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Chapter 1 Introduction

Overview

The CI2250 is a PCMCIA type II card that can be used in applications such as data acquisition and signal processing. The Texas Instruments TMS320C51, which provides the CI2250 computational power, delivers 20 million instructions per second running at 40 MHz. The system has two high-impedance differential analog input channels and two output channels. Both input and output channels have 16 bit conversion resolution and simultaneous sampling. The on-board 32 KWords SRAM makes long signal capture and high-resolution spectrum analysis possible.

CI2250 can be easily inserted into or removed from the PCMCIA slot of any standard notebook PC for easy configuration and setup in the field. It normally consumes about 130mA at 5V power supply and 40mA in standby mode. The CI2250 is compliant with PCMCIA standard release 2.1.

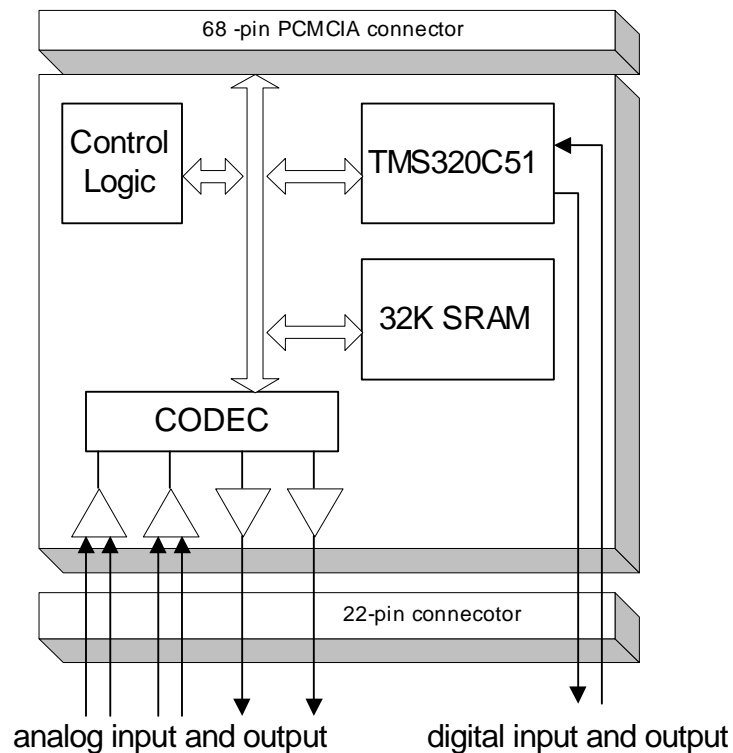


Figure 1The block diagram of the CI2250

The CI2250 provides live acquisition, analysis and display of waveform signals. The pre- and post-triggers allow the capture of only relevant data. In addition to the standard features included with your instrument, various software options such as disk-throughput and real-time spectrum analysis are available.

Used as a signal analyzer, the CI2250 signal analyzer provides various display modes for viewing data. These include the Real, Imaginary, Amplitude, Phase, Polar, Vector and Nichols graphic display and data listing modes. A user can open multiple traces to view any signal. All display traces are resizeable. The traces' color, text font, line style and grid style can be selected according to the user's preference.

In spectrum analysis, the spectrum amplitude can be displayed in different modes such as Magnitude, dB Magnitude or Log-Magnitude. The frequency axis can be displayed in linear or log scale. The spectral amplitude can be viewed in different units, such as EU, EU², EU²/Hz, EU² Sec/Hz and EU/ $\sqrt{\text{Hz}}$.

The display boundary limit can be set to Fixed, Auto or Full mode. When you need to get detailed information on specific data points, nothing beats the CI2250's marker, ZOOM display and data listing capabilities. While the system is running and the traces are updating, all the setup options made to alter the display mode are still enabled.

To be used together with other software such as modal testing package, the CI2250 can export various data format such as CI, UFF, SMS STAR or ASCII. This tremendously extends the capability of the CI2250.

PCMCIA Compliance

The Personal Computer Memory Card International Association (PCMCIA) is an alliance of computer companies that have joined together to create a nonproprietary software and hardware standard for plug-in computer devices. This organization was formed in 1989 to agree on a consistent form factor for add-on memory cards for handheld systems. Since then, the charter has grown to include everything from the card dimensions and label to system hardware and software.

As a brief description of history, in September of 1990, Release 1.0 of the PCMCIA standard was introduced. This memory only standard defined the current 68 pin physical interface. In August of 1991 Release 2.0 of the standard added the I/O interface, along with Execute in Place and definition of Socket Service. Release 2.01 is the typographical correction of the 2.0 specification. In July of 1992, Release 2.1 made major additions to the descriptors that describe the format and functions of PC Cards. In February 1995, the PC Card Standard was released. Microsoft has integrated the PCMCIA Release 2.1 into the Windows 95 and later operating systems.

For more information about PC-card or PCMCIA, contact:

PCMCIA
2635 North First Street, Suite 209
San Jose, CA 95131
Phone: (408) 433-CARD (2273)
Fax: (408) 433-9558

Currently the CI2250 can run in the Windows 95/98 environment.

CI2250 Hardware Features

- Texas Instruments TMS320C51 DSP CPU
40 MHz, 50ns instruction cycle time
2K x 16 on-chip RAM

32-bit arithmetic logic unit, 32-bit accumulator, 32-bit accumulator buffer
16 x 16 parallel multiplier with a 32-bit product
Single-cycle multiply/accumulate instructions
Eight auxiliary registers
Eleven shadow registers for interrupt service routine
Single-instruction repeat operation
Two serial ports
Programmable wait-state
Extended hold operation for concurrent external DMA
Bit-reversed index addressing mode for FFT
On-chip clock generator
Power-down mode

- Crystal Semiconductor Codec 4216
 - Two delta-sigma A/D, 16 bits
 - Two delta-sigma D/A, 16 bits
 - Sampling rate: up to 48 kHz
 - Dynamic range: 84dB
 - Signal-noise-ratio: 80dB
 - Input gain: 0dB to 22dB
 - Output attenuation: 0dB to -46dB
 - ADC clip detection
- 32K words one wait-state external SRAM
- Dual differential inputs
- Dual single-end outputs
- One digital input
- One digital output
- 68 pin PCMCIA standard connector
- 22 pin strain-relief external connector
- Low power consumption: 0.65 watts (130 mA @ 5V)

Chapter 2 Installation

What You will Need

To Install CI2250, you will need following:

- An 80386 or later processor
- 8 MB or more memory
- Approximately 1 megabyte of disk space
- A type II PCMCIA socket
- Microsoft Windows Windows 95 or Windows 98

To Install CI2250

The CI2250 diskette contains a setup utility that installs the program and all of its associated files. In this example, we'll assume that the distribution diskette is in drive A and that we'll be installing to drive C.

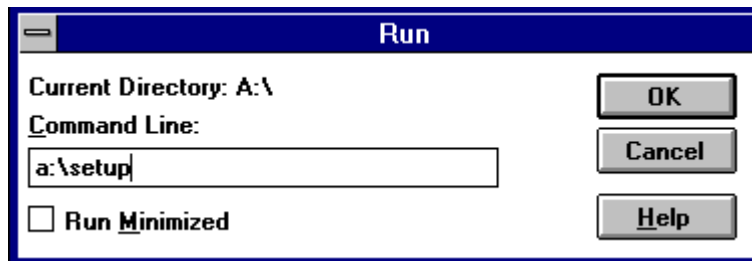
To Install CI2250 on your computer:

Step 1 Start Setup

Place the distribution diskette in drive A.

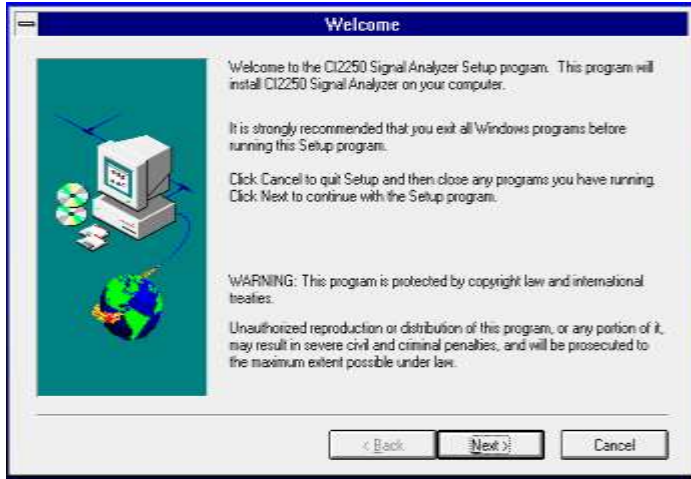
From the Program Manager, click **F**ile and choose **R**un.

When the dialog box appears, type **a:\setup**.



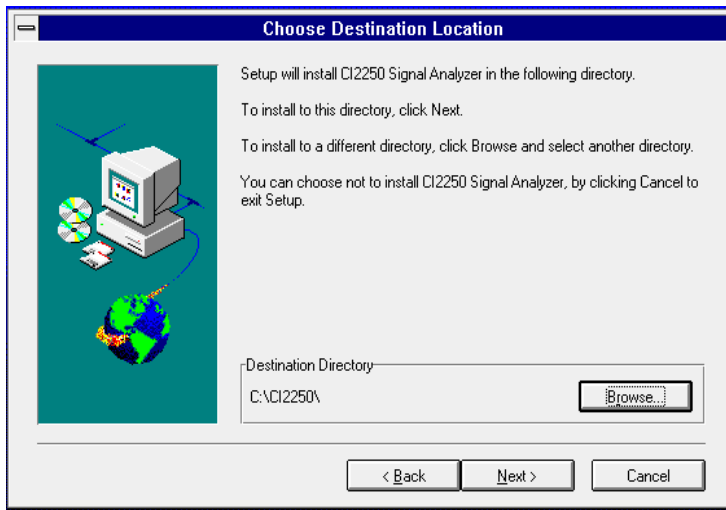
Step 2 Invoke Welcome Dialog Box

Click **OK**. After a few seconds you will see this welcome dialog box:



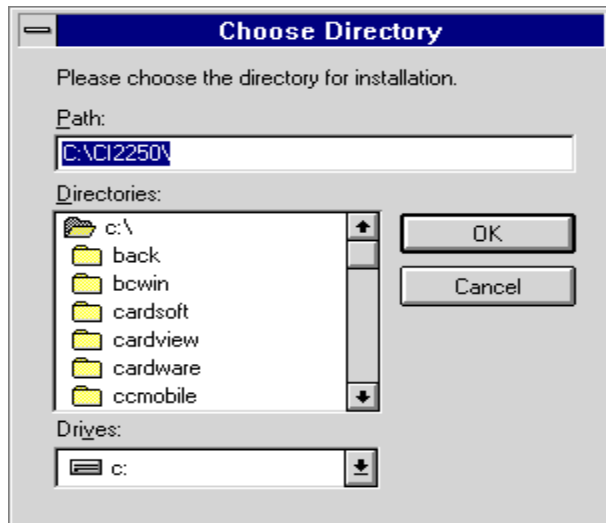
Step 3 Invoke the Destination Location Dialog Box

Click **N**ext on the welcome dialog box. The destination location dialog box will appear:



Step 4 Choose Drive and Path Name

If the drive and path name where you'd like Setup to place CI2250 is not correct, choose **B**rowse. This will call the dialog box below, which allows you to change the drive and path name.



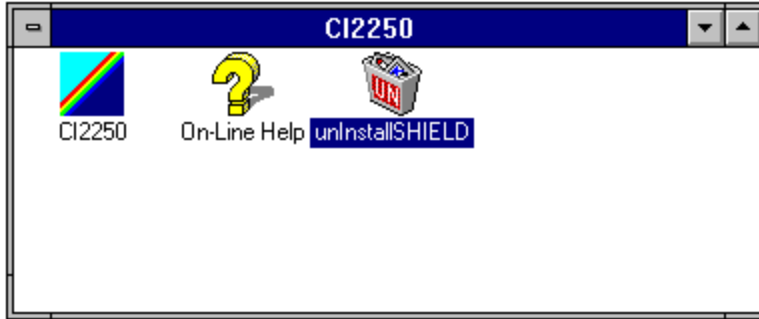
Step 5 Start Copying Files

Click **OK** on the Choose Directory dialog box and click Next on the Choose Destination Directory dialog box. Setup will begin copying files from the distribution diskette to the directory that you specified. As it is copying, Setup will display a progress bar.



Step 6 Generate Windows Group

When Setup is done copying files, it will put the CI2250 application, on-line Help and Uninstalling Tools into a group (folder) as shown below:



The unInstallSHIELD can be used if you want to totally remove the CI2250 from your system.

Loading the Sample Test

When Setup initially installs the CI2250 into your computer, it will also copy several sample test files that you can load and run directly.

Among them are:

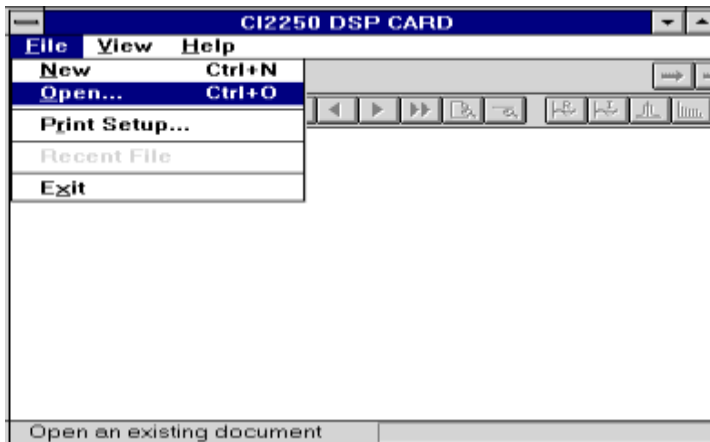
TIMECAPT.TST	A test for time capture measurements
LINEAR.TST	A test for linear spectrum measurements
PSPEC.TST	A test for power spectrum measurements
TRANS.TST	A test for transfer function measurements

To run the sample file, you can either plug the PC-card in before or after the CI2250 Windows application is started.

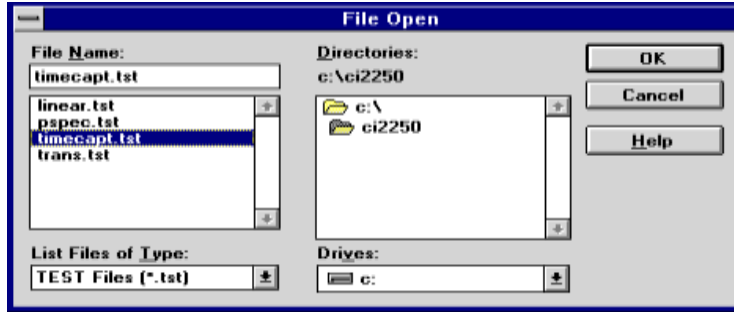
To start the CI2250 Windows application, click the CI2250 application icon:



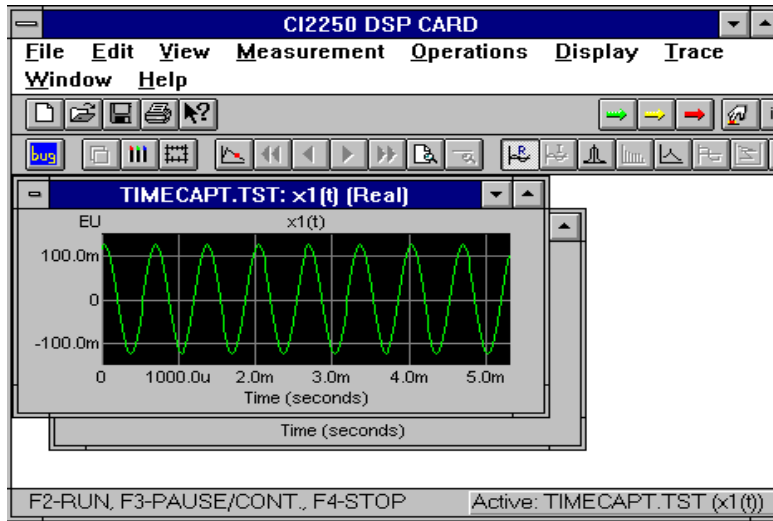
When the CI2250 Signal Analyzer is started, select **Open** under menu item **File**:



Then select one of the sample tests to run:



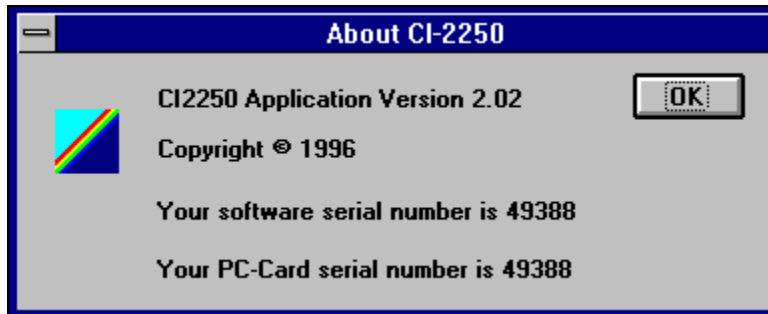
After the test file is opened, all the test parameters and signals saved before will be loaded.



For instructions on how to run a test, refer to the *General Features Chapter*.

System Serial Number

Each system will have one unique number for identification. The serial numbers in the application software, PC-card and the calibration data file have to match to each other in order to run the system. To find out the serial number of your current system, insert the PC-card into the slot and select **A**bout **C**I-2250 item under **H**elp menu. Following message box will appear:



If the numbers shown here do not match to each other, your system will not run correctly.

The system serial number is also embedded in the calibration file CALIB.DTA. The CI2250 will detect the compatibility of calibration file.

Chapter 3 General Features

Start the Application

To start the CI2250 Windows application, insert the PC-card into any of your PCMCIA slots. Then click the CI2250 icon as below:

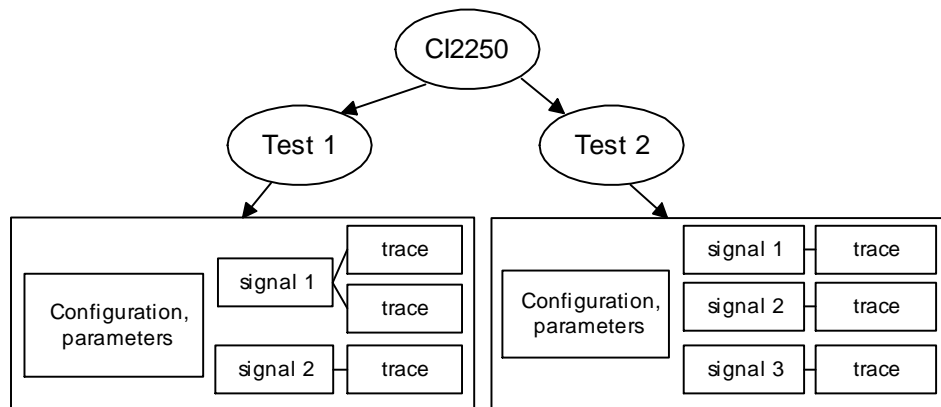


The CI2250 main window will be opened. Then follow the steps described in the next section to run a test.

Note: Please do not un-plug the card when the application program is opened. It may corrupt the test data.

What Is a Test File?

For the CI2250, a test is defined as the collection of current configurations, setup parameters and all allocated signals. Each test file name ends with the extension *.TST. When the CI2250 is used as a signal analyzer, the system data structure is described in the following diagram:



You can open one or more tests at a time within the CI2250. However, only one test is active at a time. Each signal is an array of data. It can be in either a real or complex format. In order to view the content of a signal, the system can open at least one trace for one each signal. A trace is simply a Windows View. There is only one trace in focus at any time. All toolbar buttons reflect the status of the currently focused trace.

Each time when you exit the CI2250 application, it will ask if you want to save the file that has been modified. If you save the file by selecting **YES** in the dialog box, all current test parameters and signal data are saved to the designated directory. This test will be automatically retrieved when CI2250 is opened next time.

CI2250B.INI, a Windows initialization file in your Windows system directory, is used to keep the most recent file name. This file will be automatically loaded when the CI2250

Windows application is activated next time. Since it is in ASCII format, you can manually modify it if you wish.

How to Run a Test?

The CI2250 is easy to use. Generally the customer only needs three function keys to run any test after the test is created. The three buttons are:

F2: Start a test

F4: Stop the test

F5: Parameter setup


To run a test:

Step 1. Load an old test file or create a new test file.

To load a test that has already been created, select **F**ile from the menu, then select **O**pen. Open a *.TST file.


To create a new test file, select **F**ile, then **N**ew. A dialog box is prompted. Next, select one of the measurement types, for example, **T**ime Capture, as your current measurement.

Step 2. Parameter Setup

Press **F5** to choose appropriate parameters for your test. This can also be done by selecting **P**arameter Setup under **O**perations or clicking on the button .


Step 3. Start the Measurement

Press **F2** to start the current measurement. This can also be done by choosing **S**tart

Measurement under the **O**perations menu item or clicking on the “go” button  (with the green arrow).

Step 4. Stop the Measurement

Press **F4** to stop the current measurement. This can also be done by choosing **S**top

Measurement under **O**perations menu item or clicking on the red stop button .

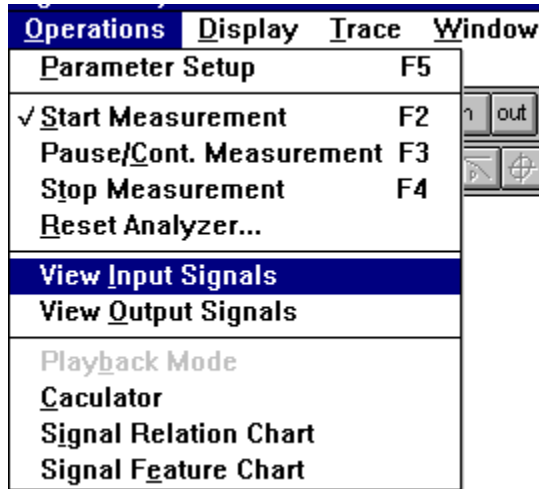
Function F3 is used to Pause/Continue the current test. This can also be done by choosing **P**ause/Cont. Measurement under **O**perations menu item or clicking on yellow

button .

Viewing Inputs and Outputs

You may view the input and output signals at any time after the card is inserted. Viewing inputs and outputs will use the current gain and sampling rate setup for each channel and use a fixed length capture. This function is useful for determining the appropriate gain setup.

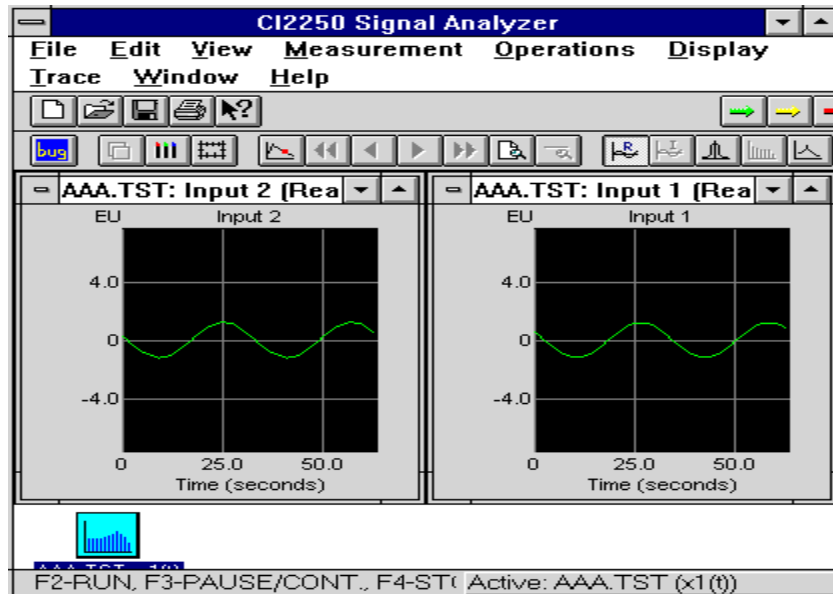
To run viewing inputs or outputs, select **View Input Signals** or **View Output Signals** under the **Operations** menu item as below:



Or click one of the smart buttons on the tool bar:



When you have selected Viewing Inputs function, two traces will be temporally allocated. All traces allocated before will be minimized at this time as shown below:



Now the live signals shown in these traces are the input raw data. They are directly read from the input buffers. The length is fixed as 64 points. The vertical scale limits is set to the same as the ADC full range multiplied by the channel sensitivity in a **FIXED** mode. For example, if ADC range is 5 volts, sensitivity is 10 EU/V, you will see the Y-scale limits are set to -50 EU to 50EU. This allows you to see where are the coming signals located.

When you switch to any operations other than Viewing Inputs, the signal **Input 1** and **Input 2** will be deallocated and the original traces will be restored to the old position.

Viewing outputs has the similar operation as the viewing inputs. Displayed vertical unit EU reads the same value as output voltage.

Notice the signals shown by the viewing outputs may not be the “true” output signals if your system has not been accurately calibrated. The DAC converter and analog amplifiers both may have a gain and offset error. What you see in the viewing output is the raw data before it is sent to the D/A converter.

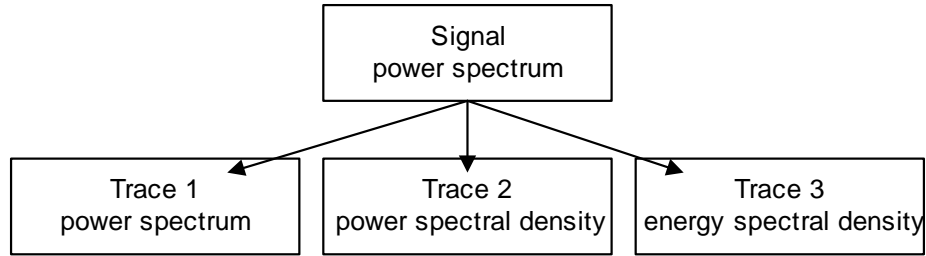
Signals and Traces

In the CI2250, a signal is an array of data together with a series of attributes. A signal can be in either a real or complex format. A *Real Signal* has a single column of data while a *Complex Signal* has two columns. For example, following signals are in real format: time capture, correlation functions, auto-spectra, histogram and coherence functions. Following signals are in complex format: transfer function, cross-spectra and linear spectra. A Real Signal can be displayed in Real or Magnitude. A Complex Signal can be displayed in Real, Imaginary, Magnitude, Phase and so on.

Signals may have several domain attributes. Among them are Time Domain, Amplitude Domain or Frequency Domain. A Time Domain signal has a horizontal axis in units of seconds (or us., ms.). A Frequency Domain signal should have a horizontal axis measured in Hertz (or kHz). The Histogram signal's horizontal axis is in EU(Engineering Unit).

The CI2250 automatically allocates all necessary signals for your given specific measurement setup. For example, once you selected **x1(t)** and **x2(t)** in the **Time Capture** measurement, the CI2250 will internally allocate these two signals for you. You can manually allocate signals by using Signal Calculator, which is an embedded signal operation tool in the CI2250.

A Trace is an opened window for viewing a corresponding signal. Multiple traces can be attached to one existing signal. The advantage of this is you can view the same signal in different perspectives at the same time. You can open a new trace under the **Window** menu item.



