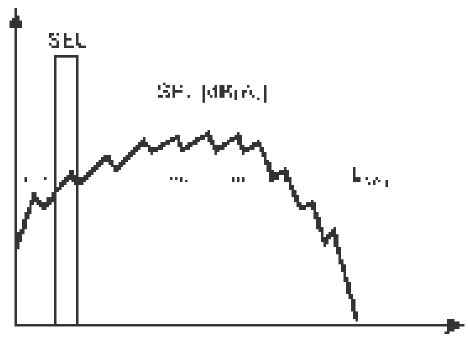


Figure 114. Sound exposure level illustration.

Figure 114 shows the relationship between the Sound Exposure Level (SEL), the Sound Pressure Level (SPL), and the Leq. The Leq is the constant level needed to produce the same amount of energy as the actual varying sound (the SPL).

The SEL is the Leq normalized to 1 second. It is what the Leq would be if the event occurred over a one second duration.

Statistical Level (L_N) is defined as the sound pressure level which is exceeded N% of the time over the duration of a measuring time interval. L0 is the maximum level over the duration of the measurement. L100 is the minimum.

Data Processing Diagram

Figure 115 shows the data processing diagram for ONE input channel for all the SLM measurements when A-weight is applied.

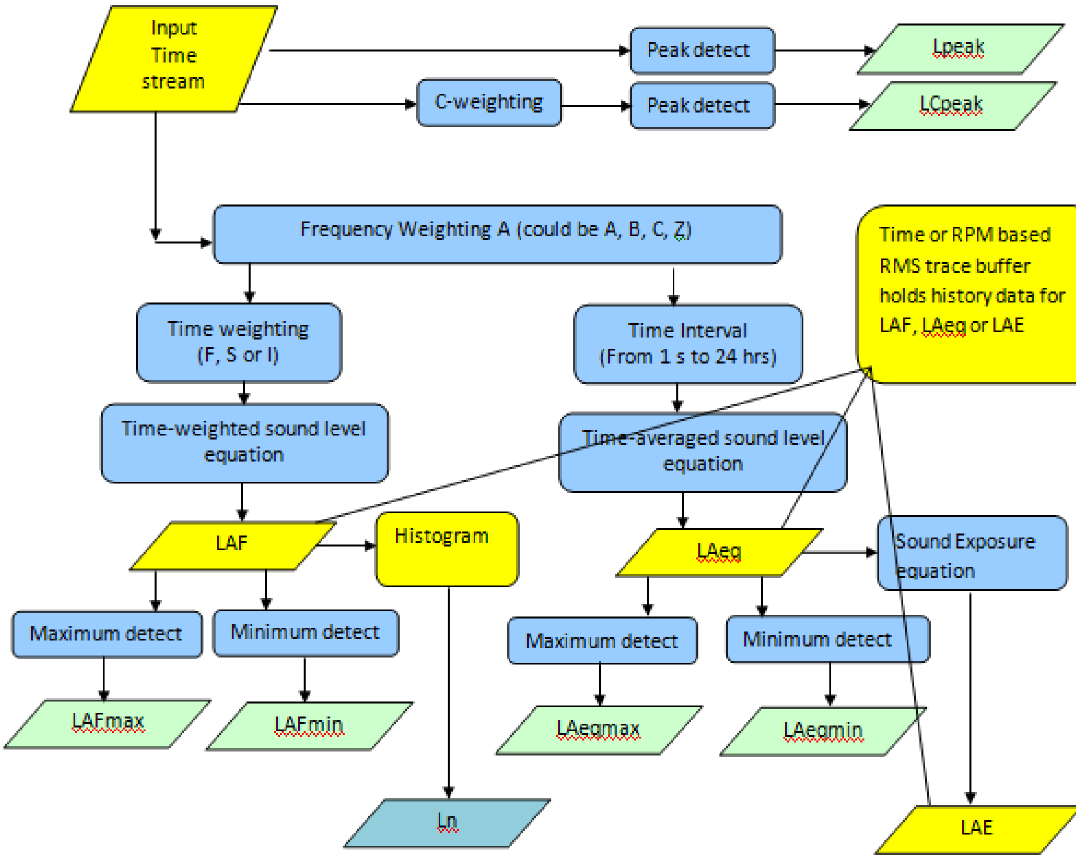


Figure 115. Sound level meter computation diagram.

In the SLM measurement, after the digitized data comes in, it is split into three paths: one goes to frequency weighting A, B, C or Z and one goes to C weighting or no weighting. The peak detection is computed from the output of C weighting or no weighting. The output of frequency weighting (A, B, C or Z) is further split into two paths. The first will go to a time weighting function which is more or less equivalent to an exponential averaging mode to calculate LAF; the second path goes to a time averaging function, which is equivalent to a linear averaging mode to calculate Leq.

With A-weighted applied as shown in the example, the list of symbol to be used by this instrument is:

Symbol of Measured Values	Description
LAF	A-weighted, F time-weighted sound level
LAFmax	Maximum A-weighted, F time-weighted sound level
LAFmin	Minimum A-weighted, F time-weighted sound level
LCpeak	Peak C sound level, greatest absolute instantaneous C-weighted sound pressure level
Lpeak	Peak sound level, greatest absolute instantaneous sound pressure level
LAeq	A-weighted, time-average sound level (equivalent continuous sound level)
LAeqmax	Maximum A-weighted, time-average sound level (equivalent continuous sound level)
LAeqmin	Minimum A-weighted, time-average sound level (equivalent continuous sound level)
LAE	A-weighted sound exposure level
LN (N = any integer between 0~100)	Statistical Level general term
L1, L5, L50, L95….	Statistical Levels with specific N values. The sound level exceeds this level 1, 5, 50 or 95 percent of the time for the duration of the measurement.

Measurements available to CoCo in SLM mode

There are two ways to view sound level measurements: instantaneous SLM measures and RMS history. Instantaneous SLM measures represent the most current value of the measurement.

RMS history not only shows the most current value, but also a record of historical values against time or RPM. Some of the measures allow only instantaneous values others allow both.

The following measurement quantities are available to CoCo in the measurement.

SLM Measures

The following SLM measures are available for real-time reading and can be saved as a data structure for future review.

Time Weighted Sound Levels

In CoCo, time weighted sound level is the output of frequency-weighting and then time weighting filters. Time weighting serves an exponential averaging operator. The computation is illustrated in Figure 116.

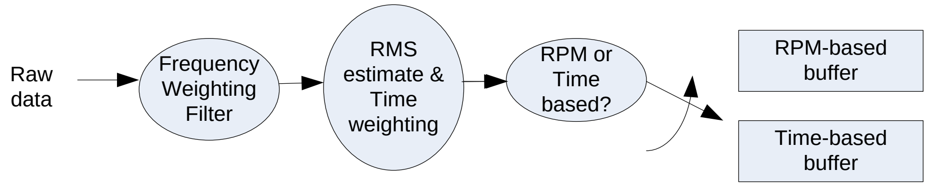


Figure 116. Time weighting sound level computation and storage against RPM or Time

The table below shows the symbols for the time-weighted sound level.

Symbol used for time weighted value		Frequency Weighting Z	A	B	C
Time Weighting	F(Fast)	LZF	LAF	LBF	LCF
	S(Slow)	LZS	LAS	LBS	LCS
	I(Impulse)	LZI	LAI	LBI	LCI
	Custom	LZC	LAC	LBC	LCC

Time Averaged Sound Levels

In CoCo, time averaged sound level is the output of frequency-weighting and then time average operation. Time average serves a linear averaging operator. Figure 117 illustrates the computation.

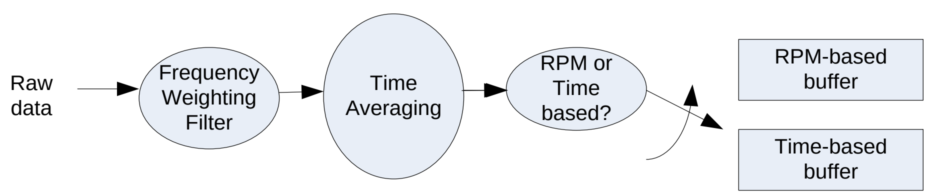


Figure 117. Time averaged sound level computation.

The table below shows the symbols for time-average sound level. In the time averaging sound level measurement, Frequency weighting can be selected as A, B, C or Z. The time interval for time averaging can be set to any value between 1 second and 24 hours.

Frequency Weighting	Z	A	B	C
Symbol	L_{eq}	L_{Aeq}	L_{Beq}	L_{Ceq}

Peak sound level

Only C-weighted and un-weighted are available for peak sound level. This is required by the standards.

Symbol	L_{peak}	L_{Cpeak}

Sound exposure level

Sound exposure level and time-average sound level have the same frequency weighting and same time interval.

Frequency Weighting	Z	A	B	C
Symbol	L_E	L_{AE}	L_{BE}	L_{CE}

Statistical level: value reading

Any statistical level L_N is the sound level which is exceeded for N% of the defined measurement duration.

Symbols for LN, N = 1, 5, 50, 95	L1	L5	L50	L95

Input Channel Time Streams

In CoCo, time domain data is always available in the form of long time history. The user can view and record the time signals. The limitation is that the sampling rate of the time signals cannot be arbitrarily changed. It is always set internally by the system based on analysis frequency range.

RMS trace of weighted level, time averaged level or sound exposure

CoCo records an RMS trace of the sound level. The user must choose between the time weighted level L_{AF}, the equivalent time averaged level L_{AEQ} or sound exposure level L_{AE}. Only one can be recorded at a time.

The RMS trace must be selected using one of Time or RMS as variable at the CSA Editor stage.

Histogram of Time Weighting

CoCo also records a signal containing a histogram of the dB values of the time weighted signal. This signal is used to compute the L_n data.

CSA Editor Operation for Sound Level Meter

This section describes the operation of the CSA Editor related to sound level meter measurements. For general operation of the CSA Editor refer to the CSA Users Manual.

CSA Editor Wizard for Sound Level Meter

This section summarizes how to create a CSA project for sound level meter measurements in the CSA Editor. We strongly recommend that you read the CSA Edit User's Manual to gain more detailed information before proceeding with this chapter.

To start, click on the CSA Editor icon in the upper-right corner in EDM and start the CSA Editor. The CSA Editor Wizard dialog box will be displayed. First select the CoCo type and number of channels of the CoCo that this CSA project will support. The number of channels must be equal to or less than the number of physical input channels on the CoCo hardware. Click on the Next Button.

Next select the Sound Level Meter template and either time or RPM based mode. Time based analysis will compute the results based on time averages. This is the most common application. RPM based mode computes results versus the RPM measured by a tachometer for rotating equipment. Click on the Next Button.

Next select the number of input channels to compute the analysis functions. In general it is best to select the minimum number of channels to conserve computational resources for the CSA. This number can be less than or equal to the number of physical input channels on the CoCo hardware. Click on the Next Button.

Next enter the description of the CSA. This data will be saved with the CSA and be shown on the CoCo device when the CSA is opened. Click on the Next Button.

Select Signal Candidates

Next the Signal Analysis Display is shown. This display lets you select which signals will be display candidates, save candidates and which will be used to compute the octave analysis. Always select the minimum number of candidates required to conserve computational resources. Note that when a signal is selected as a candidate then it is available on the CoCo hardware, meaning that it can be displayed or save, etc. If the signal is not specified as a candidate in the CSA then it will not be available on the CoCo hardware.

SLM Signal Settings lets you specify the SLM computation candidates for the input time streams.

Analysis output signal settings let you specify the display, record and save candidates for the computed data.

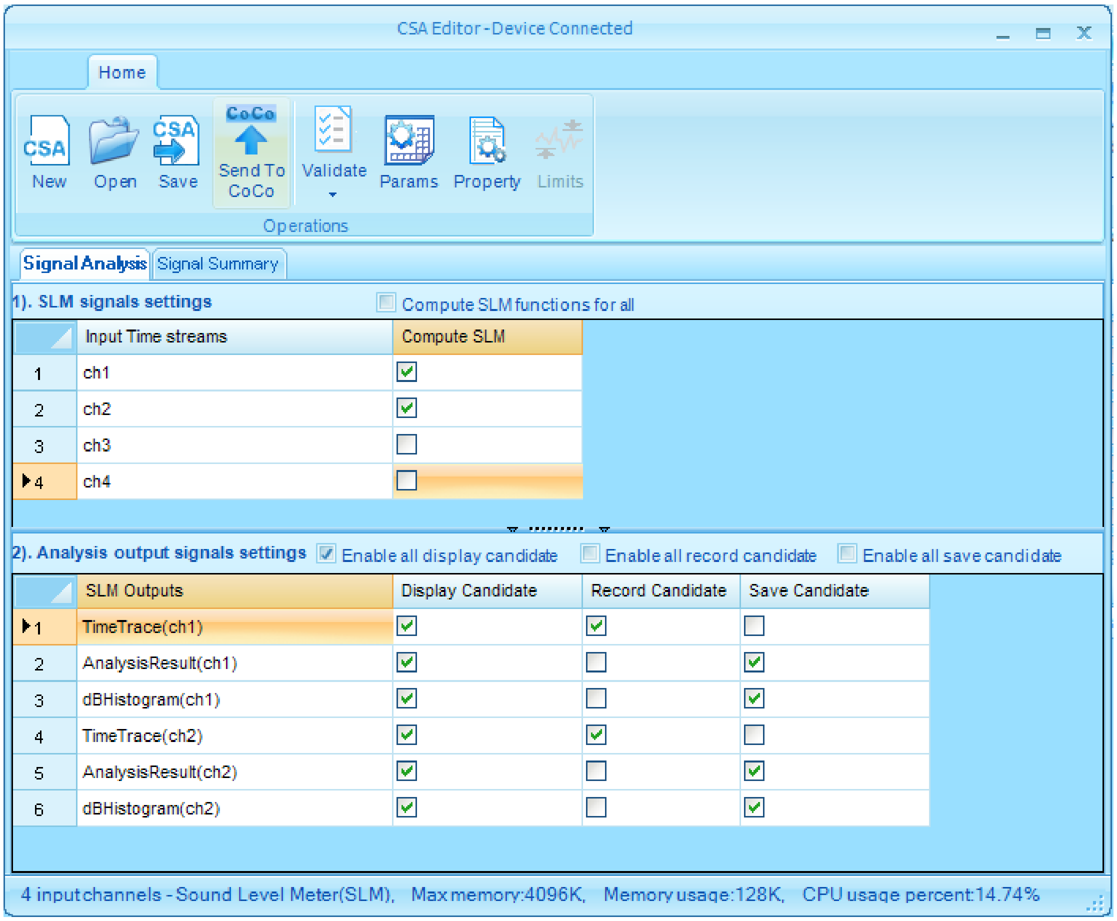
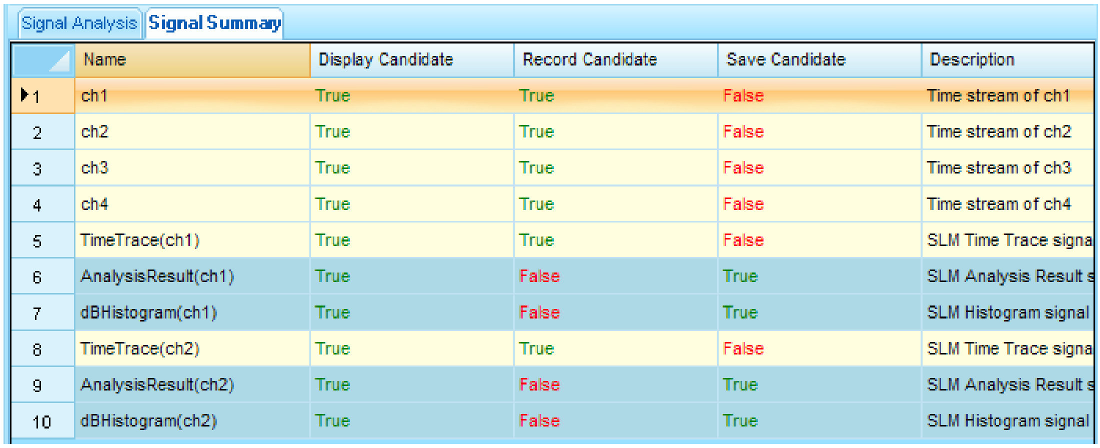


Figure 118. Signal Analysis tab in CSA Editor.

After all the candidate selections are made, a summary can be viewed by selecting the Signal Summary.



	Name	Display Candidate	Record Candidate	Save Candidate	Description
1	ch1	True	True	False	Time stream of ch1
2	ch2	True	True	False	Time stream of ch2
3	ch3	True	True	False	Time stream of ch3
4	ch4	True	True	False	Time stream of ch4
5	TimeTrace(ch1)	True	True	False	SLM Time Trace signa
6	AnalysisResult(ch1)	True	False	True	SLM Analysis Result s
7	dBHistogram(ch1)	True	False	True	SLM Histogram signal
8	TimeTrace(ch2)	True	True	False	SLM Time Trace signa
9	AnalysisResult(ch2)	True	False	True	SLM Analysis Result s
10	dBHistogram(ch2)	True	False	True	SLM Histogram signal

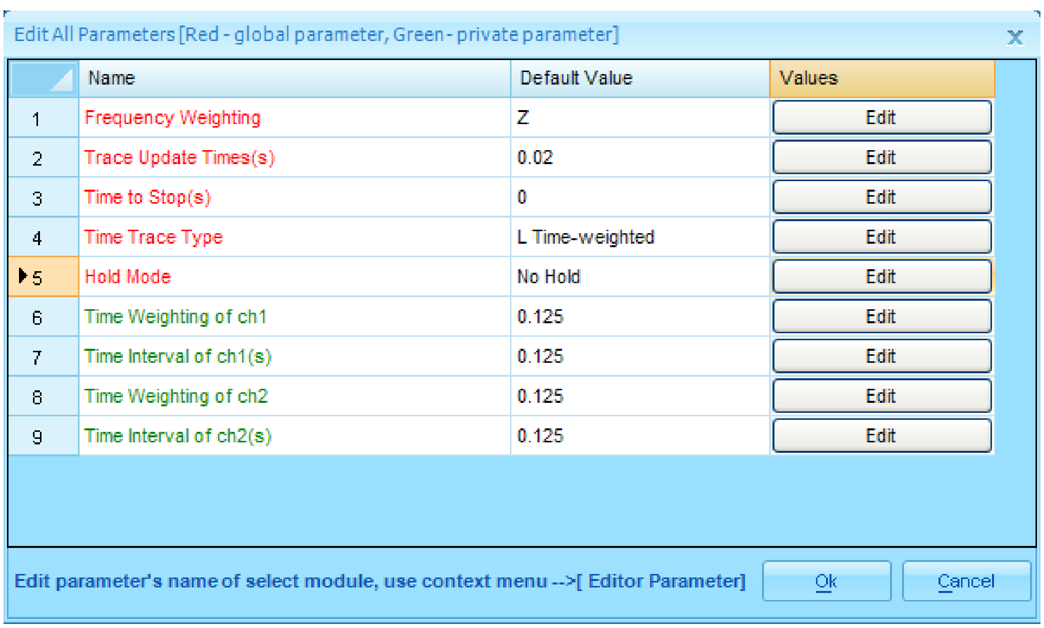
Figure 119. Signal Summary tab in CSA Editor.

Analysis Parameters

After the signals are selected the next step is to specify the Parameters by clicking on the Param icon in the CSA Editor Ribbon. The Parameters display lets you change the computation parameters such as frequency weighting, trace update time, time to stop, etc. Click on the Edit Button next to each item to edit the parameter. Click on Ok to save the updated parameters.

Time Based Acquisition Analysis Parameters

The Analysis Parameters are different if the Acquisition mode is set to Time or Frequency based analysis. The time based acquisition mode parameters are Figure 120.



	Name	Default Value	Values
1	Frequency Weighting	Z	Edit
2	Trace Update Times(s)	0.02	Edit
3	Time to Stop(s)	0	Edit
4	Time Trace Type	L Time-weighted	Edit
5	Hold Mode	No Hold	Edit
6	Time Weighting of ch1	0.125	Edit
7	Time Interval of ch1(s)	0.125	Edit
8	Time Weighting of ch2	0.125	Edit
9	Time Interval of ch2(s)	0.125	Edit

Figure 120. Edit Parameter window in CSA Editor for time based acquisition.

Frequency Weighting – defines the frequency weighting including A, B, C or Z.

Trace Update Times – defines the update rate of the time trace. Enter a larger update time for a longer display duration.

Time to Stop – defines the length of time for data acquisition. When the parameter is set to No Hold then the acquisition will continue indefinitely.

Time Trace Type – defines the time weighting includes L, Leq, L and LE.

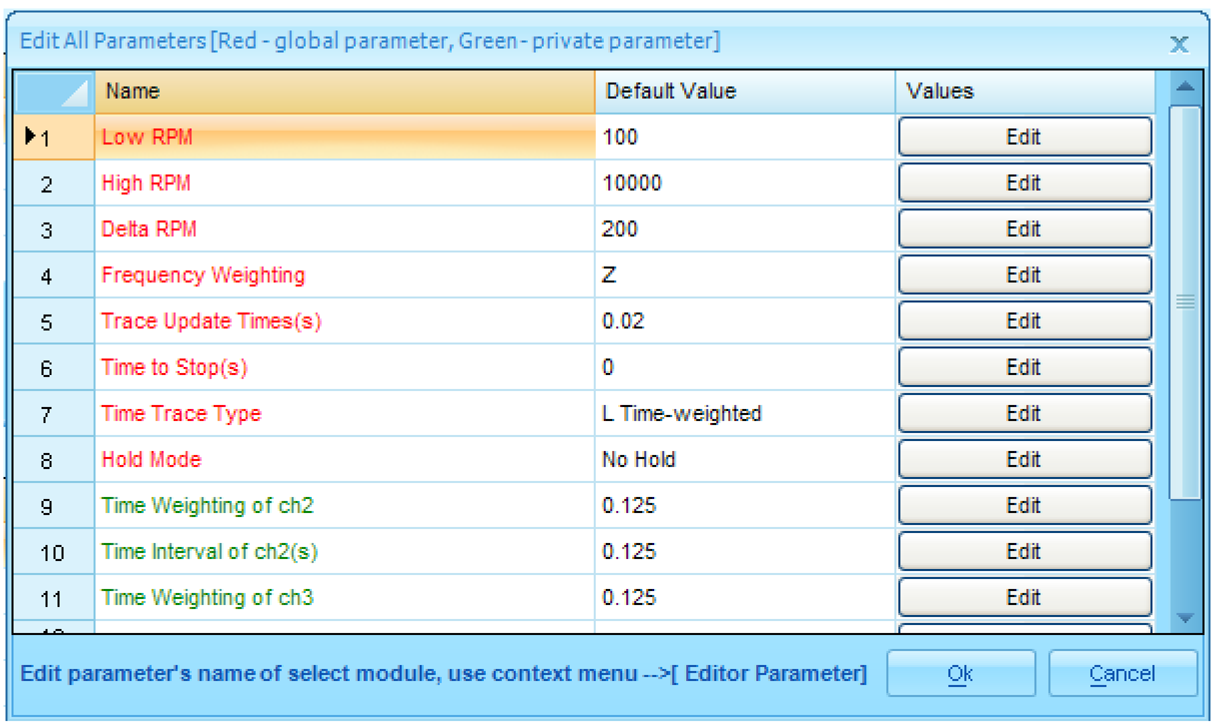
Hold Mode – This parameter only has the impact to the measurement of Lmax, Lmin, LEQmax, LEQmin, Lpeak and LCpeak. If the Hold Mode is off, for every period of Time Interval, these measurement values will be reset and calculate again. If the Hold Mode is ON, these measurements will be taken within the whole elapse time.

Time Weighting – Exponential averaging decay factor used to calculate the time-weighted sound level for that individual channel.

Time Interval – This is the time period of calculating Leq for each individual channel.

RPM Based Acquisition Analysis Parameters

The RPM based acquisition parameters are shown in Figure 121.



	Name	Default Value	Values
1	Low RPM	100	Edit
2	High RPM	10000	Edit
3	Delta RPM	200	Edit
4	Frequency Weighting	Z	Edit
5	Trace Update Times(s)	0.02	Edit
6	Time to Stop(s)	0	Edit
7	Time Trace Type	L Time-weighted	Edit
8	Hold Mode	No Hold	Edit
9	Time Weighting of ch2	0.125	Edit
10	Time Interval of ch2(s)	0.125	Edit
11	Time Weighting of ch3	0.125	Edit

Figure 121. Edit Parameter window in CSA Editor for RPM based acquisition.

Low RPM – defines the low RPM level for display limits and also the limits for trigger mode.

High RPM – defines the high RPM level for display limits and also the limits for trigger mode.

Delta RPM – defines the resolution of RPM measurements. Note that a large RPM span and high resolution (small Delta RPM) require more computation resources.

The other parameters are the same as the time based acquisition parameters.

Validation, Save and Upload

After the CSA Wizard is complete and the CSA file is created, connect the host PC to the CoCo device and press the Validate icon to validate the CSA. It may take a few minutes to finish the validation.

Figure 122. Validate and Send to CoCo icons in the CSA Editor Ribbon.

The validation process analyzes the CSA file for internal consistency and estimates the required DSA resources required to run the CSA file on the CoCo device.

If the Validation passes, then press Send to CoCo command in the Validation dialog box to send the CSA project file to CoCo. Alternatively you can manually upload it to CoCo. The uploaded CSA will be classified into the Acoustic Analysis Application Group and can then be opened on the CoCo hardware.

CoCo Operation for Sound Level Meter

This section describes the operations of CoCo that are specifically related to sound level meter analysis. For general operations of CoCo refer to the Basic Users Manual.

Select a CSA Project

After an SLM CSA is created from the CSA Editor and downloaded to the CoCo Hardware then it can be opened on the CoCo. Alternatively you can also open the default SLM CSA scripts on the CoCo Hardware. To open a CSA press the Analysis Button, then select the Acoustic Analysis. All SLM CSA files are automatically placed in this group to help organize the CSA files on the CoCo.

Next select SLM CSA from the list. SLM analysis CSA files have the name SLM() by default.

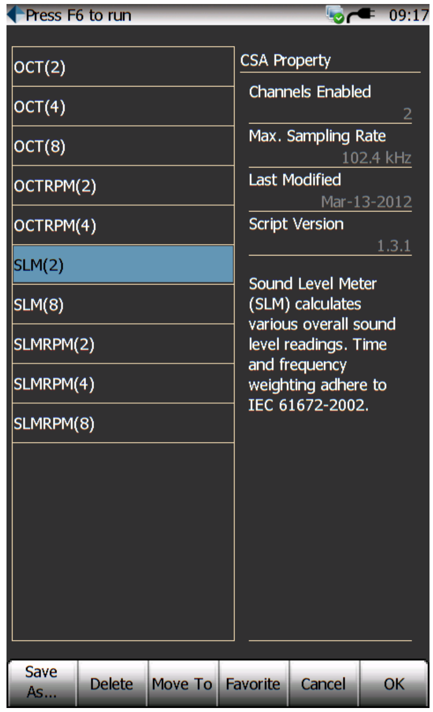


Figure 123. Select Analysis Function for SLM.

Analysis Parameters for SLM

To set the parameters press the Param button in the signal display window, select Analysis Parameters, then set the parameters. Note the default values are defined in the CSA Editor.

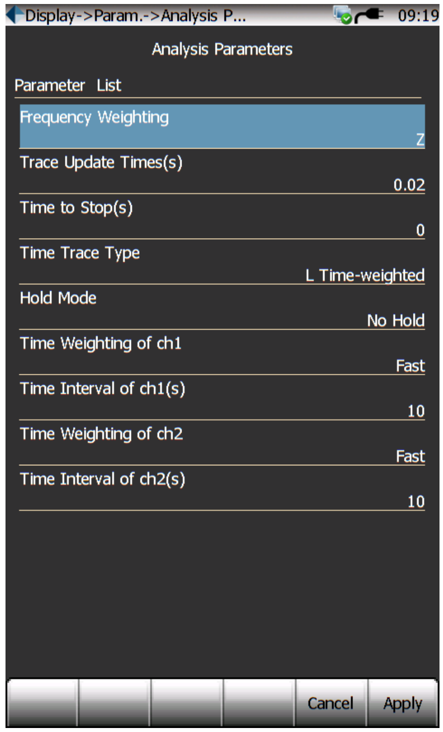


Figure 124. SLM Analysis Parameters.

The time weighting parameter can be selected so it corresponds to "Fast" or "Slow" weighting mode. For "Fast" weighting mode, set the time weighting constant to 0.125 seconds; for "Slow" mode, set it to 1.0 seconds.

SLM Displays

SLM includes traces of the native time streams and the time weighted sound levels,

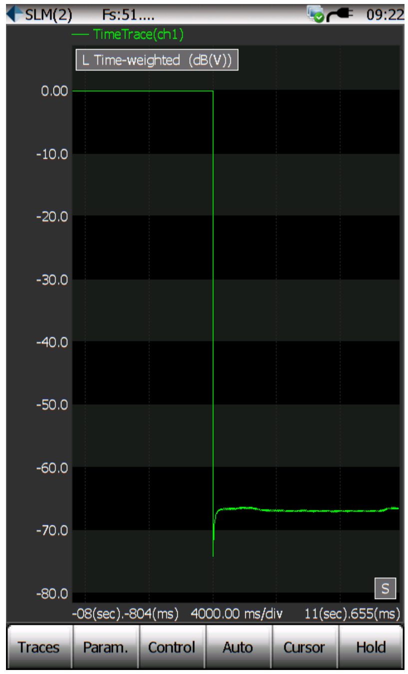


Figure 125. Native or time weighted sound levels can be viewed in a time trace.

SLM also includes a display called Analysis Results. The Analysis Results display is similar to a typical sound level meter display and shows the numerical values for the measures and a bar meter for the time and frequency weighted level and equivalent level.

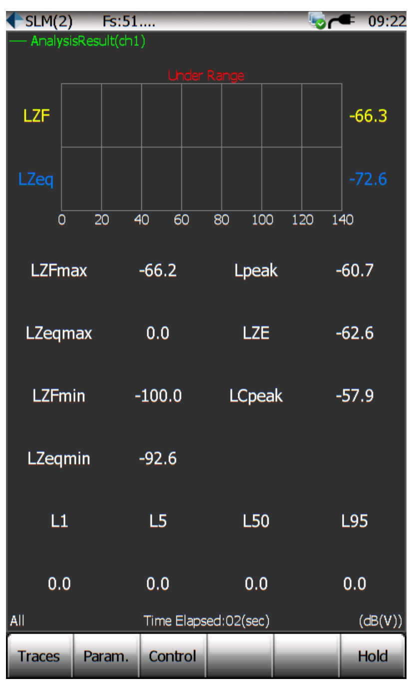
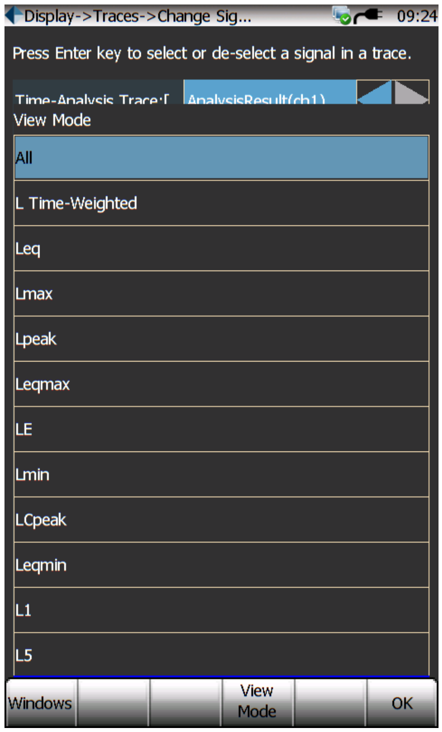


Figure 126. SLM Analysis Results display.

Notice that the statistics display, L1=93.4, L5=89.6, L50=26.8 and L95=13.6 means that since the measurement started, among the historical time weighted measurement, 1% exceeded 93.4dB; 5% exceeded 89.6dB; 50% exceeded 26.8dB and 95% exceeded 13.6dB.

Alternatively, you can select to view individual analysis measures by setting up **View Mode** under the **Trace and Window Settings.**



For example, when an analysis measurement signal is selected in a Trace and Leq is selected, following picture will be shown:

Figure 127. Numerical display for SLM.

It shows the Leq values of the input channel.

Another common display for SLM measurements is a histogram which shows a statistical distribution of the frequency of occurrence versus amplitude.

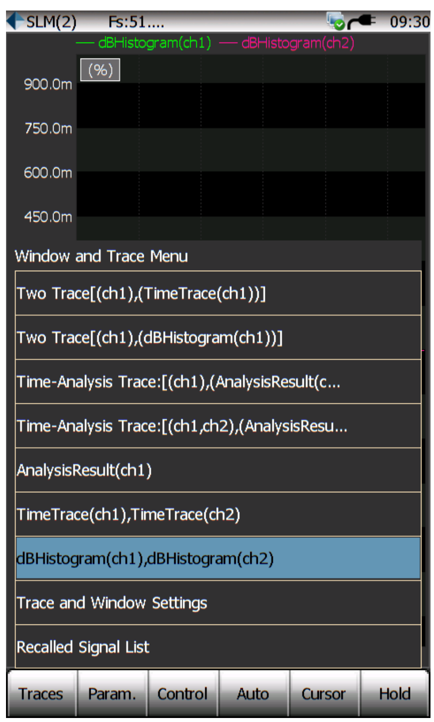


Figure 128. Histogram display for SLM measurements.

The histogram can also be viewed in cumulative format by selecting Select View Mode for Current Trace from the Traces Button and choosing Cumulative.

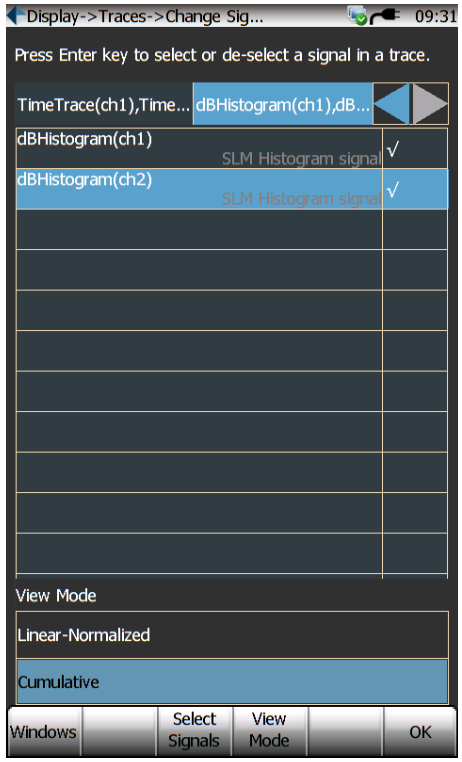


Figure 129. Linear-normalized and cumulative histogram selection for SLM measurements.

Order Tracking

Order Tracking is a general term describing a collection of software functions used for analyzing the mechanical dynamic behavior of rotating or reciprocating machinery for which the rotational speed can change over time. Unlike the power spectrum and other frequency-domain analysis standards where the changing variable is the frequency, Order Tracking functions present the data related to the variable rotating speed, i.e., RPM (revolution per minute).

The most useful measurements are order spectra and order tracks. An order spectrum gives the amplitude of the signal as a function of harmonic order of the rotation frequency. This means that a harmonic or sub-harmonic order component remains in the same analysis line independent of the speed of the machine.

The technique that observes the changes of any quantity vs. RPM is called **tracking**, as the rotation frequency is being tracked and used for analysis. Most of the dynamic forces exciting a machine are related to the rotation frequency so interpretation and diagnosis can thus be greatly simplified by use of order analysis.

Order tracks are simply the observations to the amplitude of the components with fundamental frequency or harmonics. It is one typical type of tracking. There are other types of tracking. For example, the user can track the FFT-based PSD spectra, a fixed band or an octave band etc.; all these can be called tracking.

With the CI Order Tracking package, the instrument can:

- Process a tachometer signal and give a high fidelity RPM measurement
- Measure the order spectra
- Measure the order tracks
- Measure the RPM FFT spectrum
- Measure the energy in fixed bands vs. RPM
- Measure the amplitude and phase of an order relative to the tachometer.

There are several different applications for order tracking. A discussion of some is given below.

The first application, often referred to Run Up/Run Down, is used to evaluate the noise or vibration dynamic response when RPM is used as a changing variable. In this case, the RPM range can be very large, from a few RPM to 10,000 RPM. Typical application tests are used in the automotive or aircraft engines. The measurements can be any physical quantities such as sound, displacement, velocity, acceleration, torque, etc. The analysis measure can be the amplitude or the power of an order, the energy over a fixed frequency band, a bin of octave filter, etc. The phase information of the responses to tacho is less important in this type of application. In fact the rotating element might be hidden inside of mechanical system. The primary result for this type of measurement is the magnitude of the responses vs. RPM.

The second application is rotating machine analysis that focuses on the measurement of displacement or velocity of the rotors while it is rotating. The instrument measures the amplitudes of specific orders and their relative phase to a reference signal. The phase is calculated relative to the tachometer input or a separate reference input. This application is common for machine diagnosis and balancing. In this case, the RPM is stable or quasi-stable. Order tracking technology is useful to increase the accuracy of the estimation of orders.

Order signals with phase are useful in the test of rotating machine in the Run Up/Run Down process. This is often presented as a “Bode Plot”. The Bode Plot is a borrowed concept from control theory; it is a collection of Amplitude and Phase data over a changing speed range (i.e. Run Up or Coast Down). Some of the setup information depends on the rate of change of the RPM. The Run Up or Coast Down could take anywhere from a few minutes to a few hours (such as for a cold startup on a turbine). Other displays such as the orbit plot is useful as well.

The CoCo includes the ability to measure RPM based octave analysis and sound levels. This feature is similar to order tracks except that spectra are recorded in octave bands with A, B, C or Z frequency weighting. This feature is included in the Acoustic Analysis and Sound Level Meter CSA Templates instead of the Order Tracking Template. Refer to these sections for more details.

Tachometer Signal Processing and RPM Measurement

A **tachometer (tacho)** converts the angular velocity of a rotating shaft into an electrical signal, typically a voltage. It is common for calibrated instruments to provide a measurement of the shaft in units of revolutions per minute (RPM) or revolutions per second (RPS). Many modern rotating machines (electric motors, generators, pumps, turbines, IC engines, etc.) have integrated tachometers that can measure shaft angular velocity. An example of an optical tachometer is shown in the figure below.

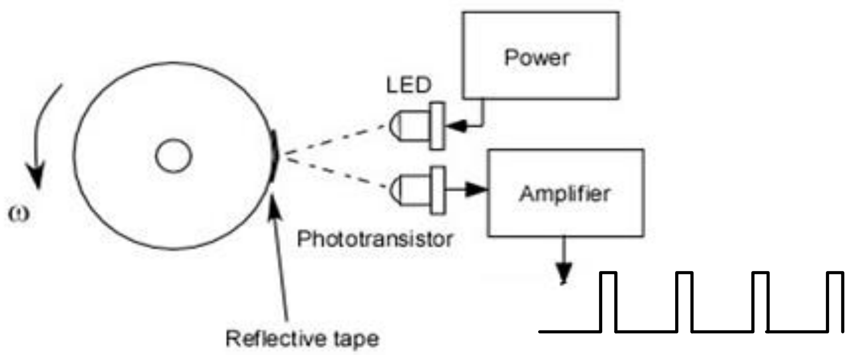


Figure 130. Optical tachometer setup.

The goal of tacho signal processing is to get a clean and stable RPM reading. The tacho signal must be carefully processed to provide a base of tracking. Any order tracking results can only be thought of as being as accurate as the tachometer signals that were used to estimate the instantaneous frequency of the order in the analysis process. If the quality of the tachometer channel is poor, the results from all other channels will be poor or even unreliable.

In old analog methods, tacho channels were conditioned with a tracking ratio tuner with a phase lock loop. The disadvantage of this method is the limited slew rate and the use of complex hardware. To overcome these limitations various digital tacho processing methods have been developed.

From hardware design point, there are two ways to implement a tacho input channel: use a dedicated tacho channel with a digital counter, or use an analog input channel.

Dedicated tacho channel using counter

Using a dedicated tacho channel, usually without A/D converter, has been popular. This hardware approach contains its own tacho clock which runs at a much higher speed; typically in MHz. This tacho hardware also contains special counters which maintain a continuous counter reading to avoid skipping any triggered cycles of the tacho signal. There is also an option to allow these counters to "average" several tacho periods for cases when the input tacho frequency is very high.

