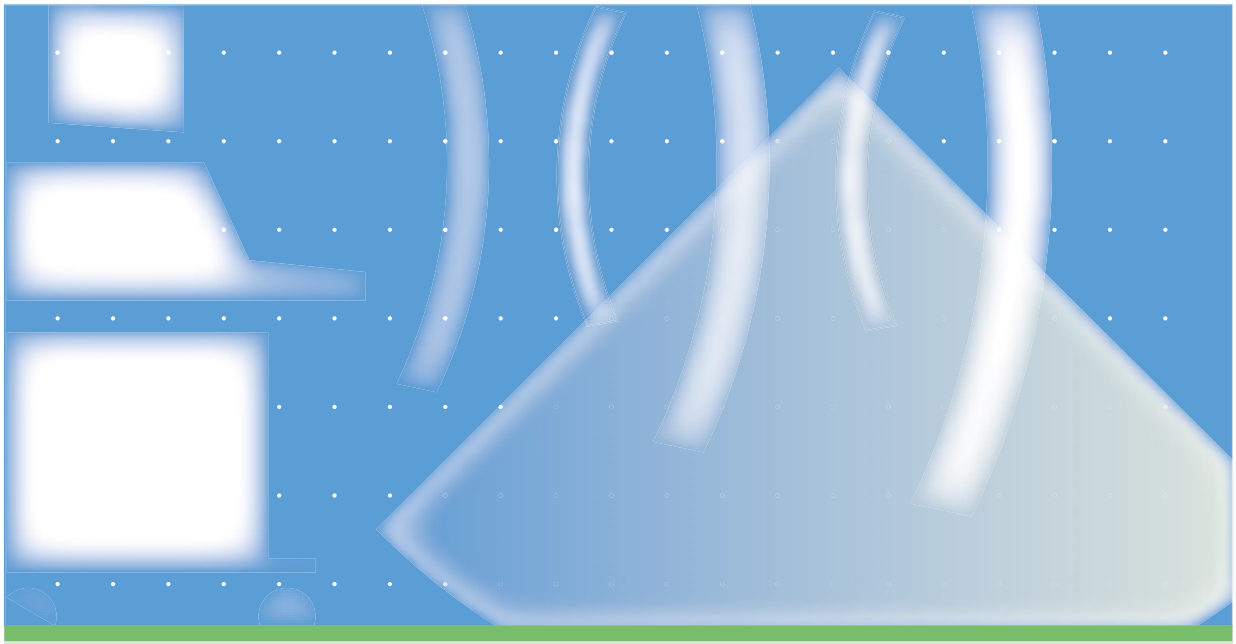

SONOS 7500/5500

Using Acoustic Densitometry

PHILIPS

User’s Guide

Using Acoustic Densitometry

Philips SONOS 7500
Philips SONOS 5500

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Electrical Shock Hazard

Do not remove system covers. To avoid electrical shock, use only supplied power cords and connect only to properly grounded wall (wall/mains) outlets.

Explosion Hazard

Do not operate the system in the presence of flammable anesthetics.

Safety Information

Before you use the Philips ultrasound system, be sure to read the *Safety and Standards* guide.

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Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the product against damage.

Indicates potential for electrical shock.

Monitor Radiation

The monitor used in this system complies with the FDA regulations that were applicable at the date of manufacture (21 CFR Subcategory J).

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The United States Food and Drug Administration requires the following labeling statement:

Caution - Federal Law restricts this device to use by or on the order of a physician.

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Preface

This guide describes the basic operation of Acoustic Densitometry, or AD, on the SONOS 7500 and SONOS 5500 systems. Use this guide in conjunction with the following books:

Use this guide in conjunction with the following books:

- *System Basics*—Describes the basic operation of the Philips SONOS 7500 and SONOS 5500 systems.
- *Controls Reference*—Provides a detailed description of all system controls.
- *Safety and Standards Guide*—Provides information on safety issues.
- *Measurements and Calculations Reference*—Provides information on measurements and calculations that you can perform on your ultrasound system.
- *Transducer Reference*—Provides information on the operation, care, and cleaning of transducers.

Additionally, several specialty guides and multimedia products describe SONOS imaging applications and optional packages:

- *Using Integrated Digital Interface (IDI)*
- *Using Stress Echocardiography*
- *Using 3-Dimensional and BiPlane Imaging*
- *Using Acoustic Quantification*
- *Using Contrast Imaging*
- *LVO and Contrast CK: A Practical Approach* (a video guide to SONOS contrast echocardiography detection techniques)
- *Stress Audio CD* (a spoken guide to performing SONOS stress echocardiography studies)

Conventions Used in This Guide

The following conventions are used in this guide:

- Touch-panel and rotary control names appear in bold text. For example, **Acquire Loop.**
- Function keys appear in a box. For example, Enter.

Contents

Chapter 3 Measurements and Calculations

Chapter 1 Introduction

About This Manual

This user's manual provides you with all the information you need to start using Acoustic Densitometry (AD).

This manual is divided into three chapters:

- Chapter 1, "Introduction," provides an overview of AD and its features.
- Chapter 2, "Procedures," explains how to perform an AD study, important information for new users. It describes how to use AD features.
- Chapter 3, "Measurements and Calculations," describes the calculations the SONOS AD package performs on data sets.

The AD manual assumes a working knowledge of the SONOS 7500 or SONOS 5500 system (see the *System Basics Guide*).

Acoustic Densitometry Overview

Acoustic Densitometry (AD) is a tool for quantification of brightness (intensity) and velocity in ultrasound images. It measures and displays either the average acoustic intensity or average velocity (depending on the imaging mode). Measurement occurs in a user-specified region of interest (ROI) at user-specified time (trigger) intervals.

Unlike conventional video densitometry, AD measurement data is minimally affected by the compression and post-processing settings of the ultrasound system.

The AD package lets you perform measurements on a selected region of an ultrasound image. AD lets you analyze loops collected using 2D, AQ, angio, integrated backscatter (IBS), 2D color doppler, and 2D color tissue doppler imaging modes. AD lets you measure image data in SONOS Study Manager—that is, after you have captured image loops.

NOTE

The AD tool can be used in research applications such as contrast, tissue doppler, and tissue characterization studies.

