



***WINDAQ/Lite/Pro/Pro+***  
*Waveform Recording Software*

***WINDAQ Waveform Browser***  
*Playback and Analysis Software*

***DI-151RS***  
*Software Configurable Analog and Digital I/O Board*

***DI-195B***  
*2-Channel Serial Port I/O Module with Signal Conditioned Inputs*

## ***User's Manual***

**Manual Revision G**

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# Introduction

This manual contains information designed to familiarize you with the features and functions of the following serial port data recording modules:

DI-151RS  
DI-195B

and also with WINDAQ/Lite waveform recording software and WINDAQ Waveform Browser playback and analysis software.

## **DI-151RS**

The DI-151RS is a portable, two-channel data recording module that communicates through your computer's RS-232 (or serial) port. It can record data at rates up to 240 samples per second with 12-bits of measurement accuracy.

The DI-151RS is powered directly from the computer to which it is connected (through the RS-232 cable).

The DI-151RS is equipped with a dedicated thermistor input, two digital inputs, and two single-ended, bipolar analog input channels.

## **DI-195B**

The DI-195B is a two-channel data recording module that communicates through your computer's RS-232 (or serial) port. It can record data at rates up to 240 samples per second with 12-bits of measurement accuracy.

The DI-195B is powered by the included wall outlet-type adapter, which can be plugged into any single-phase, 120 volt, 60 Hz. AC source. It features two, signal-conditioned, differential, bipolar analog inputs (screw terminal access, maximum measurement range is defined by the DI-5B modules). The DI-195B allows you to plug any two DI-5B signal conditioning modules into its backplane. The DI-5B signal conditioning modules then filter, isolate, amplify, and/or convert virtually any industrial signal that is applied into a high level analog voltage, perfectly suited for recording.

## **WINDAQ/Lite Waveform Recording Software and WINDAQ Waveform Browser Playback and Analysis Software**

The WINDAQ software shipped with all of the serial port instruments consists of WINDAQ/Lite waveform

recording software and WINDAQ Waveform Browser playback and analysis software.

WINDAQ/Lite waveform recording software can be used with any Dataq Instruments hardware product. It allows you to record waveforms directly and continuously to disk while monitoring a real time display of the waveforms on your computer screen. It operates at the full sample rate of the instrument being used (allowing you to see a real time display of your waveform signals on your computer's monitor at the instruments full sample rate), but is limited to 240 Hz maximum throughput when you enter the record mode.

WINDAQ Waveform Browser allows you to review, measure, analyze, compress, cut-and-paste, export/import, and otherwise manipulate the recorded waveform information. It is available for download free-of-charge from our web site ([www.dataq.com](http://www.dataq.com)).

## **Conventions Used in the Documentation**

Before you start using the DI-151RS, DI-195B, WINDAQ/Lite, or WINDAQ Waveform Browser software, it's important to understand the terms and notational conventions used in this documentation.

### General Conventions

Commands you choose are given with the menu name preceding the command name. For example, the phrase "Choose File Open" tells you to choose the Open command from the File menu. This naming convention describes the sequence you follow in choosing a command — first you select the menu, then you choose the command.

### Mouse Conventions

In general, most mouse actions require only the left mouse button. For example, carrying out a menu command or working in a dialog box requires only the left mouse button. However, the right mouse button is not totally neglected. Among other things, the right mouse button is used for copying waveform data to the clipboard, waveform scaling, selecting a waveform channel, etc.

Since the majority of mouse procedures are done with the left mouse button, we will not specify which mouse button to click, drag, or double-click with in the procedures unless it is the **RIGHT** mouse button. When the right mouse button is required, it will be specified as such. For example, "Double-click the right mouse button anywhere in the bottom annotation line to move the cursor to the

lowest displayed waveform valley.” When not specified, the left mouse button is assumed for the procedure.

- “Point” means to position the mouse pointer until the tip of the pointer rests on what you want to point to on the screen. For example, “Point to the View menu.”
- “Click” means to press and immediately release the mouse button without moving the mouse. For example, “To display the menu that contains the command you want, click the menu name in the menu bar.”
- “Double-click” means to click the mouse button twice in rapid succession. For example, “Double-click the icon to start the program.”
- “Drag” means to press the mouse button and hold it down while you move the mouse; then release the button. For example, “Drag down to Data Cursor to enabled the cursor for on-screen display.”

### **WINDAQ/Lite Operating Modes**

WINDAQ/Lite waveform recording software has three operating modes. They are, in logical order of occurrence; Setup, Record, and Standby. Each operating mode shares many features with the other three, but there are some features accessible only from one given mode. The three modes are discussed in detail as follows:

The SET UP operating mode is active when WINDAQ/Lite is first started. SET UP is used to configure data acquisition parameters such as the number of acquired channels, channel gain, and channel offset. In addition, this mode is used to adjust the real time display for a visually pleasing presentation. Virtually all other data acquisition functions and adjustments are available from the SET UP operating mode including control of the real time display screen’s scaling and offset functions. In this mode only the real time display is active, data is not yet being streamed (or stored) to disk. In this mode, sample rate is limited only by the capabilities of the hardware. In other words, you can sample as fast as your instrument will allow. When in this mode, the Status: area of the bottom annotation line displays SET-UP.

The RECORD operating mode is active when a file has been opened and the Record command has been

selected from the File menu. RECORD is used to stream waveform information to disk. While in this mode, all waveform recording features and functions are available (with some restrictions) *except* the following: all channel-specific operations (i.e., channel number, gain, offset); and sample rate adjustments. In this mode, waveform information is being continuously streamed to disk while the real time display remains active. In this mode, sample rate is limited to 240 Hz maximum throughput, regardless of the instrument being used. When in this mode, the Status: area of the bottom annotation line displays RECORD.

The STANDBY operating mode becomes active when waveform recording to disk is temporarily suspended by choosing the Stop command from the File menu. While in this operating mode, all waveform recording features and functions are available except: channel-specific operations (i.e., channel number, offset, etc.) and sample rate adjustments. In this mode only the real time display is active, waveform recording to disk has been stopped. When in this mode, the Status: area of the bottom annotation line displays STBY. It is possible to start and stop the recording process as many times as you like during a data acquisition session.



# Getting Started

The following items are included with each instrument purchase. Verify that you have the following:

- DI-151RS, or DI-195B instrument.
- Communications cable designed to connect the instrument to your computer's serial port (with the DI-195B, the AC power adapter is integrated into the serial cable).
- WINDAQ software diskette(s). We are currently shipping both WINDAQ/Lite and WINDAQ Waveform Browser software all on one disk. However that may change at any time, in which case you will have two diskettes.
- This user's manual, which covers the hardware aspects of the DI-151RS, and DI-195B serial port modules and also documents WINDAQ/Lite waveform recording software and WINDAQ Waveform Browser playback and analysis software.
- If you purchased a DI-195B, you should also have one or two DI-5B plug-in modules. Note that these are extra-cost items not included with the purchase of the DI-195B kit, but are required for operation.

If an item is missing or damaged, call Dataq Instruments at (330) 668-1444. We will guide you through the appropriate steps for replacing missing or damaged items. Save the original packing material in the unlikely event that your unit must, for any reason, be sent back to Dataq Instruments.

## Step 1

### Installing the Hardware

#### NOTE

Before installing WINDAQ software, you should already have the hardware installed or connected. If you have not done so already, install or connect your hardware at this time.

Use the following procedure to connect the DI-151RS, or DI-195B module to your computer.

If you have an instrument other than the DI-151RS or DI-195B and you have not installed it yet, do so now. Ignore the following steps and proceed instead with the installation instructions contained in your hardware User's Manual.

### DI-151RS and DI-195B Only

1. Connect the male end of the communications cable to the 9-pin female connector on the DI-151RS or DI-195B module.
2. Connect the other end of the communications cable to your computer's serial or COM port.
3. If you purchased the DI-195B, plug the AC power adapter into any standard 120V, 60Hz wall outlet.

## Step 2

### Installing WINDAQ Software

#### NOTE

WINDAQ/Lite waveform recording software and WINDAQ Waveform Browser playback and analysis software are both on the WINDAQ Resource CD, but they must be installed individually with separate installation procedures. The following procedure will install WINDAQ/Lite recording software first, then WINDAQ Waveform Browser playback and analysis software.

1. Start Windows™.
2. Insert the WINDAQ Resource CD into your CD drive and close the drive tray.

For most user's, the CD's auto-run feature will automatically display a list of options for you to pick from. If you do not see this list of options after a reasonable period of time, double-click the My Computer icon on your desktop and then double-click your CD-ROM icon to manually display the list of options.

3. Choose the Install Software button and click OK.

4. Now choose the WINDAQ/Lite and Software Development Kit button and click OK.
5. Specify the instrument series (broad category) that will be used with WINDAQ/Lite software.

For example, choose the DI-1xx Serial Data Acquisition Units button if you have either the DI-151RS module or the DI-195B module connected to your serial port (both are *100 Series* instruments), or choose the DI-4xx Series Plug-in Cards button if you have a DI-400, DI-401, or DI-410 board installed, etc.

When the instrument series button is selected, click the OK button.

6. The remaining installation steps vary by instrument. In most cases, the on-screen prompts provide enough information to successfully get you through the installation. However, if you are unsure of what to do next or if you need additional information, contact Dataq Instruments technical support.
7. When WINDAQ/Lite software has successfully been installed, double-click the My Computer icon on your desktop and then double-click your CD-ROM icon to manually display the list of installation options.
8. Again choose the Install Software button and click OK.
9. Select the WINDAQ Waveform Browser button and click OK to install WINDAQ Waveform Browser playback and analysis software. The on-screen prompts should provide enough information to successfully get you through the installation. However, if you need additional information, contact Dataq Instruments technical support.

### Step 3

## Connecting Your Input Signals to the Instrument

#### NOTE

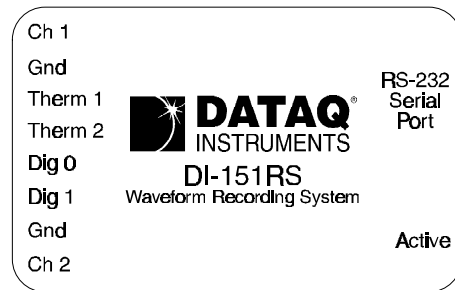
Use the following procedure to connect your input signals to the DI-151RS or DI-195B module.

If you have an instrument other than the DI-151RS or DI-195B, ignore the following steps and proceed instead with the input signal connection instructions contained in your hardware User's Manual.

To connect signals to the DI-151RS or DI-195B, insert the stripped end of a signal lead into the desired terminal directly under the screw. Tighten the pressure flap by rotating the screw clockwise with a small screwdriver. Make sure that the pressure flap tightens only against the signal wire and not the wire insulation. Do not overtighten. Tug gently on the signal lead to ensure that it is firmly secured.

#### DI-151RS

All user connections are made to the 8-port screw terminal connector as follows:



Ch 1: Channel 1 signal input.

Gnd: Channel 1 signal ground.

Therm 1: Thermistor lead 1 input.

Therm 2: Thermistor lead 2 input.

Dig 0: Digital input 0.

Dig 1: Digital input 1.

Gnd: Channel 2 signal ground.

Ch 2: Channel 2 signal input.

Your DI-151RS comes with the on-board waveform generator configured to provide a sample input signal. The onboard waveform generator is enabled by connecting a jumper wire between the Ch 1 and Dig 1 inputs. A thermistor is also included for temperature measurements. So it doesn't get lost during shipping, one leg of the thermistor is

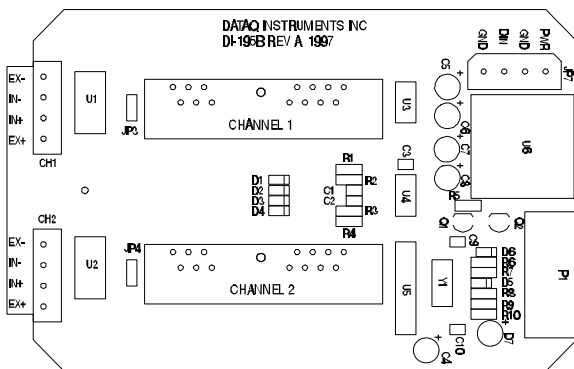
connected to a screw terminal. Unless you would like to make temperature measurements with the thermistor, remove it completely from the DI-151RS. Do not make voltage measurements with the thermistor installed. Any voltage measurement made with the thermistor installed will be inaccurate.

When using the thermistor to make temperature measurements, insert one thermistor leg into input Therm 1 and the other thermistor leg into Therm 2. In order to get accurate temperature measurements, the thermistor must be calibrated. The procedure for doing this is included in step 8.

When the DI-151RS is configured for voltage measurements, Ch 1 and its Gnd make up one single-ended analog input channel, while Ch 2 and its Gnd make up the other.

### DI-195B

All user connections are made to the two, four-port screw terminal connectors.



IN+ and IN- are the signal input terminals for each channel. EX+ and EX- are excitation voltage outputs for those transducers that require excitation. Obviously, you'll want to tailor the DI-5B signal conditioning modules used in the instrument to the kind of input signals you wish to record.

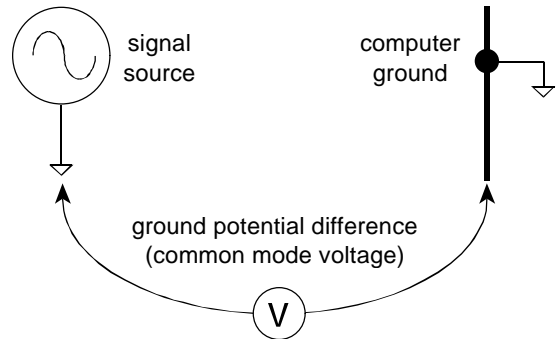
### Differential Inputs

DI-195B features two dedicated differential input channels. Differential input channels respond only to the difference in voltage between each (+) and (-) analog input, effectively suppressing common mode voltages (i.e., identical voltages appearing simultaneously and in phase on both inputs). Since most forms of interference or noise are applied with equal intensity to both inputs of a differential amplifier (that is, in the common mode), the differential amplifier is very effective at rejecting noise riding on a signal of interest.

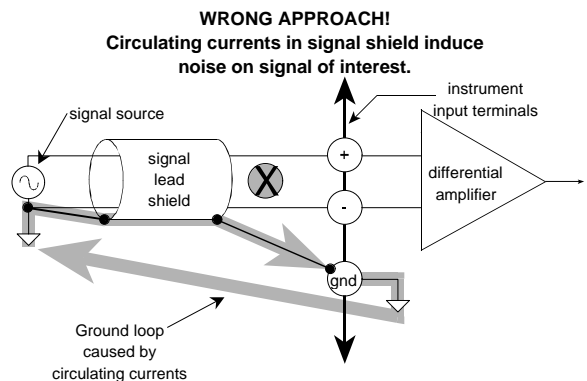
Two types of signal sources are likely to be encountered when configuring your DI-195B; the

signal to be measured is ground-referenced, or the signal to be measured is isolated from ground. In either case, it is important to properly connect the differential amplifier.

*Ground Referenced Signal Sources* — A ground referenced signal source is one with a local ground that may not be (and probably is not) at the same potential as the computer's ground. This potential difference between signal ground and computer ground is referred to as a common mode voltage and is caused by a number of different factors.

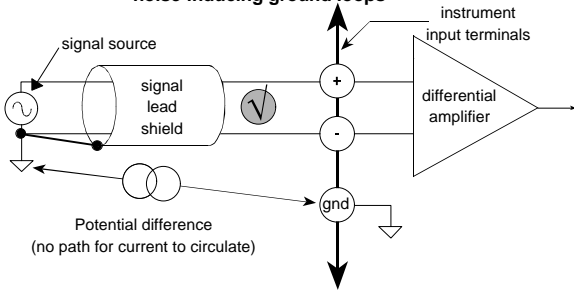


The most common of these is different physical locations of the computer and signal ground points. Since wire is not a perfect conductor (i.e., exhibiting zero resistance regardless of length) a voltage drop, however small, will always be present. The differential amplifier is unique in its ability to measure signals originating from sources with different ground potentials relative to the computer **providing it is connected properly.**

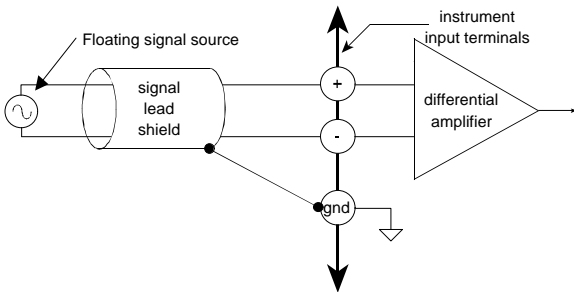


The most common error made in connecting differential amplifiers is the tendency to ground both ends of a signal shield. This causes current to flow through the shield and induces noise on the signal to be measured. This problem is eliminated by ensuring that only one ground exists on the signal circuit.

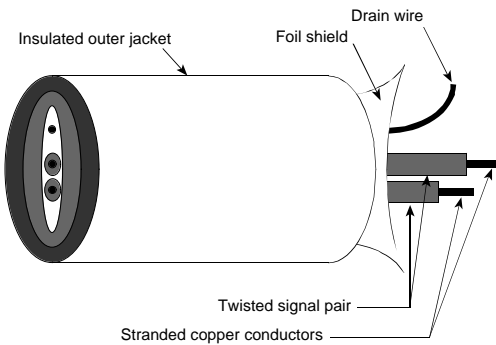
**RIGHT APPROACH ✓**  
**One ground on the signal circuit eliminates noise-inducing ground loops**



*Isolated Signal Sources* — An isolated signal source is one that is not connected to ground at any point. However the signal shield should still be grounded as before to reduce noise.



Any application requiring a differential amplifier also defines a need for quality signal cable. Four elements combine to ensure adequate quality signal cable; a twisted signal pair with low resistance stranded copper conductors, surrounded by a multiple-folded foil shield, with a copper stranded drain wire, all contained within an insulated outer jacket.



In applications where such signal cable is used, a dramatic decrease in noise pickup will be experienced. The drain wire should be considered as the shield and should be connected as described previously. Signal cable meeting all four criteria for quality is Belden No. 8641.

# Fast Start to Recording Waveforms with WINDAQ/Lite

After you have completed all hardware and software installations and connected your signals, you are ready to record.

Steps 4 through 9 below outline the “fast start” procedure for recording waveforms to disk. These are the basic steps you will take every time you record with WINDAQ/Lite waveform recording software.

The rest of this chapter contains additional recording functions that will not necessarily be used in every session or are not requisite for recording, but will make future recording sessions easier. After your initial, “get-acquainted” recording session, take a few moments and look over these functions.

## Step 4

### Enabling Channels for Acquisition

It is assumed at this point that you have WINDAQ/Lite waveform recording software running. If not, click the Start button on the taskbar, point to Programs, point to WINDAQ (or whatever you named the group window during step 11 of the installation), and click **WinDaq Acq.**

This step specifies which analog channels to record.

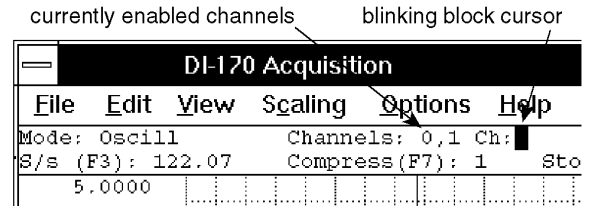
For example, suppose we have analog signals connected to channels 1 and 2, and we want to record both of them. Use this procedure to enable channels 1 and 2 for recording:

1. To enable channel configuration:



Point to the Edit menu and drag down to Channels...

This causes the Ch: block cursor to blink in the Channels: field on the status bar. The currently active list of enabled channels are displayed in this field, immediately to the left of the cursor (initially, only channel 1 is enabled for recording).



2. Enter the desired channel number and press the ENTER key. Repeat for each desired channel.

A single-ended channel is added to the list by entering the channel's number and pressing the ENTER key.

A differential channel is added to the list by entering the channel's number followed by the letter “D” (e.g., “3D”) and pressing the ENTER key.

This causes the channel number to be displayed in the enabled channels row.

3. Disable channel configuration by pressing any key other than the letters “D” and “I”.

Note that a channel may be removed by typing the channel number preceded by a minus (“-”) sign. Make sure that you use the minus sign on the main keyboard, not the minus sign that resides on the keypad (the minus sign on the keypad performs an entirely different function). For example, typing “-1” removes channel 1 from the row. Note also that it is not possible to remove *all* the channels from the row (in other words, have no channels enabled). For example, say you are using the DI-195B and you have only channel 1 configured and it is a differential channel (Channels: field reads “1D”). Typing “-1D” will not remove it from the row. Typing “1” will however, change it to a single-ended channel, and vice-versa.

Channels may not be added after the RECORD mode has been entered.

## Step 5

### Viewing Enabled Channels

This step allows you to display onscreen all enabled channels.

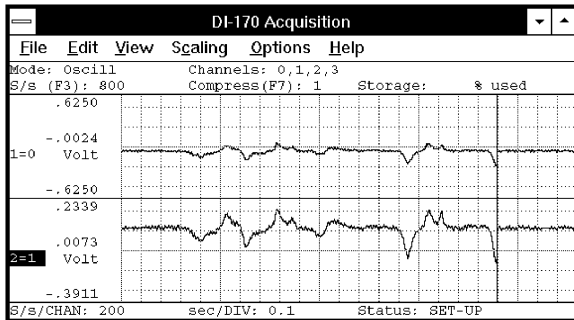
If you enabled more channels in the previous step, you will want to display them all onscreen.

1. To display enabled channels:

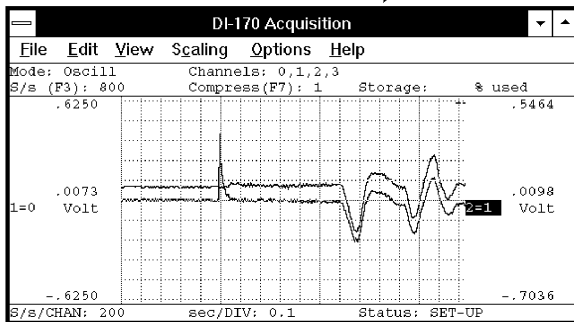


1. Point to the View menu and drag down to Format Screen.
2. In the format box, click the desired display format.

Any channel may be displayed as an overlapping or non-overlapping display.



non-overlapped display      overlapped display



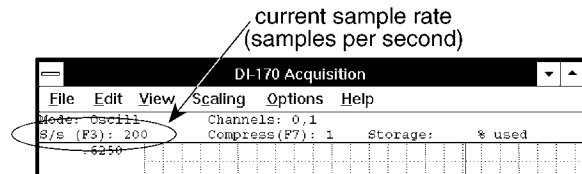
An overlapped format allows you to closely examine the time and amplitude relationship of two waveforms. A non-overlapped format may be used to isolate each waveform's transition to within a defined area. Whatever the timing relationship of your input signals, any display format may be enabled at any time without affecting the waveform information being stored to disk. Display format changes only affect the way you view waveforms on your computer's monitor.

## Step 6

### Specifying a Sample Rate

You must specify a sample throughput rate (or total scanning rate) for waveform recording.

For example, if you wanted to acquire four channels of data all at 60 Hz, you would require a sample rate of 240 Hz.



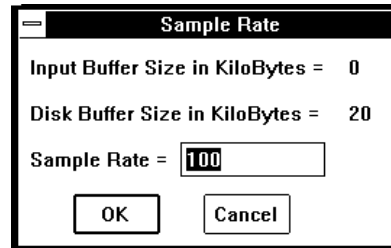
To specify a sample rate:

1. Select the Sample Rate command:



Point to the Edit menu and drag down to Sample Rate...

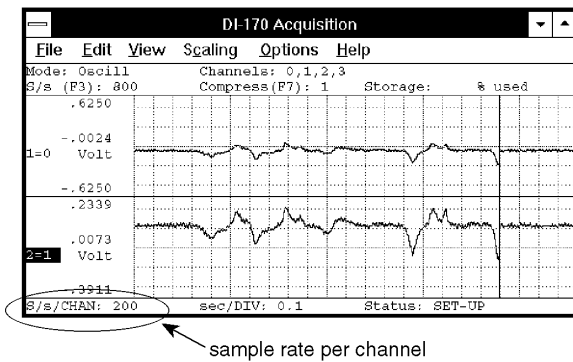
This displays the sample rate dialog box as follows:



2. Enter the desired throughput rate (or total scanning rate) in samples per second in the Sample Rate dialog box.
3. Click OK or press the ENTER key.

WINDAQ/Lite automatically allocates the correct amount of buffer space when you input a sample rate. The Input Buffer Size and Disk Buffer Size values are displayed for informational purposes only.

Keep in mind that the sample rate is actually a throughput rate. The sample rate per channel (obtained by dividing the selected sample throughput rate by the number of channels enabled) is displayed in the lower left corner of the window as S/s/CHAN:.



Although thousands of different sample rates may be configured, some discrete rates are not achievable. This limitation is due to the inability to divide the master clock in a manner that results in an even-numbered quotient. For example, say you enter a sample rate of 200. What you might actually get, because of the previously stated limitation, is 200.3.

## Step 7

### Specifying Gain and Measurement Range

#### NOTE

#### DI-151RS, DI-195B, and DI-401 Users

DI-151RS, DI-195B and DI-401 users can ignore this step and proceed with step 8. DI-151RS instruments have a fixed gain of 1 (unity) and a fixed measurement range of  $\pm 10$  volts. DI-195B and DI-401 instruments have a fixed gain of 1 (unity) and a fixed measurement range of  $\pm 5$  volts.

Choosing the proper gain factor for your input signals allows you to get the best possible measurement resolution out of your instrument.

The default WINDAQ/Lite gain setting is 1 (unity). A gain of 1 provides the widest possible measurement range. For example, say you're using a DI-400-PGH. This instrument features a maximum analog measurement range of  $\pm 10$  volts and programmable gain factors of 1, 2, 4, and 8. At a gain of 1 (gain factor = 1), the full scale measurement range is  $\pm 10$  volts. However, if we set the gain to 2, the full scale measurement range becomes  $\pm 5$  volts. The full scale measurement range gets even smaller for gain factors of 4 (range =  $\pm 2.5$  volts) and 8 (range =  $\pm 1.25$  volts).

If the signals you plan to record need the wide measurement range that a gain of 1 provides, then

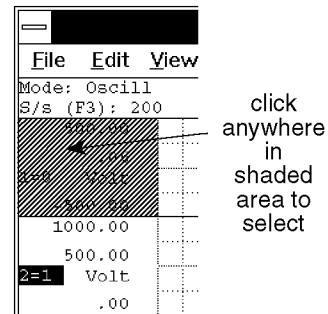
skip this step. Otherwise, continue with this step to select a higher gain factor (thus narrower measurement range) for the best possible measurement resolution.

Since gain and measurement range can be assigned per-channel, the desired channel must first be selected.

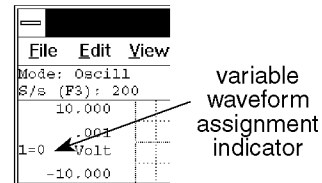
1. Select an analog channel for gain adjustment:



Click the left mouse button in the unselected channel's annotation margin.

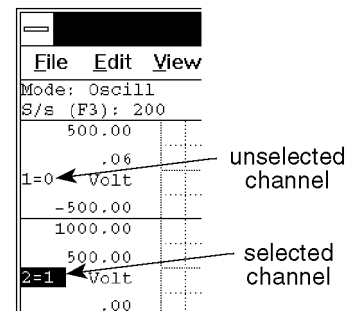


The focal point for selecting a channel for any type of adjustment is the variable waveform assignment indicator.



This two-element equality ( $X=Y$ ) is displayed for every enabled channel. Element "X" (1 in the illustration above) is the window number. Element "Y" (0 in the illustration above) is the analog channel assigned to that window.

When selected, a box surrounds the variable waveform assignment indicator, indicating that the window is enabled for adjustment.



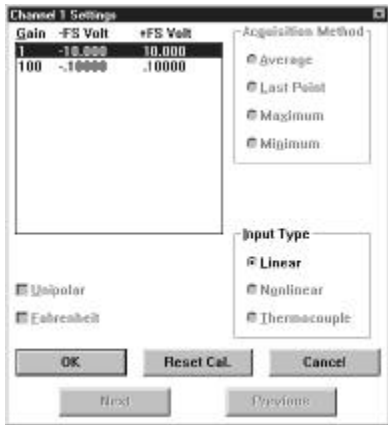
When the desired channel is selected, gain adjustments to that channel are now possible.

2. Select the Channel Settings... command:



Point to the Edit menu and drag down to Channel Settings...

This displays the “Channel X Settings” dialog box (where X represents the enabled channel):



The gain factors you see displayed at the top of this dialog box are hardware dependent. Displayed next to each gain are the equivalent plus and minus full scale voltages that result from selecting that gain factor. These voltages vary by hardware device.

3. Click on the desired gain factor.
4. Click OK or press the ENTER key.

As the gain factor for a channel is sequenced upward and downward through gain ranges,  $\pm$ full scale annotation adjusts to reflect the application of the various gain factors.

A channel's gain factor cannot be adjusted following the initiation of data storage to disk. Only the SET-UP operating mode allows gain factor adjustments.

### Unipolar/Bipolar Measurement Range Option

You can specify whether the signal you will be acquiring is unipolar or bipolar. A unipolar signal is one that ranges from 0 to + full scale (never goes below zero), and a bipolar signal is one that ranges from some negative value to some positive value (is both positive and negative going). If your signal is only a positive going waveform or a negative going waveform, always select the Unipolar check box. If your signal is both positive and negative going,

leave the Unipolar box unchecked, thus specifying bipolar.

### Reset Cal. Button

Whenever the gain or unipolar/bipolar setting is changed, any calibration is preserved and adjusted to reflect the new gain or unipolar/bipolar setting. Selecting Reset Cal allows you to reset the selected channel from a significant engineering units calibration back to the default voltage (or temperature, if using thermocouples) calibration.

### Acquisition Method

Allows you to select the method used for recording and displaying data (intelligent oversampling).

All Dataq Instruments hardware products continuously sample data using a burst sampling technique. The hardware samples data at one rate (referred to as the *burst rate*) while your computer reports (i.e., displays and stores) this data at another rate (called the sample rate or *throughput rate*). For example, let's say we want to record one channel at 100 Hz and our burst rate is set at 50kHz. This means that for every 500 data points sampled, only 1 will be reported. The dilemma becomes; which data point out of the 500 gets reported? Fortunately, you have a choice for reporting this single data point:

*Average* - Averages all of the data points in the burst sample and reports this average as the single value for storage and display.

*Last Point* - Reports the last input data point in the burst sample, ignoring the rest.

*Maximum* - Reports the highest value data point in the burst sample, ignoring the rest.

*Minimum* - Reports the lowest value data point in the burst sample, ignoring the rest.

### Input Types

Linear - The default setting, available on all instruments, should be used with all linear inputs.

Thermocouple - Selectable only on instruments with the hardware to support thermocouples.

Nonlinear - Also only on instruments that support thermocouples. Used only with a specialized, non-linear, non thermocouple type of sensor.

### Next and Previous Buttons

Allow you to step through the next or previous enabled channel (in order), setting up each channel



for gain, unipolar/bipolar, sample rate, etc., without closing this dialog box.

## Step 8

### Calibrating Your Input Signals

Calibration allows you to view and record your waveform data in significant engineering units.