Using Analog Input Channel

Alternatively, some systems use an analog input data channel as a tacho channel. In this case, the tacho clock is actually the sample rate of the data channels. This sample rate usually limits the tacho frequency range since the tacho range is now set by the input data frequency range requirement. In addition, due to the "frame processing" nature of some not-so-well designed input sampling processes, some instruments may be limited to how they acquire the tacho signal. This restriction usually means they get several tacho cycles in every data frame. The result is often an "averaged" value which is okay unless the tacho signal is changing frequency during the data frame event, which is often the case.

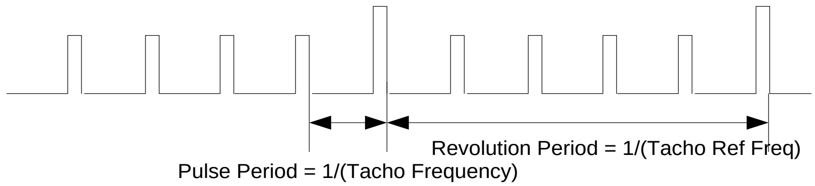
With the advances of electronics and lower cost of electronic components cost is less of a concern. The approach of dedicated tacho channel with a digital counter, without A/D, may or may not be the best choice.

The CoCo-80/90 can use any of the data channel as tacho channel. For simple interface design, usually channel 1 is used for the tacho. While the data input channel is used as a tacho measurement, the special hardware circuitry allows this data channel to sample at the highest possible sampling rate. In the other words, the accuracy of tacho speed measurement is depending on the current range of the analysis frequency. This technique has several obvious advantages:

- The time domain signal of the tacho input is transformed by A/D converter into a digital signal. The user can observe the pulse trains of the tacho signal and set threshold arbitrarily.
- Accurate phase information can be obtained relative to each data channel because the tacho channel, which is fed by high frequency sampling counter, is synchronized with data channels.
- The RPM estimation is not influenced by the current data sampling rate.

Pulse per Rev is defined as the number of pulses per revolution. Pulse per Rev. must be defined by the user so the instrument can calculate the reference frequency of tacho using tacho frequency. The relationship is:

Tacho Reference freq = Tacho freq / Pulses per Rev



In most rotor tests, especially in balancing, the Pulses per Rev is simply 1. However, in other cases, such as in flywheel or geared data measurement, the Pulses per Rev can be as high as hundreds. To deal with this situation, a dedicated tacho channel with high speed counter might work better.

In the CoCo-90, in addition to using any data channel as tacho input, a dedicated tacho channel is installed to measure a high speed RPM, or deal with high Pulses/Rev or digital TTL trigger. The counter speed is about 25MHz. This second choice provides a more versatile solution to the user for their applications.

The special tacho hardware design on the CoCo system with the Order Tracking package offers the most accurate possible approach for performing a wide range of Real-Time machinery-related vibration and noise analysis.

Pulse Detection

A good tacho processing device should allow the user to see the tacho signal in its original time waveform visually, and set the Pulse per Rev., the threshold of pulse detection. This will help setup the tachometer and diagnose any problems quickly. In the CoCo hardware, a special display window is created so the user can switch between the RPM trace and the tacho original time waveform displays conveniently. The pulse detection threshold can easily be controlled by using Up/Down buttons.

Order Tracks and Order Spectrum

Knowledge of the rotating speed allows presentation of measurement results in the angle and order domains, corresponding to the time and frequency domains. An order is a frequency normalized with some reference frequency, e.g. the shaft frequency. This means that the order of a vibration component in the order spectrum indicates the number of vibration cycles per shaft revolution. The magnitude, which can be measured using EU_{pk}, EU_{rms} or EU_{rms}^2 , of an order is the measurement extracted through a tracking filter with the center frequency located at this frequency. Multiple measurements of a range of orders will construct a so called Order Spectrum. An order power spectrum measurement gives a quantitative description of the amplitude, or power, of the orders in a signal. It provides a good view of all order components of a signal. This can help you find significant orders and compare the level of different order components

There are two methods to perform rotationally coherent sampling, phase-locked frequency multipliers and digital re-sampling. Phase-locked frequency multipliers were mainly used in early work. They generate sampling pulses based on a rotational reference signal. These sampling pulses control the sampling process.

Note that the sampling frequency will depend on the rotational speed, and thus an adjustable anti-aliasing filter is needed. This complicates the method considerably. In the digital re-sampling technique, the time signal is conventionally sampled together with some rotational reference signal. The time signal is then digitally re-sampled to the angle domain by interpolation techniques. The rotational reference signal can be acquired with a tachometer or an incremental pulse encoder.

The following picture shows conceptually how angle data re-sampling can be used to analyze vibrations from an engine during start up. Once the signal has been transformed into its angle domain, the FFT can be applied to analyze the order spectrum of the vibrations.

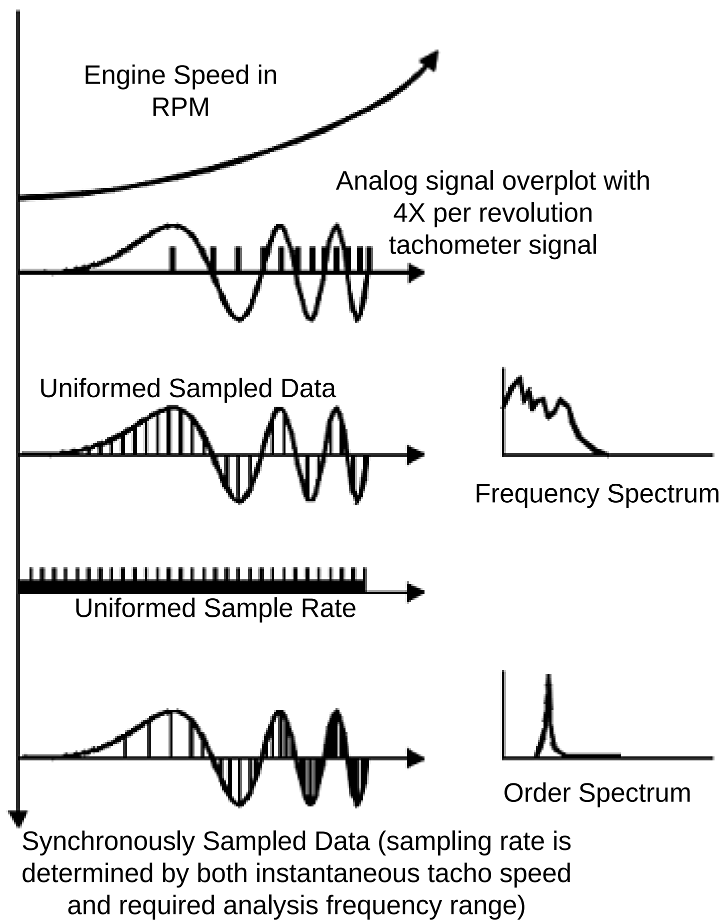


Figure 131 Angular Data Re-sampling of a Chip Signal

The last plot in the picture shows that the sampling rate will be determined by both instantaneous tacho speed and required analysis frequency range.

In the CoCo system, the order tracks and order spectrum are computed with a proprietary technology that combines digital re-sampling, data decimation, and interpolation, DFT and FFT calculations.

Three measurements can be generated from order tracking computation: Order Spectrum shown in Figure 133. Order Tracks shown in Figure 134, and the 3D RPM Order Spectrum shown in Figure 135. The 3D RPM Order Spectrum is simply the a 3-dimensional view of the other two types of measurement.. Another way to visualize these types of plots is that the order spectrum is a cross section of the 3D plot along a fixed RPM value while the order track is a cross section along a fixed order number. The relationship of them is:

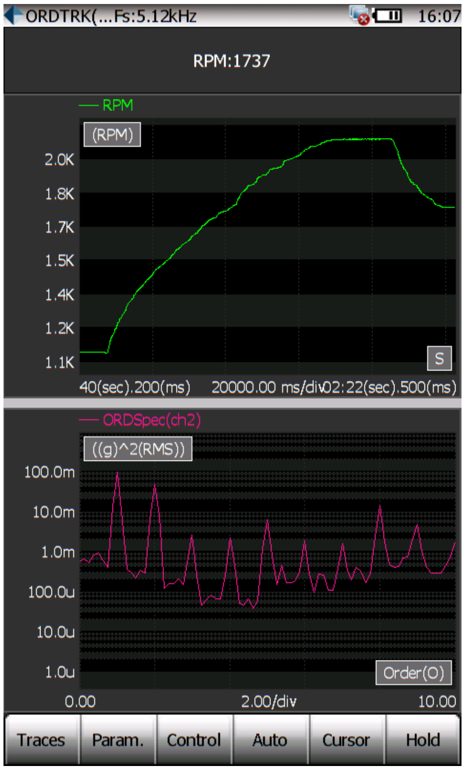


Figure 132. Typical order spectrum.

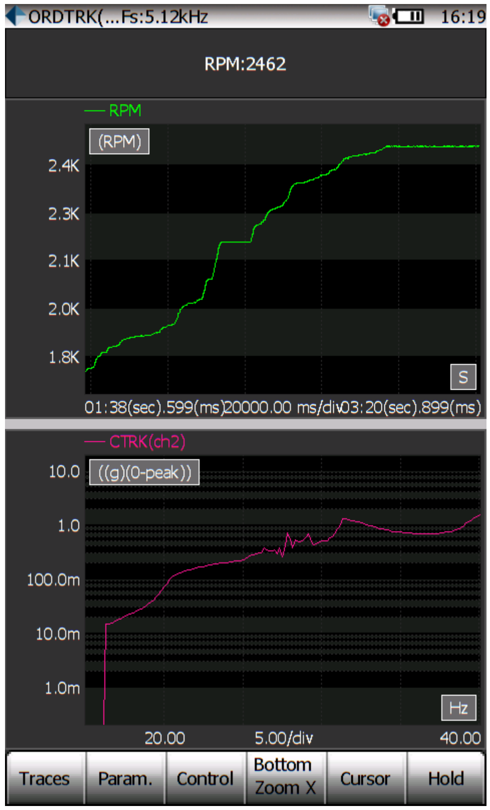


Figure 133. Typical order tracks.

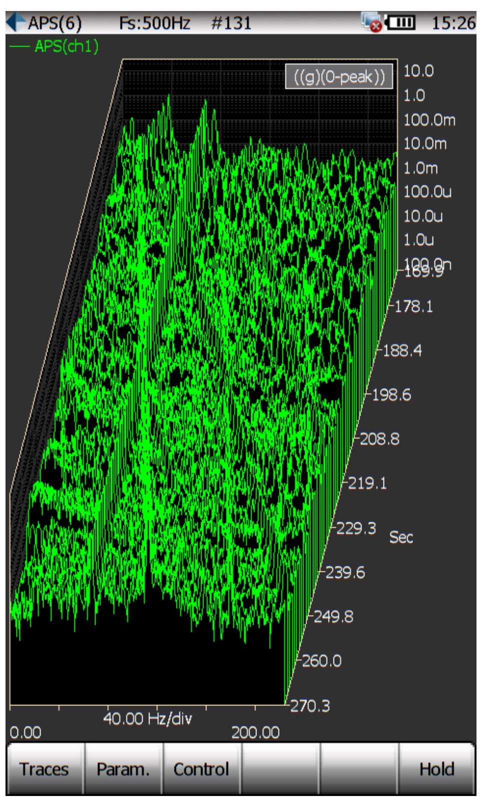


Figure 134. Typical 3D order track waterfall plot.

An important concept that must be introduced now is called delta order, ΔOrder. In the FFT based frequency spectrum analysis, the frequency span and frequency resolution are fixed. The capability of discriminating frequency components is equal in both low and high frequency. In rotating machine analysis, we want to have better analysis resolution in the low frequency than that in high frequency. For example, if the rotating speed is at 60 RPM, we definitely care if the instrument can tell the difference between 1 Hz (order 1) and 2 Hz (order 2); on the contrary, if the rotating speed is at 6000 RPM, the user probably won't care if the instrument can discriminate the measurement between 100Hz (order 1) and 101Hz.

With the digital re-sampling technique, the order tracks and order spectrum are extracted based on a filter with equal ΔOrder instead of equal ΔFrequency. The concept is illustrated in the following figure:

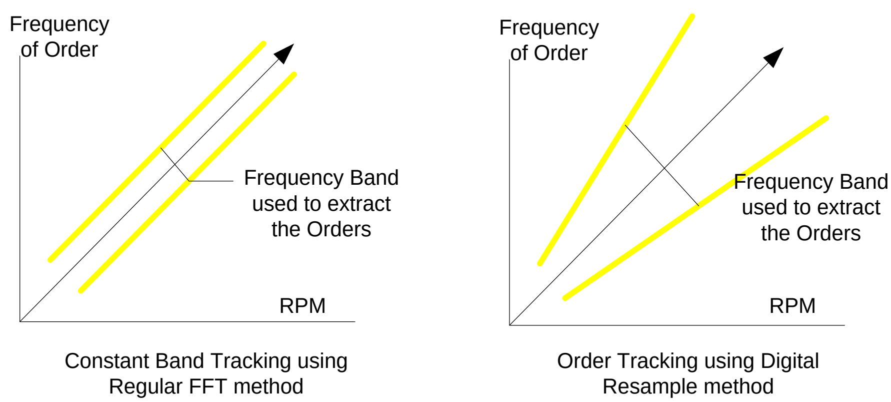


Figure 135. Comparison of constant band tracking and digital re-sampling method.

In this figure, the left side shows when the order tracks are extracted using conventional FFT method with fixed resolution, the ΔFrequency of tracking filter will be fixed; the right side shows that if the order tracks are extracted using digital re-sampling, the ΔFrequency tracking filter will be increased proportionally with the RPM. Obviously, the method of digital re-sampling is more desirable in extracting the measurement of orders.

RPM Frequency Spectrum

While the order tracks and order spectra are developed to analyze the characteristics of the system on the order space, the measures of fixed bands are also helpful for analysis. Similar to the RMS time trace for a given frequency band with time as variable, the RMS trace can be extracted for a given frequency band with RPM as the independent variable. This is simply called an RPM Spectrum. An RPM Spectrum can be described as a 3D waterfall as shown below:

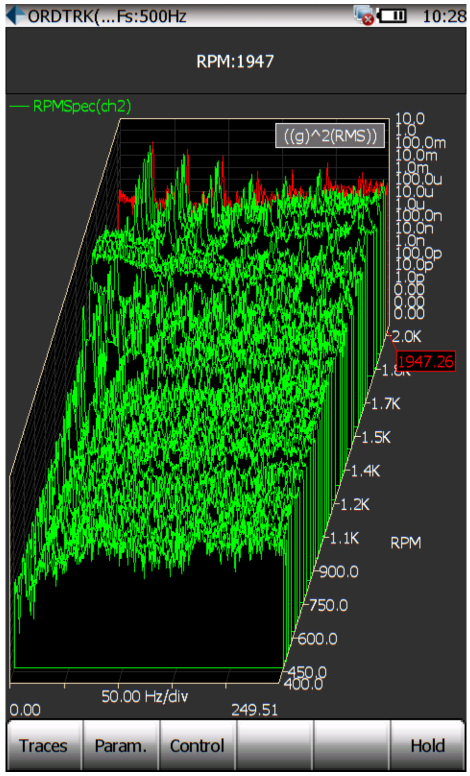


Figure 136 RPM spectrum.

The horizontal axis of the 3D RPM Spectrum is frequency. The z-axis is RPM and the measurement unit is usually EU_{rms}^2 or EU_{rms}. A color map can also be used to describe the magnitude of the whole range as shown below.

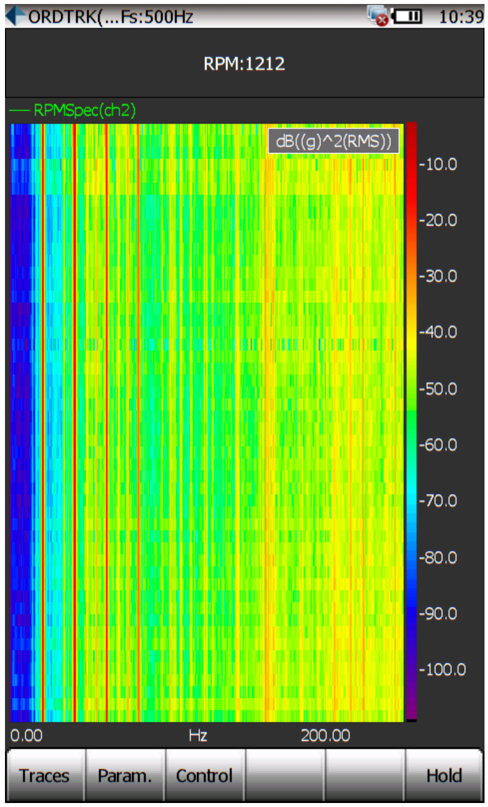
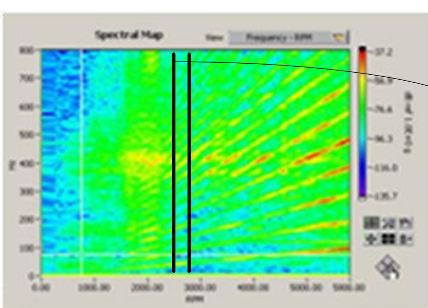


Figure 137 Color map of an RPM spectrum.

With a 3D RPM frequency spectrum, the instrument can extract the total energy over a fixed frequency band, and plot it with RPM as the independent variable. This is called Fixed Band RPM Spectrum as shown below.

To be completed.



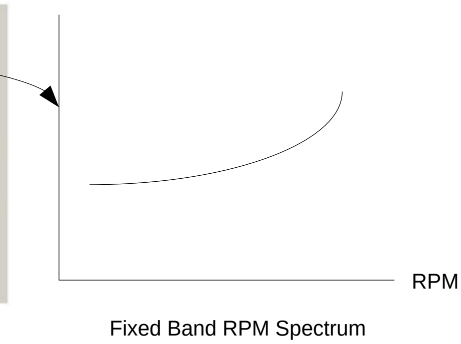


Figure 138 Fixed band RPM spectrum.

The measurement engineering unit of Fixed Band RPM Spectrum is EU_{rms}^2 or EU_{rms} representing the total power in a fixed band measured versus rotating speed change. This data is particularly useful to watch the total magnitude in a resonance area when the rotating speed of the shaft is changing. You can define the frequency band around the resonant frequency and perform a run up/down test. Both order tracking and order spectrum cannot extract the response magnitude of the resonance as accurately as a fixed band RPM spectrum because the bandwidth of the tracking filter of order tracking is not explicitly controlled.

Overall Level Measurement

In order tracking, about it is important to monitor the overall RMS level or power level of the measurement versus RPM. The overall level is a good reference for comparing with other signals such as order tracks or fixed band RPM spectrum.

Overall level can be in unit of RMS (EU_{rms}) or power (EU_{rms}^2). The horizontal axis is RPM. Below is a typical overall level display.

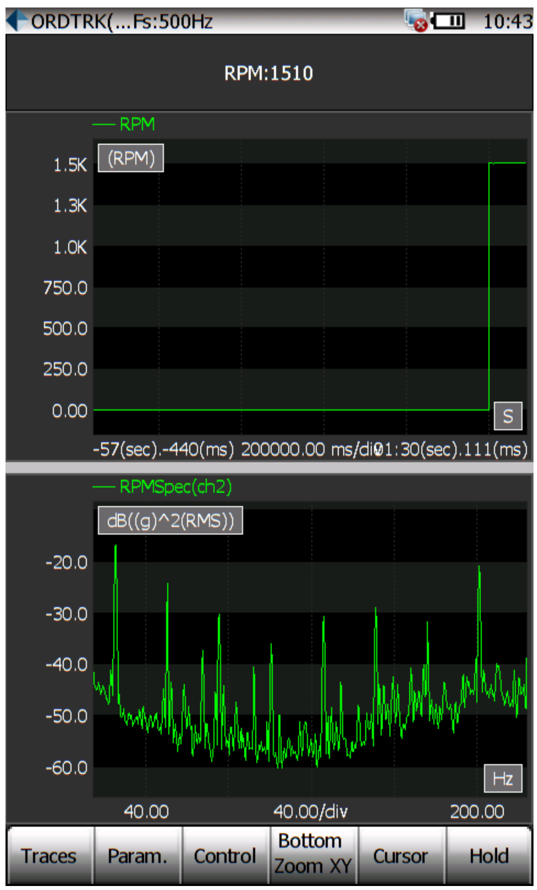


Figure 139.Overall RMS level plot.

Raw Data Time Streams

In many other order tracking software products, the user can either conduct real-time order tracking analysis, or record the data with other tools and then post process the order tracks, but not both at the same time. The CoCo is a high performance data recorder in addition to a real time analyzer and can do both at the same time. Continuous time streams of each input channels are always available even while order track data is computed..

Order Tracks with Phase

The Phase in Rotating Machine Analysis

Many mechanical faults are associated with certain orders, analyzing order magnitude and phase can help you detect mechanical faults directly. For example, a strong first order magnitude indicates imbalance in most cases. Analyzing the first order magnitude can help you identify the imbalance. Moreover, the magnitude and phase of the first order can help you correct the imbalance by adding weights on the appropriate rotor positions. However to fix such an imbalance problem requires phase information of order tracks. A list of the sources of vibration in the rotating machine are:

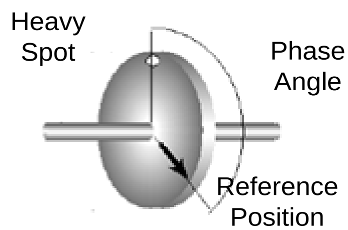
Order	Source of Problem
0.05X~0.35X	Diffuser Stall
0.43X~0.49X	Instability
0.5X	Rubbing
0.65X~0.95X	Impeller Stall
1X	Imbalance
1X+2X	Misalignment
(#Vane)X	Vane/Volute gap
(#Blades)X	Blade/Diffuser Gap

As previously discussed, an order track is the measurement taken for an order, i.e., normalized frequency, versus RPM. In most of the applications of engine related test, the phase information of order tracks are not important. In rotating machine analysis, the phase of the signal is vitally important.

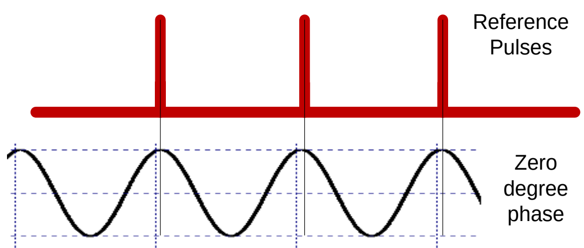
Phase is a relative measurement quantity and can only be measured with a pair of signals. It indicates the time delay at certain frequency between two signals. The phase value can be translated into the difference of relative angle, relative position or propagation time if additional information is given. When we refer to the phase information of one signal, we imply its phase is relative to a reference signal that was mentioned in context.

In rotating machine analysis, the phase of the first order of the rotor can be directly mapped to an angular difference between a signal and the reference signal. The reference signal can be another channel of measurement, or the tachometer signal. The phase difference between two waveforms is often called a phase shift or phase delay. A phase shift of 360 degrees is a time delay of one cycle, or one period of the wave, which actually amounts to no phase shift at all. A phase shift of 90 degrees is a shift of 1/4 of the period of the wave, etc. Phase shift may be considered positive or negative, i.e., one waveform may be delayed relative to another one, or one waveform may be advanced relative to another one. These conditions are called phase lag and phase lead respectively.

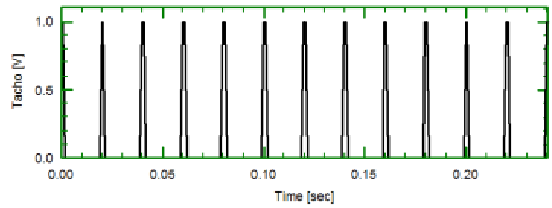
An example of this is the phase of an imbalance component in a rotor with reference to a fixed point on the rotor, such as a key way. To measure this phase, a trigger-pulse must be generated from a certain reference point on the shaft. This trigger can be generated by a tachometer or some type of optical or magnetic probe that senses a discontinuity on the rotor, and is sometimes called a "tach" pulse.

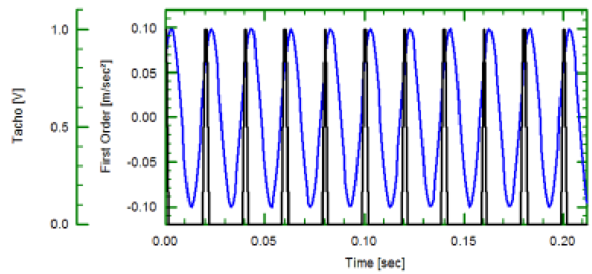


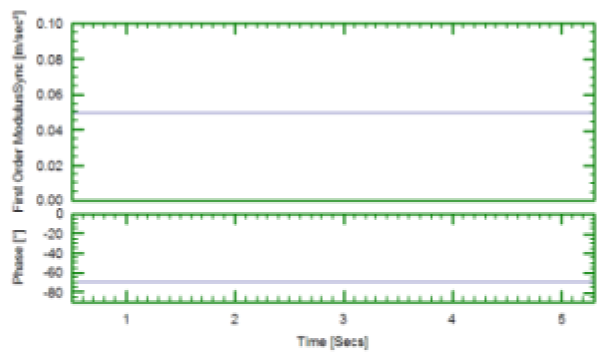
A zero degree phase delay at a frequency can be depicted as a series of pulses overlaid with a sine wave where the pulse edge is exactly located in peak position of the sine wave.



In Figure X a section of the tacho signal is shown on its own and then overlaid on the vibration signal. The tacho signal in this example crosses the vibration signal at exactly the same point on each cycle. If the phase of the vibration signal were to change then its position relative to the tacho pulse would also change. Extracting the first order modulus and phase, as before, gives the curves shown in Figure Y. The phase is now constant near -60^o as it should be for such a signal. Because the rotating period of the signal is about 20 ms, -60^o corresponds to a 20*60/360=3.3 ms delay.







The phase measurement at higher orders will have the similar physical interpretation although they are difficult to comprehend intuitively.

It must be noted that the order tracks with phase, or Complex Order Tracks by name, are not regular complex signals as frequency response or cross spectrum. They are really auto spectra with assigned phase. These synthesized signals can certainly be viewed as a complex signal using tools including Bode Plot, polar and orbit diagram. However the user must keep in mind that the magnitude and phase of a complex order track are calculated separately.

In the following sections, we will present how the order tracks with phase can be presented graphically with the Bode, polar and orbit plot.

CSA Editor Operation for Order Tracks

This section discusses how to create a CSA project for order tracking measurements in the CSA Editor. We strongly recommend that you read the CSA Edit User's Manual to gain more detailed information before proceeding with this chapter.

With the previous discussion, the Order Tracking software option is categorized into three sub groups based on different purpose of application. In each sub-group, different measurement quantities can be obtained. The measurements available in each group are:

Order Tracking Analysis Sub-Groups	Description	Measured Signals and View Mode
Normalized Order Spectra and Order Tracks	Use digital re-sampling and FFT or DFT to calculated normalized order spectra and order tracks. Order tracks have no phase information. This is mainly used in engine test, Run Up and Run Down.	Raw time streams of data channels Normalized Order Spectrum viewed in EUrms2, EUrms, EUpk vs. Orders Normalized Order Spectrum Waterfall viewed vs. order and RPM Order Tracks viewed in EUrms, EUpk vs. RPM Overall in EUrms or EUrms2 vs. RPM
Constant Frequency Bands	Use FFT method to calculate the RPM spectrum either in a fixed frequency band or whole frequency range. This is mainly to observe the response of specific frequency range or to gain overall picture of frequency spectrum when RPM changes.	Raw time streams of data channels Waterfall RPM Spectrum viewed in any spectrum unit vs. frequency horizontally and RPM in Z direction Fixed Band Spectrum in EUrms2 or EUrms vs. RPM Overall in EUrms or EUrms2 vs. RPM
Order Tracks with Phase	Use digital re-sampling and FFT or DFT to calculate the order tracks, in considering the phase reference to tacho input signal. This is mainly used in Run Up/Run Down, or dynamic balancing for rotating machine	Raw time streams of data channels Order tracks vs. RPM viewed in Bode Plot Order tracks displayed in Polar plot Dual time signals displayed in orbit plot Overall in EUrms or EUrms2 vs. RPM

To start, click on the CSA Editor icon in the upper-right corner in EDM and start the CSA Editor. The CSA Editor Wizard dialog box will be displayed. First select the CoCo type and number of channels of the CoCo that this CSA project will support. The number of channels must be equal to or less than the number of physical input channels on the CoCo hardware. Click on the Next Button.

Next select the Order Tracking Analysis template and either Normalized, Constant Frequency Bands or Order Tracks with Phase and click on the Next Button.

Next select the number of input channels to compute the analysis functions. In general it is best to select the minimum number of channels to conserve computational resources for the CSA. This number can be less than or equal to the number of physical input channels on the CoCo hardware. The first channel (Ch1) is reserved for the tachometer signal. Click on the Next Button.

Next enter the description of the CSA. This data will be saved with the CSA and be shown on the CoCo device when the CSA is opened. Click on the Next Button.

Normalized Order Tracks

The setup varies somewhat between Normalized, Constant Frequency Bands or Order Tracks with Phase. This section describes the Normalized Order Tracks setup in detail. The other templates are described in the following sections with emphasis on the differences between them and the Normalized template. We recommend that you read this section before proceeding to the other template types.

Select Signal Candidates for Normalized Order Tracks

Next the Signal Analysis Display is shown. This display lets you select which signals will be display candidates, save candidates and which will be used to compute the order track analysis. Always select the minimum number of candidates required to conserve computational resources. Note that when a signal is selected as a candidate then it is available on the CoCo hardware, meaning that it can be displayed or save, etc. If the signal is not specified as a candidate in the CSA then it will not be available on the CoCo hardware.

Order Tracking Signal Settings this display is used to define which input channels are used to compute the order tracks.

Compute OrderSpec when the box in this column is checked then the order spectrum for the input channel will be computed.

Overall RMS when the box in this column is checked then the overall RMS spectrum of the input channel will be computed.

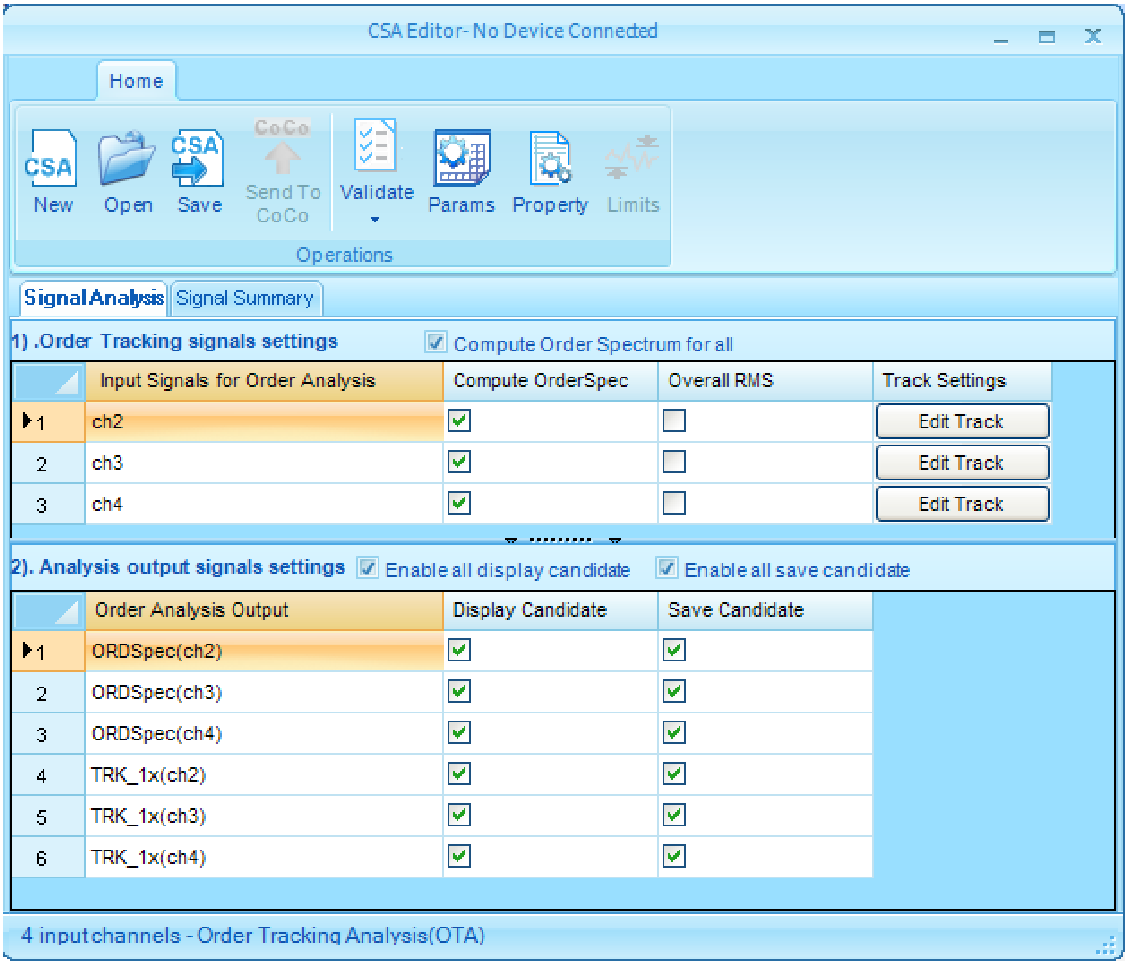


Figure 140. Select signal candidates for order tracks.

Track Settings click on the Edit Track button to edit the track settings for each input channel. Track Settings allows you to define which order tracks will be computed.

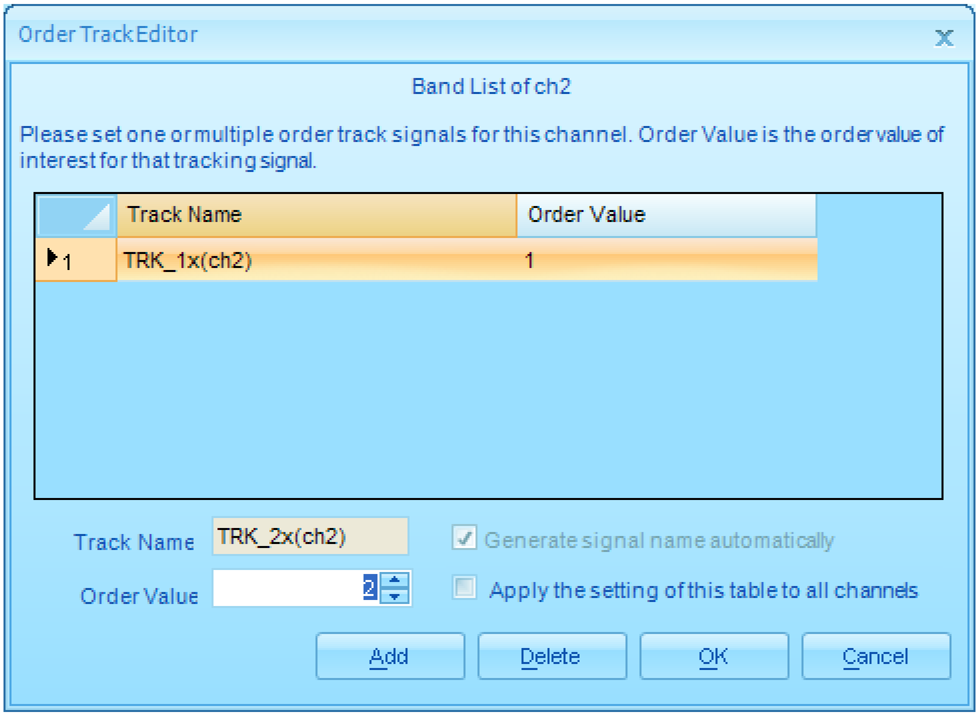


Figure 141. Edit order track settings.

To add an order track enter the Order Value. Use the up and down arrows to choose the order in increments of 0.5X.   The Track Name is automatically generated. You can automatically create a similar track for all of the input channels by checking the Apply the settings of this table to all channels button. Next click on the Add Button to create the track. The new track will appear on the Signal Analysis tab.

Analysis output signal settings are used to define which signals can be viewed and saved. As a rule you should select the minimum number of display and save candidates to conserve computation resources.

Display Candidate check the box in this column to enable the signal as a display candidate.

Save Candidates check the box in this column to enable the signal as a save candidate.

After all the candidate selections are made, a summary can be viewed by selecting the Signal Summary.

Signal Analysis | Signal Summary

	Name	Display Candidate	Record Candidate	Save Candidate	Description
1	ch1	True	True	False	Tacho original time signal
2	ch2	True	True	False	Time stream of chch2
3	ch3	True	True	False	Time stream of chch3
4	ch4	True	True	False	Time stream of chch4
5	ORDSpec(ch2)	True	False	True	Order Spectrum
6	ORDSpec(ch3)	True	False	True	Order Spectrum
7	ORDSpec(ch4)	True	False	True	Order Spectrum
8	RPM	True	True	False	Tacho RPM time signal
9	TRK_1x(ch2)	True	False	True	Order Tracks
10	TRK_1x(ch3)	True	False	True	Order Tracks
11	TRK_1x(ch4)	True	False	True	Order Tracks

Figure 142. Signal Summary.

Parameters for Normalized Order Tracks

After the signals are selected the next step is to specify the Parameters by clicking on the Param icon in the CSA Editor Ribbon. The Parameters display lets you change the computation parameters such as low, high and delta RPM, Max Order, etc. Click on the Edit Button next to each item to edit the parameter. Click on Ok to save the updated parameters.

Edit All Parameters [Red - global parameter, Green - private parameter]

	Name	Default Value	Values
1	Low RPM	100	Edit
2	High RPM	10000	Edit
3	Delta RPM	200	Edit
4	Max Order	10	Edit
5	Delta Order	0.5	Edit
6	Window Type	Hanning	Edit
7	Average Strategy	None	Edit
8	Average Number	32	Edit

Edit parameter's name of select module, use context menu -->[Editor Parameter] Ok Cancel

Figure 143. Normalized order track parameters.

Low/High RPM: The Low and High RPM define the range of RPM for any order signals, RPM waterfall or RPM traces to be analyzed. If the CoCo detects the current RPM is between the Low and High RPM, it will take the measurement and display it. Otherwise, the system will display the status as RPM High or RPM Low on the top status bar and the required signals will not get computed or displayed.

Delta RPM: The Delta RPM defines the resolution of the RPM trace or the resolution of the waterfall in the RPM axis. The higher the delta RPM, the finer the signals will be stored and displayed in the RPM axis and more storage will be required. Typically the Delta RPM is chosen between 25 and 100.

Max Order: The Max Order defines the highest order number for an order spectrum. The CoCo uses this value to determine the analysis frequency range. You should define the minimum Max Order that your application needs. If you define a Max Order too high, the system must sample at a very high frequency to cover the whole frequency range and the accuracy of lower order estimations may be poor.

Delta Order: The delta Order defines the resolution of the order spectra. The Max Order and Delta Order together define the number of points in a normalized order spectrum. You should define the minimum delta order required for your application to conserve computation resources.

Window Type defines the data windowing function used in the FFT order track computation.

Average Strategy defines the averaging strategy used in the order track computation: exponential, linear or peak hold.

Average Number defines the number of averages in a linear average or the weighting factor for exponential averaging.

After the parameters are set click the OK button.

Validation, Save and Upload

After the CSA Wizard is complete and the CSA file is created, connect the host PC to the CoCo device and press the Validate icon to validate the CSA. It may take a few minutes to finish the validation.

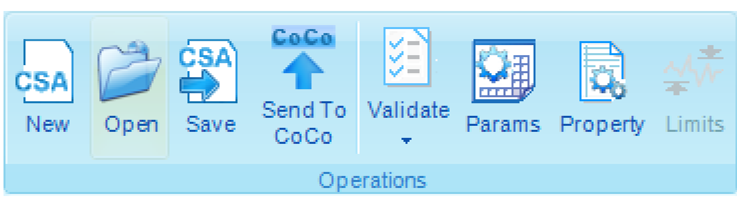


Figure 144. Validate and Send to CoCo icons in the CSA Editor Ribbon.

The validation process analyzes the CSA file for internal consistency and estimates the required DSA resources required to run the CSA file on the CoCo device. If the DSA exceeds the computational resources of the device then an error message will indicate that you must modify the CSA.