In the diagram above, three traces are attached to one signal that is saved in the power spectral format. By changing certain scaling parameters, you can view this signal in power spectrum, power spectral density and energy spectral density at the same time.

When a signal's content changed, all associated traces will be refreshed.

In the CI2250 Windows system, only one trace is in the active mode at one time. The active trace is always highlighted. You may select the active trace by clicking the mouse on any point within that trace or switch the active mode between all traces by using **Ctrl_Tab** key. All the items under the **View**, **Display** and **Trace** are applied to an active trace.

Note: Whether the trace is in active mode or not has nothing to do with the refreshing of the display. Display refreshing is operated whenever necessary and possible.

Engineering Units

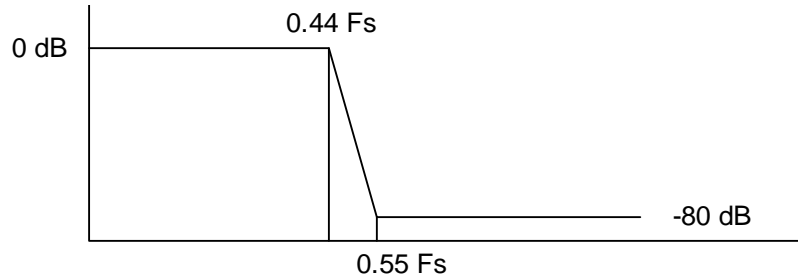
The CI2250 can calibrate and display measurements using your own engineering units (EU). For example, assume you have an accelerometer calibrated at 100 G / Volt, you can tell the CI2250 to calibrate its measurements in this special unit by inputting 100.0 into **Sensitivity** edit box in **Parameter Setup** dialog box (**F5**). Then you can change the label from the original "EU" to the new "G" designation. Now you can read the display directly and accurately in G's.

If you leave the sensitivity value as default 1.0, the EU will reads in Volts.

Anti-aliasing filter/Spectral Lines

If you apply FFT (Fast Fourier Transform) to 1024 points of data, how many useful lines can be obtained in frequency domain? The answer depends on the cutoff frequency of the anti-aliasing filter. If traditional analog anti-aliasing filter is used, to the best, you may get 400 lines in the spectra without severe aliasing effect. In the CI2250, thanks to the Sigma-Delta technique, the anti-aliasing filter is implemented digitally by Codec or a DSP chip. This dramatically increases the frequency range given the same sampling frequency.

The following picture gives the rough shape of the A/D converter's anti-aliasing filter. The decimation filter used by the DSP has a similar frequency response.



The flat range is up to 0.44 F_s , where F_s is the sampling frequency. Given these excellent anti-aliasing characteristics, about 450 useful lines can be obtained in a 1024 point FFT. This is a remarkable improvement over the traditional method.

Note: A one-order RC analog filter is applied in the front-end to prevent the aliasing of a very high frequency range (e.g., 4 MHz). This is required by all Sigma-Delta A/D converter.

The CI2250 Sampling Frequency

The following table shows the natural sampling frequencies that can be generated by the CI2250 with two different crystals:

F1	F2	F3	N	12.288MHz CLKIN	11.2896MHz CLKIN
0	0	0	256	48.00 kHz	44.10 kHz
0	0	1	384	32.00	29.40
0	1	0	512	24.00	22.05
0	1	1	640	19.20	17.64
1	0	0	768	16.00	14.70
1	0	1	1024	12.00	11.025
1	1	0	1280	9.60	8.82
1	1	1	1536	8.00 kHz	7.35 kHz

The sampling frequency of the CI2250 depends on the base frequency of the crystal that drives the CODEC. Generally, a 12.288MHz crystal is installed so the highest sampling frequency is 48KHz. For CD-compatible audio application, a 11.2896MHz crystal can be used so that the standard 44.1KHz sampling rate can be generated. On the request of customer, a crystal with any other particular frequency can be used.

For spectral analysis, the ratio between analysis frequency and sampling frequency is about 450/1024. For example, if a sampling frequency is 48KHz, the frequency range without aliasing can be up to 21.09KHz.

The lower sampling frequency on the CI2250 is generated by decimation filtering. The last three stages of frequencies listed in the table above are used as base-frequencies of decimation. The decimation filter has characteristics similar to those used in the Delta-Sigma converter. Totally 14 stages of decimation are applied.

For 48 kHz-series, 12 kHz, 9.6 kHz and 8.0 kHz are used as base-frequencies for decimation. The decimation ratio is 2 to 1. By using three base-frequencies instead of one, more sampling frequencies can be provided so that user can select appropriate sampling rate for a specific application.

The following table gives all the sampling frequencies for a 12.288 MHz crystal. The frequency numbers are in precise values. Sampling intervals are in approximate values. The frequencies in bold are generated by Codec and the others by decimation.

No.	Sampling Frequency (Exact)	Sampling Interval (Approximate)	Analysis Frequency (Approximate)
1	48.00 kHz	20.8 us	21 kHz
2	32.0 kHz	31.25 us	14 kHz
3	24.0 kHz	41.67 us	10.5 kHz
4	19.2 kHz	52.1 us	8.4 kHz
5	16.0 kHz	62.5 us	7 kHz
6	12.0 kHz	83.3 us	5.3 kHz
7	9.6 kHz	104.17 us	4.2 kHz
8	8.0 kHz	125 us	3.5 kHz
9	6.0 kHz	166.67 us	2.6 kHz
10	4.8 kHz	208.33 us	2.1 kHz
11	4.0 kHz	250 us	1.7 kHz
12	3.0 kHz	333.3 us	1.3 kHz
13	2.4 kHz	416.67 us	1.0 kHz
14	2.0 kHz	500 us	880 Hz
15	1.5 kHz	666.67 us	660 Hz
16	1.2 kHz	833.33 us	520 Hz
17	1.0 kHz	1.0 ms	440 Hz
18	750.0 Hz	1.333 ms	330 Hz
19	600.0 Hz	1.667 ms	265 Hz
20	500 Hz	2.0 ms	220 Hz
21	375.0 Hz	2.667 ms	165 Hz
22	300 Hz	3.333 ms	132 Hz
23	250 Hz	4.0 ms	110 Hz
24	187.5 Hz	5.333 ms	82 Hz
25	150 Hz	6.667 ms	66 Hz
26	125 Hz	8.0 ms	55 Hz
27	93.75 Hz	10.667 ms	41 Hz
28	75 Hz	13.333 ms	33 Hz
29	62.5 Hz	16.0 ms	27 Hz
30	46.875 Hz	21.333 ms	20 Hz
31	37.5 Hz	26.667 ms	16 Hz
32	31.25 Hz	32.0 ms	14 Hz
33	23.4375 Hz	42.667 ms	10 Hz
34	18.75 Hz	53.333 ms	8 Hz
35	15.625 Hz	64.0 ms	7 Hz
36	11.71875 Hz	85.333 ms	5 Hz
37	9.375 Hz	106.667 ms	4 Hz
38	7.8125 Hz	128.0 ms	3.5 Hz
39	5.859375 Hz	170.0 ms	2.57 Hz
40	4.6875 Hz	213.3 ms	2.1 Hz
41	3.90625 Hz	256.0 ms	1.72 Hz
42	2.9296875 Hz	341.3 ms	1.29 Hz
43	2.34375 Hz	426.7 ms	1.0 Hz
44	1.953125 Hz	512.0 ms	0.86 Hz
42	1.46484375 Hz	682.7 ms	0.64 Hz
43	1.171875 Hz	853.3 ms	0.5 Hz
44	0.9765625 Hz	1.024 ms	0.43 Hz
42	0.732421875 Hz	1.365 sec.	0.32 Hz
43	0.5859375 Hz	1.71 sec.	0.26 Hz
44	0.488281125 Hz	2.048 sec.	0.21 Hz

Output Data Format

The CI2250 can save the signals in several different file format, including Crystal Instruments' internal data format (CI Format), the SMS STAR[®] data format defined by the Spectral Dynamics, Inc., the Universal File Format (UFF) and the ASCII data format. The CI format, UFF and STAR[®] all contain the necessary information for the modal testing such as the measurement location, direction etc..

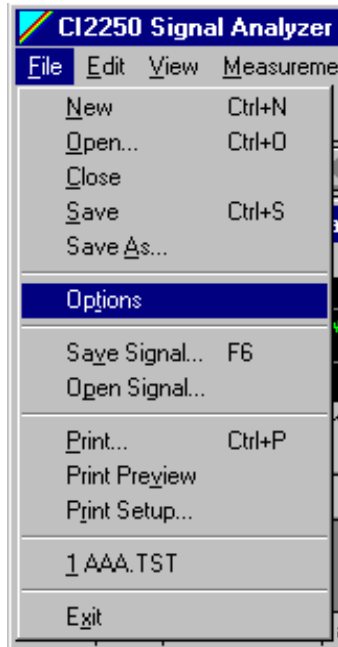
If you are not going to use the saved signals with other tools such as the modal testing software, it is suggested that you choose the CI format as your default signal format when you save the signals. This can guarantee that the signals can be restored without losing any information. When you save the signals in any format other than CI format, it will not be completely restored when you try to read it back. That's because only a portion of signal attributes are overlapped between different signal formats.

When a signal is saved, the format of the signal is depending upon the file extension that you selected. Here are the typical file extensions for the following four types of signals:

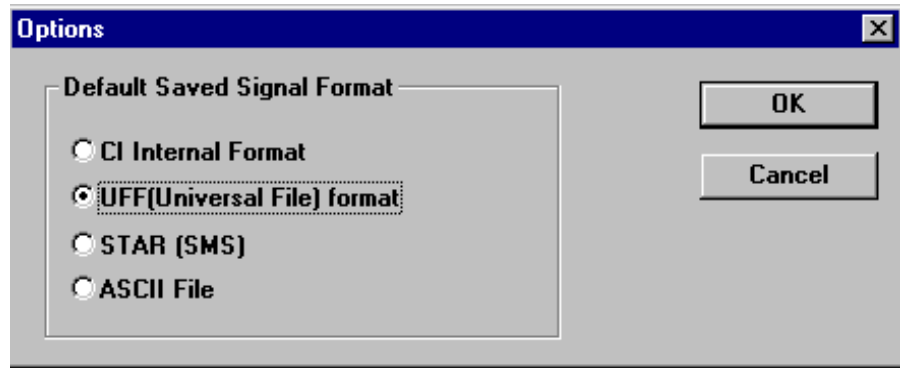
<i>CI Format</i>	<i>*.DAT</i>
<i>UFF Format</i>	<i>*.UFF</i>
<i>STAR[®] format</i>	<i>*.STR</i>
<i>ASCII format</i>	<i>*.ASC</i>

The UFF and ASCII files are saved in the text mode, which can be viewed or edited with any text editor. The CI and STAR[®] formats are saved in the compact binary mode and they can not be viewed or edited with the text editor.

The default file name is constructed based on the locations of the measurement of two channels. For example, if channel 1 is measuring point 100 in axis X and channel 2 at point 3 in axis Y, the default signal name will be *100X003Y.EXT* where *EXT* is the extension that you have chosen. You can always change the signal file name as you wish but remember, the file extension decides the file format that the signal is saved.

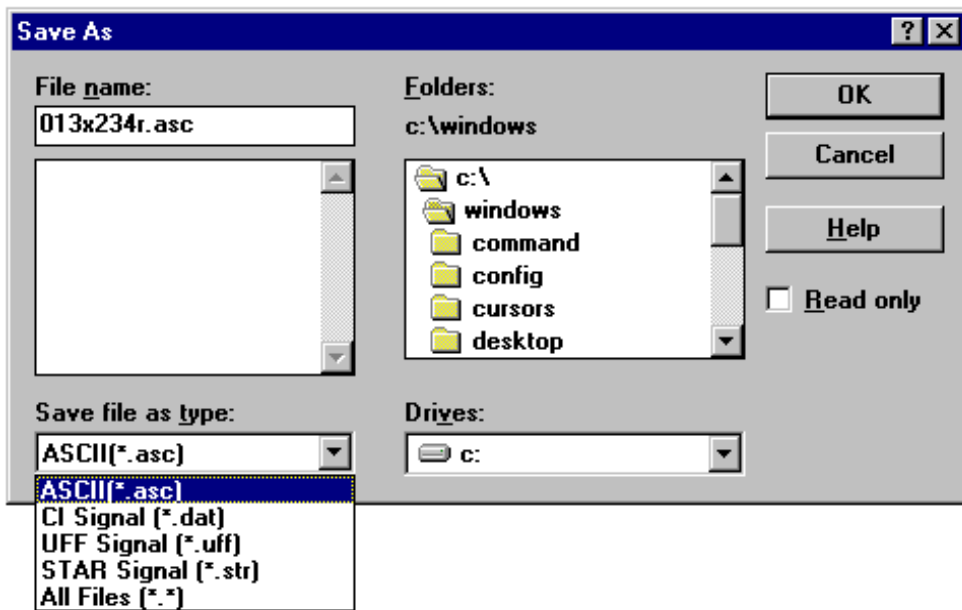


to select the default output signal data format, you need to enable the **Options** dialog box under menu item **File**:



This dialog box will allow you to select the default signal format.

When you are going to save a signal, you need to high-light the trace that the signal you want to save, then select **Save Signal** under **File**, or press **F6**. Following dialog box will be invoked for you to select a signal file name.



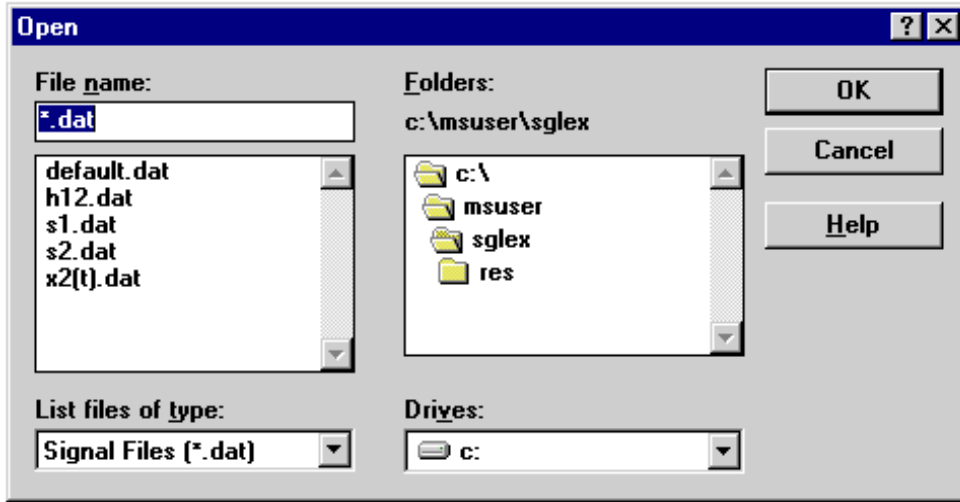
After you click **OK** button, the signal will be saved to the disk.

CI Format

The signals saved in CI Format will have a file extension **.DAT*.

CI data format is implemented with the MFC (Microsoft Foundation Class) serialization function. It generates a compact binary data format which can be restored when your read the signal from the disk. Currently the file format is not made public to the end-users. However, if you have any special request regarding to the CI file format please contact the Crystal Instruments.

If you saved a signal in CI format, you may open it by selecting **Open Signal** under **File** menu. following dialog box will be prompted:



The **Open** command will not function properly with other signal format.

UFF Format

The signals saved in UFF Format will have a file extension **.UFF*.

UFF format is an ASCII data base which is widely used in the structural analysis area. The CI2250 only implements the Data Set Type 58 of the UFF file, which is called Measurement Data Set Type. The other Data Set Type such as modal data (type 55), coordinates (type 15) or display sequence (type 82) are not implemented here.

The UFF data base is organized by records of 80 columns each in text mode. Each record is divided into a number of fields.

The first record contains a “-1”, right justified in columns 1 through 6. Columns 7 through 80 are blank.

The second record contains the data set type number, 58, right justified in columns 1 through 6. Columns 7 through 80 are blank.

The last record of the data set contains a “-1”, right justified in columns 1 through 6. Columns 7 through 80 are blank.

The specifications of data on the third through the next to last records of the data set are depending on the data set type. For type 58, i.e., Measurements, the definition is as following:

- Record 1: FORMAT(80A1)
 Field 1: Description
- Record 2: FORMAT(80A1)
 Field 1: Description continued
- Record 3: FORMAT(80A1)

- Field 1: Date and Time of Measurement
- Record 4: FORMAT(80A1)
Field 1: Excitation and Response Transducer IDs
- Record 5: FORMAT(80A1)
Field 1: "NONE"
- Record 6: FORMAT(2(I5, I10), 2(1X, 10A1, I10, I4))
Field 1: Function type
 1: Time Response
 2: Auto-Spectrum
 3: Cross-Spectrum
 4: Frequency Response Function
 6: Coherence
Field 2: Function identification number
Field 3: Version number
Field 4: Load case identification number
Field 5: Response entity name
Field 6: Response point number
Field 7: Response direction (+ or - 1,2,3,4,5,6 for X,Y,Z,R,T,P)
Field 8: Excitation entity name
Field 9: Excitation point number
Field 10: Excitation direction (+ or - 1,2,3,4,5,6 for X,Y,Z,R,T,P)
- Record 7: FORMAT (3I10, 3E13.5)
Data form
Field 1: Ordinate Data Type
 2: Real, single precision
 4: Real, double precision
 5: Complex, single precision
 6: Complex, double precision
Field 2: Number of data points (NDP)
Field 3: Abscissa spacing
 1: Even spacing
Field 4: Abscissa minimum
Field 5: Abscissa increment
Field 6: Z Axis value
- Record 8: FORMAT(I10, 3I5, 2(1X, 20A1))
Abscissa Data Characteristics
Field 1: Specific data type
 17: Time
 18: Frequency
Field 2: Length units exponent
Field 3: Force units exponent
Field 4: Temperature units exponent
Field 5: Axis label
Field 6: Axis unit label
- Record 9: FORMAT(I10, 3I5, 2(1X, 20A1))
Ordinate (or Ordinate numerator) data characteristics
Field 1: Specific data type
 0: Unknown
 8: Displacement

- 11: Velocity
- 12: Acceleration
- 13: Excitation force
- 15: Pressure

- Field 2: (Not used)
- Field 3: (Not used)
- Field 4: (Not used)
- Field 5: Axis label
- Field 6: Axis units label

Record 10: FORMAT(I10, 3I5, 2(1X, 20A1))
 Ordinate denominator data characteristics
 Field 1: Specific data type
 0: Unknown
 8: Displacement
 11: Velocity
 12: Acceleration
 13: Excitation force
 15: Pressure
 Field 2: (Not used)
 Field 3: (Not used)
 Field 4: (Not used)
 Field 5: Axis label
 Field 6: Axis units label

Record 11: FORMAT(I10,3I5,2(1X,20A1))
 Z-axis data characteristics
 Field 1: (Not used)
 Field 2: (Not used)

Record 12: Data values

Case	Type	Precision	Spacing	Format
1	Real	Single	Even	6E13.5
3	Complex	Single	Even	6E13.5
5	Real	Double	Even	4E20.12
7	Complex	Double	Even	4E20.12

Record 12 is repeated as many times as necessary to contain all data points. If the ordinate data type is real (1 or 5), then NDP is the number of data values. If the type is complex (3 or 7), then NDP is the number of data pairs (Real/Imaginary). NDP is defined in the Record 7.

Here is a sample of UFF file that written by the CI2250.

```

-1
58
Transfer function
Written by CI2250
15-Jul-96 13:28:34
EXCITATIONRESPONSE
NONE
  4          0          0          0 CHAN2          222 -6 CHAN1          111  1
    5          512          1 0.000000E+00  2.34375E+01  0.000000E+00
  18  0  0  0  0 NONE          Frequency (Hz)
    0  0  0  0  0 NONE          NONE
    0  0  0  0  0 NONE          NONE
    0  0  0  0  0 NONE          NONE
-1.57910E-04 -6.03849E-04  2.17824E-03  2.41706E-04  9.77395E-04 -9.60789E-04
  
```

```
4.59332E-04 -6.39136E-04 6.62758E-04 -2.07706E-04 5.96461E-04 -9.29071E-04
-2.80226E-04 -4.85123E-04 -3.78130E-04 -2.25243E-04 -5.73509E-04 -3.87820E-04
-2.05574E-04 8.29682E-04 -3.95670E-04 9.22981E-04 3.49134E-04 6.18858E-04
7.42096E-04 3.09162E-04 3.35763E-04 1.13467E-03 -2.12328E-03 1.41801E-03
-3.23920E-04 -1.05643E-03 7.73269E-04 3.53783E-04 1.73122E-04 8.60102E-04
-1.82758E-03 1.99394E-03 5.04087E-04 -1.20814E-03 1.31336E-03 -6.36466E-04
.....
-1
```

SMS STAR® Format

The signals saved in STAR® Format will have a file extension *.STR. STAR® data base is defined by the Spectral Dynamics Inc. (formerly Structural Testing Products).

In STAR® system, the file have specific file extension such as:

Auto Spectrum	APS
Coherence	COH
Cross Spectrum	CPS
Frequency Response	FRF
...	

You can rename the signals saved by the CI2250 to those with file extension defined by the STAR® system. However it is the file content, not the file extension, to decide the signal type in the STAR® system. Renaming file extension is not necessary for the purpose of modal testing.

For details of STAR® data base, please contact:

Spectral Dynamics, Inc.
1983 Concourse Drive
San Jose, CA 95131, USA

ASCII Format

The signals saved in ASCII Format will have a file extension *.ASC.

ASCII format is used for spread-sheet such as Microsoft Excel or any utility program that can read ASCII data. It has simpler header description than that of UFF file. If the signal is a real signal such as time domain signal, the ASCII data will have only two columns. The first column will be the value of X axis at each sample and the second the corresponding value of each point. If the signal is complex with real and imaginary parts, the ASCII file will have three columns. The first column is still the value of X axis, the second is the real part and the third column is the imaginary part of each point.

You may edit the ASCII file with any text editor to fit into your needs.

The content of the signal array will begin after the file reads “Data Begin:”

Here is a sample of the ASCII file:

```
Time Response
13-Jul-96 11:33:47
Signal Name: AAA.TST_x1(t)   Signal size: 256   Vertical unit: EU
Data Begin:
```

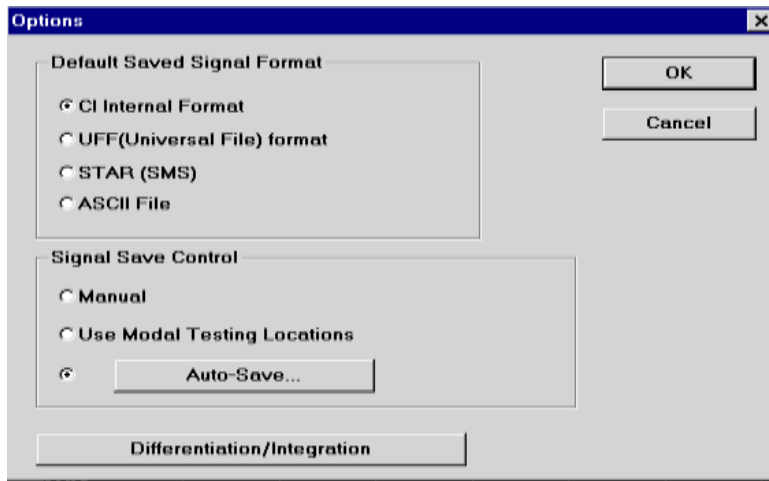
0.00000E+00	1.14692E-01
4.16667E-05	1.21424E-01
8.33333E-05	1.23490E-01
1.25000E-04	1.20810E-01
1.66667E-04	1.13488E-01
2.08333E-04	1.01804E-01
2.50000E-04	8.62085E-02
2.91667E-04	6.72997E-02
3.33333E-04	4.58046E-02
3.75000E-04	2.25492E-02

...

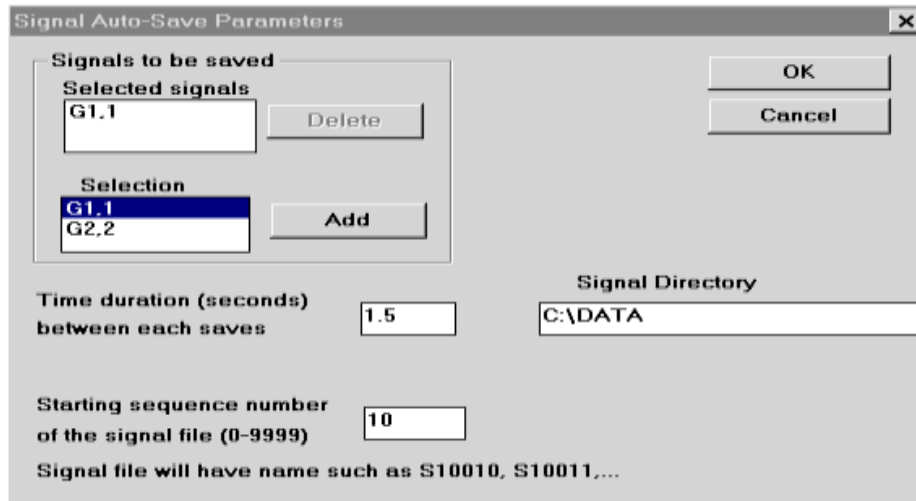
Automatic Data Store

The signals (data set) can be automatically saved to the disk at certain period of time. In order to make this happen, a few parameters need to be defined before the system is running. These parameters include:

- The names of signals to be stored
- Signal data format
- Time interval between each storage
- Starting sequence number for the signal file names



To enable Auto Data Save options, first, select **Options** under **Operations** . check **Auto-Save** radio button. The click the “**Auto-Save...**” button, which invokes the data automatic store parameter setup dialog box as following:



Now you need to select the signal that you wish to save to the disk. First, high-light the signal name under list-box “**Selection**”, then click “**Add**” button, the signal will be added to the list-box “**Selected signals**”.

The time interval definition is straight-forward. Simply type in the time interval that is defined in seconds into the edit box.

The signal directory is the place that all auto-save signals go to. Type in the directory string. If that directory does not exist, the CI2250 will create one for you.

The starting sequence number helps the system to generate the signal file names automatically. Each time after the signals are saved to the disk, the sequence number will be incremented so the new file names are synthesized based on it.

CICal — *Signal Calculator*

As long as you can use an electronic calculator, you can use the *CICal*. The *CICal* let you apply various arithmetic operations to the signals in a simple and quick manner. It has an extensive range of built-in functions and enormous flexibility to post-process measured data. When the *CICal* is used together with the CI2250, a signal analyzer based on PC-card, it will extend the measurement capabilities of DSP card. *CICal* can also be used independently for post processing the existing data. By combining a group of basic functions, you can create a sequence of very sophisticated arithmetic relationship between signals and get the results in the instant.

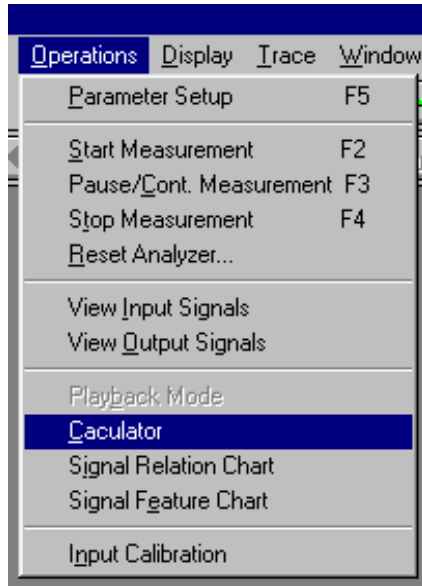
The input of each operation is a group of signals and the output is one single signal(result). All signals allocated before can be used as inputs of next operations. All arithmetic operation can be applied multiple times and *CICal* keeps tracking all the causal relationship of inputs and outputs.