Acoustic Densitometry Features

SONOS AD package provides the following capabilities:

- Lets you collect and analyze images acquired in 2D, angio, AQ, 2D color doppler, 2D color tissue doppler, and integrated backscatter imaging modes.
- Lets you perform analysis on live triggered images or loops acquired into SONOS Study Manager.
- Provides programmable colorization capability.
- Works with a contrast study.
- Lets you store twelve datasets with as many as 300 data points each.
- Displays the data on both an annotated graph and a numeric chart.
- Lets you change the baseline of the graph, changing the zero point (on the Y axis) of a curve of data points.
- Lets you apply smoothing to graphed data.
- Lets you apply non-linear curve fitting (gamma variate) of time-intensity data.
- Extracts parameters from time-intensity curves, including peak intensity, area under the curve, half-time of washout, mean-transit-time, descending slope, time-to-peak intensity, and goodness-of-fit.
- Compares data sets from different studies (for example, pre- and post-intervention studies).
- Stores raw time-intensity and time-velocity data for all datasets with an image file (for offline use and later analysis of data on SONOS), along with analysis results. Exports raw time-intensity and time-velocity data for all datasets to disk for offline analysis.
- Provides quick AD caliper measurements for velocity and velocity gradient.
- Provides system settings of acquired images.

Backward Compatibility

AD for SONOS 7500 and SONOS 5500 Release D.0 can read and analyze results from previously analyzed images dating back to Rev. B.1 and later.

Chapter 2 Procedures

Introduction

There are three parts to an AD study:

Acquiring an image	The image from which you collect data can be an acquired loop or a live image.
Sampling data from the images	Using the Region of Interest tool, you select data from the image and store the collected data set. You can sample data from live images as well as saved loops.
Analyzing the data	Using the data set, you can create graphs and tables, manipulate the data, and perform calculations.

For a complete description of all AD controls, see the *Controls Reference*.

Acquiring an Image

Unless you plan to sample data from live ultrasound images, acquiring loops is the first stage in an AD study.

For multiple studies of the same type, consider creating a preset. (See the *System Basics Guide*.) You can perform AD analysis on images acquired using 2D, AQ, Angio, Integrated Backscatter (IBS), color doppler, and color tissue doppler imaging modes.

NOTE

If you acquire a loop using color doppler, or color tissue doppler, the data you derive from the loop will pertain to velocity. Otherwise, AD analysis pertains to image intensity.

Tip: *The loop must be frozen for all the buttons on this touch panel to appear.*

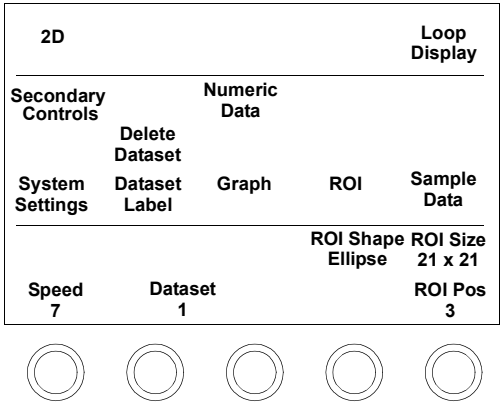


Figure 2-1 The Right Touch Panel as it Appears in Sample Mode

Sampling

Data sampled over consecutive frames constitutes the data set. (See Figure 2-3.) The SONOS system plots the data points on a graph (a time-intensity or time-velocity graph) and logs them on a chart (numerical datalog).

When you finish sampling data the system automatically goes to AD analysis mode.

The Region of Interest Marker

The region of interest (ROI) can be:

- A fixed shape (square, circle, ellipse, crescent, rectangle)
- A variable size
- Oriented in one of twelve positions, in increments of 30 degrees
- A user-defined shape

When AD is selected in the left touch panel, ROI controls appear in the right touch panel. The ROI color control appears in Secondary Controls. Touch the ROI control and move the rotaries to create an ROI tool that is the right shape and size.

For a full description of ROI controls, see the *Controls Reference*.

Creating an ROI

You can create a customized region of interest (ROI). The dimensions of the ROI must not exceed 200 X 300 pixels. Any region of the ROI that exceeds this limit is clipped to fit a 200 X 300 pixel area. A user-defined ROI exists until it is cleared or you exit AD.

To create a user-defined ROI:

1 Touch **ROI** and turn the **ROI Shape** rotary to **UserDef**.

2 If a user-defined ROI already exists, touch **Clear ROI**.
A crosshair appears.

3 Press Trace, move the trackball to outline the ROI shape, and then press Enter.

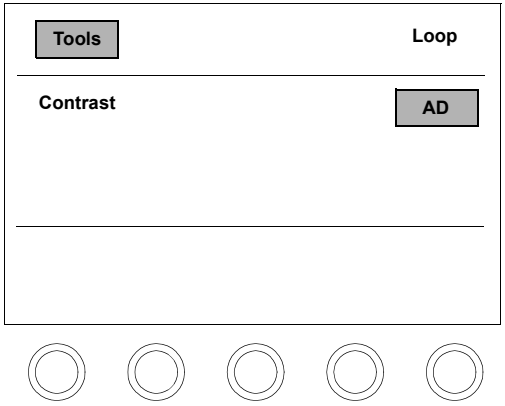
4 Move the ROI to the location you want.

NOTE

You can use the Erase key to edit the ROI.

Sampling a Loop

1 Make sure AD is selected on the SONOS system. On the left touch panel, touch Tools. Then touch the AD button.



2 Touch Graph on the right touch panel to remove the graph from the screen.

3 Select the desired loop and make sure it appears in Loop Display. Edit the loop if necessary. Press Freeze.

4 Use the Speed rotary on the right touch panel to set the frame advance speed.

5 On the right touch panel, under Secondary Controls, select the scale (default is V-Square).

6 On the right touch panel, select the Shape, Size, and Orientation for the Region of Interest (ROI) cursor.

7 Position the ROI marker on the region of the image you want to sample. Touch **Sample Data** to start the acquisition of data points into the current data set. The SONOS system records the average intensity/velocity within the ROI.

8 Move the ROI between frames by moving the trackball. You can adjust the speed of the loop using the Speed rotary on the right touch panel.

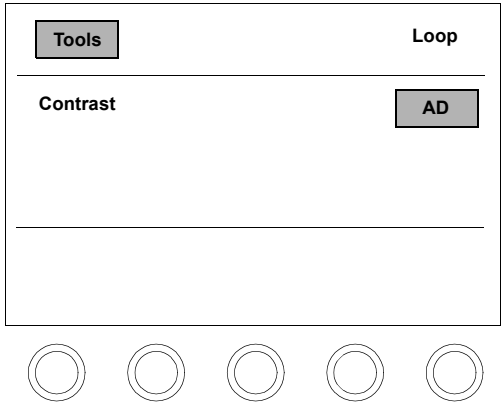
9 Use the trackball to move the ROI marker, keeping it over the region you want to sample.

10 When sampling finishes, move the trackball up or down to position the baseline, and then press Enter to set the baseline. (See "Selecting a Baseline" on page 2-9.)