If the Validation passes, then press Send to CoCo command in the Validation dialog box to send the CSA project file to CoCo. Alternatively you can manually *upload it to CoCo. The uploaded CSA will be classified into the Order Tracking Application Group and can then be opened on the CoCo hardware.*

Click the Save Icon on the ribbon to save the CSA file to the host PC. All the signal settings and parameters will be saved with the file. The CSA can be opened later and modified by clicking on the Open icon on the ribbon.

The final step is to upload the CSA file fro the host PC to the CoCo Hardware. The CoCo must be connected first. Click the Sent To CoCo icon on the Ribbon. You will be prompted to enter a name for the CSA file. Then click OK. A message will indicate that the file was successfully sent to the CoCo hardware. After the CSA is saved then the CSA Editor can be closed. Now the CSA can be opened on the CoCo and used to make order track measurements.

Constant Frequency Order Tracks

The initial steps for creating a CSA with Constant Frequency Order Tracks are identical to the previous section. This section describes the differences between the Constant Frequency and Normalized template. We recommend that you read the previous section before reading this one.

Select Signal Candidates for Constant Frequency Order Tracks

The difference occurs on the Signal Analysis tab. Display and save candidates are the same as before.

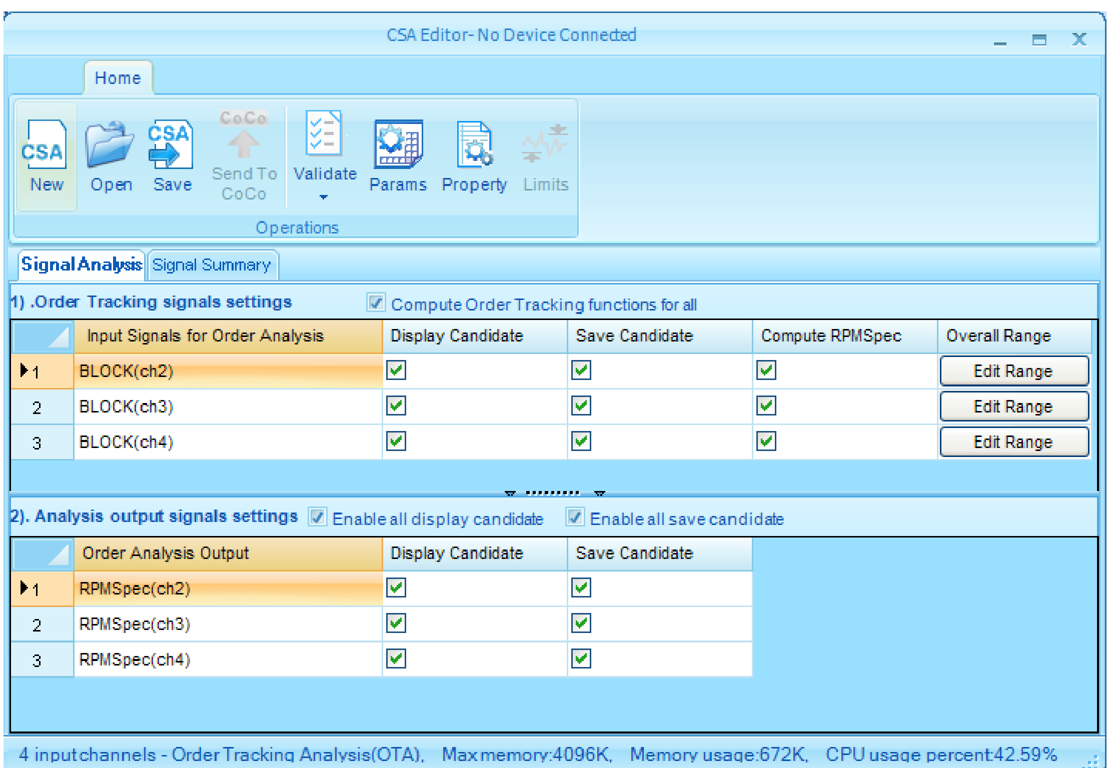


Figure 145. Select signal candidates.

Compute RPMSpec check the box in this column to compute the RPM spectrum for this input channel.

Overall Range click on the Edit Range button in this column to edit the frequency range settings used to compute the order tracks for this input channel.

To add a Fixed Band RPM Spectrum, first edit the Start and Stop Frequencies using the up and down arrows and then click the Add Button. The frequencies can be edited in the table after the range is created by clicking on the frequency values and editing them. The Range Name is automatically generated and include the start and stop frequencies. You can remove a Fixed Band RPM Spectrum by highlighting it and clicking the Delete Button. After you have created all the desired spectra click the OK Button.

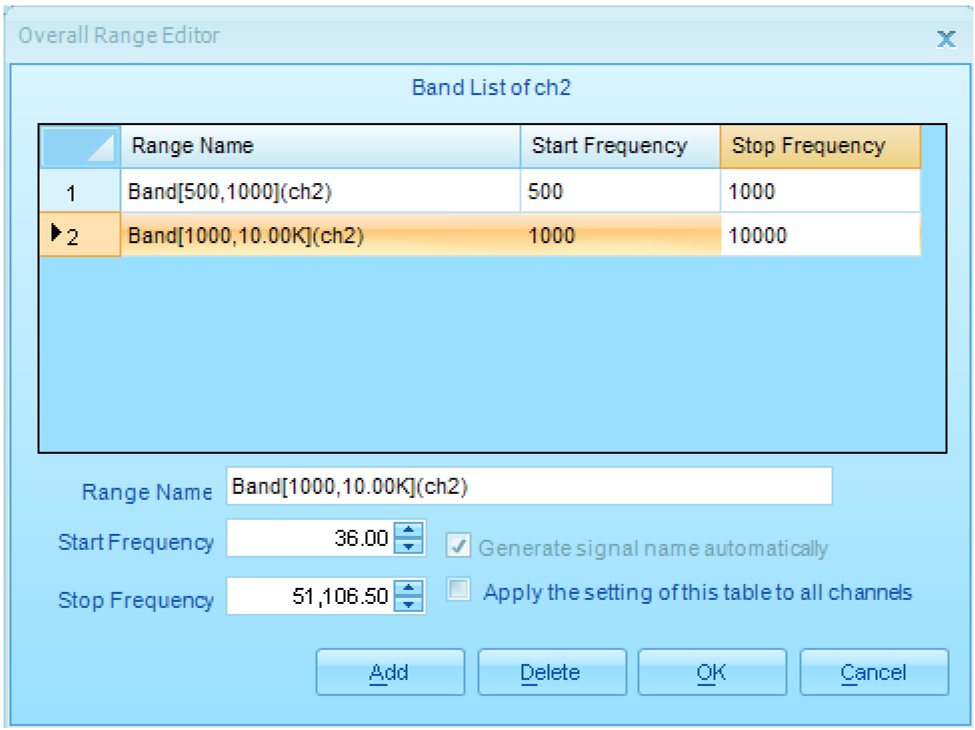


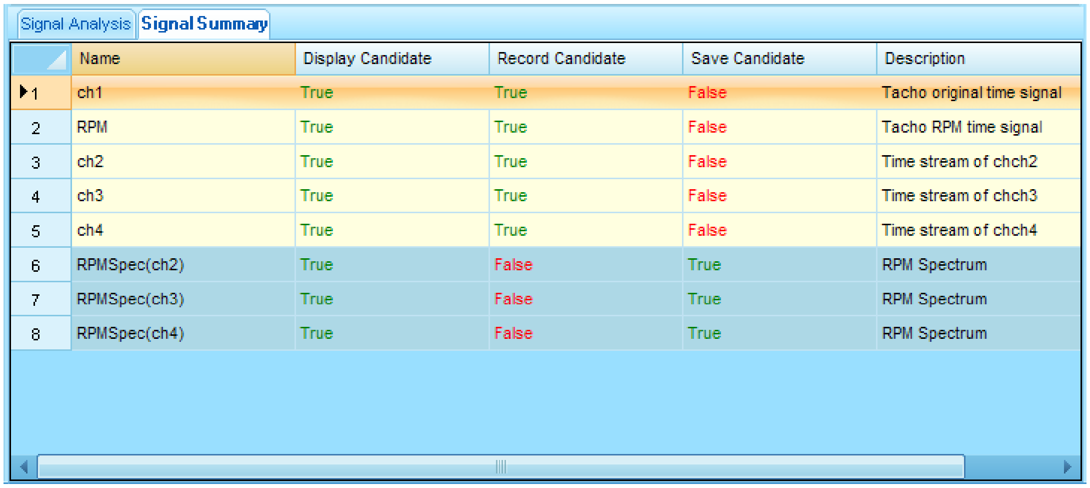
Figure 146. Edit order track settings.

Analysis output signal settings are used to define which signals can be viewed and saved. As a rule you should select the minimum number of display and save candidates to conserve computation resources.

Display Candidate check the box in this column to enable the signal as a display candidate.

Save Candidates check the box in this column to enable the signal as a save candidate.

After all the candidate selections are made, a summary can be viewed by selecting the Signal Summary.



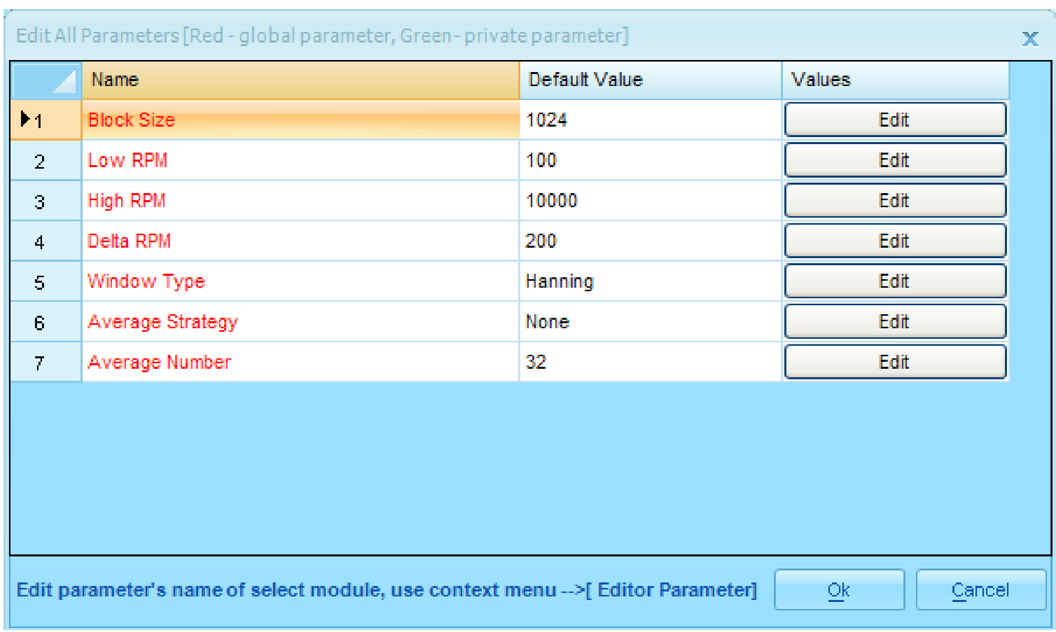
Signal Analysis | Signal Summary

	Name	Display Candidate	Record Candidate	Save Candidate	Description
1	ch1	True	True	False	Tacho original time signal
2	RPM	True	True	False	Tacho RPM time signal
3	ch2	True	True	False	Time stream of chch2
4	ch3	True	True	False	Time stream of chch3
5	ch4	True	True	False	Time stream of chch4
6	RPMSpec(ch2)	True	False	True	RPM Spectrum
7	RPMSpec(ch3)	True	False	True	RPM Spectrum
8	RPMSpec(ch4)	True	False	True	RPM Spectrum

Figure 147. Signal Summary.

Parameters

After the signals are selected the next step is to specify the Parameters by clicking on the Param icon in the CSA Editor Ribbon. The Parameters display lets you change the computation parameters such as block size, low, high and delta RPM, etc. Click on the Edit Button next to each item to edit the parameter. Click on Ok to save the updated parameters.



Edit All Parameters [Red - global parameter, Green - private parameter]

	Name	Default Value	Values
1	Block Size	1024	Edit
2	Low RPM	100	Edit
3	High RPM	10000	Edit
4	Delta RPM	200	Edit
5	Window Type	Hanning	Edit
6	Average Strategy	None	Edit
7	Average Number	32	Edit

Edit parameter's name of select module, use context menu -->[Editor Parameter] Ok Cancel

Figure 148. Parameter settings.

Block Size defines the number of data points used in the FTT computation.

Low/High RPM: The Low and High RPM define the range of RPM for any order signals, RPM waterfall or RPM traces to be analyzed. If the CoCo detects the current RPM is between the Low and High RPM, it will take the measurement and display it. Otherwise, the system will display the status as RPM High or RPM Low on the top status bar and the required signals will not get computed or displayed.

Delta RPM: The Delta RPM defines the resolution of the RPM trace or the resolution of the waterfall in the RPM axis. The higher the delta RPM, the finer the signals will be stored and displayed in the RPM axis and more storage will be required. Typically the Delta RPM is chosen between 25 and 100.

Window Type defines the data windowing function used in the FFT order track computation.

Average Strategy defines the averaging strategy used in the order track computation: exponential, linear or peak hold.

Average Number defines the number of averages in a linear average or the weighting factor for exponential averaging.

After the parameters are set click the OK button.

Validation, Save and Upload

After all the Signal Settings and Parameters are defined then you should validate the CSA, save it and upload it to the CoCo hardware.

After the CSA is saved then the CSA Editor can be closed

Order Tracks with Phase

The initial steps for creating a CSA with Order Tracks with Phase are identical to the previous sections. This section describes the differences between the Order Tracks with Phase and the Normalized template. We recommend that you read the previous sections before reading this one.

The initial steps for creating a CSA with Order Tracks with Phase are identical to the previous section. The difference is on the Signal Analysis tab.

Select Signal Candidates for Order Tracks with Phase

Display and save candidates are the same as before.

Overall RMS when the box in this column is checked then the overall RMS spectrum of the input channel will be computed.

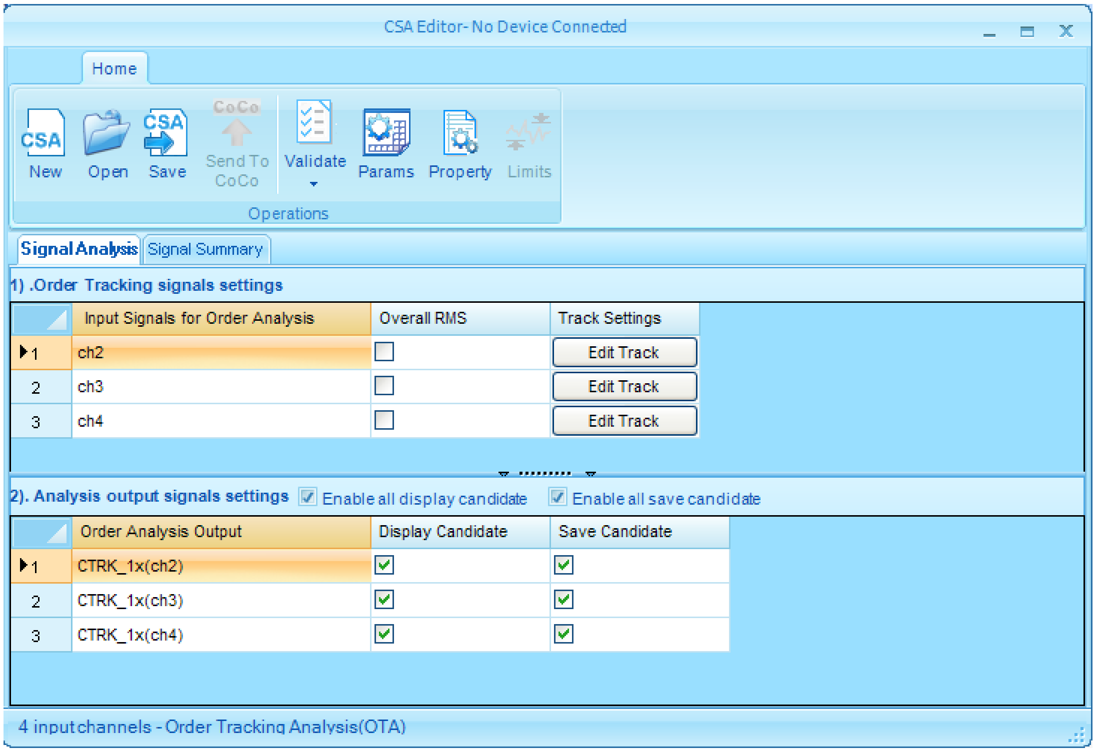


Figure 149. Select signal candidates for order tracks with phase.

Track Settings click on the Edit Track button to edit the track settings for each input channel. Track Settings allows you to define which order tracks will be computed.

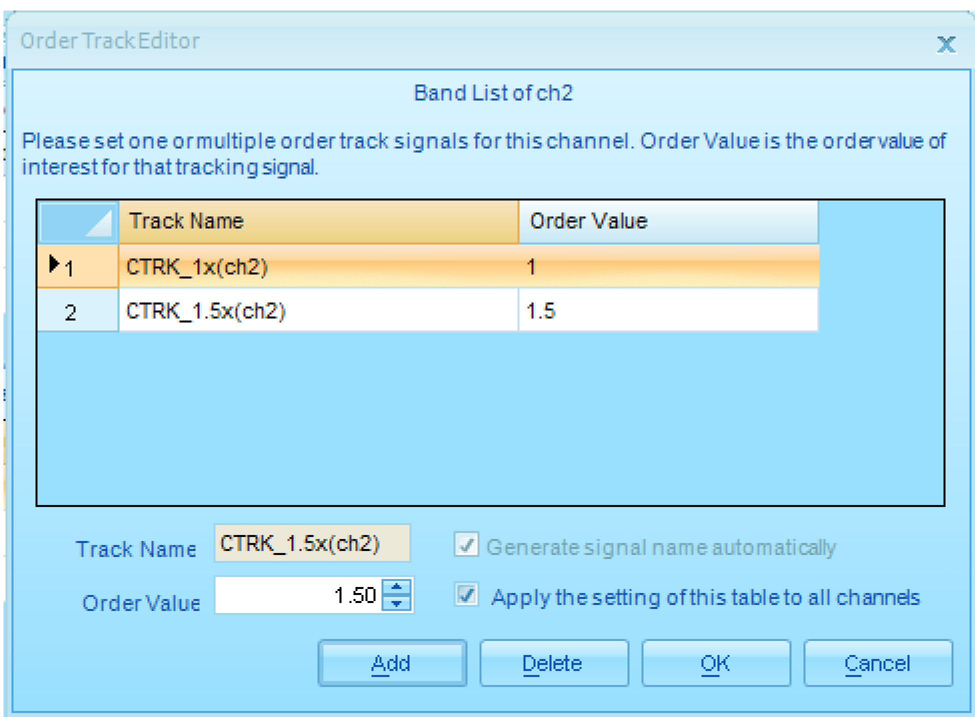


Figure 150. Order track settings.

To add an order track enter the Order Value. Use the up and down arrows to choose the order in increments of 0.5X. The Track Name is automatically generated. You can automatically create a similar track for all of the input channels by checking the Apply the settings of this table to all channels button. Next click on the Add Button to create the track. The new track will appear on the Signal Analysis tab.

Analysis output signal settings are used to define which signals can be viewed and saved. As a rule you should select the minimum number of display and save candidates to conserve computation resources.

Display Candidate check the box in this column to enable the signal as a display candidate.

Save Candidates check the box in this column to enable the signal as a save candidate.

After all the candidate selections are made, a summary can be viewed by selecting the Signal Summary.

Signal Analysis | **Signal Summary**

	Name	Display Candidate	Record Candidate	Save Candidate	Description
1	ch1	True	True	False	Tacho original time signal
2	RPM	True	True	False	Tacho RPM time signal
3	ch2	True	True	False	Time stream of chch2
4	ch3	True	True	False	Time stream of chch3
5	ch4	True	True	False	Time stream of chch4
6	CTRK_1x(ch2)	True	False	True	Order Tracks
7	CTRK_1x(ch3)	True	False	True	Order Tracks
8	CTRK_1x(ch4)	True	False	True	Order Tracks

Figure 151. Signal summary.

Parameters

After the signals are selected the next step is to specify the Parameters by clicking on the Param icon in the CSA Editor Ribbon. The Parameters display lets you change the computation parameters such as low, high and delta RPM, etc. Click on the Edit Button next to each item to edit the parameter. Click on Ok to save the updated parameters.

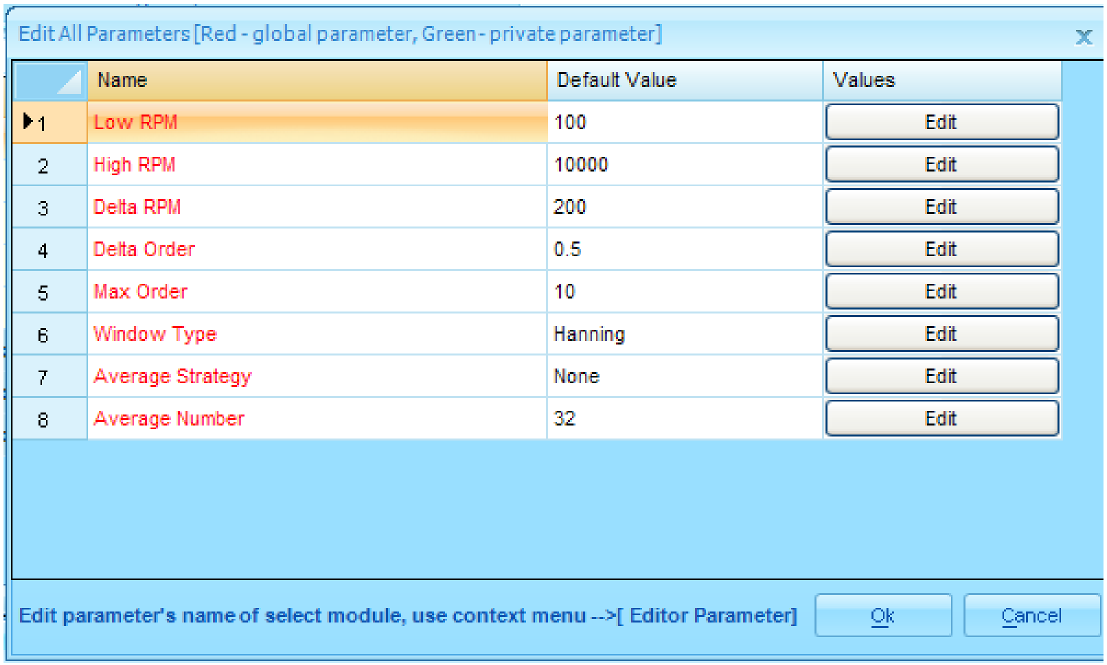


Figure 152. Order track parameters.

Low/High RPM – defines the range of RPM for any order signals, RPM waterfall or RPM traces to be analyzed. If the CoCo detects the current RPM is between the Low and High RPM, it will take the measurement and display it. Otherwise, the system will display the status as RPM High or RPM Low on the top status bar and the required signals will not get computed or displayed.

Delta RPM – defines the resolution of the RPM trace or the resolution of the waterfall in the RPM axis. The higher the delta RPM, the finer the signals will be stored and displayed in the RPM axis and more storage will be required. Typically the Delta RPM is chosen between 25 and 100.

Max Order – defines the highest order number for an order spectrum. The CoCo uses this value to determine the analysis frequency range. You should define the minimum Max Order that your application needs. If you define a Max Order too high, the system must sample at a very high frequency to cover the whole frequency range and the accuracy of lower order estimations may be poor.

Delta Order – defines the resolution of the order spectra. The Max Order and Delta Order together define the number of points in a normalized order spectrum. You should define the minimum delta order required for your application to conserve computation resources.

Window Type – defines the data windowing function used in the FFT order track computation.

Average Strategy – defines the averaging strategy used in the order track computation: exponential, linear or peak hold.

Average Number – defines the number of averages in a linear average or the weighting factor for exponential averaging.

After the parameters are set click the OK button.

Validation, Save and Upload

After all the Signal Settings and Parameters are defined then you should validate the CSA, save it and upload it to the CoCo hardware.

After the CSA is saved then the CSA Editor can be closed

CoCo Operation for Order Tracks

The CoCo operation for order tracks is similar for all three templates: Normalized, Constant Frequency and Order Track with Phase. In the following sections the Normalized will be described in detail first. Then the other templates will be discussed with emphasis on the differences between them and the Normalized template. We recommend you read the Normalized section first before proceeding to the others.

Normalized Order Tracking

This section describes the CoCo operation for Normalized Order Tracking in detail. The operation consists of selecting a CSA project, setting the Analysis Parameters, setting up the displays and making the measurement.

Selecting a CSA Project

The first step in setting up the CoCo to make an order track measurement is to select a CSA file. An order track file must be uploaded from the host PC to the CoCo first. Press the Analysis button then select the Order Tracking template and choose a CSA file to run and press the Enter Button. Order tacking CSAs are automatically saved in the Order Track Application Group to help organize the files on the CoCo.

Analysis Parameters

The next step is to set the Analysis Parameters. Note that the default values are defined when the CSA is created in the CSA editor but can be modified after the CSA is uploaded to the CoCo. Select Analysis Parameters under the Param. Button. To modify any of the parameters move the cursor to the desired parameter using the Up and Down Buttons and press the Enter Button. Then select from the menu or edit the value using the key pad display.

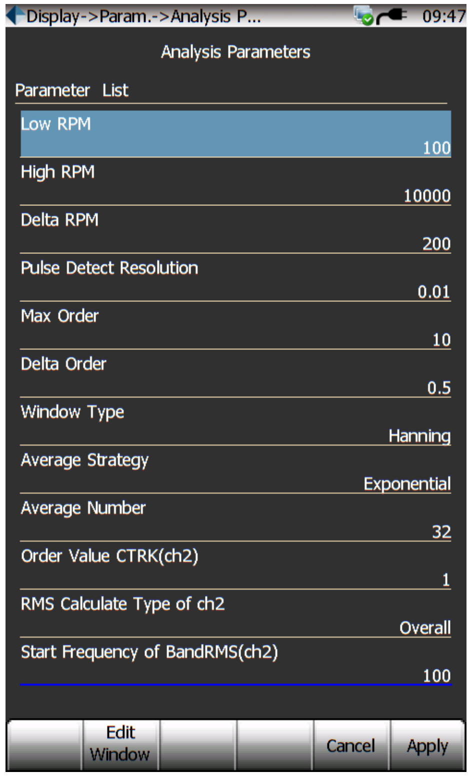


Figure 153. Set the Analysis Parameters.

After you have set all the necessary Analysis Parameters press the Apply Button so save the new parameters with the CSA. Next the Display Window will be shown.

Acquisition Mode

In order tracking mode, Acquisition Mode controls the processing of the tachometer signal including the trigger mode, pulse detection level and the pulses per revolution. The current RPM is displayed in numerical and graphical format. Also the trigger mode, level and pulses per rev settings are indicated on the display. The settings can be changed to ensure the most accurate RPM processing possible.

Trigger Mode includes the following settings:

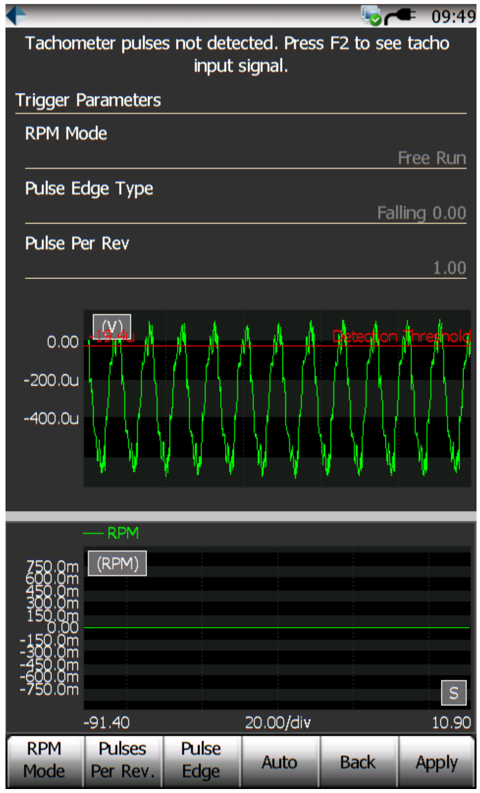


Figure 154. RPM trigger mode.

Free Run – data is acquired regardless of the direction of the RPM as long as the RPM is between low and high RPM limits.

Run Up – data is only acquired when RPM starts below low RPM limit and then increases. Acquisition stops when RPM exceeds high RPM limit.

Run Down – data is only acquired when RPM starts above high RPM limit and then decreases. Acquisition stops when RPM exceeds low RPM limit.

Up Down – data is only acquired when RPM starts below low RPM limit and increasing. Acquisition continues as RPM increases past high RPM limit and then as RPM decreases past the low RPM limit.

Down Up – data is only acquired when RPM starts above high RPM limit and decreasing. Acquisition continues as RPM decreases past low RPM limit and then as RPM increases past the high RPM limit.

Pulse Edge Detection – controls the pulse trigger edge conditions.

Rising – sets the trigger condition to a rising slope.

Falling – sets the trigger condition to a falling slope.

Edge Detection Threshold Level – lets you enter a RPM level threshold using the keypad instead of the up and down arrow buttons.

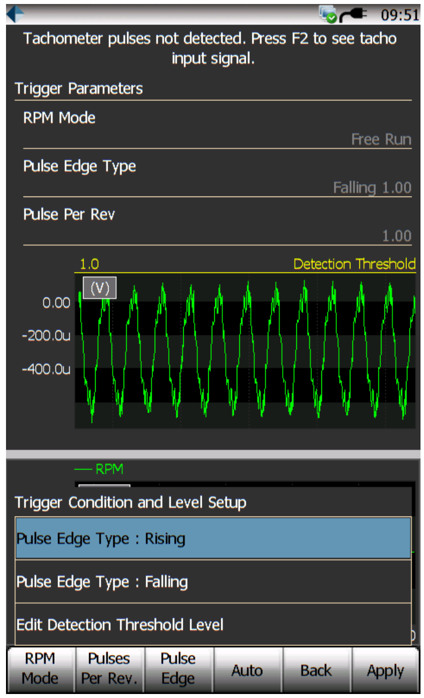


Figure 155. Tacho pulse edge type settings.

After all the settings are complete press the Apply button to save the settings then press the Back Button to view the order track measurement window.

Displays

After the Analysis Parameters are set, the next step is to define the necessary displays. Press the Traces Button to view the existing displays or to modify the traces.

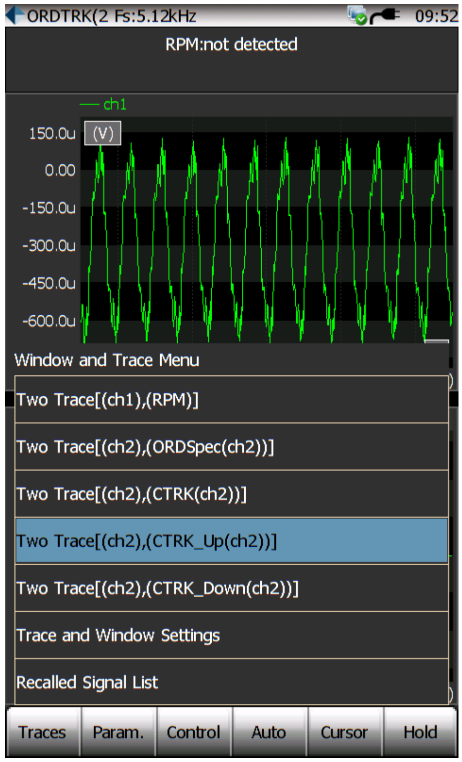


Figure 156. Modify the traces.

You can change from one window to another by selecting it from the menu and pressing the Enter Button.

The time trace of channel 1 is reserved for the tachometer input. It can be used to view the raw tachometer signal vs. time. This can be useful to diagnose any problems with the tachometer signal.

Trace and Window Settings lets you add, delete or modify an existing window.

Add Window includes windows that are specific to order tracking: Waterfall Trace and Color Map Spectrogram.

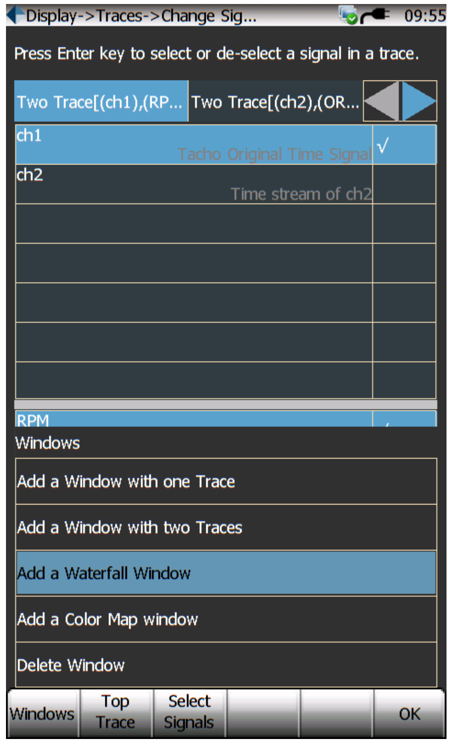


Figure 157. Add a window for order tracking.

Waterfall Window is used to display order spectra and order tracks vs. RPM in three dimensions.

Color Map Window is used to display order spectra and order tracks vs. RPM in 2 dimensions using color to represent the magnitude of the signal.

The limits of the waterfall and color map spectrogram depend on the Analysis Parameters such as low and high RPM and max order. The resolution of the plots depends on the Analysis Parameters delta RPM and delta order. Note that a larger RPM or order span or a higher resolution will affect the acquisition of the data and the memory required. You should use the minimum span and resolution necessary for your application to conserve computation resources and get the highest quality results.

Make a Measurement

To start the measurement press the Run Button. Order track measurements require an RPM input so spectra displays may only update when an RPM signal is detected. The current RPM is displayed in the status bar at the top of the display. If no RMP signal is detected or if the RPM not between the minimum and maximum RPM parameter, and the spectrum will not be updated and the RPM status will display “rpm not detected”, “rpm: too low,” or “rpm: too high”.

The Ch1 trace is reserved for the tachometer input signal. This shows the raw time waveform of the tachometer signal before it is processed into the RPM vs. time signal. It shows a tachometer signal. The example has no data for the first few seconds until the tachometer is activated. Then the increasing tachometer speed can be seen in the increasing frequency of the sinusoidal wave.

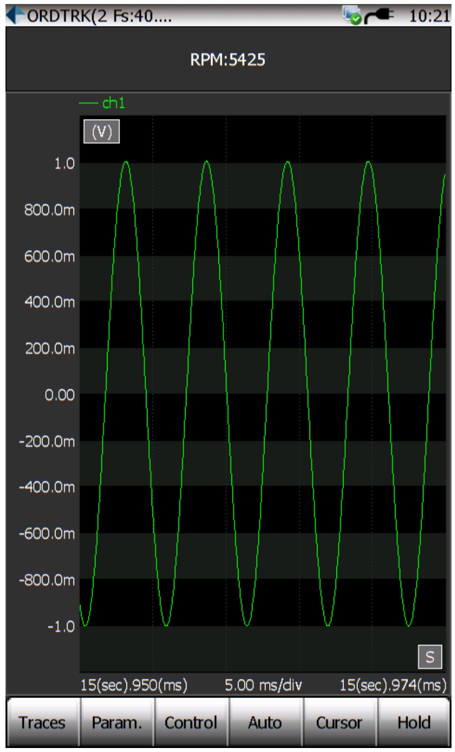


Figure 158. Ch1 is reserved for the tachometer input trace.

The RPM trace is generated by processing the tachometer signal and computing the RPM vs. time. Figure 159 shows an example RPM trace with two run up, run down sequences.

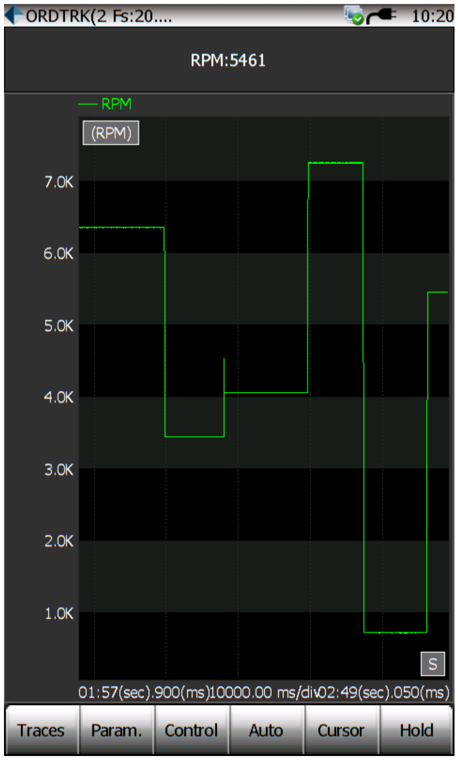


Figure 159. RPM trace shows the processed tachometer input signal vs. time.

A 3D Waterfall shows order spectra vs. RPM. As the RPM changes the current RPM is indicated as a red spectrum as shown in Figure 160. Note that the spectra is plotted vs. orders of the fundamental.

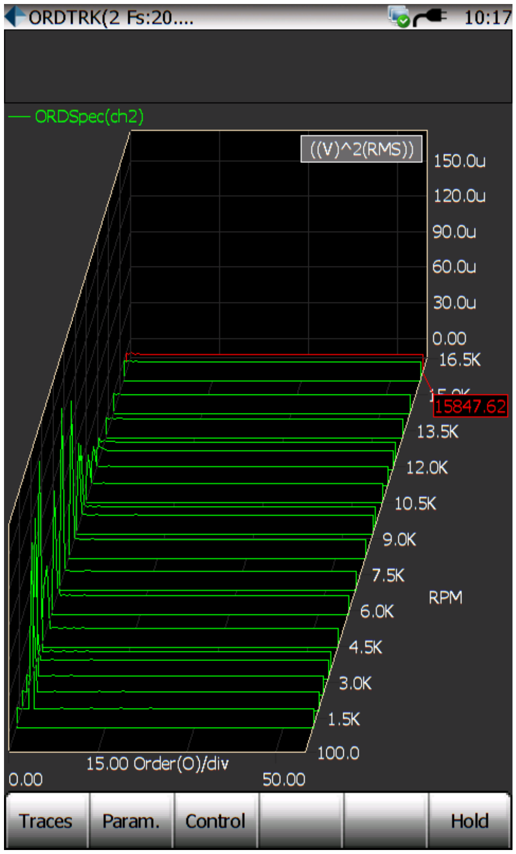


Figure 160. 3D Order spectrum shows current rpm in red.

An order spectrum shows the amplitude of orders at the indicated RPM. This type of trace is the same as a cross section of the 3D waterfall cut along the current RPM value.

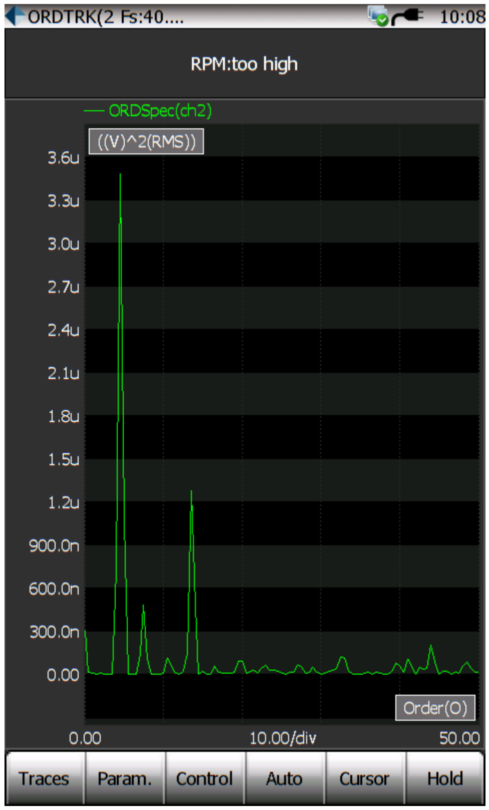


Figure 161. Order spectrum shows the amplitudes of orders at the current RPM.

An order track shows the amplitude of a specific order vs. RPM. This type of trace is the same as a cross section of the 3D waterfall cut along the specific order value.