Signal Calculator Dialog Box

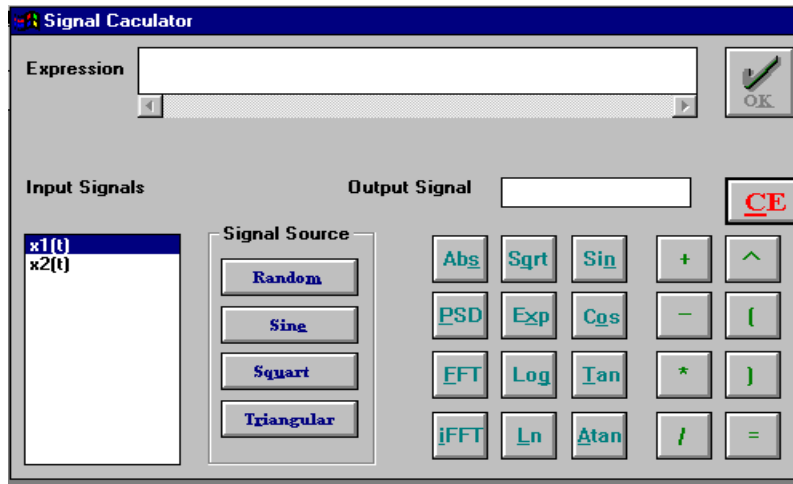
The dialog box contains a series of push buttons, for example, +, -, x, /, Ln, exp, sin, cos, FFT etc.. User will define the arithmetic descriptions in this dialog box. *CICal* will allocate and display the result signal. The dialog box is responsible for all validation

checking. For example, it is not allowed to add two signals together with different sizes or different domain.

To enable the Signal Calculator Dialog Box, select **Calculator** under menu item **Operations**:



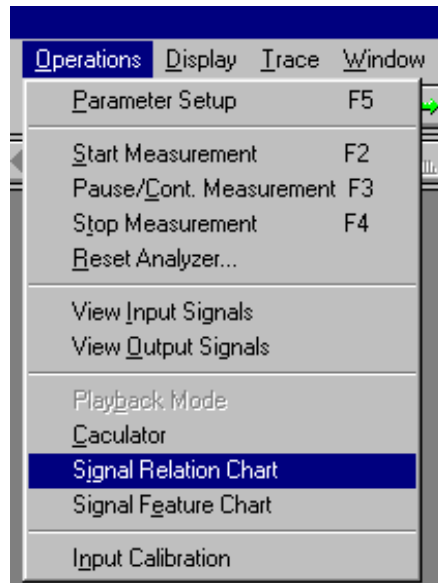
Then the Calculator Dialog Box will be invoked as partially shown below:



For details of how to use the Calculator, please refer to the example listed later in this section.

Operation Relationship Chart

The operation relation chart describe all the causal relationship between all active signals by a combination of nodes and lines. When user click one of the nodes, corresponding calculator dialog box is activated. To enable the operation relation chart, select **Signal Relation Chart** under **Operations**:



Signal Sources

When the *CICal* is embedded in the CI2250, all signals allocated by the CI2250 can be used as original signal sources. When the *CICal* is used separately, The signals recalled from disk as well as a few standard signal sources such as sine, random waveform can be used as original signal sources. In either cases, all result signals can be used as signal sources of next step.

Signal can be saved and recalled for review at any time.

The Arithmetic Functions

The *CICal* includes many arithmetic functions such as:

+, -, *, /, sin, cos, tan, arctan, power, square-root, log10, loge, absolute, exponential, FFT, Inverse FFT, power spectrum etc..

Example of Using *CICal*

Here is one example showing how to use the *CICal*:

Example: Result = (X1(t) + 1)*4;

We are going to show to calculate the result of signal X1(t) plus 1 then multiplied by 4.

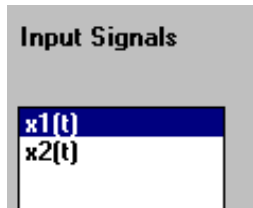
- Select **Time Capture** under **Measurement**
- Select **Calculator** under **Operations** so that a Calculator dialog box is enabled
- Click button “(“



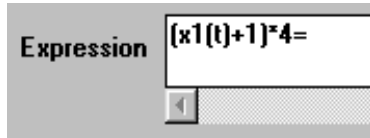
Expression is:



- double click signal $x_1(t)$ in the **Input Signals** list



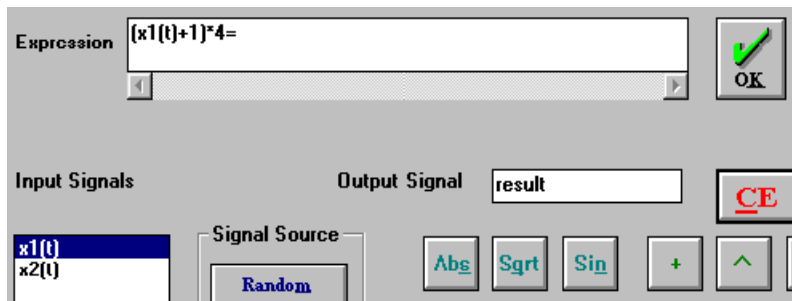
- Click button “+”, “1”, “*”, “4” and “=” in order, the expression will become:



- Type in a string such as “**result**” in the **Output Signal** box



- Finally click “**OK**”:



Then a new signal “**result**” is allocated. When you run the test by pushing **F2**, “**result**” will be updated with its input, i.e., $x_1(t)$.

You can create very complex relation equations by using cascaded Calculators because each output signal can be used as input signal of next stage.

How to re-structure or delete a signal allocated by the Calculator:

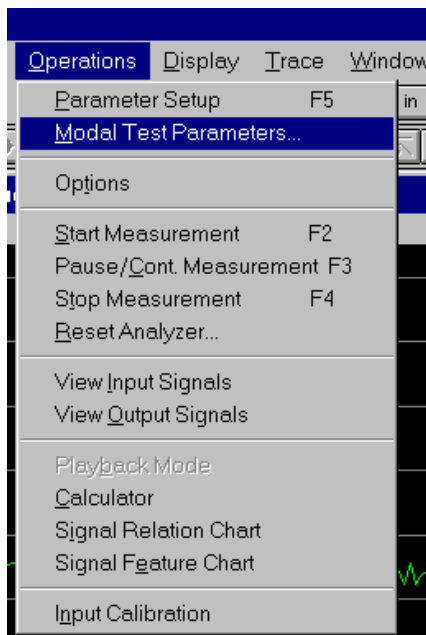
Select **Signal Relation Chart** under **Operations**

Double click the relation equation that you want to edit then the corresponding dialog box will be displayed.

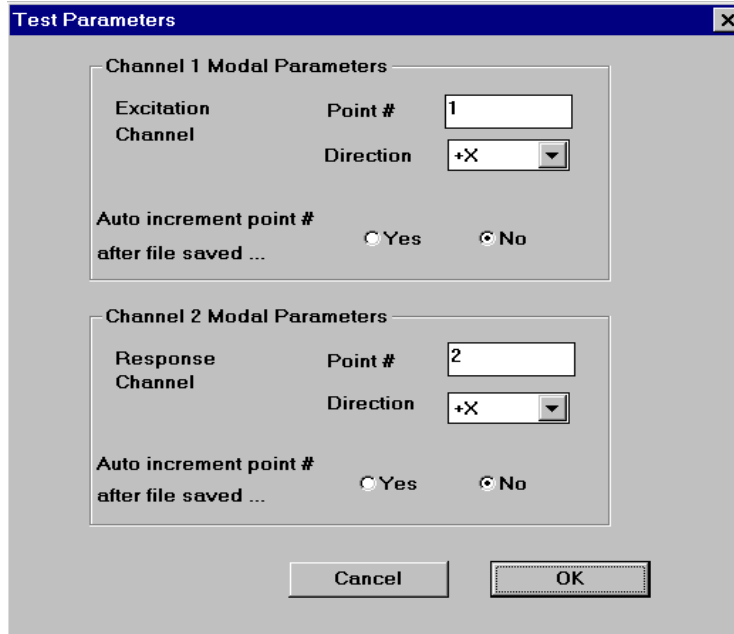
If you want to edit the equation, use “**Back**” button; if you want to delete the output signal, use “**Del**” button.

Using the CI2250 in Modal Testing

The CI2250 Signal Analyzer provides the basic measurements for the modal testing purpose. The key modal testing information are kept and carried over with stored data so that your modal testing software can use it. The Universal File Format is one of the popular data format accepted by most of modal testing software. The SMS Star data format can be used by SMS modal testing package or compatible software.



Under **Operations**, selecting **Modal Testing Parameters** will open following dialog box:

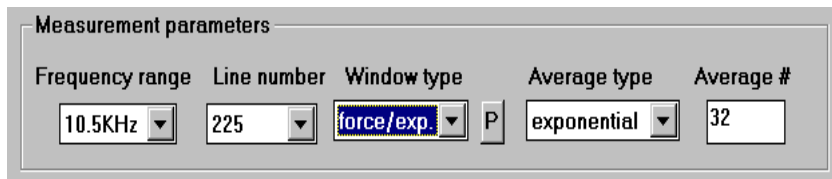


The CI2250 asks you to use channel 1 as excitation channel (Force transducer channel) and channel 2 as response channel. For each channel, you may define the location number and coordination labels.

Some modal testing process requires that the location number is automatically incremented after the signals are saved. You may select “**Yes**” under “**Auto increment...**” category. This function has to be used when you select “**Use Modal Testing Locations**” as Signal Save Control in the **Options** dialog box.

Another useful function that you may want to use in the modal testing is the Force/Exponential window.

In each spectral measurement parameter setup dialog box, you may select **Force/Exp.** window. When you selected this item, a small button “**P**” is enabled (P stands for “Parameters”). By clicking “**P**” button, you are able to set up the **Force/Exponential** window parameters:



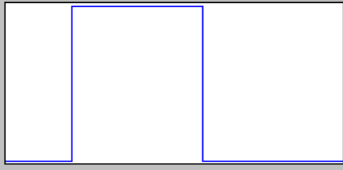
In the dialog box, the total time block size in the measurement is given for your reference.

Force/Exponential Window Parameters

The total time block size is 512

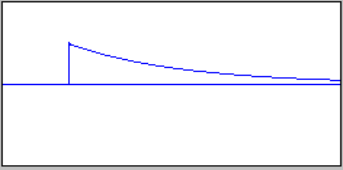
Force window is applied to channel 1

Starting point	Ending point
<input style="width: 80%;" type="text" value="100"/>	<input style="width: 80%;" type="text" value="300"/>



Exponential window is applied to channel 2

Exponential window time constant
Tau/T, defined in $\exp(-\text{Tau}/T)$



Force window, which is always applied to channel 1, is controlled by two parameters: starting point and ending point. The numbers you typed in should not exceed the total time block size. The window value between starting and ending points is 1.0 and outside is zero.

Exponential window, which is always applied to channel 2, is also controlled by two parameters, that is, the starting point that is defined by channel 1, and the time constant ratio τ/T . A typical number of τ/T ratio is 3. The greater the ratio, the heavier the exponential weighting. The exponential window starts to apply from the “**Starting Point**”.

Chapter 4 The Basics of Spectral Analysis

Reference Books

To understand the topics in this Chapter, we found the following three books to be very helpful:

1. Julius S. Bendat and Allan G. Piersol, **Random Data, Analysis and Measurement Procedures**, 2nd Edition, Wiley-Interscience, New York, 1986.
2. Julius S. Bendat and Allan G. Piesol, **Engineering Applications of Correlation and Spectral Analysis**, 2nd Edition, Wiley-Interscience, New York, 1993.
3. Sanjit K. Mitra and James F. Kaiser, Ed. **Handbook for Digital Signal Processing**, Wiley-Interscience, New York, 1993.

Signal Notation

Standard industrial notation is used to name signals. Each type of signal will be represented by one specific letter. For example, “G” stands for a one-side power spectrum, while “H” stands for a transfer function.

The following table defines the symbols used by the CI2250:

Cxy	Coherence function between input signal x and output signal y
Gxx	Auto-spectral function (one-sided) of signal x
Gxy	Cross-spectral function (one-sided) between input signal x and output signal y
Hxy	Transfer function between input signal x and output signal y
k	Index of a discrete sample
Rxx	Auto-correlation function of signal x
Rxy	Cross-correlation function between input signal x and output signal y
Sx	Linear spectral function of signal x
Sxx	Instantaneous auto-spectral function (one-sided) of signal x
Sxy	Instantaneous cross-spectral function (one-sided) between input signal x and output signal y
t	Time variable
x(t)	Time history record

Digital Spectral Analysis

Fourier Transform

Fourier Transform is a bilateral transform typically used to convert quantities from time domain to frequency domain and vice versa, usually derived from the Fourier integral of a periodic function when the period grows without limit, often expressed as a Fourier transform pair. In the classical sense, a Fourier transform takes the form of

$$X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft} dt$$

where

$x(t)$ continuous time waveform
 f analysis frequency
 $X(f)$ Fourier transform of $x(t)$

In the discrete or sampled sense, this can be expressed as

$$X(k) = \sum_{n=0}^{N-1} x(n)e^{-j2\pi kn/N}$$

where

$x(k)$ samples of time waveform
 n running sample index
 N total number of samples or “frame size”
 k finite analysis frequency, corresponding to “FFT bin centers”
 $X(k)$ discrete Fourier transform

In the CI2250, a Radix-2 DIF FFT algorithm is used thus, total number of samples has to be power of 2 (total number of samples in FFT = 2^m , where m is an integer).

Windowing

When only a portion of a record is analyzed the record is truncated by a data window. A window can be expressed in either the time domain or in the frequency domain, although the former is more common. To reduce the edge effects, which cause leakage, a window is often given a shape or weighting function. For example, a window can be defined as

$$w(t) = \begin{cases} g(t) & -T/2 < t < T/2 \\ 0 & \text{elsewhere} \end{cases}$$

where $g(t)$ is the window weighting function and T is the window duration.

The data analyzed, $x(t)$ are then given by

$$x'(t) = w(t) x(t)$$

where $x'(t)$ is the original data and $x(t)$ is the data used for spectral analysis.

A window in the time domain is represented by a multiplication and hence, is a convolution in the frequency domain. A convolution can be thought of as a smoothing function. This smoothing can be represented by an effective filter shape of the window; i.e., energy at a frequency in the original data will appear at other frequencies as given by the filter shape. Since time domain windows can be represented as a filter in the frequency domain, the time domain windowing can be accomplished directly in the frequency domain.

In the CI2250, rectangular, Hann, Flattop and several other data windows can be used;

Rectangular Window

$$w(k) = 1 \quad 0 \leq k \leq N-1$$

Hann Window

$$w(k) = 0.5 * (1 - \cos (2\pi k / (N-1))) \quad 0 \leq k \leq N-1$$

Because creating data window chops off a portion of the original data, certain amount of correction has to be made in order to get un-biased estimation on the spectra. In linear spectral analysis, a *Line Correction* is applied; in power spectral measurements, an *Area Correction* is applied. See the sections in below for details.

Linear Spectrum

A linear spectrum is the Fourier transform of windowed time domain data. The linear spectrum is useful for analyzing periodic signals. You can extract the harmonic amplitude by reading the amplitude values at those harmonic frequencies.

An averaging technique is often used when synchronized triggering is applied. Because the averaging is taking place in the linear spectrum domain, or equivalently, in the time domain, based on the principles of linear transform, averaging make no sense unless a synchronized trigger is used.

The CI2250 uses following steps to compute a linear spectrum:

Step 1

First a window is applied:

$$x(t) = w(t) x(t)'$$

where $x(t)'$ is the original data and $x(t)$ is the data used for the Fourier transform.

Step 2

The FFT is applied to $x(t)$ to compute $X(k)$, as described above.

Step 3

Averaging is applied to $X(k)$. Here Averaging can be either an Exponential Average or Stable Average. Result is Sx' .

$$Sx' = Average (X(k))$$

Step 4

To get a single-sided spectrum, double the value for symmetry about DC, Line Correction is applied to Sx' so that the final result has an un-biased reading at the harmonic frequencies.

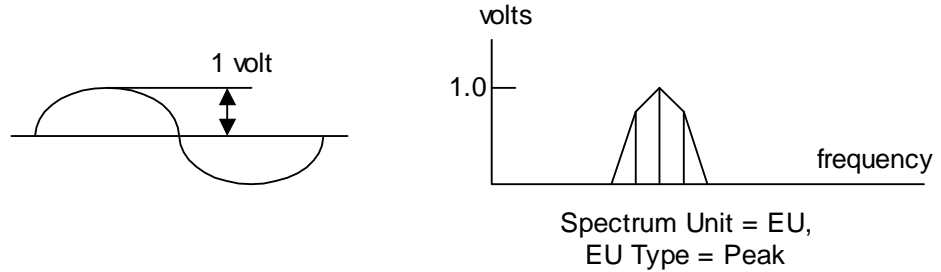
$$Sx = 2 \bullet Sx' / LinCorr$$

where LinCorr is the line correction factor, defined as:

$$LinCorr = \sum_{k=0}^{N-1} w(k)$$

where $w(k)$ is the window weighting function.

This correction will make the reading at specific frequency correct even when window is applied. For example, if a 1.0 volt amplitude sine wave is analyzed by Linear Spectrum with Hann window, you will get following spectral shape:



In the CI2250, line correction is automatically applied when you select EU as your Spectrum Units. For details about Spectrum Units, see the section entitled Spectrum Units in this Chapter.

The linear spectrum is saved internally in the complex data format with real and imaginary parts. Therefore, you should be able to view the real, imaginary, amplitude or the phase part of the spectrum.

Power Spectrum

Spectral analysis of data has for a long time been popular in characterizing the operation of mechanical or electrical systems, etc. A type of spectral analysis, the power spectrum (and power spectral density), is especially popular because a “power” measurement in the frequency domain is one that engineers readily accept and apply in their solutions to problems. Single channel measurements (auto-power spectra) and two channel measurements (cross-power spectra) have both played important roles.

In the CI2250, Power Spectrum Analysis is a general name for computing the following four types of different spectra:

Power Spectrum	The EU type is EU^2
Power Spectrum Density(PSD)	The EU type is EU^2/Hz
Energy Spectrum Density(ESD)	The EU type is EU^2S/Hz
RMS Spectrum	The EU type is EU / \sqrt{Hz}

In power spectrum measurements, window line correction is used to get un-biased final spectrum reading at specific frequency. In PSD, ESD or RMS Spectrum measurements, window area correction is always used to get an un-biased spectral density reading.

To compute the spectra listed above, follow these steps:

Step 1

A window is applied:

$$x(k) = w(k) x(k)'$$

where $x(k)$ ' is the original data and $x(k)$ is the data used for a Fourier transform.

Step 2

The FFT is applied to $x(t)$ to compute Sx

$$Sx = \sum_{n=0}^{N-1} x(k) e^{-j2\pi kn/N}$$

Now, periodogram method is used to compute the spectra with area correction

Step 3.1

$$\text{Power Spectrum } S_{xx} = Sx Sx^* / (\text{LineCorr})^2$$

Step 3.2

$$\text{Power Spectral Density} = Sx Sx^* T / \text{AreaCorr}$$

Step 3.3

$$\text{Energy Spectral Density} = Sx Sx^* T^2 / \text{AreaCorr}$$

Step 3.4

$$\text{RMS Spectrum} = \sqrt{\text{PowerSpectralDensity}}$$

where T is the time duration of the capture. The symbol $*$ is for complex conjugation. AreaCorr is a factor for area correction, which is defined as:

$$\text{AreaCorr} = \frac{1}{N} \sum_{k=0}^{N-1} w(k)^2$$

N is the total number of the samples and $w(k)$ is window function.

For any power spectral measurement of the four types listed above, the EU type is automatically chosen as EUrms because only EUrms has a physical meaning related to signal power.

Because the CI2250 only shows single-sided spectra, the power spectra is doubled again for symmetry about DC. Averaging then is applied. As a complete example, here is the procedure to compute the Power Spectral Density of signal $x(k)$ ($k = 0, \dots, N-1$) using a Hann window:

Step 1, compute the Fourier transform

$$Sx = \sum_{n=0}^{N-1} x(k) w(k) e^{-j2\pi kn/N}$$

Step 2, compute the instantaneous power spectral density

$$S_{xx} = Sx Sx^* T$$

Step 2, Average the M frames of S_{xx} to get the averaged PSD G_{xx}

$$G_{xx}' = \text{Average}(S_{xx})$$

where the Averaging can be one of Exponential Averaging, Stable Averaging or Peak-Hold.

Step 3, Do area correction and double the value for single-sided spectra

$$G_{xx} = 2 G_{xx}' / AreaCorr$$

where $AreaCorr = 3/8$ for a Hann window. G_{xx} is the power spectral density. For the other types of spectra listed above, the computation procedure is the same.

To compute the cross-power spectral density G_{xy} between channel x and channel y:

Step 1, compute the Fourier transform

$$S_x = \sum_{n=0}^{N-1} x(k)w(k)e^{-j2\pi kn/N}$$

$$S_y = \sum_{n=0}^{N-1} y(k)w(k)e^{-j2\pi kn/N}$$

Step 2, compute the instantaneous cross power spectral density

$$S_{xy} = S_x^* \cdot S_y T$$

Step 2, average the M frames of S_{xx} to get averaged PSD G_{xx}

$$G_{xy}' = Average (S_{xy})$$

Step 3, Do area correction and double the value for single-sided spectra

$$G_{xy} = 2 G_{xy}' / AreaCorr$$

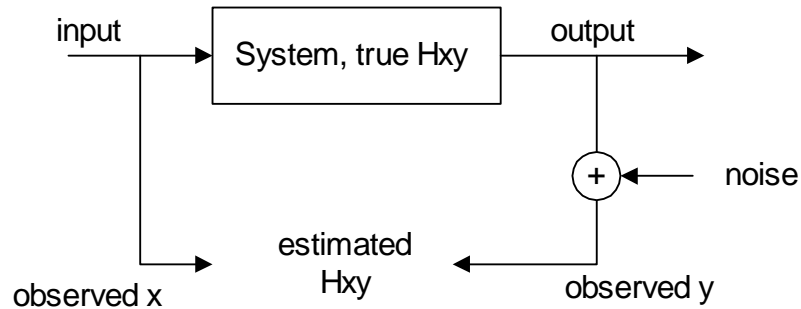
Transfer Function and Coherence Function

The cross power spectrum method is used for estimating the transfer function between channel x and channel y. The equation is:

$$H_{xy} = \frac{G_{xy}}{G_{xx}}$$

where G_{xy} is the averaged cross-spectrum between the input channel x and output channel y. G_{xx} is the averaged auto-spectrum of the input. Either power spectrum, power spectral density or energy spectral density can be used here because of the linear relationship between input and output.

This approach will reduce the effect of the noise at the output measurement end, as shown below.



The transfer function has a complex data format. You can view it in real, imaginary, magnitude or phase display format.

The coherence function is defined as:

$$C_{xy}^2 = \frac{|G_{xy}|^2}{G_{xx} G_{yy}}$$

where G_{xy} is the averaged cross-spectrum between the input channel x and output channel y. G_{xx} and G_{yy} are the averaged auto-spectrum of the input and output. Either power spectrum, power spectral density or energy spectral density can be used here because of the linear relationship between input and output.

When the averaging number is 1, coherence function has a meaningless result of 1.0 due to the estimation error of the coherence function.

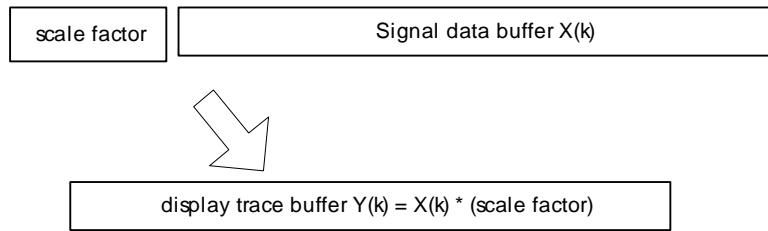
The coherence function is a non-dimensional real function in the frequency domain. You can only view it in the real format.

Note: When describing a system with input x and output y as shown above, some people are used to a notation H_{yx} instead of H_{xy} . The CI2250 follows the convention used in the reference books listed before. H_{xy} stands for a transfer function with input x and output y.

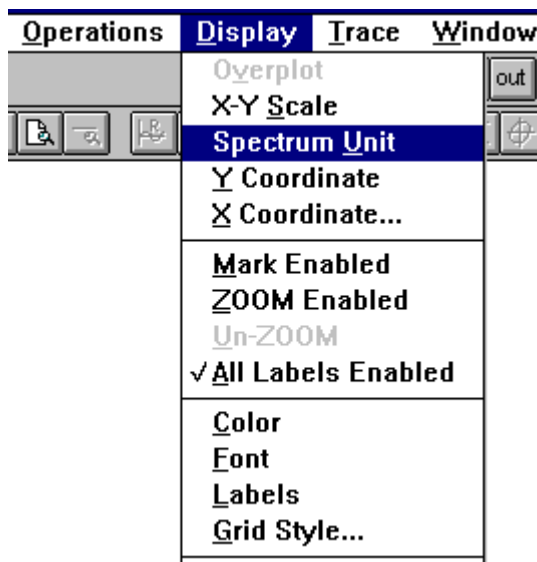
Spectrum Units

There may be times when you may wish to view a single set of data from different perspectives. The time domain signal can be transformed into frequency domain by FFT(). In the frequency domain, it can be viewed in five or more different types of spectra.

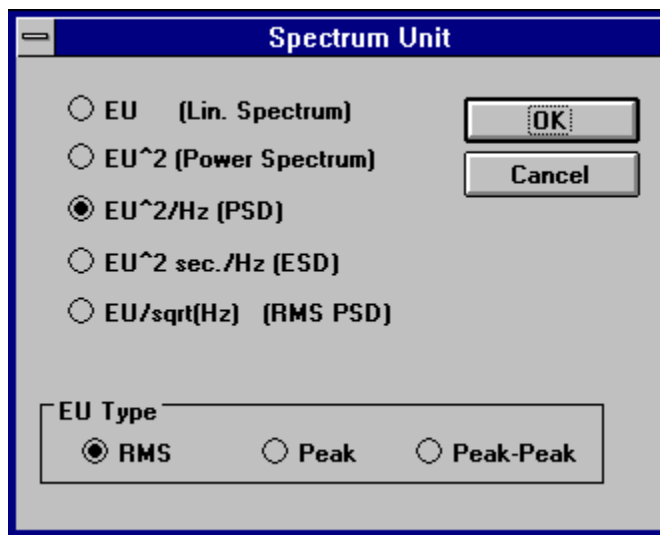
In the CI2250, to avoid making the display too complex, we display the trace buffer alone, separating it from the signal data buffer. Therefore, What user see on the screen is the content in the trace buffer.