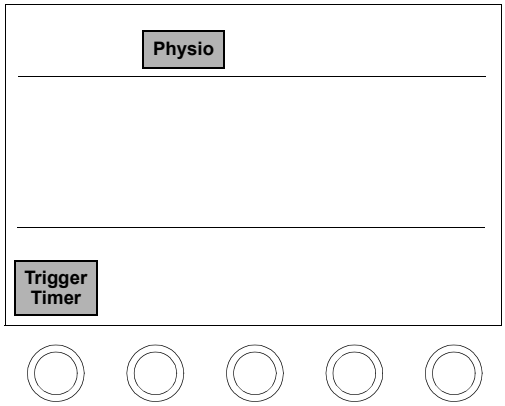
Sampling a Live Image

AD can sample images live, but they must be triggered images.

1 Make sure AD is selected on the SONOS system: On the left touch panel, touch Tools. Then touch the AD button.



2 Touch **Physio**. Make sure the **Trigger** rotary is set to either **ECG** or **Timer**, not **Off**.



3 On the right touch panel, select the Shape, Size, and Orientation for the Region of Interest (ROI) cursor.

4 Position the ROI marker on the region of the image you want to sample. On the right touch panel, touch **Sample Data** to start the acquisition of data points into the current data set. The SONOS system records the average intensity or average velocity within the ROI.

5 Use the trackball to move the ROI marker, keeping it over the region you want to sample.

6 When you are finished sampling, press **Sample Data again, to unselect it.**

7 Move the trackball up or down to set the baseline, and then press **Enter** to set the baseline. (See "Selecting a Baseline" on page 2-9.)

The system records the average intensity or velocity for each frame as it advances. After selecting a baseline the system performs the calculations you chose for the type of image to be analyzed.

Analyzing the Data

When you finish sampling data from a loop, the SONOS system goes to Analysis mode.

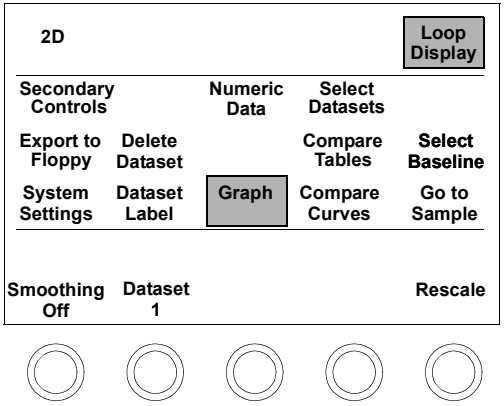


Figure 2-2 Right Touch Panel As It Appears in AD Analysis Mode

After you finish sampling a dataset and selecting the baseline, the right touch panel displays the primary Analysis mode keys, as shown in Figure 2-2. The Analysis graph for the currently selected data set appears on the screen with a plot of the sampled data points, as shown in Figure 2-3.

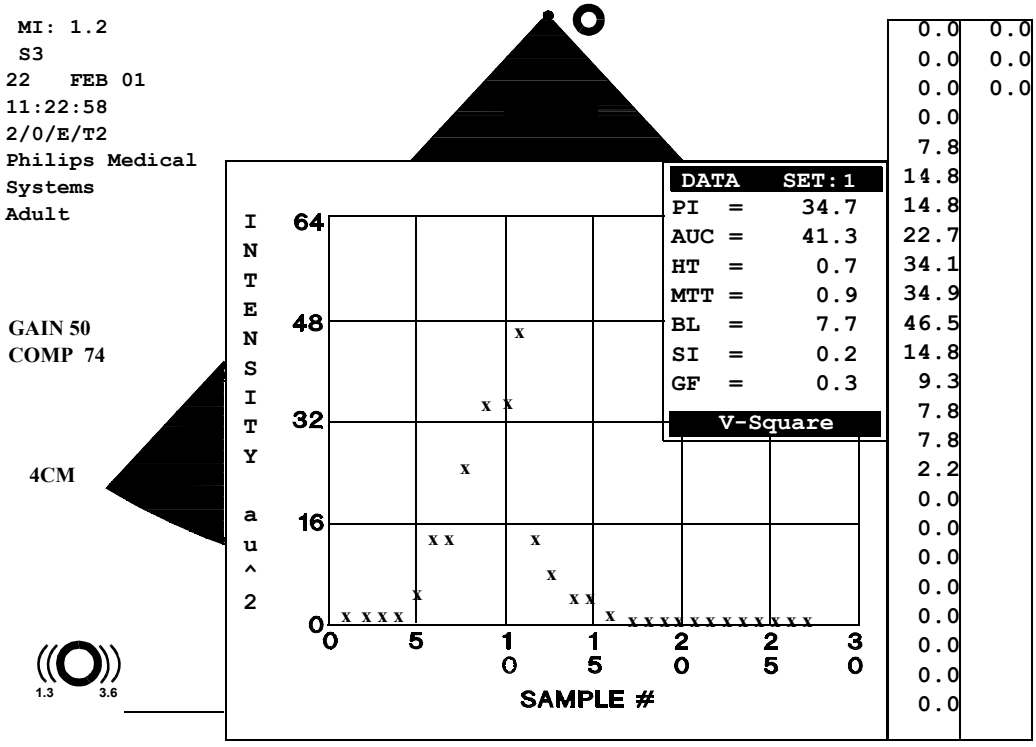


Figure 2-3 The Analysis Graph

On the right touch screen, touching **Numeric Data** or **Graph** turns these features on or off on the screen.

Colormap Display

The SONOS AD Colormap feature helps you visualize changes in a 2D image, showing the intensity in a loop image before you sample data. When you turn Colormap on, the gray-scale AD image changes to an image with colorization and gray-scale.

NOTE

AD Colormap works only on a 2D image. **AD Colormap** is only available before a data set is sampled.

To enable Colormap, do the following:

1. Make sure the loop you want to measure is in Loop Display.
2. On the right touch panel, touch **Secondary Controls**.
3. Touch **AD Colormap**. The loop image is displayed in color, with the areas of greatest intensity accented.
4. Turn the **Baseline** rotary on the right touch panel to modify the intensity range of the colormap. This control adjusts the threshold that determines what part of the image is colored and what part remains black and white. The effect appears on the scale in the upper right of the screen.

Selecting a Baseline

In a contrast study, the AD package lets you subtract the pre-contrast background intensity from the data acquired using contrast to get an estimate of the intensity solely due to the contrast agent.

The **Select Baseline** key automatically turns on when the SONOS system enters AD Analysis mode (after data sampling ends). You can also touch the **Select Baseline** button. When you select **Select Baseline**, the original data set is plotted on the time-intensity graph with the baseline displayed in the same color as the graph.

NOTE

Changing the baseline in Color Flow/Tissue Doppler does not effect the calculations.

1 Select the desired data smoothing and curvefit options with Select Baseline off.

2 Touch Select Baseline and set the baseline. This is the amount that will be subtracted from every data point.

3 When you finish selecting the baseline, press **Enter**. The results are displayed.

4 Use the **Rescale** rotary to display the graphed data with the desired magnification. You may make a different baseline selection and repeat this step.