Without calibrating, waveform data is scaled, annotated, and displayed in volts, which in many cases is not very meaningful. Calibration is used to give meaning to the displayed data. Instead of volts, your data can be scaled, annotated, and displayed in significant engineering units (i.e., PSI, RPM, lbs, ft/s, etc.).

This function allows your waveform data to be calibrated in significant engineering units using *any* known or verified transducer output values.

For example, suppose you were acquiring pressure data with a transducer that had a known output of -1 volt at 0 psi and 4.5 volts at 100 psi. Whether these output levels were read from the manufacturers specifications or verified through use, they can be used as calibration values.

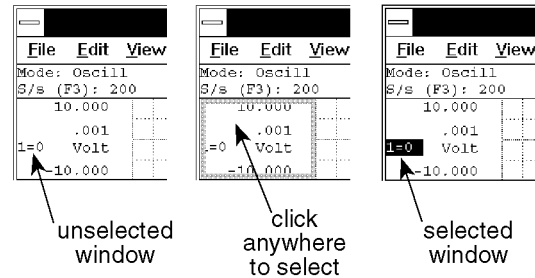
With this method, you can even calibrate the data without knowing the transducer output relationship. Simply let WINDAQ/Lite software establish these output voltage values for you. For example, suppose you were acquiring pressure data and you had no idea what kind of output voltages to expect from the transducer you're using. You could vent the pressure apparatus to quiescence or atmospheric pressure and observe what voltage the transducer is outputting at quiescence from the Input Level text box in the Low Calibration dialog box (select Low Calibration... from the Edit menu). In this same dialog box, enter what you would like this quiescent state to be, such as "0", in the Low Cal Value text box, and enter "PSI" in the Engr. Units text box. Now activate the OK command button to close the dialog box, and increase the pressure until the manometer reads a convenient value, say 100 psi. In a similar manner, observe what voltage the transducer is outputting at this 100 psi level from the Input Level text box in the High Calibration dialog box (select High Calibration... from the Edit menu). Enter "100" in the High Cal Value text box, enter "psi" in the Engr. Units text box, choose the OK command button, and you're done.

To calibrate a waveform using this high/low calibration method:

1. Select the window that contains the desired waveform:



Click the left mouse button in the unselected window's annotation margin.



2. If not already enabled, enable the Current Data and Data Display options (on the Options menu).

3. Select Low Calibration... as follows:

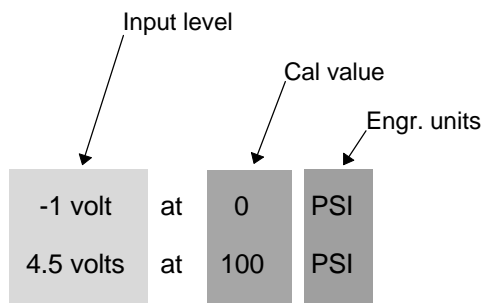


Point to the Edit menu and drag down to Low Calibration...

This displays the Low Calibration dialog box:

This is where you enter the low calibration data value that is to be assigned to the input voltage level. For instance, referring back to our previous examples:

- a) For the case where the transducer output is known,



we would enter “0” in the Low Cal Value text box, “-1” in the Input Level text box, and “psi” in the Engr. Units text box.

- b) For the case where the transducer output is unknown, we would also enter “0” in the Low Cal Value text box (with the test apparatus vented to atmospheric pressure), ignore the Input Level text box (WINDAQ/Lite software has established the input voltage level for you), and enter “psi” in the Engr. Units text box.

Press the TAB key to position the insertion point in the various text boxes.

Type up to a four character optional engineering unit tag (i.e., PSI, f/s, rpm, etc.).

4. Complete the low calibration entry as follows:



Click OK.

The Low Calibration dialog box disappears and if no high calibration has been done yet, an offset is applied to the waveform to achieve the entered value. But you are only half done, the high calibration value must also be entered.

5. Select High Calibration... as follows:



Point to the Edit menu and drag down to High Calibration....

This displays the High Calibration dialog box:

This is where you enter the high calibration data value that is to be assigned to the input voltage level. For instance, referring back to our previous examples:

- a) For the case where the transducer output is known, we would enter “100” in the High Cal Value text box, “4.5” in the Input Level text box, and “psi” in the Engr. Units text box.
- b) For the case where the transducer output is unknown, we would also enter “100” in the High Cal Value text box (after 100 psi has been applied in our example), ignore the Input Level text box (WINDAQ/Lite software has established the input voltage level for you), and enter “psi” in the Engr. Units text box.

6. Complete the high calibration entry as follows:



Click OK.

The High Calibration dialog box disappears and the waveform channel displays all waveform data values calibrated in the chosen engineering units.

If desired, the upper and lower grid limit values may be specified (and the waveform automatically scaled to fit). This feature allows the channel's full scale display span to be shown in whole numbers rather than obscure fractional values, which sometimes result from calibrating. For example, a waveform scaled in mmHg can be automatically expanded or contracted to fit within grid limits of 0 to 100 mmHg, or -200 mmHg to +200 mmHg, or whatever is desired. Note that a channel spanning 0 - 200 mmHg is much easier to read and interpret on a per division basis than one that spans 10.372 - 189.628 mmHg.

To specify convenient upper and lower chart edge values:

7. Select Scaling Limits... as follows:



Point to the Scaling menu and drag down to Limits....

This displays the Display Limits dialog box:

8. Type convenient top and bottom chart-edge values in their respective text boxes.

9. Complete the chart-edge value entry as follows:



Click OK.

Your specified values will now be displayed on the upper and lower chart-edges and the waveform will be automatically scaled to fit the new values.

The **Next** and **Previous** buttons allow you to step through all of the enabled channels in order, entering the desired display limits for each channel, without closing this dialog box.

When using the DI-151RS, the following procedure can be used to calibrate the thermistor transducer:

1. With the thermistor connected to the DI-151RS as described in step 3 of this fast start procedure, submerge the tip of the thermistor in an ice water bath. Submerge only the tip of the thermistor, do not submerge the DI-151RS. Let it remain in the ice water long enough for the thermistor output to stabilize (you can monitor the thermistor output with WINDAQ/Lite's real time display).
2. Follow steps 1 through 4 of the calibration procedure described above, but enter "32" in the **Low Cal Value** text box, and "F" in the **Engr. Units** text box. Note that WINDAQ/Lite has established the **Input Level** value automatically.
3. Now remove the thermistor from the ice water bath and allow it to stabilize at room temperature.
4. Follow steps 5 through 9 above, but enter "72" (or whatever your room temperature is) in the **High Cal Value** text box, and "F" in the **Engr. Units** text box. For convenient display limit values, enter "100" in the **Top Limit** text box and "0" in the **Bottom Limit** text box.

## Step 9

### Recording Waveforms to Disk

The Record function on the File menu initiates recording to disk. To begin waveform recording:

1. Select the Record command:



Point to the File menu and drag down to Record.

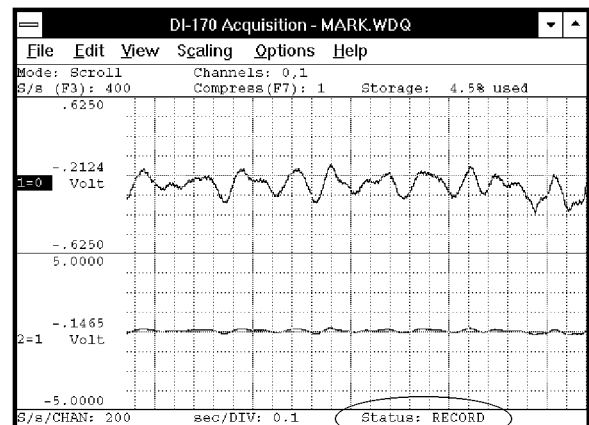
This displays the Open dialog box. Here is where you specify a file name (to create a new file) or open an existing file (to append to it).

If creating a new file, you will be prompted to specify a maximum file size. If appending to an existing file, you will be prompted to specify how much additional data to add to the existing file.

In either case, you can specify file size in kilobytes or recording time. In the case of recording time, file size is based on the currently selected sample rate. Note that you can experiment with different file sizes, sample rates, and recording time to get the desired result. Move between the two text boxes with the TAB key.

2. Enter the desired file size or accept the default.
3. Close the dialog box and begin recording by clicking OK or pressing the ENTER key.

When you enter the desired file size or accept the default, you are placed in the active record-to-disk operating mode where enabled analog channel data is simultaneously digitized, displayed, and streamed to disk. The status field in the bottom annotation line indicates RECORD.



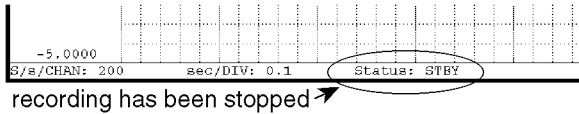
Actively recording to disk

To stop acquisition to disk:

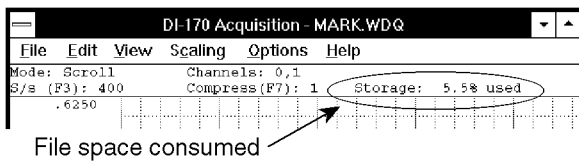


Point to the File menu and drag down to Stop.

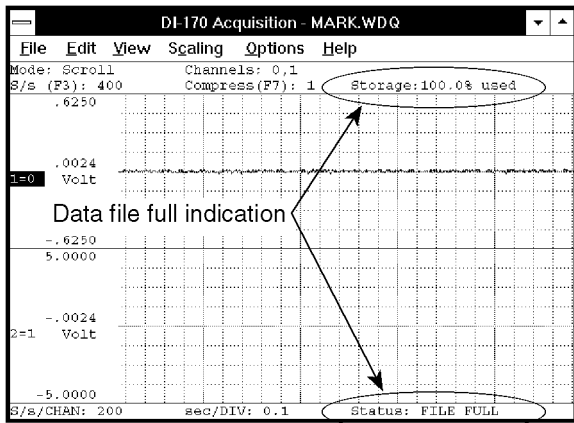
This suspends data storage to disk, but the real time display remains active. The status field in the bottom annotation line indicates STBY when acquisition has been stopped. The Stop function on the File menu only becomes selectable when in the record-to-disk mode.



As data is being recorded to disk, the amount of file space consumed is displayed in the "Storage:" field of the status bar as a percentage of total file space consumed.



Data acquisition to disk may be started and stopped as many times as desired. When the target data file has been filled, data acquisition to disk will cease, the "Storage:" field of the status bar will display "100% used", and the "Status" field of the status bar will display FILE FULL.



Each time recording is activated, an event marker is automatically inserted in the data stream. This allows acquisition break points to be reviewed using WINDAQ Waveform Browser playback and analysis software.

This concludes the "fast start" procedure for recording waveforms to disk. The next logical step is to review the data you just recorded. This is done with WINDAQ Waveform Browser playback and analysis software (WWB). To make timing and amplitude measurements, review event markers, overlap waveforms to examine interdependencies,

cut and paste portions of waveforms, and do all forms of interpretive analysis, launch the WINDAQ Waveform Browser by clicking or double-clicking on the WINDAQ Waveform Browser icon (created during installation). Then refer to the section of this manual titled "Reviewing Recorded Waveforms with WINDAQ Waveform Browser" for complete details.

# Additional Waveform Recording Functions

These functions are not requisite for recording or will not necessarily be used every time WINDAQ/Lite is used, but are included to make recording easier and more productive, or to increase display performance and visual appeal.

## WINDAQ/Lite

### Browse

This function starts WINDAQ Waveform Browser playback and analysis software directly from WINDAQ/Lite recording software. This enables you to have both software packages running simultaneously to playback, review, analyze, measure, quantify, etc. the data that was just recorded.

If you are in the record mode when Browse is selected, WINDAQ Waveform Browser will automatically open the very same file you are actively recording to.

If you are not in the record mode when Browse is selected, WINDAQ Waveform Browser will prompt you for the file you wish to review.

To enable this multitasking feature:



Point to the File menu and drag down to Browse.

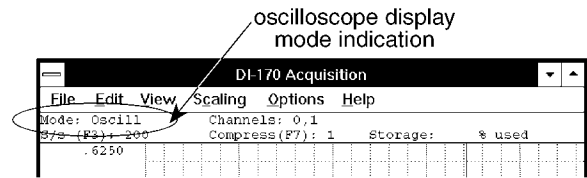
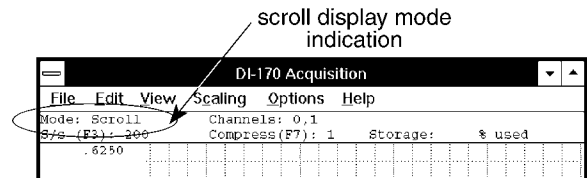
This starts the WINDAQ Waveform Browser. Since waveform data is constantly being written to this WINDAQ Waveform Browser file while WINDAQ/Lite is actively recording, you must request updates to see all of the latest data. This is done in WINDAQ Waveform Browser by

periodically pointing to the View menu and selecting Refresh.

## WINDAQ/Lite

### Scroll Mode, Oscilloscope Mode, & Pause Graphics

Waveform information can be displayed on your monitor in either a continuous smooth scroll mode or in a triggered sweep oscilloscope mode.



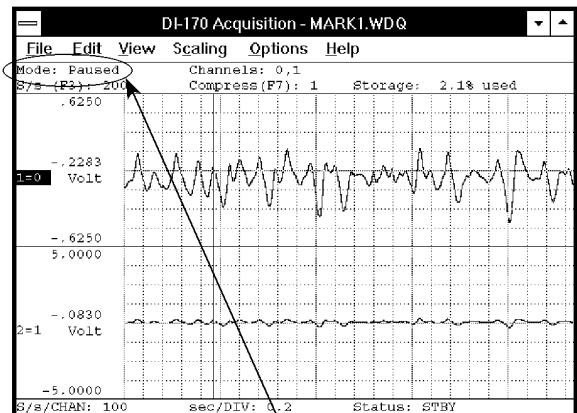
Either display mode may be enabled at any time during data acquisition without affecting the information being stored to disk. Display mode changes only affect the way waveforms are displayed on your monitor.

1. Select a display mode:



Point to the Options menu and drag down to Scroll Mode or Oscilloscope Mode...

Note that in either display mode, the waveform display can be paused. This allows you to get a stationary look at some point on the waveform. While paused, the Mode: field in the status bar changes from the chosen display mode to Paused.



To enable/disable the waveform display pause feature:

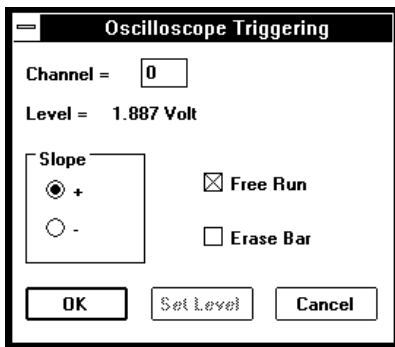


Point to the Options menu and drag down to Pause Graphics.

When pause is enabled, a subsequent pause attempt disables the paused waveform. The display mode that was active before pausing is restored.

If the display is paused while in the Record operating mode, data acquisition to disk continues unimpeded, only the display is paused.

When Oscilloscope Mode... is chosen from the Options menu, the Oscilloscope Triggering dialog box is displayed as follows:



This dialog box allows you to select one trigger channel and display the data in a triggered sweep oscilloscope format or in a free-running oscilloscope format. Checking the Free Run check box selects the free running oscilloscope format. Leaving the Free Run check box unchecked selects the triggered sweep oscilloscope format.

If free running is selected, the waveform continuously updates on your monitor in a manner identical to an oscilloscope display and the rest of this dialog box can be ignored (no triggering conditions need be set).

If triggered sweep is selected, you can also set display trigger conditions (such as channel, level, and slope) that define the “trigger” or starting point for displaying the waveform on your monitor. In this mode, the waveform is not displayed until a trigger condition is detected. When a trigger is detected, a single sweep of the waveform will be displayed on your monitor and will remain on your monitor until the next trigger condition is detected.

**Slope option buttons** - The slope option buttons allow you to select the slope (positive or negative) at which the waveform display will trigger. Selecting the + option button triggers the display to start at the trigger level, but on the waveform’s rising slope. Selecting the - option button triggers the display to start at the trigger level, but on the waveform’s falling slope.

**Channel text box** - Allows you to specify or select a channel for the trigger source.

**Level field** - Indicates the current trigger level in volts.

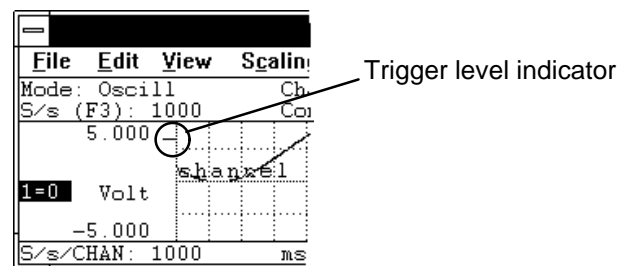
**Free Run check box** - Allows you to select between a triggered sweep oscilloscope display or a free-running oscilloscope display (see discussion above). Note that this box must be unchecked to set the trigger level.

**Erase Bar check box** - Allows you to enable/disable the display of the vertical erase bar (cursor) on the waveform. Whether the erase bar is displayed or disabled, the waveform information on screen is still “erased” and replaced with a fresh sweep of data.

**OK command button** - Closes the Oscilloscope Triggering dialog box and applies the just configured display trigger conditions.

**Set Level command button** - Allows you to adjust or set the trigger level. Note that the Free Run check box must be unchecked to set a trigger level.

When this button is selected, the Oscilloscope Triggering dialog box closes and causes the cursor to point to a short horizontal line at the right side of the annotation margin. This short horizontal line is the trigger level indicator.



At this point, mouse movement is limited to dragging the line up or down to the desired trigger level. Note that when the mouse is moved, the data

display in the left annotation margin changes to indicate trigger level. When set where desired, clicking the left mouse button sets a new trigger level while clicking the right mouse button retains the existing level. Note that if the trigger level is set somewhere above or below the current signal, the signal will disappear from the display.

**Cancel command button** - Closes the Oscilloscope Triggering dialog box and cancels any changes made to trigger conditions (provided the changes were not saved with the OK command button).

## WINDAQ/Lite

### Open Reference File

Allows you to use an existing data file as a “set up” for a new data file. All recording parameters (such as number of channels, scaling constants, engineering units, display format, compression, display mode, gain, etc.) are ported from the existing file to become the default conditions for the new data file.

This function allows instantaneous setup, thus making it easy to run similar but separate waveform recording sessions.

To use an existing file’s recording parameters for a new file:



Point to the File menu and drag down to Open Reference File...

You will be prompted for the name of the existing data file. This file must be one created by WINDAQ software and must already exist. When a filename is entered and the dialog box is closed, the new file immediately inherits the existing file’s recording parameters.

This function is enabled only when in the SET-UP operating mode (Status: field in bottom annotation line indicates SET-UP).

## WINDAQ/Lite

### Current Data, Data Display, Limit Display & User Annotation

Allows you to enable or disable on-screen annotation options. Each annotation option is described as follows:

**Current Data** - Enables/disables the display of the current waveform data value in the left or right annotation margin. The **Data Display** option must first be enabled for this option to work.

When enabled in the oscilloscope mode, the current waveform data value at the cursor position is displayed in the annotation margin (the cursor does not have to be enabled).

When enabled in the scroll mode, the current waveform data value at the real time point (far right screen edge) is displayed in the annotation margin.

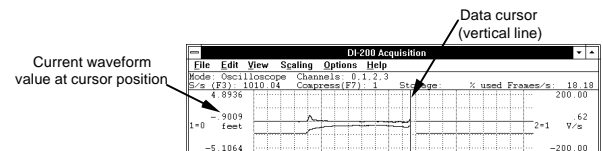
When disabled (in either mode), the base line value is displayed in the left/right annotation margin (if **Data Display** is enabled).

To enable current waveform data (if disabled, or disable it if enabled):



Point to the Options menu and drag down to Current Data.

When enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the Current Data command:



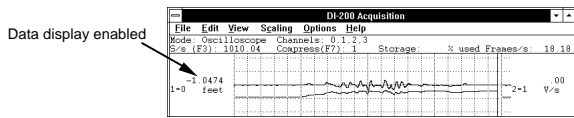
Current data enabled (shown in oscilloscope mode)

**Data Display** - Displays or hides the current waveform data value (or the baseline value, depending on the state of the **Current Data** option) in the annotation margin. If **Limit Display** is not enabled, the engineering units will toggle on and off along with the value. To display data (if hidden, or hide it if displayed):



Point to the Options menu and drag down to Data Display.

When the data display option is enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the Data Display command:

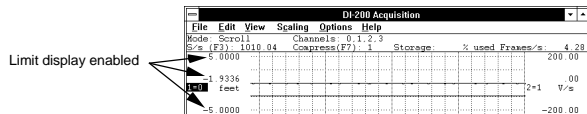


**Limit Display** - Displays or hides the upper and lower chart-edge limits in the left/right annotation margin. If **Data Display** is disabled, engineering units toggle on and off along with the limits. To display upper and lower chart-edge limits (if hidden, or hide them if displayed):



Point to the Options menu and drag down to Limit Display.

When the limit display option is enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the Limit Display command:

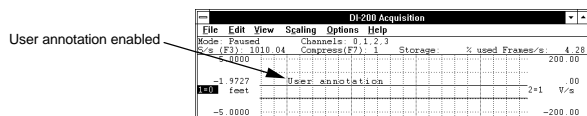


**User Annotation** - Toggles the display of user annotation (entered from the Edit menu, User Annotation... command) in the waveform strip. To display user annotation (if hidden, or hide it if displayed):



Point to the Options menu and drag down to User Annotation.

When user annotation is enabled, the waveform strip will display the specified channel's annotation (entered with Edit User Annotation...) and a check mark (✓) will be displayed on the Options menu immediately preceding the User Annotation command:



Screen annotation options can be enabled in virtually any combination to provide the desired result. However, in some instances one option will override another. For example, if Data Display is disabled, it is not possible to enable Current Data. Similarly, if Limit Display is disabled, it is not possible to enable Current Data.

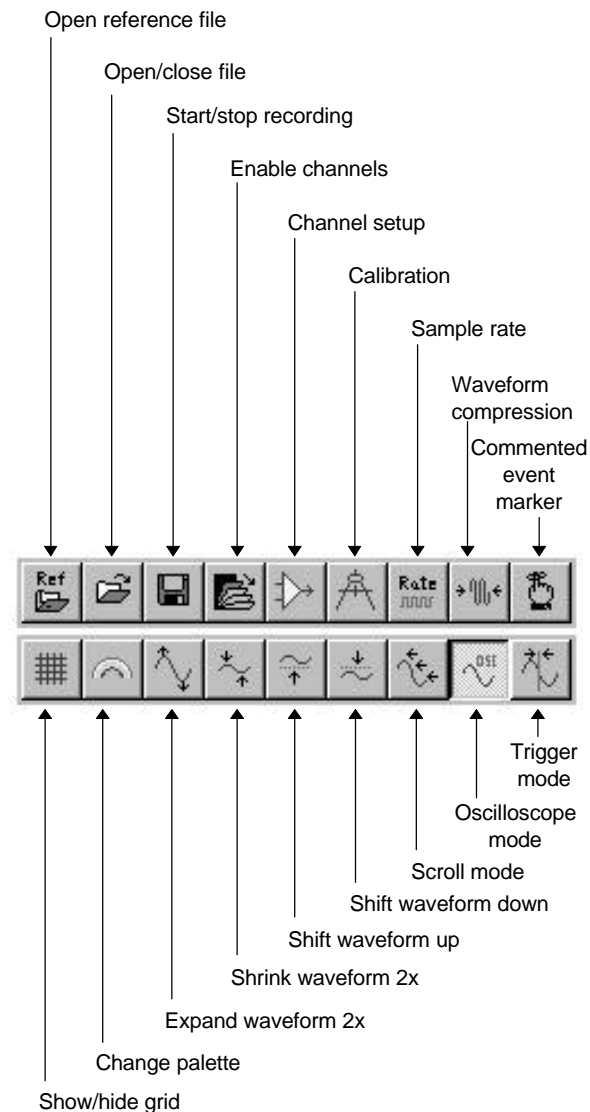
## WINDAQ/Lite ToolBox

When enabled, a floating “toolbox” of buttons is displayed on your screen. The toolbox buttons provide quick access to commonly used commands. To display the toolbox:



Point to the View menu and drag down to ToolBox.

Each button on the ToolBox provides quick access (a shortcut) to commonly used functions as follows:



**Open Reference File** — The same as choosing Open Reference File... from the File menu.

**Open/Close File** — The same as choosing Open... from the File menu or, when a file is already open, closes the file.



**Start/Stop Recording** — When activated with a data file already open, recording starts immediately. When activated without a data file open, the Open dialog box appears prompting you to specify a new file name or select an existing file. When activated during recording, recording is stopped.

**Enable Channels** — The same as choosing Channels... from the Edit menu.

**Channel Setup** — The same as choosing Channel Settings... from the Edit menu.

**Calibration** — The same as choosing Fixed Calibration... from the Edit menu.

**Sample Rate** — The same as choosing Sample Rate... from the Edit menu.

**Waveform Compression** — The same as choosing Compression... from the Edit menu.

**Commented Event Marker** — The same as choosing Insert Commented Mark from the Edit menu.

**Show/Hide Grid** — The same as choosing Grids from the Options menu.

**Change Palette** — The same as choosing User Palette... from the File menu.

**Expand Waveform 2X** — The same as choosing Grow 2X from the Scaling menu.

**Shrink Waveform 2X** — The same as choosing Shrink 2X from the Scaling menu.

**Shift Waveform Up** — The same as choosing Waveform Up 10 Pixels from the Scaling menu.

**Shift Waveform Down** — The same as choosing Waveform Down 10 Pixels from the Scaling menu.

**Scroll Mode** — The same as choosing Scroll Mode from the Options menu.

**Oscilloscope Mode** — The same as choosing Oscilloscope Mode... from the Options menu.

**Triggered Mode** — The same as choosing Triggered Mode... from the Options menu.

## User Annotation...

Allows you to display a custom message (up to 30 characters) on the baseline of each display channel (used in tandem with the User Annotation function on the Options menu).

The desired channel annotation must first be entered before it can be toggled on or off. To enter channel annotation:



Point to the Edit menu and drag down to User Annotation...

This displays the Channel Annotation dialog box as follows:



This dialog box prompts you to enter the desired channel annotation for the currently selected channel, or any other channel. If not the currently selected channel, enter the desired channel number for which you want to provide annotation in the Channel # = text box. In the Annotation = text box, enter the desired channel annotation (up to 30 characters).

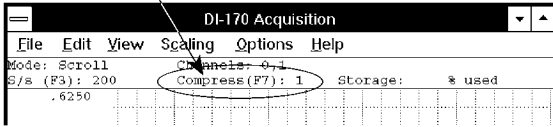
Once the channel annotation is entered, the display of user annotation can be toggled on or off with the User Annotation command on the Options menu.

The Next and Previous buttons allow you to step through all of the enabled channels in order, entering the desired channel annotation for each channel, without closing this dialog box.

## Compression..., Compression x2, Compression /2

Allows you to vary the number of data points used to display the real time waveform on your computer screen.

current compression setting



This function is simply a “graphics adjuster” that only affects how the display looks on your screen. Data acquisition is independent of this function and is always recorded (gap-free) at a compression factor of 1 (no compression applied).

When compression is applied to the waveform, *multiple* A-D readings (equal to the compression factor) are evaluated for plotting. In this instance, less CPU time is required for the display. For example, if compression equals 100, then 100 consecutive A-D readings are evaluated to define a waveform point.

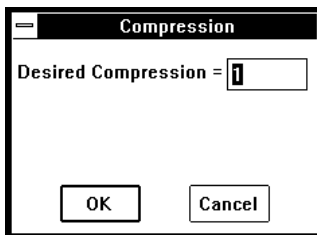
When compression is selected, a true min/max is performed on the waveform to ensure that transient information is always displayed.

The degree of waveform compression is controlled as follows:



Point to the Edit menu and drag down to Compression...

This displays the Compression dialog box as follows:



To specify a degree of waveform compression:



Enter the desired compression factor (from 1 to 65,536) and click OK.

A fast and convenient way to experiment with many different compression factors is with the Compression x2 and Compression /2 commands. These commands respectively multiply or divide the current compression factor by 2.

To multiply the current compression factor by 2:



Point to the Edit menu and drag down to Compression x2.

To divide the current compression factor by 2:



Point to the Edit menu and drag down to Compression /2.

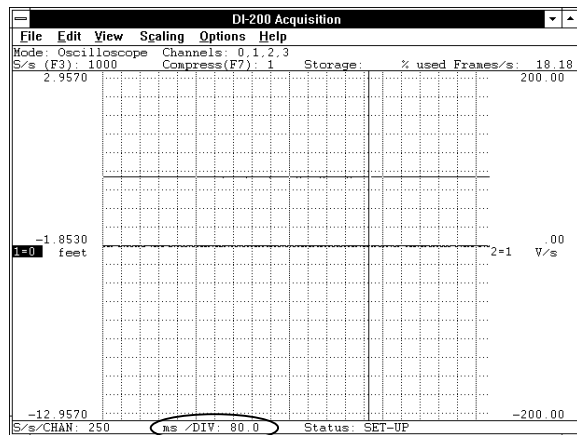
Perhaps these two functions are most useful when the accelerator keys (PGUP for Compression x2 and PGDN for Compression /2) are used. This allows you to press one key several times in succession to find just the right amount of compression for a smooth scrolling, visually pleasing display.

As the waveform compression factor is changed, the time base field (ms /DIV: or sec /DIV:) displayed in the bottom annotation line is automatically adjusted to reflect the proper time scaling of displayed waveforms.

## WINDAQ/Lite

### Time Base

Displays the time per major division at the bottom of the real time screen as sec / DIV: or ms / DIV:. The displayed value is a function of the selected sample rate, the number of channels enabled, and the selected waveform compression factor.



Time per major division

Time per major division is displayed at all times in all operating modes.

## WINDAQ/Lite

### Beep on File Full

When enabled, this option sounds an audible beep when the target file is full.

To enable the beep on file full function:



Point to the Options menu and drag down to Beep on File Full.

When enough data has been recorded to fill the allocated file space, an audible beep sounds (when this function is enabled) to warn you that acquisition has stopped and WINDAQ/Lite software is in the STBY operating mode.

## WINDAQ/Lite

### Close

Allows you to close the data file you are currently working with. Closing a data file removes the file from your screen, but does not quit WINDAQ/Lite software.

A new data file must first be opened and data must be recorded to it before the Close command is selectable (undimmed).

However, the Close command is immediately selectable on an existing data file that you are appending to.

Once Close becomes selectable, you can close a currently open data file as follows:



Point to the File menu and drag down to Close.

## WINDAQ/Lite

### Save Default Setup

Allows all current WINDAQ/Lite recording parameters to become default settings for all subsequent recording sessions.

When you have set up WINDAQ/Lite exactly the way you like, you can make this configuration the default, so it always appears this way when started. To make the current screen design the default condition:



Point to the File menu and drag down to Save Default Setup.

Virtually every WINDAQ/Lite recording parameter is saved to determine the default condition: display format, sample rate, compression, channels enabled, etc.

## WINDAQ/Lite

### Insert Mark, Insert Commented Mark

This function allows you to insert event markers (either commented or uncommented) at any point in the data stream going to disk. Event markers (along with appropriate comments) can be used to mark an event, or flag an uncommon occurrence in the data stream going to disk, thus providing a complete record of what happened and why.