There are two sets of parameters associated with this operation. One is the EU Type. The second is Spectrum Units. To change either or both of these parameters, open the Spectrum Unit dialog box by selecting **Spectrum Unit** under **Display** menu item.

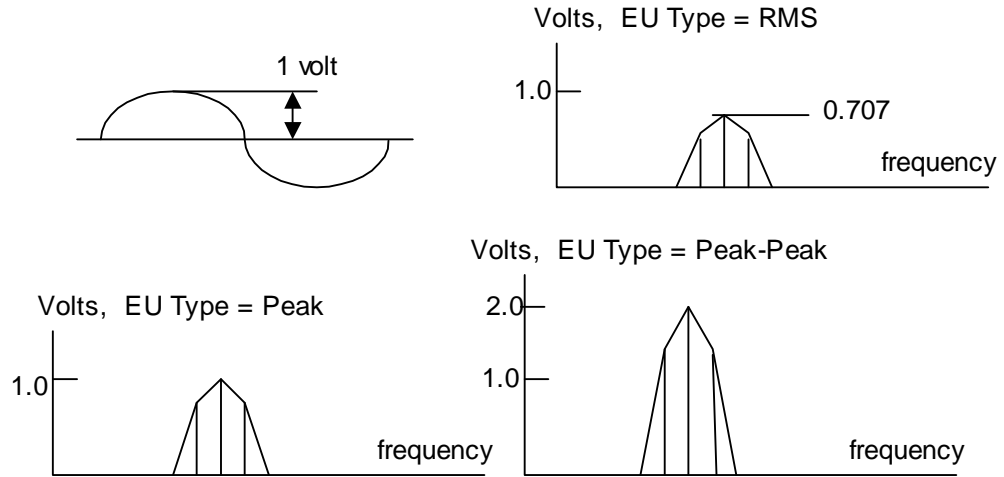


Spectrum Unit Dialog Box:



The EU Type

Specifies whether amplitude is displayed in peak, peak-peak, or RMS units. In the picture shown below, given the same sine input with 1 volt amplitude, you may display its RMS, Peak or Peak-Peak value in a linear spectrum.



Spectrum Units

Five types of spectrum units are given for both Linear Spectrum and Power Spectrum measurements.

EU, Linear Spectrum

Displays the trace in engineering units. The EU type can be one of RMS, Peak or Peak-Peak. This is useful for narrow band signals.

EU², Power Spectrum

Displays the trace in engineering units squared. This is useful for measuring the power of narrow band signals.

EU²/Hz, Power Spectrum Density

Displays the trace in engineering units squared divided by the equivalent filter bandwidth. This provides power normalized to a 1Hz bandwidth, or power spectral density (PSD). This is useful for wideband, continuous signals.

EU²S/Hz, Energy Spectrum Density

Displays the trace in engineering units squared per seconds divided by the equivalent filter bandwidth. This provides energy normalized to a 1Hz bandwidth, or energy spectral density (ESD). This is useful for wideband, continuous signals or transient signals.

EU /√Hz: RMS Spectrum

Displays the trace in engineering units divided by the square root of equivalent filter bandwidth (square root power spectral density). This is useful for wideband, continuous signals.

When the EU type is EU^2 , EU^2/Hz , $\text{EU}^2\text{S}/\text{Hz}$ or $\text{EU}/\sqrt{\text{Hz}}$, only selecting EU type as RMS is meaningful because RMS is power-related.

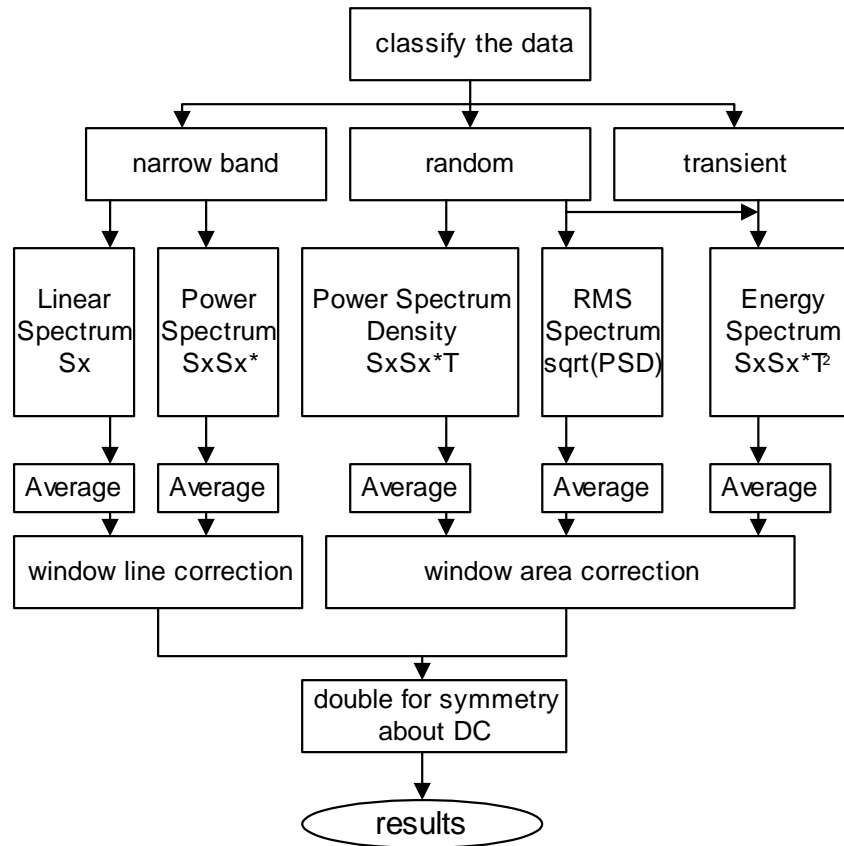
When a data window is used, we either do line correction for the spectrum peak reading or an area correction for the total power reading. Due to that a window is always applied in time domain, which corresponds a convolution in the linear spectrum, we can not have both a valid line and correct area correction at the same time. The choice of any one of EU^2/Hz , $\text{EU}/\sqrt{\text{Hz}}$ or $\text{EU}^2\text{S}/\text{Hz}$ as unit indicates that the user is primarily concerns with the power density or energy density distribution. After choosing this, we shall apply area correction in order to have the right area reading. The integrated PSD calculated after windowing will be the same as before windowing (Parseval Theorem). In the case that EU or EU^2 is chosen, we apply line correction to get the right spectrum peak reading. For example, given a sine wave with a 1.0Volt RMS, the reading of the spectrum peak will be $1.0 \pm \text{error}$ when EURms is selected as the EU type, where *error* is the uncertainty caused by window. (If a FlatTop window is used, *error* will be as small as 0.01dB).

In a Linear Spectrum measurement, a signal is saved in its complex data format. Then is averaging operation applied to the linear spectrum. In a Power Spectrum measurement, the averaging operation is applied to the squared spectrum, which has only real parts. Because of different averaging technique, the final results of Linear Spectrum and Power Spectrum will be different even though the same EU type and the same spectrum unit is used.

Spectrum units selection only make effective in frequency domain to the signals with units. Transfer function, phase function or coherence function don't need to select spectrum units.

Measurement Method

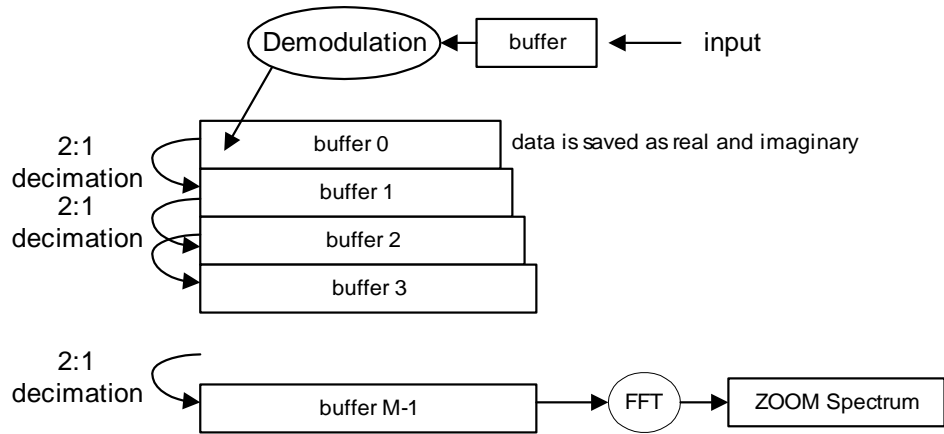
To summarize, here is a general flow-chart to choose one of the measurement technique:



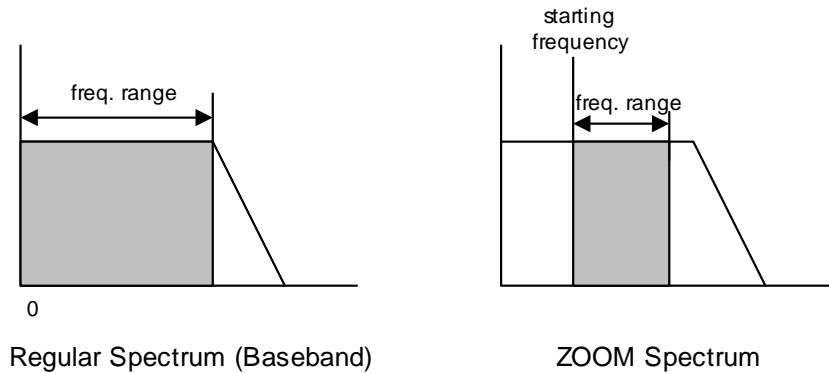
ZOOM Analysis

ZOOM analysis (Complex Demodulation) is a technique for examining the frequency content of a signal with fine resolution over a relatively narrow band of frequencies. The technique basically takes a band of frequencies and translate them to a lower band of frequencies (demodulation) where the signals can be decimated to reduce the sample size. A standard DFT then can be used to analyze the data.

The increased resolution of this technique requires a corresponding increase in the time record length. The sample rate is decreased by decimation, to reduce the number of samples in the time window, only after the demodulation.



In ZOOM mode, the CI2250 provides the same spectral types as in regular spectral analysis, i.e., the linear spectrum, power spectrum, transfer function, coherence function etc.. In regular spectral analysis, a user needs to select appropriate frequency range. In ZOOM mode, a starting frequency has to be selected as well, as shown below:



Once the starting frequency and the frequency range are selected, a fixed analysis frequency band is defined. The CI2250 will automatically compute the demodulation frequency and the number of decimation stages internally and then compute the spectra to the decimated data.

During the ZOOM spectral analysis, you still may enable the signal source channels.

Averaging Techniques

Six Averaging Techniques

Averaging is widely used in spectral measurements. It improves the measurement and analysis of signals that are purely random or mixed random and periodic. Averaged

measurements can yield either higher signal-to-noise ratios or improved statistical accuracy.

Six types of averaging methods are available in the CI2250. They are:

Linear Averaging; Exponential Averaging; Peak-Hold; Peak-Continue; Single and Off

Linear Averaging

In linear averaging, each set of data element (a record) contributes equally to the average. The value at any point in the linear average is given by the equation:

$$Avg = \frac{Sum \ of \ Records}{Number \ of \ Records}$$

The advantage of this averaging method is that it is faster to compute and the result is unbiased. However, this method is suitable only for analyzing short signal records or stationary signals, since the average tends to stabilize. The contribution of new records eventually will cease to change the value of the average.

When specified averaging number reached, the measurement will stop.

Exponential Averaging

In exponential averaging, records do not contribute equally to the average. New records are weighted more heavily than old ones. The value at any point in the exponential average is given by:

$$Avg(k) = (Avg(k - 1) \times (1 - \alpha) + Record(k) \times \alpha) \quad 0 < \alpha < 1$$

where Avg(k) is the kth average and Record(k) is the kth new record. α is the weighting coefficient. Usually α is defined as $1/(\text{Number of Averaging})$.

The advantage of this averaging method is that it can be used indefinitely. That is, the average will not converge to some value and stay there, as is the case with linear averaging. The average will dynamically respond to the influence of new records and gradually ignore the effects of old records.

Exponential averaging simulates the analog filter smoothing process. It will not stop even when a specified averaging number is reached.

Peak-Hold

This method, technically speaking, does not involve averaging in the strict sense of the word. Instead, the “average” produced by the peak hold method produces a record that at any point represents the maximum envelope among all the component records. The equation for a peak-hold is

$$Avg = Max(All \ Records)$$

Peak-hold is useful for maintaining a record of the highest value attained at each point throughout the sequence of ensembles.

Peak-hold averaging will stop when a specified averaging number is reached.

Peak-Continue

Peak-continue is the same as Peak-Hold except it will not stop when the averaging number is reached. It will only stop when the user presses the Pause/Cont. or Stop key.

Single

When averaging is **Single**, the analyzer makes only one capture.


This is equivalent to linear averaging with the averaging number defined as 1.

Averaging Off

When averaging is **Off**, the analyzer makes continual measurements with one average, erasing the result of each measurement.

This is equivalent to exponential averaging where the averaging number defined as 1.

Pause/Continue Key

The yellow arrow button  is used for the Pause/Continue operation during the average. If the Pause/Continue key is pressed while the measurement is in progress, the measurement stops at the completion of the current average. If it is pressed again, the measurement continues with the next average. If the measurement is restarted rather than continued, it begins with the first average.

Linear Spectrum versus Power Spectrum Averaging

Averaging can be applied to either linear spectrum or power spectrum. If you want to extract repetitive or periodic small signals from the noise, you can use triggered capture and average them in linear spectral domain. If you want to reduce the spectral estimation variance, use power spectral averaging.

Here is a list of the features using the average in two spectra.

Linear Spectrum Averaging	Power Spectrum Averaging
No statistical spectral estimate, for deterministic signals only.	Statistical spectral estimate, for signals with random characteristics.
Signal must have periodic components.	Applicable to both pure random and mixed random/periodic signals.
Improve SNR.	Does not improve SNR.
Requires a synchronized trigger in fixed relation to the signals.	Does not require a synchronized trigger.

Spectral Estimation Error

Assume the data is captured from a stationary random process, here are a few useful equations to compute the standard deviation of the spectra when linear averaging is used:

Functions being estimated	Standard Deviation
Auto-spectrum G_{xx}	$\frac{1}{\sqrt{n}}$
Cross-spectrum G_{xy}	$\frac{1}{ C_{xy} \sqrt{n}}$
Coherence Function C_{xy}^2	$\frac{(1 - C_{xy}^2)\sqrt{2}}{ C_{xy} \sqrt{n}}$
Transfer function H_{xy}	$\frac{\sqrt{(1 - C_{xy}^2)}}{ C_{xy} \sqrt{2n}}$

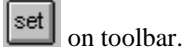
where n is the average number in linear averaging. The transfer function is computed in the cross-power spectrum method as presented earlier.

Please refer to the reference books listed above for further discussion.

Chapter 5 Signal Sources

The source is used to stimulate devices under test. The CI2250 has two output channels, which can be programmed independently and generate their own output during the measurement. The digital to analog converter (DAC) and analog to digital converter (ADC) are driven by the same crystal so that the input and output are synchronized on a per sample base.

The output parameters are set in the Parameter Setup dialog box. It can be invoked by selecting **Parameter Setup** under the **Operations** menu item or click setup button



The selecting of a source output depends on the nature of the device under test, time versus accuracy trade-offs, and your measurement objectives. Several types of outputs are provided in the CI2250.

The intensity of outputs is defined in voltage.

Sine

Fixed sine output supplies a constant frequency sine wave at the specified source level. A fixed sine is used to excite a device under test at a single frequency.

To measure the spectrum excited by the sine output, you need to be aware of whether the time record covers the integer cycles. If the time record does truncate a full number of periods of sine wave, you may use rectangular window (window off) to measure the spectrum and then you get a “clean” single line spectrum. If the time record truncates non-integer cycles of the sine, which is usually the case, you need to provide a window to prevent the leakage effect. Flattop window is commonly used for sine measurement because it provide the least uncertainty to measure the spectral peaks.

In the CI2250, the sine level is defined by its amplitude in voltage.

Random Noise

Random noise supplies true random noise at the selected level. Its frequency range is limited to the **Frequency Range** on the setup panel. Random noise is often used to obtain a fast, linear estimate of a system’s frequency response at the current operation point. Because it is not periodic in the time record, random noise excited measurement requires a window, usually a Hann window, to reduce the leakage for spectral analysis.

Random noise does not characterize non-linearities because the device under test is excited differently each time record, so averaging over a number of time records tends to reduce the effects of nonlinear distortion in the measurement.

In the CI2250, the random noise is generated by a timer-based randomizer combined with a pseudo-random generator. This method really does generate a “true random” signal.

The random noise level is specified by its RMS value in voltage. For Gaussian distributed random noise, the peak to RMS ratio is about 5 (but theoretically, it is infinite).

Therefore, the maximum RMS level that you can specify is $(Output\ Range) / 5$ if clipping is not allowed.

What happens to the Output during Capture?

If an output channel is enabled, signal source will continue to generate output during the data capture. It will continue until the next measurement is started (i.e., F2 is pressed). Output has no discontinuity at any time during the data capture once it is started. If you press the **Pause/Continue** key, the output does not stop either.

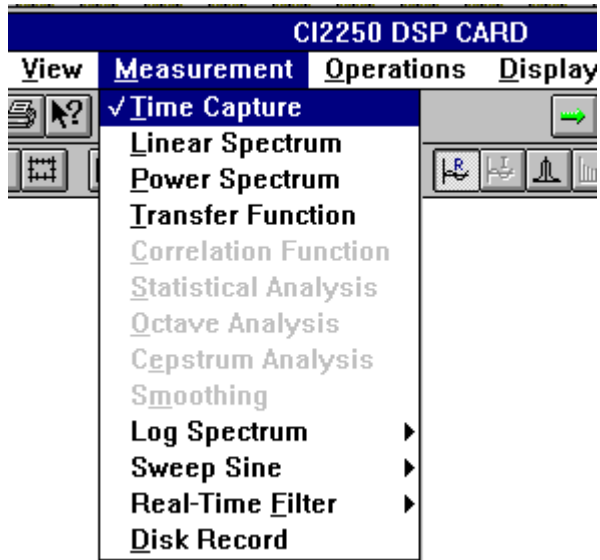
If you want to stop the output at any time, select **Reset Analyzer** under the **Operations** menu item. The capture will also be stopped at this time.

Chapter 6 Measurement Operations


Time Capture



Running Time Capture

Under menu item **M**measurement, choose **T**ime Capture:



Once you have selected **T**ime Capture, the CI2250 will reload the parameters pertaining to this measurement automatically. If you want to view or configure these parameters,

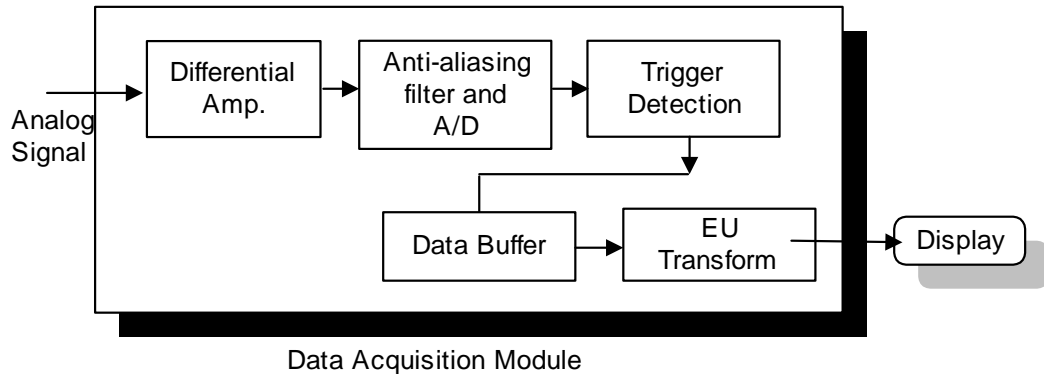
press F5 or click the button  on the tool-bar. Signals and associated traces are automatically allocated based on parameter setup. For more details about parameter setup, turn to the Section entitled Parameter Setup in this Chapter.

Now press F2 or click on the green arrow button  to start the measurement. To stop the measurement, press F5 or click on the red arrow button .

Operating Principles

Time Capture is one of the primary functions provided by CI2250. It is used to capture the transient process of either single or dual input signals. The description we use in this section are the bases for all other measurements.

Following diagram describes how a signal is captured.



After the signal conditioning, the analog signal is digitized by a sigma-delta A/D converter. The anti-aliasing filter cutoff frequency of the sigma-delta A/D converter is about $0.44 f_s$, where f_s is the sampling frequency. Because of the anti-aliasing effect, you may sometimes find the digitized signal is different to its “original” analog signal. In this case, try to increase the sampling rate to reduce the effect of high frequency content distortion.

In triggered data acquisition, the CI2250 does not begin capturing data until some event, or trigger, occurs. You need to select the parameters in the dialog box shown below to setup the trigger:

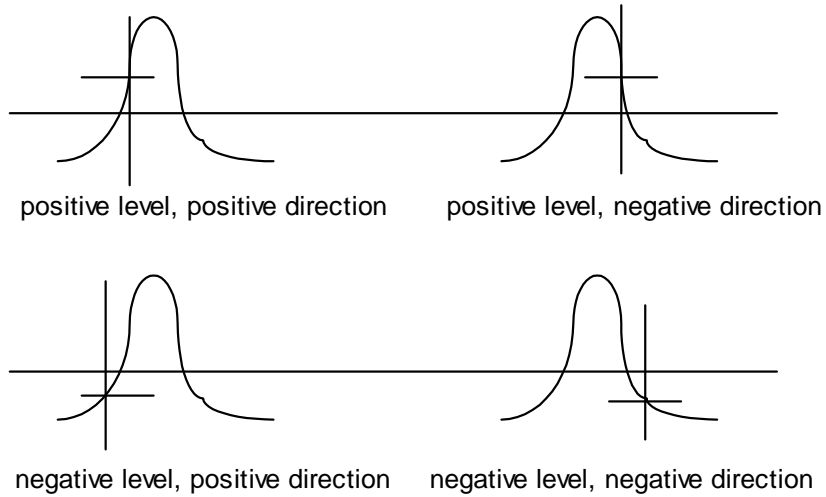
Trigger setup				
	Type	Level	Direction	Delay
channel 1	Edge	0.	<input checked="" type="radio"/> Pos. <input type="radio"/> Neg.	0

The first combo-box shows the channel number you wish the trigger occur. If you want to turn off the trigger, select “off” in this box. Once you have selected “off”, the rest of parameter windows will be hidden. The second box indicates the trigger type. It is either Edge or Level trigger.

When you select a given channel as a trigger channel, you also need to define the trigger level and direction. Level can be positive or negative. The value of the level is in a range from -1.0 to +1.0, which stands for the fraction of the full input range. For example, if input range is $\pm 1V$ and the trigger level is selected as -0.5, then the capture will be triggered at -0.5V.

The direction of the signal is defined as the sign of $(x(k) - x(k-1))$ where $x(k)$ and $x(k-1)$ are two adjacent points. In the case of Level-trigger, the system only detects the value of one single point. In Edge-trigger, it not only detects the value, but also the slope. The CI2250 allows both positive slope or negative slope triggering when you select Edge-trigger.

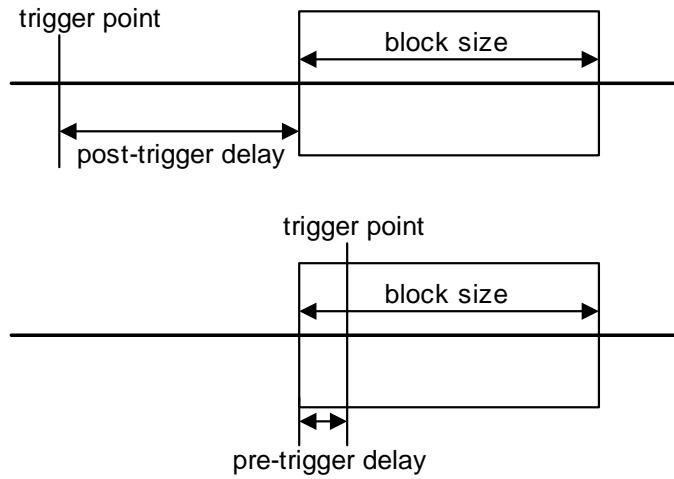
Four different triggering cases



To summarize, here is the condition a trigger is invoked at sample $x(k)$:

Type	Direction	Condition
Edge	Positive	$x(k) > \text{Level}$ and $x(k-1) < \text{Level}$
Edge	Negative	$x(k) < \text{Level}$ and $x(k-1) > \text{Level}$
Level	Positive	$x(k) > \text{Level}$
Level	Negative	$x(k) < \text{Level}$

When assigning a trigger, you also need to define its delay number of trigger. The delay number is in a range of $\{-\text{block size}, 32767\}$. The CI2250 can pre-trigger up to Block Size and post-trigger up to 2^{31} samples. Pre-triggering is useful for impact analysis to ensure that you have captured the entire impulse. Post-triggering is helpful when analyzing systems with time delays because the measurement can wait until the desired signal arrives. Delayed triggering is also used when recalling and measuring throughput files from a disk (Play-back).




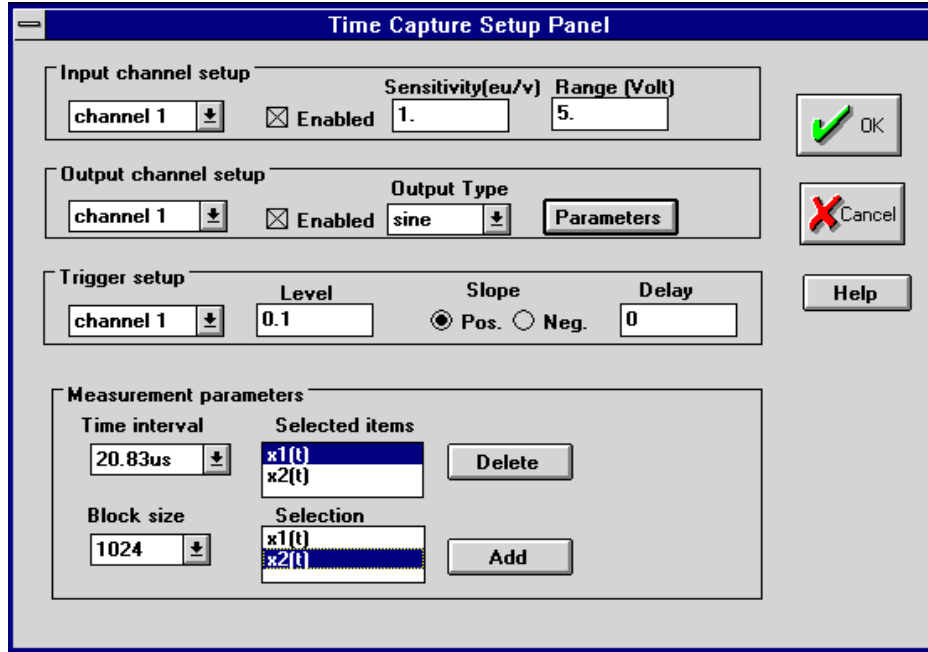
The delay is specified in number of samples. For pre-trigger delay, enter a negative numbers. A post-trigger uses positive number. The dialog box will compute a delay time in seconds for you for your reference. The free-run triggering (**trigger off**) overrides trigger delays.