The measurements and calculations are automatically performed from the time-intensity data after baseline subtraction. The new data points appear on the time-intensity graph.

NOTE

Changing the baseline in Color Flow/Tissue Doppler does not effect the calculations.

Data Smoothing

The AD package lets you further reduce noise data by smoothing data across image frames prior to curve-fitting and data analysis.

NOTE

Collecting data with larger ROIs minimizes noise.

Statistical errors in the individual time-intensity curve samples, resulting from patient motion, breathing artifact, and other causes, can obscure the underlying shape of the time-intensity curve. In these cases, you can smooth the data before further analysis. Figure 2-4 shows a time-intensity plot for a data set with no data smoothing. Figure 2-5 shows the result of smoothing the data with low, medium, and high smoothing filters.

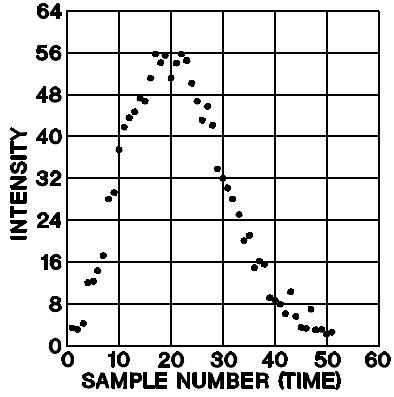


Figure 2-4 Time-Intensity Graph with no data smoothing

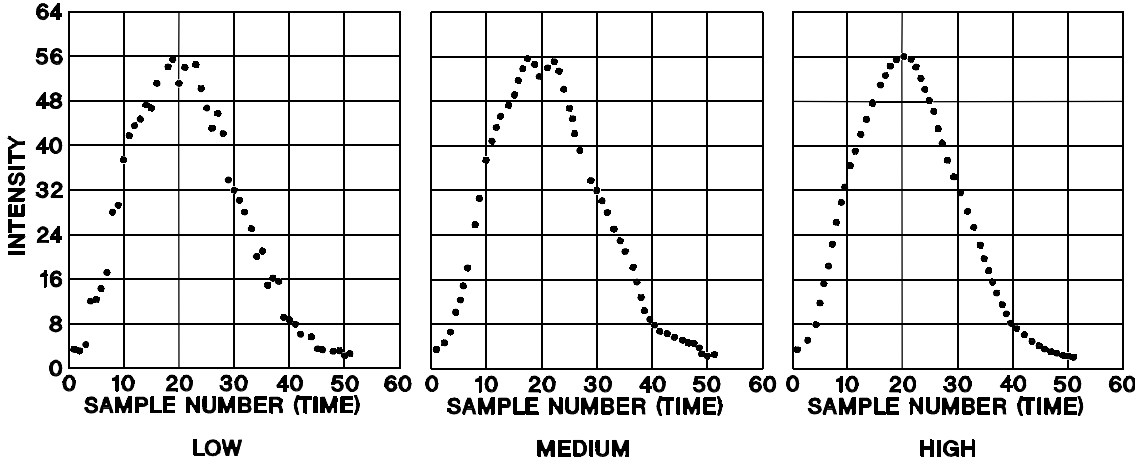


Figure 2-5 Time-Intensity graphs after low, medium, high smoothing

NOTE

A high degree of smoothing reduces random noise significantly, but also tends to mask genuine changes in the data.

To perform data smoothing do the following:

- On the right touch screen, turn the **Smoothing** rotary to the desired smoothing setting (Off, Low, Medium, Or High).

The system calculates a new set of measurements, applying a smoothing filter.

Exporting a Data Set

When you have a data set that you are satisfied with, you can save the values to the floppy disk or optical disk.

To save the values to the floppy disk:

1 Insert a floppy disk.

2 On the right touch panel, touch **Export to Floppy**.
The data exported includes intensity/velocity and time.

To save the values to an optical disk:

1 Insert an optical disk.

2 On the left touch panel, ensure **Loop** and **Display** are highlighted.

3 Touch **Disk Store**.
Data set values are saved with the loops.

NOTE

Only the datatsets that belong to the image loop are saved with the image.

Comparing Data Sets Simultaneously

The AD package lets you acquire as many as twelve data sets (and twelve associated time-intensity or time-velocity curves). You can select up to three data sets for simultaneous display and comparison.

1 Touch **Select Datasets** on the right touch panel. The Select Dataset window appears. Data sets containing data are displayed (others are grayed-out).

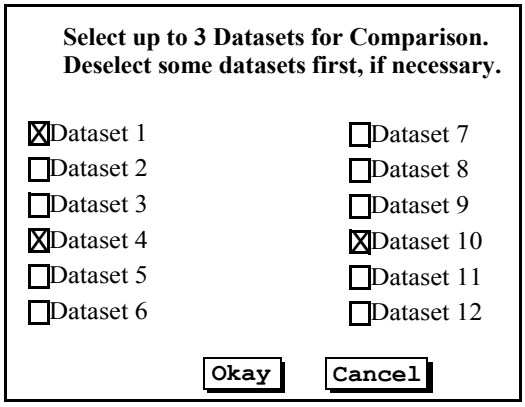


Figure 2-6 The Select Datasets Dialog Box

NOTE

If none of the data sets in a study are analyzed, then the **Select Datasets** key is not displayed. You cannot compare data sets that are not yet analyzed.

2 Highlight the data sets you want to compare. Press Enter. An X appears in the check box. To deselect a check box, select it again and press Enter.

3 When you have selected the data sets you want to compare, highlight Okay and press Enter.

4 You can compare data sets on a table or on a graph. On the right touch screen, touch **Compare Table** or **Compare Curve**. A table or a graph appears, displaying the multiple data sets you selected. Figure 2-7 shows a graph comparing two datasets.

NOTE

On a graph comparing data sets, the data points from different data sets are designated by different markers, as shown by the rectangles and Xs in Figure 2-7.

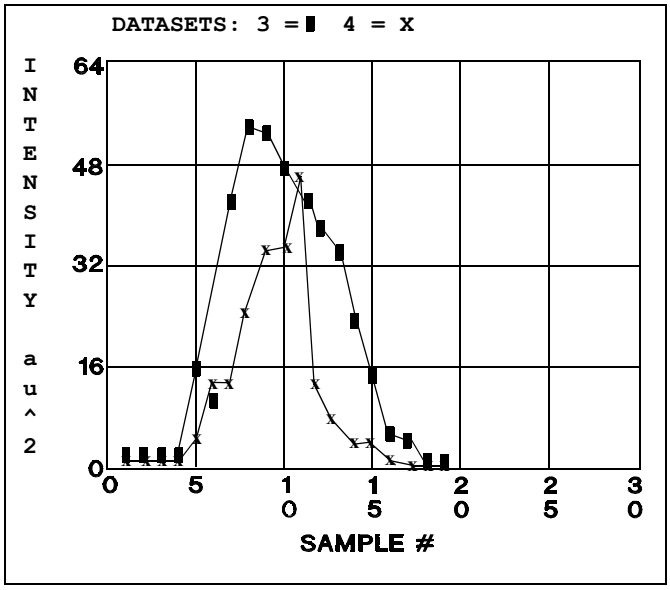


Figure 2-7 Graph Comparing Two Data Sets

Using Acoustic Densitometry Data Sets

AD lets you acquire up to twelve data sets. To select a data set, on the right touch panel, turn the **Dataset** rotary to the number of the data set. The data set number appears in the upper right corner of the graph. If the selected data set contains data, it is plotted on the graph.