After the waveform recording session, WINDAQ Waveform Browser playback software allows you to automatically search and move to the point in the data file where the event markers were placed during data acquisition.

A transition from the SET-UP or STBY operating mode to the RECORD operating mode automatically inserts a positive going time and date stamped event marker in the data stream going to disk, thus marking the start of acquisition. You must be in the RECORD mode to insert additional event markers into the data going to disk.



While in the RECORD operating mode, point to the Edit menu and drag down to Insert Mark for an uncommented event marker or Insert Commented Mark... for a commented event marker.

A commented event marker allows you to enter up to a 39-character comment that will be associated with the event marker. When Insert Commented Mark... is chosen from the Edit menu, the Event Marker Comment dialog box is displayed as follows:

The dialog box titled "Event Marker Comment" contains a text input field labeled "Event Comment =" and two buttons: "OK" and "Cancel".

Enter the desired comment (up to 39 characters) in the text box. The comment will be displayed with its associated event marker when Event Markers... is selected from the View menu in the WINDAQ Waveform Browser playback and analysis software package. A commented event marker is anchored at

its position in the data file the instant the event marker function is enabled. Data acquisition to disk continues while you enter your comment.

If the Cancel command button is chosen while recording, the event marker will not be deleted from the data or trailer file but the comment will be blank. If the Cancel command button is chosen while not recording, the comment will be applied to the “start acquisition” marker generated automatically when the next RECORD mode is activated. In this case, the comment may be changed or canceled at any time before activating RECORD.

When the desired comment is entered, close the dialog box by:



Clicking the OK command button.

It is possible to “preprogram” a comment for the automatically generated “start acquisition” marker. While in the SET-UP or STBY operating modes, choosing Insert Commented Mark... immediately causes the Event Marker Comment dialog box to appear, prompting you for an event marker comment. When entered, the comment will be automatically associated with the very next event marker stored to the data file upon transition to the RECORD operating mode.

Event markers are saved to disk along with A-D data. Any event marker comments that were provided ride with the data acquisition file as a trailer file.

Event markers may be enabled either locally (manually through the keyboard) or remotely through a switch closure or TTL signal. Refer to the Remote Events +, Remote Events -, Remote Storage 1, Remote Storage 0 function for details related to remote triggering of event markers.

An event marker is automatically inserted in the data stream each time the RECORD operating mode is activated. An event marker created in this manner is always tagged with a time and date stamp that allows any point in a recorded waveform file to be correlated with a precise date and time of occurrence (to the nearest second). Refer to Next Mark, Previous Mark, Insert Mark, and Delete Mark in the WINDAQ Waveform Browser playback and analysis software documentation for further information related to searching for event markers and using time and date stamp information.

## WINDAQ/Lite

### Remote Events +, Remote Events -, Remote Storage 1, Remote Storage 0

This function allows you to remotely trigger event markers or data storage to disk through the digital input port (labeled DI0 and DI1 on DI-200 and DI-400 Series instruments, REMOTE STOP/START and REMOTE EVENTS on DI-500 Series instruments, and R. START/STOP and EVNT on DI-720 and DI-730 instruments) using a TTL level signal or switch.

#### REMOTE TRIGGERING OF EVENT MARKERS

- To remotely trigger event markers, your TTL level signal or switch must be connected across the digital input pin 0 (DI0) and digital ground (POWER GND), across REMOTE EVENTS and POWER GND, or across EVNT and POWER GND. When properly connected, event markers can be remotely triggered on the rising or falling edge of the trigger signal.

To generate an event marker on low-to-high transitions (rising edge) of the digital input:



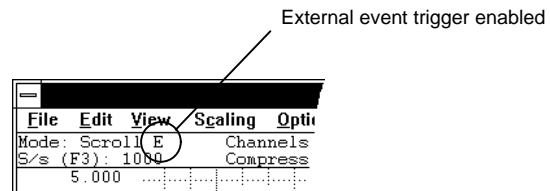
Point to the Options menu and drag down to Remote Events +

To generate an event marker on high-to-low transitions (falling edge) of the digital input:



Point to the Options menu and drag down to Remote Events -

When the external event trigger feature is enabled, an “E” will be displayed in the status bar immediately following the display mode descriptor as follows:



Event markers may be enabled either locally by choosing the appropriate command from the Edit menu or remotely through a switch closure or TTL signal. When event markers are generated remotely,

it is not possible to enable them locally. Nor are comments possible when recording with remotely triggered event markers.

**REMOTE TRIGGERING OF DATA STORAGE TO DISK** - To remotely trigger data storage to disk, your TTL level signal or switch must be connected across digital input pin 1 (DI1) and digital ground (POWER GND), across REMOTE STOP/START and POWER GND, or across R. START/STOP and POWER GND, and you must choose either Remote Storage 1 or Remote Storage 0 before entering the RECORD operating mode. You must be in the RECORD operating mode because the state of the signal on the digital input determines whether data acquisition to disk is enabled or disabled. All digital inputs are held high via pull-up resistors. DI1, REMOTE STOP/START, or R. START/STOP must be taken low to disable data storage. When properly connected, data storage to disk can be remotely enabled/disabled on all high or low levels of the trigger signal.

To enable data storage to disk when the digital input goes high (while in the RECORD operating mode):



Point to the Options menu and drag down to Remote Storage 1.

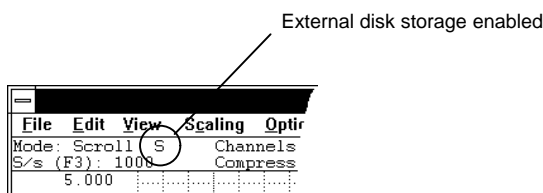
To enable data storage to disk when the digital input goes low (while in the RECORD operating mode):



Point to the Options menu and drag down to Remote Storage 0.

Note that unlike the event trigger signal which is *edge* sensitive, the disk storage trigger signal is *level* sensitive. When remotely storing data to disk, manual event marker generation is disabled.

When the external disk storage trigger feature is enabled, an “S” will be displayed in the status bar immediately following the display mode descriptor as follows:



HELP is a complete online reference tool that you can use at any time to display a brief summary of WINDAQ/Lite software contents. When you finish reading the HELP information, you are returned to the WINDAQ/Lite waveform display screen with everything exactly as you left it.

HELP information is displayed in its own window—you can move and size the HELP window just as you would any other window.

When using WINDAQ/Lite, you can get help any time you want it. You can request Help in a couple of different ways:

- From the Help menu, choose a Help category by:



Pointing to the Help menu and dragging down to the desired menu item.

- Use the cursor control keys to highlight or select an item on a menu, and then press F1 to get context-sensitive help on the item.

While in Help, you can move to other topics to find exactly the information you want, including help on Help (how to use Help). If you are new to Help, it is strongly recommended that you view Help Basics from the How to Use Help category.

When you finish using Help, you can leave the Help window open but out of your way, or you can close the Help window. Because Help is an application that appears in its own window, you can display the Help information next to the window in which you're working. As you work, you can switch to the Help window and find the Help information you need for a particular task.

To exit Help, choose File Exit from the Help window. If you want to return to your work without closing Help, you can shrink Help to an icon by clicking the Minimize button or by choosing Control Minimize.

# Functions Common to Recording and Playback

These functions appear in both WINDAQ/Lite waveform recording software and WINDAQ Waveform Browser playback and analysis software packages and function identically in either.

WINDAQ/Lite  
& WWB

## Copy

Copies the graphics in the graphic selection rectangle to the clipboard.

The Copy command on the Edit menu is dimmed until a graphic selection rectangle is drawn to enclose the desired graphics.

To copy graphics to the clipboard:

1. Position the mouse pointer anywhere in the graphics area.
2. Drag with the **RIGHT** mouse button until the desired graphics have been enclosed

With the graphics selection rectangle drawn, the Copy command on the File menu is enabled and the enclosed graphics can be copied to the clipboard as follows:



Point to the Edit menu and drag down to Copy.

The graphic is copied to the clipboard in both bitmap and device-independent bitmap (DIB) formats.

WINDAQ/Lite  
& WWB

## Invert

Allows you to flip the selected waveform upside down, exchanging the top and bottom limits.

To invert the waveform:



Point to the Scaling menu and drag down to Invert.

A subsequent activation of the Invert command flips the selected waveform back to its original orientation.

WINDAQ/Lite  
& WWB

## Next, Previous, & User Palette

Allows the selection of one of 16 pre-defined display palettes. Additionally, a user-palette option allows you to redefine the color scheme of the displays by selecting different background, gridline, user annotation, and waveform colors from among 16 choices.

A different palette can be displayed by selecting either the Next Palette or the Previous Palette command from the View menu. These commands allow you to pan through and display all 16 palette selections in either a forward or backward direction.



### Display the Next Palette

Point to the View menu and drag down to Next Palette.

### Display the Previous Palette

Point to the View menu and drag down to Previous Palette.

Note that you are not limited to the color combinations presented on the 16 pre-defined display palettes. It is possible to tailor one, several, or all palettes to suit your color preference, taste, or room lighting requirements. The tool used to accomplish this is the User Palette... command. The User Palette... command allows you to redefine the palettes color scheme by selecting different background, gridlines and user annotation, or waveform colors from among 16 color choices.

When a palette is changed, you have the option of making the new color scheme permanent or canceling all color changes. If the changes are canceled, the palette reverts back to the original color scheme you started with. If the changes are made permanent, the new color scheme is saved as one of the 16 display choices and the original color combinations are overwritten.

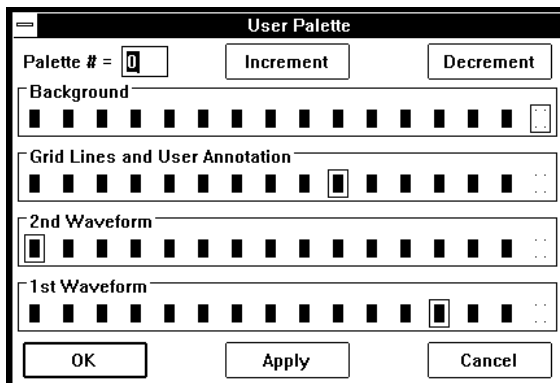
To change a palettes color scheme:



1. Using the technique described above, display the palette you want to change.
2. Point to the View menu and drag down to User Palette.... This displays the Palette dialog box.
3. In the Palette dialog box, click the Background, Grid Lines and User Annotation, 1st Waveform, or 2nd Waveform colors you want. A dotted box appears around the selected color sample.
4. Click Apply to apply the colors you have selected.
5. If you are satisfied with the color scheme you have selected, click OK. This saves the newly defined color scheme as one of the 16 display palettes, overwriting the existing palette. If you are not satisfied, repeat steps 3 and 4 above, or click Cancel to get back to the original palette you started with.

#### User Palette Dialog Box

The following information can be referred to when using the User Palette... function.



**Palette # = \_** - Serves as a label or identifier for the selected color scheme. Range is from 0 to 15.

**Increment command button** - Displays the color scheme that defines the next palette. Activating this button increments the Palette # and updates the background, waveform, and grid lines and user annotation color selection bars to show what the palette will look like when the Apply command button is activated.

**Decrement command button** - Displays the color scheme that defines the previous palette. Activating this button decrements the Palette # and updates the background, waveform, and grid lines and user annotation color selection bars to show what the palette will look like when the Apply command button is activated.

**OK command button** - Saves the new color combination as one of the 16 display choices. When saved, the original color combination is overwritten.

**Apply command button** - Allows you to apply or “try out” new color combinations without having to save them. Also used in conjunction with the Increment/Decrement buttons to view the 16 defined palettes. For example, to see what each palette currently looks like, activate the Apply button then the Increment button. Repeat this procedure 16 times to see each defined palette.

**Cancel command button** - Allows you to cancel any color changes made to a palette, provided that the changes have not been saved with the OK button. When canceled, the color scheme will revert back to the original palette you started with.

#### Monochrome Displays

If you are using WINDAQ software with a monochrome monitor, select the Monochrome color scheme from the Windows™ Control Panel. Selecting a color scheme other than monochrome may cause display conflicts. For example, with other color schemes, the cursor may seem to disappear when positioned coincident with a dark vertical gridline. The same result can happen with a waveform that rides the window baseline (the signal seems to disappear, but it is merely the same shade as the baseline). Selecting the monochrome color scheme ensures that your monitor will show every shade it is capable of showing without any conflicts.

#### Color Selection Conflicts

When selecting color combinations, it is important to note that the cursor color (not modifiable) will always be the inverse of the background. For example, if the background color is black the cursor color will be white, or if the background color is red the cursor color will be dark cyan.

For this reason, do not pick the inverse color of the background for grid lines and user annotation. If you do, the cursor will seem to disappear when coincident with vertical grid lines.

As a general rule, do not assign the inverse color of the background to any other parameter (grid lines and user annotation, 1st waveform, or 2nd waveform) and do not make both waveforms the same color.

**WINDAQ/Lite & WWB**  
**Exit**

Quits the WINDAQ/Lite waveform recording or WINDAQ Waveform Browser playback and analysis program.

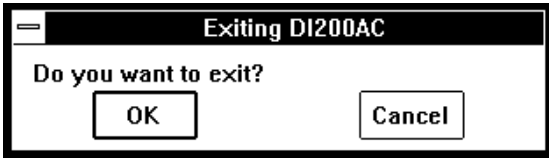
To quit either recording or playback:



Point to the File menu and drag down to Exit

Exiting From WINDAQ/Lite

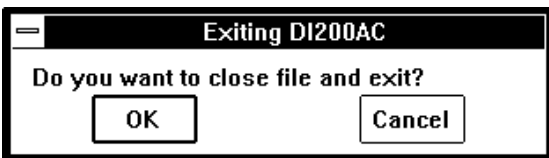
When in the SET-UP operating mode and the Exit command is chosen, the following dialog box is displayed. You are required to select one of the options prior to exiting.



**OK Command Button** - Exits to the Program Manager window without saving anything (i.e., calibration or set-up parameters). If calibration or set-up parameters were previously provided and saved (by using the SAVE DEFAULT SETUP command), they will be unaffected by this command.

**Cancel command button** - Returns to acquisition (cancels your exit request).

When in either the RECORD or STBY operating mode and an exit is requested, the prompt in the exit dialog box indicates that the data file will first be closed if the OK button is selected:

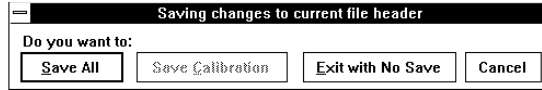


In this case, the command buttons function exactly the same as described above. However, the calibration or set-up parameters can be saved by first

selecting the Cancel button, followed by SAVE DEFAULT SETUP (from the File menu), then selecting the OK button.

Exiting From the WINDAQ Waveform Browser

When the Exit... command is chosen, the following dialog box is displayed. You are required to select one of the following options prior to exiting:



**Save All... command button** - Saves the entire state of playback data (including display format, scales, offsets, compressions, calibration constants, etc.).

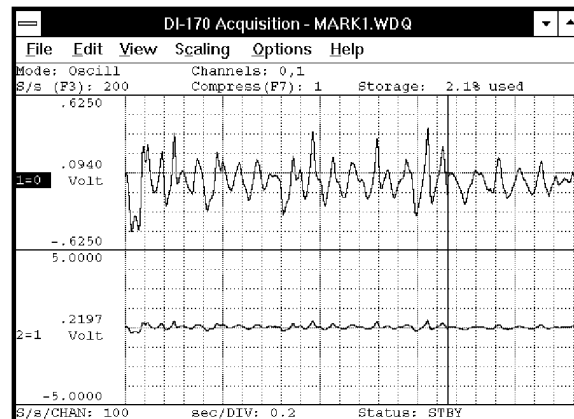
**Save Calibration... command button** - Saves the calibration data only. The next time the data file is reviewed, all waveforms will appear calibrated without needing to repeat the calibration process.

**Exit with no save... command button** - Exits without saving calibration or state. If calibration data was previously provided and saved, the constants provided are unaffected by this command. They remain intact for future file review.

**Cancel command button** - Returns to playback without saving anything (cancels your exit request).

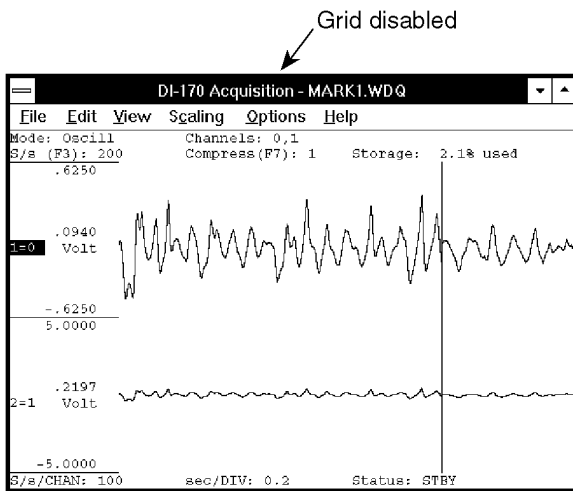
**WINDAQ/Lite & WWB**  
**Grids**

Enables or disables the real time waveform display grid pattern.



Grid enabled





To enable grid lines for display (if disabled, or disable them if enabled):



Point to the Options menu and drag down to Grids.

When grid lines are enabled, a check mark (✓) is displayed on the Options menu immediately preceding the Grids command. When grid lines are disabled, the check mark is not displayed.

### WINDAQ/Lite & WWB

## Show Dynamic Range

Allows you to see the waveform file with respect to the entire dynamic range of the A/D converter. Activating this function modifies the vertical scale (and automatically adjusts the waveform) so the + and - full scale counts are placed at the top and bottom of the waveform strip.

By seeing your waveform with respect to the entire dynamic range of the A/D converter, you see how much of this range you are using. Ideally, the waveform should use the entire dynamic range of the A/D converter in order to take full advantage of its resolution.

To show the dynamic range of the A/D converter:



Point to the Scaling menu and drag down to Show Dynamic Range.

This modifies the vertical scale (and automatically adjusts the waveform) to place the + and - full scale A/D converter counts at the top and bottom of the waveform strip, thus showing you the waveform file with respect to the entire dynamic range of the A/D converter.

Subsequent activations of the Show Dynamic Range command does nothing, the function does not toggle. To revert to the previous display (prior to activating the Show Dynamic Range function), use the Undo command on the Edit menu.

### WINDAQ/Lite & WWB

## Undo

Allows you to reverse the last screen scaling or offset operation performed on a selected channel.

When “undone”, the waveform will revert back to the original values before the previous scaling or offset operation. Note that this feature only works on the same channel as the most recent scaling or offset operation.

Subsequent undo operations toggles between the previous and most recent versions of screen scaling or offset.

A scaling or offset operation must first be performed on a selected channel to make the Undo command selectable (undimmed). Once Undo becomes selectable, you can perform any other operation (*except* another scaling or offset operation) on any other channel and still have the capability to come back to the selected channel and undo the last screen scaling or offset operation.

After scaling or offsetting a waveform, reverse the operation as follows:



Point to the Edit menu and drag down to Undo.

### WINDAQ/Lite & WWB

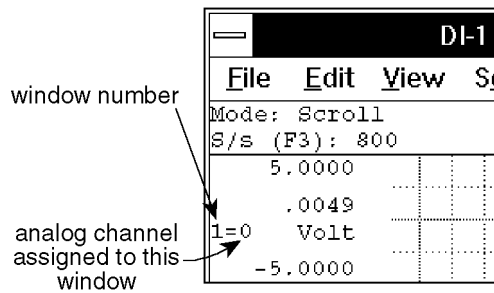
## Assign Channel

Allows any enabled channel to be assigned to any display window.

WINDAQ/Lite supports up to 16 waveform channels, which can be displayed in any of the 16 waveform display windows. In some cases, any two waveforms may be displayed in an overlapping format within the same window.

The two-element equality (X=Y) displayed for every enabled channel is called the variable waveform assignment indicator. This indicator shows which channel is assigned to which window. The first

element is the window number. The second element is the analog channel assigned to that window.

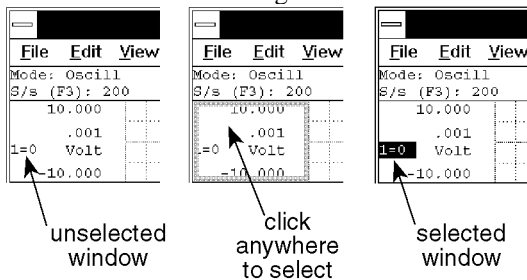


By default, WINDAQ software always displays channel 0 in window 1, channel 1 in window 2, channel 2 in window 3, channel 3 in window 4, etc. However, you can display any channel in any window.

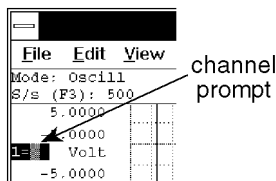
To display a channel in a window other than its default assignment:



1. Select the **window** to receive the channel by clicking the left mouse button in the unselected window's annotation margin.



2. Point to the View menu and drag down to Assign Channel... The channel portion of the variable waveform assignment indicator flashes.



3. Enter the desired **channel** number and press the ENTER key if required.

## WINDAQ/Lite & WWB

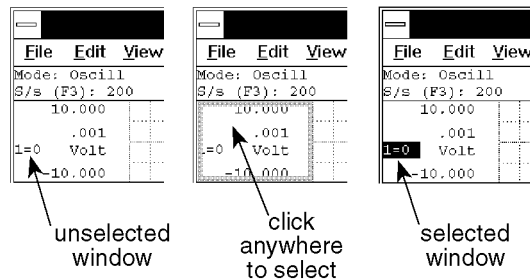
### Grow 2X, Shrink 2X, Waveform Down 1 Pixel, Waveform Up 1 Pixel, Waveform Down 10 Pixels, Waveform Up 10 Pixels

Used to dynamically scale or offset a specified channel's waveform on the real time display.

1. Select the window that contains the desired waveform:



Click the left mouse button in the unselected window's annotation margin.



The waveform displayed in the selected window is now enabled for scale and offset adjustments.



#### Expanding the Waveform's Amplitude

Point to the Scaling menu and drag down to Grow 2X. This expands the specified waveform two times its original size in the amplitude direction.

OR

Point to the right or left annotation margin and click the left mouse button. This also expands the specified waveform two times.

#### Contracting the Waveform's Amplitude

Point to the Scaling menu and drag down to Shrink 2X. This contracts the specified waveform one-half its original size in the amplitude direction.

OR

Point to the right or left annotation margin and click the right mouse button.

This also contracts the specified waveform one-half its original size.

#### **Moving the Waveform Down (↓ Offsetting)**

Point to the Scaling menu and drag down to Waveform Down 1 Pixel or Waveform Down 10 Pixels. Waveform Down 1 Pixel moves the specified waveform down a single pixel in the strip and Waveform Down 10 Pixels moves the specified waveform down 10 pixels in the strip.

#### **Moving the Waveform Up (↑ Offsetting)**

Point to the Scaling menu and drag down to Waveform Up 1 Pixel or Waveform Up 10 Pixels. Waveform Up 1 Pixel moves the waveform up a single pixel in the window while Waveform Up 10 Pixels moves the waveform up 10 pixels.

As a scaling or offset operation is performed on any selected channel, the channel's annotated  $\pm$  full scale and base line values will automatically adjust to reflect the operation.

Scaling and offsetting data does not, in any way, affect the information stored to disk. These operations are only provided to configure the real time display.

# Reviewing Recorded Waveforms with WINDAQ Waveform Browser

After waveforms have been recorded, WINDAQ Waveform Browser playback and analysis software

is used to make timing and amplitude measurements, review event markers, overlap waveforms to examine interdependencies, cut and paste portions of the waveform, and do all forms of interpretive analysis. To run WINDAQ Waveform Browser software, click or double-click the WWB icon.

The first four items listed below are the functions you will use most in the WINDAQ Waveform Browser. They involve moving around and otherwise navigating through the WINDAQ Waveform Browser.

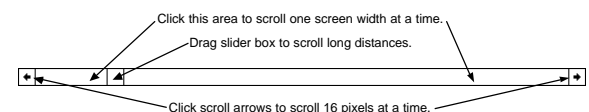
## **WINDAQ Waveform Browser**

### **Moving Around in the Data File**

Smooth scrolling (panning) or paging of waveforms in either a right-to-left (positive time) or left-to-right (negative time) direction are possible in the WINDAQ Waveform Browser.

The horizontal scroll bar controls waveform scrolling. With it, you can move from one part of the waveform file to another.

For optimum scrolling speed, ensure that the WINDAQ Waveform Browser window is positioned entirely on the screen. If a portion of the currently active window is hidden offscreen, scrolling speed is dramatically reduced. For best scrolling speed results, position (or resize) the active window so it is contained entirely onscreen.



- Clicking the left or right scroll arrow scrolls the waveform 16 pixels at a time. Clicking and holding either scroll arrow repeats the scrolling action until the beginning or end of the file is reached.
- To scroll by less than 16 pixels, you must use the cursor in conjunction with the mouse. Click in the bottom annotation line and drag the data cursor to the desired point in either direction.
- Clicking anywhere in the horizontal scroll bar on either side of the slider box scrolls the waveform one screen width toward the

beginning or end of the data file. The left mouse button can be held down to scroll rapidly until the slider box reaches the mouse pointer.

The keyboard's number lock (NUM LOCK) function must *not* be enabled when waveform scrolling is activated.


Using a floppy disk-based data file as opposed to a hard disk-based file will adversely affect the maximum speed of waveform travel in either direction.

To achieve maximum waveform scroll speed for your particular computer, copy the file to hard disk. If you do not have a hard disk, copy the data file to virtual disk and specify the virtual disk's "drive" letter when invoking Playback. Refer to the VDISK command of your computer's DOS manual (version 3.0 or greater) for full VDISK details.

**WINDAQ Waveform Browser**  
**Autoscroll Right, Autoscroll Left**

Automatically (hands off) scrolls the data file. When selected, either one of these functions will scroll the file in the direction selected (left or right) until the end of the file is reached or any other key on the keyboard is pressed.

To autoscroll the data file:


 Point to the Search menu and drag down to Autoscroll Right or Autoscroll Left.

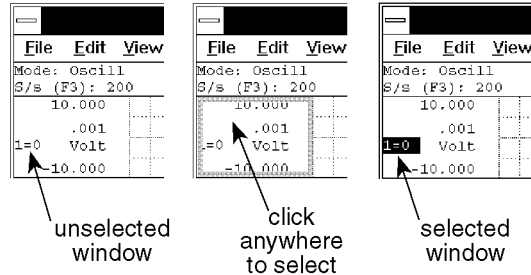
**WINDAQ Waveform Browser**  
**Channel Settings...**

Provides information about the selected channel. This information tells you what the sample rate, acquisition method, input type, dynamic range, etc. settings were when the channel was recorded.


Since most of the settings this function displays can be assigned on a per-channel basis in WINDAQ/Lite recording software, the desired channel must first be selected.

1. Select the desired channel:

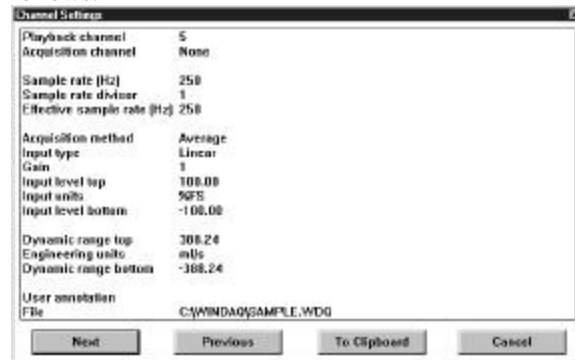
 Click the left mouse button in the desired channel's annotation margin.



2. With the desired channel selected, select Channel Settings...

 Point to the View menu and drag down to Channel Settings...

This displays the Channel Settings dialog box as follows:



The Next and Previous command buttons allow you to step through all of the enabled channels in order, viewing the channel settings for each enabled channel without closing this dialog box.

The To Clipboard command button allows you to send all of the information in this dialog box to the clipboard in text format, ideal for pasting into a word processor or spreadsheet. Since the information pasted from the clipboard is in text format (not a bitmap), the values are separated from the settings labels by tabs and can easily be edited with your word processor or spreadsheet program.

The following describes each item in the Channel Settings dialog box (these items are originally set from within WINDAQ/Lite recording software by choosing Channel Settings... from the Edit menu):

**Playback channel** - Displays the channel you are currently viewing the settings for.

**Acquisition channel** - Displays the physical channel number that was used during recording. If NONE is displayed, it means this channel was never recorded

but instead is a “calculated” channel, created by Advanced CODAS Analysis Software (available as an extra-cost option).

**Sample rate (Hz)** - Displays the sample rate (in Hz) that was used to record this channel.

**Sample rate divisor** - Displays the sample rate divisor that was used for this channel to achieve a specific sample rate. Note that if the file was recorded with WINDAQ/Lite or WINDAQ/Pro waveform recording software, this divisor will always be 1. If the channel was recorded with WINDAQ/Pro+ waveform recording software, this divisor can range from 1 to 255, indicating the factor that was used to divide the per channel sample rate down to a desired value.

**Effective sample rate (Hz)** - Displays the channels effective sample rate. When the sample rate divisor is 1, the effective sample rate is the same as the sample rate. When a sample rate divisor other than 1 is used, the effective sample rate describes the rate at which data was recorded to disk.

When a sample rate divisor other than 1 is used on a channel, the sample rate still accurately describes the rate at which data gets sampled, but does not accurately describe the rate at which data was recorded to disk. This is why we need a new value, called “effective sample rate”. It takes into account the original sample rate, the number of enabled channels, and the sample rate divisor of all enabled channels. Full effective sample rate details can be found in the WINDAQ/Pro and WINDAQ/Pro+ User’s Manual.

**Acquisition method** - Displays the method chosen for displaying data on your monitor and recording it to disk. Valid displays are Average, Last Point, Maximum, or Minimum.

**Input type** - Displays the type of transducer originally used on this channel to record the data. Valid displays are Linear, Thermocouple, and Nonlinear. Complete details of each input type can be found in the WINDAQ/Pro and WINDAQ/Pro+ User’s Manual.

**Gain** - Displays the gain chosen for this channel prior to recording. Gain varies with the instruments being used.

**Input level top** - Displays the input level at the top of the A/D converter’s range. This value will be a voltage (either +5.00 or +10.00 volts) if the channel was truly used for recording, or it will be expressed

as a percentage of full scale (+100.00%) if this is a “calculated” channel created by Advanced CODAS Analysis Software.

**Input units** - Displays volts if the channel was used for recording, or displays %FS (percent full scale) if the channel is a “calculated” channel created by Advanced CODAS Analysis Software.

**Input level bottom** - Displays the input level at the bottom of the A/D converter’s range. This value is a voltage (either -5.00 or -10.00 volts) if the channel was truly used for recording, or it will be expressed as a percentage of full scale (-100.00%) if this is a “calculated” channel created by Advanced CODAS Analysis Software.

**Dynamic range top** - Displays the engineering unit value at the top of the A/D converter’s range. This value will be an engineering unit value if the channel was calibrated in WINDAQ/Lite, or it will be expressed as a percentage of full scale (+100.00%) if the channel was not calibrated.

**Engineering units** - Displays the units used to calibrate the waveform in WINDAQ/Lite, or it displays %FS (percent full scale) if the channel was not calibrated.