After triggering occurs, the data is collected and scaled with Engineering Units (EU). the relationship between EU and input voltage is defined by the sensitivity in a unit of EU/V. Each channel will have its own sensitivity value. Therefore, if the input is 2.0 V and sensitivity is 100.0EU/V, the final readout of captured signal will be 200.0 EU.

In the CI2250, two ADC channels acquire the data simultaneously. Other analysis mode, such as Linear Spectrum, Power Spectrum or Transfer Function will use the same front-end data acquisition module to collect data.

Parameter Setup

In order to activate the parameter setup dialog box, you can select **Parameter Setup** under the **Operations** or click the setup button  on toolbar. The Time Capture parameter setup panel is shown as below.

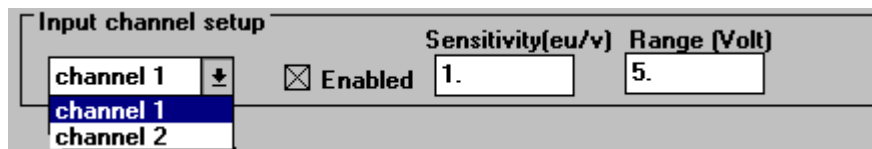


Generally, the parameters are divided into four groups. These include **input channel setup**, **output channel setup**, **trigger setup** and **measurement parameter setup**. This dialog box is responsible for all parameter validation guaranteeing that all selected parameters are meaningful. For example, if you select x1(t) as one of your measurements while channel 1 is disabled, the dialog box will give you an error message when it is closed.

When both channels are enabled, the simultaneous time capture from each channel will have the same time base. Trigger will be applied to both channels.

The parameter selection in each group is explained in the follow section.

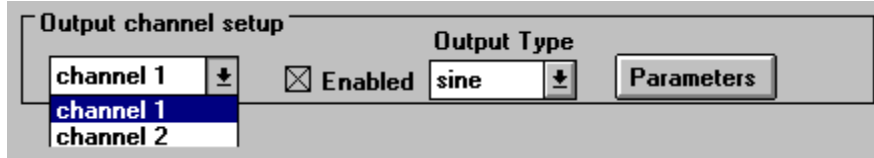
Input Channel Setup



First you choose “**channel 1**” or “**channel 2**” in the combo box of this group. Check the **Enabled/Disabled** box to turn on or off this input channel. If this channel is enabled, you are able to type in the sensitivity of the corresponding channel. If this channel is disabled, the edit box for sensitivity is hidden.

Sensitivity is described in a unit of EU/V, where EU stands for Engineering Unit. This parameter will be applied to the captured data. Therefore, in time domain capture, the signal displayed is in EU. If you want to display the voltage value, adjust the sensitivity to 1.0 EU/V.

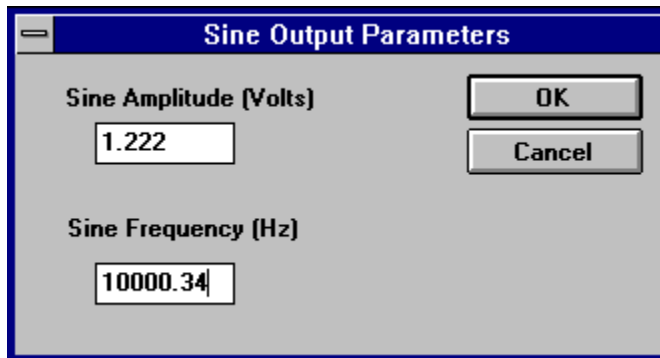
Output Channel Setup



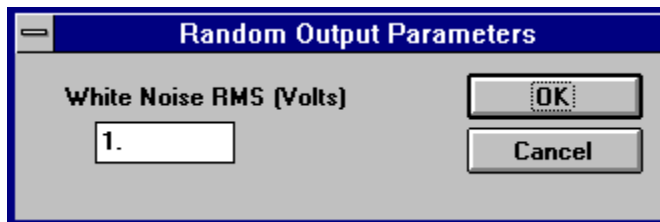
First choose “**channel 1**” or “**channel 2**” in the combo box of this group. Check the **Enabled/Disabled** box to turn on or off this output channel. If this channel is enabled, you are able to select an output type. If it is enabled, press the parameter button for further parameter selection. If it is disabled, the output type and parameter button are hidden.

Each channel has its own parameter sets.

For a sine type output, the following dialog box will be prompted when you press the output parameter button. An output level is defined by a sine amplitude (0 to peak) in volts. Here the frequency is defined in Hertz.



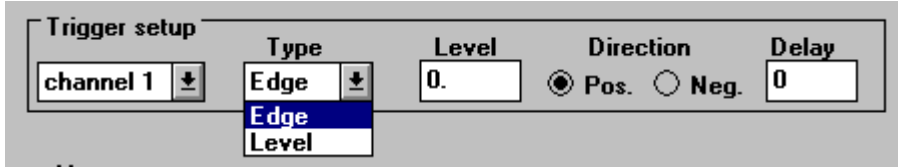
For a random type output, level is defined as its RMS value. Since random output is Gaussian (the ratio of peak to RMS is greater than 4), usually you will select a level with a number less than a quarter of full DAC range in random output. Its dialog box is shown below:



When you start a measurement, the CI2250 begins to output signals. The output will not stop even if the capture or processing is completed. The output will not stop either when you press Pause/Cont. key. This feature is helpful when a continuous output is required.

If you want to stop the output at any time, select **Reset Analyzer** under the **Operations** menu item. The capture will also be stopped at this time.

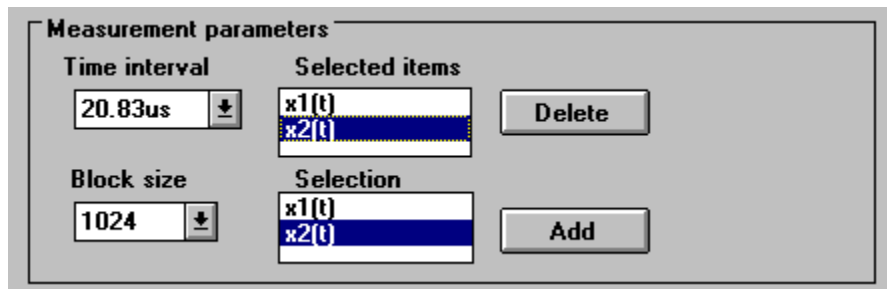
Trigger Setup



Triggering is useful when you want to capture data based on certain events, such as the rising or falling edge of input signal. CI2250 provides both positive and negative delays for triggering. In the case of a negative delay trigger, a portion of the input signal happens before the trigger point is captured.

You can choose either “channel 1”, “channel 2” or “off” as the internal trigger status. When you select “off”, the CI2250 will ignore the trigger and process the data as fast as possible. This is sometimes called “free-run”.

Measurement Parameters



To capture data, you need to select appropriate **time interval** and **block size**. Time interval can be in microseconds, milliseconds or seconds. The block size should be greater than 2 but less than 20480 for single channel capture and less than 10240 for a dual-channel capture.

Measurement Items

For **Time Capture**, you may elect to capture signals from just channel 1, just channel 2 or both. **x1(t)** stands for the time capture from **channel 1** and **x2(t)** for **channel 2**. Each signal has one unique name to identify it.

Use the **add** push-button when you want to add one more element for the measurement and use **delete** button to delete the item highlighted in the **selected item** group.

Viewing Data

The time domain signal $x(k)$ ($k=0, \dots, N-1$) is in real format (one-column). For this type of signal, the following display formats are available:

Real, Histogram, Magnitude, Orbits

Note: Orbits is only available when two channel acquisition is enabled.

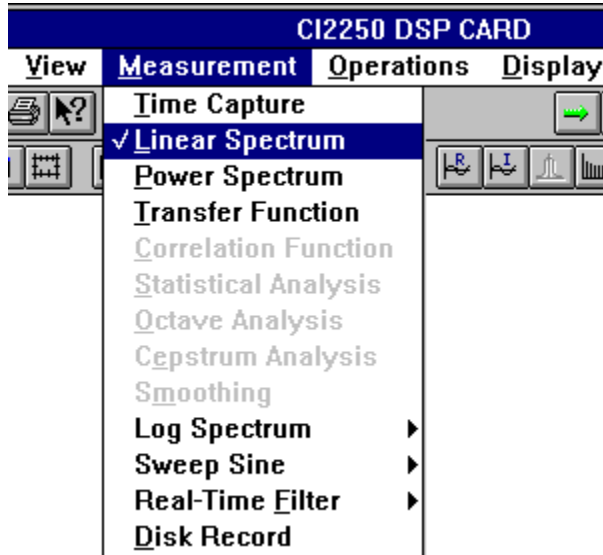
All signals can be viewed in the data listing mode (text mode). To invoke this mode, select **View Trace Data** under the **View** menu item.


See Chapter 7: Display Configuration for more details.



Linear Spectrum

Running a Linear Spectrum

Under the **M**measurement, choose **L**Linear Spectrum:



Once you select **L**Linear Spectrum, the CI2250 will reload the parameters pertaining to this measurement. If you want to view or configure these parameters, press F5 or click the  button on the tool-bar. The signals and associated traces are automatically allocated based on parameter setup. For details about parameter setup, see the section on Parameter Setup later in this chapter.

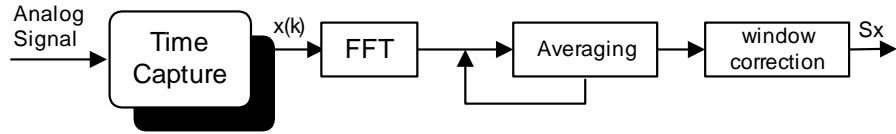
Now press F2 or click on the green arrow button  to start the measurement. To stop the measurement, press F5 or click on the red arrow button .

Operating Principles

The raw data used for linear spectrum analysis is captured in the same way described in Time Capture. Please refer to section Time Capture for detailed information on acquiring raw data.

After the raw data is acquired, it is transformed into linear spectrum by FFT. The data format of the linear spectrum is in complex. Averaging operation is applied directly to linear spectrum. Unless synchronized trigger is used, averaging is rarely applied because an un-correlated average of the linear spectrum may yield meaningless final results.


For a detailed description of the algorithm, please refer to *Chapter 4: Basics of Spectral Analysis*.

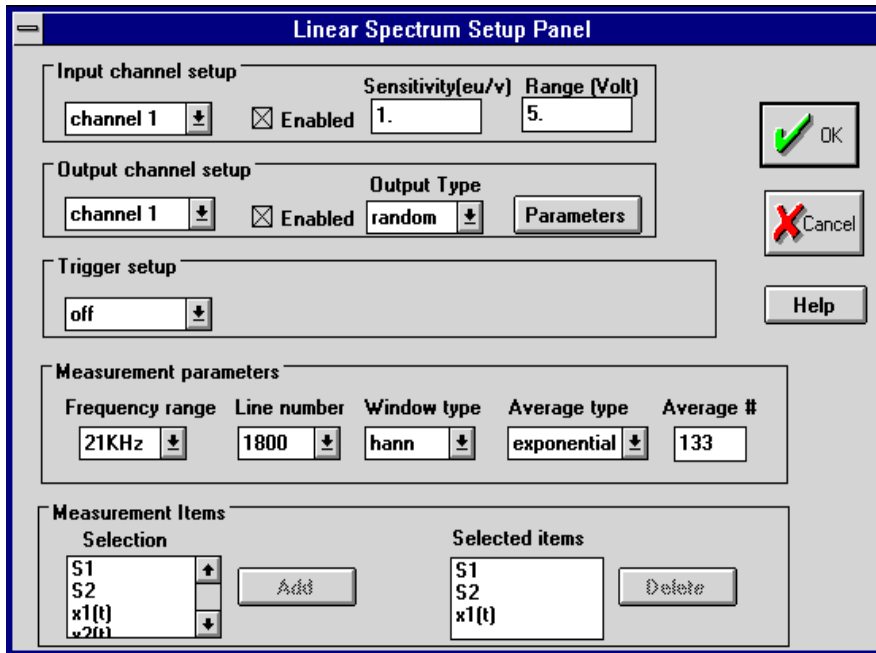


Spectrum Units

See Chapter 3: General Features, section Spectrum Units.

Parameter Setup

In order to activate the parameter setup dialog box, select **Parameter Setup** under the **Operations** menu item or click the setup button  on the toolbar. Linear Spectrum parameter setup panel is shown below.



The parameters are divided into four groups, i.e., **Input channel setup**, **Output channel setup**, **Trigger setup** and **Measurement parameter setup**. This dialog box is responsible for all parameter validation guaranteeing that all selected parameters are meaningful.

For the following topics, please refer to its corresponding sub-sections under Section Time Capture earlier in this chapter:

- Input Channel Setup**
- Output Channel Setup**
- Trigger Setup**

Measurement Parameters

Measurement parameters

Frequency range	Line number	Window type	Average type	Average #
21KHz	1800	hann	exponential	133

For spectral analysis, you need to select an appropriate **Frequency range** and **Line number**. A **Frequency range** can be in Hertz or kilohertz. A **Line Number** is from 56 to 3600. A **Window type** is one of **Hann**, **Rect** or **Flattop**. The Averaging type is one of **Stable**, **Exponential**, **Peak-Hold**, **Peak-Continue** or **Off**. If you select one of **Stable**, **Peak-Hold** or **Exponential** as the averaging type, you also need to define the **Average number**.

Measurement Items

Measurement Items

Selection	Selected items
S1	S1
S2	S2
x1(t)	x1(t)
x2(t)	

For Linear Spectrum measurement, you may select the following signals to measure:

- x1(t)** Current time capture for channel 1
- x2(t)** Current time capture for channel 2
- S1** Averaged linear spectrum for channel 1
- S2** Averaged linear spectrum for channel 2

Use the **add** push-button when you want to add one more element for the measurement and use the **delete** button to delete the item highlighted in the **selected item** group.

Viewing Data

More complete details on the various viewing modes and how to configure them are found in Chapter 7: Display Configuration.

for x1(t) and x2(t), the following displaying formats are available:

Real, Histogram, Magnitude, Orbits

For linear spectra S1 and S2, the following displaying formats are available:

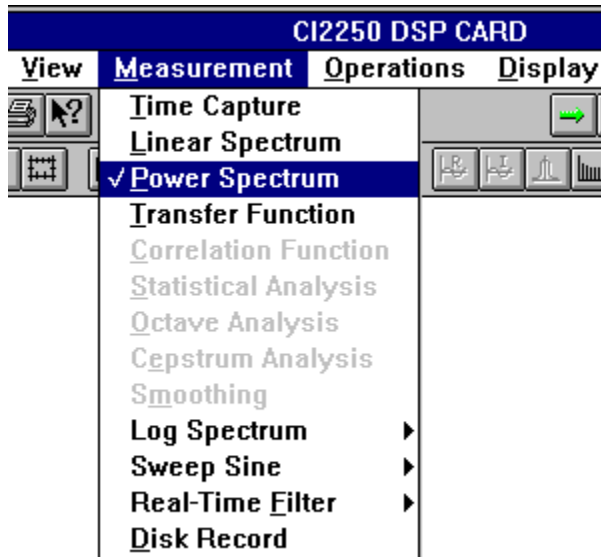
Real, Imaginary, Magnitude, Bar Chart, Phase, Polar, Vector, Unwrap Phase, Nichols

All signals can also be viewed in the data listing mode (text mode). To invoke this mode, select **View Trace Data** under the **View** menu item.


Power Spectrum



Running Power Spectrum

Under the **M**measurement menu item, choose **P**Power Spectrum:



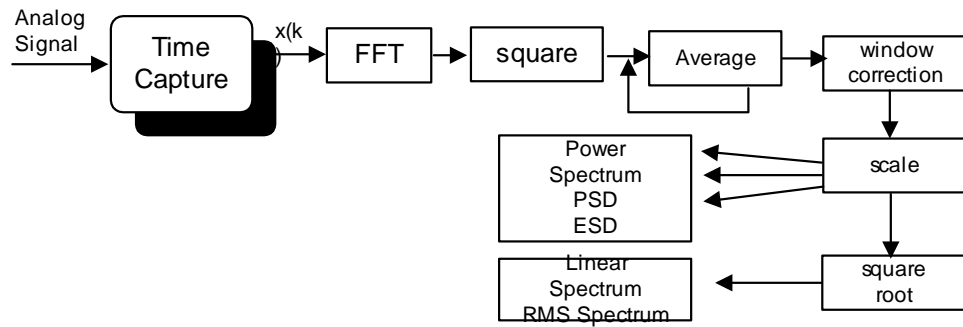
Once you have selected **Power Spectrum**, the CI2250 will reload the parameters pertaining to this measurement. If you want to view or configure these parameters, press

F5 or click the  button on the tool-bar. The signals and associated traces are automatically allocated based on parameter setup. For details about parameter setup, see the section Parameter Setup described later.

Now press F2 or click on the green arrow button  to start the measurement. To stop the measurement, press F5 or click on the red arrow button .

Operating Principles

The raw data used for power spectrum analysis is captured in the same way described in Time Capture. Please refer to this section for more information on acquiring raw data.




After the raw data is acquired, it is transformed into Fourier spectrum by FFT then squared to power (phase information is lost here). After averaging, various scaling factor may be applied based on the spectrum unit user selected.

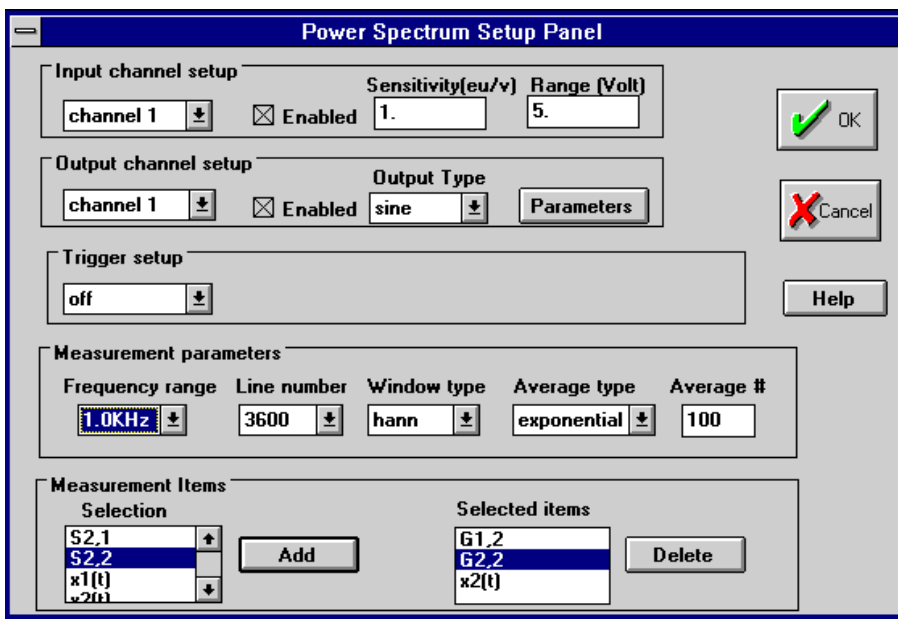
For a detailed description of the algorithm, please refer to *Chapter 4: Basics of Spectral Analysis*.

Spectrum Units

See Chapter 3: General Features, section Spectrum Units.

Parameter Setup

In order to activate the parameter setup dialog box, you can select **Parameter Setup** under the **Operations** menu item or click setup button  on toolbar. The Power Spectrum parameter setup dialog box is shown below.

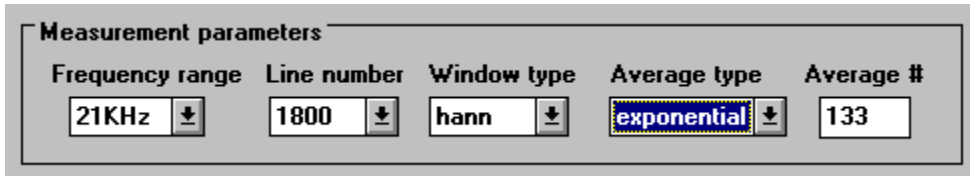


The parameters are divided into four groups, i.e., **Input channel setup**, **Output channel setup**, **Trigger setup** and **Measurement parameter setup**. This dialog box is responsible for all parameter validation in order to guarantee all selected parameters are meaningful.

For the following topics, please refer to its corresponding sub-sections under Section Time Capture earlier in this chapter:

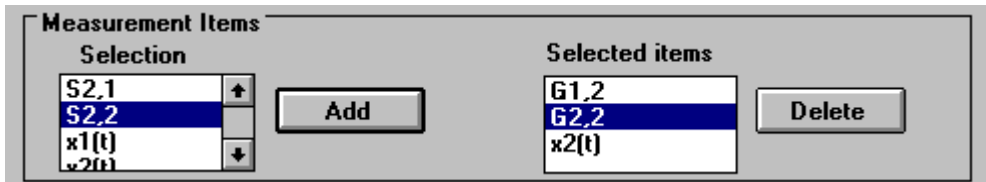
- Input Channel Setup
- Output Channel Setup
- Trigger Setup

Measurement Parameters



For power spectral analysis, you need to select an appropriate **Frequency range** and **Line number**. A **Frequency range** can be in Hertz or kilohertz. A **Line Number** is from 56 to 3600. A **Window type** is one of **Hann**, **Rect** or **Flattop**. The Averaging type is one of **Stable**, **Exponential**, **Peak-Hold**, **Peak-Continue** or **Off**. If you select one of **Stable**, **Peak-Hold** or **Exponential** as the averaging type, you also need to define the **Average number**.

Measurement Items



For the Power Spectrum measurement, you may opt to measure the following signals:

- x1(t)** Current time capture for channel 1
- x2(t)** Current time capture for channel 2
- Sx,x** Instantaneous auto-spectrum for channel x
- Sx,y** Instantaneous cross-spectrum between channel x and channel y
- Gx,x** Averaged auto-spectrum for channel x
- Gx,y** Averaged cross-spectrum between channel x and channel y

Use the **add** push-button when you want to add one more element for the measurement and use the **delete** button to delete the item highlighted in the **selected item** group.

Viewing Data

Please refer to Chapter 7: Display Configuration on how to configure the trace displays.

For $x_1(t)$ and $x_2(t)$, following display formats are available:

Real, Histogram, Magnitude and **Orbits**

For auto-power spectrum $S_{x,x}$ or $G_{x,x}$, the following displaying formats are available:

Magnitude, Bar Chart and **Polar**

for cross-power-spectra $S_{x,y}$ or $G_{x,y}$, the following displaying formats are available:

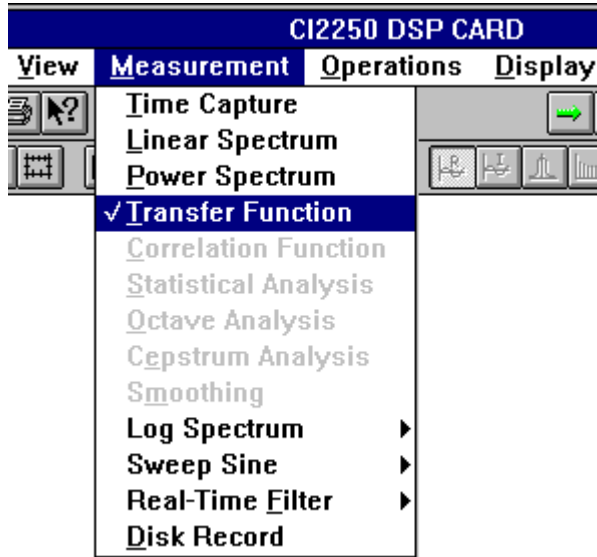
Real, Imaginary, Magnitude, Bar Chart, Phase, Polar, Vector, Unwrap Phase
and **Nichols**

All signals can be viewed in the data listing mode (text mode). To invoke this mode, select **View Trace Data** under the **View** menu item.


Transfer Function



Running Transfer Function

Under the **M**measurement menu item, choose **T**ransfer Function:



Once you have selected **T**ransfer Function, the CI2250 will reload the parameters pertaining to this measurement. If you want to view or configure these parameters, press

F5 or click the  button on the tool-bar. Signals and associated traces are automatically allocated based on parameter setup. For details about parameter setup, see the section Parameter Setup described later.

Now press F2 or click on the green arrow button  to start the measurement. To stop the measurement, press F5 or click on the red arrow button .

Operating Principles

In **T**ransfer Function measurement, the transfer function and coherence function are computed based on auto- and cross- power spectra. Please refer to the section Power Spectrum for information on computing power spectra.

After the power spectra are computed, the transfer and coherence function are calculated by:

$$H_{xy} = \frac{G_{xy}}{G_{xx}} \quad C_{xy}^2 = \frac{|G_{xy}|^2}{G_{xx} G_{yy}}$$


where G_{xy} is the averaged cross-spectrum between input channel x and output channel y. G_{xx} is the averaged auto-spectrum of input. G_{yy} is the averaged auto-spectrum of output.

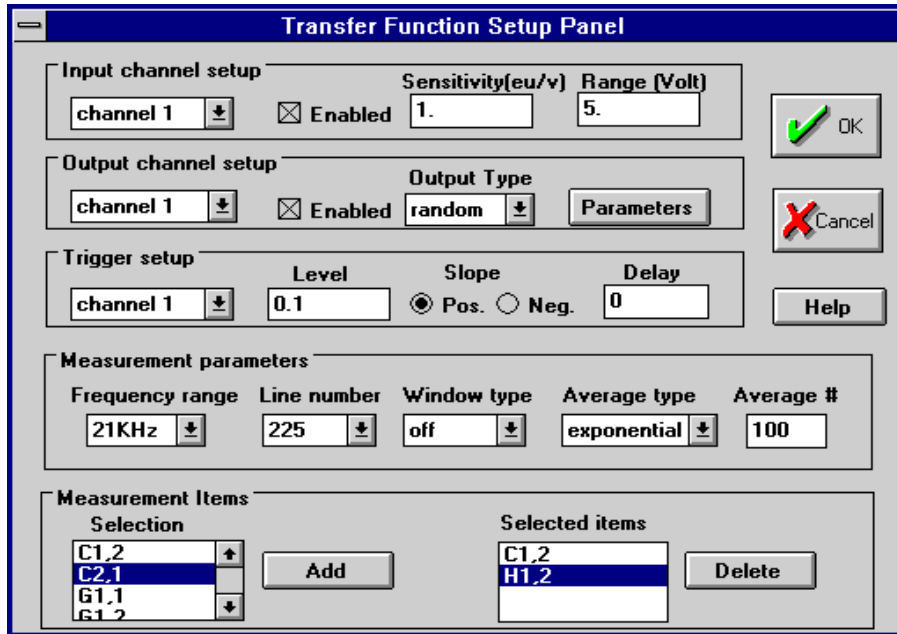
For a detailed description of the algorithm, please refer to *Chapter 4: Basics of Spectral Analysis*.

Spectrum Units

See Chapter 3: General Features, the Spectrum Units section.

Parameter Setup

In order to activate the parameter setup dialog box, you can select **Parameter Setup** under the **Operations** menu item or click setup button  on toolbar. The transfer function dialog box below will appear:



The image shows a dialog box titled "Transfer Function Setup Panel" with several sections for configuring measurement parameters.