Labeling Data Sets

You can attach labels to the graphed curve for the selected data set. Touch **Dataset Label** on the right touch panel. A dialog box appears on the screen. (See Figure 2-8.) Enter the text of the label. The label text appears at the top of the Analysis time-intensity or time-velocity graph display.

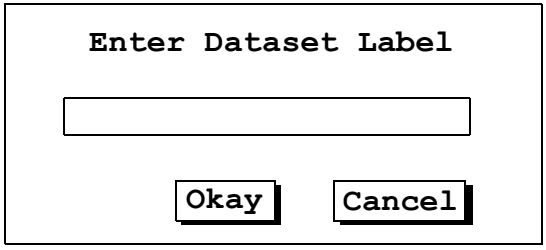


Figure 2-8 Dialog Box for Dataset Annotation

Deleting a Data Set

Touch **Delete Dataset**. The dialog box shown in Figure 2-9 appears.

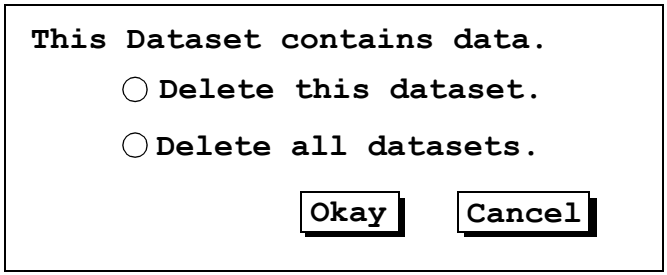


Figure 2-9 Dialog Box For Dataset Deletion

You can chose to delete all data sets or only the data set you selected. Highlight the corresponding item on the dialog box—move the cursor to it and press Enter. Highlight Okay and press Enter.

Caliper Measurements of Velocity in AD

AD also allows calculations with the caliper in Color Flow/Color Tissue Doppler images. You can use the caliper feature to derive velocity for a small square ROI around a single point in the image, or the myocardial velocity gradient between two points.

Measuring Velocity

To display the flow or tissue velocity at a certain point in a Color Doppler or Color Tissue Doppler loop, do the following:

1 Make sure the loop you want to measure is in Loop Display.

2 Press **Caliper**. A crosshair appears on the screen.

3 Use the trackball to position the crosshair where you want to measure velocity.

The velocity at the crosshair point is shown in a box at the upper left corner of the SONOS screen. The velocity is displayed in centimeters per second.

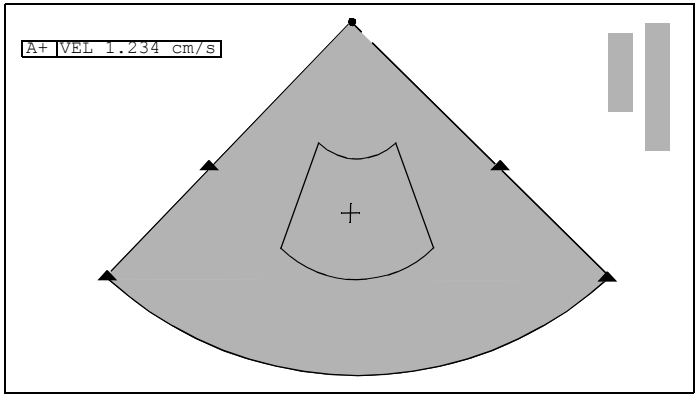


Figure 2-10 SONOS Screen As It Appears With the Velocity Caliper Active

Measuring the Myocardial Velocity Gradient

The Myocardial Velocity Gradient (MVG) is the difference in velocity between two points divided by the distance between the two points.

$$\frac{|V_2 - V_1|}{distance}$$

To display the MVG at two points in a color doppler loop, do the following:

1 Make sure the frame you want to measure is in Loop Display. The image must be frozen.

2 Press **Caliper**. A crosshair appears on the screen.

3 Use the trackball to position the crosshair where you want to measure the first instance of velocity.

4 Press **Caliper**. A second crosshair appears on the screen.

5 Use the trackball to position the second crosshair where you want to measure the next instance of velocity. Press **Enter**.

A dashed line appears between the two crosshair points. The myocardial velocity gradient (MVG) between the two crosshair points is shown in a box at the upper left corner of the SONOS screen.

NOTE

To get a more accurate value, MVG measurements should be made along the same acoustic line—a radial line starting at the apex of the image.

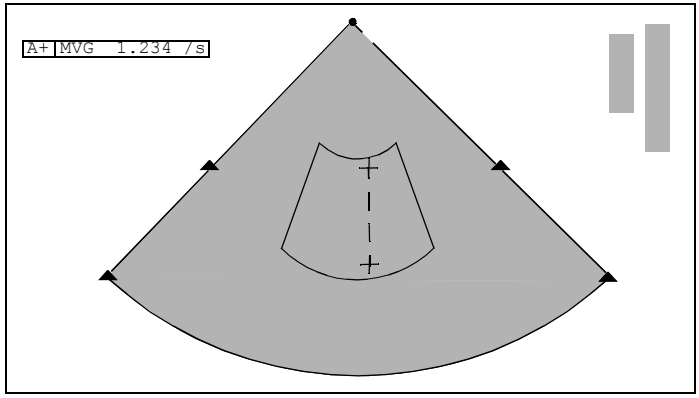


Figure 2-11 SONOS Screen As It Appears With Two Velocity Calipers Active

You can measure additional MVGs on the same image, leaving the prior measurements active on the screen.

To enable a second MVG, do the following.

1 Press **Enter** to finish deriving the first MVG.

2 Repeat steps 2 through 5 in the procedure above.

The mean velocity gradient (MVG) between the two crosshair points is shown in a second box at the upper left corner of the SONOS screen.

Chapter 3 Measurements and Calculations

Configuration

When you obtain and save a data set, a window appears showing calculations applied to the data. The calculations performed are configurable. See Figure 3-1.