**Dynamic range bottom** - Displays the engineering unit value at the bottom of the A/D converter’s range. This value will be an engineering unit value if the channel was calibrated in WINDAQ/Lite, or it will be expressed as a percentage of full scale (-100.00%) if the channel was not calibrated.

**User annotation** - Displays any channel specific user annotation that may have been entered during recording.

**File** - Displays the name and path of the file you’re working with.



## Export (Using Save As...)

Allows you to copy a range of waveform information from an existing data file and export it to a new file in a variety of different storage formats.

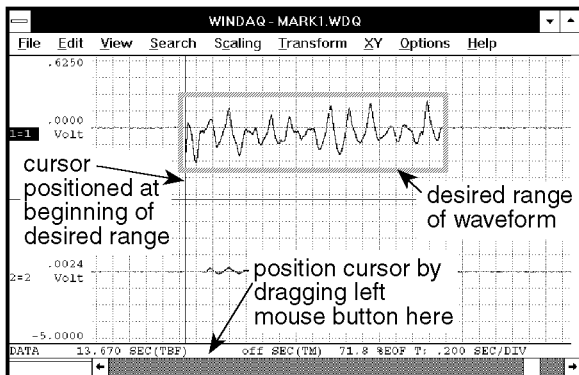
This function exports *all* channels in the data file lying between the specified range. If you wish to export only certain channels in a data file, refer to the EXTRACT CHANNELS function.

The range of data to be exported is user-definable. Created data files may be read by user-generated, or standard (i.e., ASYST, Lotus 1-2-3, Excel, Quatro Pro, etc.) software analysis packages, or by Advanced CODAS' CALC package.

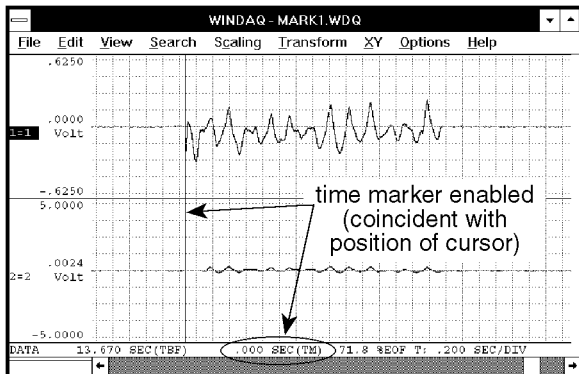
Before data may be exported to a disk file, the copy range must be selected. The copy range is defined as all data for each channel lying between the time marker and cursor.

To select the copy range:

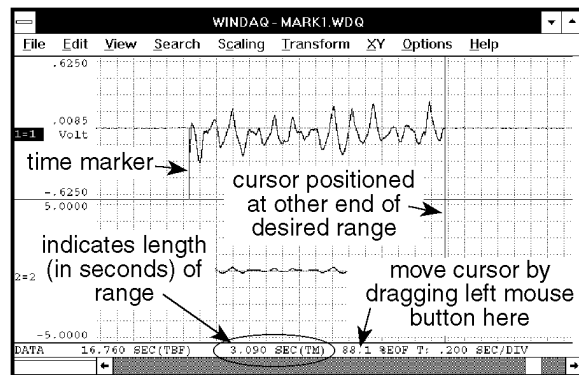
1. Position the cursor at one end of the desired range (drag the left mouse button in the bottom annotation margin to position the cursor).



2. Enable the time marker (by pressing the F4 key; by pointing to the Options menu and dragging down to Enable Time Marker; or by choosing Options Enable Time Marker with ALT, O, M keystrokes).



3. Move the cursor (in either direction) to the other end of the desired range (by dragging the left mouse button in the bottom annotation margin).



When the copy range is selected as described above, the export utility is invoked as follows:



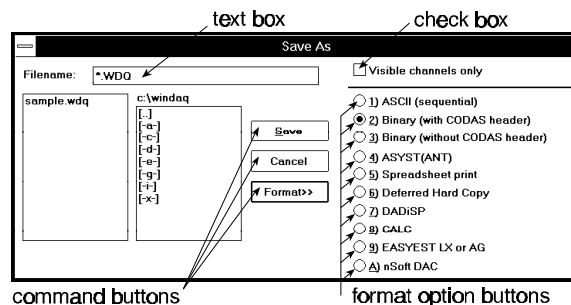
Point to the File menu and drag down to Save As....

This displays the Save As dialog box. Before you enter a file name, select a file storage format. The file storage format selections are displayed by:



Clicking the Format>> command button.

The file storage format selections appear on the right side of the dialog box as follows:



Select the storage format by:



Clicking the desired format option button.

With the desired format selected, enter in the text box the name of the data file (including desired path names) to which WINDAQ Waveform Browser software is to write the copied data.

When a file name is entered, export the specified range by:



Clicking the Save command button.

The data within your selected range and from every channel in the file will be copied to the specified data file.

Note the Visible channels only check box at the top of the Save As dialog box. This option must remain unselected (no X appears in the check box) for the export function to work on *all* channels in the data file. If this option is selected (an X appears in the check box), only the visible channels (those that are displayed on your monitor) in the data file will be exported. Refer to the EXTRACT CHANNELS function in this chapter for complete details on the Visible channels only check box.

A description of each data storage format follows:

**SEQUENTIAL ASCII** - This data storage format is one of three (Binary without CODAS header, and Lotus 1-2-3 are the others) that may be used to create a data file readable from a user-generated applications program (e.g. BASIC, FORTRAN, C, etc.). Data is stored as ASCII strings with a “,” (comma) delimiter. Each data value field consists of eleven characters (excluding the comma). The data format is scientific notation, and is scaled into engineering units as follows:

SX.XXXXESXX

Where: S is the sign of either the exponent or mantissa.  
E flags the value of the exponent.

The order of data storage is sequential with waveform channel one always being the first data value written. For example, if four waveform channels exist, the first data value written is channel one, the fourth is channel 4.

The sequential ASCII data storage format is perhaps the easiest to use from the applications program level, but you will pay a price in terms of data file length since it takes 10 characters (bytes) to represent one data value.

**BINARY WITH CODAS HEADER** - Use this data storage format to review the created data file with WINDAQ Waveform Browser software. This utility is useful when you need to break up a larger CODAS data file into smaller, easily manageable units for review by playback software.

**BINARY WITHOUT CODAS HEADER** - This data storage format, like Sequential ASCII, is used when you need to access the created data file through your own BASIC, FORTRAN, C, etc., applications program. But, unlike Sequential ASCII, the Binary-without-CODAS-header format requires only two bytes of storage to represent one data value, thus yielding much smaller data file lengths.

**ASYST** - When this data storage format is selected, playback software stores channel data in a fashion that is directly compatible with the ASYST data storage convention. The storage format allows ASYST to input data as a two-dimensional array (channel number, channel data).

When the ASYST format is invoked, you are prompted to select the storage format as either (R)real or (I)nteger. Select (I)nteger if you do not need to have waveform data scaled into engineering units. This format allows more data to be ported into ASYST(ANT) arrays. Select (R)real if you need the waveform data ported to ASYST(ANT) to be scaled in engineering units. You can also enter up to two optional comment lines that you may use to describe your particular test. The aggregate sample rate is automatically entered as a comment. The sample rate, as well as any additional comments you provide, will be printed on your monitor (by using the ASYST "?FILE" command) when you retrieve the data file into ASYST.

**ASYSTANT** - Although the data storage format for ASYSTANT (including [R]eal and [I]nteger conversions) is identical to ASYST, data files are imported slightly differently. An ASYSTANT/ASYST-formatted file is imported to ASYSTANT by using the FILE I/O option and specifying a FILE/VAR TRANSFER. Enter the data file name and the ASYSTANT variable that will be assigned the data (for this example we will assume variable T was specified), and select the READ option at the bottom of ASYSTANT's FILE INPUT/OUTPUT menu. Quit the FILE I/O menu and return to the upper-most ASYSTANT menu. Notice that variable T indicates the size of the data array. You may now operate on the data contained in variable T using all of ASYSTANT's powerful routines.

**A NOTE TO ASYST AND ASYSTANT USERS** - When waveform data are pasted in the ASYST/ASYSTANT storage format using the (I)nteger conversion, waveform channel values are equivalent to A-D converter counts (integers). To translate A-D converter counts into a voltage, perform the following operation from the ASYST or ASYSTANT level:

$$\text{VOLTAGE} = (\text{Counts} / 8192) * \text{Volts full scale}$$

**SPREADSHEET PRINT** - Allows you to paste waveform data to files that may be read directly by Lotus 1-2-3, Excel, Quatro Pro, or any spreadsheet program that uses the comma-separated-value (CSV)

data format. Even if your spreadsheet program uses something other than a comma to separate data values, it is still possible to use this format. Contact DATAQ INSTRUMENTS for details on changing the delimiter from a comma to whatever your program requires.

Selecting the Spreadsheet option from the format option list creates a data file that, when read by Lotus 1-2-3 using their *IMPORT* command (do not use Retrieve), will present the data in spreadsheet fashion where each waveform channel fills one column (i.e., column A contains waveform channel one's data, column B waveform channel two's, etc.). When the Spreadsheet format is invoked, you are prompted to enter up to two optional comment lines that you may use to describe your particular test. The aggregate sample rate is automatically entered as a comment. The sample rate, as well as any additional comments you provide, will be printed on your spreadsheet when you import the data file to your spreadsheet program.

Some spreadsheet programs (i.e., Excel) require the newly created CSV file to contain a .CSV extension in the file name.

**DEFERRED HARD COPY** - Use this data storage format to create a print file (or several print files) that can be invoked and printed (even batch processed) at a later time from DOS with the AT-CODAS hard copy utility (HCU.EXE). The target printer and port are those specified during CODAS configuration.

WINDAQ Waveform Browser users can also use the hard copy utility (HCU) provided they have a Laserjet, Thinkjet, or IBM-compatible, dot-matrix graphics printer that CODAS supports. In this case, the hard copy utility (HCU.EXE) will be automatically installed at the time of WINDAQ Waveform Browser installation (contact DATAQ Instruments technical support for details).

After selecting this data storage format, you will be prompted to enter a comment. You may enter a line of comments (up to 70 characters) that will be passed to the hard copy record.

**DADiSP** - Selecting the DADiSP file format will create a data file that may be directly imported into the DADiSP waveform analysis program. The file format is that defined by DSP Systems where a data file header describing the format of the data is first created, and the data format is floating point binary.

**CALC** - When the CALC option in the format

selection menu is selected, the following events automatically take place:

1. A new data file is created on disk carrying the file name you supplied when EXPORT was first invoked.
2. The specified range of waveform information is extracted (copied) from the currently active waveform data file, then pasted into the newly created file using the CODAS (with data file header) format along with any calibration information.
3. CALC is run and initialized with the default file name of that containing the pasted waveforms. At this point, the CALC first-level menu will be displayed and you may execute your required CALC function(s) on the data file containing the pasted waveforms, or even change the default file name to operate on another file. When CALC is exited, control returns to the playback software in the state that existed just before EXPORT was selected. The waveform data file from which waveforms were copied remains as the active playback file.
4. **DO NOT PASTE DATA IN A COMPRESSED FORMAT WHEN USING THE ADVANCED CODAS CALC OPTION.**

Note that Advanced CODAS is a separately-purchased software utility for waveform analysis.

**EASYEST LX or AG** - When this data storage format is selected, data is stored in a fashion that is directly compatible with the "light" versions of ASYST software (called EASYEST LX or EASYEST AG). These two flavors of EASYEST are smaller, simpler, less complex versions of ASYST software.

**nSoft DAC** - When this data storage format is selected, data is stored in a fashion that is directly compatible with the "nSoft" DAC package from nCode International Inc. This format stores one file per channel, and the last two digits of the filename indicate the channel number (i.e., 01 is channel one, 02 is channel two, 10 is channel 10, etc.). Statistical information is also included in the data file when this storage format is selected.

#### **PASTING DATA IN COMPRESSED FORMAT**

Since the waveforms displayed by playback software may be compressed at the time the EXPORT utility is invoked, it is possible to paste compressed data. If waveform compression was enabled at the time



EXPORT is used, and the SPREADSHEET or ASYST(ANT) storage format is selected, the sample rate figure automatically added to the comment lines will be divided by the compression ratio that was active at the time the export function was selected. If the DADiSP storage format is selected, the time axis of DADiSP windows will be automatically adjusted.

WINDAQ Waveform  
Browser

## Data Cursor, Peak on Screen, Valley on Screen, and Center Cursor

Used to turn the waveform data cursor on or off and to control cursor movement on the screen. Including moving the cursor to the highest peak displayed onscreen for the selected channel, moving the cursor to the lowest valley displayed onscreen for the selected channel, and moving the cursor to the center of the screen.

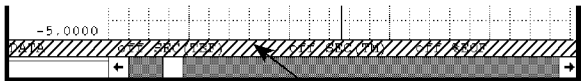


### Turning the Data Cursor On/Off

Point to the Options menu and drag down to Data Cursor. This will turn the data cursor on if it is off, or off if it is on.

OR

Click the left mouse button anywhere in the bottom annotation line.



If the data cursor is off, this will turn it on at the point coincident with the mouse pointer. If the data cursor is on, a deliberate click of the left mouse button in the bottom annotation line at the point horizontally coincident with the data cursor turns it off. Note when attempting to toggle the cursor on and off quickly, clicking the left mouse button twice in rapid succession (double-clicking) produces a much different result than turning the cursor on and off. See the following function for more details on double-clicking in the bottom annotation line.

### Moving the Cursor to the Highest Peak

Point to the Search menu and drag down to Peak on Screen. This moves the cursor to the highest waveform peak displayed on the screen in a selected channel.

OR

Double-click the left mouse button anywhere in the bottom annotation line. This will also move the cursor to the highest peak displayed on the screen in a selected channel.

### Moving the Cursor to the Lowest Valley

Point to the Search menu and drag down to Valley on Screen. This moves the cursor to the lowest waveform valley displayed on the screen in a selected channel.

OR

Double-click the right mouse button anywhere in the bottom annotation line. This will also move the cursor to the lowest valley displayed on the screen in a selected channel.

### Moving the Cursor to the Center of the Screen

Point to the Search menu and drag down to Center Cursor. This moves the cursor to the center of the screen in a selected channel. If your computer's SCROLL LOCK function is enabled, the waveform will move to center screen along with the cursor.

OR

Click the right mouse button anywhere in the bottom annotation line. This will also move the cursor to the center of the screen in a selected channel. If your computer's SCROLL LOCK function is enabled, the waveform will move to center screen along with the cursor.

When the data cursor is turned on, a check mark (✓) is displayed on the Options menu immediately preceding the Data Cursor command. This check mark indicates that the cursor is enabled, even though it might not be immediately obvious on the screen because of its position at the far right or left margin of the display or because it is otherwise

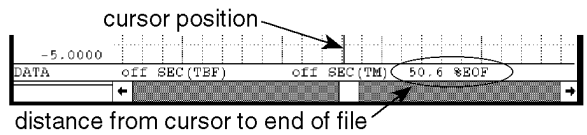
obscured. When the cursor is turned off, the check mark is not displayed.

Note that highest peak and lowest valley searches can also be done within the limits of a selection rectangle.


### WINDAQ Waveform Browser

## %EOF (Distance to End of File)

Displays the distance from the current cursor position to the end of the data file, expressed as a percentage.



This distance is displayed at the bottom of the screen where 0% EOF indicates that the cursor position is at the beginning of the data file, and 99.9% EOF indicates that the cursor position is at the end of the data file.

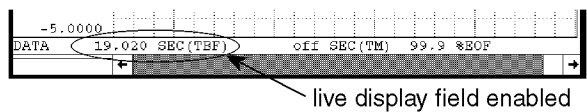
 Point to the Options menu and drag down to %EOF. This will enable the distance-to-end-of-file function in the bottom annotation line if disabled, or disable it if enabled.

When enabled, a check mark (✓) is displayed on the Options menu immediately preceding the %EOF command. When the distance-to-end-of-file function is disabled, the check mark is removed.


### WINDAQ Waveform Browser

## Enable Live Display

Displays the Time-To-Beginning-Of-File (TBF) format (or one of the other three time marker-related data formats) in the live display field.



When enabled and the waveform is panned across the screen (or the cursor is moved), this display field is constantly updated to provide a "live" readout.

 Point to the Options menu and drag down to Enable Live Display. This enables the live display field in the bottom annotation line if

disabled, or disables it if enabled.

When the live display field is enabled, a check mark (✓) is displayed on the Options menu immediately preceding the Enable Live Display command. When the live display field is disabled, the check mark is removed.

When the live display field is enabled, the data displayed in this field is determined by the Select Live Display setting. Refer to the SELECT LIVE DISPLAY function for more details.


When the live display field is disabled, off is displayed in the field with the last selected format.

### WINDAQ Waveform Browser

## Next Mark, Previous Mark, Insert Mark, Delete Mark, and Clear Marks to TM

Next Mark and Previous Mark provide a convenient method for moving from one event marker location to the next on a selected channel. Insert Mark and Delete Mark allow a positive or negative-going event marker to be placed on or deleted from any enabled window's waveform except waveform channel 1.

After a channel has been selected, you must enable event markers for display. This is done by:

 Pointing to the Options menu and dragging down to Event Marks

When event markers are enabled for display, a check mark (✓) is displayed on the Options menu immediately preceding the Event Marks command. When event markers are disabled, the check mark is removed.

With event markers enabled for display, use the following procedures to move among event markers:

 **Search for Next Event Marker**

Point to the Search menu and drag down to Next Mark... This moves the window in the positive time direction to the next event marker.

**Search for Previous Event Marker**

Point to the Search menu and drag down to Previous Mark... This moves the window in the negative time direction to

the previous event marker.

### **Insert an Event Marker**

Point to the Edit menu and drag down to Insert Mark. This inserts a positive-going event marker on the selected window's waveform at the point of waveform-cursor intersection. Repeating this action toggles the event marker from positive-going to negative-going. Note that this procedure will work on any channel *except* channel 1. Note also that the waveform must be uncompressed (waveform compression must equal 1) to insert an event marker.

### **Delete an Event Marker**

Point to the Edit menu and drag down to Delete Mark. This deletes an event marker (from the selected window's waveform) that is coincident with the waveform cursor. Note that this procedure will work on any channel *except* channel 1. Note also that the waveform must be uncompressed (waveform compression must equal 1) to delete an event marker.

### **Clear all Event Marks Between Cursor and Time Marker (On Selected Channel)**

Point to the Edit menu and drag down to Clear Marks to TM. This deletes all event marks (from the selected channel) that occur between the cursor and time marker. The range can be defined by positioning the cursor at one desired limit, enabling the time marker (by pointing to the Options menu and dragging down to Enable Time Marker), then moving the cursor over to the other desired range limit. If this function is used on channel 1, only the negative-going marks are deleted. This is because channel one contains event mark information enabled by the data recording program. These are stored as positive-going markers in the waveform data stream and are not to be deleted.

When attempting to seek an event marker in either direction where one does not exist, an audible beep will sound, the display will fail to move, and an error message will be displayed. Click on the OK box or press the ENTER key to clear the error message.

## **Extract Channels (Using Save As...)**

Allows you to copy a range of waveform information from selected channels in an existing data file and export them to a new file in a variety of different storage formats.

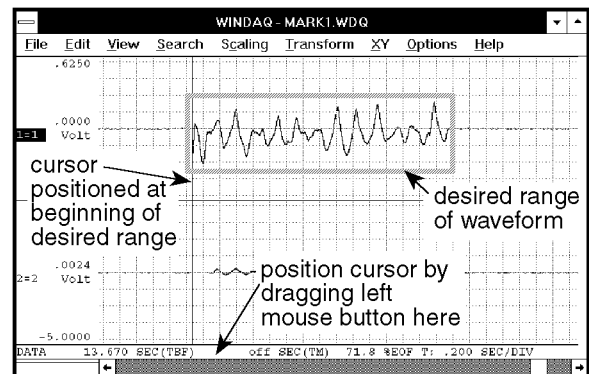
This function exports only *certain channels* (only the channels that are visible onscreen) in the data file lying between the specified range. If you wish to export all of the channels in the data file, refer to the EXPORT (Using Save As...) function.

The newly created file may contain any subset of channels from the existing data file.

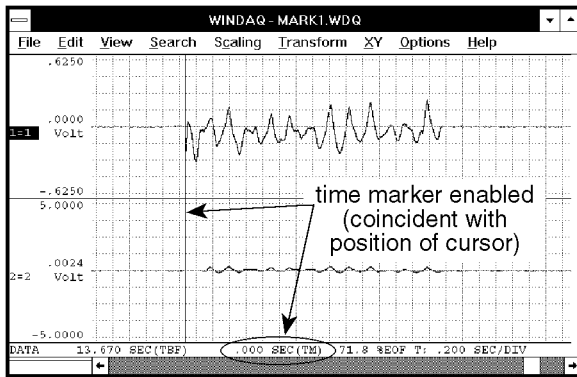
Before data may be exported to a disk file, the copy range must be selected. The copy range is defined as all data for each channel lying between the time marker and cursor.

To select the copy range:

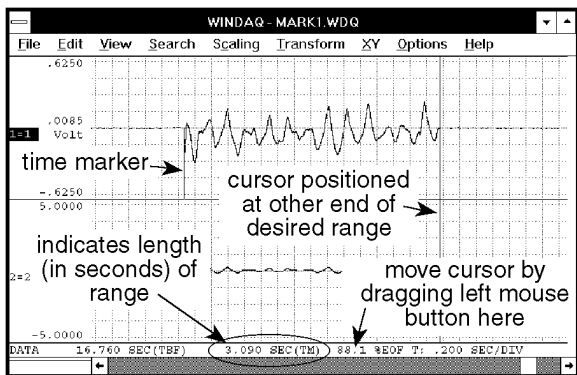
1. Position the cursor at one end of the desired range (drag the left mouse button in the bottom annotation margin to position the cursor).



2. Enable the time marker (by pressing the F4 key; by pointing to the Options menu and dragging down to Enable Time Marker; or by choosing Options Enable Time Marker with ALT, O, M keystrokes).



3. Move the cursor (in either direction) to the other end of the desired range (by dragging the left mouse button in the bottom annotation margin).



Although the range is specified only on display window one, when copied, data in all *active windows* lying between the limits are copied to your specified file name.

When the data range is selected as described above, the extract utility can be invoked as follows:



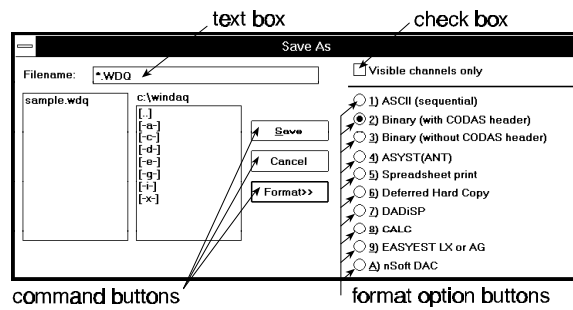
Point to the File menu and drag down to Save As....

This displays the Save As dialog box. Before you enter a file name, select a file storage format. The file storage format selections are displayed by:



Clicking the Format>> command button.

The file storage format selections appear on the right side of the dialog box as follows:



Select the storage format by:



Clicking the desired format option button.

With the desired format selected, enter in the text box the name of the data file (including desired path names) to which WINDAQ Waveform Browser is to write the extracted channel data.

When a file name is entered, extract the selected channel(s) by:



Clicking the Save command button.

The data within your selected range but only from the visible channels will be extracted from the existing file and placed in the specified data file.

Note the Visible channels only check box at the top of the Save As dialog box. This option must be selected (an X appears in the check box) for the extract channels function to work as described above. If this option is unselected (no X appears in the check box) and the extract channels procedure is completed, *all* channels in the original file will be exported rather than just the desired (visible) ones.

This function makes extensive use of the DISPLAY FORMAT and ASSIGN CHANNELS functions. Literally, whatever channels are displayed on the screen (and the order in which they are displayed) become the channels that are ported to the newly created file.

## WINDAQ Waveform Browser

### Free/Lock Cursor

This function applies mostly to those who are using the WINDAQ Waveform Browser without a mouse.

Allows the cursor to be released from its default position of screen-center. When released, it may be positioned anywhere on the screen while the displayed waveforms remain stationary.



Pressing the SCROLL LOCK key will free the cursor and allow you to position it anywhere on the screen using the ← and → cursor control keys. When the cursor is in its free state and if your computer's keyboard provides an indicator light for SCROLL LOCK, the light will be off. The light will be on when the cursor is in its locked state. The cursor state will toggle each time the SCROLL LOCK key is pressed.

The asterisk key (\*) may be used to center the cursor in the waveform display window. If SCROLL LOCK is off when the \* key is pressed, the cursor alone moves to screen-center while waveforms remain stationary. If SCROLL LOCK is on when the \* key is pressed, cursor and waveforms scroll to screen-center together.

**WINDAQ Waveform Browser**

**Jump To Beginning/End of File**

Instantly moves the display screen to the beginning or end of the waveform file, accomplished by:



Dragging the slider box in the horizontal scroll bar to the leftmost limit (for the beginning of the waveform data file) or to the rightmost limit (for the end of the waveform data file).

**WINDAQ Waveform Browser**

**Go to TM Position, Go to Range..., and Go to Time...**

Three separate functions that allow you to immediately vector or jump to a specific part of the file. Each feature is described as follows:

**Go to TM Position** - This function instantly moves the display screen to the position of the file occupied by the time marker. When at the position of the time marker, you can instantly move back to your original position. To move to the time marker position:



Point to the Search menu and drag down to Go to TM Position.

This moves the display to the position of the previously enabled time marker. If the data cursor is enabled for display, it will overlay the time marker on the screen. Pointing to the Search menu and dragging down to Go to TM Position a second time

moves the display back to the original position.

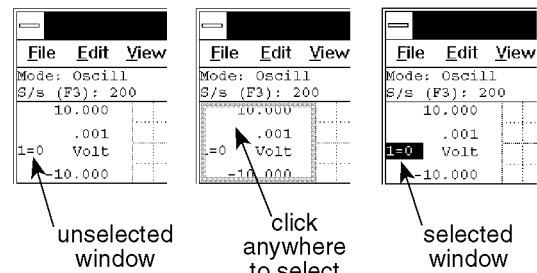
**Go to Range...** - This function instantly moves the data cursor to the next or previous data point that is inside or outside of a specified range of values on the selected channel. When a data point satisfying the range and conditions has been found, the screen is scrolled to place the cursor at the value of the point found.

To use the Go to Range... feature:

1. Select the window that contains the desired waveform:



Click the left mouse button in the unselected window's annotation margin.

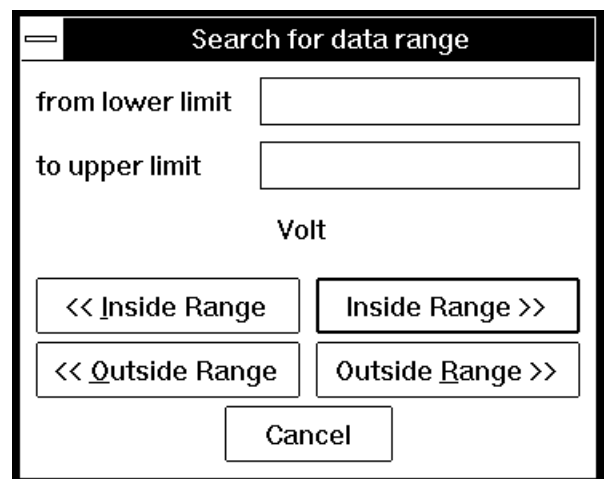


2. Specify the range as follows:



Point to the Search menu and drag down to Go to Range...

This displays the Search for data range dialog box. The Go to Range function is controlled from this dialog box as follows:



**from lower limit** - This text box allows you to enter a value representing the lower end of the

range. If this text box is left blank, the low end of the range is unbounded. This limit is retained until a search is done on a different channel or a new file is opened. When limits are assigned, the << Inside Range, << Outside Range, Inside Range >>, or Outside Range >> command buttons can be used to move the cursor to the next or previous data point inside or outside of the specified range.

**to upper limit** - This text box allows you to enter a value representing the higher end of the range. If this text box is left blank, the high end of the range is unbounded. This limit is retained until a search is done on a different channel or a new file is opened. When limits are assigned, the << Inside Range, << Outside Range, Inside Range >>, or Outside Range >> command buttons can be used to move the cursor to the next or previous data point inside or outside of the specified range.

**<< Inside Range** - This command button moves the cursor to the *previous* data point *inside* the specified range of values on the selected channel. The limiting values are considered inside and are thus included in the range.

**Inside Range >>** - This command button moves the cursor to the *next* data point *inside* the specified range of values on the selected channel. The limiting values are considered inside and are thus included in the range.

**<< Outside Range** - This command button moves the cursor to the *previous* data point *outside* the specified range of values on the selected channel. The limiting values are not included.

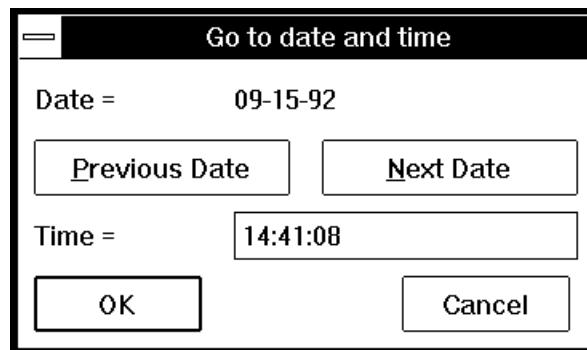
**Outside Range >>** - This command button moves the cursor to the *next* data point *outside* the specified range of values on the selected channel. The limiting values are not included.

**Go to Time...** - This function instantly moves the data cursor to the position in the file that corresponds to the specified date and time. The date and time can be specified as follows:



Point to the Search menu and drag down to Go to Time....

This displays the Go to date and time dialog box. The Go to Time function is controlled from this dialog box as follows:



**Previous Date** - Selects the previous date, which is then displayed in the middle of the dialog box, above this command button.

**Next Date** - Selects the next date, which is then displayed in the middle of the dialog box, above this command.

**Time =** - Allows you to enter a time value. The time must be entered in 24-hour format from 0:00 to 23:59:59. If omitted, the seconds value defaults to :00.

**OK** - Moves the data cursor to the position in the file that corresponds to the specified date and time. If it is not possible to move to the specified time because it falls before the first data point or after the last data point in the file, an appropriate error message is displayed and the cursor is placed at the next point after the beginning of the file, or at the end of the file.

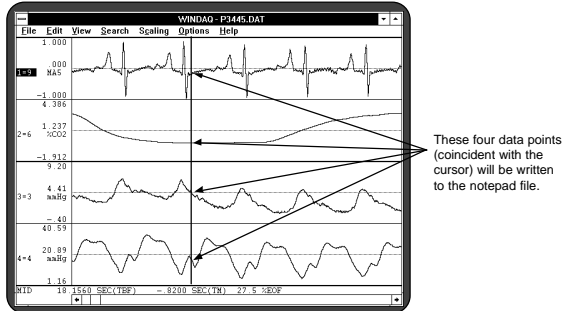
**Cancel** - This command button removes the dialog box without moving the data cursor anywhere.

Using the Go to Range... function on a compressed waveform (compression value greater than 1) will often result in the displayed data disagreeing with the search range. This is because the Go to Range... function looks at individual data values, and a compressed waveform is many individual data values compressed to form one line segment. The obvious solution is to make sure the waveform is uncompressed when using this function. If compression must be used, refer to the Help documentation for details on using this function with compression enabled.