- Input channel setup:** Includes a dropdown for "channel 1", an "Enabled" checkbox, a "Sensitivity(eu/v)" field with value "1.", and a "Range (Volt)" field with value "5.". Buttons for "OK" and "Cancel" are on the right.
- Output channel setup:** Includes a dropdown for "channel 1", an "Enabled" checkbox, an "Output Type" dropdown set to "random", and a "Parameters" button.
- Trigger setup:** Includes a dropdown for "channel 1", a "Level" field with value "0.1", "Slope" radio buttons for "Pos." (selected) and "Neg.", and a "Delay" field with value "0". A "Help" button is on the right.
- Measurement parameters:** A table with five columns: "Frequency range" (21KHz), "Line number" (225), "Window type" (off), "Average type" (exponential), and "Average #" (100).
- Measurement Items:** A table with two columns: "Selection" and "Selected items".

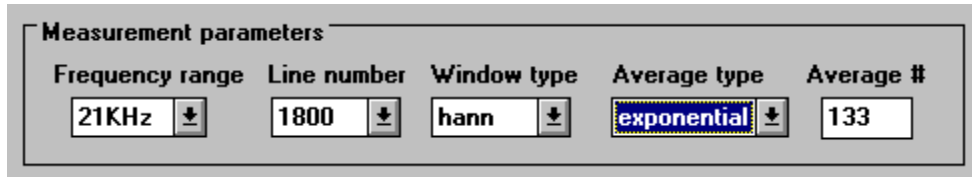
Selection	Selected items
C1.2	C1.2
C2.1	H1.2
G1.1	
G1.2	

The parameters are divided into four groups, i.e., **Input channel setup**, **Output channel setup**, **Trigger setup** and **Measurement parameter setup**. This dialog box is responsible for all parameter validation. It guarantees all selected parameters are meaningful.

For following topics, please refer to the same topic in the Time Capture section:

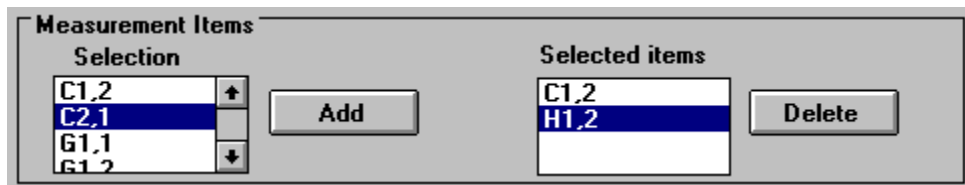
Input Channel Setup
Output Channel Setup
Trigger Setup

Measurement Parameters



For transfer function analysis, you need to select an appropriate **Frequency range** and **Line number**. A **Frequency range** can be in Hertz or kilohertz. A **Line Number** is from 56 to 3600. A **Window type** is one of **Hann**, **Rect** or **Flattop**. The Averaging type is one of **Stable**, **Exponential**, **Peak-Hold**, **Peak-Continue** or **Off**. If you select one of **Stable**, **Peak-Hold** or **Exponential** as the averaging type, you also need to define the **Average number**.

Measurement Items



For Transfer Function measurement, you may select following signals as your measurement:

- x1(t)** Current time capture for channel 1
- x2(t)** Current time capture for channel 2
- Cx,y** Coherence function between channels x and y
- Gx,x** Averaged auto-spectrum for channel x
- Gx,y** Averaged cross-spectrum between channels x and y
- Hx,y** Transfer function between channels x and y

Use the **add** push-button when you want to add one more element for the measurement and use the **delete** button to delete the item highlighted in the **selected item** group.

Viewing Data

Please refer to Chapter 7: Display Configuration to configure the trace displays.

For $x1(t)$ and $x2(t)$, the following display formats are available:

Real, Histogram, Magnitude and Orbits

For auto-power spectrum $G_{x,x}$, the following display formats are available:

Magnitude, Bar Chart and Polar

for the cross-power-spectra $G_{x,y}$, system transfer function $H_{x,y}$, the following display formats are available:

Real, Imaginary, Magnitude, Bar Chart, Phase, Polar, Vector, Unwrap Phase and Nichols

for the coherence function $C_{x,y}$, the following display formats are available:

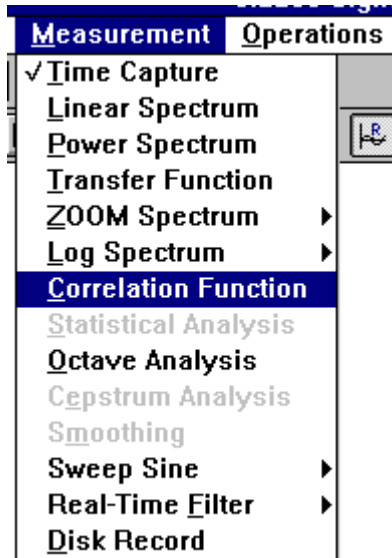
Real and Magnitude


All signals can also be viewed in the data listing mode (text mode). To invoke this mode, select **View Trace Data** under the **View** menu item.



Correlation Function

Running Correlation Function

Under the **M**measurement menu item, choose **C**Correlation Function:




If you want to view or configure these parameters, press F5 or click the  button on the tool-bar. Signals and associated traces are automatically allocated based on parameter setup. For details about parameter setup, see the section Parameter Setup described later.

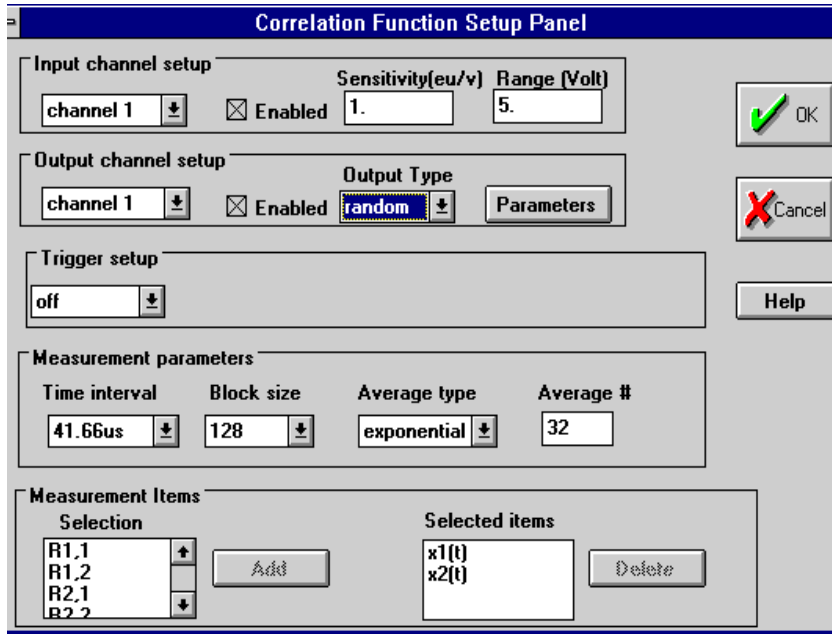
Now press F2 or click on the green arrow button  to start the measurement. To stop the measurement, press F5 or click on the red arrow button .

Operating Principles

In **Correlation Function** measurement, the auto correlation and cross correlation function are computed based on the inverse Fourier Transform of the auto- and cross-power spectra. Please refer to the section Power Spectrum for information on computing power spectra. The average operation is applied to the corresponding power spectra.

Parameter Setup

In order to activate the parameter setup dialog box, you can select **Parameter Setup** under the **O**perations menu item or click setup button  on toolbar. The transfer function dialog box below will appear:



The parameters are divided into four groups, i.e., **Input channel setup**, **Output channel setup**, **Trigger setup** and **Measurement parameter setup**. This dialog box is responsible for all parameter validation. It guarantees all selected parameters are meaningful.

For following topics, please refer to the same topic in the Time Capture section:

- Input Channel Setup**
- Output Channel Setup**
- Trigger Setup**

Measurement Items



For Correlation Function measurement, you may select following signals as your measurement:

- x1(t)** Current time capture for channel 1
- x2(t)** Current time capture for channel 2
- Rx,y** Cross-correlation function between channels x and y
- Rx,x** Auto-correlation function for channel x

Use the **add** push-button when you want to add one more element for the measurement and use the **delete** button to delete the item highlighted in the **selected item** group.

Viewing Data

Please refer to Chapter 7: Display Configuration to configure the trace displays.

For $x1(t)$ and $x2(t)$, the following display formats are available:

Real, Histogram, Magnitude and **Orbits**

For $R_{x,y}$ and $R_{x,x}$ the following display formats are available:

Real, Magnitude

All signals can also be viewed in the data listing mode (text mode). To invoke this mode, select **View Trace Data** under the **View** menu item.

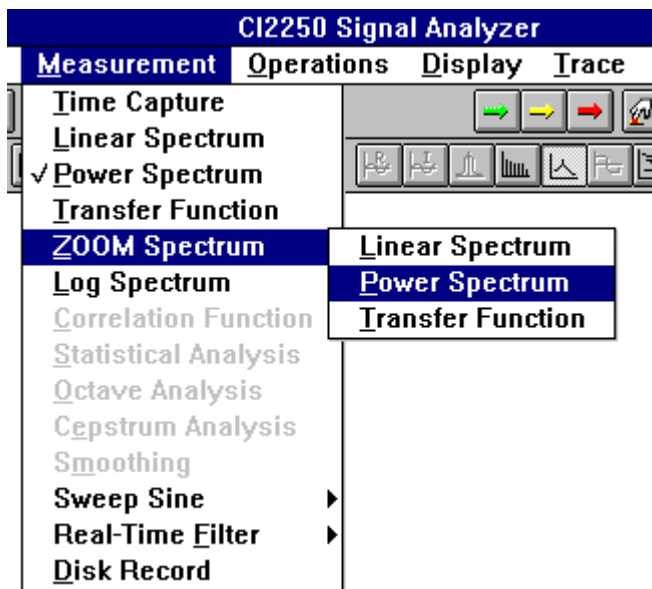
ZOOM Spectra


ZOOM Spectra include:

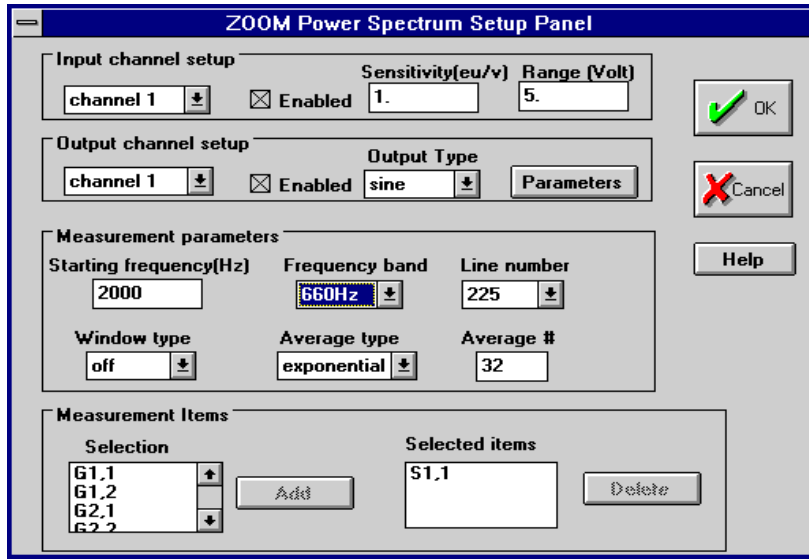
ZOOM Linear Spectrum, ZOOM Power Spectrum and ZOOM Transfer Function.

The computation algorithms, operating principles, parameter setup and display configurations are very similar to those of regular spectra (baseband spectra). Please turn to these sections presented earlier for detailed information.

To run one of these measurements, select **ZOOM Spectrum** under the **Measurement** menu item, then select a sub-item under **ZOOM Spectrum** as shown below:



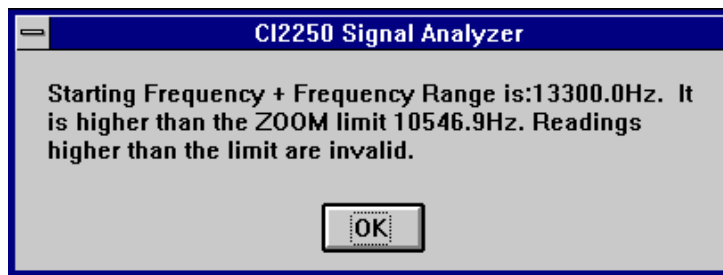
In this picture, **ZOOM Power Spectrum** is selected. In order to activate the parameter setup dialog box, you can select **Parameter Setup** under the **Operations** menu item or click setup button  on toolbar. The ZOOM power spectrum dialog box below will appear:



There are several differences between ZOOM Spectrum parameter setup and that of regular spectrum. Among them are:

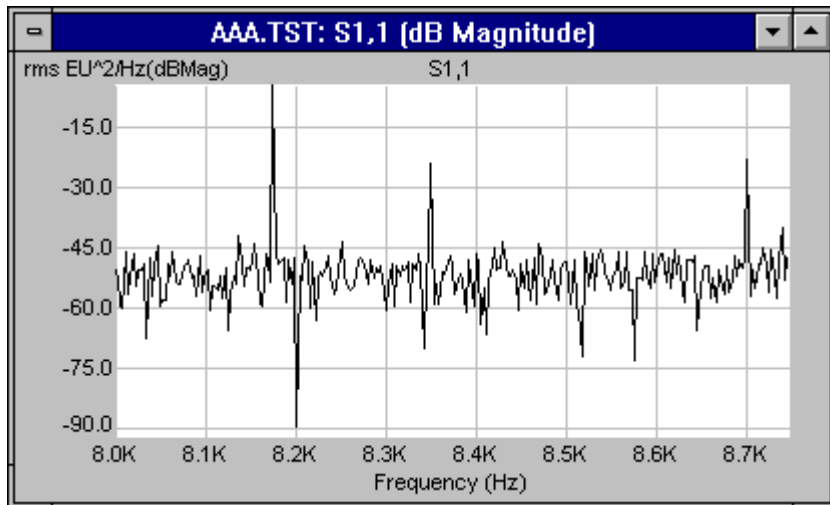
1. In ZOOM Spectrum setup, a starting frequency value has to be defined. This parameter, together with the frequency band, defines the left and right band limits of ZOOM frequencies.
2. Trigger option is not available in ZOOM spectral measurements.
3. Time waveform display is not available in ZOOM spectral measurements.

Because ZOOM requires a real-time filtering computation on the DSP card, the CI2250 has an upper frequency limit for ZOOM analysis (To know this value, please check the specifications for your current system). If the summation of **Starting Frequency** and **Frequency Band** is larger than this limit, then a warning message will appear as below:



This message box indicates that you have selected the inappropriate values for either **Starting Frequency** or **Frequency Band**. However, the system will accept this setup and continue the operation. During the display, the spectral components with invalid frequencies will be hidden.

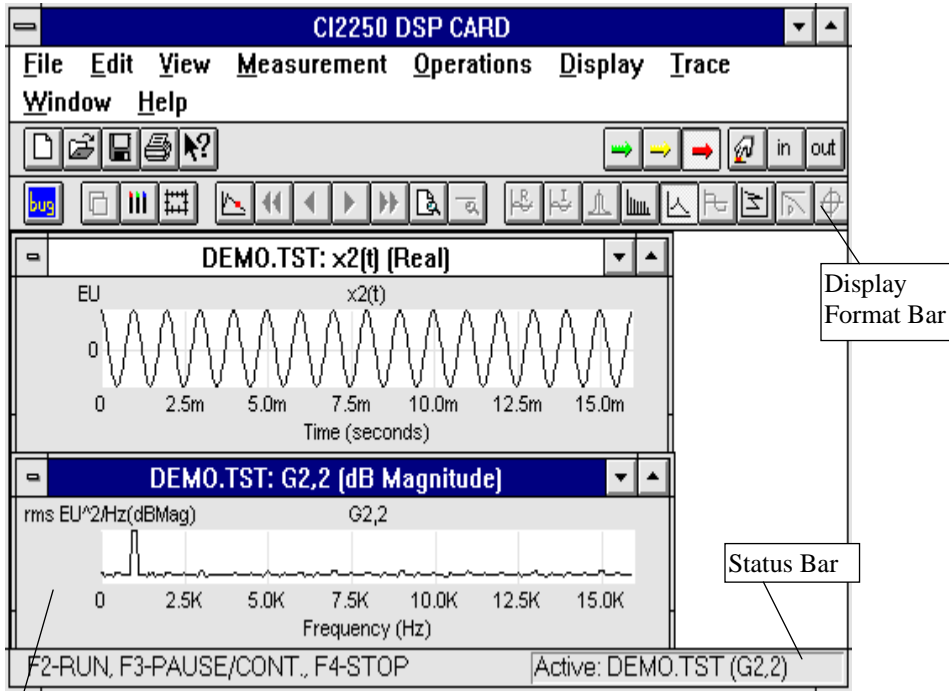
ZOOM spectral display is the same as those in the regular spectral display, except that the frequency is starting from a non-zero value, as shown below:



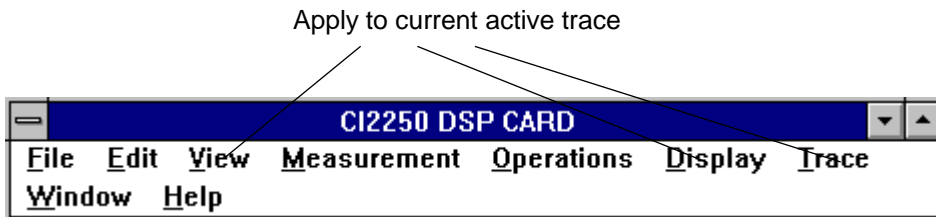
Chapter 7 Display Configuration

Selecting the Active Trace

In the CI2250 Windows system, only one trace is in the active mode at one time. The active trace is always highlighted. You may select the active trace by clicking the mouse on any point within that trace or you can use the **Ctl_Tab** key to alternatively activate any of the traces.



The highlighted bar tells us that this is the current active trace.



All the items under the **V**iew, **D**isplay and **T**race menu items are applied to an active trace. The system automatically enables or disables those items based on given conditions of the current active trace. For example, **S**pectrum **U**nit under **D**isplay is always disabled if the current active trace shows a time domain signal because the Spectrum Unit feature is only used for the spectral parameter setup.

The following smart buttons apply to the current active trace.



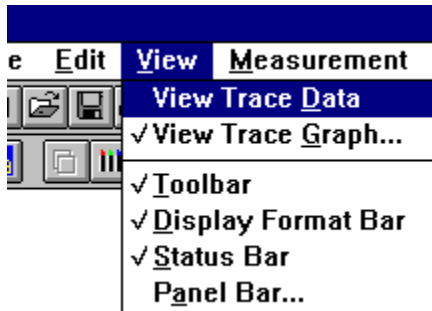
The signal name of the current active trace is displayed on the right-hand end of the status bar as shown below.

The active trace name

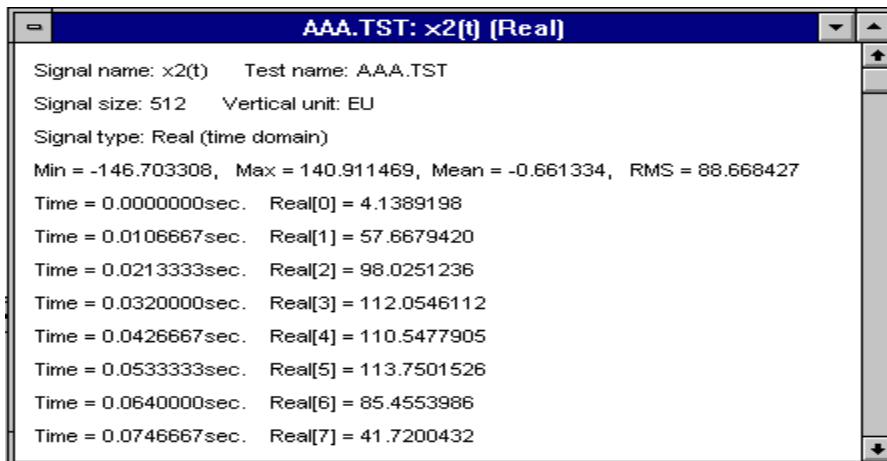


View the Signal in Text Mode

You can view the signals in either graphics or text mode. The graphics mode provides a plot of the signal. The color, font and grid style can all be modified by the user. You can switch the display to text mode under the **V**iew menu item. This is useful when you want to read the data content of the signal.



In text mode, some of the attributes of the signal are displayed. For a time domain signal, the statistical features such as the Maximum, Minimum, Mean and RMS value of the signal are also displayed in the front. After a measurement started, you may find the content of data is refreshed frame by frame.

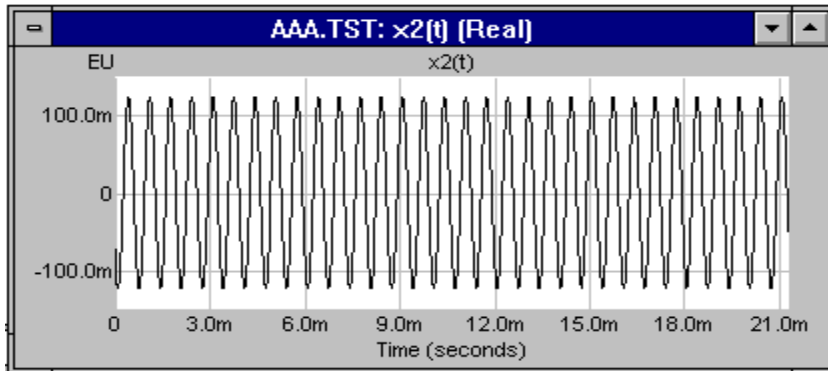


Trace Format

Only one of following trace formats can be selected at a time for each trace.

Real

This displays the real part of the signal. This format is available if the signal is either a time domain real-signal or a complex signal.



Imaginary

This displays the imaginary part of the signal. This format is available for all complex signals.

Magnitude and Bar Chart

These features display the magnitude of the signal. These formats are available for both real and complex signals. For a real signal, the magnitude signal is defined as:

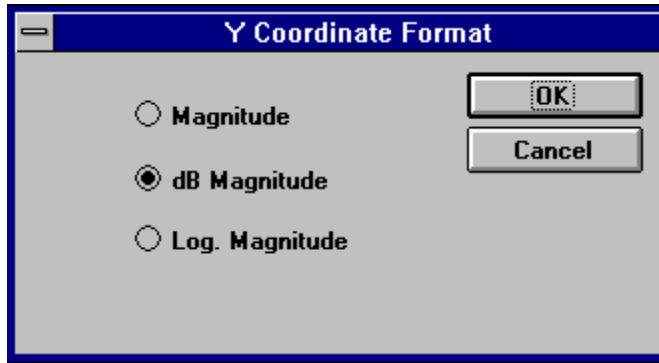
$$Mag(k) = ABS(R(k))$$

where ABS() is the absolute value operator. Mag(k) is drawn as the variable of time k.

For a complex signal, the magnitude signal is defined as:

$$Mag(k) = \sqrt{R^2(k) + I^2(k)}$$

When either a **Magnitude** or **Bar Chart** trace format is enabled, the Y Coordinate can be chosen from either **Magnitude**, **dB Magnitude** or **Log. Magnitude**. This can be done by selecting **Y Coordinate** under **Display** menu item.



Magnitude Coordinate

This setting displays the magnitude of the active trace on a linear Y-axis scale.

dB Magnitude Coordinate

This setting displays the magnitude of the active trace, in decibels, on a linear Y-axis scale.

For linear units (for example, time signal, transfer function or linear spectrum), the Y-axis values are calculated using the following equation:

$$dBMag = 20Log_{10}(Mag) = 20Log_{10}\sqrt{R^2 + I^2}$$

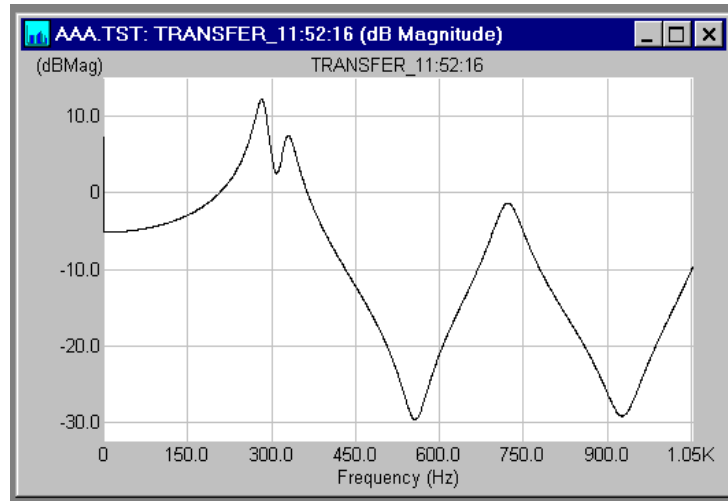
For example, if the magnitude value is 0.1, dBMag will be -20 dB.

However, for power units (for example, power spectrum, power spectral density, energy spectral density), the Y-axis value is calculated using the following equation:

$$dBMag = 10Log_{10}(Mag) = 10Log_{10}\sqrt{R^2 + I^2}$$

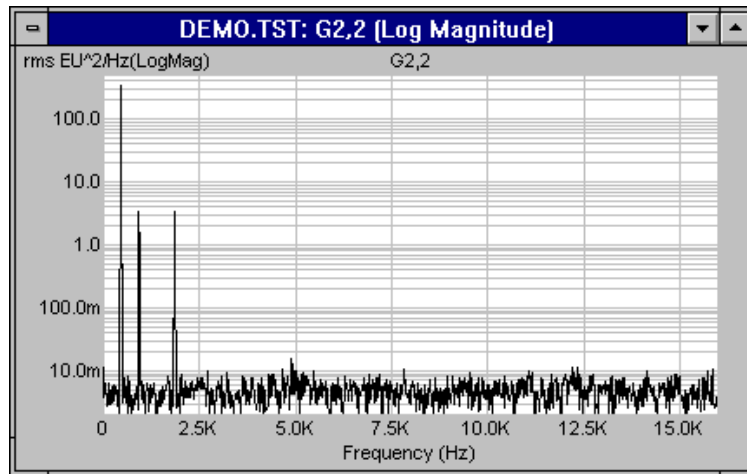
For example, if the magnitude value is 0.1, dBMag will be -10 dB.

The next picture is a typical transfer function measured with the CI2250 showing in the dBMag format:



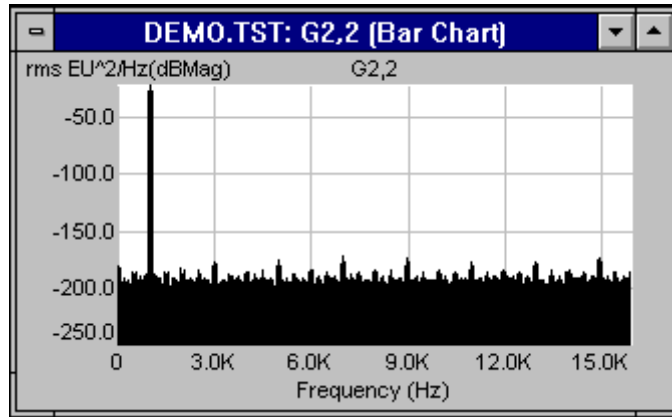
Log Magnitude Coordinate

This setting displays the magnitude of the signal on a logarithmic Y-axis scale.