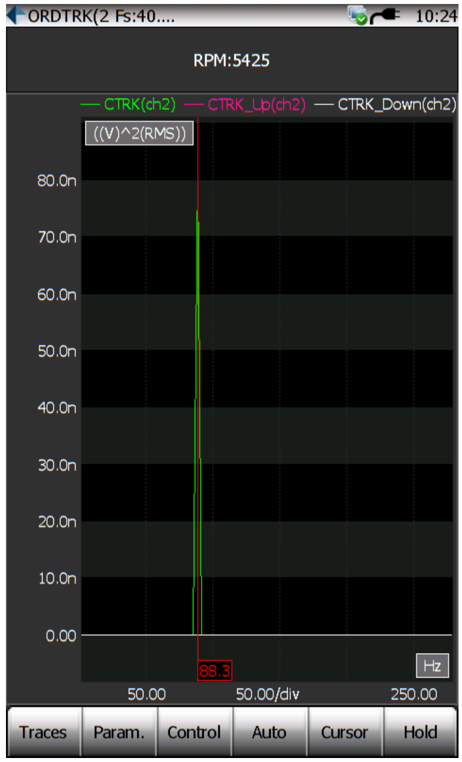


Figure 162. Order track shows the amplitude of an order vs. RPM.

A color spectrogram is a 2D trace that shows spectra vs. RPM using color to indicate the amplitude of the spectra.

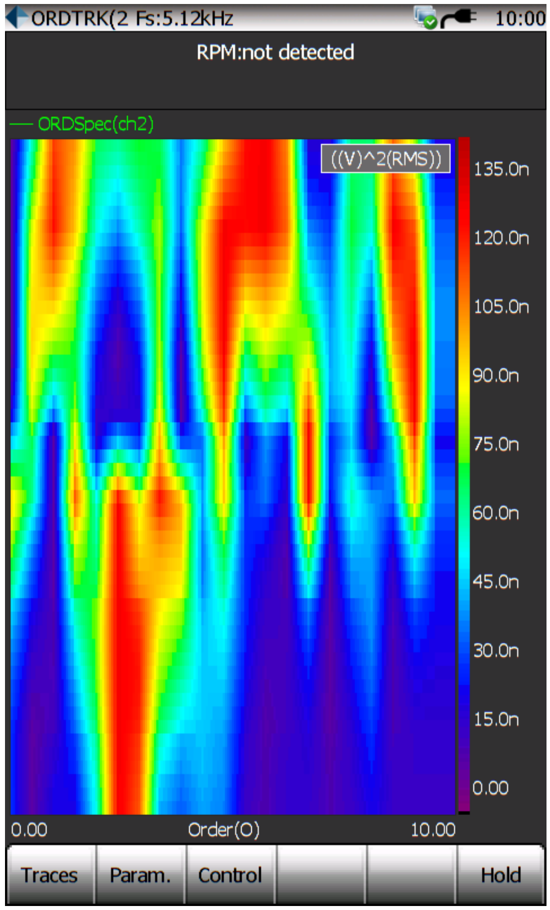


Figure 163. Color spectrogram shows order spectra vs. RPM.

A horizontal black gap in the spectrogram indicates that no spectra was recorded at the specific RPM. This can occur if the RPM changes too rapidly for the spectra to be acquired and processed. The same artifact can be seen in a 3D waterfall. This can be avoided by either slowing down the rate of change of the RPM (slew rate), or by modifying the Analysis Parameters such as reducing the order span or RPM span. This will reduce the computation resources required and possibly improve the results.

During a measurement you can press the Restart Button to reset the averaging. This will also reset all of the spectra in a 3D waterfall and spectrogram to zero

After you have acquired the desired data press the Hold Button to stop the measurement. You can and use the Save Button to save the results. Refer to the Basic User Manual for details on using Save, Cursors, and Traces

Constant Frequency Order Tracks

The CoCo operation for constant frequency order tracks is similar to operation for normalized order tracks. This section will describe the differences. We recommend that you read the previous section before proceeding with this one. This section describes the Analysis Parameters and displays.

Analysis Parameters

Most of the Analysis Parameters for constant frequency order tracks are the same as for normalized order tracks including: low, high and delta rpm, window type and average strategy and number. However since constant frequency order tracks use a fixed sampling rate you must specify the sampling rate and block size. Note that this is the not the case for normalized order tracks which use digital re-sampling to automatically change the sampling rate depending on the RPM.

Sampling Rate - Constant frequency order tracks use a fixed sampling rate FFT to compute spectra. Therefore you must manually set the Sampling Rate under the Param. Button. Select a sampling rate that is high enough to capture the highest frequency of interest for your analysis. However you should not select a sampling rate that is higher than necessary as it will require more computational resources and may reduce the quality of lower frequency data.

Block Size – The block size specifies the number of data points in an FFT window and also the FFT frequency resolution. You should choose an optimal block size for your application to give the best results and also conserve computational resources.

Make a Measurement

The operation is the same as the normalized order tracks. To start the measurement press the Run Button. Order track measurements require an RPM input so spectra displays may only update when an RPM signal is detected. The current RPM is displayed in the status bar at the top of the display. If no RMP signal is detected or if the RPM not between the minimum and maximum RPM parameter, and the spectrum will not be updated and the RPM status will display “rpm not detected”, “rpm: too low,” or “rpm: too high”.

The trace types are similar to the normalized order tracks. The Ch1 is reserved for the tachometer input signal. The RPM trace shows the RPM vs. time.

The most significant difference between constant frequency and normalized order tracks is that constant frequency order track traces are plotted vs. frequency instead of orders. Figure 164 shows an RPM spectrum vs. frequency.

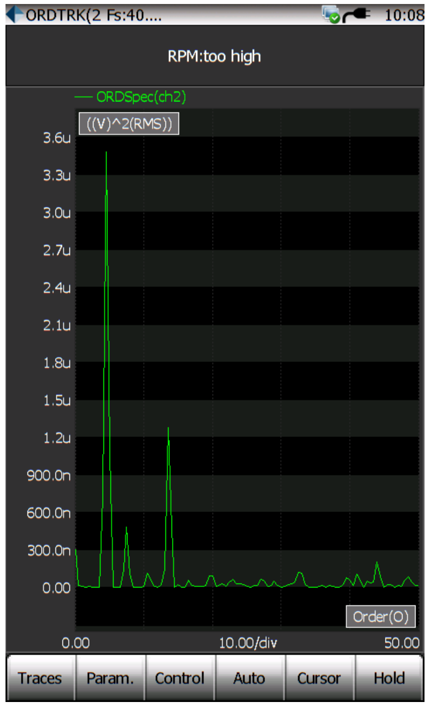


Figure 164. RPM spectra shows the spectra vs. frequency.

The figure below shows a waterfall of an RPM spectra. Note the spectra are plotted vs. frequency not orders as is done in the normalized order tracks. The consequence of this is that orders are observed as ridges that appear at skewed angles relative to the perpendicular axes of the figure. This is more apparent in the color spectrogram.

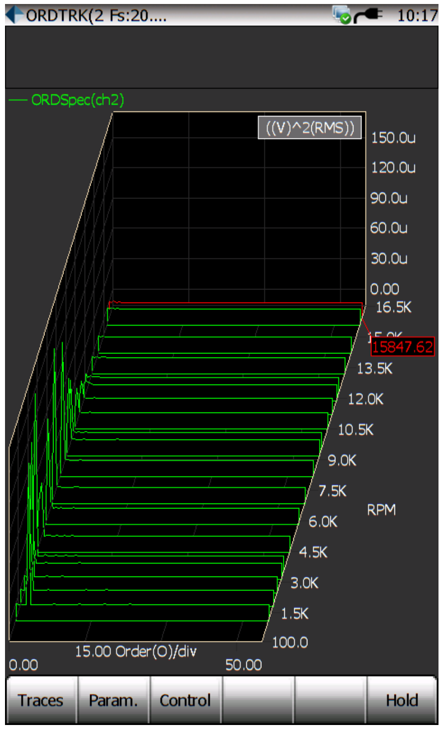


Figure 165. 3D waterfall of RPM spectra shows spectra vs. RPM.

The figure below shows a color spectrogram of an RPM spectrum. Note the spectra are plotted vs. frequency instead of order as is done in the normalized order tracks. The first order can clearly be seen as a red line at an angle. Higher orders will appear as lines radiating from the origin at increasing angles.

A horizontal black gap indicates that no spectra was recorded at the specific RPM. This can occur if the RPM changes too rapidly for the spectra to be acquired and processed. The same artifact can also be seen in a 3D waterfall. This can be avoided by either slowing down the rate of change of the RPM (slew rate), or by modifying the Analysis Parameters such as reducing the sampling rate, block size or RPM span. This will reduce the computation resources required and possibly improve the results.

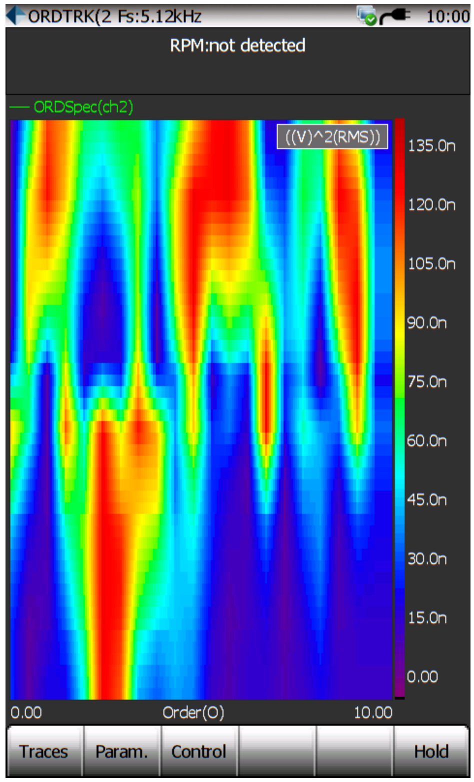


Figure 166. Color spectrogram RPM spectra.

Most other aspects of the operation are similar to normalized order tracks. Refer to the previous section and to the Basic User Manual for more detail.

Order Tracks with Phase

The CoCo operation for order tracks with phase is similar to operation for normalized order tracks. This section will describe the differences. We recommend that you read the previous sections before proceeding with this one.

Analysis Parameters

Order tracks with phase use the same digitally re-sampled method as the normalized order track template. Therefore, the Analysis Parameters for order tracks with phase are the same as for normalized order tracks

Make a Measurement

The operation is the same as the normalized order tracks. To start the measurement press the Run Button. Order track measurements require an RPM input so spectra displays may only update when an RPM signal is detected. The current RPM is displayed in the status bar at the top of the display. If no RMP signal is detected or if the RPM not between the minimum and maximum RPM parameter, then the spectrum will not be updated and the RPM status will display “rpm not detected”, “rpm: too low,” or “rpm: too high”.

The trace types are similar to the normalized order tracks. The Ch1 is reserved for the tachometer input signal. The RPM trace shows the RPM vs. time.

Shock Response Spectrum Analysis

A **Shock Response Spectrum** (SRS) is a graphical representation of an arbitrary transient acceleration input, such as shock in terms of how a Single Degree Of Freedom (SDOF) system (like a mass on a spring) responds to that input. Actually, it shows the peak acceleration response of an infinite number of SDOFs, each of which have different natural frequencies. Acceleration response amplitude is represented on the vertical axis, and natural frequency of any given SDOF is shown on the horizontal axis.

A SRS is generated from a shock waveform using the following process:

- Pick a damping ratio for the SRS
- Assume a hypothetical Single Degree of Freedom System (SDOF), with a damped natural frequency of x Hz
- Calculate (by time base simulation or something more subtle) the maximum instantaneous absolute acceleration experienced by the mass element of your SDOFs at any time during (or after) exposure to the shock in question. Plot this in g's (g's are standard, but pick any unit of acceleration you want) against the frequency (x) of the hypothetical system.
- Repeat steps 2 and 3 for other values of X, for example, logarithmically up to 1000x.

The resulting plot of peak acceleration vs. test system frequency is called a Shock Response Spectrum, or SRS. This process can be depicted in the following picture:

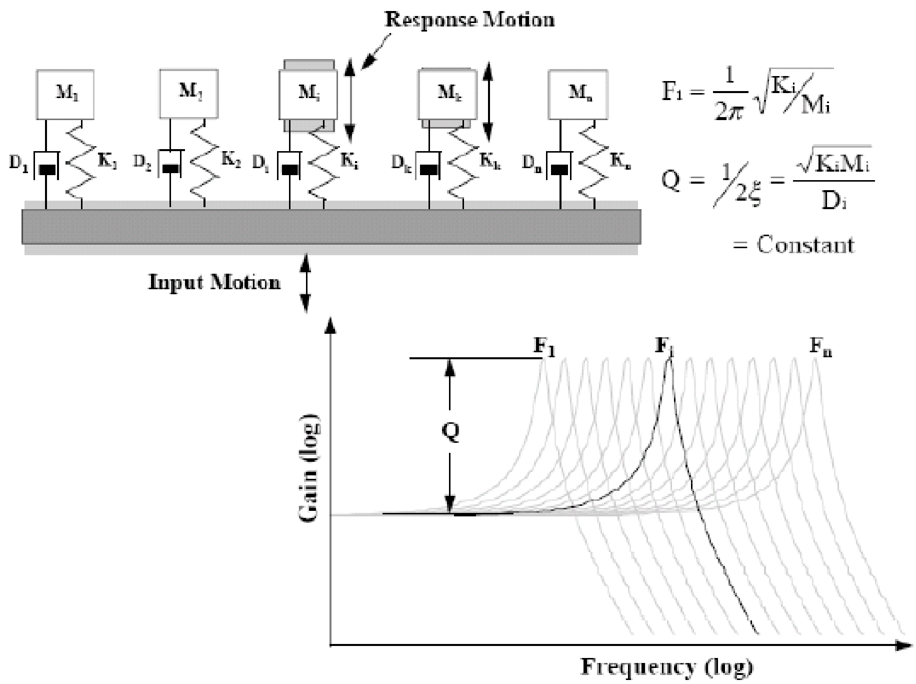


Figure 167. Illustration of multi-degree of freedom system model used to compute SRS.

A SDOF mechanical system consists of the following components:

- Mass, whose value is represented with the variable, M
- Spring, whose stiffness is represented with the variable, K
- Damper, whose damping coefficient is represented with the variable C.

The resonance frequency, Fi, and the critical damping factor, ζ, characterize a SDOF system, where:

$$Fi = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

$$\zeta = \frac{c}{2\sqrt{KM}}$$

For light damping ratio where ζ is less than or equal to 0.05, the peak value of the frequency response occurs in the immediate vicinity of Fi and is given by the following equation, where Q is the quality factor:

$$Q = \frac{1}{2\zeta}$$

Any transient waveform can be presented as an SRS, but the relationship is not unique; many different transient waveforms can produce the same SRS (something one can take advantage of through a process called "Shock Synthesis"). The SRS does not contain all the information about the transient waveform from which it was created because it only tracks the peak instantaneous accelerations.

Different damping ratios produce different SRSs for the same shock waveform. Zero damping will produce a maximum response. Very high damping produces a very flat SRS. The level of damping is demonstrated by the "quality factor", Q which can also be thought of transmissibility in sinusoidal vibration case. A damping ratio of 5% results in a Q of 10. An SRS plot is incomplete if it doesn't specify the assumed Q or damping ratio value.

Frequency Spacing of SRS Bins

Usually the SRS spectrum consists of multiple bins distributed evenly in the logarithmic frequency scale. The frequency distribution can be defined by two numbers: a reference frequency and the fractional octave number, such as 1/1, 1/3 or 1/6.

An octave is a doubling of frequency. For example, frequencies of 250 Hz and 500 Hz are one octave apart, as are frequencies of 1 kHz and 2 kHz.

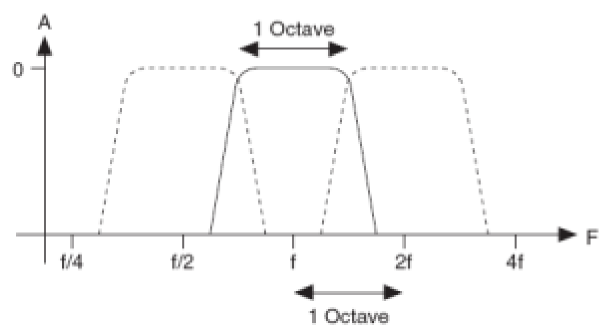


Figure 168. Full octave filter shape.

The proportional bandwidth property will divide the frequency information uniformly over a log scale. It is very useful in analyzing a variety of natural systems. For example, the human response to noise and vibration is very non-linear and many mechanical systems have a behavior that is best characterized by proportional bandwidth analysis.

To gain finer frequency resolution, the frequency range can be divided into proportional bandwidths that are a fraction of an octave. For example, with 1/3 octave spacing, there are 3 SDOF filters per octave. In general, for 1/N fraction octave, there are N band pass filters per octave such that:

$$f_{c\ j+1} = f_{c\ j} * 2^{1/N}$$

where 1/N is called the fractional octave number. f_r, the **reference frequency**, is simply any of the frequencies $f_{c\ j}$. All other center frequencies of SDOF filters reference to this frequency. When the reference frequency and the fractional octave number are fixed, the frequency distribution over the whole frequency range is determined.

SRS Measurement Quantities

Measurement quantities available to the CoCo SRS test are: time stream of each channel (raw data), block captured time signals and three SRS of each channel.

Time streams: this is the same as any other applications on the CoCo. Time streams are always available for viewing and recording. It is a very useful tool to observe whether the input signals are in the valid range. The recorded sine wave can be used for further post-processing. In CoCo, the time streams are often denoted as ch1, ch2 etc.

Block time signals: These are the block captured signals that are used for SRS analysis. Acquisition Mode will control how the block time signals are acquired.

SRS: Shock Response Spectra will be calculated for each block time signals. The engineering unit of the spectrum is determined by the sensor used by the input channel. In CoCo, the spectra are often denoted as three types: Maximum Positive spectrum; Maximum Positive spectrum and Maximum-Maximum spectrum.

Maximum Positive Spectrum: This is the largest positive response due to the transient input, without reference to the duration of the input.

Maximum Negative Spectrum: This is the largest negative response due to the transient input, without reference to the duration of the input.

Maximax Spectrum: this is the envelope of the absolute values of the positive and negative spectra. It is the most often used SRS type. The log-log Maximax is the universally accepted format for SRS presentation.

Other common SRS measures include the so called Primiary SRS, Residue SRS and Composite SRS. The CoCo only calculates the Composite SRS.

CSA Operation for SRS

This section summarizes how to create a CSA project for SRS analysis in the CSA Editor. We strongly recommend that you read the CSA Editor User's Manual to gain more detail information before proceeding with this chapter.

To start, click on the CSA Editor icon in the upper-right corner in EDM and start the CSA Editor. The CSA Editor Wizard dialog box will be displayed. Select the number of input channels on your CoCo and then click next. Then select Shock Response Spectrum from the application template list and click Next.

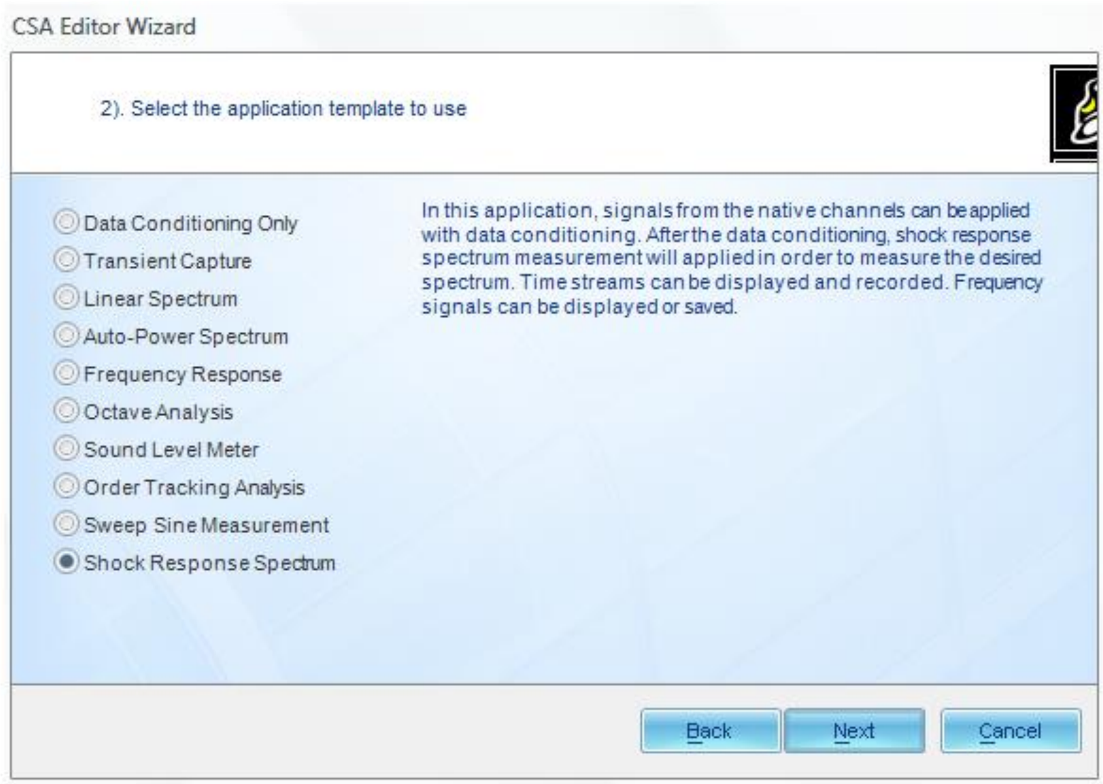


Figure 169. Application template list for SRS.

Next enable the minimum number of input channels required for your measurement and click Next.

Enter the CSA description information and click Finish.

SRS is typically used to process transient captured signals. A trigger is normally required. Click on the Acquisition Mode tab to modify the trigger settings.

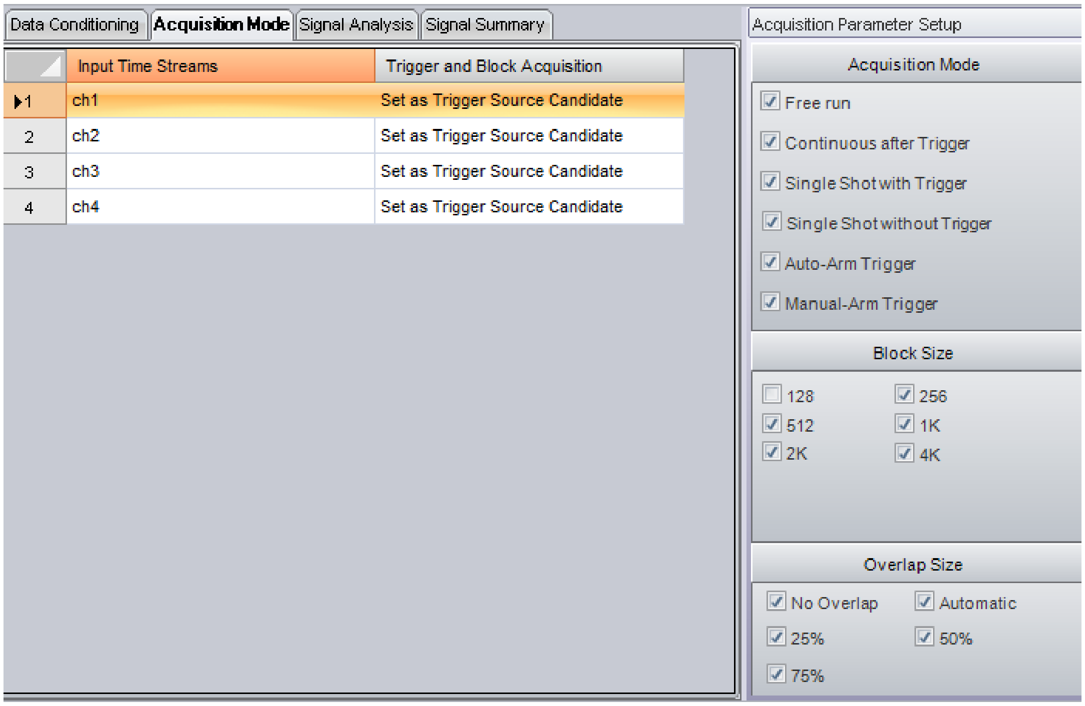


Figure 170 Enable Acquisition Modes

Click on the Signal Analysis tab to enable the display, save and compute options. The Analysis output settings at the bottom of the screen include the signals that are unique to SRS.

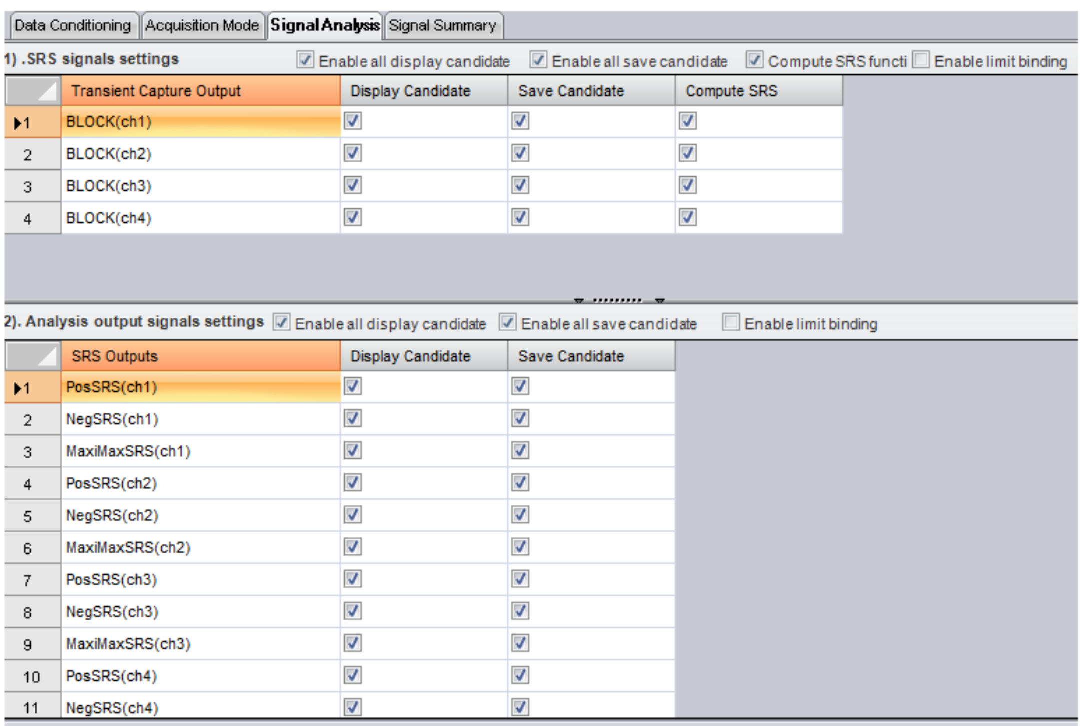


Figure 171 Create Signals to be displayed and saved

After the CSA has been configured it must be validated and uploaded to the CoCo device before it can be used.

Figure 172 Validate and then Send to CoCo

SRS CoCo Operation

This section describes the operations of CoCo that are specifically related to SRS analysis. For general operations of CoCo, refer to previous chapters of this manual.

Select an SRS CSA Project

To run a SRS CSA press the Analysis button and select SRS application group then press the F6 OK Button.

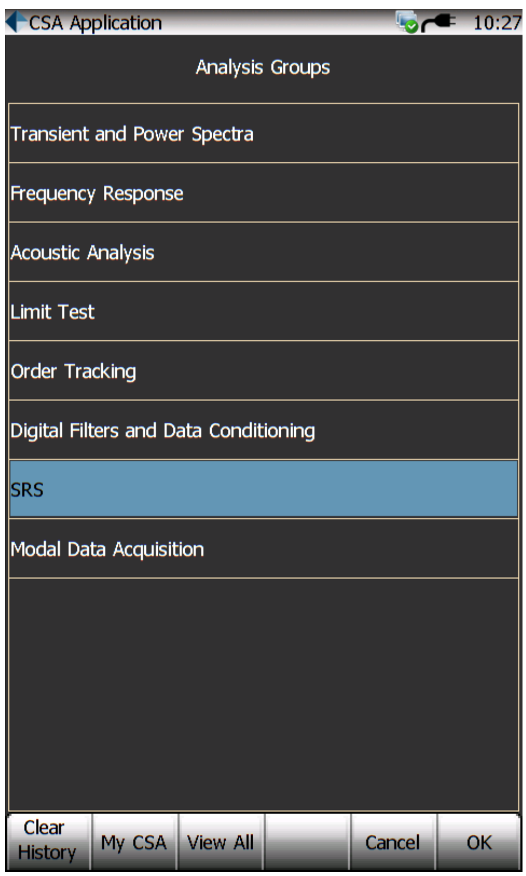


Figure 173. SRS CSAs are saved in the Swept Sine and SRS application group.

Then use the up and down arrow buttons to highlight an SRS CSA and press the F6 OK button to load it.

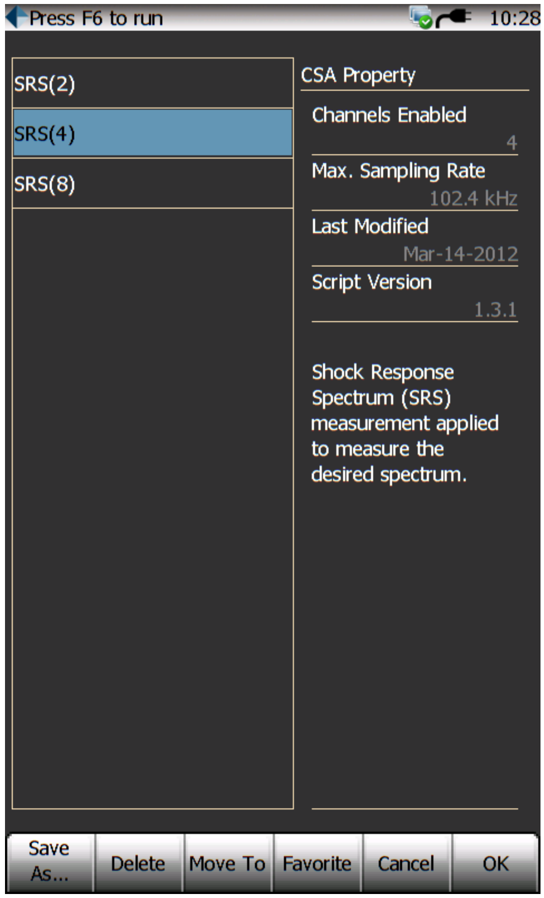


Figure 174. Press the F6 Run button to load the SRS CSA.

SRS Analysis Parameters

Analysis parameters that are unique to SRS CSAs can be modified with Analysis Parameters from the Param menu.

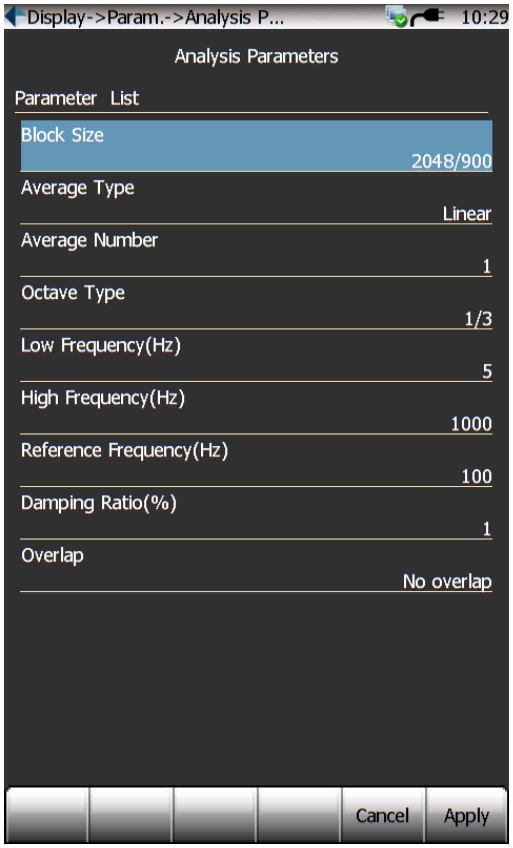


Figure 175. SRS Analysis parameters screen.

Block Size: is the size of the time block buffer. The time block signals will be used as input signals of SRS analysis.

Average Type: Average can be applied to SRS spectrum. But in most cases no average is applied. Setting the Averaging Number as 1 will result in no averaging.

Octave Type: defines the fractional octave number which defines the spectral resolution.

Low Frequency: defines the lowest frequency boundary of the SRS spectrum.

High Frequency: defines the highest frequency boundary of the SRS spectrum.

Reference Frequency: defines the reference frequency the SRS spectrum.

Damping Ratio (%): defines the percentage of the damping factor.

Overlap: defines the overlap ratio from 0, 25%, 50%, 75%, to As High As Possible.

SRS Signal Display

Signals that are unique to SRS analysis can be viewed in the same way as any other signal.

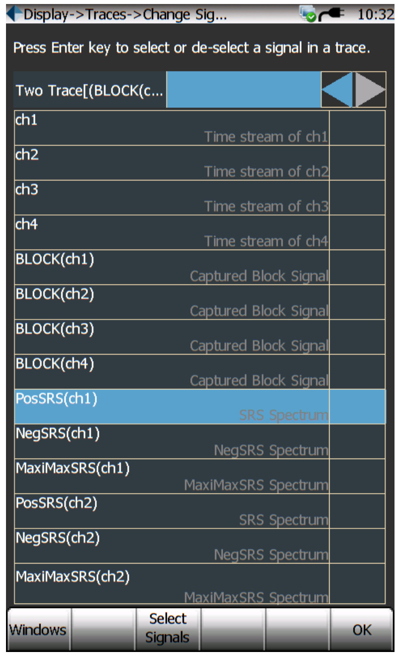


Figure 176 Select the signals for display

The figure below shows the PosSRS, MaxiMax, and NegSRS signals overlaid in a single window.

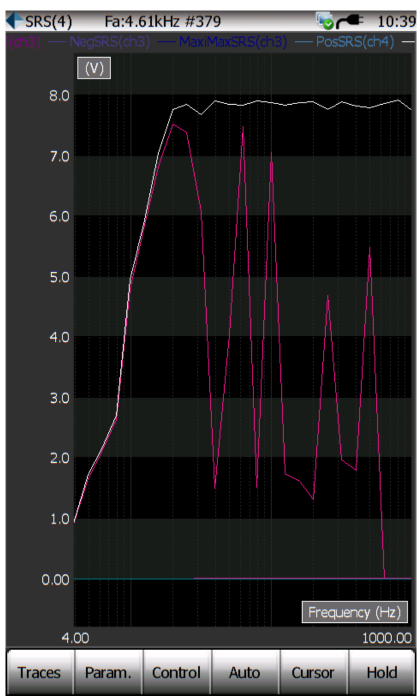


Figure 177 Three overlaid SRS Signals

Limit Test

The automated limit test allows engineers and technicians to set up a pass/fail measurement on any measured signal. This feature automates the process of determining whether an acquired signal meets, or is within, a given set of criteria.

A limit test typically consists of comparing a waveform to upper and lower boundaries which the measured waveform must not cross. These boundaries are typically defined by the user to specify a tolerance band around a waveform. If any part of the waveform falls outside the limit, the software returns a failure message and the location of the failure on the waveform.

Application Examples

A common example for automated testing is related to structural testing. When excited, a structure will resonate at its natural frequencies. Structures can be excited through impact or by other means. Structural defects can result in a shift in resonant peaks. Therefore, in structural tests, frequency 'alarms' are used to monitor the frequency response in areas of spectral interest.

Another example of automated testing is related to rotating machinery. Rotating or moving assemblies produce vibration and noise patterns that can be examined to identify the fingerprint of 'good quality.' Product defects will cause additional spectral peaks, or changes in peak levels. Therefore, in 'self-excited' product testing, 'level alarms', which can be set to trigger on peak or RMS values, are placed around the areas of spectral interest. Unwanted signals, from background noise, are therefore ignored.

Testing Limit Signals and Testing Schedule

The automated limit test can be performed on a wide variety of signals including a time domain capture, an auto-power spectrum, an octave spectrum, an order track signal, or a frequency response function. The CoCo instrument compares the limits to the live measured signal in real-time, after every single frame of measurement. If the limits are exceeded, the CoCo takes the appropriate actions based on the user setup.

An upper and or lower limit can be applied to a signal to be tested. Limit signals are constructed by defining breakpoints. A breakpoint is controlled by a pair of X/Y values. The figure below shows a typical automated test limit signal with 4 breakpoints.

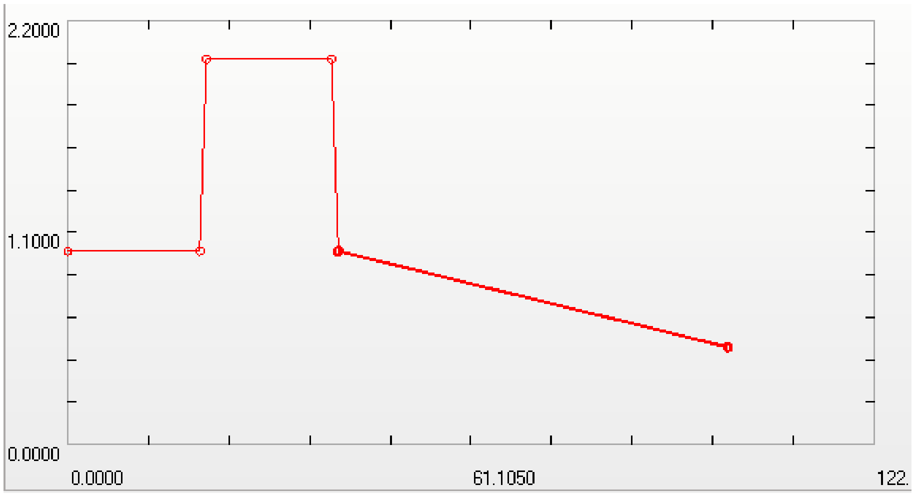


Figure 178. Typical automated test limit signal with 4 breakpoints.

To automatically control the limit checking test, a **testing schedule** is developed for CoCo. The testing schedule defines the various operations to automate the process. For example the testing schedule can tell the instrument when the limit checking will be turned on, when it will be turned off and for how long the test will be conducted.

To record the events of the test a Testing Log and a summary report are needed. The Testing Log records the important events, including whether the limits are exceeded, in chronological order. The Summary Report provides the status of limiting check since the last time when the test was started.

When the limit signal is exceeded then a user defined limit alarm event will be triggered. This can include an audible beep, Save Signals, send messages and so on.

To summarize, an automated limit checking test requires the following building blocks:

- At least one test signal
- At least one limit signal applied to the measured signals
- A testing schedule
- A testing log and summary report
- A setup for the limit alarm events

The figure below illustrates the automated testing process

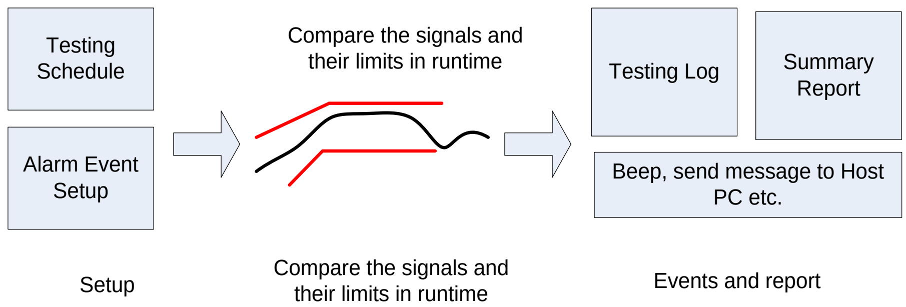


Figure 179. Illustration of automatic testing process.

Test Signals: Any block signal can be used for testing. Typically the test signals are time captured blocks, auto power spectra, frequency response, octave spectra or order tracks. Time streams are not used for limiting test.

Limit signals including upper and/or lower limits are defined in the CSA Editor. Limit signals are applied to testing signals. Up to a maximum of 64 segments can be defined for each limit signal. The maximum number of limit signals is 64.

Testing Schedule: The testing schedule automatically controls the test using an event driven process. Multiple testing schedules can be developed and one is executed at a time. Testing schedule event entries include: Loop/End-Loop, Set Sampling Rate, Set All Input Mode, Run Duration, Hold, Limit Check on, Limit Check off, Start Recording, Stop Recording, Save Signals, Turn Signal Source On and Turn Signal Source Off.

Testing Log: A log file is automatically created for each run of the schedule to record major events.

Log Test Results: Generate a testing report to the *Reports* sub-menu. This report includes basic information about the device, as well as input channel settings, parameter settings, trigger settings, and a screenshot.

Limit Check Alarm Event Setup: Events include an audible beep from the CoCo, CoCo screen flashing, entry into the Testing Log, send message to host PC via EDM software and Save Signals.