Allows individual data points to be written to a notepad data file on disk, with or without text

annotation.

The data sent to the target file are those data points from each channel coincident with the position of the data cursor at the time the NOTEPAD function is invoked.



The NOTEPAD function may be invoked at any time during data review. The first time during the review session that NOTEPAD is invoked, the Open Notepad File dialog box will appear prompting you to name the file to which screen data will be written. Any valid file name (including path names) may be entered. Thereafter, invoking NOTEPAD sends the selected data directly to that file.

With the cursor positioned at the desired point on the waveform, data can be written to a notepad file as follows:

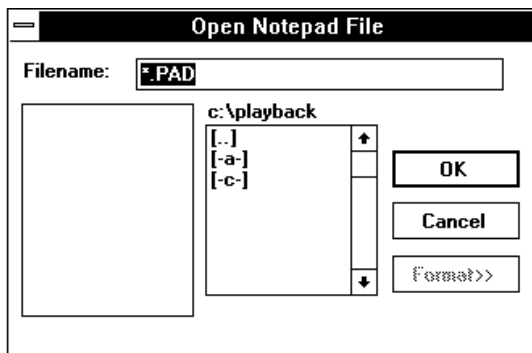
**Note only (plain data, no annotated text)**

1. Select File Note as follows:



Point to the File menu and drag down to Note.

When selected for the first time, the Open Notepad File dialog box is displayed on the screen:



2. In the Filename text box, enter the name of the file (including desired path names) to which WINDAQ Waveform Browser is to write the notepad data.

3. Click OK.

The procedure for writing data *and* text information to a notepad file is similar. The text is entered in the Notepad Annotation dialog box, which is displayed when the Commented Note command is chosen from the File menu. The number of text characters that may be stored for each annotated note conforms to the following equation:  $(11 \times \# \text{ of channels enabled}) + 22$ . With the cursor positioned at the desired point on the waveform, data and comments can be written to a notepad file as follows:

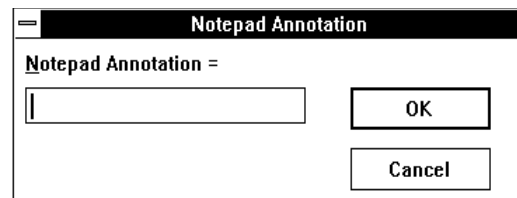
**Commented Note (data with comments)**

1. Select File Commented Note as follows:



Point to the File menu and drag down to Commented Note.

When selected, the Notepad Annotation dialog box is displayed on the screen as follows:



2. In the Notepad Annotation text box, enter the desired comment.
3. Click OK.

Data is written to the target file in a columnar format. A maximum of six columns may be written depending upon the number of waveforms in the data file. When the playback program is exited and a notepad file is typed to the screen or printed, the columns seen are defined as follows:

Column 1 (left-most)	Time-to-beginning-of-file
Column 2	Time marker
Column 3	Channel zero data
Column 4	Channel one data
Column 5	Channel two data
Column 6	Channel three data

Data for all waveform channels, time-to-beginning-of-file, and time marker data are all written to the notepad file whenever the NOTEPAD function is invoked.

All data is written in scientific notation format. The only exception to this rule is time marker data. If a

time marker was enabled at the time the NOTEPAD function was invoked, time marker data will be annotated in scientific notation. If the time marker WAS NOT enabled, column two will contain nine zeros 000000000 indicating that the time marker was not enabled.

If the channel has been calibrated, the data written to the notepad file will be in engineering units. Channels that have not been calibrated will be written as raw analog voltages.

When NOTEPAD is activated with a compressed waveform display, waveform values reported to the notepad file will be the minimum, maximum, or mid point value of the waveform's line segment that is coincident with the cursor depending on the state of the cursor mode. Refer to the WAVEFORM COMPRESSION section for complete details.

All NOTEPAD files are directly compatible with spreadsheet, ASYST, and ASYSTANT software. In the case of the latter two, the notepad file will have to be converted from ASCII into the ASYST/ASYSTANT format before being read. ASYST and ASYSTANT provide the file conversion utilities.

**WINDAQ Waveform Browser**  
**Print**

Allows any playback display currently active on the monitor to be printed (hard copied) on a compatible graphics printer.

This function offers a “print screen” feature, a “print rectangle only” feature, and a continuous hard copy feature. The print screen feature prints whatever is currently displayed on your monitor in your choice of two formats and two size options. The print rectangle only feature prints only the graphics enclosed by the graphic selection rectangle. The continuous hard copy feature provides a continuous hard copy record of all data between the time marker and cursor. When executed, the continuous hard copy is printed immediately from within playback.

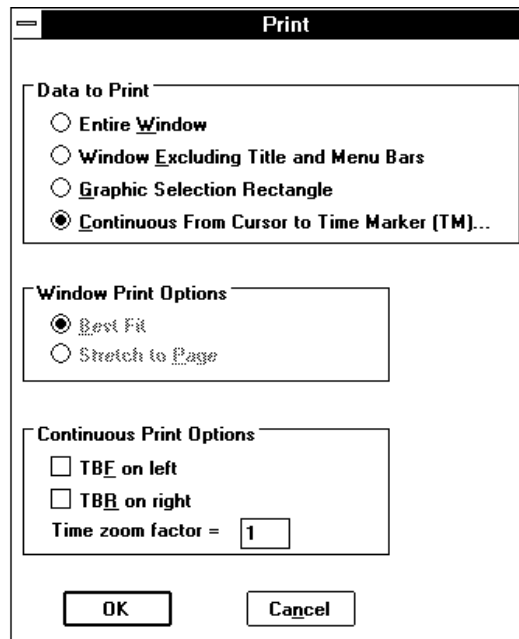
**Print Screen Feature**

To generate a print screen:



Point to the File menu and drag down to Print....

This displays the Print dialog box:



**Entire Window** - Prints everything as displayed on the screen, could be considered a “screen shot”.

**Window Excluding Title and Menu Bars** - Prints only the most pertinent information about the waveform file(s) displayed on the screen (Does not print the title or menu bar at the top of the display)..

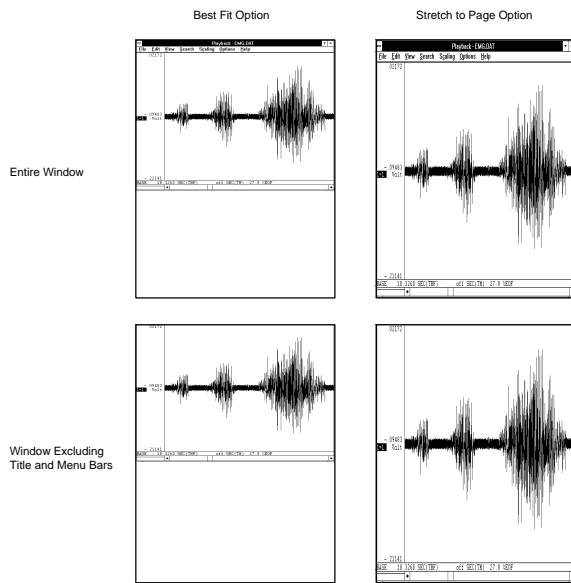
Note that when either of these formats are selected, the Continuous Print Options are dimmed, thus not selectable. However, the Window Print Options are selectable. These options control the size of the print screen. The two size options are as follows:

**Best Fit** - Maintains the aspect ratio of the display on the screen. The size of the printout fills the page as much as possible without destroying the aspect ratio.

**Stretch to Page** - Fills the entire page with the printout. With the paper portrait oriented, the printed image is stretched in the vertical direction to fill the entire page, thus not maintaining the aspect ratio of the display on the screen.

The following illustrates a typical waveform printed on an 8½ x 11 inch sheet of paper in each format and size option.





### Graphic Selection Rectangle Feature

To generate a hard copy of only the waveform(s) bounded by the graphic selection rectangle, you must first draw the graphic selection rectangle to enable the normally dimmed Graphic Selection Rectangle radio button. This is done by clicking and holding the **RIGHT** mouse button anywhere in the waveform graphics to enclose the area of interest. Once the rectangle is drawn, the Graphic Selection Rectangle radio button can be selected.

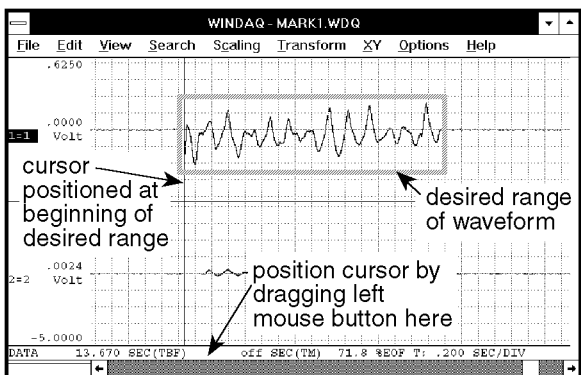
### Continuous Hard Copy Feature

To generate an immediate, continuous hard copy, you must first select a range of waveform data to be hard copied.

This range is defined as all data lying between the time marker and cursor.

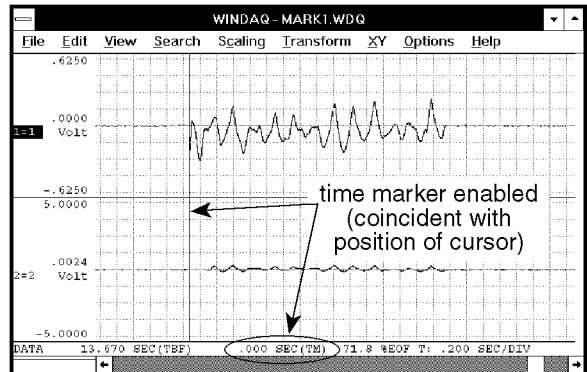
To select the copy range:

1. Position the cursor at one end of the desired range (drag the left mouse button in the bottom annotation margin to position the cursor).

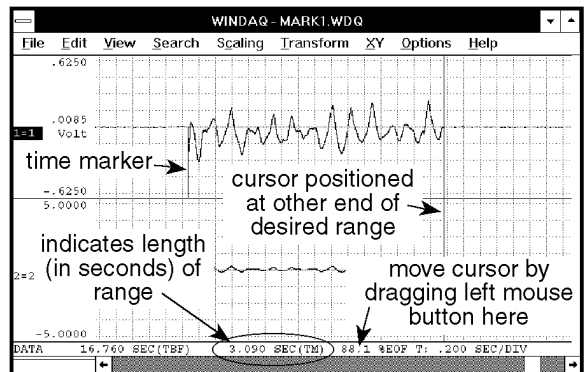


2. Enable the time marker (by pressing the F4 key);

by pointing to the Options menu and dragging down to Enable Time Marker; or by choosing Options Enable Time Marker with ALT, O, M keystrokes)



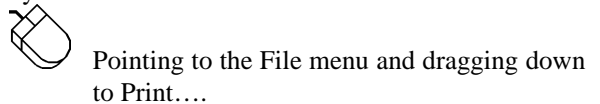
3. Move the cursor (in either direction) to the other end of the desired range (by dragging the left mouse button in the bottom annotation margin).



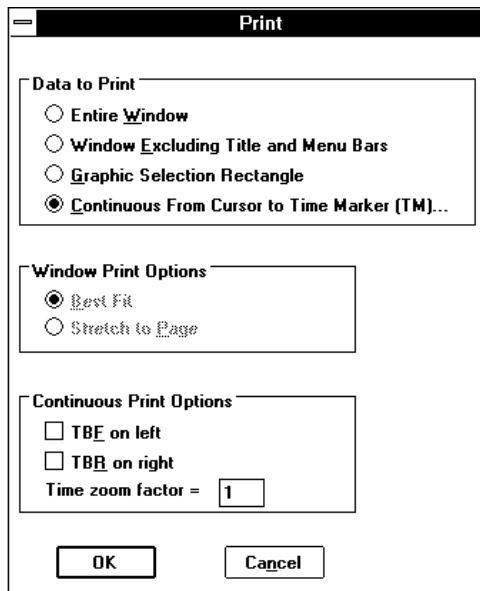
Although the range is specified only on display window one, when hard copied, data for all channels lying within the range is hard copied.

Note that each waveform channel should be scaled, offset, calibrated, and compressed on the screen display exactly the way you would like it to appear when hard copied. Also note that grid lines will be printed if enabled for display.

When the hard copy ranges are selected as described above, the continuous hard copy feature is invoked by:

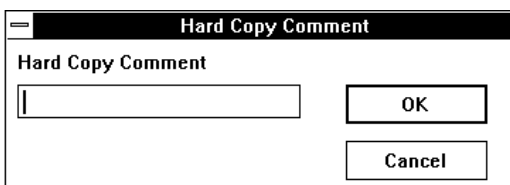


This displays the Print dialog box. Select the Continuous From Cursor to Time Marker (TM)... option button in order to generate a continuous hard copy.



Note that when the Continuous From Cursor to Time Marker (TM)... format is selected, the Window Print Options are dimmed, thus not selectable. However, the Continuous Print Options are selectable. These check boxes allow the user to enable or disable the annotations in the left and right margins of the hard copy and to set a time zoom factor. A time zoom factor can be entered to enhance readability when printing on a high resolution printer (300 dpi or higher). For example at a time zoom factor of 1 printed at 300 dpi, there will be 300 samples per vertical inch of waveform. This may not reveal enough important detail in the waveform. Increasing the time zoom factor allows you to vertically spread out the samples (the horizontal dimension remains unchanged) for better visibility. A time zoom factor of 2 would produce 150 samples per vertical inch and thus more detail in the hard copy. Set these options as desired and activate the OK command button.

When the OK command button is activated, the screen will be cleared and the following dialog box will be displayed:



You have the option of entering up to one full line (70 characters) of text (comments) that will be passed to the hard copy record. After your comments are entered, or if you choose not to comment, activate the OK command button. At this point,

waveform hard copy will begin at your printer.

**Interpreting the Hard Copy Record** — The following describes the information provided by the record:

**File Information** - Original CODAS-formatted data file name, and the date and time the file was acquired. Your comments (if any) are shown as entered when the hard copy was enabled.

**Waveform Information** - Describes the  $\pm$ full scale and base line values in whatever engineering unit was selected for each waveform. If engineering units were not enabled, the units displayed will be volts. Any waveform scales, offsets, or calibrations applied while using Playback will be similarly duplicated in the hard copy record. When interpreting the hard copy record, the + full scale limit is the top-most horizontal grid line (be sure to orient hard copy record with reference arrow pointing up), the - full scale limit is at the bottom-most horizontal grid line, and mid scale limit is the horizontal grid line in the middle.

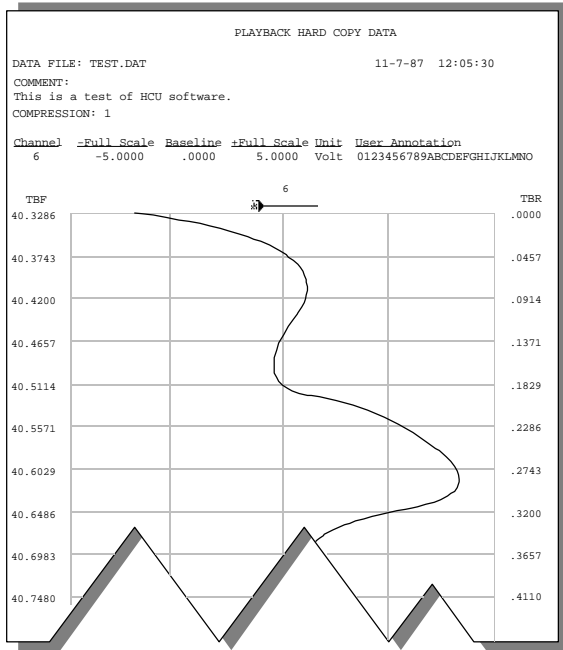
Also annotated is the Waveform Compression Factor selected at the time the hard copy was enabled. This factor is provided for reference only since all time functions are automatically adjusted as a function of the compression factor.

**Time Annotation** - The hard copy produces two types of time annotation: Time referenced to the beginning of the hard copy record (TBR); and time referenced to the beginning of the parent data acquisition file (TBF). The hard copy record yields a time division marker approximately every 1cm. Each such marker is annotated on the right and left chart-edge with TBR, and TBF in seconds respectively. The need for TBR is obvious. This annotation allows any waveform event to be placed in time relative to the beginning of the hard copy record. The need for TBF is more subtle, but just as important.

Playback provides a TBF (Time-To-Beginning-Of-File) function which allows the current position of a waveform cursor to be known relative to the time in seconds from the beginning of the file being reviewed. TBF annotation provided by the hard copy directly correlates with Playback software's TBF function. This means that a waveform event occurring on the hard copy record can be similarly located on the computer-based record by scrolling the waveforms forward or backward until TBF equals that observed in the hard copy record.

Correlation of a hard copy record with its computer-based parent is a valuable feature, especially when coupled with Waveform Compression. Large portions, or even an entire data file may be

compressed, hard copied, then used as a tool for determining where detailed analysis should begin and end. In this manner, the feature allows you to get a handle on large quantities of data in a purely logical and organized fashion.



**FIGURE 1** — A sample of the hard copy output shows the file, waveform, and time information provided. See text for a complete description of each function.

**WINDAQ Waveform Browser**

**Refresh**

Updates the scroll bar position and %EOF field to reflect the new length of a file being acquired.



Point to the View menu and drag down to Refresh.

**WINDAQ Waveform Browser**

**Save**

Saves a copy of the file you are working with on disk. All header information is saved in the current data file, resulting in the same display when the file is reviewed again. Note that this function does not cause you to exit the file or prompt you for format or save options, it merely saves the current state of your data file.



Point to the File menu and drag down to Save.

Use the Save function when you want to update a file on disk with the most-recent changes. If you want to save a copy of a file without affecting the version of the file already on disk, use the Save As function.

**WINDAQ Waveform Browser**

**Select Live Display**

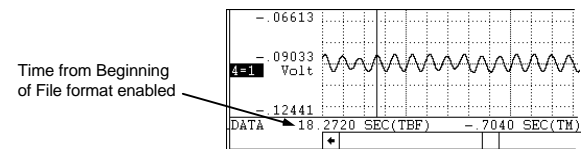
Allows you to select between four different data formats for display in the live display field. These formats report waveform information for the currently selected channel as: time from beginning of file, difference from time marker point, % change from time marker point, and slope of line to time marker point.

**Time From Beginning of File** - Annotates the quantity of time from the beginning of the data file to the point of waveform/cursor intersection in seconds. To display time from beginning of file in the live display field:



1. Point to the Options menu and drag down to Select Live Display.
2. Click on Time from Beginning of File.

When the Time from Beginning of File format is selected, the live display field will show XXXXXXXX SEC(TBF), where XXXXXXXX is the time-to-beginning-of-file from the point of waveform/cursor intersection in seconds.



**Difference From Time Marker Point** - This format annotates the difference in waveform values between

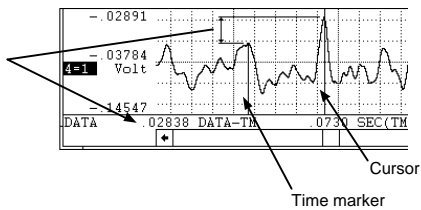
the time marker position and the current cursor position. To display the difference from TM point in the live display field:



1. Point to the Options menu and drag down to Select Live Display.
2. Click on Difference from TM pt.

When the difference from time marker point format is selected, the live display field will show XXXXXXXXX DATA-TM, where XXXXXXXXX is the difference in waveform values between time marker position and cursor position.

Live display field shows the difference in waveform values at the point of time marker and cursor.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker and compression is 1, the live display field shows zero (no difference).

It is possible to see a negative difference value in the live display field. This occurs when the cursor is moved to a point on the waveform that is smaller than the value of the waveform at the time marker.

If waveform compression is enabled, the data values reported by the time marker and cursor will be MID, MIN, or MAX line segment values rather than a single data point value that would be displayed on an uncompressed waveform.

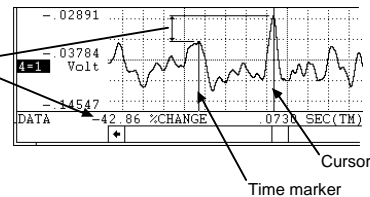
**Percent Change from Time Marker Point** - This format annotates the percent change in waveform values between the time marker position and the current cursor position. To display the percent change from TM point in the live display field:



1. Point to the Options menu and drag down to Select Live Display.
2. Click on % Change from TM pt.

When selected, the live display field will show XXX.XX %CHANGE, where XXX.XX is the percent change in waveform values between time marker position and cursor position.

Live display field shows the percent change in waveform values at the point of time marker and cursor.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker and compression is 1, the live display field shows zero (no change).

It is possible to see a negative percent change value in the live display field for this format. This occurs when the cursor is moved to a point on the waveform that is larger than the value of the waveform at the time marker.

If waveform compression is enabled, the data values reported by the time marker and cursor will be MID, MIN, or MAX line segment values rather than a single data point value that would be displayed on an uncompressed waveform.

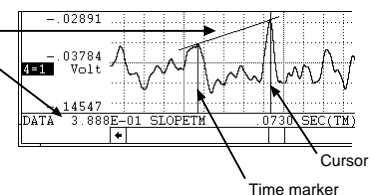
**Slope of Line to Time Marker Point** - This format annotates the slope of an imaginary line formed by connecting the waveform value at the time marker position with the waveform value at the cursor position. To display the slope of the line to TM point in the live display field:



1. Point to the Options menu and drag down to Select Live Display.
2. Click on Slope of line to TM pt.

When the slope of line to time marker point format is selected, the live display field will show XXXXXXXXX SLOPETH, where XXXXXXXXX is the slope of an imaginary straight line between time marker position and cursor position (expressed in scientific notation).

Live display field shows the slope of an imaginary line drawn through the points of time marker and cursor intersection.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker and compression is 1, the live display field

indicates on because the function is undefined.

If waveform compression is enabled, the data values reported by the time marker and cursor will be MID, MIN, or MAX line segment values rather than a single data point value that would be displayed on an uncompressed waveform.

Each of these display formats report waveform information for the currently selected channel. If no channel is selected, the live display field shows Time from Beginning of File.

**WINDAQ Waveform Browser**

**Select Marker Display**

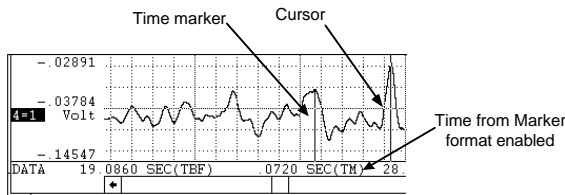
Allows you to select between four different time formats for display in the marker display field. These formats report the data lying between the time marker and cursor as: time from marker, samples from marker, Hz for cycle to marker, and cycles/minute for cycle to marker.

**Time From Marker** - Annotates the time difference from the cursor to the time marker in seconds. To display time from marker in the marker display field:



1. Point to the Options menu and drag down to Select Marker Display.
2. Click on Time from Marker.

When selected, the marker display field will show XXXX SEC(TM), where XXXX is the time difference from the cursor to the time marker in seconds.



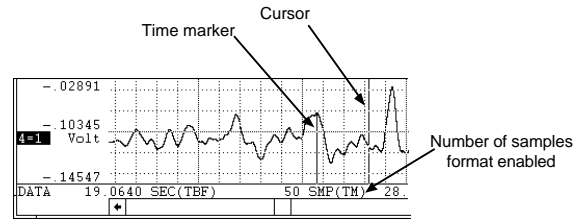
**Samples from Marker** - Annotates the number of samples (or individual data points) in the section of waveform bounded by the cursor and time marker. To display the number of data samples in the marker display field:



1. Point to the Options menu and drag down to Select Marker Display.
2. Click on Samples from Marker.

When selected, the marker display field will show XXXXX SMP(TM), where XXXXX is the number of

samples in the section of waveform bounded by the cursor and time marker.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker, the live display field shows zero (no samples).

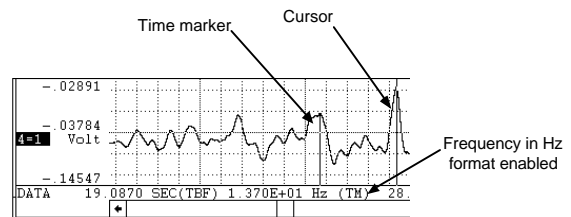
It is possible to see a negative samples value in the marker display field for this format. This occurs when the cursor is moved to a point on the waveform left of the time marker.

**Hz for Cycle to Marker** - Displays a frequency (in Hz) for the section of waveform (or cycle) defined by the cursor and time marker. To display the frequency (in Hz) of the selected cycle in the marker display field:



1. Point to the Options menu and drag down to Select Marker Display.
2. Click on Hz for Cycle to Marker.

When selected, the marker display field will show XXXXXXXX Hz(TM), where XXXXXXXX is the frequency (in scientific notation) of the cycle defined by the positions of the time marker and cursor.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker, the marker display field displays on because a cycle has not been defined.

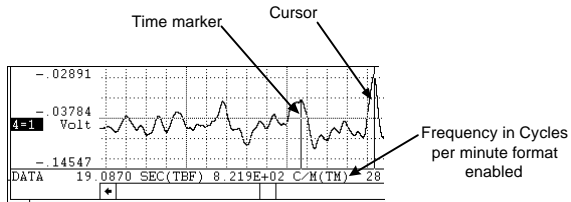
**Cycles per minute for Cycle to Marker** - Displays a frequency (in cycles per minute) for the section of waveform (or cycle) defined by the cursor and time

marker. To display the frequency (in cycles/minute) of the selected cycle in the marker display field:



1. Point to the Options menu and drag down to Select Marker Display.
2. Click on Cycles/min for Cycle to Marker.

When selected, the marker display field will show XXXXXXXXX C/M(TM), where XXXXXXXXX is the frequency (in scientific notation) of the cycle defined by the positions of the time marker and cursor.



Note that the time marker must be enabled for display with this format.

If the cursor is positioned directly on top of the time marker, the marker display field displays on because a cycle has not been defined.

The time marker formats will be displayed in the marker display field only if time markers are enabled for display. If time markers are disabled, off is displayed in the marker display field rather than a numerical value.

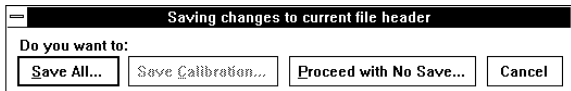
### WINDAQ Waveform Browser **Open**

Allows you to open and review multiple files from within the playback program.



Point to the File menu and drag down to Open....

This displays the following dialog box.



You are required to select one of these options for the currently active data file before you can switch to a different file.

**Save All... command button** - Saves the entire state of playback data (including display format, scales,

offsets, compressions, calibration constants, etc.) before returning you to the Program Manager.

**Save Calibration... command button** - Saves the calibration data only. The next time the data file is reviewed, all waveforms will appear calibrated without needing to repeat the calibration process.

**Proceed with No Save... command button** - Proceeds to the Program Manager window without saving calibration or state.

**Cancel command button** - Returns you to the playback display without saving anything.

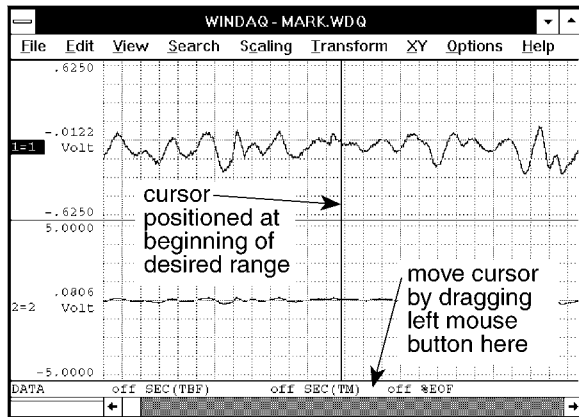
Following your selection of an option for the currently active data file, the Open dialog box will appear prompting you for the new file name. Supply the name of the data file you wish to review (including path, if necessary).

**WINDAQ Waveform Browser**  
**Enable Time Marker**


The time marker is used to define one end of a range of waveform information (the data cursor is used as the other end). When a range of waveform is defined, the data lying between the time marker and cursor can be reported in one of four selectable, time-related formats.

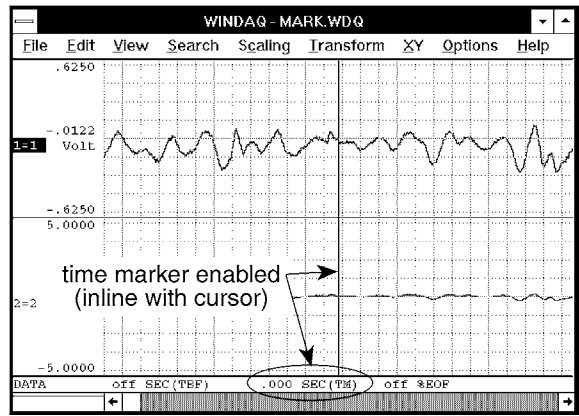
To set a time marker:

1. Position the cursor (by using the mouse in the bottom annotation line, or by using the left- and right-arrow keys) at a point on the waveform in window 1 where the time marker is to be placed.



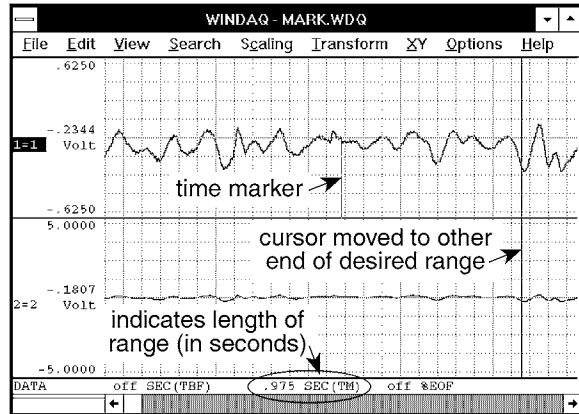
2. Enable the time marker by:

 Pointing to the Options menu and dragging down to Enable Time Marker. Note that you can also enable a time marker by pressing the F4 key or with ALT, O, M keystrokes.



When enabled, a check mark (✓) is displayed on the Options menu immediately preceding the Enable Time Marker display field. The check mark indicates that the time marker function is enabled, even though it might not be immediately obvious on the screen for various reasons. When the time marker function is disabled, the check mark is removed and the display field shows off.

3. Move the cursor away from the time marker, (in either direction) to the other end of the desired range (again, by using the mouse or the arrow keys).



As the cursor is moved, the time difference between the cursor and time marker will be displayed in the bottom annotation margin in one of four selectable formats (refer to the SELECT MARKER DISPLAY function for more details on time marker display formats). Time differences are annotated as both positive and negative numbers. When the cursor is to the right of the time marker, the time difference will be displayed as a positive value. When the cursor is to the left of the time marker, the time difference will be displayed as a negative value.

A time marker can be set with or without the cursor enabled, however it is much easier to see what is

transpiring with the data cursor on.

Since cursors for all channels align perfectly in time, the time difference for events on channels other than that in window one may be measured even though the time marker itself is displayed only on window one's waveform. You can display any waveform channel in window one, allowing time measurements to be made on any channel.

When a time marker is placed directly over an event marker, the time marker has priority and the event marker disappears.

Selecting Options Enable Time Marker a second time turns the time marker function off.