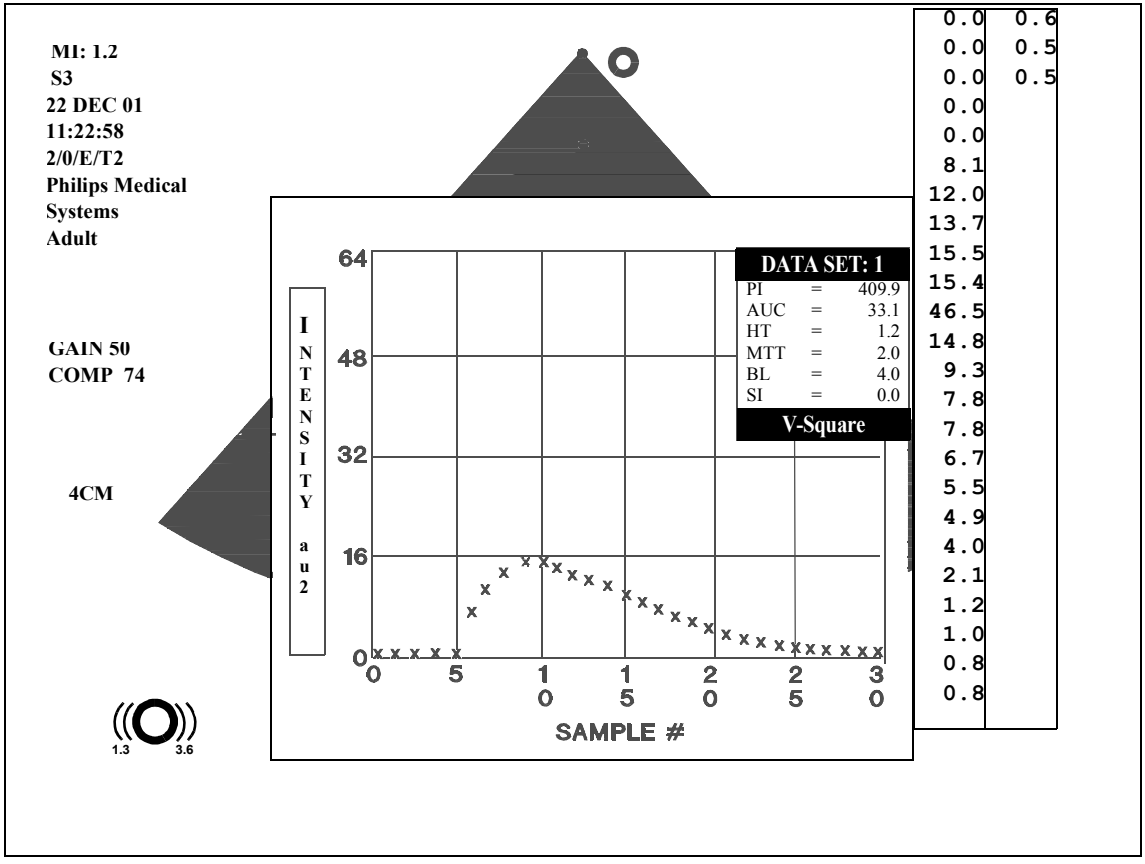


Figure 3-1 AD Screen Showing Measurement and Calculations Window For a Contrast Study

An AD analysis can be conducted in three types of studies. For each study type, the AD package provides a default set of measurements and calculations. You can change the type of measurements and calculations during a study.

1 Touch **Secondary Controls** on the right touch panel.

2 The **Calcs** rotary defaults to the current type of study. You may rotate it to select IBS, TD (Tissue Doppler), or Contrast.

NOTE: The **Calcs** rotary control appears only after measurements are taken from a sampled data set.

3 Touch **Select Calcs**. Depending on which type of study you select, one of three selection boxes appears. These selection boxes let you chose which calculations you want for each type of study:

- Contrast (see Figure 3-2)
- Integrated Backscatter (see Figure 3-3)
- Color Doppler/Color Tissue Doppler (see Figure 3-4)