When a limit is exceeded, the predefined events are triggered. For example, the CoCo may beep, flash the screen, save the signals to the storage device, or send the message to the host PC.

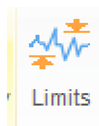
Networked CoCo used for Automated Test

CoCo has an Ethernet network interface that provides a unique advantage that multiple CoCo units can be connected remotely using an Ethernet network. This is particularly useful for vibration monitoring or production test that requires long distance access.

When multiple CoCo units are managed through the EDM software, the host computer can record or react to the alarm events from each remote CoCo unit.

CSA Editor Operation

Limit signals are defined on the host computer with the CSA Editor software. After the limit signals are defined, they are kept in a Limit Collection pool. Next, you define which limit signal is compared which measured signal. To define limit signals, complete the CSA Wizard process then click on the Limits icon in the CSA Editor.



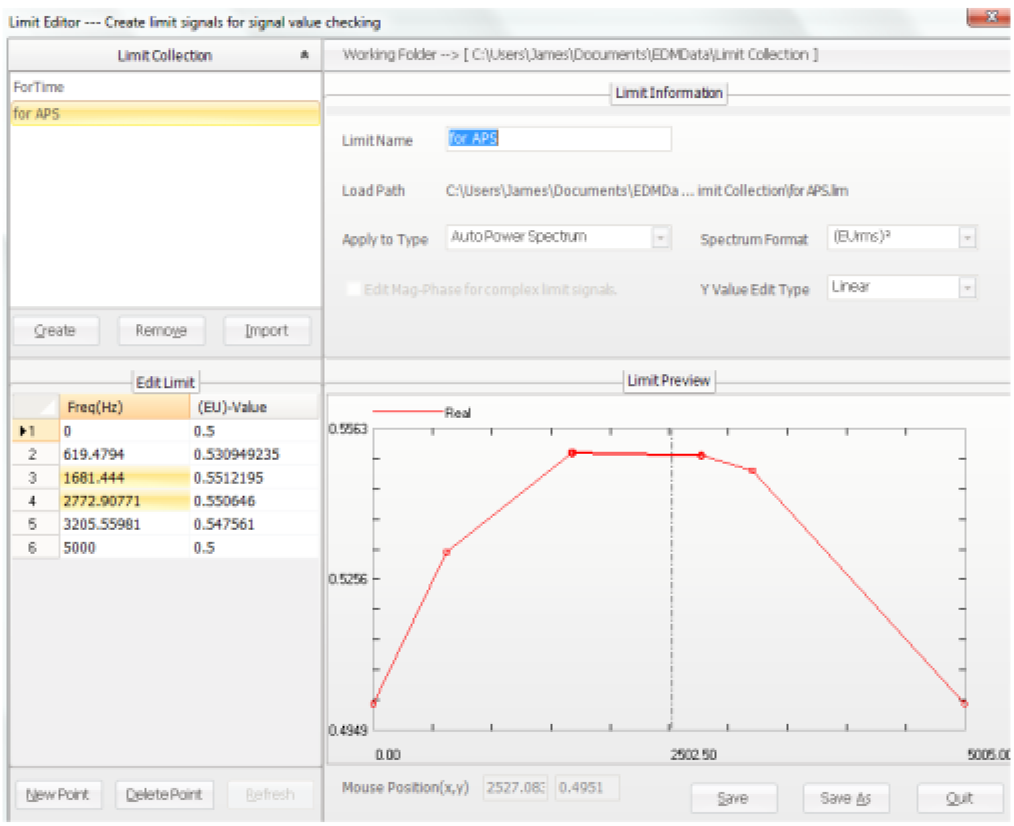


Figure 180. Limit Editor is used to define a limit signal on the host computer.

The figure below shows the Limit Editor dialog box which is divided into four areas. The **Limiting Collection** area holds all the limit signals that you create. Later you will bind one or two limit signals to any signal that you want to test on CoCo.

The **Limit Information** area defines the name of the limit signal, the type of the signal and other attributes. For example if you want to apply the limits to an auto power spectrum, you must select auto spectrum type under the Apply to Type field, and select the appropriate spectrum type. Spectrum type selection is critical for any auto spectrum test. The default directory indicates where these limit signals are saved on the host computer. The path is defined in the Settings of the Home tab, under the Working Folder item as shown in Figure 181.

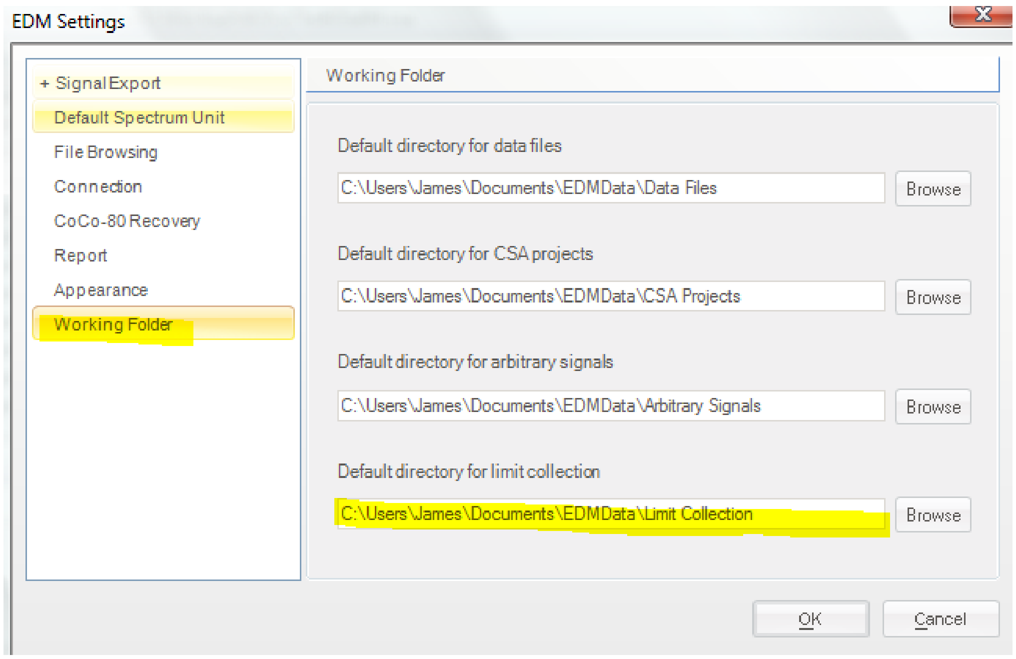


Figure 181. Limit signals are saved in the location defined under EDM Settings.

The **Edit Limit** and **Limit Preview** areas are for editing the limit signal. A limit signal consists of multiple break points. With the table, you can manually add or remove the breakpoints. Alternatively you can use the mouse to drag and draw breakpoints.

After the limit definition is done, use the Save button to save the limit signals on the host computer. The Save As button lets you save the limit signal into different folder or with a different name. The Quit button exits the dialog box.

The next step is to apply a limit signal to a measured signal. This process is referred to as binding. Click on the Signal Analysis tab and check the Enable limit binding box. A new column, Limit Binding, will be shown.

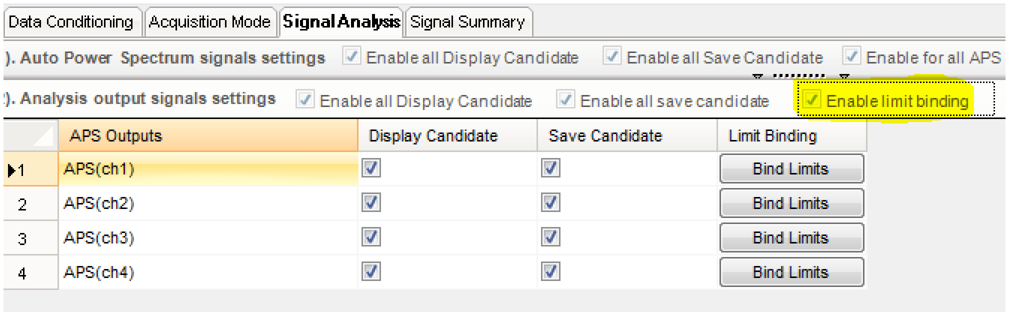


Figure 182. Bind the limit signal from the Signal Analysis tab.

Click on the Bind Limits button next to each APS Output signal. This will display the following dialog box.

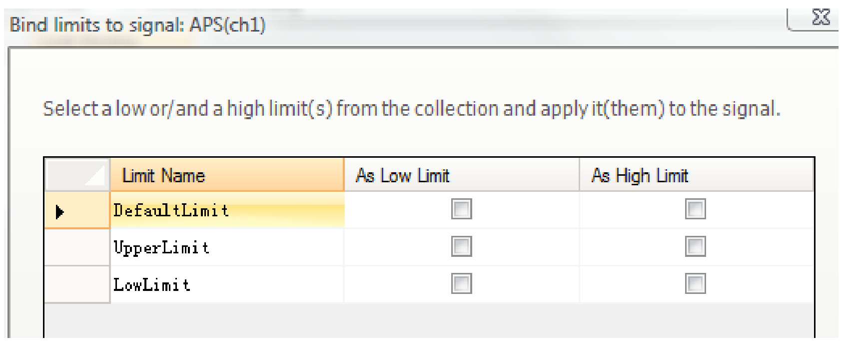


Figure 183. Define the limit signal for a specific measured signal.

To apply a limit signal to the measured signal, check either the Low and/or High limit box next to the desired limit name. Then click OK.

After the binding process, you should validate the CSA project and send it to CoCo for run-time execution. The limit signals will be sent together with the CSA project file.

CoCo-80 Operation for Limit Test

This section describes how to run a limit test on the CoCo hardware. To run an automated limit test, you need to do the following on the CoCo:

4. Load a CSA with a limit signal
5. Make a testing schedule and enable the limit test in the testing schedule
6. Set up the limit alarm actions
7. Create windows, and choose the appropriate limit signals for display
8. Activate the testing schedule
9. After the test is done, view the report

Select a CSA Project

After a CSA with a limit signals is downloaded from the host PC to the CoCo, the CSA script will be available under the Limit Test Application Group. To open a CSA press the Analysis Button, then select the Limit Test Application Group. All Limit Test CSA files are automatically placed in this group to help organize the CSA file on the CoCo.

Next select a CSA file from the list.

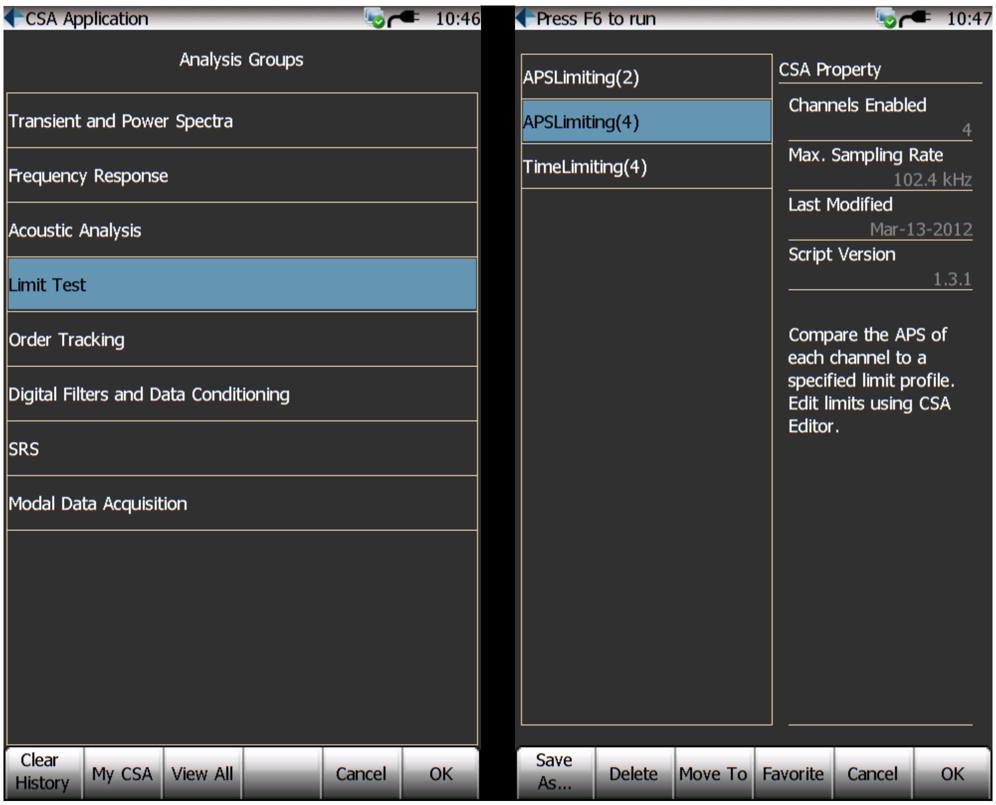


Figure 184. Select a CSA file with a Limit Signal from the Limit Test Application group.

Make a Testing Schedule and Enable the Limit Test

The next step is to make a testing schedule and enable the limit test. First select Schedule Setup from the Param. Button.

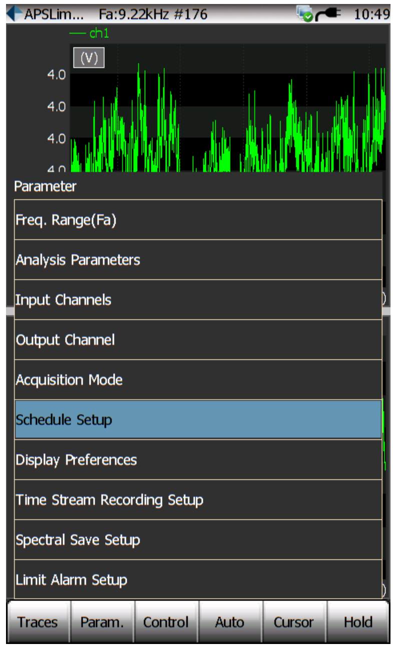


Figure 185. Schedule Setup window.

Next insert schedule events using the Insert Entry Button. Events can also be deleted from the schedule.

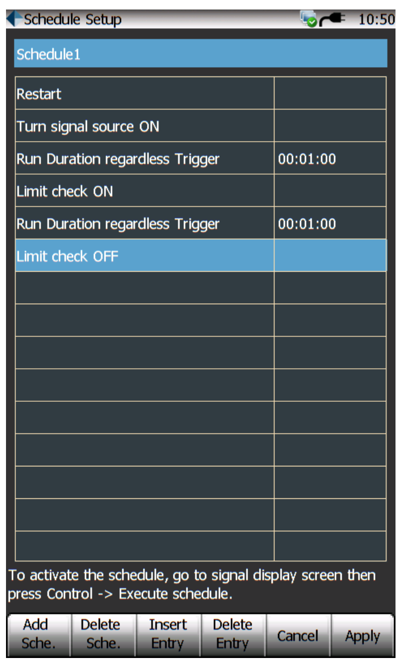


Figure 186. Test Schedule Settings window.

The testing schedule automatically controls the test duration and automates the testing process. Multiple testing schedules can be saved but only on can be executed at a time. The testing schedule event entries include: Loop/End-Loop, Run Duration, Hold, Limit Check on, Limit Check off, Start Recording, Stop Recording, Save Signals, Turn Signal Source On and Turn Signal Source Off.

The Loop/End Loop function is useful for automating a repetitive function. For example, the following schedule will loop 5 times. In each loop, the system will pause for 60 seconds and then record data for data for 60 seconds then stop the recording and pause again.

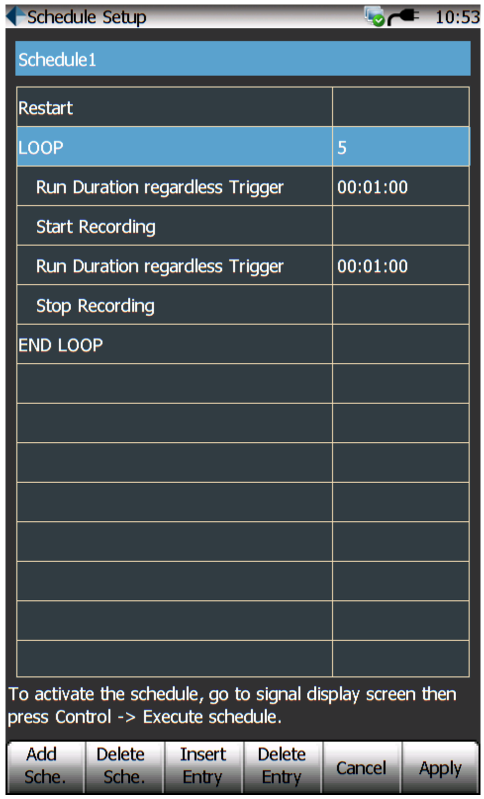


Figure 187. A loop can be used to repeat a sequence of events.

Set up Limit Alarm Actions

Limit alarm actions determine the event that occurs when a measured signal exceeds the limit signal. To enable actions select Limit Alarm Setup from the Param. Button.

Figure 188. Limit Alarm Actions window.

The Limit Alarm Actions display is only available for a CSA that includes at least one limiting check function. The CoCo will trigger the events that are selected including:

Log Event to Testing Log: log limit exceeded information to a text file.

Beep Sound: generate a beep sound from the CoCo unit.

Save Signals: save the frame into a file

Send Message to EDM: send a message contains limit exceeded information to connected host computer with EDM software. The EDM software then can be setup to make a beep sound or save the message to a file.

Turn On Output: send an output signal defined in the output setup.

Display Limit Signals

A common display for limit testing includes the measured signals on the same window as the limit signal. This display can be created by selecting Limit Signals Display Setting from the Traces Button. This setup item will only be available for a CSA that includes at least one limiting check function.

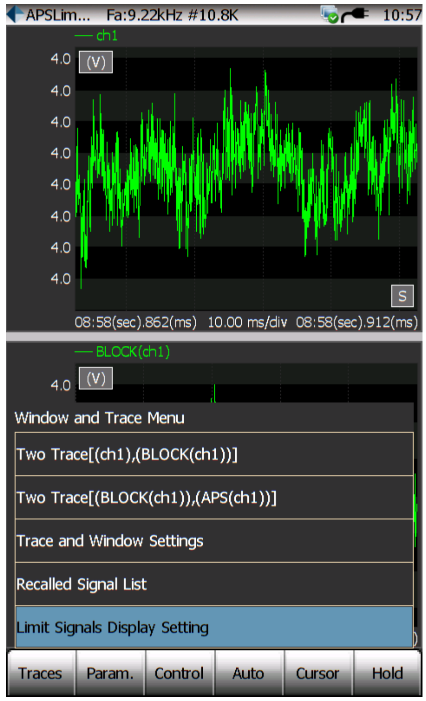


Figure 189. Limit signals can be displayed with live data.

Next select the limit signal from the Limit Signal Display window. When you select a limit signal then it is automatically added to any window that contains the associated measured signal.

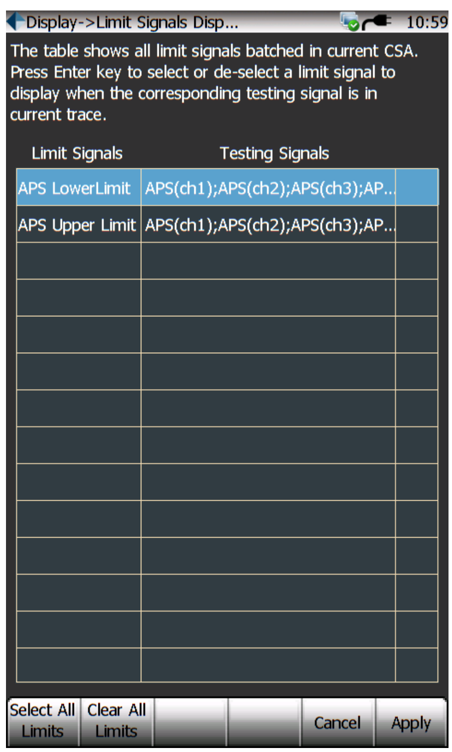


Figure 190. The Limit Signal Display dialog lets you choose which limit signals to display.

Figure 191 shows a typical limit signal in red on the same trace as a measured signal in yellow. Note that the measured signal exceeds the limit signal in this case because the first and second harmonic peaks are too large.

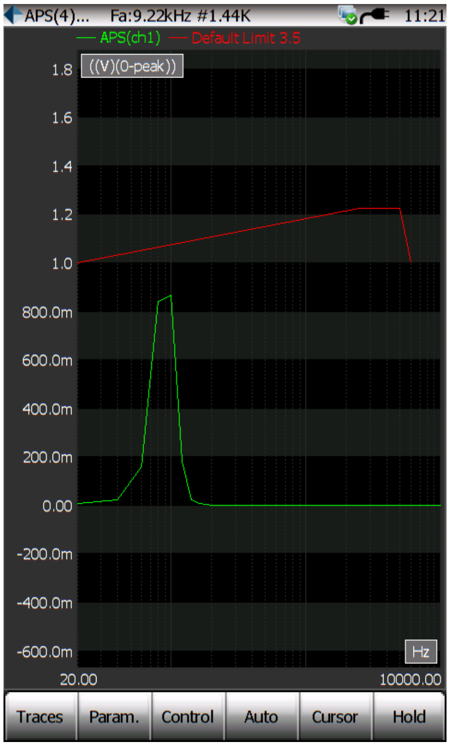


Figure 191. Limit signal on the same trace as a measured signal.

Activate the Testing Schedule

After the limit test is set up, the next step is to activate the test. When the signal display widow is shown as below, press the Control button and Execute Schedule button to activate the schedule. Once the testing schedule is activated, all the function buttons will be disabled. You cannot switch to other screens during the test schedule.

During a test schedule you can stop the test by pressing the Exit Button. After the test is complete you can start it again manually by pressing the Redo Button.

View the Limit Report

The Limit Report shows the status of each limit signal. When the limit test finished, Press F1 to show the limit report.

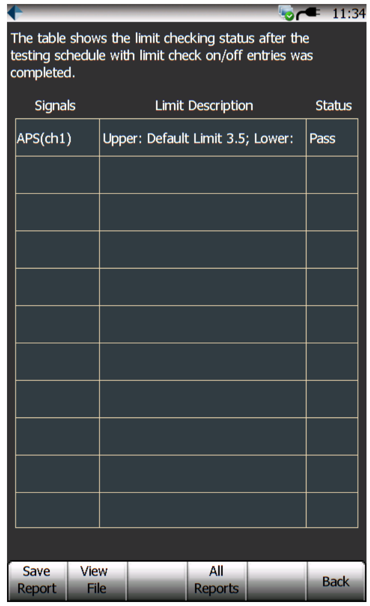


Figure 192. Limit Report.

View the Testing Log

The Test Log records every event during the test schedule.

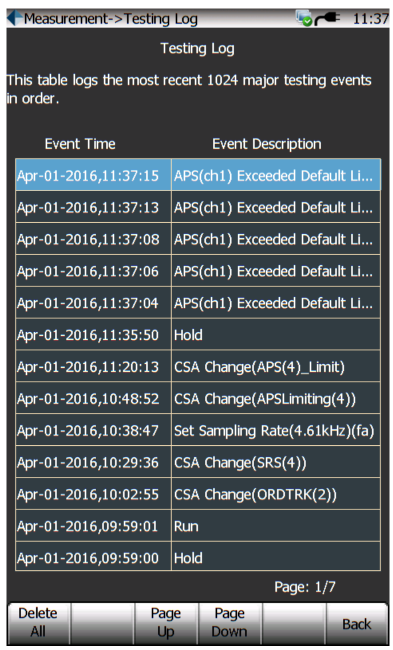


Figure 193. Testing Log View.

Vibration Intensity Analysis

Vibration Intensity testing concerns human exposure to whole-body vibration, hand-transmitted vibration, building vibration, and ship-cabin vibration.

Whole Body Vibration (WBV) testing measures the human interpretation of vibration levels in a tool, vehicle, or industrial process. Extended exposure to vibration, particularly low frequency vibration, from these sources can have a noticeable effect on the health and perception of the user. Using WBV analysis techniques can help minimize the disruptive low frequency vibration during design, or guide repairs and modification to equipment currently in use.

The vibration is weighted as 1/3 octaves according to ISO 2631-1 and includes analysis for Health, Comfort, Perception, and Motion Sickness applications. While ISO 2631-1 does not provide values for acceptable and harmful levels of vibration, it does include approximate ranges for Comfort applications. These levels have been included in the CI WBV analysis in the Report feature.

For Health, Comfort, and Perception applications the bandwidth of concern is from 0.5-80Hz. For Motion Sickness the frequency range is focused on lower frequencies, from 0.1-0.5Hz.

Hand-Arm Vibration testing is concerned with measurement and evaluation of hand-transmitted vibration. ISO 5349 specifies the general requirements for the measurement and evaluation of human exposure to hand-transmitted vibration.

Building Vibration testing is concerned with human exposure to whole-body vibration and shock in buildings with respect to comfort and annoyance of the occupants. ISO 2631-2 specifies the method for measurement and evaluation – it defines the frequency weighting W_m which is applicable in the frequency range 1 Hz to 80 Hz where the posture of an occupant does not need to be defined.

Ship-Cabin Vibration testing is concerned with evaluating habitability of different areas on a ship. ISO 6954 gives guidelines for measurement, evaluation, and reporting of vibration with regard to habitability. The habitability is evaluated by the overall frequency-weighted r.m.s. vibration values from 1 Hz to 80 Hz.

Equations and Definitions

Applications

Health analysis is concerned with the effects of periodic, random and transient vibration on the health of persons exposed to whole-body vibration during travel, at work, and during leisure activities. It is generally applied to seated individuals.

Comfort analysis is concerned with the effect of vibration on the comfort of persons.

Perception analysis is concerned with the effect of vibration on the perception of persons.

Motion Sickness analysis is performed on lower frequencies, ranging from 0.1-0.5 Hz. These lower frequencies are linked to discomfort and commonly kinetosis (motion sickness).

Basic Method

$$a_w = \left[\frac{1}{T} \int_0^T a_w^2(t) dt \right]^{\frac{1}{2}}$$

Where:

$a_w(t)$ is the weighted acceleration as a function of time

T is the duration of the measurement in seconds

Running RMS Method

$$a_w(t_0) = \left\{ \frac{1}{\tau} \int_{t_0-\tau}^{t_0} [a_w(t)]^2 \, dt \right\}^{\frac{1}{2}}$$

Where:

$a_w(t)$ is the instantaneous frequency-weighted acceleration

τ is the integration time for running averaging, 1 second for CoCo WBV measurements

t is the time (integration variable)

t_o is the time of observation (instantaneous time)

The maximum transient vibration value (MTVV) is defined as

$$MTVV = \max \, [a_w(t_0)]$$

Fourth Power Vibration Dose Method

$$VDV = \left\{ \int_0^T [a_w(t)]^4 \, dt \right\}^{\frac{1}{4}}$$

$a_w(t)$ is the weighted acceleration as a function of time

T is the duration of the measurement in seconds

Measurement Quantities

Time Streams: this is the same as any other applications on the CoCo. Time streams are always available for viewing and recording. It is a very useful tool to observe whether the input signals are in the valid range. The recorded sine wave can be used for further post-processing. In CoCo, the time streams are often denoted as ch1, ch2 etc.

Weighted RMS Values: 1/3 Octave analysis is performed on the incoming time streams. Weighting factors are applied to each 1/3 Octave bin according to ISO 2631 and the RMS value is calculated every 1 second.

Weighted RMS Time Trace: A trace of the Weighted RMS values can be displayed and recorded which tracks the RMS value over time.

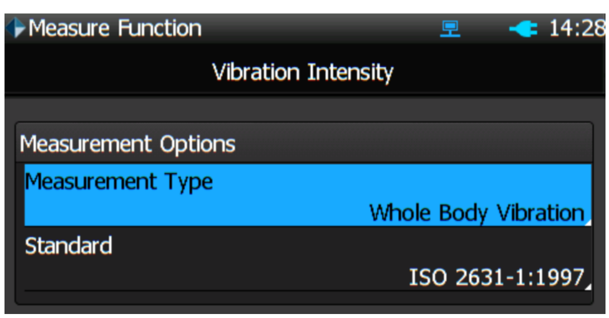
Basic Analysis RMS Result:

Running RMS MTVV: Using the Running RMS analysis method, the Maximum Transient Vibration Value (MTVV) can be save to the report.

Fourth Power VDV: Using the ¼ Power analysis method, the Vibration Dose Value (VDV) can be saved to the report.

CoCo Operation

The Vibration Intensity application is different from most other CSA's on the CoCo and operates more as a standalone application. When Vibration Intensity is selected from the CSA menu, a startup screen will let the user select the measurement type.



Choose Whole-Body Vibration as the measurement type. A startup page will be loaded to define the basic parameters of the test, Application and Position.

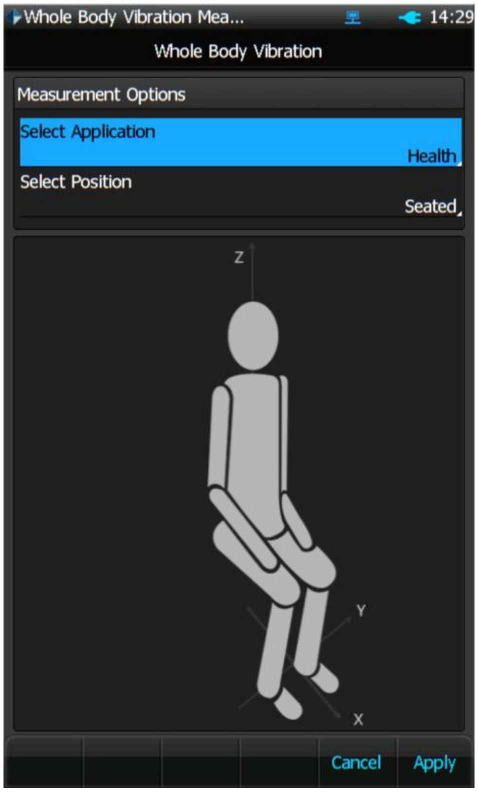


Figure 194: Whole Body Vibration Start Page

Press **Enter** to open a list of available options for Application and select using the arrows keys. Press **Enter** again to select the Application. Set the Position in the same way. Once Application and Position are specified, press **F6 (Apply)** to begin the test.

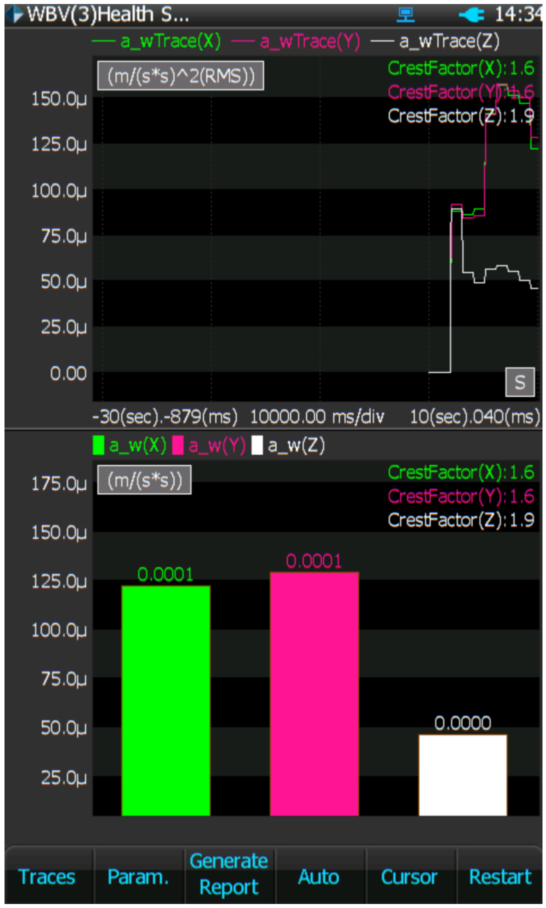


Figure 195: Weighted RMS Time Trace and Line Bar Trace

To remainder of the setup options for WBV can be accessed by pressing **F2 (Param.).** Open the **Analysis Parameters** menu to set up the test. From this menu the Time Hold can be defined and the additional analysis method can be selected. Press **F6 (Apply)** to save the settings and return to the test window.

Be sure to define the input channel sensitivities and input modes from **F2 (Param) > Input Channels**. This is the same menu as all other CoCo projects.

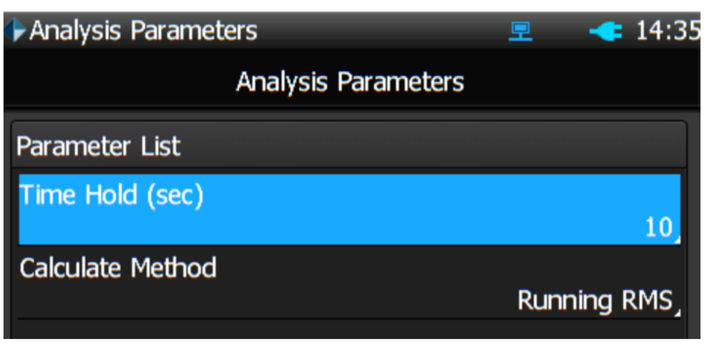


Figure 196: Analysis Parameters

When the Time Hold timer is reached, the test is complete. A message will pop up on the display to alert that a report can be generated. Press **F3 (Generate Report)** to save the readings to a report.

Figure 197: Test Complete dialog

Saving Time Streams and Traces

While Signal data (APS, FRF, etc) cannot be saved with the WBV application, the raw Time Streams and the RMS Traces can still be recorded. To record data in addition to saving the test results, open the Time Trace Recording Setup menu from the **F2 (Param)** menu. Select channels by highlighting them using the Arrow buttons, and toggle the channel on or off by pressing **Enter**.

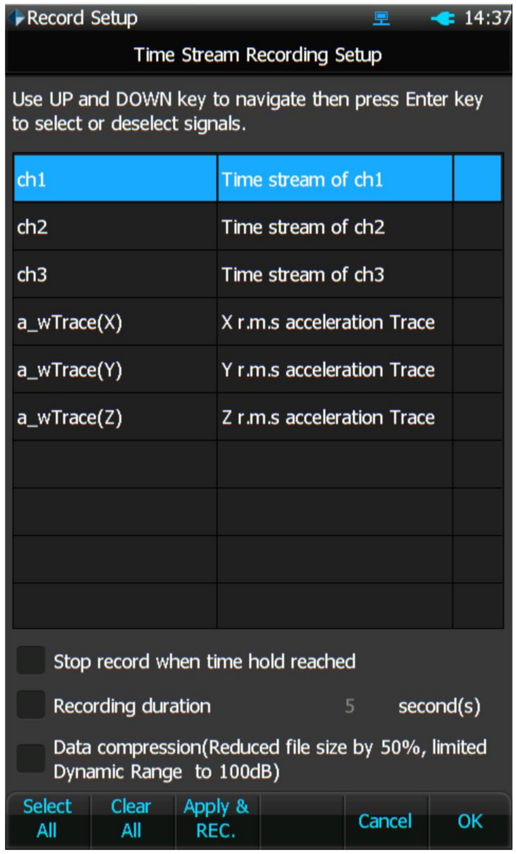


Figure 198: Time Stream Recording Setup

Additional setting can be specified from this menu, including using a Trigger to start a recording, setting the recording to stop automatically after a given amount of time, compressing data, and recording to the SD card. Press **F6 (OK)** to apply the settings and return to the test window.

To record the signals defined in the Time Stream Recording Setup menu, press **Rec/Stop** on the CoCo. To stop the recording, press **Rec/Stop** again.

Reports

To access the reports generated after each test access the Setup menu by pressing the **Setup** button. The WBV project will be left and the main Setup menu will open. Select **Report** from the icons on this menu to view a list of saved test reports.

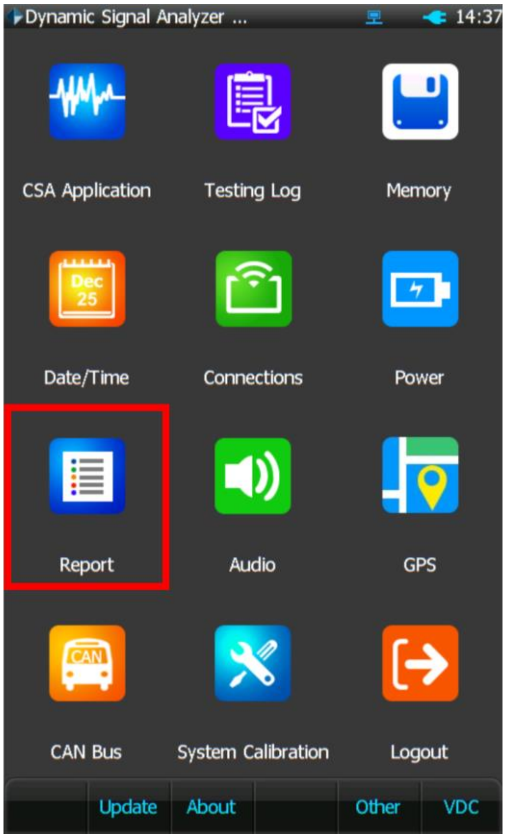


Figure 199: Accessing Reports from the Setup Menu

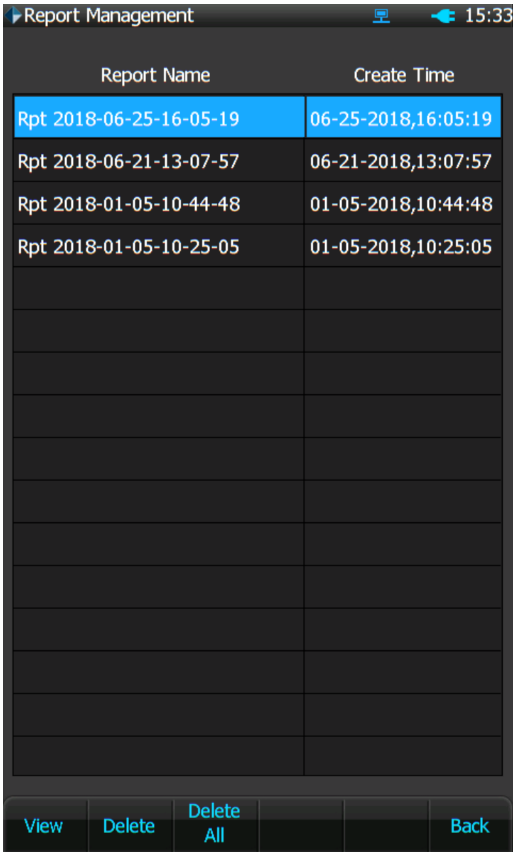


Figure 200: List of saved Reports

To view a report, highlight it using the Arrow keys, then press **F1 (View)** to open the report. One or all reports can be deleted using **F2 (Delete)** and **F3 (Delete All)**.

Reports are separated into three sections, Parameters, Results, and Conclusion. The Parameters section lists the ISO standard, Application, Position, Frequency Range, Method, and Time Hold.

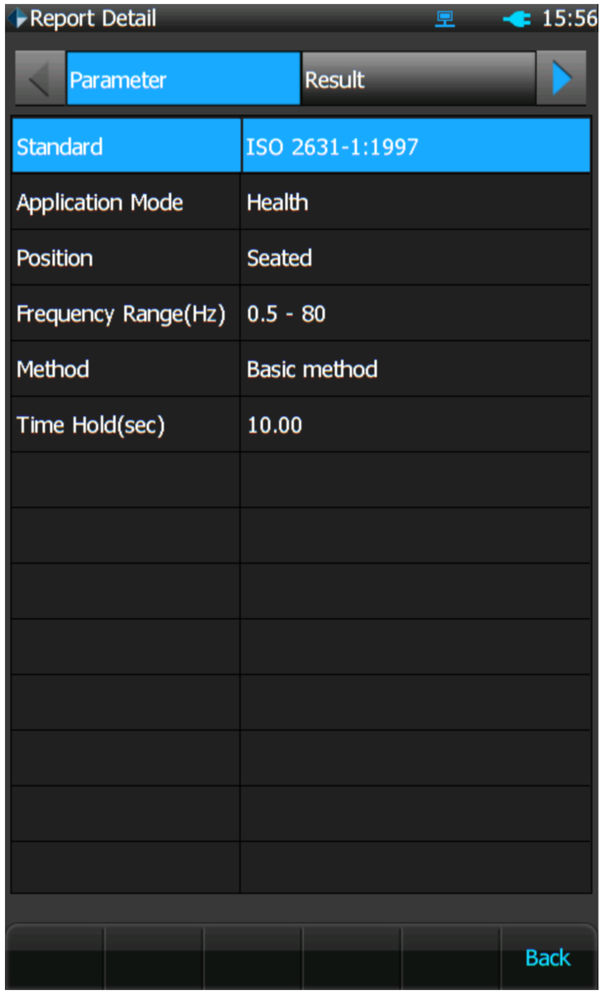


Figure 201: Report Parameter section

The second section of the report is the Result section. To switch from Parameters to Results, press the **Right** arrow button. On this page the weighted RMS values will be reported as well as the overall weighted RMS. If Fourth Power or Running RMS methods are used, the MTVV or VDV will be reported for each channel as well.

