

Doppler String Phantom

Model 043



USER GUIDE

CIRS

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OVERVIEW

Features of the Doppler String Phantom

The Doppler String phantom is a very accurate device for testing Doppler ultrasound scanners. It is especially useful for checking sample volume registration, color registration, directional discrimination, and Doppler velocity accuracy.

The Doppler String Phantom offers superior accuracy by using a string target that never changes (unlike suspended scatterers in fluid flow phantoms) and a crystal-controlled motor. The motor speed is adjusted 1000 times per second, allowing realistic reproductions of human blood flow velocity patterns and a wide range of constant velocities.

The Doppler String Phantom has been designed for ease of use. It can be set up quickly and easily with ordinary tap water. It is simple to use and almost no maintenance is required. An RS-232 interface is also provided for automated use, if desired. Ultrasound technologists, biomedical technicians, researchers and manufacturers all rely on the Doppler String Phantom for hassle-free, reliable testing.

Starting a Quality Assurance Program

Each ultrasound lab will have different Quality Assurance (QA) needs depending on equipment, maintenance agreements and applicable laws and policies. However, many technicians recommend performing QA tests every 3 months. Of course, any time you suspect a problem with an ultrasound scanner, you will want to test it immediately.

CIRS recommends using a standard form to record the results of your tests, so you can be sure that each testing session is consistent and thorough. Recording your findings also provides written documentation of your QA program. A sample QA form is provided in Appendix B of this User Guide.

SETUP INSTRUCTIONS

Parts List

When you unpack the Doppler String Phantom for the first time, you should find:

- Electronic Controller
- Acrylic tank with motor and pulleys attached
- Scanhead Clamp
- Set of 5 String Loops (not pictured)
- Rubber Diffuser Mat (not pictured)
- Power Cord (not pictured)
- Carrying Case (not pictured)



Figure 1: Doppler String Phantom

Using the Diffuser Mat

The black rubber Diffuser Mat is provided to reduce reverberations in the tank by absorbing and scattering the ultrasound beam. Place the mat in the bottom of the tank with the ridges facing up, if desired.

Installing the String

If your Doppler String Phantom was shipped in a custom carrying case, the string target is already installed. If not, you will need to install the string by doing the following:

1. Loosen the adjusting screw on the two pulleys at the end of the tank opposite the motor.
2. Take one of the string loops out of the bag and lay it over the pulley that is attached directly to the motor (Motor Pulley).
3. Draw the string half-way around the Motor Pulley, behind the two Idler Pulleys below the motor, and around the pair of Adjustable Pulleys at the other end of the tank. (See Figure 2).
4. Adjusting the string tension by moving the Adjustable Pulleys until the string is fairly tight, but not tight enough to break. The actual tension will not affect the data.

About Reverberations:

Water conducts ultrasound more efficiently than the human body, so it may be necessary to reduce the power level on your ultrasound scanner to a minimum for best results.

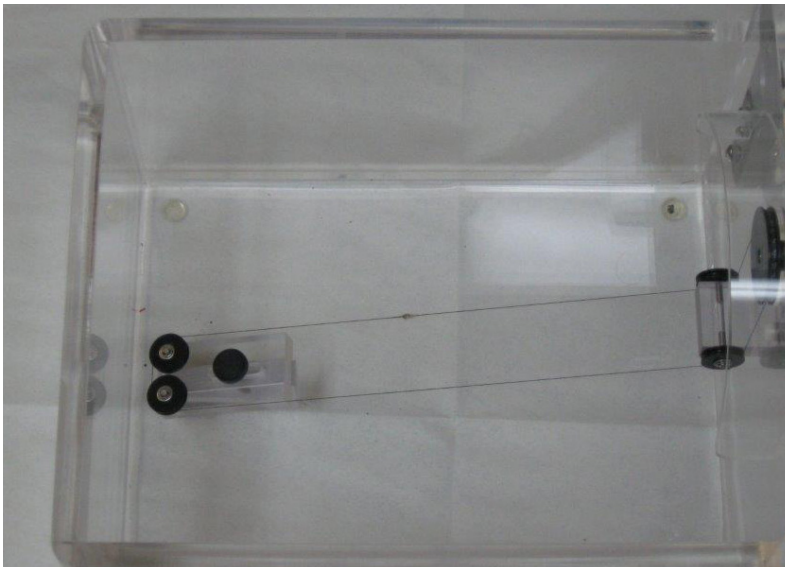


Figure 2: String Installation

FILLING THE TANK

Place the tank on a firm surface and fill it with either cold tap water or velocity-corrected fluid (see sidebar). Fill the tank until the two small pulleys beneath the motor are just submerged. This depth works well, but it may be changed to meet your needs.

After filling the tank, there will be dissolved air bubbles in the water. For best results, wait an hour before using the Doppler String Phantom so the water can de-gas.

Setting up the Clamp

The Doppler String Phantom is shipped with a scanhead clamp system consisting of a clamp (see *Figure 3*), an "arm" with a center joint and an arm attachment fixture, which is bolted to the tank. If your Doppler String Phantom was shipped in a custom carrying case, the clamp will have been set up at the factory and you should skip step 1.