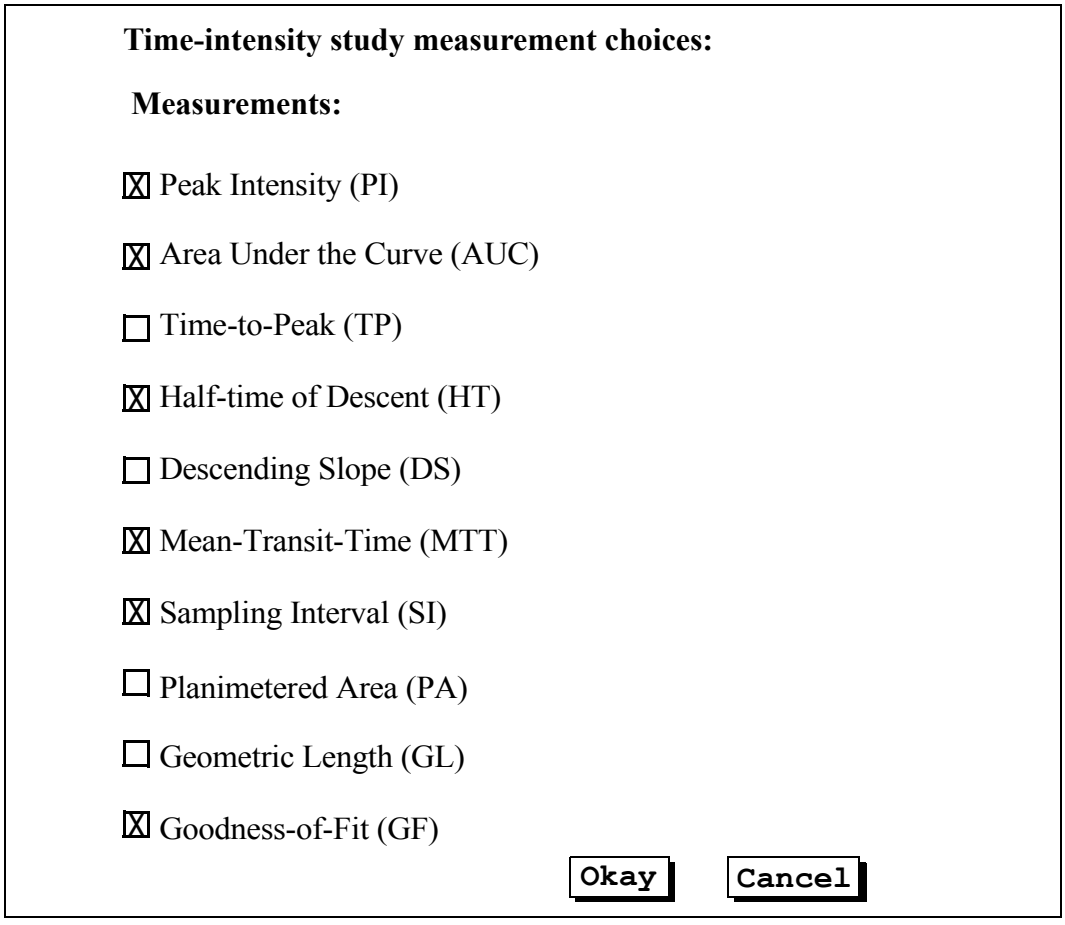


Figure 3-2 Calculations For a Contrast Study

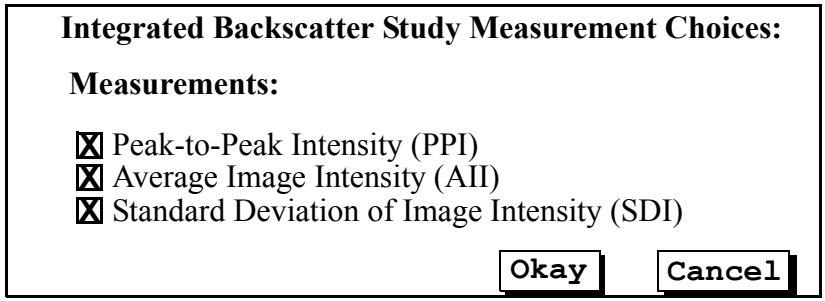


Figure 3-3 Calculations For an Integrated Backscatter Study

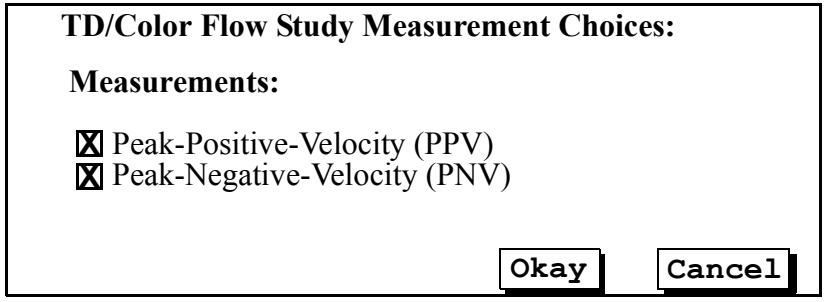


Figure 3-4 Calculations For a Tissue Doppler or Color Study

4 In the selection box, highlight the calculations you want to perform. Press Enter. An X appears in the check box. To deselect a check box, select it again and press Enter.

5 When you have made your selections, highlight Okay and press Enter.

Reference

Below is a detailed description of the measurements and calculations performed for contrast and integrated backscatter studies.

Contrast Studies

Figure 3-5 shows a time-intensity curve for a contrast study.

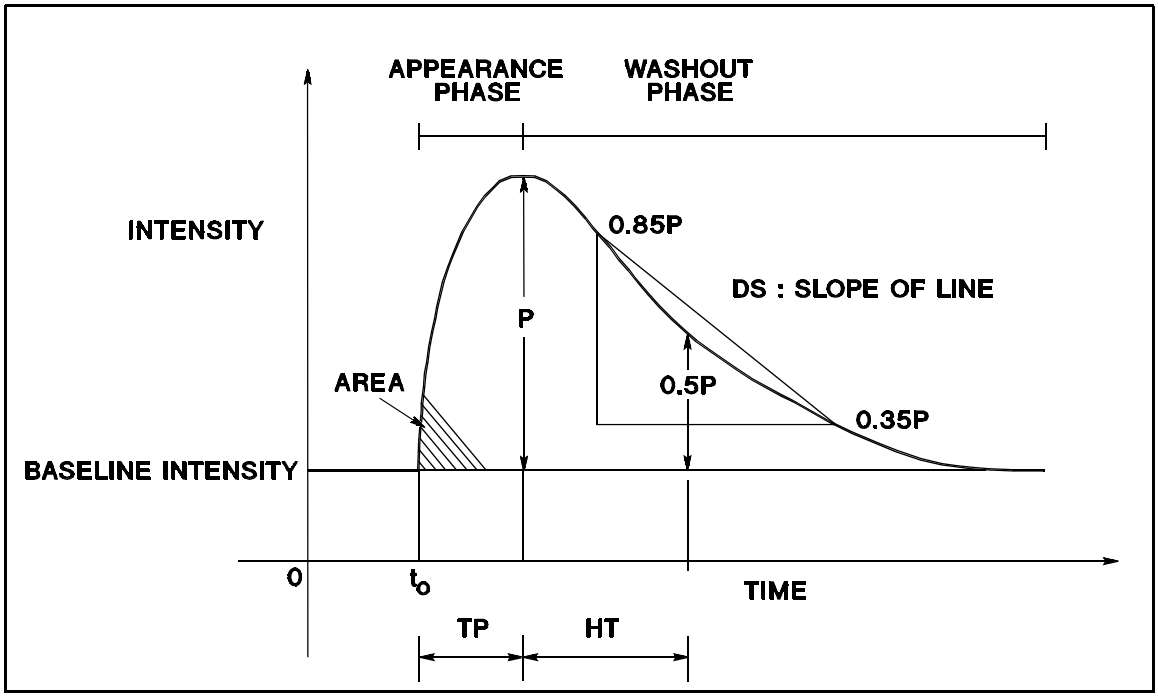


Figure 3-5 Time-Intensity Curve For A Contrast Study

For a contrast study, the following parameters are measured and computed:

Symbol	Unit	Description
BL	au,au^2,dB	Pre-contrast baseline or background intensity.
SI	sec	Sampling time interval. For ECG triggers, it is the R-R interval and for Internal triggers, it is the interval delay. For non-gated and frame-locked modes, it is the frame interval, which is 33 msec for NTSC (US) and 40msec for PAL (Europe).
PI	au,au^2,dB	Peak of the time-intensity curve after background subtraction.
AUC	au-sec, au^2-sec, dB-sec	Area under the time-intensity curve after background subtraction.
TP	sec	Time elapsed from the first appearance of contrast to the time at peak-intensity.
HT	sec	Half-time of descent of the time-intensity curve (that is, from peak intensity to half-peak intensity).
MTT	sec	Mean-Transit-Time, which represents the average time of flow of contrast within the region of interest.
DS	au/sec, au^2/sec, dB/sec	Descending slope of the time-intensity curve. For gamma-variate curvefit, the descending slope represents the maximum descending slope. For no curvefit, the descending slope is computed from the 0.85P to 0.35P points on the descending limb of the time-intensity curve.
GF	none	Goodness of fit measure of the gamma curvefit to the raw time-intensity data. A goodness of fit of 1.0 represents a very good fit, whereas a GF of 0.0 represents a very poor fit to the data. **If GF is not selected, raw and fitted data are graphed.**
GL	cm	The geometric length of a line segment on the image, using the measurement calipers.
PA	cm2	The planimetered area of a region of interest in the image, using the trace measurement calipers.

Integrated Backscatter Studies

Figure 3-6 shows a typical time-intensity curve for an integrated backscatter study.