### WINDAQ Waveform Browser

## Start Time, End Time, Cursor Time, and Time per Division

Four individual functions that when enabled provide a time reference for the waveform as follows:

1. Start Time - Displays the date and time the file was opened for acquisition.
2. End Time - Displays the date and time the file was closed for acquisition.
3. Cursor Time - Displays the date and time at the current cursor position.
4. Time/Division - Displays the time per screen grid division.

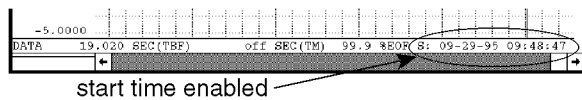
Each of these three functions share the same display field (the lower right corner of the bottom annotation line), therefore only one of these functions can be displayed at a time.

### To Display Start Time:



Point to the Options menu and drag down to Start Time.

This displays the date and time the file was opened for acquisition in the S display field at the lower right corner of the bottom annotation line.

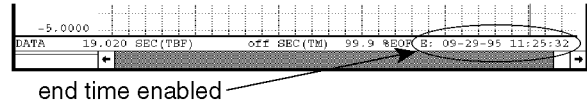


### To Display End Time:



Point to the Options menu and drag down to End Time.

This displays the date and time the file was closed for acquisition in the E display field at the lower right corner of the bottom annotation line.



### To Display Cursor Time:



Point to the Options menu and drag down to Cursor Time.

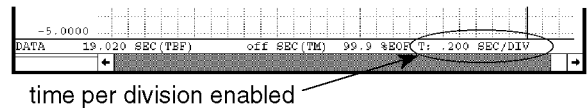
This displays the date and time at the current cursor position in the C display field at the lower right corner of the bottom annotation line. This option lets you position the cursor anywhere in the data file and find out exactly when a certain event occurred.

### To Display Time/Division:



Point to the Options menu and drag down to Time/Division.

This displays the time per screen grid division in the T display field at the lower right corner of the bottom annotation line.



### WINDAQ Waveform Browser

## Data Display, Limit & Frequency Display, Acquisition Assignments, User Annotation, and User Annotation...

Allows you to configure waveform display annotation many different ways. Annotation options data display, limit & frequency display, acquisition assignments, and user annotation can be enabled or disabled, in any combination, to customize the waveform display.

**Data Display** - Enables/disables the display of data values or baseline values in the left/right annotation margin.

If neither limit & frequency display nor acquisition assignments are enabled, the engineering units toggle on and off along with the baseline value. To

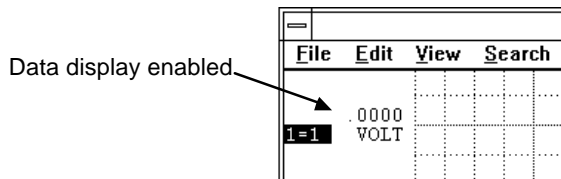


enable Data Display (if disabled, or disable it if enabled):



Point to the Options menu and drag down to Data Display.

When enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the Data Display command:



**Limit & Frequency Display** - Enables/disables the display of upper and lower chart-edge limits in the left/right annotation margin (assuming the display window is large enough to have limits).

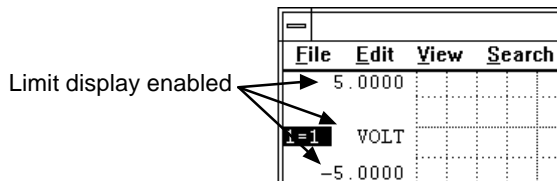
If acquisition assignments were displayed when the limit & frequency display was enabled, engineering units replace them at the baseline.

If data display is disabled when the limit & frequency display is enabled, engineering units toggle on and off along with the limits. To enable Limit & Frequency display (if disabled, or disable it if enabled):



Point to the Options menu and drag down to Limit & Frequency Display.

When enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the Limit & Frequency Display command:



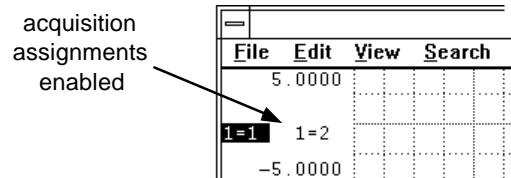
**Acquisition Assignments** - Enables/disables the display of acquisition assignments in the field normally used for engineering units. When enabled, the logical vs. physical channel number assignments replace the engineering units at the baseline, and upper and lower chart-edge values are also displayed. Note that it is impossible to enable both acquisition assignments and the limit & frequency display option at the same time. If the data display

option is enabled, the logical vs. physical channel number assignments revert to engineering units instead of toggling off when acquisition assignments are disabled. To enable Acquisition Assignments (if disabled, or disable them if enabled):



Point to the Options menu and drag down to Acquisition Assignments.

When enabled, the annotation margin will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the acquisition assignments command:

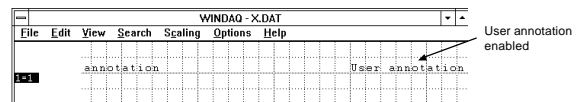


**User Annotation** - Enables/disables the display of user channel annotation provided during acquisition. To enable User Annotation (if disabled, or disable it if enabled):



Point to the Options menu and drag down to User Annotation.

When enabled, the waveform strip will have the following appearance and a check mark (✓) will be displayed on the Options menu immediately preceding the User Annotation command:



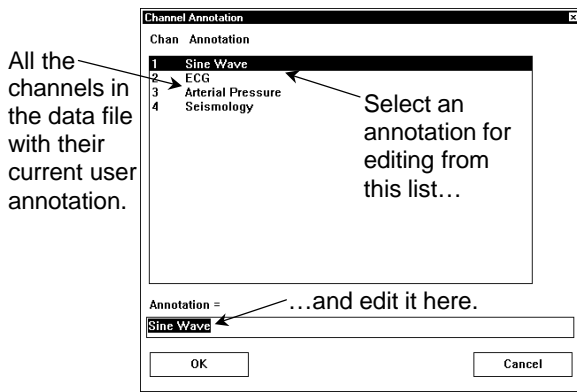
**User Annotation...** - Allows you to edit or change the channel annotation that was provided during waveform recording. It is not necessary to enable the display of channel annotation in order to use this function, but you will not see the results of your editing session unless user channel annotation is enabled for display (by pressing ALT+U).

To edit user channel annotation:



Point to the Edit menu and drag down to User Annotation...

This displays the Channel Annotation dialog box as follows:



The top portion of the Channel Annotation dialog box displays all the channels in the data file along with their current user annotation. To edit a channel's annotation, highlight (click) on the annotation in the list at the top of the window and perform the editing in the Annotation = box at the bottom of the window.

Activating the OK button accepts all of the editing you have done and closes this box.

Activating the Cancel button closes this box and ignores any editing changes made.

Note that the display annotation options can be enabled in virtually any combination to provide the desired result. However in some instances, one annotation option will override another. For example, it is not possible to enable both limit & frequency display and acquisition assignments. When limit & frequency display is enabled, it will be automatically disabled when you attempt to enable acquisition assignments, and vice versa.

A logical channel number corresponds to a channel number's appearance in a data file. The first channel acquired is the first in the file, the second is the second, etc. In Playback, logical channels are always specified. However, during acquisition you have the ability to acquire any number of channels, *not necessarily in sequential order*. For example, you may have acquired channels 0, 2, and 3. These channel numbers are called physical channels  $\phi$  relating to the actual physical channel number that provided the waveform. Their logical channel numbers are 1, 2, and 3. When acquisition assignments are active, L=P means logical channel number L is assigned to physical channel number P.

Acquisition assignments annotation provides a convenient method of determining, for any given waveform, which physical channel number provided the signal.

## WINDAQ Waveform Browser Compression

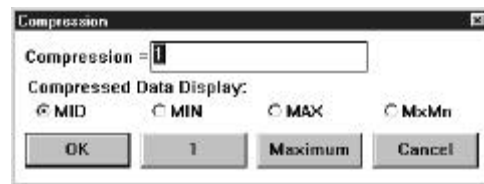
Allows the waveform data file to be compressed: a) entirely onto one screen width or b) to any given ratio.

To enable waveform compression:



1. Point to the Edit menu and drag down to Compression....

When enabled, the waveform compression dialog box is displayed on the screen:



### Compression Onto One Screen Width

To achieve waveform data file compression so that the entire file is compressed onto one screen width:



- Click the Maximum command button.

Conversely, time compression can be disabled (causing the data file to be "uncompressed") just as easily. To disable time compression:



- Click the 1 command button.

When the entire waveform data file is compressed, the following features are also activated:

1. The entire waveform data file fits within one screen width.
2. The cursor will not automatically be displayed, it must be manually enabled.
3. The ← and → cursor control keys are active, allowing the cursor to be moved in a left or right direction across the waveform(s).
4. The cursor position at any given location on the screen will define the center of the screen when the screen is expanded by entering a lower compression factor.
5. The fully compressed file display is saved in memory to allow fast reentry when moving between lower (or uncompressed), and the full

file compressed formats.

When time compression is disabled, the compression ratio displayed in the Compression text box reverts to a value of 1.

### **Compression to Any Given Ratio**

The value displayed in the Compression = text box is the selected waveform compression ratio. This ratio can range from 1 (time compression disabled) to whatever value is required to compress the entire file on the screen. When the compression dialog box is first displayed, a blinking vertical line (called the insertion point) appears behind the compression factor in the Compression = text box. This insertion point indicates the active area of the dialog box—the next action you perform will occur in this area. To increase or decrease the compression ratio, make sure the insertion point is in the Compression = text box, then simply enter the new compression ratio. If you choose a compression value that is too large, an “Invalid Compression” message box will appear. Click OK or press ENTER to clear the message box and try a smaller compression value.

Entering a compression ratio of 1 disables time compression, resulting in an “uncompressed” data file.

The Compression ratio (displayed in the Compression = dialog box) is the number of data points for each enabled channel that are evaluated for a min/max value. For example, if the compression ratio equals twenty, then twenty data points are evaluated to plot a min/max line.

**Cursor Mode Control (Mid/Min/Max/MxMn) for compressed displays** - The waveform compression function operates by accumulating  $n$  number of waveform samples (where  $n$  equals the compression ratio). From these samples, a min/max line is then drawn or displayed, where the end points of the line equal the absolute minimum and maximum values detected for the sample group. When both the cursor and compression are enabled, a dilemma exists regarding the appropriate value to report since multiple waveform segments have been compressed into one. To a degree, the cursor mode control solves this problem by allowing you to specify the value of a compressed line segment at cursor intersection as either its minimum, maximum, mid point, or maximum and minimum quantity.

Compression allows you to choose between MID, MIN, MAX, and both Maximum and Minimum (MxMn) line segment reporting. To select the desired line segment reporting method:



1. Click the desired option button (either MID, MIN, MAX, or MxMn).
2. Click OK.

The currently active cursor mode is automatically reported at the bottom of the screen where the normal DATA annotation is replaced by MIN, MAX, MID, or MxMn. The default state is MID. In the case of MxMn, both maximum and minimum values are displayed, in a blood pressure like format, in the annotation margin. This gives you an idea of the range of the data point values.

### **WINDAQ Waveform Browser**

### **Data Cursor**

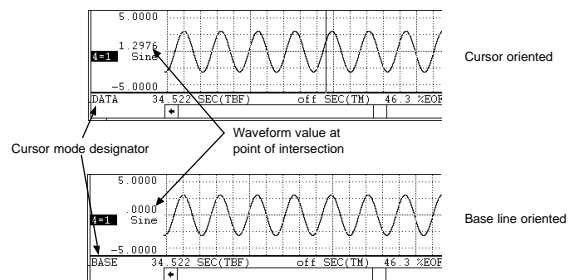
Allows annotation of waveform values at the point of waveform/cursor, or waveform/base line intersection. The values are annotated in the left/right annotation margin next to the VARIABLE WAVEFORM ASSIGNMENT indicator.

The data display waveform annotation option must be enabled before waveform/cursor or waveform/base line values can be toggled. With the data display option enabled:



- Point to the Options menu and drag down to Data Cursor.

In addition to turning the data cursor on and off, this toggles the waveform value display between waveform/cursor intersection point values and waveform/base line intersection point values. As the following illustrations show, when cursor oriented waveform data is enabled, the cursor mode designator at the bottom of the screen indicates DATA and when base line oriented waveform data is enabled, the cursor mode designator indicates BASE.



The annotated waveform value will be either the raw waveform voltage, or the waveform voltage converted into engineering units if calibrated.

## Event Markers...

Allows you to: automatically locate event markers that were enabled during data acquisition; display the date and time at the current cursor position; quickly vector to any part of the data file; and enable or disable the display of event markers.



Point to the View menu and drag down to Event Markers....

This displays the Event Markers window as follows:

Event #	TBF	%EOF	DATE	TIME	COMMENT
1*	0.000	0.0	03-12-92	14:48:36	
2	2.850	3.3	03-12-92	14:48:38	
3	3.800	4.4	03-12-92	14:48:39	
4	4.670	5.4	03-12-92	14:48:40	
5	5.690	6.6	03-12-92	14:48:41	
6	6.630	7.7	03-12-92	14:48:42	Intervention 1
7	13.590	15.9	03-12-92	14:48:49	
8	14.330	16.7	03-12-92	14:48:50	
9	15.210	17.7	03-12-92	14:48:51	
10	16.230	18.9	03-12-92	14:48:52	
11	17.880	20.9	03-12-92	14:48:53	Intervention 2
12	27.120	31.6	03-12-92	14:49:03	
13	28.060	32.7	03-12-92	14:49:04	

While the Event Markers window is displayed, you may scroll through the list of all enabled event markers as follows:



Click the up- or down-scroll arrow on the right side of the window to scroll one line at a time.

Click in the scroll bar above or below the slider box to scroll 12 lines at a time.

Drag the slider box to go to a specific part of the list.

When a specific event number is highlighted, activating the OK command button (or double-clicking on the highlight bar) repaints the playback screen with the segment of waveform that contains the specified event number. If the data cursor is enabled for display, the cursor will appear positioned directly over the specified event number. If no event markers were enabled during data acquisition, the file will contain 256 equally spaced *transparent* event markers. These markers will not appear on the screen, but they will allow you to quickly vector to any part of the data file.

Activating the Cancel command button will abort the SEARCH-FOR-EVENT function without vectoring the display to the indicated event number.

Activating the To Clipboard command button copies all event marker columnar information to the clipboard in text format. Since the data is copied to the clipboard in text format (as opposed to bitmapped format), it can be pasted into a word processing document or a spread sheet and edited. The information can be viewed with the Clipboard Viewer feature of Windows™ (to maintain the vertical alignment of the data, select the OEM Text display option from the Clipboard Viewer).

The current position of the cursor relative to date and time is displayed at the top of the screen as Cursor date and time = date time

The EVENT # column indicates a unique number applied to the event marker at the time it was enabled during data acquisition. Event marker numbers are always assigned sequentially (i.e., starting with 1 and incrementing until the last event marker enabled is reached, or until the maximum number of event markers is achieved. Event marker numbers followed by a star (\*) indicate those automatically created by data acquisition at the start of a storage-to-disk cycle.

The TBF column indicates the event marker's position in time relative to the beginning of the data acquisition file. All values are annotated in seconds.

The TM column displays the event marker's position in seconds relative to the time marker if the time marker is enabled.

The %EOF column indicates the position of the event marker relative to the end of the data file as a percentage.

The DATE column displays the date on which the event marker was enabled.

The TIME column indicates the time at which the event marker was enabled to the nearest second.

The COMMENT column displays the comment that was provided (if any) at the time the event marker was enabled during data acquisition. Assuming a full 39-character comment was provided for the event marker when it was enabled, the comment will appear truncated if the time marker function is enabled. Characters consumed by the time marker column are freed for comment display when the time marker is disabled.

When you scroll the event list to an event number greater than the total enabled during acquisition, all

columns (except EVENT #) will display \*\*.

The TM column is active only if the time marker was enabled before Event Markers... was chosen from the View menu. If the time marker was not enabled, \*\* will be displayed in the TM column.

If no event markers were enabled during data acquisition, playback will pad the data file with 256 equally spaced event markers, allowing you to quickly vector to any area of the data file.

**WINDAQ Waveform Browser**

**Split, Exit/Enter Split, More Bottom Y, Less Bottom Y, Left Limit, Right Limit, Toggle Pane**

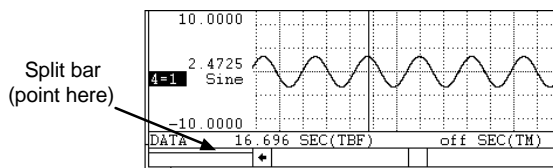
Seven individual functions provide a way for you to manipulate the split screens (or top and bottom panes), which are present when the Fourier Transform Operations or X-Y Plotting functions have been used. Operations such as Split, Exit/Enter Split, More Bottom Y, Less Bottom Y, Left Limit, Right Limit, and Toggle Pane allow you to adjust, maneuver, or otherwise control the split screen display. Each function is described as follows:

**SPLIT Function** - This command allows you to adjust the size of the split between the top and bottom screen sections or panes.



Point to the View menu and drag down to Split. This causes a horizontal bar to appear onscreen. Use the mouse to move the bar to the desired position and click to anchor the split at the new location.

The split can also be adjusted by pointing to the split bar with the mouse as follows:



When positioned anywhere inside the split bar, the mouse pointer takes on a different shape, indicating that you can now drag with the left mouse button to adjust the split, which divides the window into horizontal panes. When the left mouse button is released, the split will appear where positioned.

The split function can be canceled by pressing the

ESC key.

**EXIT/ENTER SPLIT Function** - This command allows you to toggle between the regular and split screen displays. This feature can be used after a Fourier Transform operation to examine a magnified display of the inverse transform in waveform strip 2. When the split screen view is exited, the spectrum data displayed there is retained, allowing quick access for subsequent looks at the split screen display. To exit from or return to the split screen display, proceed as follows:



Point to the View menu and drag down to Exit/Enter Split.

**MORE BOTTOM Y Function** - This command increases the height of the bottom pane (allows you to see more of the Y-axis) by 1/16th of the total plot height. To increase the height of the bottom pane by a fixed amount, proceed as follows:



Point to the View menu and drag down to More Bottom Y.

**LESS BOTTOM Y Function** - This command decreases the height of the bottom pane (allows you to see less of the Y-axis) by 1/16th of the total plot height. If the bottom pane is completely closed with this command, the spectrum data retained in memory (including the inverse transform) will be lost. To decrease the height of the bottom pane by a fixed amount, proceed as follows:



Point to the View menu and drag down to Less Bottom Y.

## Fourier Transform Operations

**LEFT LIMIT Function** - This command selects the left limit cursor in the Y-T waveform area (or upper pane), allowing you to reposition it with the ← and → cursor control keys. Repositioning the left limit cursor allows you to adjust the amount of data to be transformed, however the amount of travel is bounded by the left chart edge and the center cursor. Note that when the left limit cursor is selected, it appears as a solid line while the center and right cursors remain dotted. Note also that the left limit cursor may be selected and adjusted more easily by dragging with the left mouse button just below it in the analysis reporting area. To select the left limit cursor for adjustment, proceed as follows:



Point to the View menu and drag down to Left Limit.

**RIGHT LIMIT Function** - This command selects the right limit cursor in the Y-T waveform area (or upper pane), allowing you to reposition it with the ← and → cursor control keys. Repositioning the right limit cursor allows you to adjust the amount of data to be transformed, however the amount of travel is bounded by the right chart edge and the center cursor. Note that when the right limit cursor is selected, it appears as a solid line while the center and left cursors remain dotted. Note also that the right limit cursor may be selected and adjusted more easily by dragging with the left mouse button just below it in the analysis reporting area. To select the right limit cursor for adjustment, proceed as follows:



Point to the View menu and drag down to Right Limit.

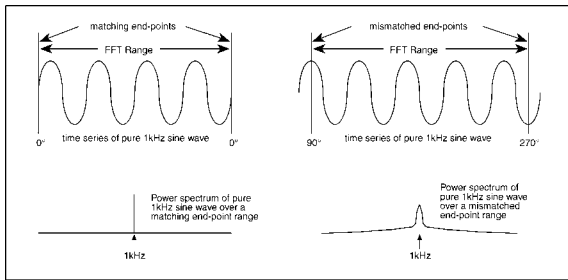
**TOGGLE PANE Function** - This command allows you to toggle between the pane in which the cursor control keys and numeric pad keys operate. When the upper pane is active (cursor control keys manipulate cursors in the upper pane), the analysis reporting area contains TBF and TM data just as in a standard display. When the lower pane is active (cursor control keys manipulate the cross hairs on the power spectrum plot), FRQ and DB or MAG data is displayed, replacing the TBF and TM data. Note that either pane can be selected more easily by clicking with the left mouse button in the desired pane. To make the desired pane active (if not already active), thus allowing the cursor control keys to operate in that pane, proceed as follows:



Point to the View menu and drag down to Toggle Pane.

The Fourier Transform converts information in the time domain into the frequency domain. It is an important analytical tool whenever it is necessary to determine the frequency components of a given time series waveform. The thumbnail theory is that any periodic waveform may be represented by a series of sine wave functions at different amplitudes, frequencies, and phase shifts which when summed together for each time series increment will reproduce the original waveform. Given an appropriate multi-term sine function (Fourier expansion) for a time series waveform, the magnitude of each term of the expansion may be plotted versus its frequency to yield a power spectrum that is representative of the frequency makeup of the time series waveform. WINDAQ Waveform Browser software contains three types of Fourier transforms; the fast Fourier transform (FFT), the discrete Fourier transform (DFT), and the inverse Fourier transform (IFT).

The FFT is the most computationally efficient transform of the three but also the least versatile. The FFT function automatically places some restrictions on the time series to be evaluated. It requires that the range or length of waveform to be evaluated contains a total number of data points precisely equal to a power of 2 (e.g., 256, 512, 1024, etc.). Therefore, with an FFT you can only evaluate a fixed length waveform containing 512 points, or 1024 points, or 2048 points, etc. For example, if your time series contains 1096 data points, you would only be able to evaluate 1024 of them at a time using an FFT since 1024 is the highest  $2^n$  that is less than 1096. Additionally, the FFT also requires that the time series to be evaluated is a commensurate periodic function, or in other words, the time series must contain a whole number of periods within the FFT bounds. Obviously, the chances of a section of waveform containing a number of data points equal to a  $2^n$  number *and* having the last point match the first in magnitude and slope are slim at best. Significant distortion in the resulting power spectrum can result if care is not taken to ensure that end-points match as demonstrated by the following figure:



*End-point mismatches over the FFT range can result in significant power spectrum distortion*

Fortunately a number of solutions exist to minimize the effects of end-point mismatches. One solution is to window the time series waveform so that the distortion is greatly attenuated or reduced to zero depending upon the window type. This approach multiplies the time series waveform by a function resembling a bell-shaped curve before applying the FFT. The section titled **FFT GENERATION** describes how windows may be applied to correct the power spectrum of time series waveforms generated over a number of points equal to a power of 2. Refer to the subheading in this section titled **WINDOW OPTIONS FOR FFTs** for further information on FFT window options.

Another solution abandons windowing in favor of allowing the user to precisely define the range over which the transform is calculated. This approach nullifies the  $2^n$  limitation and is known as the DFT. Refer to the subheading in this section titled **DFT GENERATION** for further information on Fourier transform generation over variable, user-defined ranges.

The IFT allows you to reconstruct the original signal (as a function of time) from the power spectrum (as a function of frequency). This capability makes power spectrum filtering possible. The IFT also comes in handy when determining what a certain power spectrum represents. Suppose you open a file that was saved and exited from the split screen Fourier transform utility. The screen will display the typical split screen Fourier transform mode with a power spectrum that you know very little about at first glance. The quickest way to find out what that power spectrum represents is to do an IFT and compare this result (displayed in window 2 of the Y-T area) with the original waveform in window 1 of the Y-T area. The IFT will show you the portion of the original waveform that was used to generate the power spectrum. Refer to the subheading in this section titled **IFT GENERATION** for further information on editing in the frequency domain.

## **FAST FOURIER TRANSFORM (FFT)**

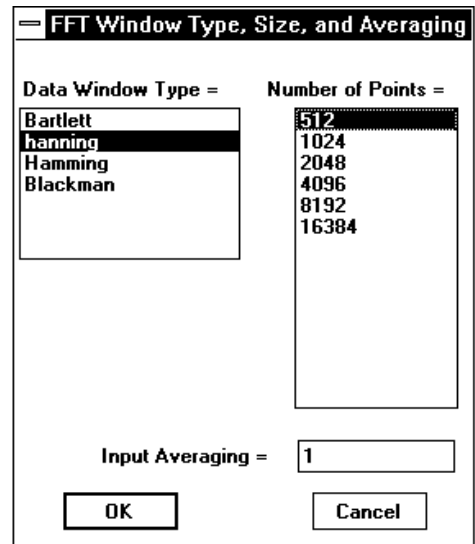
### **FFT GENERATION**

The FFT is ideally suited for homogeneous-type waveforms (waveforms that have the same structure throughout, or have a similar cyclic repetition) but need not be limited to this type. Before an FFT can be generated, the channel you wish to transform must be moved into display window one (e.g., type "1=5" if you wish to transform channel 5). After this is accomplished, scroll the display of the selected channel to center the area you wish to transform on the screen. The FFT can now be generated directly from either the Y-T or the X-Y display modes as follows:



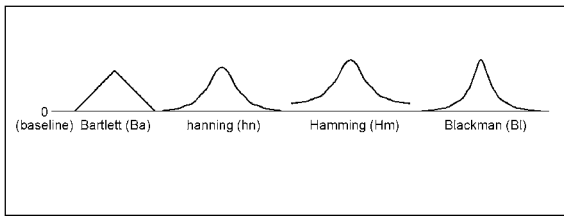
Point to the Transform menu and drag down to Windowed FFT...

This displays the FFT Window Type, Size, and Averaging dialog box as follows:



From this dialog box, you are able to select the type of FFT window that will be applied, the size of the FFT, and the input averaging factor.

The FFT algorithm supports four different types of windows that may be applied to minimize the effects of end-point distortion. These are Bartlett, hanning, Hamming, and Blackman windows. The characteristics of each window are described by the following figure:



Each window has different characteristics that make one window better than another at separating spectral components near each other in frequency, or at isolating one spectral component that is much smaller than another, or whatever the task. The window that you use depends on your skill at manipulating the tradeoffs between the various windows and also on what you want to get out of the power spectrum or its inverse (for complete information on the Fourier transform algorithm, request Dataq Instruments' free Application Note number AN-11, *Waveform Analysis Using the Fourier Transform*).

The FFT algorithm supports a number of different sized FFTs (size refers to the number of data points contained in the FFT). Because the FFT function uses a base 2 logarithm by definition, the range or length of the time series to be evaluated must contain a number of data points equal to a  $2^n$  number. This is why the FFT selections you see in the Number of Points list box are all a power of 2 (256, 512, 1024, etc.). The number of selections you see displayed in this list box will vary for any one data file depending on the factors that affect this power-of-2 limitation. These factors include the size of the data file, the width of the window that WINDAQ Waveform Browser is running in on your monitor, the screen format (whether overlapped or non-overlapped), and whether or not the data file is compressed. The overall size of the data file determines whether or not the larger FFT options (such as 8192 and 16384) are displayed in the list box, while the size of the window that WINDAQ Waveform Browser is running in and the screen format determines whether or not the smaller FFT options (such as 32, 64, or 128 points) are displayed. The minimum sized FFT that can be displayed in the list box is 32, and the maximum is 16384.

When the FFT algorithm is first initiated with an uncompressed waveform, the FFT selection highlighted in the Number of Points list box is the maximum power of 2 that will fit on the screen. For example, if you have a VGA display, 640 pixels of horizontal screen resolution are available for display. In this case the maximum power of 2 that will fit inside 640 pixels is 512, so the 512-point FFT

selection will be highlighted in the Number of Points list box. When the OK command button is activated and the 512-point FFT is performed, the data to be transformed is taken from the center of the screen in window 1. 256 data points in both directions from the center of the screen will be transformed. Similarly with a 1024 point FFT, 512 data points in both directions are included in the FFT calculation, and so on with the other choices.

Note that you are not limited to only a 512-point FFT. You can select a smaller or larger sized FFT from the list. So which size FFT is right for your waveform? That depends on what you want to see in the power spectrum and how much resolution you want. Beside calculation speed (which is negligible), the only difference between a 512-point transform and a 16384-point transform is resolution. A power spectrum always ranges from the dc level (0 Hz) to one-half the sample rate of the waveform being transformed, so the number of points in the transform defines the power spectrum resolution (a 512-point FFT would have 256 points in its power spectrum, a 1024-point FFT would have 512 points in its power spectrum, and so on). Suppose you wanted to see separate 20 and 21 Hz frequency components in the power spectrum of a complex waveform. A 512-point FFT might not show these individual components clearly since its entire power spectrum is only divided into 256 equally spaced points and the desired frequencies are so close together. However, if the transform contained more points, it would be able to devote more points to the definition of closely spaced frequency components. The more the number of points in a transform, the better the frequency resolution.

When you select an FFT from the list that is larger than the number of horizontal pixels your screen is capable of displaying, the waveform will automatically be compressed. This happens semi-transparently and requires no additional user input. The compression becomes obvious when the split screen display is exited (with the View, Exit/Enter Split command) and the normal Y-T waveform display is shown.

If you would like to perform a smaller FFT than what is shown on the list, you will have to reduce the amount of pixels your screen has available for display (the less you see, the less you FFT). This can be done primarily by horizontally shrinking or resizing the window that WINDAQ Waveform Browser is running in, and to a lesser degree by selecting an overlapped screen format. Refer to your Windows™ documentation for details on resizing the window border. For example, with a VGA display and an uncompressed waveform, it is

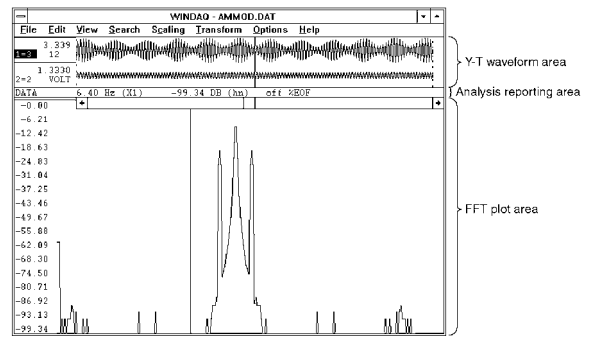


possible to display a 32-point FFT option by reducing the window to its minimum horizontal size and selecting an overlapped screen format.

The FFT algorithm also supports input averaging. Input averaging allows you to perform FFTs on more data points than the value selected in the Number of Points list box. For example, suppose you have a waveform file that contains 82,000 data points and you want to perform an FFT on the entire file. The largest FFT selection available in the Number of Points list box is 16384, which is nowhere close to 82,000. However, input averaging provides a way for you to perform an FFT on the entire 82,000 point file. This is done by *averaging* the total number of data points to be transformed. For every  $N$  points on the original waveform, input averaging develops a single point on the transformed waveform. You have complete control over the number of data points that will be averaged to form each FFT input point. The number you enter in the Input Averaging text box determines the number of data points that will be averaged to form one FFT input point. In our example, an input averaging factor of 5 should be entered since  $82,000 \div 16384$  equals approximately 5. This means that for every 5 data points in the original file, an average value is computed. This value now forms a single point on a waveform that will be used as the input to the FFT algorithm. It should be noted that because you are averaging data points, some distortion will occur in the power spectrum. Averaging the input waveform values will not give you a true representation of the original signal in the power spectrum but instead will give you a very close approximation.