Bar Chart

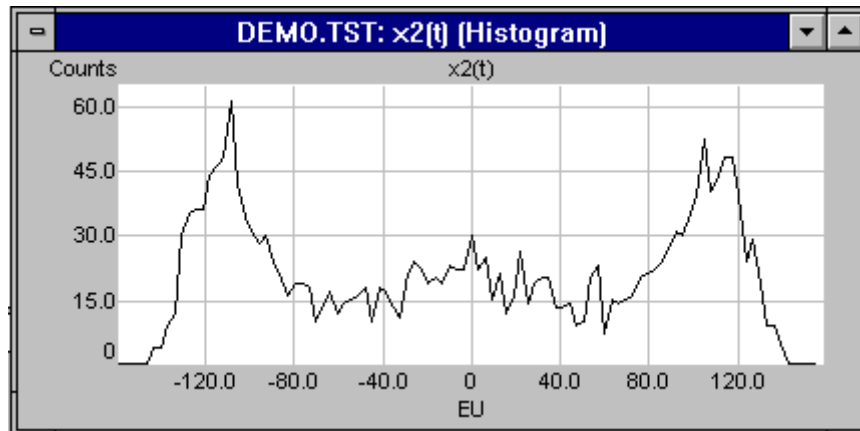
A Bar Chart display is the same as a Magnitude display, except that it is not drawn point to point, instead, it is drawn by extending each point to the bottom as shown below.



Histogram

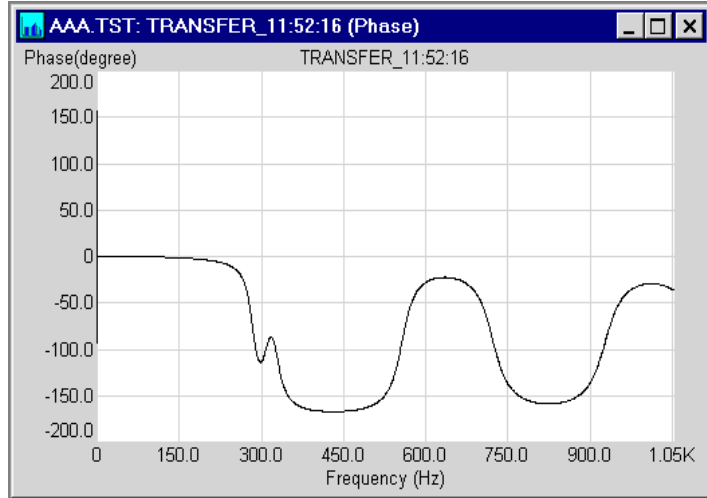
Histogram displays the probability density distribution of a time history. The default horizontal axis range is the same as input range. This display mode is used to view the dynamic range of input signal, given a current input range.

The following chart illustrates the histogram of a signal contains three sines plus noise. The horizontal unit is in EU's and the vertical in Counts.



Phase

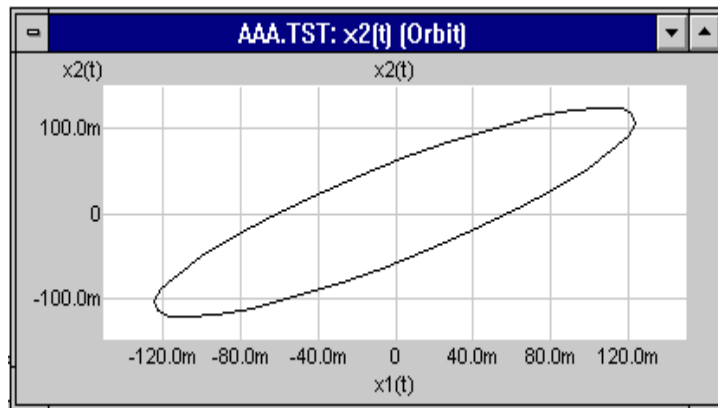
Phase displays a wrapped phase on the active trace. This feature is available for all complex signals.



A wrapped phase means that all phases are shifted to between the phase limits. For the Phase Center Scale of 0 degrees, the limits would be -180 to +180 degrees. If the actual phase is outside this range, it is increased or decreased by a multiple of 360 degrees to put it within the phase limits.

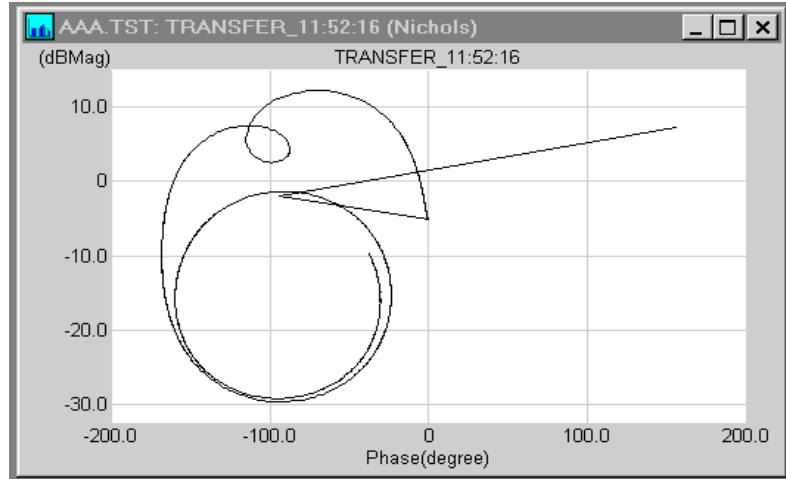
Orbits

The orbits diagram, often referred to as a Lissajous pattern, compares the two input time waveforms, channel 1 versus channel 2. One of its uses is detecting asymmetries in rotating machinery. This display format is available when the dual-channel time capture is enabled.



Nichols

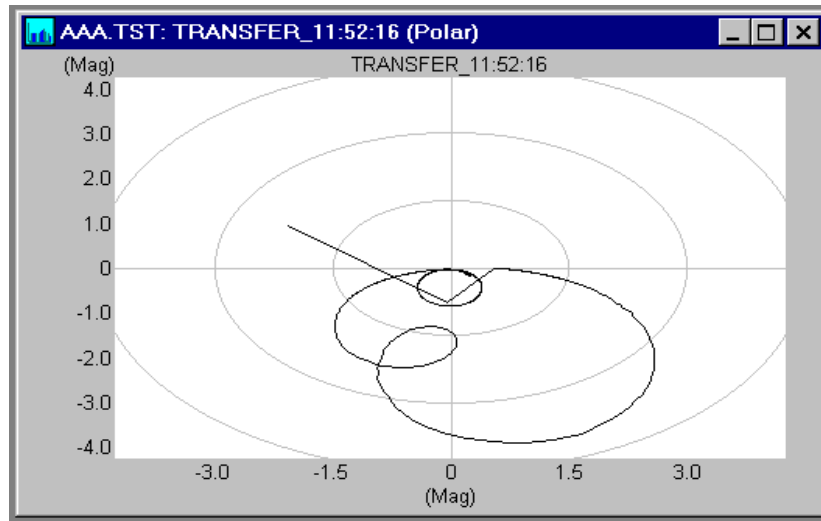
A Nichols displays the magnitude portion in dB units on the x-axis versus the phase part on the y-axis. This is available to all complex signals.



Polar Coordinate

This displays a polar diagram on the active trace. This is available to all frequency domain signals.

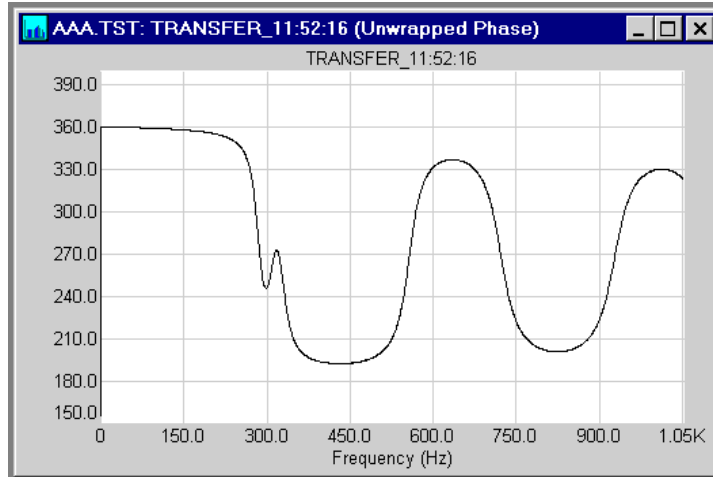
A polar diagram represents each point of the measurement data vectorially: its magnitude is determined by its displacement from the origin; its phase is determined by its angle from the 0 degree line. The marker readout displays the magnitude and phase values and the implied frequency or time at the marker position.



Unwrap Phase

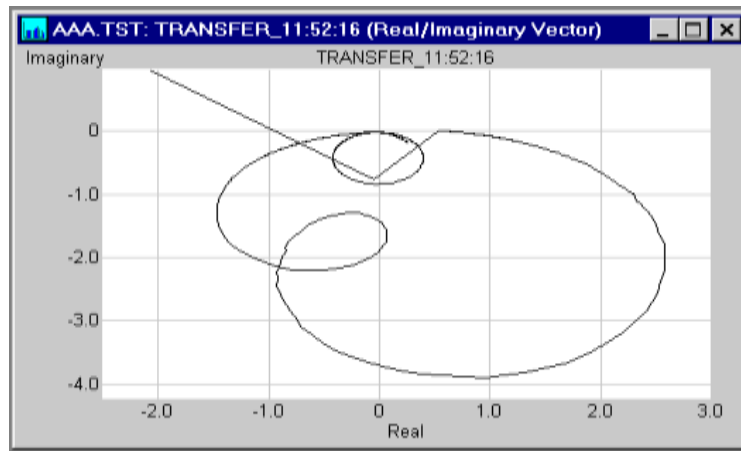
This displays the unwrapped phase on the active trace. This is available to all complex signals.

If you select this trace coordinate, phase is not wrapped to keep it within the current phase limits. You can display the wrapped phase by selecting Phase Coordinate.



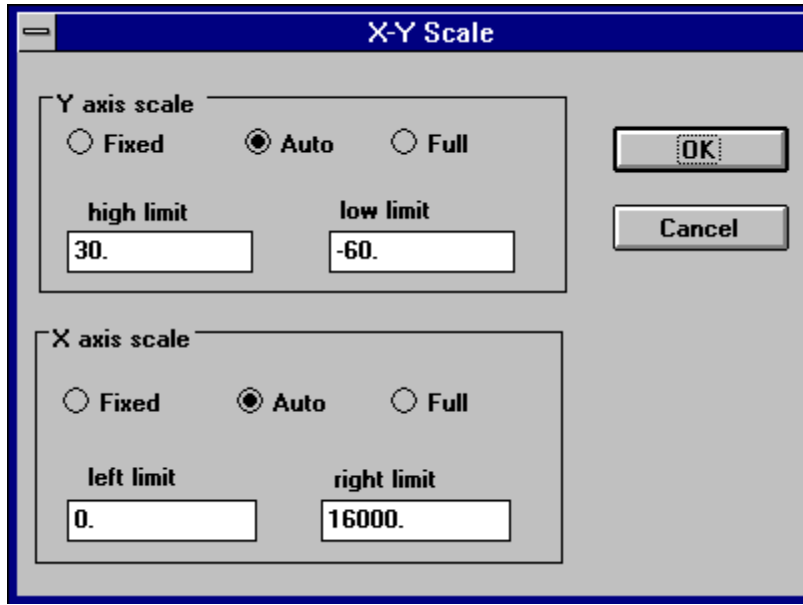
Vector (Nyquist)

The Vector displays the real part on the x-axis versus the imaginary part on the y-axis. It's available to all complex signals.



Scaling the Display

In the graphics mode, you may scale the trace limits by selecting the **X-Y Scale** item under menu item **Display**. The horizontal and vertical axes offer several scaling options. You can explicitly enter minimum and maximum values for either axis, or the CI2250 can auto scale to obtain the optimum display.



X Axis Scaling

X-axis scaling operates in one of three modes: **Auto** and **Full** and **Fixed**. In the **Auto** mode, the CI2250 measure the maximum and minimum horizontal values of current signal and provides “nice” limits for displaying them. When signal content changes, the scaling limits will be estimated again. **Full** mode is similar to **Auto** mode, in that the Maximum and minimum values are used directly as the left and right limits. In **Fixed** mode, the left and right limits are explicitly defined by the user.

Using the **ZOOM** display will switch the X scale to **Fixed** mode.

Y Axis Scaling

Y-axis scaling operates in one of three modes: **Auto** and **Full** and **Fixed**. In the **Auto** mode, the CI2250 measure the maximum and minimum vertical values of current signal and provides “nice” limits for displaying them. When signal content changes, the scaling limits will be estimated again. **Full** mode is similar to **Auto** mode, in that the Maximum and minimum values are used directly as the upper and bottom limits. In **Fixed** mode, the upper and bottom limits are explicitly defined by the user.

Using the **ZOOM** display will switch the Y scale to **Fixed** mode.

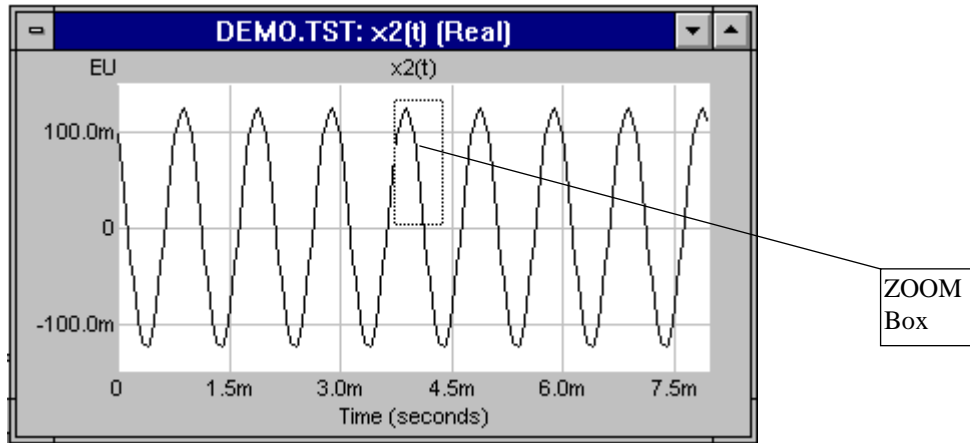
ZOOM Display



ZOOM and **Un-ZOOM** buttons.

The ZOOM display is simply another way to change the X-Y scales by using the mouse. Because the mouse is used for several purposes, you have to enable the ZOOM display mode to do this. To enable the ZOOM display, you can either select the **ZOOM Enabled** under the **Display** menu item or click the appropriate smart button.

When the ZOOM display is enabled, you will move the mouse arrow to the upper-left corner of the area that you want to ZOOM in, press mouse's left button, drag to the bottom-right corner of the ZOOM-in area, then release the mouse button. Now you will see an enlarged picture.



You can ZOOM-in many times. Once a picture is ZOOM'd, the **un-ZOOM** item under the **Display** is enabled so that you can return to the last stage before this ZOOM is operated. The CI2250 will keep the ZOOM history of each trace.

The ZOOM operation will put both the X-Y scales in the **Fixed** mode.

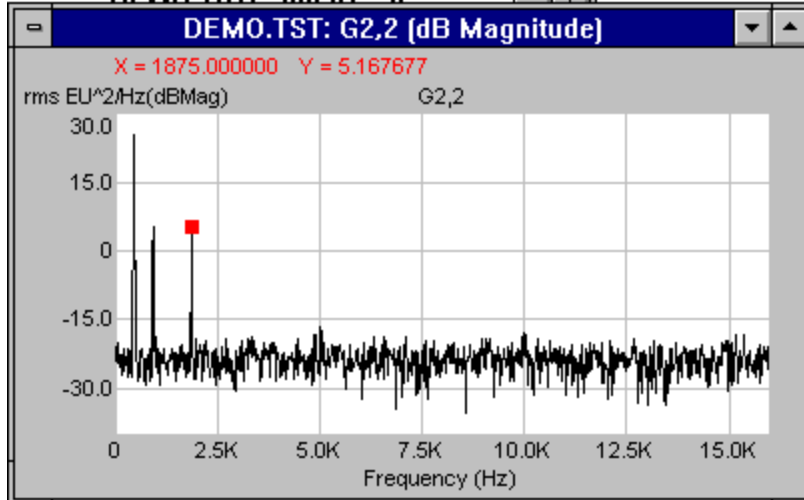
Note: The ZOOM Display has nothing to do with ZOOM Spectral Analysis. ZOOM Spectral Analysis is a technique for examining the frequency content of a signal with a fine resolution over a relatively narrow band of frequencies. For details see *Chapter 4: Basics of Spectral Analysis*.

Mark Operation



These are the Mark operation buttons.

Mark can be enabled by selecting **Mark Enabled** under the **Display** menu item. Once the Mark mode is enabled, the mouse is used to locate the position of the mark. You may move the mouse to where you want to put the mark, and click once. The vertical and horizontal value at the mark's location is given on the top of the trace, as shown below.



Sometimes you may feel it is not convenient to use the mouse to pin-point the location. Instead, you can use either the arrow key on the keyboard or push the arrow button shown on the display bar. The left and right arrow keys are used for moving one sample to the left or right. If you want to have a faster move, use the Ctrl Key plus the arrow key.

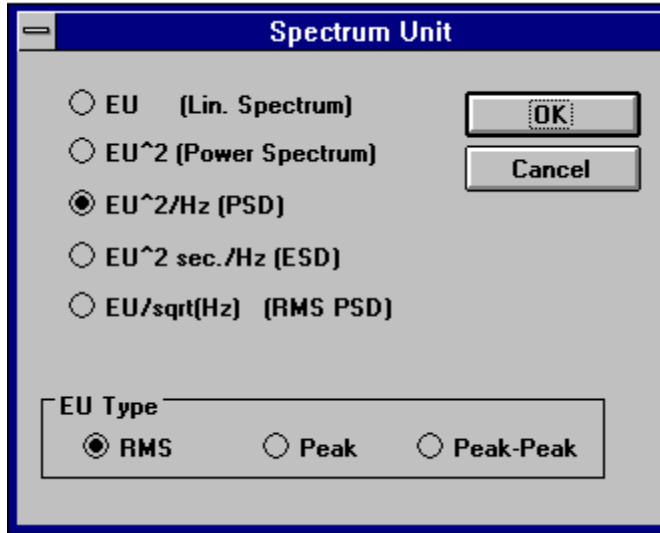
The units of mark value are the same as the vertical and horizontal units. In the picture shown above, the X value at the mark is 1875 Hz; the Y value is 5.167677 dB in EUrms^2/Hz .

When the X-Y scale limits change, the location (i.e., signal index) of mark will keep the same as before. This makes it possible that you can track down the details of the signal while maintaining the same mark location.

Spectrum Unit

To view the spectrum in different units, you may select **Spectrum Unit** under the **Display** menu item.

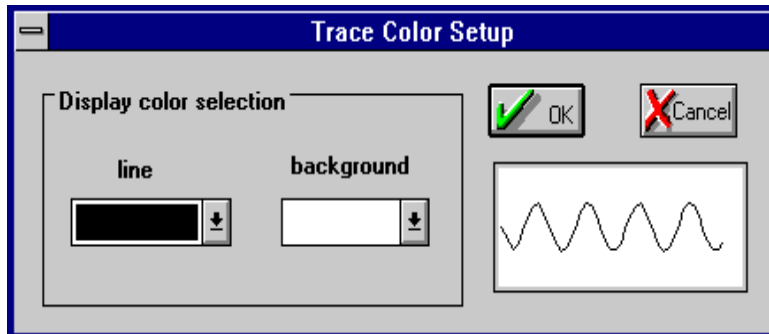
This selection is only applied to linear and power spectra. Five options are provided here as shown in following dialog box. For detail discussion on Spectrum Unit, please refer to *Chapter 7: Basics of Spectral Analysis*.



Change the Picture Color

In graphics mode, you can choose the color for the lines and background. You do this by selecting **C**olor under the **D**isplay. Following dialog box will be enabled. When you change the color, a sample of plot is shown in the dialog box.

If you want to change the color of the text, you need to select the Font Dialog Box and change it there.



When you prepare to print the illustration with a black/white printer, you'll usually need to switch the color to one appropriate for printing. For example, white lines on a black background will not print as distinctly as black lines on white background.

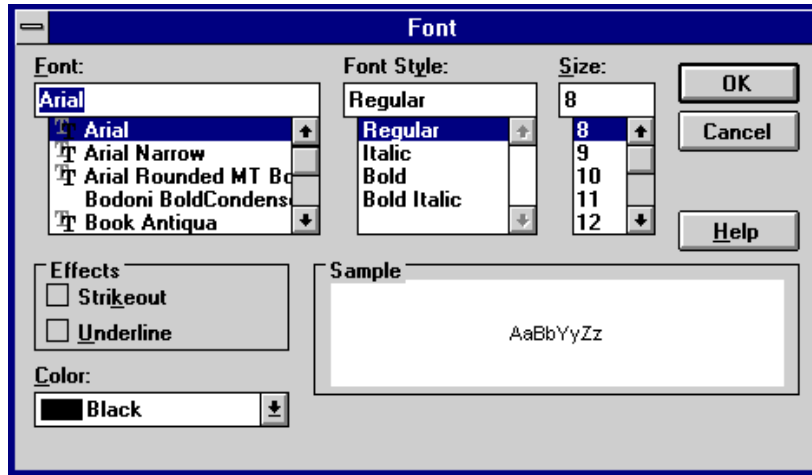
Every time the color is changed, the current trace will be refreshed.

Change the Fonts

Text font can be customized by selecting **F**ont under the **D**isplay menu item. A sample of the current selected font is given in the Font Dialog Box. The new font will be applied to the active trace either in the text mode or graphics mode.

You can change the color of text here.

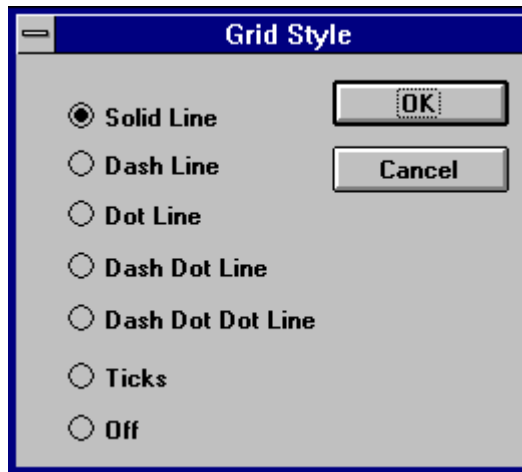
When the font is changed, the current trace will be refreshed.



Change the Grid Styles

The grid style can be changed by selecting **Grid Style** under the **Display** menu item. Seven grid styles are provided as shown in following dialog box.

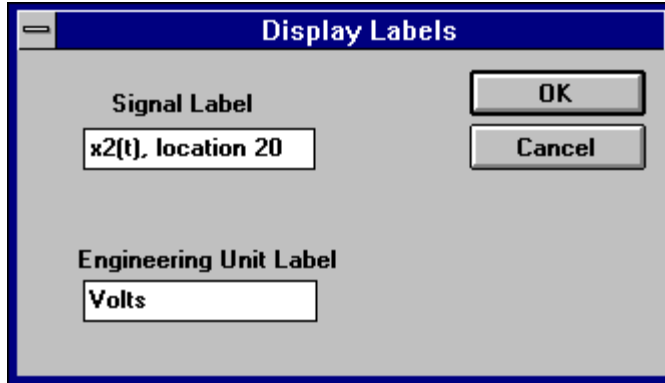
When the grid is changed, the current trace will be refreshed.



Change the Labels

Each signal needs a label. Initially the signal will receive a default label. Later on you can change the label to any title desired by selecting **Label** under menu item **Display**. Similarly, an Engineering Unit can have a different name other than EU, as shown in the following dialog box.

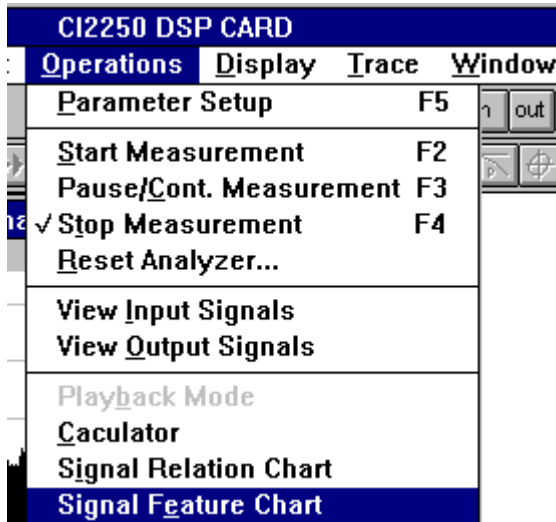
When labels are changed, the current trace will be refreshed.



Displaying the Signal Features

The CI2250 can display the information of current allocated signals. To do this, first select **Signal Feature Chart** under the **Operations** menu item. Once you've selected this item, a brand new window will open. This window will give you the key information of allocated signals.

This feature is useful when you use Signal Calculator.

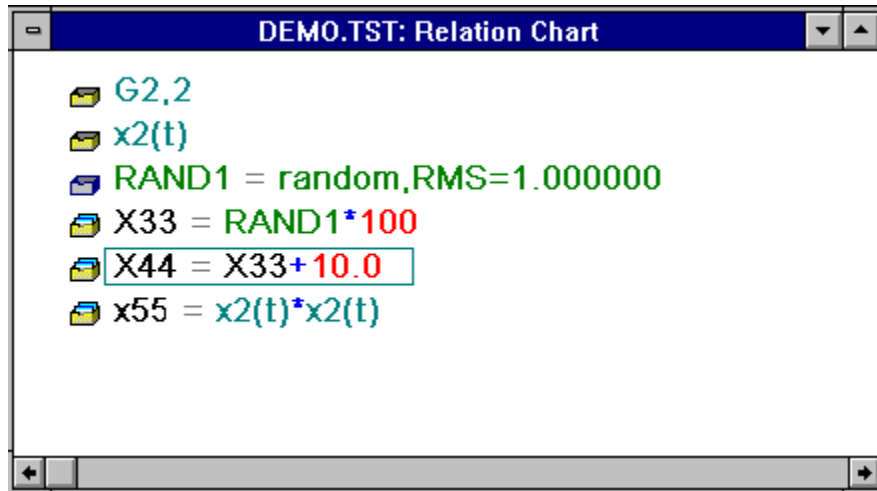


The following illustration shows some key information of the current allocated signals belonging to current test.

DEMO.TST: Feature Chart							
Name	Size	Type	Source	DataFormat	DataPower	FreqUnit	EUT
G2,2	256	SIMPLE	—	APS_FREQ	TWO	PSD	RMS
x2(t)	512	SIMPLE	—	REAL_TIME	ONE	—	RMS

Display Signal Relationship

This function is used to display the causal relationship between signals. Generally it is used together with SignalCalculator. To enable this, you need to select **Signal Relation Chart** under the **Operations** menu item. Once this item is selected, a brand new window will open. In this window, the relationship between allocated signals is given.



Chapter 8 Windows Menu

This Chapter summarizes the uses of each Windows menu item.