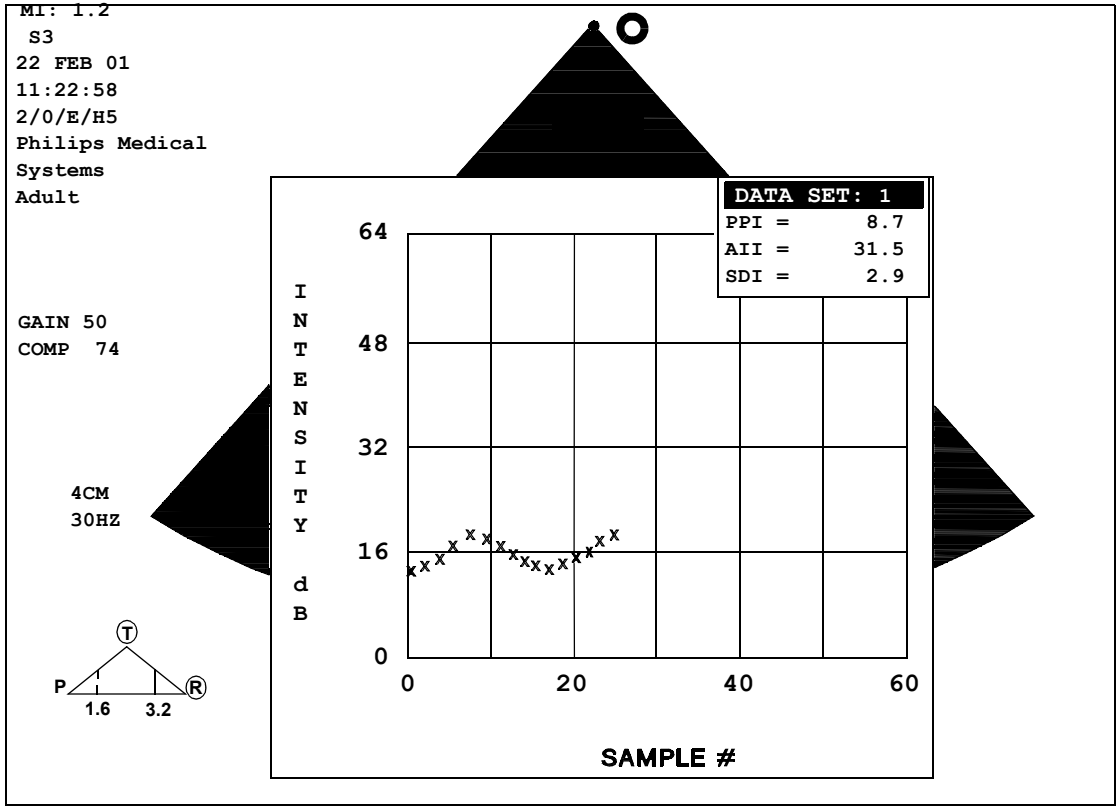


Figure 3-6 Typical Time-Intensity Curve for a Cyclic IBS Study

In an integrated backscatter study, the AD package measures and computes the following parameters:

Symbol	Unit	Description
AII	dB	Average image intensity
SDI	dB	Standard deviation of image intensity
PPI	dB	Peak-to-peak amplitude of the image intensity

Color Flow Studies

Figure 3-7 shows a time-velocity curve for color flow study.

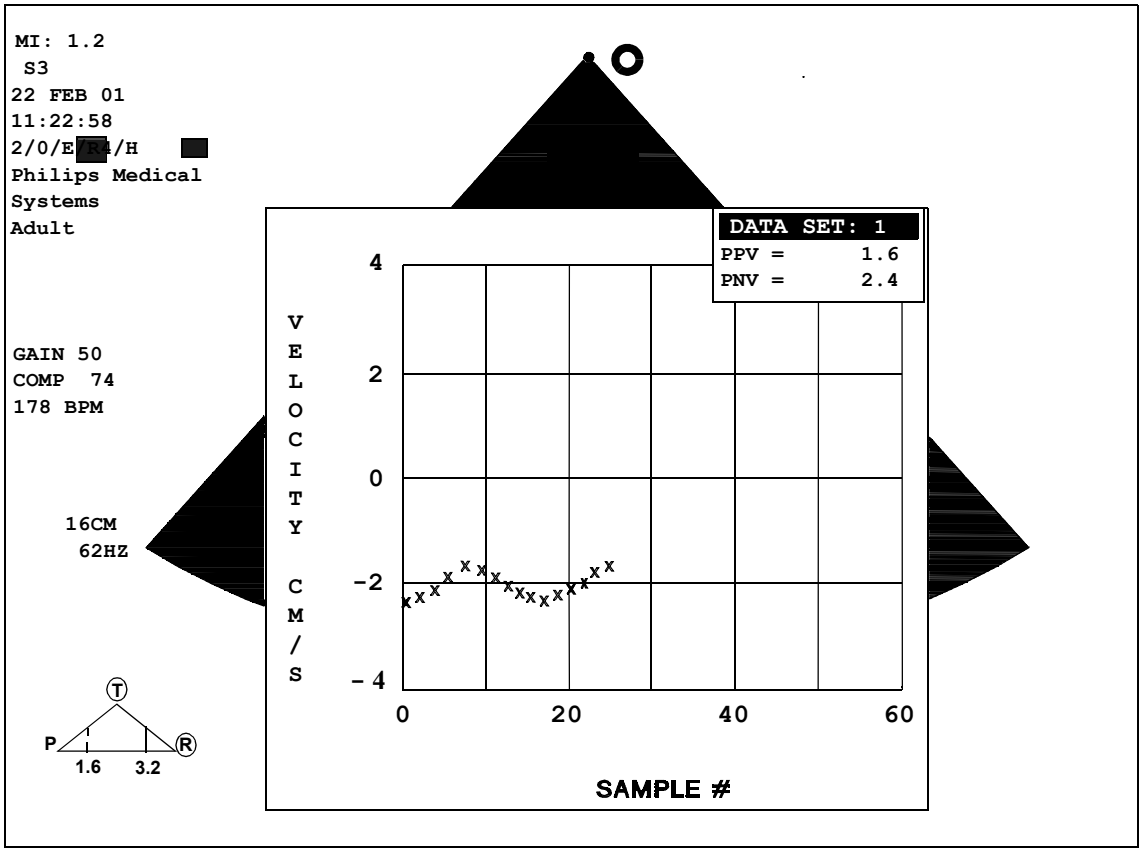


Figure 3-7 Time-Velocity Curve for a Color Flow Study

In a velocity-time study, the AD package measures and computes the following parameters:

Symbol	Unit	Description
PPV	cm/sec	Peak-Positive-Velocity of V-t curve
PNV	cm/sec	Peak-Negative-Velocity of V-t curve

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