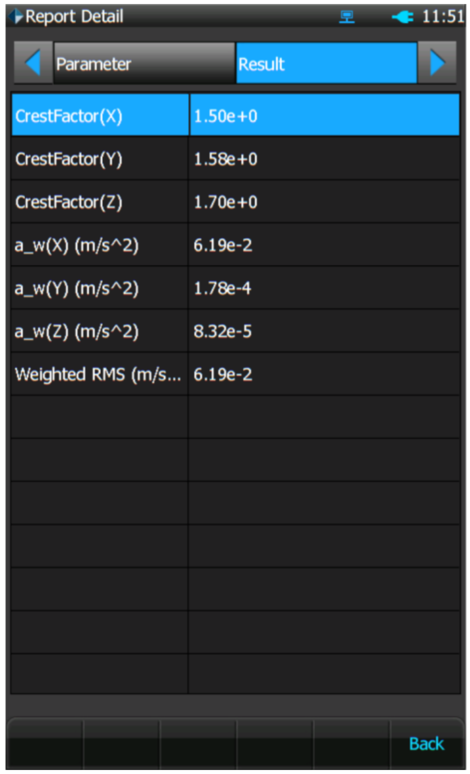


Figure 202: Report Results page

To save Reports to a computer, remove the SD card from the side of the CoCo unit and use a card reader to view the files on it. The report files are stored as PDF documents in a folder titled “Report” on the SD card.

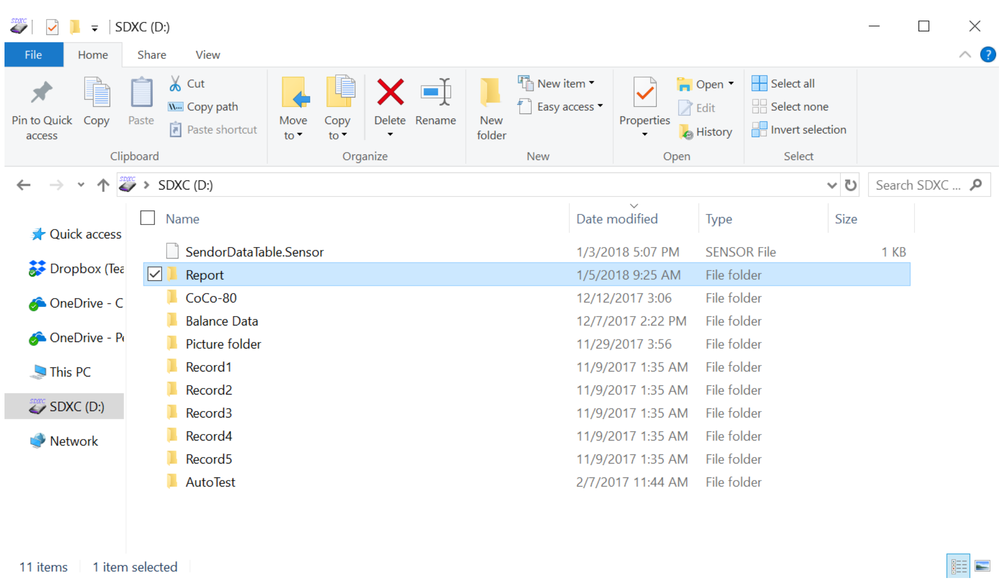


Figure 203: Report folder on the SD card

Real time digital filters

Real Time Digital Filters is a powerful analysis tool that can be used to filter a measured signal in real time and then apply the FFT and time based analysis built into the CoCo. You can precisely define the filter characteristics to meet your specific application. The filter definition is performed in the EDM software and the filter is included in the CSA file that is downloaded to the CoCo. This capability in a small portable unit makes the CoCo a very powerful analysis tool.

For example, a user might want to look at the energy distribution over time, for a specific band of frequencies instead of the entire frequency spectrum from zero to the maximum sampling rate. This can be done by creating a band-pass filter then applying an RMS estimator to the output of the filter. Figure 204 shows the graphical representation of this process which is used to define the real time filter in the EDM software. The icon on the left, CH1 represents the native measured time stream. It is connected to an IIR Filter which computes a signal named iirfilter (ch1) which is connected to an RMS estimator. The output of the RMS estimator is a signal named rms(iirfilter(ch1)). The EDM software will be discussed in more detail later.

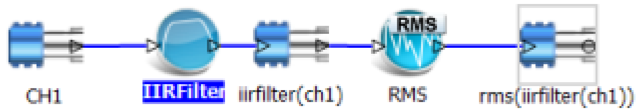


Figure 204. Example real time digital filter application.

Another example is that the user might want to look at the frequency energy over 100 Hz to 200 Hz and 1000 Hz to 2000 Hz separately. This can be done by deriving two output streams from the native channel 1, then applying the band-pass filter to each path as shown in Figure 205.

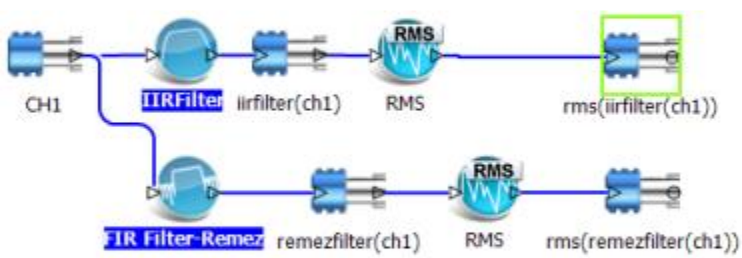


Figure 205. Digital Real Time Filter example with two output streams.

In another example, a user might want to look at the very fast time characteristics of a channel at high frequency, and the same channel at a very low sampling rate. This can be done by applying a decimation filter to the native time stream as shown in Figure 206 . The native channel time stream is split into two streams so the signal from the same channel is recorded at both high and lower sampling rates.

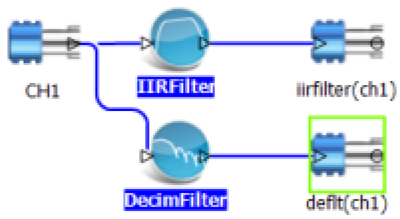


Figure 206. Example computing high and low sampling rate with a decimation filter.

The Real Time Digital Filters option includes three types of digital filters: FIR, IIR and decimation filters. For FIR and IIR filter, you can specify low-pass, high-pass, band-pass or band-stop types with several different methods. This chapter first explains the theory about the filter design, and then introduces the operations within the CSA Editor and CoCo hardware.

Real Time Filter implementation can be divided into two steps that include the filter definition on the EDM software, and secondly download and run the CSA on the CoCo hardware.

You design a filter based on certain criteria such as cut-off frequency, pass band ripple, attenuation level and so on. The EDM software walks you through this process. The outcome of this design process is simply a number of filter coefficients that represent the filter which are included in a CSA. The software will upload the CSA including the filter coefficients to the CoCo hardware.

After filter is defined and the coefficients downloaded to the CoCo hardware you can run the CSA. When the CoCo is running, the filter coefficients created in the filter design process will be used. The time streams will pass through the filters and generate new time stream signals.

The goal of filter design is to calculate a series of filter coefficients based on the user specified criteria. The criteria are often described by following variables:

Number of filter coefficients: this is also known as the order of the filter. The filter order defines how many coefficients are required to define the filter. A lower order filter consists of a fewer number of coefficients. A low order filter responds relatively faster than a higher order filter, that is there is less of a time lag in the output of the filter.

Cutoff frequencies: For low-pass or high-pass filters, only one cutoff frequency is needed. Band pass or band-stop filters require two cutoff frequencies to fully define the filter shape. Figure 207 shows a typical band-pass filter design with the two cutoff frequencies set to approximately 0.1 and 0.2 Hz as indicated by the blue and yellow vertical lines.

Attenuation of stop band in dB: This defines how much of the input signal is cut out of the output at the rejected frequencies. In theory the higher the attenuation the better. In Figure 207 the stop ban attenuation is > 40 dB as seen from the highest side lobe just below 0.25 Hz.

Pass band ripple: Ripple is an unavoidable characteristic if a digital filter. It refers to the fluctuation in the filter shape outside the transition frequencies. If a very flat filter is required then it can be specified by choosing a very low ripple. In Figure 207 ripple is seen in the stop band and no ripple is evident in the pass band. Ideally the pass band should be very flat and some ripple is tolerable in the stop band.

Width of transition bands: This refers to the filter shape between a band pass and a band stop region. Ideally this transition band should be very small. However, a very narrow transitional band requires a higher order filter which affects the filter response time and can also affect ripple. In Figure 207 the transition bands are between 0.05 to 0.1 and 0.2 to 0.25.

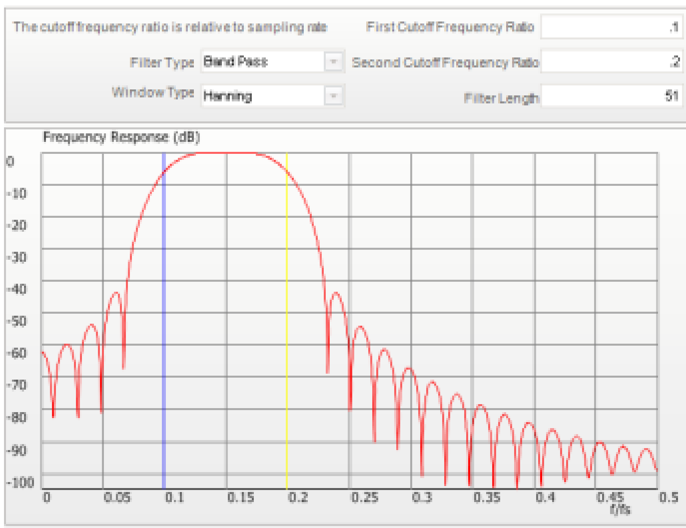


Figure 207. Filter design shows cutoff frequencies, ripple, band stop attenuation.

In most cases filter design includes making tradeoffs between minimizing the filter order, ripple, and transition band width and response time. Not all can be satisfied at the same time. Filter design can be an iterative process and experience is helpful.

FIR Real Time Digital Filters

Finite Impulse Response (FIR) filters have the distinctive trait that their impulse response lasts for a finite duration of time as opposed to, an Infinite Impulse Response (IIR) filters whose impulse response is infinite in duration. This trait is due to the fact that there are no feedback paths in the FIR filter. FIR filters offer several advantages over IIR filters:

- Completely constant group delay throughout the frequency spectrum. Group delay refers to the time delay between when a signal goes into the filter and when it comes out. Constant group delay means that an input signal will come out of the filter with all parts delayed the same amount with no distortion.

- Complete stability at all frequencies regardless of the size of the filter.

FIR filters also have some disadvantages as well:

- The frequency response is not as easily defined as it is with IIR filters
- The number of coefficients required to meet a frequency specification may be far larger than that required for IIR filters.

CoCo allows up to 128 taps (orders) for the real-time FIR filter.

A digital filter can be understood by considering the difference equation which defines how the input signal is related to the output signal as

$$y[n] = b_0 x[n] + b_1 x[n-1] + \cdots + b_N x[n-N]$$

where x[n] is the current input signal sample, x[n-1] is the previous signal sample and x[n-N] is the last sample in the series. The series multiplies the most recent N+1 samples with associated the N+1 filter coefficients. , y[n] is the current output signal and b_i are the filter coefficients. The number N is known as the filter order; an N^{th}-order filter has (N + 1) terms on the right-hand side and N+1 filter coefficients also referred to as "taps".

This equation illustrates why a higher order filter has a slower response time. It takes more samples and therefore more time for an event to work its way though the series until the output is no longer affected by the event as compared to a lower order filter with fewer coefficients.

The previous equation can also be expressed as a convolution of the filter coefficients and the input signal.

$$y[n] = \sum_{i=0}^{N} b_i x[n-i]$$

The Impulse Response of the filter shows how the historical data affect the current filtered value. The longer the impulse response, the farther the old data will affect the current filtered value. To find the impulse response we set

$$x[n] = \delta[n]$$

where δ[*n*] is the Kronecker delta impulse. The equation below shows that the impulse response for an FIR filter is simply the set of coefficients b_n, as follows

$$h[n] = \sum_{i=0}^{N} b_i \delta[n-i] = b_n \qquad for\ n = 0\ to\ N$$

FIR filters are clearly stable, since the output is a sum of a finite number of finite multiples of the input values, so can be no greater than $\sum_{n=0}^{N} |b_n|$ times the largest value appearing in the input.

Data Windows FIR Filter Design

In the academic world, hundreds of methods are available to design an FIR filter to meet various criteria. The EDM includes the most popular filter design methods: Data Window and Remez. Both methods are discussed below.

The Data Window FIR Filter Design method is the easiest to understand. The name "Window" comes from the fact that these filters are created by scaling a sinc (SIN(X)/X) function with a window such as a Hanning, Flat Top, etc. to produce the desired frequency effect.

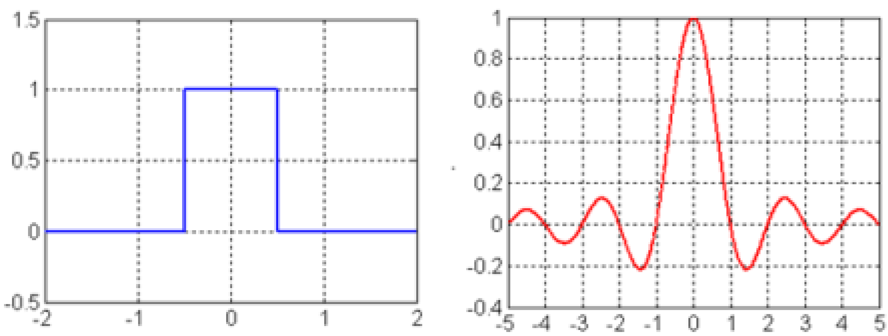


Figure 208 Sinc function is the Fourier transform of a square shape.

A data window FIR filter is generated by starting with an ideal "brick-wall" shaped filter, that is a filter with vertical edges or zero transition band width as shown on the left in Figure 208. The brick-wall filter is specified by the cutoff frequencies and has a band-pass amplitude of 1 and a stop band amplitude of zero. The problem with the ideal brick-wall filter is that the time response oscillates forever and it requires an infinite number of filter coefficients. This ideal filter can be modified by applying a data window to force the time response to decay in a finite time. Of course this degrades the shape of the ideal brick-wall filter performance. It introduces ripple, increases the transition band width and decreases the stop band attenuation. However it allows the filter to be defined by a finite number of filter coefficients. The filter performance can be modified by using different data windowing functions and making the tradeoff between filter order and response time. The user must choose these settings during the filter design.

Figure 209 through Figure 214 show a comparison of different data window choices for the same filter settings. In all cases the low and high cutoff frequencies are 0.1 and 0.2 relative to the sampling frequency. The number of filter taps is 51.

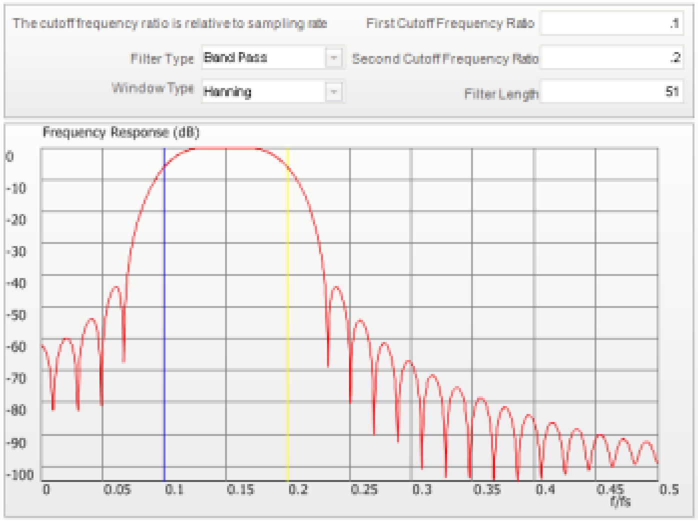


Figure 209 Hanning window method.

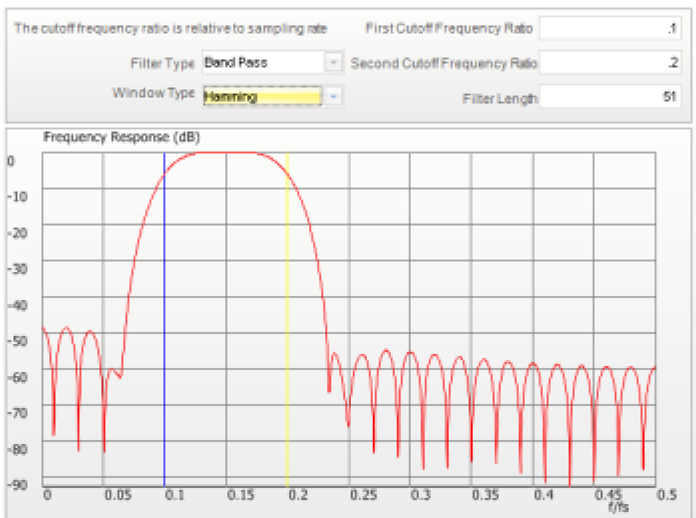


Figure 210 Hamming window method.

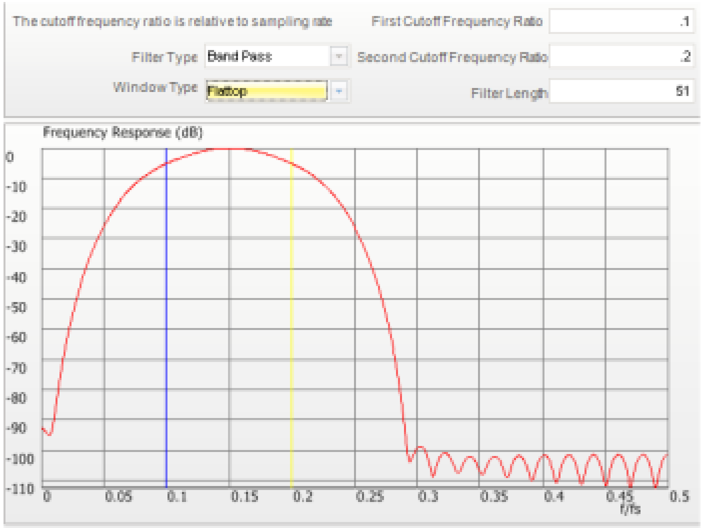


Figure 211 Flattop window method.

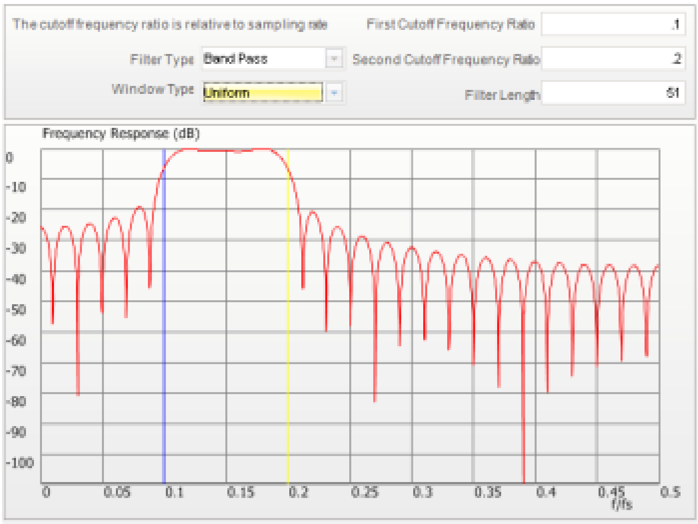


Figure 212 Uniform window method.

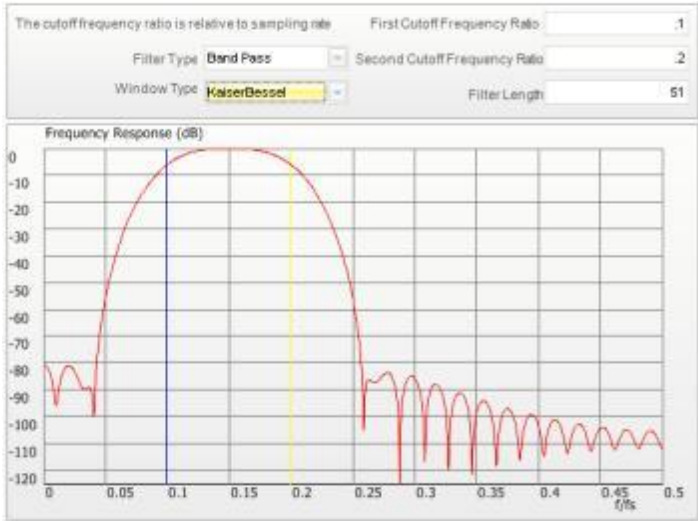


Figure 213 Kaiser Bessel window method.

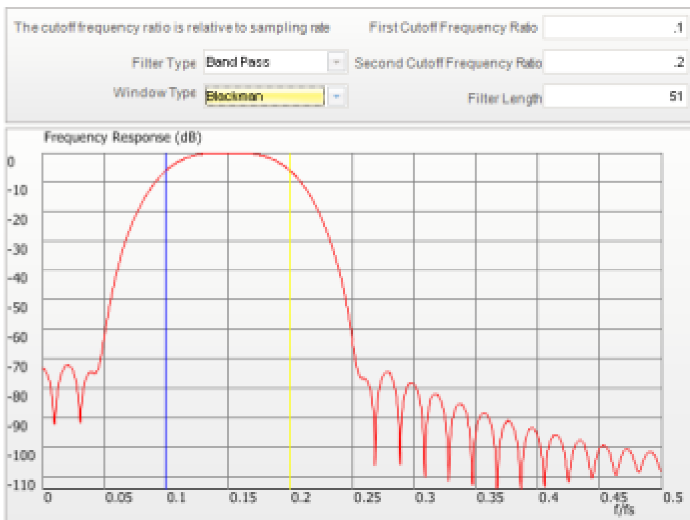


Figure 214 Blackman window method.

As shown in the pictures, different window methods produce different filter performance, i.e., different attenuation of the main lobe and side lobes. The best data window choice depends on your specific application. Refer to the Basic Spectral Analysis section for a comparison of windowing functions.

Remez Filter Design

The Remez Filter is a different method for designing an FIR filter. It is more computationally intensive than the data window method. A Remez filter is generated with iterative error-reducing algorithms designed to reduce the pass band error. In addition to allowing stop band ratio and frequency definition, the Remez filter allows the "Ripple Ratio" to be defined as a user specified parameter.

Figure 215 shows an example of a filter design using the Remez method in the EDM software. The low and high cutoff frequencies are 0.1 and 0.2 relative to the sampling frequency. The number of filter taps is 51.

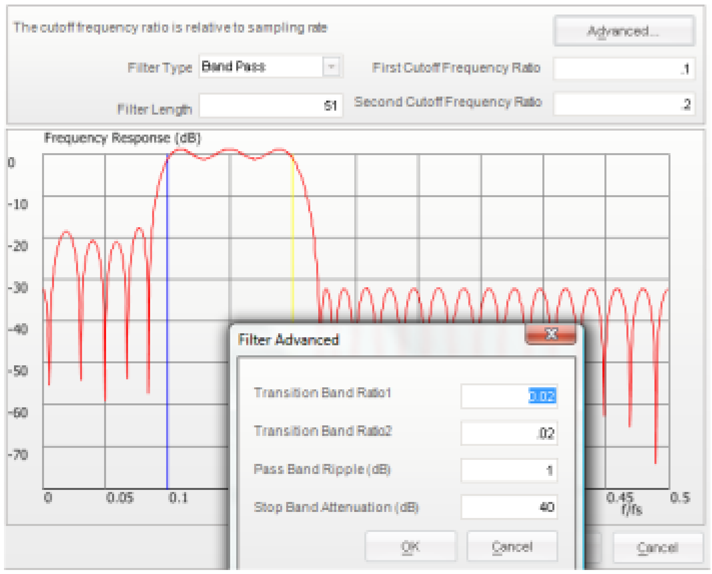


Figure 215. Ramez FIR Filter design dialog.

The software is intelligent enough to automatically calculate the total FIR filter length based on these criteria. For example if the user asks for very high attention, very small ripple or very sharp transition band, the filter length will go very high. The user must make tradeoffs between these parameters so that appropriate filter length can be generated and used.

IIR Real Time Digital Filters

Infinite impulse response (IIR) filters have the trait that their impulse response decays very slowly but theoretically lasts forever. This is due to the fact that the filter input includes the measured signal and also the filter output creating a feedback path which results in the infinite impulse duration. This is in contrast to finite impulse response filters (FIR) which have fixed-duration impulse responses.

The design procedures for IIR filters is somewhat more complicated than FIR filter design because there is no direct design method like the data window method for FIR filters. Instead IIR filters are typically designed by starting with an ideal analog filter in terms of the frequency response characteristics such as the Chebyshev, Butterworth, or Bessel filter. Then the analog filter is converted into a digital filter using a method known as the Bilinear transformation or impulse invariance method.

An IIR digital filter can be understood by considering the difference equation which defines how the input signal is related to the output signal as

$$y[n] = b_0x[n] + b_1x[n-1] + \cdots + b_px[n-P] - a_1y[n-1] - \cdots - a_qy[n-Q]$$

where P is the feed-forward filter order, b_i are the feed-forward filter coefficients, Q is the feedback filter order, a_i are the feedback filter coefficients, x[n] is the input signal and y[n] is the output signal.

The previous equation can also be expressed as a convolution of the filter coefficients and the input signal.

$$y[n] = \sum_{i=0}^{P} b_i x[n-i] - \sum_{j=0}^{Q} a_j y[n-j]$$

which, when rearranged, becomes:

$$\sum_{j=0}^{Q} a_j y[n-j] = \sum_{i=0}^{P} b_i x[n-i] \quad if\ we\ let\ a_0 = 1$$

To find the transfer function of the filter, we first take the Z-transform of each side of the above equation, where we use the time-shift property to obtain:

$$\sum_{j=0}^{Q} a_j z^{-j} Y(z) = \sum_{i=0}^{P} b_i z^{-i} X(z)$$

We define the transfer function to be:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\sum_{i=0}^{P} b_i z^{-i}}{\sum_{j=0}^{Q} a_j z^{-j}}$$

The transfer function gives the frequency response that relates the input to the output magnitude and phase relationship.

Various analog filter types can be used as the basis for the IIR filter. The Butterworth Filter is the filter type that results in the flattest pass-band and contains a moderate group delay. Below are examples of Butterworth low-pass and band-pass filters.

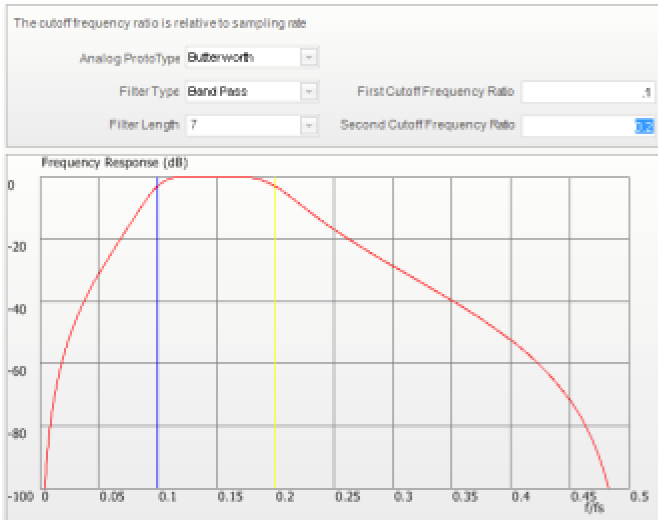


Figure 216. Butterworth band-pass filter.

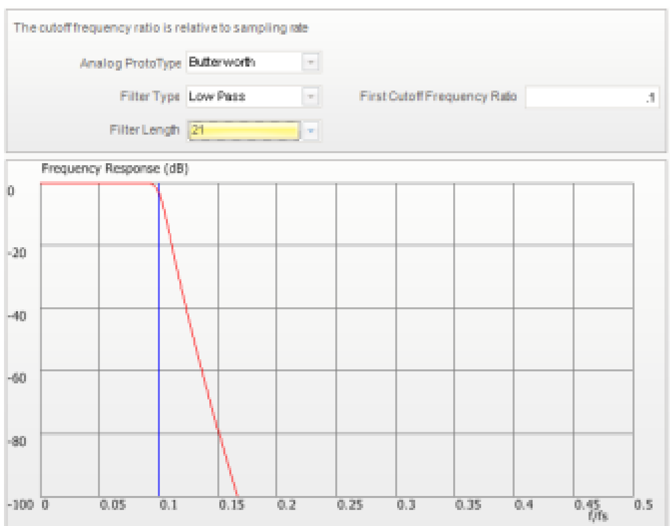


Figure 217. Butterworth low-pass filter.

The Chebyshev Type I Filter results in the sharpest pass-band cut off and contains the largest group delay. The most notable feature of this filter is the significant ripple in the pass-band magnitude. A standard Chebyshev Type I Filter's pass-band attenuation is defined to be the same value as the pass-band ripple amplitude. Below are examples of Chebyshev Type I band-pass and high-pass filters.

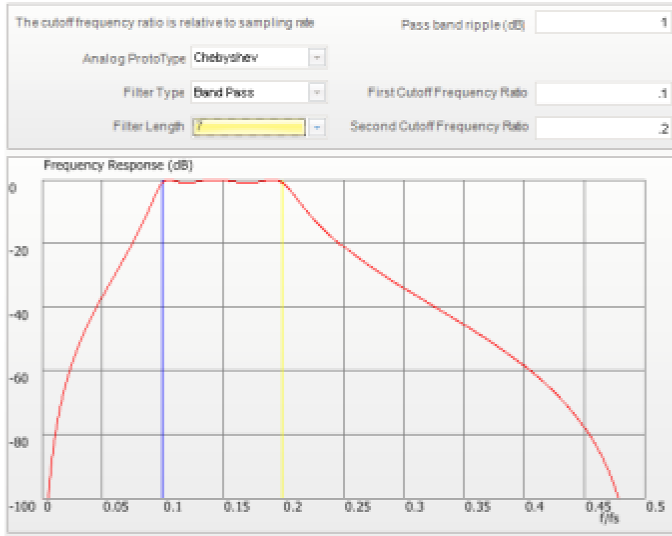


Figure 218. Chebyshev type I band pass filter.

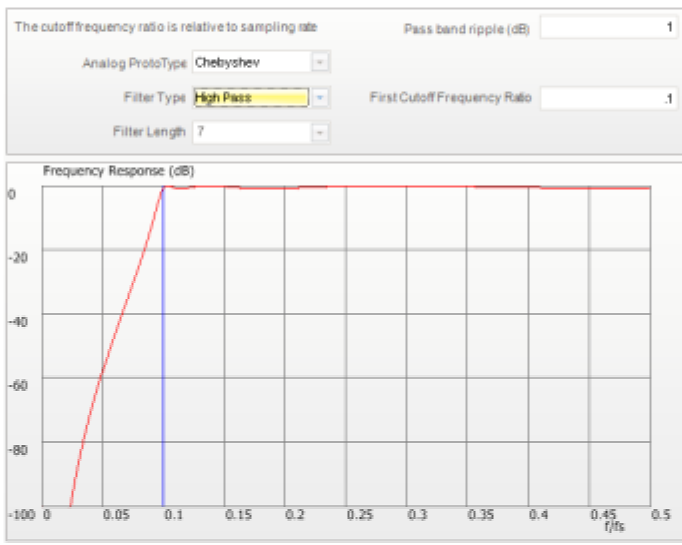


Figure 219. Chebyshev type 1 high pass filter.

The Elliptic Filter contains a Chebyshev Type I style equi-ripple pass band, an equipped stop band, a sharp cutoff, high group delay, and the greatest possible stop band attenuation. Below are examples of 7th order Elliptic low-pass, band-stop filters.

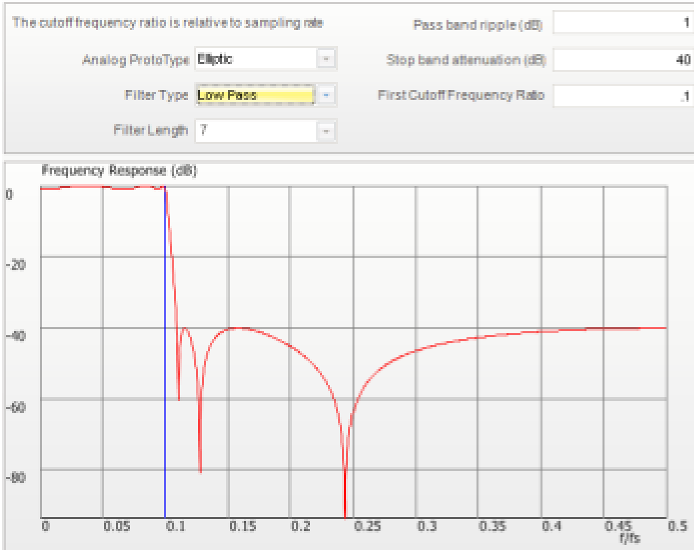


Figure 220. Elliptical low-pass filter.

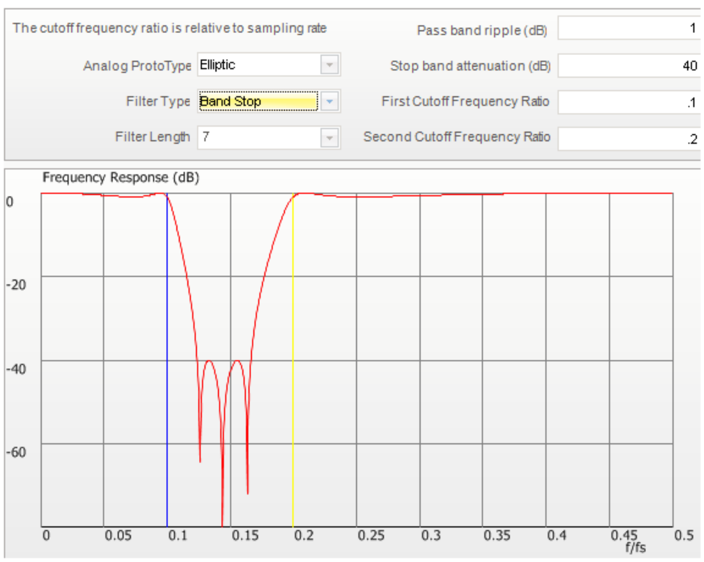


Figure 221. Elliptical band stop filter.

Filter Design Using Fixed instead of Relative Frequency

Filter design can be accomplished using either fixed or relative frequency methods. In the relative frequency method the cutoff frequencies are defined relative to the maximum sampling rate. For example if the sampling rate is 1000 Hz and a low-pass filter is defined with a cutoff frequency of 0.5 with the relative frequency method then the cutoff frequency is 500 Hz. Note that if the sampling rate is changed to 500 Hz and the cutoff frequency is no changed from 0.5, then the cutoff frequency will change to 250 Hz. The relative frequency method is the preferable method because the filter performance such as ripple or transition band width will not change when the sampling rate is changed.

The alternative is the fixed frequency method where the cutoff frequency is defined by a fixed frequency. With this method the cutoff frequencies do not need to be changed when the sampling rate is changed. While this method is more user friendly than the relative frequency method, it is not the recommended method because the filter performance, such as ripple or transition band width can vary when the sampling rate is changed.

To change between fixed or relative frequencies, go to Filter Type menu and select a filter type with Fixed. The filter types without Fixed are relative by default. :

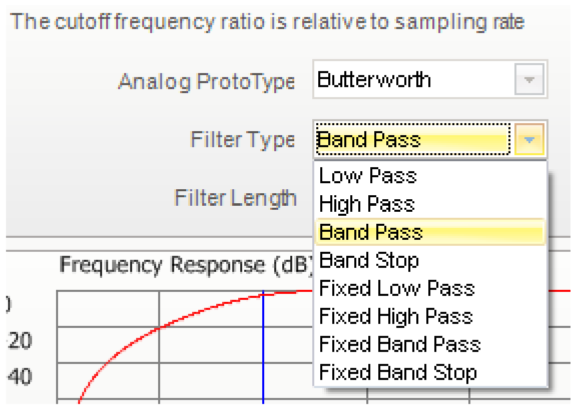


Figure 222. Fixed or relative frequency setting.

Decimation Filters

The decimation filter is a special filter available on the CoCo. Decimation reduces the original sampling rate for a sequence to a lower rate. The decimation process filters the input data with a low-pass filter and then re-samples the resulting smoothed signal at a lower rate.

The figure below shows how a decimation filter reduce the number of sampled points from 150 to 30 while the signal shape which is dominated by the low frequency components is still retained.

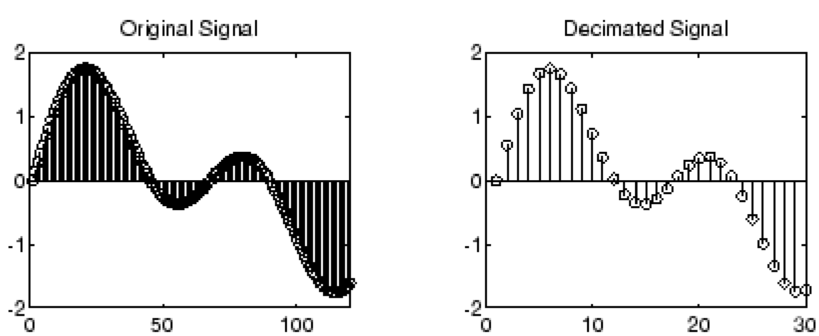


Figure 223. Illustration of a decimation filter.

Low-pass filtering is important in the decimation process to ensure no aliasing occurs. Aliasing refers to the effect of under sampling a high frequency signal and misrepresenting the high frequency behavior by a lower frequency. When aliasing occurs there is no way to distinguish the erroneous aliased signal from the actual signal. In the CoCo hardware the decimation filter uses a fixed proprietary low-pass FIR filter with excellent ripple performance in the pass-band and very high attenuation in the stop band.

In the CoCo hardware, the decimation filter module contains multiple stages of decimation filters. In each stage the data is decimated by a factor of two. After N stages of decimation, the data will be reduced to its $1/2^N$. In the example below, since the decimation stage is set to 3, the data will be reduced to $1/2^3 = 1/8$ of its input points after this decimation module.

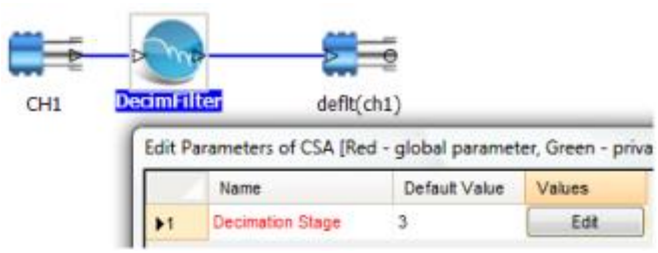


Figure 224. Decimation filter in the EDM software.

The decimation filter is widely used to view, analyze and record low frequency signals. For example, a system may be used to acquire the vibration and pressure or temperature data simultaneously. While the signals are all sampled at the high data rate, the pressure channel and the temperate channel should be viewed and recorded at a much lower rate because these types of signals typically do not change dynamically (at a high frequency). In this case, we can simply apply decimation filters to the channels that measure and record pressure or temperature.

Integrating decimation filter with other filter techniques allows the user to analyze high frequency and lower frequency signals with different frequency resolution simultaneously. This capability is unique to the CoCo system.

For example, in a CSA file you can apply a 3-stage decimation filter to channel 1 as shown in the figure below.

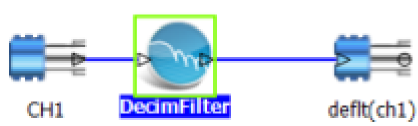


Figure 225. Decimation filter example.

If you connect a signal source with 1 kHz sine output to channel 1 and set the sampling rate to 64 kHz, you can see the broad spectrum up to 28 kHz as shown in the figure below.