There are also some limits on the number you can enter in the Input Averaging text box. First, it must be a whole number, fractional values are ignored. Second, the maximum number (or input averaging factor) that can be input is a function of the total number of samples in the channel to be transformed divided by the selection made in the Number of Points list box.

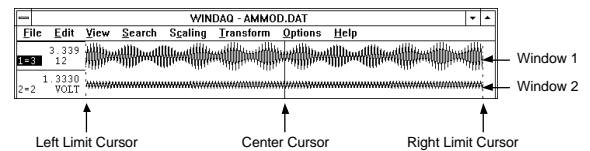
After the data window type, number of points, and input averaging (optional) selections have been made, activate the OK command button to calculate the FFT. When calculated, the following screen is displayed. This screen is composed of three basic sections; the Y - T waveform area, the analysis reporting area, and the FFT plot area.



An example screen showing how the FFT screen is divided

The Y-T waveform area is divided into two windows (window 1 and window 2). Window 1 displays the waveform from which the transform was derived. Window 2 initially displays the waveform it contained before the transform was invoked, but is used as the target window for subsequent IFTs if this feature is activated. The waveforms contained in both windows may be manipulated by using the same functions available in the Y-T mode of WINDAQ Waveform Browser playback software while a power spectrum is displayed.

Following the transform, three cursors will appear in the Y-T waveform area to show the waveform portion that was used to generate the power spectrum.



The center cursor is automatically placed in the center of the screen to indicate the center of the FFT. The left cursor indicates the left limit of the FFT range, which is 256 pixels away from the center on a full screen VGA display. The right cursor indicates the right limit of the FFT range, which is 255 pixels to the right of the center cursor on a full screen VGA display. The actual data used in the FFT calculation is the raw data contained between the two limit cursors. Assuming that a compression factor of one (1) was enabled at the time the FFT was activated, and a full screen (not resized) VGA display is used, a 512 point FFT will be generated.

The analysis reporting area performs a dual role. When manipulating the waveforms in the Y-T area, the analysis reporting area contains information about the waveforms in this area just as a typical playback screen would. When examining the power spectrum in the FFT plot area, the analysis reporting area changes to display information about the setup

conditions and the power spectrum data. This data is updated as the cross hair, displayed on the power spectrum plot, is moved. A typical display with the cross hair placed over a frequency of 6.40 Hz with a relative magnitude of -99.34 dB is shown as follows:

DATA 6.40 Hz (X1) -99.34 DB (hn) off %BOF

The (X1) and (hn) descriptors define the zoom factor and window currently applied to the spectrum. Refer to the “X-axis Scaling” and “Power Spectrum Windowing” headings below for further information related to these functions. When the analysis reporting area is displaying power spectrum data, the display can be toggled to show normal waveform information by clicking in the left/right annotation area of either waveform displayed in the Y-T area. Similarly, when the analysis reporting area is displaying waveform information, the display can be toggled to show power spectrum data by clicking anywhere in the FFT plot area.

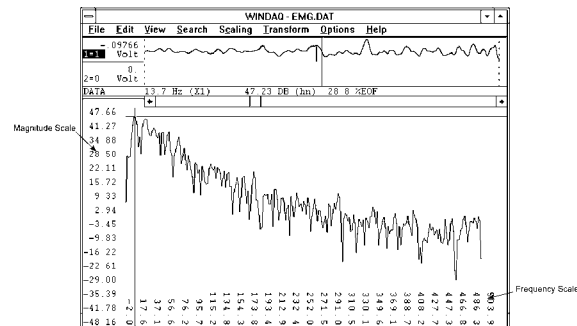
The FFT plot area contains the actual plot of the power spectrum. Examining the power spectrum is possible through use of a cross hair which may be moved anywhere on the plot. When the FFT is plotted, the origin of the cross hair is placed at the strongest frequency component of the waveform by default. The position of this cross hair is displayed in the analysis reporting area in terms of its frequency and magnitude as described above.

The vertical crosshair can be moved to display a specific frequency value in the analysis reporting area. Clicking the left mouse button anywhere in the FFT plot area allows you to position the vertical cross hair at the mouse pointer position. Dragging anywhere in the FFT plot area with the left mouse button held down allows you to drag the vertical cross hair anywhere on the plot. When dragged the horizontal crosshair follows the plot, and the analysis reporting area updates to reveal current values. After releasing the left button, SHIFT+F4 will rescale the power spectrum plot to place the horizontal crosshair at the top of the FFT plot area and use it as the 0dB reference. This rescale can be undone by dragging the left mouse button in the left magnitude scale margin to position the horizontal cross hair at the very bottom of the FFT plot area, then by pressing SHIFT+F4 again.

The horizontal crosshair can be moved to display a specific decibel or magnitude value in the analysis reporting area. Clicking the left mouse button anywhere in the left magnitude scale margin allows you to position the horizontal cross hair at the mouse pointer position. Dragging anywhere in the left

magnitude scale margin with the left mouse button held down allows you to drag the horizontal cross hair anywhere on the plot and simultaneously update the decibel or magnitude value in the analysis reporting area. After releasing the left button, SHIFT+F4 will rescale the power spectrum plot to place the horizontal crosshair at the top of the FFT plot area and use it as the 0dB reference. This rescale can be undone by dragging the left mouse button in the left magnitude scale margin to position the horizontal cross hair at the very bottom of the FFT plot area, then by pressing SHIFT+F4 again.

Grid lines and axis annotation are also available to aid waveform analysis. Grid lines can be toggled on and off in the same manner as described in the Grids section. When displayed, the X-axis of the plot represents the frequency axis of the power spectrum with the scale displayed at the bottom of the screen. The Y-axis represents the magnitude axis of the power spectrum with the scale displayed at the left edge of the screen. The magnitude axis (Y-axis) is always displayed when a transform is performed, however the frequency axis (X-axis) can be toggled on and off by selecting the Limit & Frequency Display command from the Options menu.



### EXITING THE FFT MODE

To exit the split screen mode and return to the Y-T mode of operation:



Point to the View menu and drag down to Exit/Enter Split.

Exiting the split screen display in this way retains the power spectrum data in memory so the two modes can be quickly toggled between if desired.

Alternatively, you may terminate WINDAQ Waveform Browser from the split screen mode by:



Pointing to the File menu and dragging down to Exit....

If you exit from the split screen mode with the option of saving the WINDAQ Waveform Browser state, the state that existed at the time the program was terminated becomes the default condition the next time the file is reviewed. Elements of the saved state are marker positions, whether an FFT or DFT was activated, the input average factor, magnitude in engineering units or db, the window type (Hamming, Blackman, etc.), and the frequency axis magnification factor.

Note that a significant relationship exists between the location of markers and the resulting power spectrum. To ensure that the current screen display is reproduced when quitting with the save-state option, no marker adjustments should be made following the generation of the last FFT.

**DISCRETE FOURIER TRANSFORM (DFT)**  
DFT GENERAL INFORMATION

When it is necessary to select a portion of the waveform more accurately than an FFT will allow, or when a non-windowed transform is desired, DFT generation may be used. All the functions available for FFT generation such as scaling, averaging, and smoothing are also available for DFT generation with the exception of windowing. When using DFT's, the need for a windowing function is replaced by the ability to adjust the end-points that define the time series range as discussed earlier in the FOURIER TRANSFORM BASICS section above. With the DFT, there are two ways to define the range of the time series to be transformed. One method allows you to adjust right and left limit cursors so the desired length of time series is enclosed within these limit cursors. This approach allows you to see on window 1 in the Y-T display area precisely what you are transforming. The other method allows you to use the time marker and cursor to specify the DFT range. The location of the time marker on a waveform represents one limit of the transform, while the location of the waveform cursor represents the other limit. This approach does not require that the full range of waveform information to be transformed be viewed on the screen at once. When a DFT is performed, the analysis reporting area is changed to reflect the lack of windowing as shown below:

DATA 6.40 Hz (X1) -99.34 DB (hp) OFF %EOF

Window designator indicates an FFT

DATA 15 Hz (X1) 39.34 DB (C1) 0.8 %EOF

"C" denotes time marker and Cursor approach DFT

DATA 13.3 Hz (X1) 50.64 DB (E0) 29.2 %EOF

"E" denotes End-point or limit cursor approach DFT

The window designation is replaced by a C or E (which denotes the DFT approach that was applied) and by the factors of 2 in the compression factor applied to the waveform being transformed. For example, in the middle display shown above, the (C1) descriptor indicates a DFT generated by the time marker and cursor approach with  $2^1$  (or 2) as the highest power of 2 used in the DFT calculation. In some cases, an asterisk (C\*) will appear in this field. This indicates that the power of 2 used in the DFT calculation is 100 or greater (the field can only accommodate a two digit number). For the same reason, when the power of 2 is greater than 9 but less than 100, the C will be dropped from the display field and only the compression factor will be displayed (i.e., 12). Whichever approach you take, the DFT provides a more accurate power spectrum plot than the FFT at the expense of added time for set-up and calculation. The resulting power spectrum may then be examined in the same manner as the FFT.

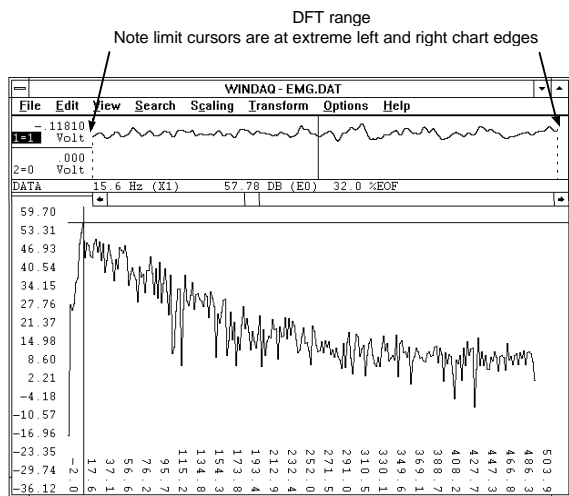
GENERATING A DFT USING LIMIT CURSORS

To generate a DFT with the limit cursor approach, ensure that the time marker is turned off (e.g., press F4 until OFF is displayed in the marker display field of the bottom annotation line. With the time marker disabled, the transform algorithm assumes that the time series is defined by the left and right limit cursors. Now move the channel you wish to transform into display window one (e.g., type "1=5" if you wish to transform channel 5). After this is accomplished, scroll the display of the selected channel to center the area you wish to transform on the screen. The DFT can now be generated directly from either the Y-T or the X-Y display modes as follows:



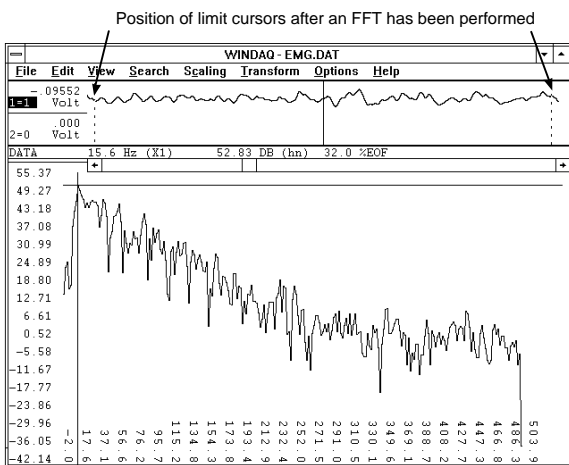
Point to the Transform menu and drag down to DFT.

If an FFT **was not** done prior to this DFT, the resulting calculation will consist of the points on the waveform bounded by the Y-T window chart edges as shown below:



With the limit cursors at the extreme left and right chart edges of the Y-T window, you get a DFT of exactly what you see in Y-T window 1. Of course, you can adjust the limit cursors to get any length of waveform you desire.

If an FFT **was** done prior to generating the DFT, the limit cursors will not be at the extreme left and right chart edges but instead will be some power of 2 apart (i.e., 512 pixels apart). Which does not give you a DFT of exactly what you see in window 1. The following illustration shows this subtle but important point:



Since the transform algorithm assumes that the time series is defined by the left and right limit cursors, a DFT performed after an FFT will produce a power spectrum over the range defined by the position of the limit cursors as shown above. A very different power spectrum will be obtained from this range compared to one obtained with the limit cursors at extreme chart edge.

It is possible to reposition the limit cursors at the

chart edges (or wherever desired) of window 1 and then perform the DFT. Such a procedure is described as follows:

### Defining the DFT Range Using Limit Cursors

Before generating a DFT, the right limit cursor and left limit cursor should be adjusted to enclose an integer or whole number of cycles on the waveform to be transformed. This is best accomplished by picking a spot on the waveform where the slope is steep and a single points value is well defined, like near the midpoint of a waveform. Also keep in mind that the DFT is generated over the range including those points occupied by the limit cursors. So position the limit cursors accordingly, taking care not to enclose one-too-many points when defining your cycle. To adjust the limit cursors:



1. Position the mouse pointer in the bottom annotation line underneath the desired limit cursor.
2. Drag with the left mouse button to adjust the position of the limit cursor. Note that when the mouse button is pressed, the limit cursor changes from a dotted line to a solid line in window 1. When the mouse button is released, the limit cursor remains a solid line until a different limit cursor is adjusted.

Note that the cursors can be moved in either direction, but the right limit cursor cannot be moved to the left of the center cursor and the left limit cursor may not be moved to the right of the center cursor. Note also that the center cursor is ignored, except when it becomes necessary to adjust it to allow the desired placement of the left and right limit cursors.

In cases where compression is enabled, the number of points contained in the resulting DFT is a function of both the compression factor and the number of pixels laying between the right and left limit cursor (or in other words, window size). The relationship of compression to the number of points in the power spectrum is described by the following table. In this table, a random assumption was made about how many pixels were contained between the right and left limit cursors. To demonstrate the math, we randomly assumed 607 pixels were contained between the right and left limit cursors:

Column A (Waveform Compression Factor)	Column B (Highest Power of 2)	Column C (Number of Points Averaged)	Column D (Points Contained in DFT)
All odd factors	—	Compression factor	607
2	2	1	1214 (607×2)
4	4	1	2428 (607×4)
6	2	3	1214
8	8	1	4856 (607×8)
10	2	5	1214
12	4	3	2428
14	2	7	1214
16*	16	2	4856
18	2	9	1214
20	4	5	2428
22	2	11	1214
24	8	3	4856
26	2	13	1214
28	4	7	2428
30	2	15	1214
32*	32	4	4856
34	2	17	1214
•	•	•	•
•	•	•	•
•	•	•	•

\*The maximum number of data values that may be transformed is 8191. Any combination of compression factor and pixels contained between the right and left limits that exceeds this value will be automatically transformed by removing as many factors of two as necessary from the highest power and multiplying the number of points averaged by the factor removed.

To illustrate an example from the table above, suppose we need a compression factor of 10 to compress the waveform enough so the area of interest can all be seen on the screen. So we enter 10 as our waveform compression factor and then perform the DFT. The value from column B is derived by evaluating the expression  $2^x$ , where the exponent  $x$  is the number that appears in the (EX) descriptor field of the analysis reporting area (a direct result of the compression factor). In our example, a 1 appears in the (EX) descriptor field of the analysis reporting area when a compression factor of 10 is used, so  $2^1 = 2$ . The value in column B is then divided into the waveform compression factor to get the value in column C, which is the number of data points averaged. In our example,  $10 \div 2 = 5$ . This means that for every 5 data points on the original waveform, one average value was used as the input to the DFT algorithm. The value in column D is the number of data points contained in the transform, which is derived by multiplying the number of pixels between the left and right limit cursors by the value from column B.

The limit cursor approach has the advantage of displaying all waveform information to be transformed on the screen at once. By adjusting the waveform compression factor, virtually any range of waveform information may be displayed on the screen, isolated by adjusting the limit cursors, then transformed. However, if a compression factor is enabled to bring the desired range on screen, this approach suffers from the disadvantage that each point on a waveform represents multiple acquired

points. For example, each displayed point on the waveform represents a combination of 15 acquired points if a compression factor of 15 is enabled, making precise end-point placement difficult. For this reason, a second DFT placement approach is available. This approach defines end-points through use of the time marker and cursor.

### Defining the DFT Range Using the Time Marker and Cursor

The time marker approach to specifying a DFT range allows precise placement of end-point markers. Unlike the previous method of power spectrum generation, the time marker approach does not require the onscreen display of the full range of waveform information to be transformed. The location of the time marker on a waveform represents one limit of the transform, and the location of the waveform cursor the other limit. Since the time marker need not be displayed on the screen to remain active, large transforms are possible at low compression factors. Transforms up to 8192 points are possible at a compression factor of 1 allowing precise placement of end-points without the indecision of marker placement at compression factors greater than 1. This approach, however, does support compression factors greater than 1 adding more flexibility to its use.

Time marker and cursor placement on the waveform to be transformed may occur from either the Y-T or DFT modes of operation. Since the object of using the time marker approach to end-point definition is precision, it is recommended that the time marker and cursor positions be defined from the Y-T mode, using display format 1 to allow full screen resolution during the placement process. Just as with the limit cursor approach, the time marker and cursor should be adjusted to enclose an integer or whole number of cycles on the waveform to be transformed. This is best accomplished by picking a spot on the waveform where the slope is steep and a single points value is well defined, like near the midpoint of a waveform. Also keep in mind that the DFT is generated over the range including those points occupied by the time marker and cursor. So position the time marker and cursor accordingly, taking care not to enclose one-too-many points when defining your cycle. The recommended procedure is as follows:



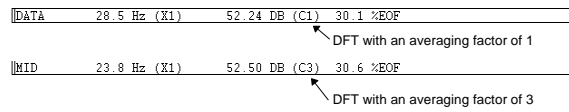
1. Exit the DFT mode and enter the Y-T display mode by pointing to the View menu and dragging down to Exit/Enter Split.

- Assign the waveform to be transformed to window 1 by pointing to the View menu and dragging down to Assign Channel..., then entering the desired channel number.
- Enter your desired compression factor by pointing to the Edit menu and dragging down to Compression...

Note that regardless of the range of waveform information to be transformed or the magnitude of the compression factor, DFT software will always ensure that the number of points in the result does not exceed 8192 by multiplying the compression factor by the smallest integer necessary. More on the effects of waveform compression follow shortly. The selected compression factor, however, must be 1 to allow precise end-point placement.

- Scroll the window to your first desired end-point (using the ← or → cursor control keys).
- Place the time marker at the desired location by pressing the F4 key. Make certain that the waveform cursor is enabled to allow precise placement of the time marker.
- Scroll the window until the waveform cursor is directly over the second desired end-point.
- Perform the DFT over the selected range by pointing to the Transform menu and dragging down to DFT.

Waveform compression operates slightly differently when the time marker approach is used as compared to the other method. When the time marker is used, the compression factor defines the number of consecutive Y-T points averaged before transforming the waveform. For example, if 2244 points exist between the cursor and time marker then the result is a 2244 point transform if the compression factor equals 1. Leaving the markers' position unchanged and incrementing the compression factor to 2 would yield a 1122 point transform since one point representing the average of each two consecutive points is passed through the transform. Whenever a DFT is activated using the time marker method, the analysis reporting area will display the actual averaging factor as follows:



## POWER SPECTRUM MEASUREMENTS CROSS HAIR ADJUSTMENT

The cross hair may be scrolled along the plot to examine other points of interest. As the cross hair is scrolled along the plot, the frequency and magnitude at the cross hair origin are displayed in the analysis reporting area. The cross hair can be scrolled by:



Dragging with the left mouse button anywhere in the FFT plot area.

Note that the display of the cross hair may be toggled off and on by pressing ALT+F2.

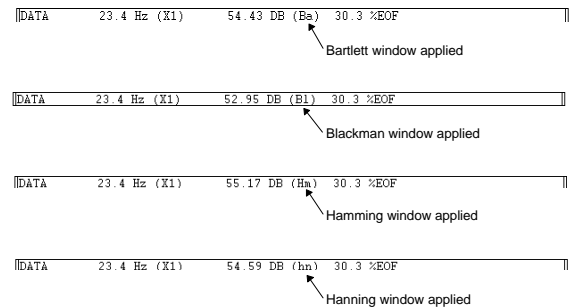
## POWER SPECTRUM WINDOWING

After the power spectrum is plotted, the type of windowing applied to the FFT calculation can be changed. WINDAQ Waveform Browser supports four window types: Bartlett, Hanning, Hamming and Blackman. The window applied is changed by:



Pointing to the Transform menu and dragging down to Windowed FFT...

This displays the FFT Window Type, Size, and Averaging dialog box, from which you simply select a different window and activate the OK command button. The window designator is always displayed in the analysis reporting area as follows:



## POWER SPECTRUM SMOOTHING

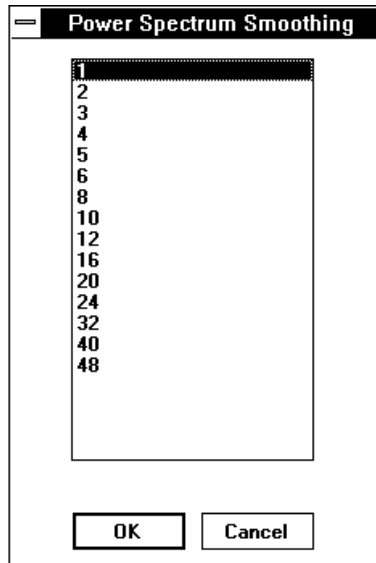
After the power spectrum is plotted, a moving average filter can be applied to smooth the spectrum. The moving average utility takes X data points (you specify how many) from the spectrum, adds them together, divides their sum by the total number of data points added, replaces the first data point in the power spectrum with the average just computed, repeats these steps with the second, third, and so on data points until the end of the power spectrum is reached. This technique attenuates random, small

amplitude frequency spikes often encountered in a power spectrum plot. You control the amount of smoothing by specifying the moving average factor. Available factors are no averaging (1) or factors of 2, 3, 4, 5, 6, 8, 10, 12, 16, 20, 24, 32, 40, and 48. When displayed, the spectrum can be smoothed as follows:

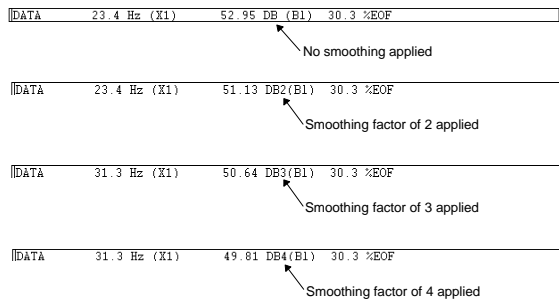


Point to the Transform menu and drag down to Average Power...

This displays the Power Spectrum Smoothing dialog box:



From this dialog box, highlight the smoothing factor (or number of points to be averaged) and choose OK. This displays the FFT Window Type, Size, and Averaging dialog box, from which you simply select a different window and activate the OK command button. The smoothing factor chosen is displayed in the analysis reporting area as follows:



### X-AXIS SCALING

When a power spectrum is plotted, the entire spectrum is displayed on the screen regardless of the number of points in the transform. If a transform containing a large number of points is performed, the resulting power spectrum is compressed in order

to fit on one screen width. This is fine for spotting the overall trend of a spectrum but what if you wanted to examine a selected portion of the plot more closely? This can be done by scaling the frequency axis.

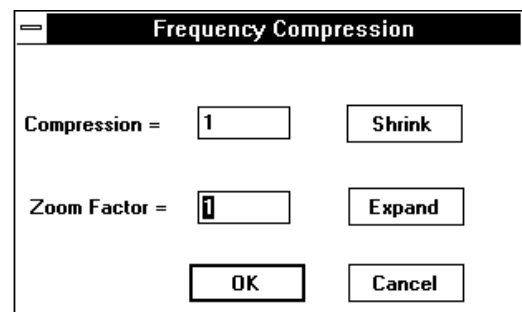
A VGA monitor provides 640 picture elements (pixels) of horizontal resolution. If a 512-point FFT is performed, the 256 points generated by the transform fit nicely on a screen capable of displaying 640 points. The same is true of a 1024-point FFT, where 640 pixels is more than adequate to contain the 512 points generated by the transform. The problem arises when a transform larger than 1024 points is performed. Suppose an 8192-point FFT is performed. The 4096 points generated by the transform is much wider than the 640 pixel width of the screen. In order to get the entire power spectrum on one screen, compression (in this case, a factor of 7) is automatically applied. To zoom in on the power spectrum and examine it in greater detail, you must magnify the spectrum (or in effect, scale the frequency axis).

After the power spectrum is plotted, scaling of the frequency axis may be used to examine a selected portion of the plot more closely. To do this, scroll the cross hair along the spectrum until it reaches the desired section of the plot and:



Point to the Transform menu and drag down to Compress FRQ...

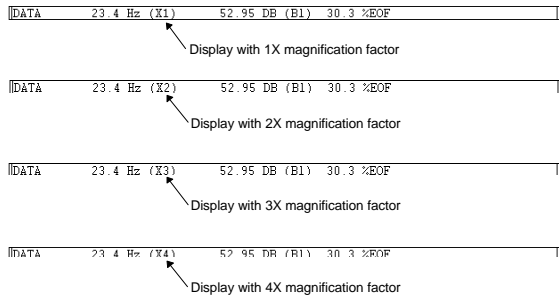
This displays the Frequency Compression dialog box as follows:



From this dialog box, you activate the Expand command button to change the spectrum's frequency compression. Successive activations apply increasing magnification scaling factors to a maximum value of 4X. When the desired magnification factor is entered, activating the OK command button applies the magnification. When the spectrum is magnified in a way that prohibits the display of the entire power spectrum on a single screen width, a scroll

bar appears at the bottom of the plot area, allowing you to pan the entire plot.

Activating the shrink command button decreases the magnification factor to a limit of  $\frac{1}{p}$ , where  $p = [(n/2+1)/640]+1$  and is the number of pages needed to display individual frequencies of an n-point transform. The current power of magnification is displayed in the analysis reporting area as follows:



### Panning the Power Spectrum

Whenever a magnification factor greater than  $\frac{1}{p}$  is active, the entire power spectrum cannot appear on a single screen. For this reason, a scroll bar automatically appears at the bottom of the plot to allow you to scroll the entire plot.

### Y-AXIS SCALING

After the power spectrum is plotted, the Y-axis can be re-scaled to aid spectrum analysis. Activating Y-axis scaling causes the selected Y level to be plotted at the top of the screen and the rest of the plot to be re-scaled accordingly. The dB values will also be re-scaled using the top of the screen as the 0 dB reference with decreasing values displayed as the bottom of the screen is approached. With a power spectrum displayed, the Y-axis can be re-scaled relative to the position of the horizontal cross hair as follows:



1. Adjust the horizontal cross hair to the desired reference level by dragging with the left mouse button in the left annotation margin of the bottom pane (or transform plot area).
2. Re-scale the spectrum plot relative to the horizontal cross hair by pointing to the Transform menu and dragging down to Scale DB.

If the results obtained from this re-scaling operation are unsatisfactory, the default Y-axis scale can be restored by positioning the cross hair at the extreme bottom of the screen and repeating step 2 (in effect, re-scaling with the cross hair positioned at the

extreme bottom of the screen).

### CHANGING POWER SPECTRUM AMPLITUDE UNITS

The strength of the frequency component can be displayed in either engineering units or relative magnitude in the form of decibels (dB). The default scale of decibels (db), assuming the scale has not been changed by adjusting Y-axis scaling as described above, is derived from the following equation:

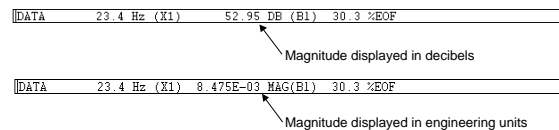
$$dB = 20 * \log_{10} (32768 * MAG / FS)$$

where MAG is the magnitude in engineering units of the frequency component and FS is the full scale value of the Y-T waveform from which the transform was derived. For example: if the full scale value was 100 mmHg and the magnitude at a given frequency component is 39.78, the dB value would be 82.30. After the power spectrum is plotted, the strength of the frequency component can be toggled from engineering units to relative magnitude (or vice versa) by:



Pointing to the Transform menu and dragging down to Mag Engr Units.

This causes the display in the analysis reporting area to change as follows:



### EXPORTING THE POWER SPECTRUM COORDINATES

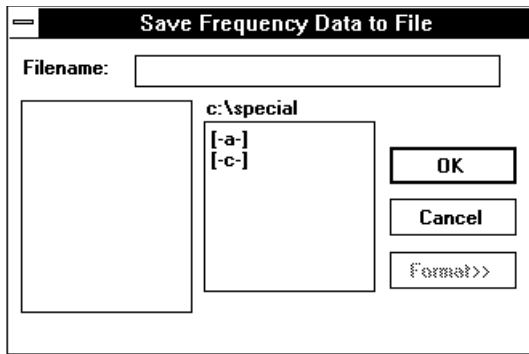
While in the transform mode, it is possible to export the coordinates that define a transform plot to an ASCII file. This is done by:



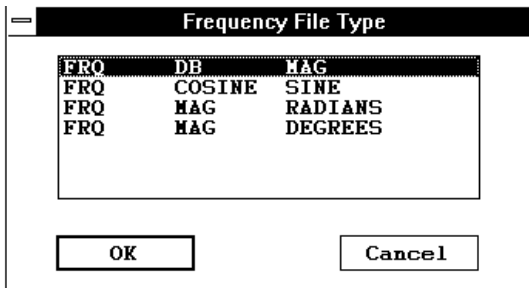
Pointing to the Transform menu and dragging down to Output FRQ Data...

This displays the Save Frequency Data to File dialog box as follows:





Enter in the text box the name of the data file (including desired path names) to which the ASCII file is to be written. When a file name is entered and the OK command button is activated, a second dialog box is displayed as follows:



From this dialog box, you can specify the type of frequency information to be saved as an ASCII file. The transform plot information is saved as an ASCII file in the form of a three column spreadsheet. These three columns contain the information necessary to reproduce the spectrum four different ways in any spreadsheet program (or in any program that is capable of importing ASCII files). The FRQ DB MAG selection will reproduce the spectrum showing magnitude and frequency information (exactly as displayed in the plot area of WINDAQ Waveform Browser). The FRQ COSINE SINE selection will reproduce the spectrum in a rectangular coordinates format, showing phase information with the cosine value representing the real component and the sine value representing the imaginary component. The FRQ MAG RADIANS selection will reproduce the spectrum in a polar coordinates format, showing the vector angle in radians. The FRQ MAG DEGREES selection will also reproduce the spectrum in polar coordinates format, but with the vector angle in degrees.

When the desired file type is highlighted and the OK command button is activated, the transform plot is exported to an ASCII file. The display will return to the power spectrum plot and analysis can be resumed.

It is possible to reproduce the spectrum with WINDAQ Waveform Browser software. This is useful when you wish to see phase information for a plot currently displaying magnitude and frequency information. ASCII files are saved in the form of a three column spreadsheet preceded by a header. The header contains the set up information used in the transform calculation including: the filename of the waveform, the assigned channel, position in the file from which the FFT was taken, compression applied to input, the number of averaged points in the FFT, window type used, and the size of the FFT. A portion of a sample file is shown as follows:

```

FILE = sample.dat
CHANNEL = 1
TBF OF LEFT POINT = 1.86080
TBF OF CENTER POINT = 1.912
TBF OF RIGHT POINT = 1.96300
SCREEN COMPRESSION = 1
INPUT AVERAGING = 1
WINDOW TYPE = hanning
FRQ SMOOTHING FACTOR = 1
POINTS = 512
FRQ      DB      MAG
  0.    -6.02    7.6294E-05
 10.    40.21    1.5640E-02
 20.    39.19    1.3899E-02
 29.    40.02    1.5302E-02
 39.    40.21    1.5631E-02
 49.    40.63    1.6023E-02
  .      .      .
  .      .      .
  .      .      .