File

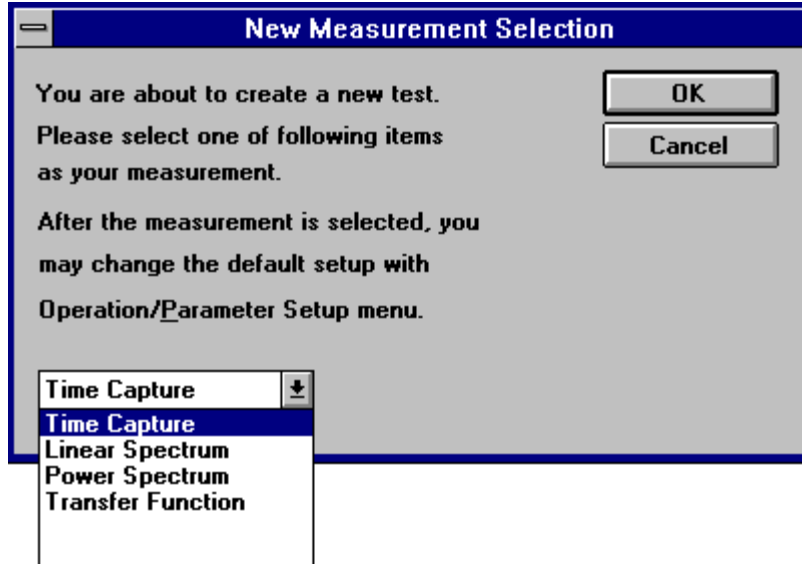
<u>F</u> ile	<u>E</u> dit	<u>V</u> iew	<u>M</u> easurement
<u>N</u> ew			Ctrl+N
<u>O</u> pen...			Ctrl+O
<u>C</u> lose			
<u>S</u> ave			Ctrl+S
Save <u>A</u> s...			
<u>E</u> xport ASCII Signal...			
<u>O</u> pen Signal...			
Save <u>S</u> ignal...			
<u>P</u> rint...			Ctrl+P
Print <u>P</u> review			
Print <u>S</u> etup...			
<u>1</u> DEMO.TST			
<u>2</u> AAA.TST			
<u>E</u> xit			

For the CI2250, a test is defined as the collection of current configurations, setup parameters, and all allocated signals. A test file has an extension of *.TST.

The following commands apply to a test: **New**, **Open**, **Close**, **Save** and **Save As..**

New

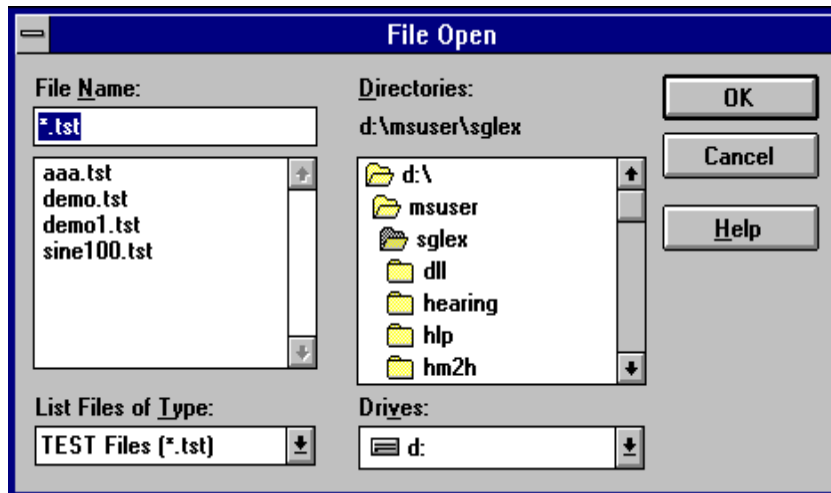
This creates a test with default parameters. The CI2250 will prompt a dialog box that allows you to select one of the measurement types, for example, **Time Capture** or **Power Spectrum**.



After the default test has been created, you may change any of measurement parameters. You may also switch to the other measurement types such as ZOOM spectral analysis. The **New** command creates the default parameters for all measurement types available in your system.

Open

The File Open Dialog Box looks like this:



This command allows you to load an existing test from the disk. When a test is opened, all parameter saved last time will be restored. The CI2250 will attach a trace window to each allocated signal for viewing.

Close

This closes the active test. If the signals of this test are displayed in more than one window (trace), this command closes all of the windows that contain the active document.

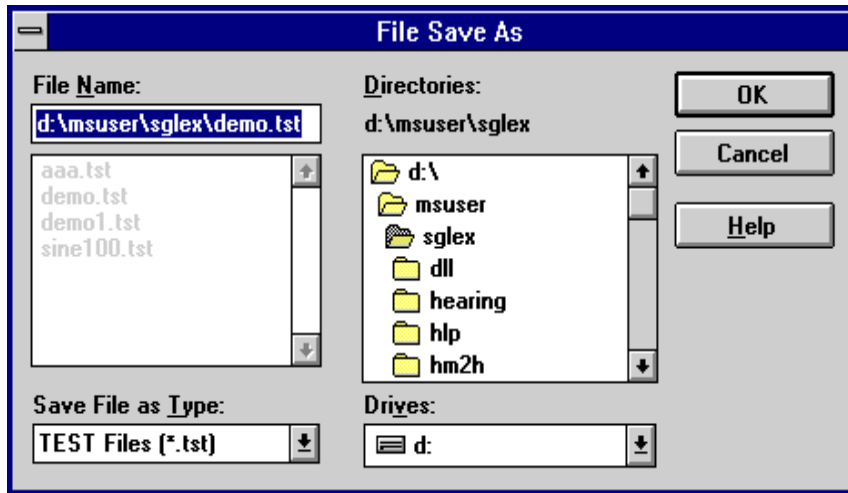
If you have not previously saved changes to the test, CI2250 asks if you want to save the test before you close it. If you close a test without saving, you lose all the changes that you had not previously saved.

Save

This saves the active test with the name and location you previously set in the **Save As** dialog box. The file will have a *.TST format. When you save a test for the first time, CI2250 displays the **Save As** dialog box. If you want to change the name or location of an existing test, choose the **Save As** command to do so.

Save As

displays the **Save As** dialog box, where you specify the name, location, and file format of the active test.



You can also use this command to protect a document so that others cannot change its contents simply by renaming it.

You can also save and open a single signal by using the following commands: **Export ASCII Signal**, **Open Signal** and **Save Signal**.

Export ASCII Signal

This saves the current active signal (whose trace is highlighted) to the disk in a ASCII format. It will not only save the array of data together with a few attributes that are related to this signal.

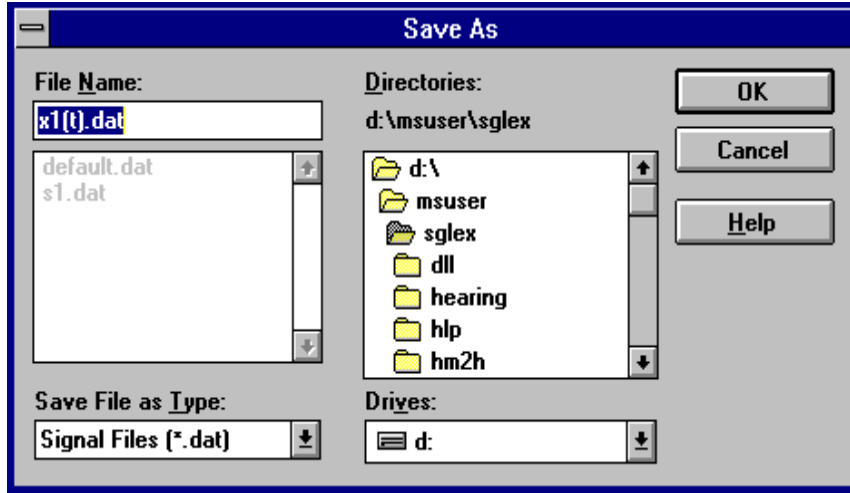
An ASCII format signal has a file extension of *.ASC.

Save Signal

This saves the current active signal (whose trace is highlighted) to the disk in a binary format. It will not only save the array of data, but it also saves all attributes that are related to this signal.

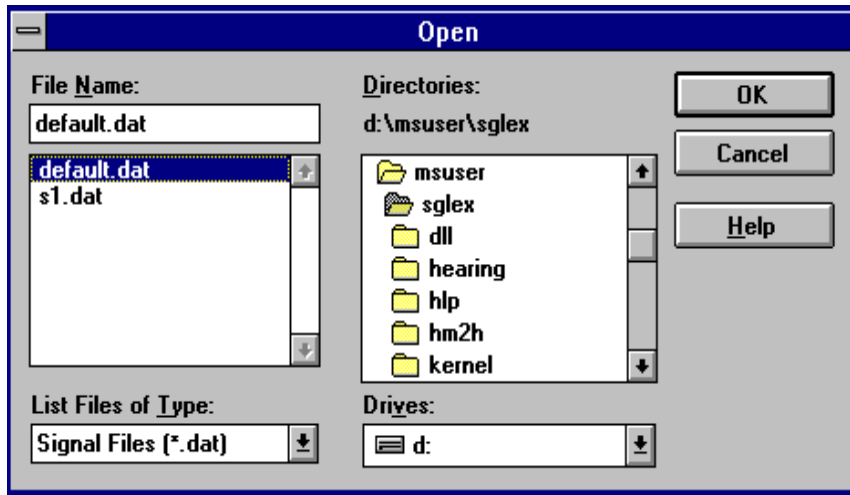
The dialog box shown below will be prompted so that you can choose a file name for this signal.

A binary format signal has a file extension of *.DAT.



Open Signal

Here's the Open Signal Dialog Box



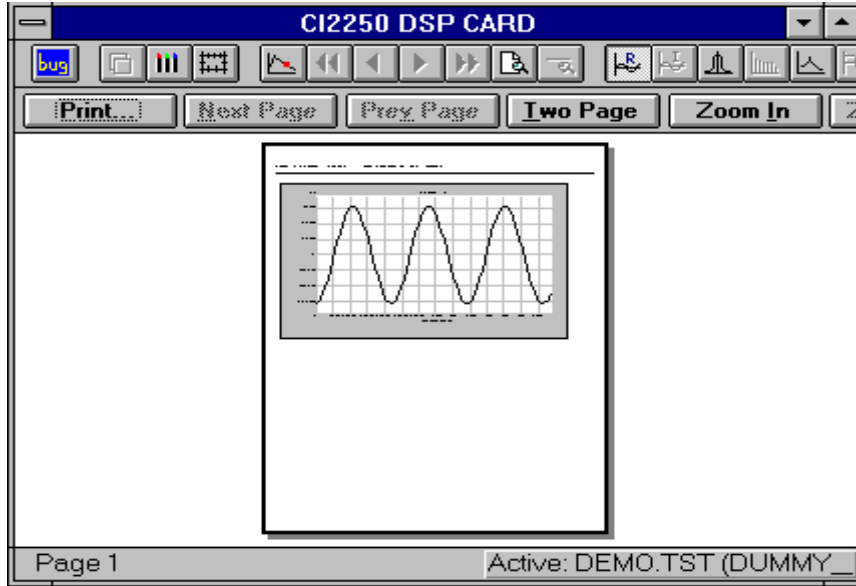
This command loads an existing binary signal from the disk. When a signal is opened, it is allocated in the current active test document and CI2250 will attach a window (trace) to it for viewing. The signal file will have an extension of *.DAT.

Print

Print controls how a trace is printed. Before using this command, you must install and select a printer. To install a printer, see your Windows documentation. To select a printer, see Print Setup dialog box later in this Chapter.

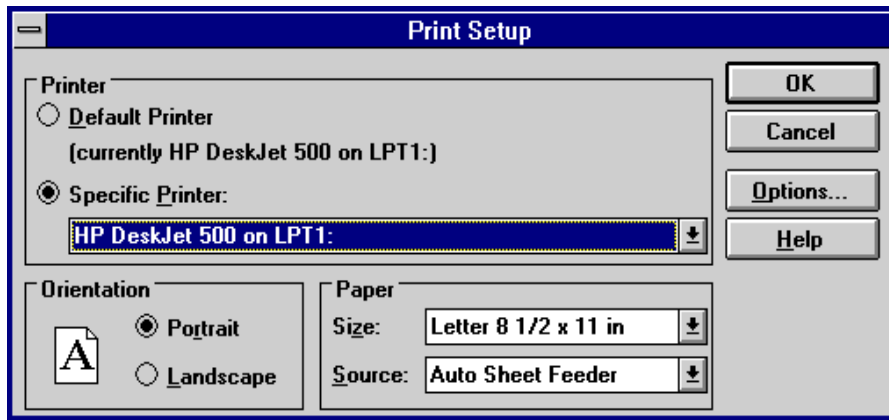
Print Preview

This shows how an active trace will look when you print it. You will get a representation of the printed page as the illustration below shows:



Print Setup

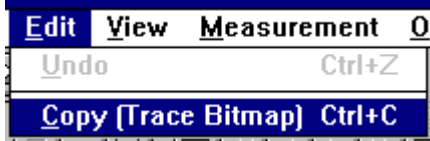
After choosing **Print Setup**, the following dialog box will be prompted. This lets you use the standard Windows printer setup procedure to configure the printer.



Exit

ends the CI2250 session. The CI2250 prompts you to save any unsaved changes in a document.

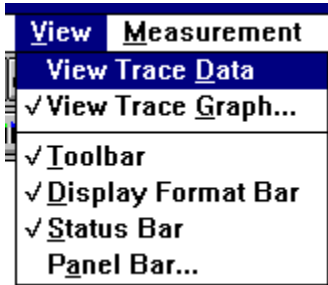
Edit



Copy (Trace Bitmap)

This command will copy the picture in the current active trace into Windows clipboard in a Bitmap format. From there you can paste the bitmap to other Windows applications.

View



View Trace Data

This shows the current active trace in the data listing mode.

View Trace Graph

shows the current active trace in the graphics plotting mode.

Toolbar

displays, or hides, the toolbar. The toolbar looks like this:



Display Format Bar

displays, or hides, the Display Format Bar. The Display Format Bar appears as below:



Status Bar

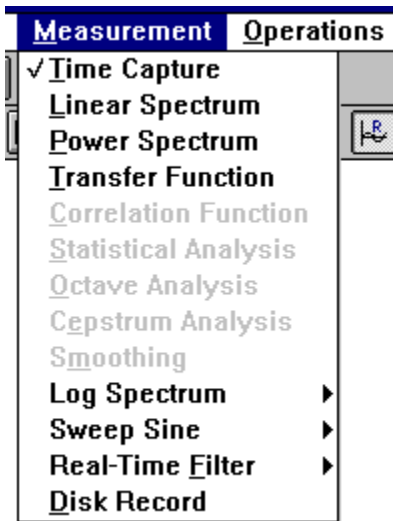
This displays, or hides, the Status Bar. The Status Bar appears as below:



Panel Bar

displays or hides the Panel Bar.

Measurements






This menu lets you select one of the different types of measurements. Each measurement has its own set of setup parameters, so once you select a specific measurement, the previously stored parameter status will be restored.


Some of the items are dimmed, meaning that those software options are not installed in your CI2250 system. If you want to purchase one or more of these options, please contact Crystal Instruments.

For detailed information about the items listed under **Measurements**, please refer to *Chapter 6: Measurement Operations*.

Operations

<u>O</u> perations	<u>D</u> isplay	<u>T</u> race	<u>W</u> indow
<u>P</u> arameter Setup		F5	
<u>S</u> tart Measurement		F2	
<u>P</u> ause/ <u>C</u> ont. Measurement		F3	
√ <u>S</u> top Measurement		F4	
<u>R</u> eset Analyzer...			
View Input Signals			
View Output Signals			
Playback Mode			
<u>C</u> aculator			
Signal Relation Chart			
Signal Feature Chart			

Parameter Setup

Short-cut key **F5**, Button .

Chooses appropriate parameters for the current measurement.

Start Measurement

Short-cut key **F2**, Button  (with green arrow).

This starts the current measurement.

Pause/Cont. Measurement

Short-cut key **F3**. Button  (with yellow arrow).

If the measurement is in progress this action will put the measurement into the pause mode. If the measurement is in the pause mode already, this action will continue the measurement (continue the averaging if average is turned on).

Stop Measurement

Short-cut key **F4**, button  (with red arrow)

This stops the measurement. This measurement will not stop the output. To stop the output, use **Reset Analyzer** command.

Reset Analyzer

This initializes the CI2250 to a default state. Both input and output will stop.

View Input Signals

This displays the input signals with current input settings. The display is always in a fixed scale so the full range of input can be monitored.

View Output Signals

displays the output signals with current the output settings. The display is always presented in a fixed scale so that full range of output can be monitored. However, if the measurement has never been started, there will be no output.

If the CI2250 has not been calibrated, the output displayed by **View Output** command may be different to the “true” output. This is due to the gain and offset error of D/A converter and analog front-end of the CI2250.

Playback Mode

This command plays back the data stored on a disk. This time the input does not come from A/D converter. Instead, the pre-recorded signal is replayed, and goes through the same measurement procedure.

Calculator

This opens a signal calculator dialog box. See *Chapter Signal Calculator*.

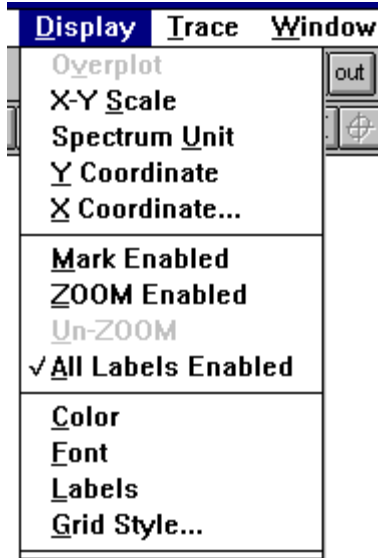
Signal Relation Chart

Opens a signal relation chart window. See *Chapter Signal Calculator* and *Chapter Display Configuration*.

Signal Feature Chart

Opens a signal feature chart window. See *Chapter Signal Calculator* and *Chapter Display Configuration*.

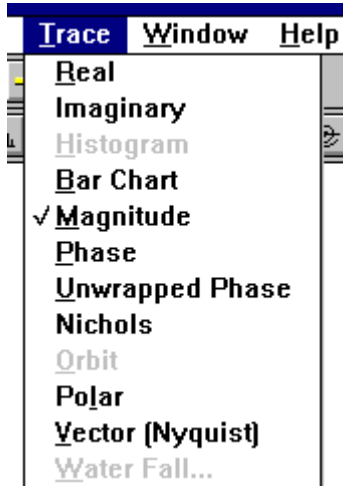
Display



The commands listed here are applied to the current active trace.

For detailed information about the items listed under **Display**, see *Chapter 7: Display Configuration*.

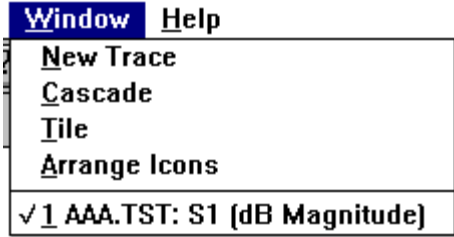
Trace



The commands listed here are applied to the current active trace. These items are enabled or disabled based on the attributes of the signal that is associated with the active trace.

For detailed information about the items listed under **Traces**, see *Chapter 7: Display Configuration*.

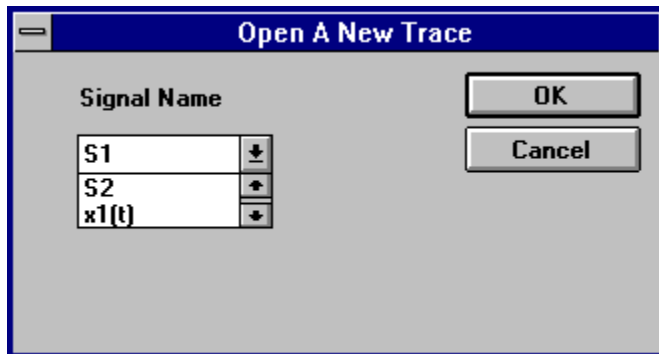
Window



New Trace

New Trace opens a new window (trace) and associates it with an existing signal.

The following dialog box will appear to let you select a signal to attach that this new trace to. It's very helpful to open multiple traces for one signal because you can view them in different display format.



Cascade

Cascade arranges multiple opened windows (traces) in an overlapped fashion.

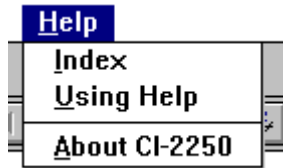
Tile

Tile arranges multiple opened windows (traces) one beside the other, so they do not overlap.

Arrange Icons

arranges the icons for minimized windows at the bottom of the main window. If there is an open document window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this document window.

Help



Index

displays a comprehensive index to information contained in the MS-Windows Help system.

Using Help

shows how to use the Windows Help system.

About CI2250

displays information about your copy of CI2250, including the version number; the copyright, legal, and licensing notices.

Chapter 9 CI2250 Product Data

Hardware Specifications

Analog Inputs

Two true differential inputs
 CMR > 75dB
 Input impedance: 1M Ω
 Full input range:
 $\pm 0.5V$ to $\pm 5V$
 Cross-talk between two inputs: -80 dB
 Phase match between two input channels
 Typical: less than ± 0.05 degree
 Amplifier frequency response: DC - 50 kHz

Antialiasing filter
 RC analog plus 64th order FIR digital filter
 ± 0.2 dB passband ripple

Analog Outputs

Two single-ended output channels
 Full output range: ± 0.3 Volts to ± 3 Volts
 Arbitrary output programmable

A/D and D/A Converters

Two delta-sigma A/D, 16 bits
 Two delta-sigma D/A, 16 bits
 Simultaneous sampling
 Sampling rate: 1Hz to 48kHz
 Dynamic range: 84dB
 Signal-noise-ratio: 80dB
 Input gain: 0dB to 22dB in 1.5 dB step
 Output attenuation: 0dB to -46dB

Digital Input and Output

Input
 TTL level trigger. Special instruction detectable

Output
 Three states: High/Low/High-impedance
 Set by instructions

System

Texas Instruments TMS320C51 DSP chip
 40 MHz, 50ns instruction cycle time
 2K x 16 on-chip RAM

Memory: On-board 32K x 16 SRAM

Power Consumption
 Typically 0.65 watts during data capture

Size: 85.60mm \times 54.0 mm \times 5 mm

PC Card Standard
 PCMCIA Type II Card, release 2.1 compliant

Accessories

ICP[®] Sources (CI2250-P)
 External Cable Connector
 ICP[®] sources: 4.8 mA, +33.5 V
 Can be used with regular ICP[®] accelerometer

General Software Specifications (Applied Optionally)

Platform / Operating System

IBM-PC Compatible
 Windows 3.1, 3.11
 Windows 95

View Data

Graphic plot
 Numerical data listing
 Multiple traces can be opened

Display Types and Format:

Linear/Log/dB Magnitude
 Real
 Imaginary
 Histogram
 Bar Chart
 Phase
 Unwrapped Phase
 Nyquist Diagram
 Nichols
 Orbits

Polar
Vector
Overplot

Data Output Format

Crystal Instruments internal data format
Universal File Format (UFF)
ASCII file
SMS Star[®] File Format

Signal Auto-Save

User designated signals can be saved at specified time interval.
Selected saving format
File name auto change

Modal Testing Parameters

Signal file names can be created based on modal testing locations
Testing location auto increment

Color And Font

Text, line, foreground and background color selection
Text font selection

Scale and Limits

Auto scale, Fixed scale, Full scale
Ylog, YdB, Ylog grids, YdB grids, other grids for non-XY plot
Xlog, Xlog grids

Grid Style

Solid Line, Dash Line, Dot Line, Dash-Dot Line, Dash-Dot-DotLine, Ticks, Off

ZOOM Display

ZOOM display operation by mouse, arrow key, Infinite ZOOM-in times

Mark Operation

Enable/disable mark for each trace
Move mark with arrow keys or mouse or locate mark with mouse clicking
Move mark to left/right at different speed
High/low peak auto search

Frequency Units

EU, EU², EU²/Hz, EU/ $\sqrt{\text{Hz}}$, EU² S/Hz

EU Type

RMS, Peak, Peak-Peak

Signal Operation

Save signals
Recall signals
Review single signal saved before

Test Management

Auto create test from template or from old test
Review test, including review signals
Save and recall test during run-time
Open several tests at same time (run one at one time)
Single data set (signal) stored in ASCII or binary format
Review or process history data

Print and Plot

Standard Windows[™] 3.X printer setup
Print preview
Compatible with a wide variety of printer/plotters supported by MS-Windows.

Help file and Related Document

Index help
Context-sensitive help

Internal Triggering

Available in Time Capture and all Spectral Analysis

Continuous (Freerun)
Internally selectable for any input channel
Slope: rising or falling edge
Pre-Trigger: The measurement can be based on data from 1 to capture size prior to trigger conditions being met.
Post-Trigger: The measurement is initiated from 1 to 65536 samples after the trigger conditions are met.

Output Type

Available in Time Capture and all Spectral Analysis

Gaussian white noise, sine and DC, two channel separately programmable

Window Type

Hann, Hamming, Flat-top, Uniform(Rectangular)

Available in all Spectral Analysis

Averaging Type

Off, Single, Exponential, Linear, Peak-Hold, Peak-Contd.

Time Capture (CI2250S, Standard Option)

Maximum Capture Size

Single channel: 20480 points

Dual channels: 10240 points / channel

Sampling Interval

44 stages: 20 us, 31.25 us, 42 us, 52 us, ...1.71 sec, 2.048 sec.

Spectrum Analysis (CI2250S, Standard Option)

Spectrum Type

Linear Spectrum (Real/Imaginary)

Auto-Power Spectrum

Cross-Power Spectrum

Transfer Function (Real/Imaginary)

Coherence Function

Phase Spectrum

44 stages: 48 kHz, 32 kHz, 24 kHz, ... 0.58 Hz, 0.49 Hz

Frequency Span (Nominal)

44 stages: 21kHz, 14 kHz, 10.5 kHz, ... 0.26 Hz, 0.21Hz

Resolution (Lines per Frequency Span)

3600, 1800, 900, 450, 225, 112, 56, 28

Spectral Units

Linear spectrum, Power spectrum, Power spectral density, Energy spectral density, RMS spectrum

FFT Transform Size

8192, 4096, 2048, 1024, 512, 256, 128, 64

Sampling Frequency

Correlation Analysis (CI2250S, Standard Option)

Functions

Auto-correlation for either channel 1 or 2

Cross-correlation between two channels.

Hann, Flat-top, Uniform

Averaging Type

Off, Single, Exponential, Linear, Peak-Hold, Peak-Contd.

Sampling Interval

44 stages: 20 us, 31.25 us, 42 us, 52 us, ...1.71 sec., 2.048 sec.

Transform Size

8192, 4096, 2048, 1024, 512, 256, 128, 64

Window Type

ZOOM Spectrum (Opt CI2250-4)**ZOOM Frequency Range**

Two channels: up to 10.5 kHz

ZOOM Frequency Bandwidth

(Frequency span) to (Frequency span)/ 2¹⁰

Resolution (Lines per Frequency Span)

1800, 900, 450, 225, 112, 56, 28

Spectrum Type

Linear Spectrum (Real/Imaginary)
Auto-Power Spectrum
Cross-Power Spectrum
Transfer Function (Real/Imaginary)
Coherence Function
Phase Spectrum

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