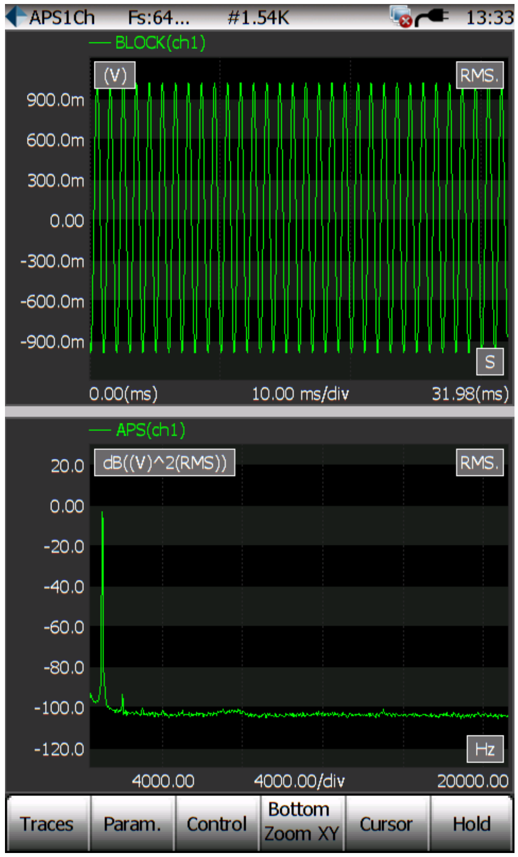


Figure 226 The auto spectrum of an 1kHz sine wave when sampled at 64kHz

However you can also **simultaneously** show the spectrum of the decimated signal, decimated(ch1), with 8 times frequency resolution as shown in Figure 227. Note that in this example the two spectra are of the exact same time signal not of two samples acquired at different times.

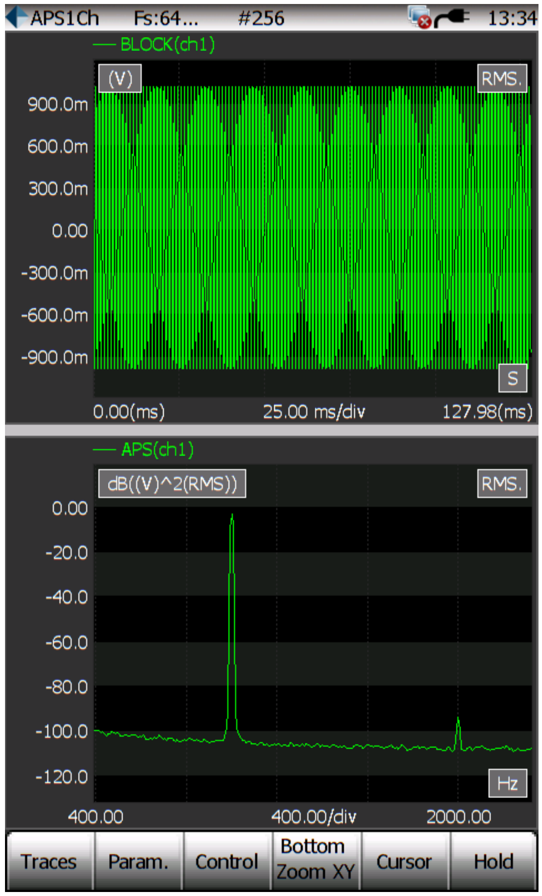


Figure 227 The same sine wave at 1kHz, after decimated 8:1, shows at different location on the spectrum

CSA Editor Operation for Real Time Filters

Applying a real time filter in the CSA Editor is very easy. The Real Time Filters can be applied to a CSA created with any of the first five CSA templates including: Data Conditioning Only, Transient Capture, Linear Spectrum, Auto Power Spectrum and Frequency Response. It cannot be applies to Octave Analysis, Sound Level Meter or Order Tracking Analysis.

In the Data Conditioning Tab, drag and drop the filter module to after any of data time streams and connect them. Note that the time stream can be split into multiple paths so for example you can monitor the time stream with two different filters at once as shown below or the filtered and unfiltered signals can be monitored at the same time.

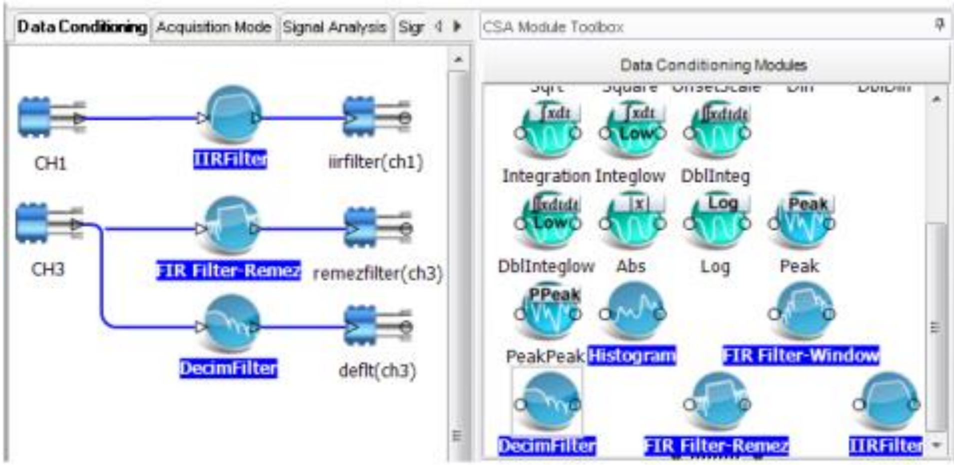


Figure 228. Add filters in the Data Conditioning tab.

To enter the filter design dialog box, right click on the filter icon in the Data Conditioning Window, then select Edit Parameters. This opens the filter design window where you can edit the filter settings.

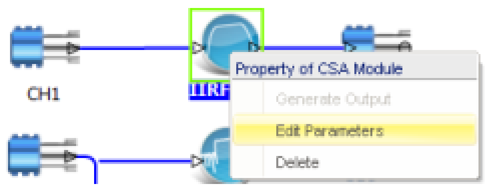


Figure 229. Edit filter parameters.

Validation, Save and Upload

After the CSA design, you should validate the CSA by pressing the Validate icon. If the validation passed, you can upload it to CoCo and run it there in real-time.

CoCo-80X Operation

There is no special operation on the CoCo hardware when real-time filters are applied. Each of the filter outputs are available as a regular time stream. You can display, record or analyze the time streams in the same way as you do with the native input time streams.

It is important to keep in mind that the cutoff frequencies are relative to the sampling rate, when the sampling rate changes, the cutoff frequencies in absolute Hz will be changed. For example, when the sampling rate is 1000 Hz, a 0.1 cutoff frequency means 100 Hz. If the sampling rate is changed to 102.4 kHz, the cutoff frequency will be moved to 1.024 kHz.

An Example

The following figures show an example from design to run-time results. It shows a band-pass Hanning filter with cutoff frequency from 0.12 to 0.37. The Filter order is 13.

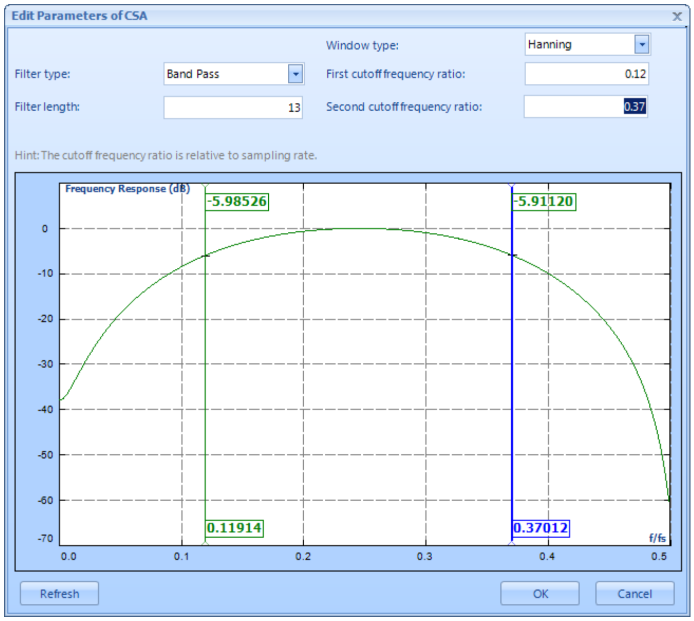


Figure 230. CSA filter design window.

After the CSA is created, validated and uploaded to the CoCo, the signal source is set as white noise and connect to the channel with this filter applied.

The following figure shows the time domain display for the signals before in green and after the filter in pink.

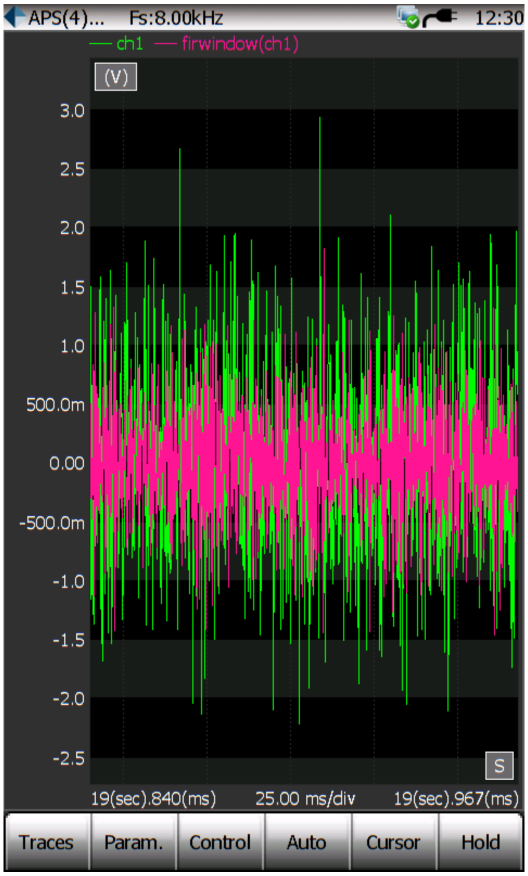


Figure 231. Filtered and unfiltered white noise in the time domain.

Histogram and Statistic Measures

A histogram is a graphical display that shows the number (or frequency) of events that fall into each of several or many specified categories. Figure 232 shows a typical histogram.

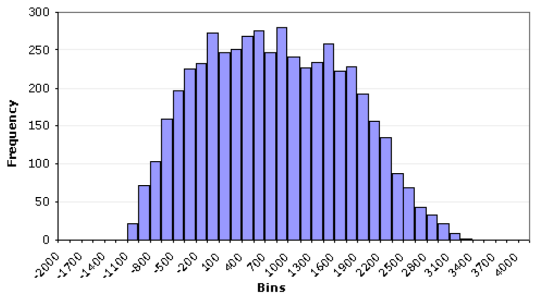


Figure 232. Typical Histogram.

Mathematically, a histogram is a mapping mi that counts the number of observations that fall into various disjoint categories (known as bins). Thus, if we let n be the total number of observations and k be the total number of bins, the total number of events can be found by adding the frequency in all the bins as

$$n = \sum_{i=1}^{k} m_i$$

Cumulative Histogram

A cumulative histogram is a mapping that counts the cumulative number of observations in all of the bins up to the specified bin. That is, the cumulative histogram M_i of a histogram m_i is defined as:

$$M_i = \sum_{j=1}^{i} m_j$$

In CoCo implementation, the Histogram and Statistics function is a single CSA module that can be applied to any time stream. The output of the Histogram and Statistics module is a histogram signal and the associated statistics results. You can change the display format on CoCo.

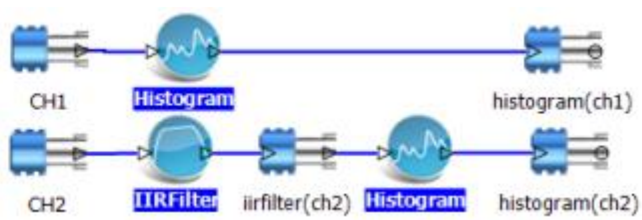


Figure 233. Histogram example.

CoCo provides the following measurement parameters for a histogram: bin number for the bar chart and amplitude ranges. It provides the following display formats for the histogram graph: normalized-linear, normalized -logarithmic, un-normalized and cumulative. While the histogram is measured, it also provides the following statistics values: mean, max, min, RMS, variance, skewness, crest factor and kurtosis. The definitions of these statistics measures for N samples are:

$$Mean = \mu_x = \bar{x} = E(x) = \left(\sum_{i=1}^{N} x_i\right)/N$$

$$Variance(x) = \left(\sum_{i=1}^{N} (x_i - \bar{x})^2\right)/N$$

$$standard\ deviation\ \sigma = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^2\right)/N\right]^{\frac{1}{2}}$$

$$rms(x) = \left[\left(\sum_{i=1}^{N}(x_i)^2\right)/N\right]^{\frac{1}{2}}$$

The rms(x) is equal to the standard deviation when the mean is 0.

Skewness is a measure of the asymmetry of the data around the sample mean. If the skewness is negative, the data are spread out more to the left of the mean than to the right. If the skewness is positive, the data are spread out more to the right. The skewness of the normal distribution (or a perfectly symmetric distribution) is zero.

$$Skewness(x) = \left(\sum_{i=1}^{N}(x_i - \bar{x})^3\right)/N\sigma^3$$

Kurtosis is a measure of how outlier-prone a distribution is. The kurtosis of the normal Gaussian distribution is 3. Distributions that are more outlier-prone than the normal distribution have kurtosis greater than 3; distributions that are less outlier-prone have kurtosis less than 3.

$$Kurtosis(x) = \left(\sum_{i=1}^{N}(x_i - \bar{x})^4\right)/N\sigma^4$$

As an example, a histogram of a Gaussian random noise is displayed in the figure below.

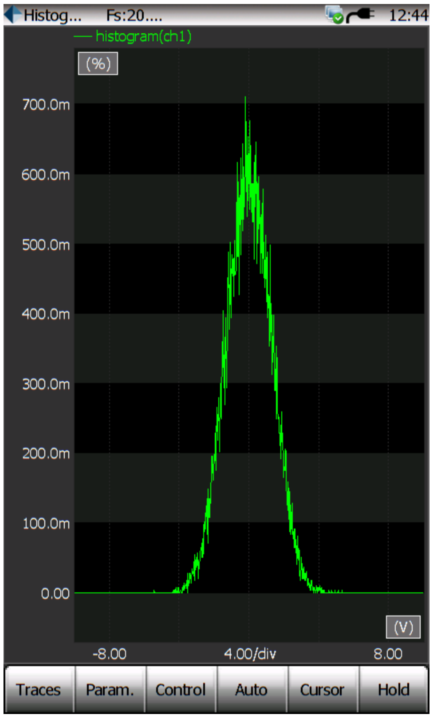


Figure 234. Histogram of a Gaussian distributed random signal.

Its cumulative histogram is displayed in the figure below.

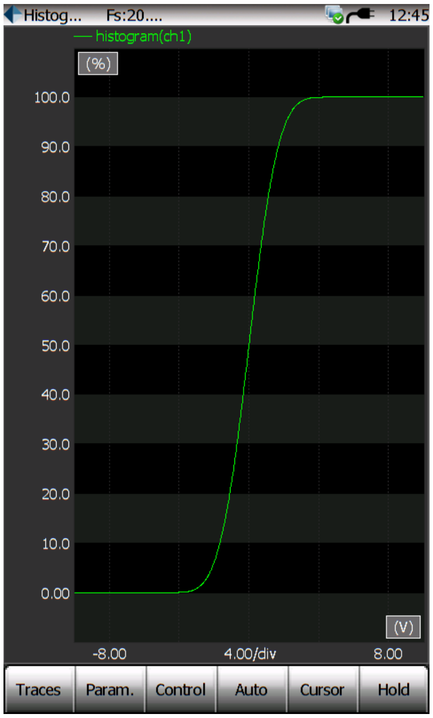


Figure 235. Cumulative Histogram of random Gaussian signal.

The display format can be changed to analyze the histogram. For example, a signal distribution with high Kurtosis can be observed using a logarithmic vertical scale with dB units, in the unit of dB, as shown in the figure below. Here the low frequency outliers can more easily be seen.

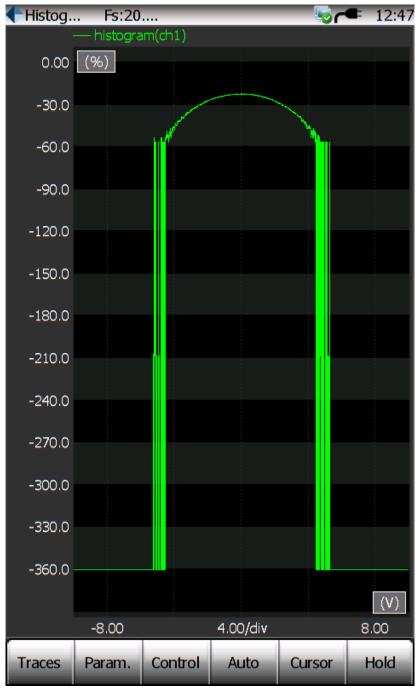
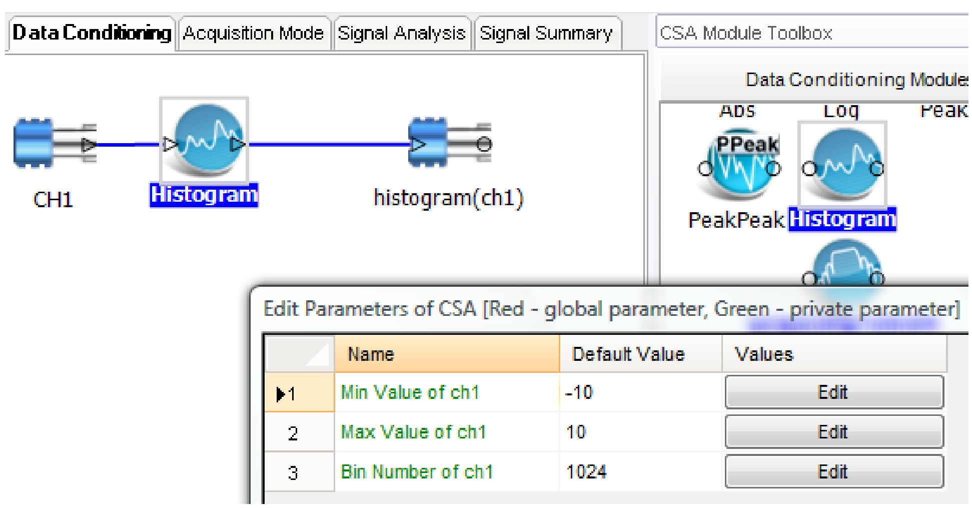


Figure 236. Histogram with dB scale.

CSA Editor Operation

Drag the Histogram module to any time streams that you want to analyze, and then connect the time stream to that histogram module. The output signal of Histogram will be display automatically on the screen.



Right-click on the Histogram module, select item of Edit Parameters, the dialog box will be prompted to all you to set the range and the default values of three parameters:

Min Value: minimum value in the amplitude, in engineering unit, for this histogram measurement

Max Value: maximum value in the amplitude, in engineering unit, for this histogram measurement

Bin Number: number of bins within the range,

Finally validate and Upload the CSA to the CoCo hardware.

CoCo-80X Operation

The CoCo can display the histogram in five different modes: normalized, un-normalized, log normalized, log un-normalized, and cumulative. To make such a selection, select View Mode in the Trace and Window Setting under the Traces menu.

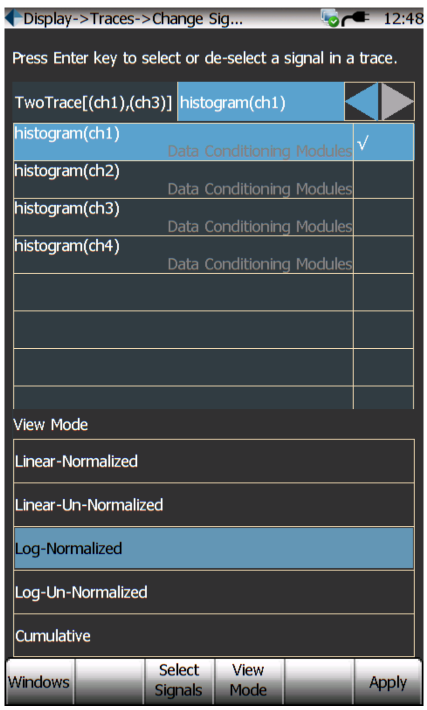


Figure 237. Change the histogram display format.

Saving and Recording Data

Ranging from different applications, several ways are devised to save the signals that are being measured. The media of storage can be either internal flash memory or SD memory card.

Save Long Time Waveform Signal: the time streams can be saved either automatically by a preset schedule or manually.

Save Block Signals Continuously: The transient capture time signals, frequency signals or other block signals can be saved automatically or manually.

Save Points: The current value of the time streams, or RMS of a spectrum, or multiple statistics of signals, can be saved automatically or manually into one file over long period of time. This is particularly useful in the monitoring applications.

The data can be saved either manually or automatically.

Save Long Time Waveform Signals

The Rec./Stop Button is used to control the streaming of time stream data to memory. After a CSA project is selected, pressing the Rec./Stop button will start the display and also start recording the time stream to memory. The red flashing Rec icon at the top of the screen indicates that the data is recording.

To stop the recording, press the Rec./Stop button again. The red flashing Rec icon will not be displayed, indicating that the recording has stopped.

Before a timestream can be recorded it must be defined in the Parameter Settings/Time Steam Recording Setup. If no time streams are defined in this setting when the Rec./Stop button in pressed then a message will indicate that no signal are selected.

The Rec./Stop button can also be pressed after the Run button is pressed. The Run button starts the display of live signals but does not start recording. After a recording is stopped the display will continue to display live signals until the Hold button is pressed.

A special data compression algorithm is developed in order to save the storage space. It only applies to time stream recording.

Each data point sampled by the CoCo-80X is an effective 32bit sample. The estimated total recording time for uncompressed data is as follows:

$$\frac{32\ bits}{sample} * \frac{samples}{\text{second}} = \frac{\boldsymbol{X}\ bits}{\text{second}}$$

$$\frac{\boldsymbol{X}\ bits}{second} * \frac{1\ byte}{8\ bits} = \frac{\boldsymbol{Y}\ bytes}{second}\ per\ channel$$

$$\frac{Total\ memory\ in\ bytes}{\boldsymbol{Y}\ bytes/sec} = \boldsymbol{Z}\ seconds\ total\ recording\ time$$

As an example, with a default sampling rate of 20.48 kHz for 2 channels recording to a 4GB SD card that yields 3.74GB of total storage, the total recording time amounts to:

$$\frac{32\ bits}{sample} * \frac{20{,}480\ samples}{\text{second}} = \frac{655{,}360\ bits}{\text{second}}$$

$$\frac{655{,}360\ bits}{second} * \frac{1\ byte}{8\ bits} = \frac{81{,}920\ bytes}{second}\ per\ channel$$

$$\frac{81{,}920\ bytes}{second} * 2\ channels = \frac{163{,}840\ bytes}{second}\ on\ two\ recording\ channels$$

$$\frac{3{,}740{,}000{,}000\ total\ memory\ in\ bytes}{163{,}840\ bytes/sec} = 22{,}827\ seconds\ total\ recording\ time$$

Or 380 minutes or 6.34 hours total recording time.

When data compression is used, the storage space will be doubled. The spectrum dynamic range of compressed data will be reduced to about 100dB. If the storage space and downloading time is not an issue for your application, then data compression should not be used.

The figure below illustrates the difference between the concepts of **Display - Run/Hold**, **Time Stream - Record/Stop** and **Signal - Save**. The Display mode is independent of the Record or Save functions. When you change the Display mode between Run and Hold it has no effect on the Save or Record functions. That means that time streams can continue to be recorded when the display is in Hold mode.

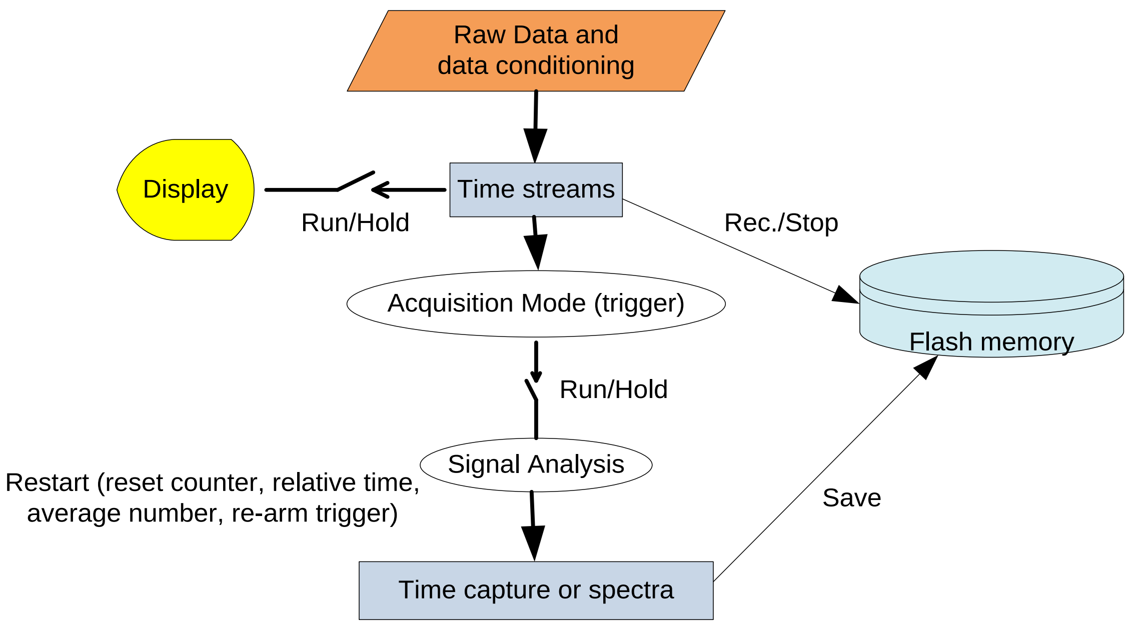


Figure 238. Illustration of the difference between Display Run/Hold, Time Stream Record/Stop and Signal Save.

Save Block Signals

Data can be saved by defining which signals to save and under what conditions. Select Spectral Save Setup under the Param. Button.

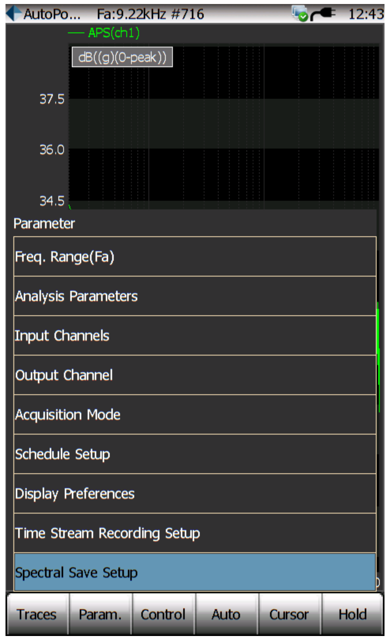


Figure 239. Spectral Signal Save Setup

Choose which signals should be saved by using the Up and Down Arrows and the Enter Button to add a check next to the desired signals. These signals will be saved during a measurement when you manually press the Save Button.

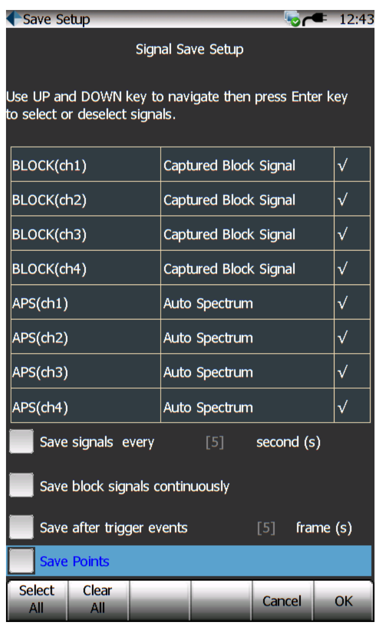


Figure 240. Spectral Signal Save Setup

In addition, these signals can be automatically saved by placing a check next to "Also enable a timer" and specifying the number of seconds between automatic saves. The signals can be saved with no delay between blocks by selecting Save Signals Continuously. This option can be used to view all data blocks on a waterfall plot.

Save Points

Save Points function saves a data point per signal at one time. This function is particularly useful in the very long period monitoring applications. For example people can save and monitor the vibration or acoustic level over a few months by looking at the data points saved every hour.

All data points in one test will be saved into one data file. The user can easily open, view and analyze the data files using EDM PC software.

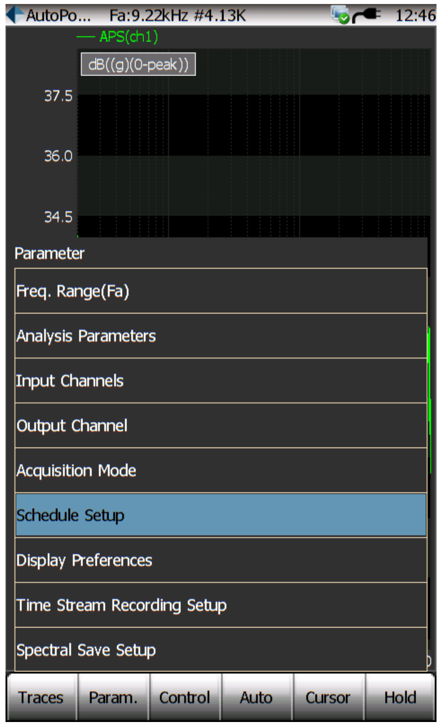
To set up the Save Points, first go to Param.->Signal Save Predefined List screen, then press F4 the Save Point Setup button, which will show a tab display. The user can select Current Value, Max, Min, Peak, Average, or RMS for time signals or Peak, RMS, or Frequency of Peak for spectral data. In the Sound Level Meter function, Leq or Lmax can also be selected.

Using Schedule to Save Data

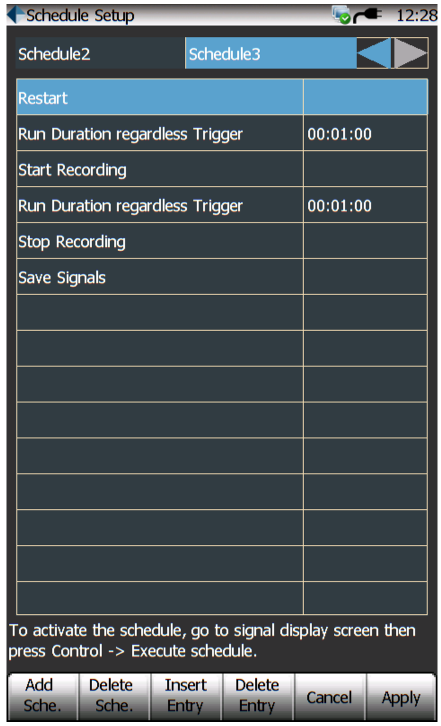
An automated schedule can be developed for recording the time streams, saving the block signals or data points.

1. Restart
2. Hold
3. Run Duration regardless Trigger
4. Run Duration after Trigger
5. Waiting for one time
6. LOOP
7. END LOOP
8. Limit check ON
9. Limit check OFF
10. Start Recording
11. Stop Recording
12. Save Signals
13. Turn signal source ON
14. Turn signal source OFF
15. Activate Timer to Save Signals
16. Deactivate Timer to Stop Saving Signals
17. Set all input mode
18. Reset Average
19. Set Output Parameters
20. Enable Channel Calibration
21. Disable Channel Calibration
22. Log Test Result

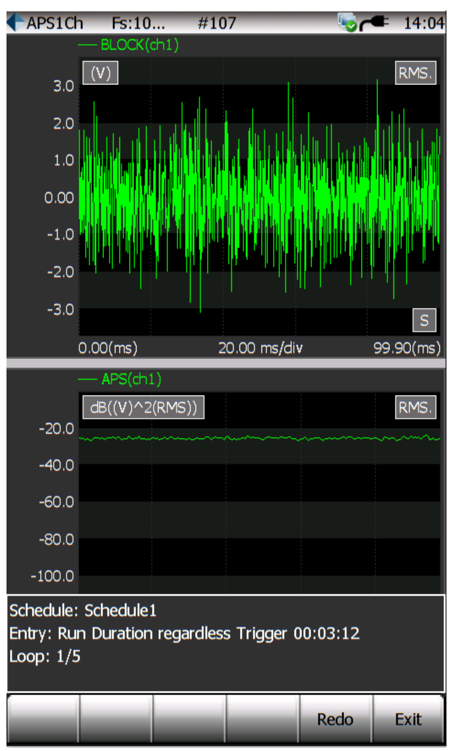
To make a schedule, first go to the Schedule Setup screen:



Insert appropriate entries into the schedule:



To activate the schedule, press the Display button for more than 3 seconds then release the button.



To deactivate the schedule, press F6 Exit button in the signal display screen.

Recall Signals

Signals that are the result of a current measurement are named "live" signals. Occasionally it is helpful to compare live signals with previously saved signals and stored on the CoCo device. This can be done with the recall feature. Recalled signals can be overlaid with live signals for comparison or displayed in a separate window. Signals can also be un-recalled which removed them from all displays but does not affect the data saved on the CoCo.

To recall the signals that you just saved, press the Recall hard button.

To recall a signal that you previously saved, press the File Button, then press the F4 View Files Button. Next use the up and down arrow buttons to highlight a signal to be recalled and press the F4 Recall Button. Next highlight a signal from the Record Files list and then press the F4 Recall Button.

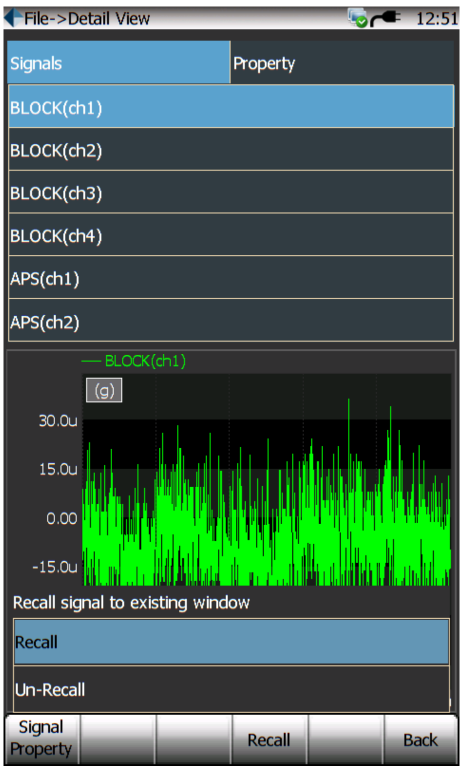


Figure 241. File review screen for recalling signals.

The CoCo will show a menu listing all available windows that this signal can be recalled into. The last item is always "Recall the signal to a new window". This item will create a new display window in the current active project and display the recalled signal into this window. Other selections will allow the recalled signal to be overlaid with the others.

After a signal is recalled, it can then be un-recalled. This removes the signal from the all displays however the original data file remains stored on the CoCo. To un-recall a signal, take one of the following two actions.

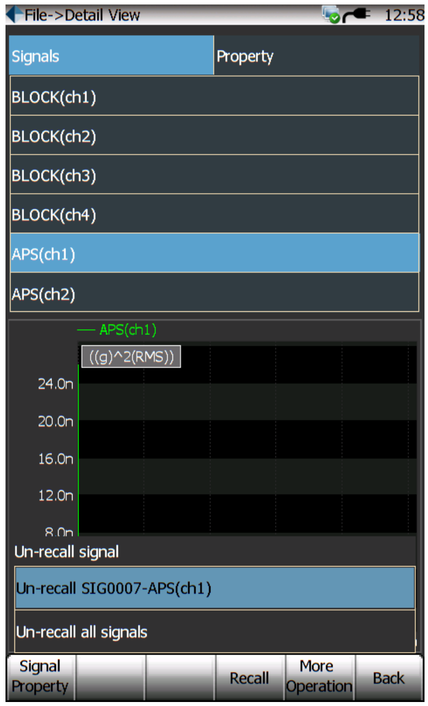


Figure 242. Recall signal popup menu.

Method 1: In the above file menu, press F4 to see all signals that can be un-recalled. You can either un-recall one signal or un-recall all of them.

Method 2: Under the *Traces* menu, select the last command *(Recalled Signal List)*:

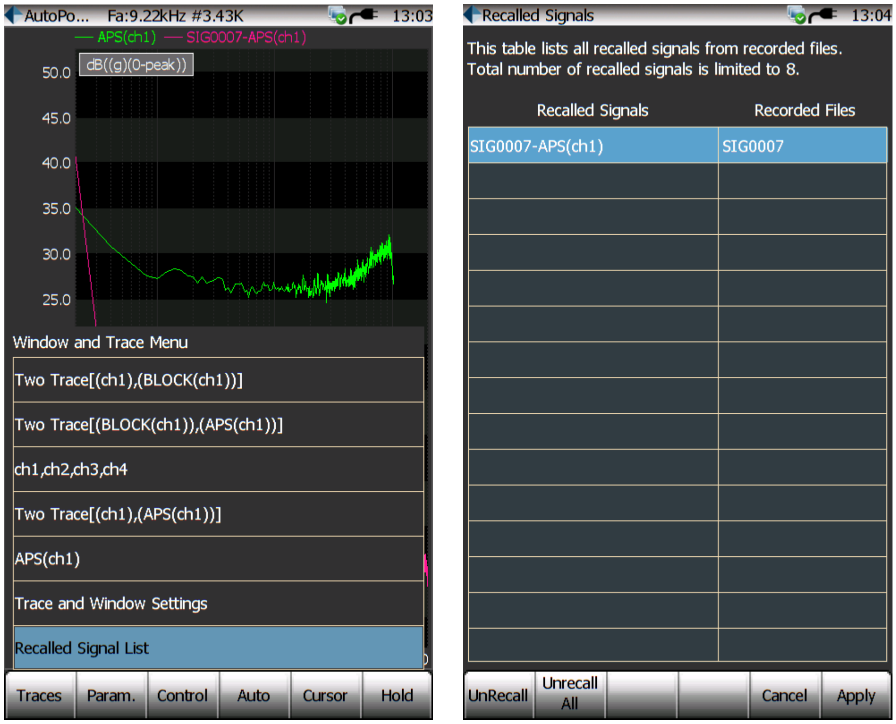


Figure 243. Recall signals from the trace menu and un-recall the signal

The recalled signals will have a signal name with a prefix of its file name. The recalled signals can be displayed in the same way as live signals.

The picture below shows a recalled signal in pink color overlaid with a live signal in green.

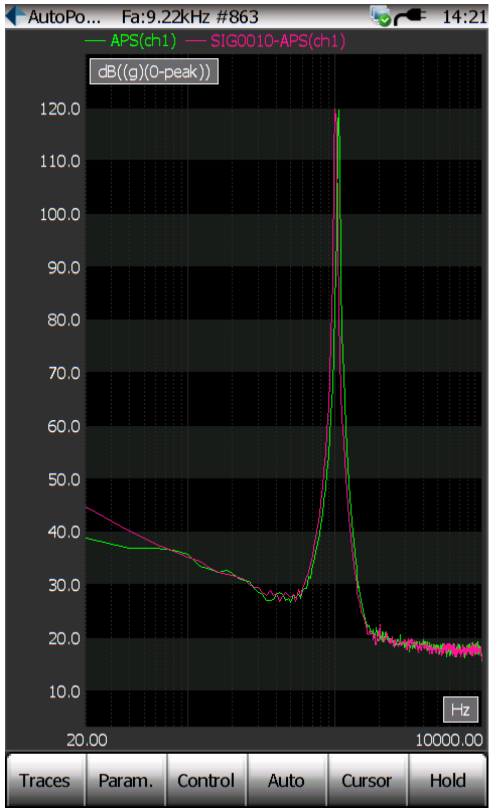


Figure 244. Live signal overlaid with recalled signal.

The CoCo DSA Mode of EDM

The EDM Software functions as both the means of transferring data from the CoCo-80X to the PC and also as a data management and analysis tool. The main features of the software include: transferring data between the CoCo-80X and a PC, viewing, searching and exporting data to other formats and using the analysis tools to measure signal characteristics.

Data Transfer

After a connection is established between the CoCo-80X and a PC, the EDM software manages the transfer of data between the two devices. The data includes recorded time streams, saved signals, and CSA projects. When EDM detects the connection, the software displays a list of the files available for transfer and allows the use to initiate the download to the PC. After files are downloaded they can be deleted from the CoCo-80X flash memory to create free space for new data files.