```

This header information may be used to completely reproduce the spectrum (in another format, if desired) through WINDAQ Waveform Browser software. An FFT may be reproduced as follows:

1. With waveform compression equal to one, position the cursor in the original file so that TBF (in the bottom annotation line) is equal to the TBF OF CENTER POINT value shown in the header.
2. With SCROLL LOCK on, position the cursor *and* waveform at screen-center by pressing the gray asterisk (\*) key.
3. Set the compression factor of the original file equal to the SCREEN COMPRESSION value shown in the header.
4. Reproduce the spectrum by pressing CTRL+W.

A DFT spectrum may be reproduced as follows:

1. In the original file, set the waveform compression factor to 1.
2. Move the cursor until TBF (in the bottom annotation line) is equal to the TBF OF RIGHT POINT value shown in the header.
3. With the cursor at this position, press F4 to set a time marker.
4. Now set the waveform compression factor equal to the INPUT AVERAGING value shown in the header.
5. Now move the cursor so that TBF (in the bottom annotation line) is equal to the TBF OF CENTER POINT value shown in the header.
6. Reproduce the spectrum by pressing CTRL+F.

## **INVERSE FOURIER TRANSFORMATION (IFT)**

### **EDITING THE POWER SPECTRUM**

In many cases it is desirable to examine a waveform without any “noise” present to distort the true nature of the signal. This can be done by applying high-pass, low-pass, band-pass, and notch filter functions to the power spectrum to eliminate the noisy frequency components. WINDAQ Waveform Browser software provides high-pass filter, low-pass filter, band-pass filter, and notch filter functions to eliminate these unwanted frequencies from the plot. The high-pass filter removes all frequency components to the left of the position of the cross hair origin. The low-pass filter removes all frequency components to the right of the cross hair origin. The notch filter removes the frequency (or frequencies if the frequency axis is compressed) at the cross hair origin. The band-pass filter is a combination of high-pass and low-pass filters applied to isolate a narrow band of interest on the spectrum. The power spectrum can be edited as follows:

To apply a high pass filter (remove unwanted frequency components to the left of cross hair origin), position the cross hair origin at the desired point on the spectrum and:



Point to the Transform menu and drag down to High-pass Filter.

To apply a low pass filter (remove unwanted frequency components to the right of cross hair

origin), position the cross hair origin at the desired point on the spectrum and:



Point to the Transform menu and drag down to Low-pass Filter.

To apply a notch filter (removes the frequency or frequencies if compressed, at the cross hair origin), position the cross hair origin at the desired point on the spectrum and:



Point to the Transform menu and drag down to Erase Frequency.

The band pass filter is simply a combination of High-pass and Low-pass filters, applied to isolate a band of interest. See the individual procedures as described above for details on applying each.

### **INVERSE FFT GENERATION**

After editing the power spectrum, it is possible to perform an IFT by:



Pointing to the Transform menu and dragging down to Inverse Transform.

This generates a waveform in Y-T window 2 representing the edited power spectrum currently plotted in the FFT plot area. This new waveform will be scaled like the original as well as having the current compression factor, but will appear multiplied by the data window if an FFT was applied. From this point, the IFT waveform may be further examined or exported by using the analysis functions provided by WINDAQ Waveform Browser software from within the FFT mode or after exiting the FFT mode by pressing CTRL+Y.

Note that when an IFT is generated, the previous IFT (if any) is not saved and therefore cannot be pasted together to form a large waveform made up of several sections of different IFT's. The waveform originally occupying window 2 is deactivated, not removed from the waveform file. Window annotation “2=0” at the bottom of the screen is automatically enabled by the software when it displays the IFT waveform. The original waveform may be restored by typing

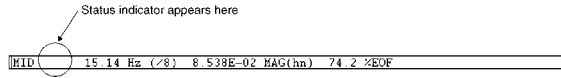
$$2=x$$

where x is the channel number of the originally displayed waveform.

## **TRANSFORM CALCULATION TIME CONSIDERATIONS**

Since some large transforms take a long time on

computers without a numeric coprocessor, a status indicator in the form of a letter (A, C, D, F, L, M, S, or W) is displayed in the analysis reporting area to indicate the FFT operation currently in progress.



This feature is provided to indicate that the computer is currently active and to discourage you from activating the transform again, thereby queuing up more time-consuming requests and tying up the machine for several minutes. Another reason for providing the indicator is to indicate where the computer is spending its time through the course of a transform calculation. Using the following table as a guide, the “Time-minimizing Element” column defines what can be employed to minimize the time required to make the calculation:

Letter	Time-minimizing Element	Action
A	Computer type and speed	Compute squared magnitudes, averaging by frequency smoothing factors.
C	Computer type and speed	Change variable-point sine-cosine table when number of points changes for DFT of other than a power of 2 points.
D	Hard disk with fast access time	Gather input data from disk or compute output from IFT.
F	Computer type and speed	Perform basic FFT algorithm or its inverse.
L	Coprocessor	Compute exponential look-up table for use in logarithmic plotting.
M	Computer type and speed	Multiply input data by window or multiply transforms during indirect DFT of a number of points which is not a power of 2.
S	Computer type and speed	Form sine-cosine table for basic FFT. This is done each time an FFT is needed that is two or more times larger than the previous largest.
W	Computer type and speed	Compute Bartlett, hanning, Hamming, and Blackman windows. Done each time an FFT is performed that is two or more times larger than the previous FFT.

L time, which is proportional to the height of the frequency part of the split screen, can be dramatically shortened by a numeric coprocessor.

C time is roughly proportional to the number of transform points, and will show up each time the number of points changes for FFTs.

D time is proportional to the total number of transform points and the number of data points to be averaged per transform point. For forward transforms, it is also proportional to the number of channels in the file and the time required for disk operations.

F, M, C, W, S, and A times are roughly proportional to the number of transform points and machine instruction times. S and W will have to be recalculated after memory deallocation occurs to spawn another program, to perform a maximum compression, or to enter the X-Y mode. But, memory is retained after an Exit/Enter Split from the FFT mode to allow reentering with another Exit/Enter Split without a time penalty.

## WINDAQ Waveform Browser

### Statistics

Allows you to derive statistical information from specified segments of the enabled waveform channel. The statistics function is available only from the Y - T display mode of WINDAQ Waveform Browser software. It is not available from the X - Y or FFT display modes.

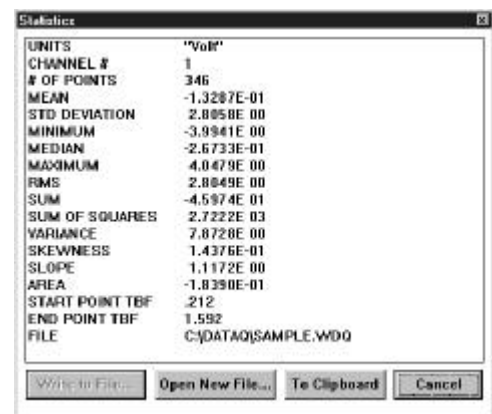
Statistical information about a waveform is obtained by first enabling the window containing the waveform of interest. Statistics may be reported for the entire length of the waveform channel, or any section of the channel by isolating the area of interest between the time marker and cursor. A time marker is enabled by positioning the cursor at the desired location and pressing the F4 function key.

Statistics may be reported for the area of the enabled waveform window isolated between the time marker and cursor by the following procedure:



Point to the View menu and drag down to Statistics.

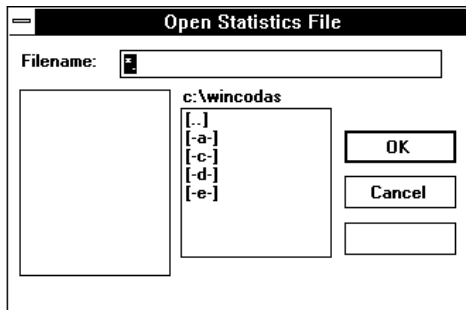
Following this procedure, the screen will clear and the following window will be displayed:



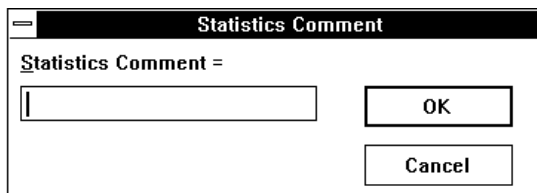
The Write to File and Open New File command buttons are used for sending the reported information to a disk file. The Write to File button originally appears dimmed because a file name has

## X-Y Plotting

not yet been specified. To specify a filename, you must first activate the Open New File command button. When activated, you will be prompted to enter a file name (and path) on the Open Statistics File dialog box:



Respond by entering any valid DOS file name and any paths that may be necessary. Next, you will be prompted for an optional comment to be associated with the data written to disk:



Respond by entering a comment, or canceling the comment opportunity. After entering a comment or canceling, the open windows will be cleared, and the playback screen will be restored to the state that existed before activating the STATISTICS function.

Subsequent requests for statistical information allow the option of appending the reported information with comments to the previously defined data file if you activate the Write to File command button. Activating the Open New File command button will prompt you for a new file name, thus allowing you to send various statistical information to different files if you desire.

Disk files created by the statistical routine are tabular ASCII files with a comma delimiter and are suitable for importing to any spreadsheet and most other analysis software packages.

The To Clipboard button sends the text in the Statistics window to the clipboard in text format, but with leading “+” signs replacing the spaces in order to line up the digits in the variable-pitch system font.

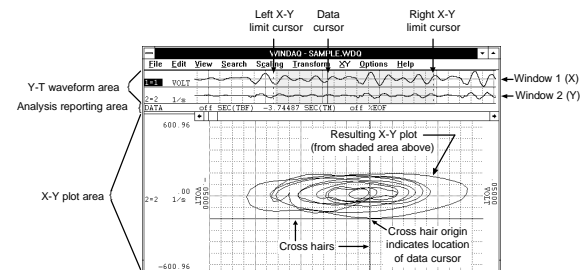
Allows any two amplitude/time (Y-T) oriented waveforms to be plotted versus each other, one waveform designated as the independent (or X-axis) variable and the other waveform as the dependent (or Y-axis) variable. Once plotted, this function allows some analysis of the resulting X-Y plot (i.e., measure excursions, slopes, and areas).

Before an X-Y plot can be generated, you must decide which channel will be the independent (or X-axis) variable and which will be the dependent (or Y-axis) variable. The channel assigned to display window 1 is defined as the X waveform and the channel assigned to display window 2 is defined as the Y waveform. Any channels may be assigned to display windows 1 and 2. For example, typing “1=3” and “2=12” causes waveform channel 3 to be displayed in window 1, thus designating it as the independent (X) variable, and waveform channel 12 to be displayed in window 2, thus designating it as the dependent (Y) variable. With the desired channels moved into display windows 1 and 2, the X-Y plot can now be generated as follows:



Point to the XY menu and drag down to Exit/Enter XY.

This displays the following X-Y plotting screen:



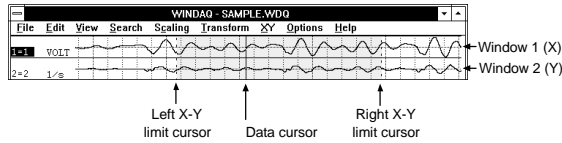
The X-Y plotting screen is composed of three basic sections; the Y-T waveform area, the analysis reporting area, and the X-Y plot area. Each of these components and the purpose they serve will be discussed as follows:

### Y-T Waveform Area

The Y-T waveform area is divided into two display windows (window 1 and window 2). Window 1 displays the independent (X) variable channel and window 2 displays the dependent (Y) variable channel. The waveforms in these windows may be manipulated in the same way and with the same functions (i.e., scrolling, scaling, offsetting, etc.) that are available in the standard (non X-Y) WINDAQ

Waveform Browser display mode. In other words, the way you review and analyze the waveforms is still the same regardless of the fact that the waveforms are displayed in a smaller window space.

Three cursors appear in the Y-T waveform area to show the portion of the waveform used to generate the X-Y plot. They are the left X-Y limit cursor, the right X-Y limit cursor, and the data cursor.



The portion of the Y-T waveforms to be plotted versus each other is all waveform information lying between the left and right limit cursors (shown above as the shaded region). The left and right limit cursors and data cursor may be placed anywhere in the Y-T waveform area with the following limitations:

1. The left limit cursor may not be moved to the right of the data cursor or past the left edge of the screen.
2. The right limit cursor may not be moved to the left of the data cursor or past the right edge of the screen.
3. Movement of the data cursor is restricted to the region between the left and right limit cursors. When the data cursor is moved between the left and right limit cursors, the X-Y plot remains stable while the cross hairs trace the X-Y plot to indicate the position of the data cursor on the X-Y plot.

**To move the left or right limit cursor:**



1. Position the mouse pointer in the analysis reporting area, directly underneath the desired limit cursor.
2. Drag with the left mouse button to move the limit cursor to the desired position. Note that when the left mouse button is pressed, the limit cursor changes from a dotted line to a solid line in the Y-T waveform area. When the left mouse button is released, the limit cursor remains a solid line until a different limit cursor is adjusted.

**To move the data cursor:**



1. Position the mouse pointer in the analysis reporting area, directly underneath the data cursor.
2. Drag with the left mouse button to move the data cursor to the desired position.

There are two ways to generate an X-Y plot; statically or dynamically. Both methods produce exactly the same result and are presented as follows:

**Static X-Y Plot Generation**

The use of the word *static* here denotes that the Y-T waveforms are stable on the screen (not scrolling) and any X-Y plots generated are those that result from adjusting the limit cursors (and the data cursor for the cross hair). As the limit cursors are moved on the screen, the X-Y plot will update to reflect a plot of only the region of Y-T waveform information isolated between the limit cursors. Movement of the data cursor, as described, allows the origin of the cross hair to trace the X-Y plot. The origin of the cross hair at any given point on the X-Y plot correlates exactly with the location of the data cursor on the Y-T plot.

Static X-Y plotting fully supports the waveform compression features of WINDAQ Waveform Browser software. This allows you to compress entire files so they can be displayed on the screen in their entirety. Then the left limit cursor may be moved to the left edge of the screen and the right limit cursor to the right edge of the screen to produce an X-Y plot of one entire waveform file versus another entire waveform file. When waveform compression of any degree is active, the representative X-Y plot may be a function of minimum, maximum, or mid-point compressed Y-T values.

While in the static X-Y plotting mode, it is possible to move the cross hair independently of the data cursor. This is done as follows:



Dragging with the left mouse button to position the crosshair origin anywhere in the Y-T plot area.

This independent movement of the cross hair has absolutely no waveform measurement utility, but you will need this feature when you want to determine areas bounded by curves using the area fill function described later. When making these

measurements, the cross hair origin is positioned anywhere within a confined region of the X-Y plot before the area fill command is activated. We will discuss this capability in greater detail in paragraphs to follow.

### Dynamic X-Y Plot Generation

The use of the word *dynamic* here denotes that the Y-T waveforms are scrolling on the screen and any X-Y plots generated are those that result from the waveforms being scrolled through the region bounded by the limit cursors. This mode of operation generates a very dynamic X-Y plot allowing large quantities of waveform information to be examined quickly in an X-Y environment and within a defined span of time. Like static X-Y plotting, dynamic X-Y plot generation fully supports waveform compression.

To generate a dynamic X-Y plot:



While pointing to the left or right scroll bar arrow in the analysis reporting area, press and hold the left mouse button to scroll the waveform.

### Analysis Reporting Area

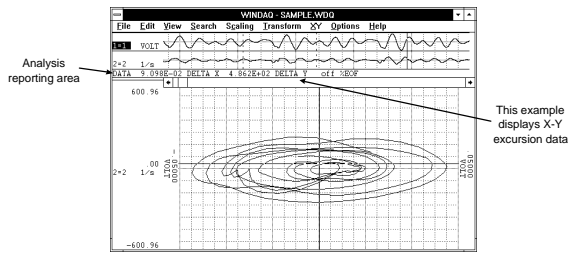
The analysis reporting area performs a dual role. When manipulating the waveforms in the Y-T area, the analysis reporting area contains information about the waveforms in this area just as a typical playback screen would. When examining the X-Y plot, the analysis reporting area changes to display information about the X-Y plot such as total area size, delta information, slope information, etc.

### X-Y Plot Area

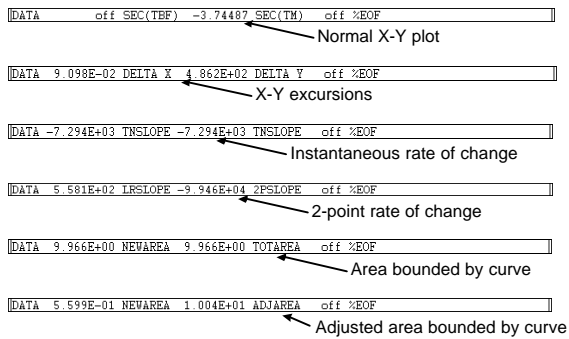
The X-Y plot area contains the actual X-Y plot of the waveforms. Examining the X-Y plot is possible through use of a cross hair which may be moved anywhere on the plot.

### Introduction to X-Y Plot Analysis

The X-Y plot utility provides five analysis options that may be activated while an X-Y plot is displayed. These are the calculation of X-Y plot excursions, instantaneous rate of change, 2-point rate of change, linear regression rate of change, and area bounded by curve. The result of each analysis function is displayed directly on the X-Y screen in the analysis reporting area as shown in the following figure:



Text in the analysis reporting area will change depending upon the analysis option chosen. The following examples appear in the analysis reporting area for each analysis option:



### Calculating X-Y Excursions

For any displayed X-Y plot, the total excursion in the X and Y directions may be reported. To report the total X and Y direction excursions:



Point to the XY menu and drag down to Deltas.

This causes the analysis reporting area to display the following data:

```
DATA 9.098E-02 DELTA X 4.862E+02 DELTA Y off %EOF
```

Where the value to the left of DELTA X is the total X direction (peak-to-peak) excursion in channel X's unit of measure, and the value to the left of DELTA Y is the total Y direction (peak-to-peak) excursion in channel Y's unit of measure.

### Calculating Instantaneous Rate of Change

An instantaneous rate of change for any point on an X-Y plot may be calculated. This is done by positioning the cross hair at the point of interest on the X-Y plot, then:



Pointing to the XY menu and dragging down to Slopes.

When the instantaneous rate of change function is activated, the analysis reporting area will display:

```
DATA -7.294E+03 TNSLOPE -7.294E+03 TNSLOPE off %EOF
```

Where the value to the left of TNSLOPE is equal to the instantaneous rate of change between the points to the left and right of the point chosen (cross hair origin) in units of channel Y's units divided by channel X's units. For example, if channel X's Y-T waveform is calibrated in units of PSI and channel Y's in units of Liters, the rate of change is expressed in units of Liters/PSI.

#### Calculating 2-point and Linear Regression Rate of Change

Unlike the instantaneous rate of change, which calculates the rate of change at one point on a plot, the 2-point rate of change allows the slope of a line connecting two defined points on the X-Y plot to be determined. Linear regression rate of change reports the slope of a best-fit line between the two defined points. Both 2-point and linear regression rates of change are reported simultaneously in the analysis reporting area.

The two points over which the rates of change will be calculated are defined by moving the data cursor between the left and right limit cursors on the Y-T waveforms and enabling a time marker on window 1's (X channel) waveform. This defines the first point. The second point is defined by moving the data cursor to another point on the Y-T plot (the cross hair moves automatically on the X-Y plot). Note that cursor movement must be done with both "Scroll Lock" and "Caps Lock" off. Following your selection of the two points, the 2-point and linear regression rate of change is displayed in the analysis reporting area by:



Pointing to the XY menu and dragging down to Slopes.

When the 2-point and linear regression rate of change function is activated, the analysis reporting area will display:

```
DATA 5.581E+02 LRSLOPE -9.946E+04 2PSLOPE off %EOF
```

Where the value to the left of LRSLOPE is the rate of change of the best-fit linear regression line and the value to the left of 2PSLOPE is the rate of change of a line intersecting the two defined points. In addition, a vector will be drawn on the X-Y screen connecting the two points over which the 2-point derivative is calculated. As with instantaneous rate of change, the derivative is presented in units of channel Y's units divided by channel X's units. For example, if channel X's Y-T waveform is calibrated

in units of PSI and channel Y's in units of Liters, the rate of change is expressed in units of Liters/PSI.

#### Calculating Areas Bounded By Curves

Using the cross hair to target specific bounded areas of the X-Y plot, it is possible to determine the area bounded by the curve. When the desired X-Y plot is displayed on the screen and the plot area to be determined is completely enclosed, adjust the cross hair such that its origin lies within the area to be determined. To fill the enclosed area and calculate the area it occupies:



Point to the XY menu and drag down to Area.

When the area function is activated, the desired plot area is filled and the analysis reporting area will display:

```
DATA 9.966E+00 NEWAREA 9.966E+00 TOTAREA off %EOF
```

Where the value to the left of NEWAREA is the area of the bounded curve just filled, and the value to the left of TOTAREA is the accumulated result of all bounded and filled areas. The latter quantity (TOTAREA) is possible since multiple area fills are possible for any given plot by repositioning the cross hair to a new area and filling again as described above (ALT+F3 is the quickest). As consecutive areas of an X-Y plot are filled, TOTAREA accumulates a total while NEWAREA displays the area of the last fill. Any given area may be unfilled by positioning the cursor within the filled area and pressing ALT+F3 a second time. When this feature is activated, NEWAREA will display a negative number equal to the area eliminated and TOTAREA will decrease by an equal amount.

The value displayed for NEWAREA and TOTAREA is in units of channel X's units times Channel Y's units. For example, if channel X's Y-T waveform is calibrated in units of PSI and channel Y's in units of Liters, area is expressed in units of Liters · PSI.

When using ALT+F3 to fill areas, it is possible for the screen to fill completely if the selected area was not completely bound. If this happens, pressing ALT+F3 a second time without moving the cross hair will unfill the screen. X-Y plots appearing on your screen that are not bound (i.e., areas that are not completely surrounded by an X-Y trace) may be forced closed by:



Pointing to the XY menu and dragging down to Clear Areas.

When this feature is activated, the two end points of the X-Y plot are connected with a straight line allowing the now closed area to be calculated using the procedure described above. If Clear Areas is chosen while there are active area fills on the screen, they will be cleared and NEWAREA and TOTAREA are reset to zero.

#### Calculating Adjusted Area

When an X-Y plot is displayed with one or multiple area fills, an adjusted area may be displayed that includes all X-Y traces passing through the filled area as well as half of the fill area's border. To adjust the enclosed area(s) and calculate the area it occupies:



Point to the XY menu and drag down to Adjust Area.

When the adjust area function is activated, the desired plot area is adjusted and the analysis reporting area will display:

```
DATA 5.599E-01 NEWAREA 1.004E+01 ADJAREA off %BOF
```

Where the value to the left of NEWAREA is the amount by which the area was adjusted (the amount occupied by the traces passing through the fill and half of the fill's border), and the value to the left of ADJAREA is the total area fills plus the value shown to the left of NEWAREA).

Selecting Adjust Area a second time causes the value to the left of NEWAREA to exclude the internal traces, which were included the first time the command was selected.

#### Amplitude Adjustments and Plot Scaling

Scaling of the X-Y plot automatically conforms to that of the associated Y-T waveforms. The "X" Y-T channel scaled in mmHg will scale the X-Y plot's X axis in mmHg. Similarly, the "Y" Y-T channel scaled in ml will scale the X-Y plot's Y axis in ml.

Beyond engineering units calibration, WINDAQ Waveform Browser software allows changes in amplitude and offset to be applied to any Y-T waveform. As the X or Y channel of a Y-T waveform is adjusted for scale and offset, the X-Y plot automatically adjusts. This feature may be used to center an X-Y plot on the screen (by applying offset adjustments to the Y-T waveforms), or to bring off-scale portions of X-Y plots into view (by applying scaling adjustments to the Y-T waveforms).

#### X-Y Plot Grids, Annotation, and Hard Copy

The Grid pattern and  $\pm$ full scale annotation for the X-Y plot assume the same state as that enabled for normal operation. In addition, the X-Y display mode is supported by the print screen function allowing a hard copy of any display to be generated.



# Using ActiveX Controls

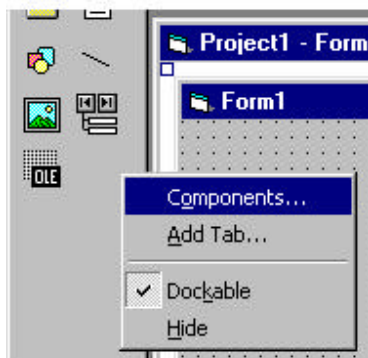
Before ActiveX controls, programming was a complete chore. Before you could run a program, you had to write pages of code. And, as we well know, if there is one mistake anywhere, the rest of the code is useless. This is why ActiveX controls are so valuable. They eliminate the pages of programming. They eliminate the possibility of mistakes. They do the work for you.

An ActiveX control can best be described as a software module that performs a specific function. Multiple ActiveX controls can be combined to perform a multitude of functions. In fact, Active X controls from any combination of vendors may be combined as though one vendor supplied them all. In one line, you'll be able to refer to numerous lines of code that have already been tested and are ready to go to work for you.

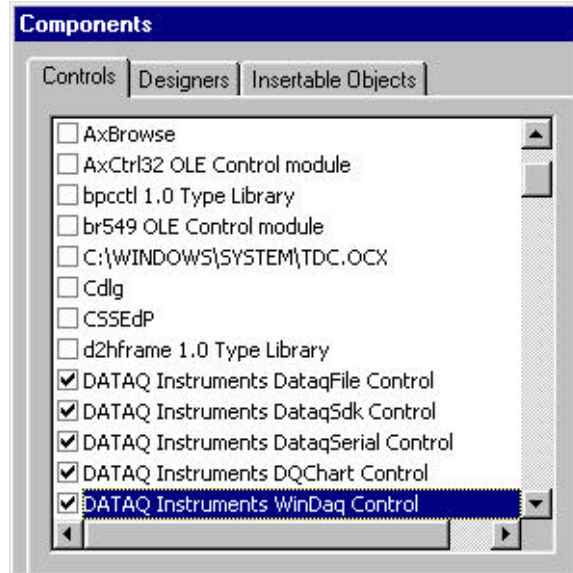
ActiveX controls have three types of functions: properties, methods and events. Properties are the attributes of the control. They describe the appearance and operation of the control. Methods are function calls inside the control that allow information about the control to be sent or received. Events are notifications generated by a control in response to some particular occurrence.

ActiveX controls can be easily put in any application that supports them. For example, it takes two steps to use an ActiveX control in Visual Basic:

1. Right click on the tool bar and select "Components" from the pop-up menu.



2. A window will open with all of the components that are installed on your computer. Check the boxes in front of the five DATAQ Instruments components. Then click "OK".



You will see the ActiveX control symbols on your tool bar. To apply one to your form, simply double click on the symbol. To access a help file, select the control or select a specific property, method or event and press "F1".

The first ActiveX control, "DataqFile" has two parts to it: WriteDataqFile and ReadDataqFile.

**WriteDataqFile** can be used to create a WinDag-compatible file. Although your data acquisition program may not use WinDag software, it may still be beneficial to allow the data files your program acquires to be accessed, displayed and manipulated using WinDag waveform browser software. This control ensures that the files created by your program may be used in this manner.

Some of the features of WriteDataqFile are:

- File manipulation utilities that allow controlled access to data.
- File manipulation utilities that allow controlled access to data.
- +/- Full-scale definitions per channel in engineering units.
- Sample rate throughput definition that is used by WinDag browser software for all timing measurements.

WriteDataqFile has the following limitations:

- Supports only regular WinDaq files (i.e. no support for different channels sampled at different rates).
- No commented-event marker support.
- No user annotation support

**ReadDataqFile** can be used to read WinDaq-compatible files. In many instances, you may wish access to data acquired by WinDaq data acquisition software. Examples include custom analysis and export requirements. This control provides a convenient way to perform these special operations.

Some of the features of ReadDataqFile:

- Open and close file manipulation capability.
- File navigation utilities.

It also has the following limitations:

- Supports only regular WinDaq files (i.e. no support for different channels sampled at different rates).
- No commented-event marker support.
- No user annotation support.

The second ActiveX control, **“DataqSDK”**, provides access to the most basic elements of data acquisition hardware. (In contrast, the WinDaq control relieves you of general data acquisition housekeeping and delivers scaled waveform data to your application.)

DataqSDK may be used with all Dataq Instruments’ hardware, including the DI-22x/4xx/5xx/7xx series devices. (Use the DataqSerial control to access and manipulate Dataq Instruments’ serial Dataq Instruments’ data acquisition modules, like the DI-194 and DI-151RS.)

Features of DataqSDK include:

- Data acquisition mode definitions for continuous and triggered data acquisition.
- Sample rate, channel, single-ended and differential definitions and various other scan list items.
- Immediate mode access to digital I/O and analog outputs.
- Access to acquired data using either burst or streaming methods.
- DataqSDK does not currently offer streaming DAC output.

The third ActiveX control, **“DataqSerial”** may be used with all Dataq Instruments’ hardware that supports a serial (COMM port) interface, including the DI-150/151/190/194/195 series devices. (Use

the DataqSDK control to access and manipulate all other Dataq Instruments’ hardware products like the DI-22x/4xx/5xx/7xx series devices.)

DataqSerial features include:

- Continuous access to acquire data.
- Sample rate, COMM port and acquired channel definitions.
- Access to acquired data using streaming methods.

The fourth control, **“DQChart”**, is provided to allow basic charting capability from the VB samples included in the ActiveX installation.

**DQChart offers the following features:**

- Plots up to 16 channels on the same chart.
- Allows analog or digital plotting.
- Displays color legends (see below) at the upper left corner of the chart.
- Supports scaling and offsetting via mouse control.
- Supports WinDaq compatible event marker.
- Plots a specified channel from a data stream.

The final control, **“Windaq”**, can be used to eavesdrop on the data stream being acquired by WinDaq Data Acquisition software. Use this control to return the single value or the latest frame of data if you use the data frame methods or it can monitor the whole data stream if you use the data stream methods.

The primary advantage of this control is to relieve you of the tasks associated with initializing data acquisition. These include, but are not limited to, scan list initialization and management, sample rate definitions, engineering unit scaling and many others. These tasks are performed by Windaq turnkey data acquisition software at a very high level. However, the data acquired by the application can be made available in real time by this control. In this manner, the control allows you to concentrate on specific requirements of the task at hand without regard to mundane and obscure data acquisition details.

Windaq offers the following features:

- Derives the number of channels, sample rate, engineering units scaling, m and b scaling constants and full-scale ranges in engineering units as defined by Windaq software for each channel.
- Provides access to acquired channel data using one of three options: immediate mode by defined channel, immediate mode by all enabled channels

and a stream approach that guarantees waveform continuity.

- Allows asynchronous access to the hardware's digital input and output ports and analog output ports.

Cautionary note: During program development, while your program is still in the interpretive mode, ensure that the Windaq application is not terminated before the program that is accessing the application. Terminating Windaq before your application will cause your host program to become unstable. This anomaly is not an issue after your program is compiled into an .EXE.

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