Data Management

The nature of signal measurement generates a large number of records. The EDM software provides tools to manage this data to simplify searching, reviewing and exporting the data. Data can be searched by key words, date, time, size or other file attributes. Data can be previewed via thumbnail representations of the data or by text file attributes. Data can be replayed within the search tool including the ability to scroll through a long time stream to verify that the record contains the required properties. EDM simplifies the process of exporting data from the native ASAM ODS format to other popular universal formats including UFF, BUFF and ASCII.

Data Analysis

The EDM software includes basic analysis tools that help measure signal characteristics such as zoom, pan and cursors. Multiple signals can be overlaid on one trace for comparison. Long time streams can be played back and time or frequency data can be displayed.

CoCo-80X – PC Communication

The first step in downloading data from the CoCo-80X to a PC is to establish communication between the two devices. CoCo-80X is equipped with a number of hardware connectivity functions for easy communication with a host PC. These include:

- USB port
- 100BaseT Ethernet
- Wireless 802.11b/g/n
- External SD card

You can choose one of the following four typical connections:

- Connect CoCo-80X to a PC directly using a USB cable
- Connect CoCo-80X to a PC directly using Ethernet via cross-over cable
- Connect CoCo-80X to a local network using Ethernet where a host PC resides on the local network
- Connect CoCo-80X to a local wireless network

The table below summarizes the configuration for these connections.

Connection method	CoCo-80X Configuration	Host PC Configuration	Transfer Data	EDM Connection
Connect CoCo-80X to a PC directly using USB	No special configuration required	Install the EDM host PC software	✓	✗
Connect CoCo-80X ethernet directly to a PC (One-to-One)~~directly using Ethernet via cross-over cable~~	~~CoCo-80X must be configured with a fixed static IP~~Fixed Static IP or DHCP, depending on PC configuration	Fixed Static IP or DHCP, depending on PC configuration~~Host PC IP must be configured with fixed static IP at the same subnet mask as that of CoCo-80X~~	✓	✓
Connect CoCo-80X to a local network using Ethernet where a host PC resides on the local network	If DHCP server is installed on the local network, CoCo-80X can obtain an IP address automatically. If DHCP server is not installed on the local network, fixed static IP address must be configured on CoCo-80X.	If DHCP server is installed on the local network, host PC can obtain an IP address automatically. If DHCP server is not installed on the local network, fixed static IP address must be configured on the host PC. Same subnet mask must be used.	✓	✓
Connect CoCo-80X to PC wirelessly	Enable the Wi-Fi on the CoCo-80X which acts as a DHCP Server with a broadcasting SSID.	Host PC searches and connects to the CoCo-80X via its wireless adapter.	✓	✓

Table 5. PC to CoCo-80X Configuration Summary.

In this table, *DHCP (dynamic host configuration protocol) server* refers to a piece of software installed on the local area network, either wired or wireless, that supports the "Obtain an IP address automatically" function on any networked device. DHCP is commonly used in most office networks.

This table indicates that the USB connection can transfer data to EDM, but it can't 'connect with EDM'. This connection with EDM allows for additional features beyond data transfer, such as Remote Display and CSA configuration.

Transfer Data Files to the Host PC

To transfer the recorded data files to a PC, you must:

1. Establish a physical network connection between the CoCo-80X and a PC. This can be done either by using the Ethernet, USB-client port, or SD wireless card.

2. Execute the EDM software on the PC.
3. Download the data files from the CoCo-80X to PC using EDM software.

The data files will be automatically stored in the ASAM-ODS format. They can be converted into other formats with the EDM software.

Configuring the CoCo-80X Network Settings

CoCo-80X Network Settings must be configured when an Ethernet or Wi-Fi is used for communicating with the host. When USB is used for the connection, this section can be ignored.

To configure the network settings for the CoCo-80X, complete the following steps:

1. Power on the CoCo-80X. In the Main Setup page, tap the Connections and press ENTER.

2. In the **Connection Type** window, click **IP Address** to specify a static IP address and subnet mask. Type in the **IP address** and **Subnet mask**. You must specify a static IP address and use a crossover cable to directly connect the CoCo-80X to the host computer. In this case, both the Gateway and DNS server fields must be blank or set to zeroes. If the network uses a DHCP server and you are not directly connecting the CoCo-80X to the host computer with a crossover cable, click the **Obtain an IP address via DHCP** option button.

3. Click **Apply** to apply the changes.

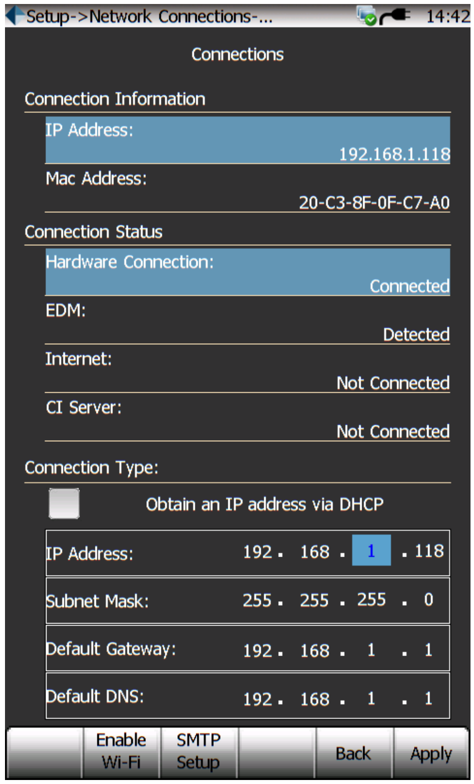


Figure 245. Ethernet connection status.

Configuring the Host PC Network Settings

If the host system is a PC, which is only connected directly to the CoCo-80X using a cross over Ethernet cable, you can manually configure the TCP/IP settings. You can also use the “alternate configuration” functionality to maintain seamless operations on both office and private networks without having to manually reconfigure the TCP/IP settings. Choose whichever method best applies to your system configuration and connectivity needs. Refer to the Microsoft support website for more information on “alternate configuration”, which can be found at http://support.microsoft.com/kb/283676.

Note: You must be logged onto the host system as an Administrator in order to change network settings. Contact the system administrator to get access to the necessary privileges.

Connect CoCo-80X to a PC directly using USB client

A USB connection is the easiest method to connect the CoCo-80X to a PC. This only requires installing the EDM software on the PC.

Connect CoCo-80X to the PC through the provided USB cable. This cable has a mini-client port connecting to the CoCo-80X and a flat USB port connecting to the PC.

Connect CoCo-80X to a PC directly using Ethernet via crossover cable

Another way to connect the CoCo-80X to a PC directly is to use the Ethernet port and a CAT-5 (or above) cross-over cable. The advantage of using Ethernet compared to USB is that the data transfer speed is faster with Ethernet. The disadvantage is that you must configure the IP settings on the host PC so it can communicate with the CoCo-80X.

In this case, both PC and CoCo-80X must be configured with a fixed IP address with the same subnet mask. The host PC can also use the Alternative Configuration feature for convenient communication with its office local area network. Alternate Configuration is a networking option within Windows to maintain seamless operations on both office and home networks without having to manually reconfigure TCP/IP settings. Refer to the Microsoft support website for more information of this feature.

http://support.microsoft.com/kb/283676

Connect CoCo-80X to a local network using Ethernet

In this connection case, if DHCP server is not installed on the local area network, both PC and CoCo-80X must be configured with a fixed IP address with the same subnet mask. If DHCP server is installed, then both the PC and the CoCo-80X can use the **Obtain an IP address automatically** function.

Connect CoCo-80X to a PC directly via Wi-Fi

In this connection case, CoCo-80X is a DHCP server and broadcast its SSID. Use PC to find the CoCo-80X from its wireless connection list; join the network hosted by the CoCo-80X.

Network Connection Diagnosis

The following section describes methods for diagnosing network connectivity from the CoCo-80X or the PC which may be helpful when setting up the network connection.

The network setting detection shows the following status:

IP Address: indicates the IP address of the CoCo-80X.

DHCP server: indicates whether the CoCo-80X has detected a DHCP server on the local area network.

Hardware Connection: indicates whether the CoCo-80X is connected to the EDM.

EDM: indicates whether CoCo-80X is detected by the EDM

Internet: indicates whether the CoCo-80X is connected to the Internet.

CI Server: indicates whether the CoCo-80X is detecting the Crystal Instruments server. The CI server is used to host new software to keep the CoCo-80X up to date.

Diagnosis from the PC

The connection between the CoCo-80X and a PC is managed within the EDM software on the PC. The EDM software provides connection diagnosis capability. The Connection Wizard dialog box will show one of the following four connection pictures:

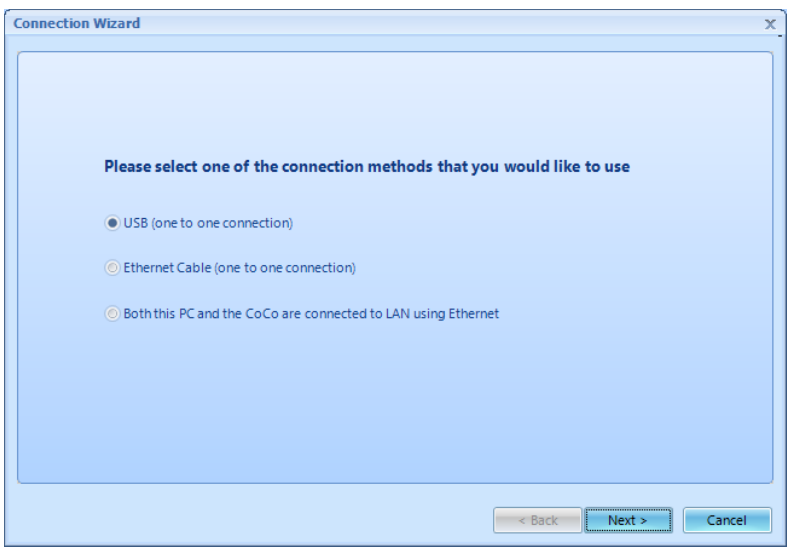


Figure 246. EDM network connection status screen.

Select appropriate connection type, and follow the online instructions. The EDM will provide diagnose information.

Data Format

The data format within the CoCo-80X and the EDM software is the ASAM ODS File format. ASAM ODS files have the suffix ATFX. EDM also interfaces to other file formats including NI-TDM, MatLab, UFF, BUFF and user-defined ASCII files.

ASAM ODS (Open Data Service)

The rapid progress in hardware and software leads to storage of data in many different data base systems as well as under different hardware and/or server generations. During development and production of complex products, a huge mass of data is produced. Today, data are stored within the automotive industry in a standardized format specified by the ASAM ODS workgroup. ASAM stands for *Association for Standardization of Automation and Measuring Systems*, and ODS stands for "Open Data Services". The CoCo-80X uses the ASAM ODS data format as the internal data format and data is saved by default in this format when it is downloaded from the device to a PC.

The ASAM ODS standard has the fundamental quality of storing data with an architecture-independent method. This leads to great advantages when exchanging data between different sources and possible prospective customers.

Many systems in test, evaluation, and simulation environments have their own proprietary formats to store data. These formats usually are very different from each other regarding the description of the configuration (unit under test, test sequence, test equipment, etc.) as well as the way results are stored (database, binary files, etc.).

The main objectives for standardization of data access interfaces are to reduce costs and risks within projects, and to provide a reliable basis for implementations in the area of data storage and data usage. Using standardized interfaces and common structures minimizes the efforts for the system integration within the heterogeneous environments discussed above and makes it much easier to exchange data.

Because of these benefits the ASAM ODS data format was chosen as the internal format for the CoCo-80X and the EDM software.

UFF Files

The CoCo-80X and EDM Software also support the Universal File Format (UFF). This format was originally developed by the Structural Dynamics Research Corporation (SDRC) in the late 1960s and early 1970s to facilitate data transfer between computer aided design (CAD) and computer aided test (CAT) in order to facilitate computer aided engineering (CAE). SDRC, as part of EDS, continues to support and utilize the UF formats as part of their CAE software. Currently, MTS, Noise and Vibration Division supports and continues to develop IDEAS software in the test area that utilizes UF formats.

The formats were originally developed as 80 character (card image), ASCII records that occur in a specific order according to each UF format. As computer files became routinely available, single UF formats were concatenated into computer file structures. Recently, a hybrid UF file structure (UF Dataset 58 Binary) was developed for experimental data that allows data to be stored in a more efficient binary format.

Before the introduction of ASAM ODS, the use of the Universal File Format as a de-facto "standard" has been of great value to the experimental dynamics (vibration and acoustic) community, particularly in the area of modal analysis. Both users and vendors have benefited from this de-facto standard.

The EDM software will be able to export the data into UFF (Dataset 58) and BUFF (Dataset Binary 58). For more information on UFF refer to http://www.sdrl.uc.edu/uff/uff.html.

The Binary 58 Universal File Format (BUFF)

The CoCo-80X and EDM software also support the BUFF format. The basic (ASCII) universal file format for data is universal file format 58. This format is completely documented by SDRC and a copy of that documentation is on the UC-SDRL web site (www.sdrl.uc.edu/UFF2/58.asc). The universal file format always begins with two records that are prior to the information defined by each universal file format and ends with a record that is placed after the information defined by the format. First of all, all records are 80 character ASCII records for the basic universal file format. The first and last record are start/stop records and are always -1 in the first six columns, right justified (Fortran I6 field with -1 in the field). The second record (Identifier Record) always contains the universal file format number in the first 6 columns, right justified.

This gives a file structure as follows (where b represents a blank character):

```
bbbb-1
bbbb58
...
...
...
bbbb-1
```

The Binary 58 universal file format was originally developed by the UC-SDRL in order to eliminate the need to compress the UFF 58 records and to reduce the time required to load the UFF 58 data records. The Binary 58 universal file format yields files that are comparable to compressed files (approximately 3 to 4 times smaller than the equivalent UFF 58 file). The Binary 58 universal file format loads approximately 30 to 40 times faster than the equivalent UFF 58 file, depending on the computing environment. This new format was submitted to SDRC and subsequently adopted as a supported format.

The Binary 58 universal file format uses the same ASCII records at the start of each data file as the ASCII dataset 58 but, beginning with record 12, the data is stored in binary form rather than the specified ASCII format. The identifier record has the same 58 identifier in the first six columns, right justified, but has additional information in the rest of the 80 character record that identifies the binary format (the size of the binary record, the format of the binary structure, etc.).

```
    -1
    58b      x      y           11          zzzz      0      0
0           0
...
... (11 ASCII header lines)
...
...
... (zzzz BINARY bytes of data, in format specified by x
and y, above)
... (interleaved as specified by the ASCII dataset 58)
...
    -1
```

When reading or writing a dataset 58b, care must be taken that the binary data immediately follows the ASCII header lines and the closing '   -1' immediately follows the binary data. The binary data content is written in the same sequence as the ASCII dataset 58 (i.e. field order sequence). The field size is NOT used, however the data type (int/float/double) content is. Note: there are no CR/LF characters embedded in or following the binary data

ASCII UFF

The CoCo-80X and EDM software also support the ASCII UFF format. The ASCII UFF file format is a form using the ASCII type to represent all the data sets. For details, see: http://www.sdrl.uc.edu/uff2/58.asc

MATLAB file

This is the standard file that can be imported into MatLab.

NI-TDM file

This is a structured data format that is defined and widely used by the LabVIEW from National Instruments.

User Defined ASCII file

These are the ASCII files where you have the freedom to define its attributes and header format.

.CSV (Microsoft Excel) File

This is the ASCII file that the Microsoft Excel can directly read.

.WAV File

This is the sound wave files that can be played by most of the media players. Due to limited information a wave file can carry, the wave files exported only contain very basic waveform shape and do not hold any attribute information of ODS. You are expected to use the .WAV file to listen to its sound effect, instead of for data processing.

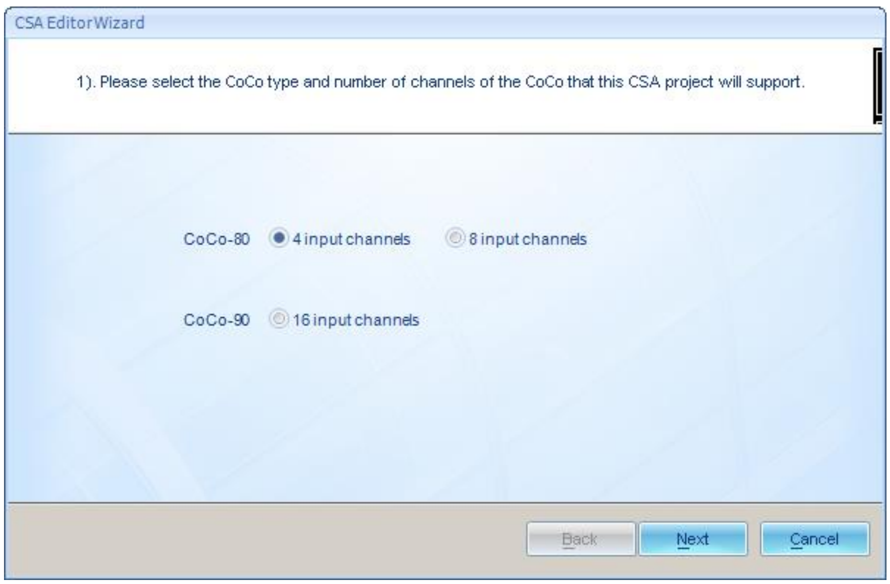
CSA Editor Operation for Spectral Analysis

This section describes the operation of CSA Editor related to FFT based spectral analysis. For general operation of CSA Editor, refer to the CSA User's Manual.

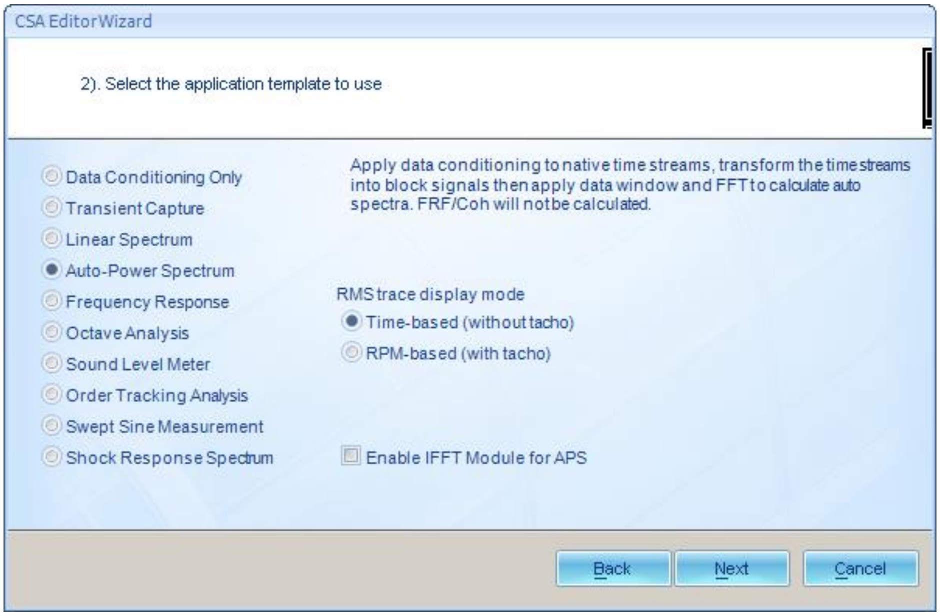
CSA Editor Wizard

To start the CSA Editor, click on the CSA Editor icon in the upper-right corner in EDM. The CSA Editor Wizard dialog box will be displayed.

First, select the number of channels for the project based on the CoCo device it will run on.



In the next screen, select the application template for the CSA project. Different templates have different functions available for signal processing. For FFT spectrum analysis, select Linear Spectrum, Auto Spectrum or Frequency Response. The software will open the CSA Application Group associated with the template that you choose.



The *Linear Spectrum* template can apply data conditioning to native time streams, transforms time streams into block signals, and do data windowing and FFT calculations to generate linear spectra.

Auto Power Spectrum is same as Linear Spectrum but can also calculate power spectra.

Frequency Response adds functions to calculate the cross spectra, Frequency Response Function (FRF), and coherence between two (or more) input channels.

Table 6 shows the functions available in the CSA templates. The other application groups, such Octave Analysis and Order Tracking Analysis, have more specialized functions and are not discussed here.

CSA Template	Time streams of native channels	Time streams for each data conditioning output	Acquisition Mode, Blocked Time Capture	FFT and Auto-Power Spectra	Cross Spectra	FRF/Coh
Data Conditioning Only	Yes	Yes	No	No	No	No
Transient Capture	Yes	Yes	Yes	No	No	No
Linear Spectrum	Yes	Yes	Yes	Yes	No	No
Auto Power Spectrum	Yes	Yes	Yes	Yes	No	No
Frequency Response	Yes	Yes	Yes	Yes	Yes	Yes

Table 6. Comparison of measurement quantities for different spectral analysis templates.

The Frequency Response template contains the most complete set of analysis functions. However, this does not mean that it is always the best template to use. Application groups with more measurement functions available require greater DSP resources. Heavy use of these resources, such as when using complex data conditioning, many channels, and high sample rates, will result in degradation of real-time computation ability.

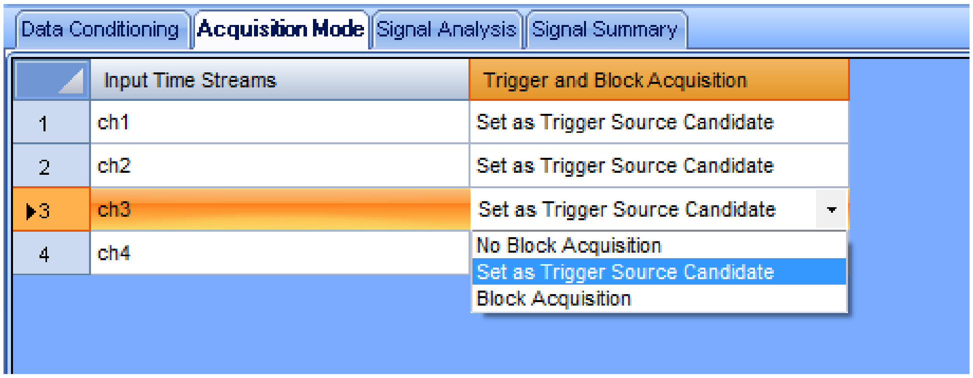
Every CSA project has a parameter for *Maximum Sampling Rate*. If the processing requirements of the project are too high, this setting will have to be reduced. It is best to choose the lowest sampling rate that will be required for the application to conserve resources.

After the CSA Editor Wizard is finished, an empty project will be created. Data conditioning functions can be configured by connecting the data conditioning modules to time stream blocks under the Data Conditioning tab. For more details, refer to the CSA Editor User's Manual.

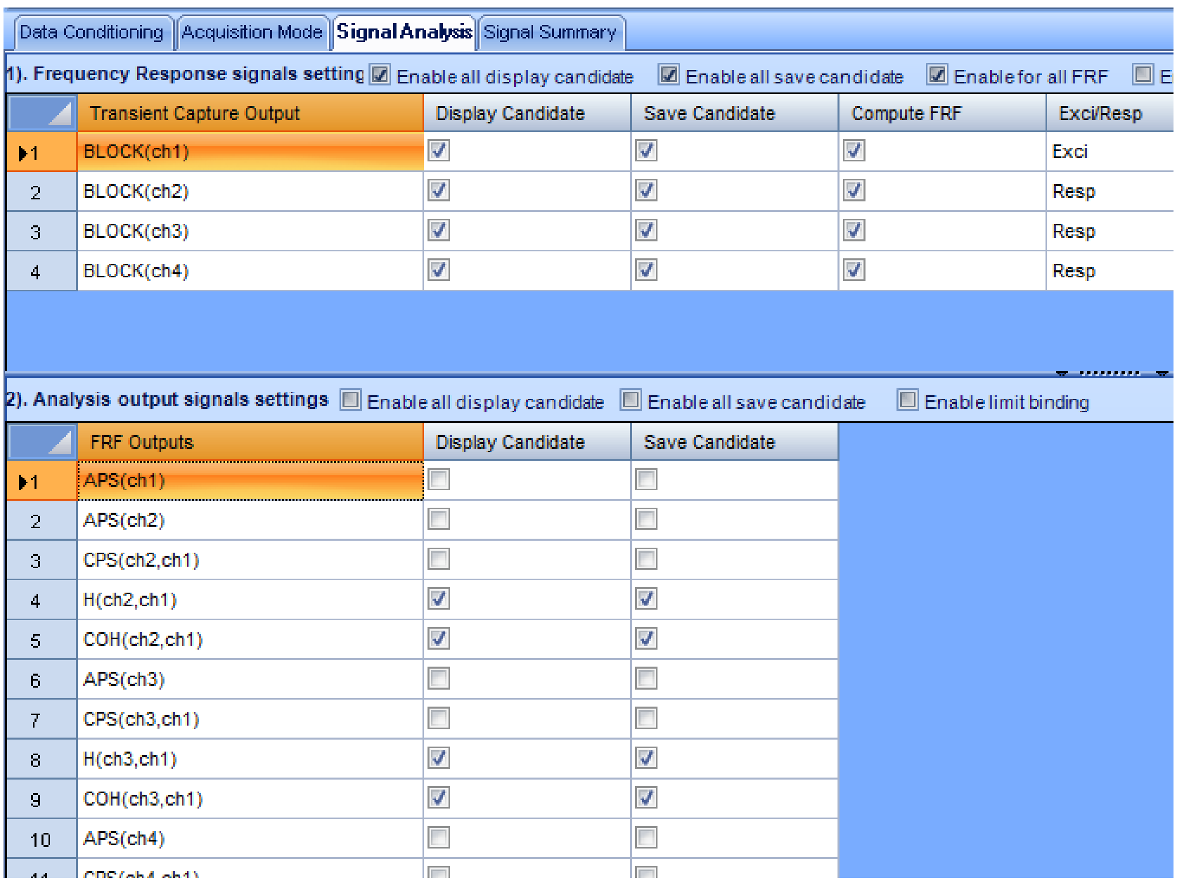
Select the Signals to Compute

The rest of this section assumes the Frequency Response template is used. With the other templates, some of these functions will not be available.

Under the Acquisition Mode tab, time stream signals can be selected for block acquisition. This is the process by which time streams are converted to a series of blocks. These block signals are then available for spectrum analysis functions such as Auto Power Spectrum and Frequency Response Functions. Time stream signals include the native channel sources and the output of data conditioning modules. Selecting "Set as Trigger Source Candidate" also enables the channel to be used as a trigger source in triggered acquisition modes. See __________ for more details.



The Signal Analysis tab has two sections. The upper half shows all available block signals, which are all the signals under the Acquisition Mode tab that do not have "No Block Acquisition" selected. The bottom half shows the available spectral analysis functions available for these block signals.



EDM uses a consistent naming convention for all signals. Time stream signals have a name, such as CH1, that identify its source. Signals derived from the time streams are named by the function that generated them followed by the source time stream signal in parenthesis. The types of signals include:

CH*n*: the native time stream signal of the *n*th input channel

BLOCK(*sig*): the block signal acquired from the time stream *sig*

APS(*x*): the Auto Power Spectrum of time stream *x*

CPS(*y*,*x*): the Cross Power Spectrum of excitation *x* and response *y*

COH(*y*,*x*): the coherence function of the excitation *x* and response *y*

FRF(*y*,*x*): the FRF of excitation *x* and response *y*

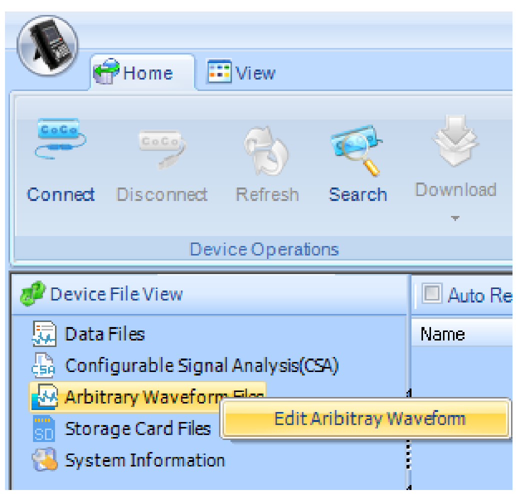
Signals enabled as *Display Candidates* will be selectable for display on the CoCo, and signals enabled as *Save Candidates* will be selectable for block data saving. Disabling some signals for Save and Display ability will simplify the interface on the CoCo.

For FRF and CPS, one signal must be selected as the excitation channel. The other channels become the response channels. The FRF, CPS, and COH functions are available for the response channels with the excitation channel as the reference.

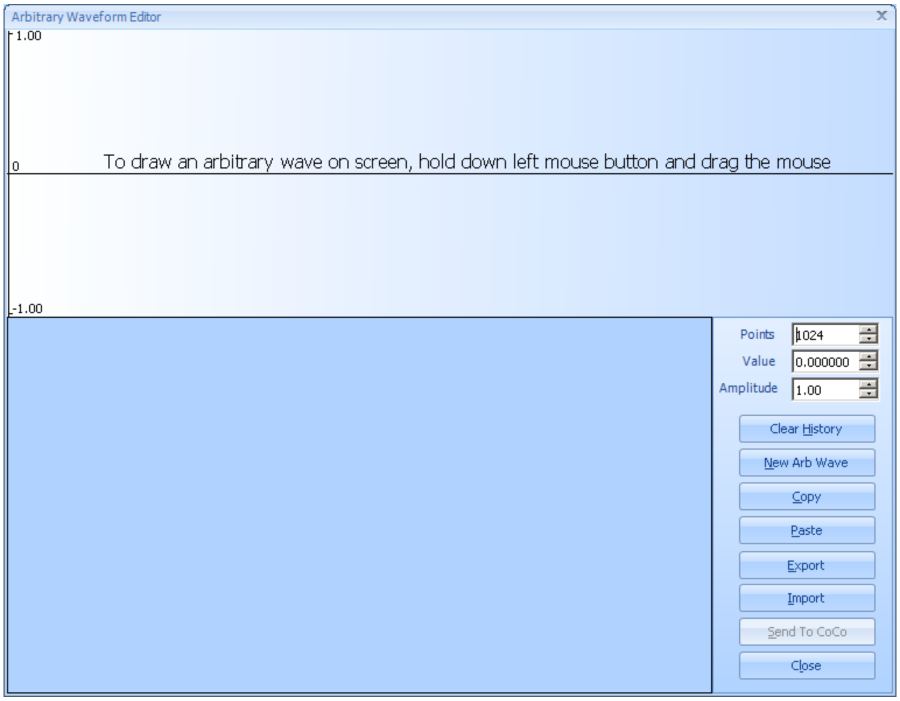
Editing an Arbitrary Waveform

The CoCo output channel can generate an arbitrary waveform from a file which can be programmed in the EDM software and uploaded to the CoCo.

To open the Arbitrary Waveform Editor in EDM, right click on “Arbitrary Waveform Files.”



To draw a waveform by hand, click and hold the mouse button then draw the desired Arbitrary waveform on the top half of the window.



After the waveform is completed, the value of each point can be changed by entering the value into the box.

New Arb Wave - creates a blank pane for another arbitrary waveform.

Copy and Paste let you copy the current waveform into a new waveform.

Export lets you save the arbitrary waveform as a text file which can be opened in a text editor or spreadsheet.

Import lets you import an arbitrary waveform that is saved as a text file.

You can also right-click on the name of waveform. This opens a pop up menu with copy, paste delete, export, and import.

Finally, right-click on the arbitrary waveforms and upload them. Then the arbitrary waveforms are ready to be output in CoCo.

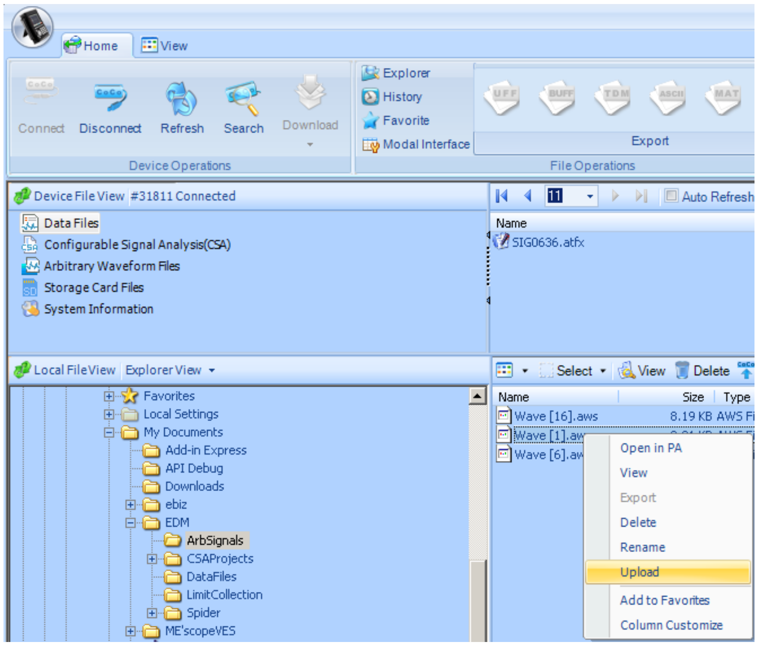


Figure 247. Upload the arbitrary waveform to the CoCo hardware.

Finally click on the Send to CoCo button to save the arbitrary waveform file on the CoCo hardware.

Validation

After the CSA Wizard is complete and the CSA file is created, connect the host PC to the CoCo device and press the Validate icon to validate the CSA. It may take a few minutes to finish the validation.

The validation process analyzes the CSA file for internal consistency and estimates the required DSA resources required to run the CSA file on the CoCo device.

If the Validation passes, then press the *Send to CoCo* command in the Validation dialog box to send the CSA project file to CoCo. Alternatively you can manually upload it to CoCo. The CSA uploaded will be classified into different CSA Application Groups based on the template that was used.

Advanced Audio Functions

CoCo-80X is equipped with advanced audio functions. These audio functions allow you to listen to the vibration or any measurement quantity or record voice annotations during signal recording. This document describes how to use the audio functions.

The advanced audio features can be summarized as following:

1. You can listen to any measurement input using headphones without interrupting the measurement or recording process. The audio monitoring is automatically scaled to the listening range and the headphone audio can be manually adjusted.
2. You can record voice annotations at any time and length during time stream recording.
3. A customized microphone is available with a push button to control voice annotation recording.
4. Voice annotations can be replayed on the CoCo hardware through headphones.
5. Voice annotations are attached to each recorded file, and can be played back on the PC using the EDM software
6. CoCo can play back any recorded time streams using its output port. The output port can drive another audio device such as headphones or external speakers.

These advanced audio functions require the following minimum hardware and software versions: CoCo Software Version ≥ 1.7.8; Base Hardware System Version ≥2.0.9; Measurement Hardware Version ≥ 10.1.0; Firmware Version ≥ 1.5.0.

Hardware Audio Peripherals

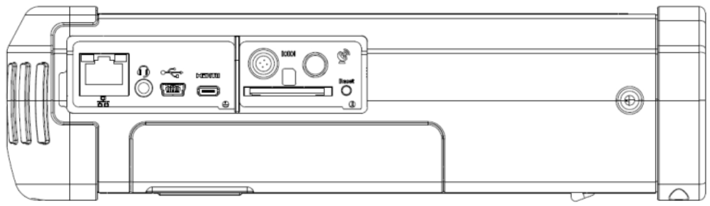
Three hardware audio peripherals are used for the advanced audio functions:

1. Internal Speaker
2. External Headphone
3. External Microphone

The internal speaker is used to generate system-related signals, such as the sound simulating the key press, power-on/off, or alarm. Voice annotations and measurement input audio can only be played back through headphones and not through the internal speaker.

The external headphone jack uses the 3.5mm stereo jack connector. You can connect any headphone to this connector.

The headphone jack is located at the second to the left with a headphone symbol. Voice annotations and measured input audio can be played back through the headphones.



The external microphone must be ordered from CI. It is designed so that when the microphone button is pushed, the voice annotation recording is activated. The microphone jack connector is on the left side of the peripheral panel. Do not use any microphone other than the specified CI microphone because you will not be able to start a voice annotation recording without the microphone button hardware.

Figure 248 Microphone with push button (part # CoCo-A12)

Audio Functions

The audio functions are controlled through the CoCo, Setup/Other/Audio screen.

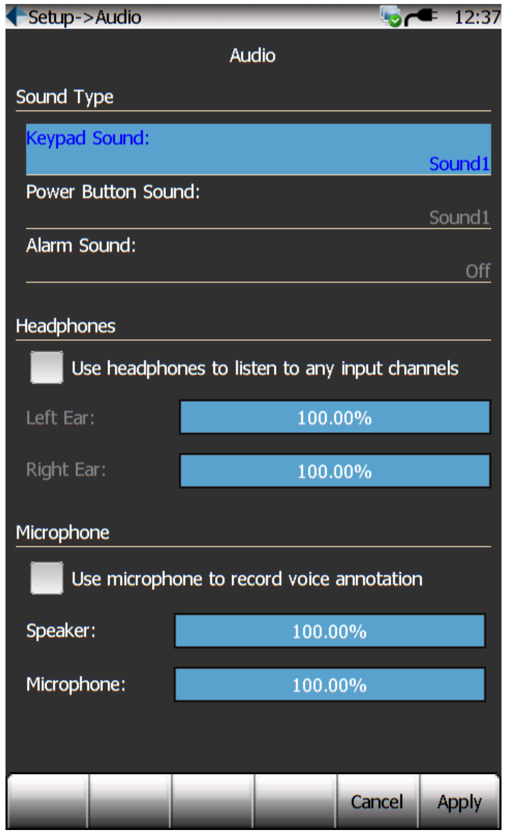


Figure 249. Audio Setup Screen

Keypad Sound: Enable and select the internal speaker sound output when any of the buttons are pressed.

Power Button Sound: Enable and select the internal speaker sound output when the power button is pressed.

Alarm Sound: Enable and select the internal speaker sound output for system alarms.

Use microphone to record the voice annotation: Enable the external microphone recording function. When this item is checked and the user presses the connected microphone button, the voice annotation is recorded until the button is released. Multiple annotations can be recorded during a measurement. If this item is not checked, the microphone button will not activate any voice recording.

Use headphone to listen to any input channel: Enable the external headphone listening function.

Headphone Listening

When *Use headphone to listen to any input channel* is enabled, under the Control (F3) menu of the signal display screen, you will see the Audio Playing… item. The input channels to listen to in both the left and right side can be set here. If you do not want to listen to the input channels, then set the selection to "System Sound or Recorded Annotations."

Record Voice Annotations

After *Use microphone to record the voice annotation* is checked in the audio setup, connect the external microphone to the microphone jack. Press the Rec/Stop button to record the time signals. While the time signals are being recorded, you can press the microphone button to record your voice annotation. The voice annotations will be attached to the recorded time streams. The green bar on the right bottom corner on the screen indicates the volume of the signal received by the microphone.

Playback the Voice Annotations on CoCo

To play back the voice annotation, first press the File button, then the Files, then the Voice button.

The Play button allows you to hear the previously recorded voice annotation. Then you can use the F1 Previous Annotation or F2 Next Annotation Buttons to play all the annotations. If the Voice button is not shown, it means the signal file saved has no voice annotation attached.

Voice annotations will be listed under each recorded or saved signal files and can be played back with EDM PC software.

Playback the recorded signals from output channel

The CoCo can playback any of the recorded signals from its output channel. To do so, open a recorded file and press the Playback button.

If the user made voice annotations while the time stream is recorded, the voice annotations will be played back as well.

After the signal playback is finished, the screen will show the message *Waveform playback finished.*

Notice that the recorded signal will be played back at the sampling speed of when it was acquired. Inside CoCo, the A/D converters and D/A converter share the same sampling clock. Due to this design, when the signal is played back, input signal cannot be analyzed.

Declaration of Conformity

Declaration of Conformity for CI CoCo-80X, Handheld Data Acquisition System

Manufacturer: Crystal Instruments Corporation, 2370 Owen Street, Santa Clara, CA 95054

EC Declaration of Conformity

Council Directive 2004/108/EC on Electromagnetic Compatibility

Crystal Instruments, 2370 Owen Street, Santa Clara, CA 95054, USA.

Product Name: CoCo-80X (Handheld Data Acquisition System)

Model No.: CoCo-80X

Assessment of compliance of the product with the requirement relating to Electromagnetic Compatibility Directive .The product has been assessed by the application of the following standards:

EN 61326:1997+A1:1998+A2:2001

EN61000-3-2: 2000

EN61000-3-3: 1995+A1:2001

CE

The tests have been performed in a typical configuration.

This Conformity is indicated by the symbol, i.e. CE "Conformité Européenne".