Figure 3: Scanhead Clamp

1. The arm attachment fixture on the tank has two sockets. Insert one end of the arm into either of the sockets and tighten the thumbscrew.
2. Turn the clamp adjusting knob to open or close the clamp so that it fits your scanhead.
3. Adjust the clamp and articulated arm so that the transducer end of the scanhead is in the water. (See *Figure 4*). Make sure your scanhead is at the desired angle with respect to the string.

Note: Although the scanhead clamp can be placed in water temporarily, it should be stored in a dry location to prevent corrosion.

About Velocity Corrected Fluid:

The speed of sound is 1480 meters per second in water and 1540 meters per second in the human body. Doppler scanners are calibrated for 1540 meters per second, so some ultrasound professionals prefer to use a water/glycol mix that also has a speed of sound of 1540 meters per second. This mix is called velocity corrected fluid.

The Doppler String Phantom has been designed to work with either plain water or velocity-corrected fluid (H₂O/Glycol). When you turn on the power, the Doppler String Phantom will ask you which type of fluid you are using. When set for use with water, the Doppler String Phantom compensates for the different speed of sound by adjusting the speed of the string and the display indicates the speed your scanner should be detecting. When set for use with velocity-corrected fluid, the Doppler String Phantom moves the string at the actual speed indicated on the display.



Figure 4: Scanhead clamp and articulated arm

About Scanning Angles:

The best angle for most Doppler ultrasound scans is 60°. The string target in the Doppler String Phantom is set at an angle, so that a scanhead aimed straight down will be at a 60° angle to the string. Of course, you should scan at the angle that is needed for your tests.

Connecting the Controller

You are now ready to connect the controller to the motor and the power supply.

1. Before plugging in the controller make sure the power switch on the back is turned off.
2. Plug the motor cable into the **Drive Motor** receptacle on the back of the controller.
3. Plug the power cable into the **AC Receptacle** and into an AC power source. If using in a country other than the United States you will need to connect the transformer as well. This can be purchased for an additional price.

SPECIAL FEATURE

Using the ECG Output

The ECG (electrocardiogram) output is an output that the user can elect to use to synchronize the waveforms to the ultrasound scanner. It is located on the rear panel of the phantom. This is a rarely used feature that can aid ultrasound researchers as they test new ultrasound machines. Since most users of this phantom do not deal with that aspect it may be simply ignored.

When used, this output will generate a signal pulse at the very beginning of each test or physiological waveform. That pulse is 10 milliseconds long and rises from zero volts up to five volts and then back down. This may be used to tell the ultrasound researcher exactly when the waveform started and is useful for internal adjustments to the ultrasound scanner.



OPERATING INSTRUCTIONS

Using Constant Speeds

The Doppler String Phantom can be set for constant string speeds ranging from 20 to 200 cm/sec. Constant speeds are useful for a quick check to verify that your scanner is reporting correct image registration and target velocity for the scanning angle you're using. You can also detect false data caused by a broken transducer or a loose connection.

1. After setting up the Doppler String Phantom, turn on the power switch (located on the back of the controller). The display reads **UP=H2O DOWN=H2O/GLYCOL**.
2. If the tank is filled with water, press **UP**. If the tank is filled with velocity-corrected fluid, press **DOWN**. (See About Velocity-Corrected Fluid on page 4 for more information.) The display reads **SELECT A FUNCTION**.
3. Press **CONST. SPEED**; then press **UP** or **DOWN** to select the desired speed.

Note: Holding down either the **UP** or **DOWN** button causes the display to scroll faster. The motor starts automatically.

4. To reverse the direction of simulated flow, press **FLOW REV** at any time. An arrow in the bottom right corner of the display indicates the flow direction.
5. To change functions (for example, to switch from constant speeds to test waveforms), press **ESCAPE**. The display reads **SELECT A FUNCTION**.

Using Preprogrammed Waveforms

The Doppler String Phantom has several preprogrammed waveforms to help you test your ultrasound scanner under realistic conditions with velocity fluctuations you might expect in a patient. Each waveform has 1000 data points to provide accurate simulations. The waveforms are divided into two groups: test waveforms and physiological waveforms. Graphs of all the waveforms are included in Appendix A of this User's Guide.

The test waveforms are:

- Sine waves with peak speeds of 100, 150, and 200 cm/sec
- Triangle waves with peak speeds of 100, 150, and 200 cm/sec
- Stepped ramp wave with stops at 1, 20, 40, 60, 80, and 100 cm/sec

The physiological waveforms are:

- Adult common carotid
- Adult aortic
- Adult femoral
- Pediatric umbilical
- Stenotic common carotid
- Pediatric renal
- Pediatric ductus arteriosus
- Pediatric middle cerebral
- Pediatric descending thoracic

After setting up the Doppler String Phantom, turn on the power switch (located on the back of the controller). The display reads **UP=H2O DOWN=H2O/GLYCOL**.

1. If the tank is filled with water, press **UP**. If the tank is filled with velocity-corrected fluid, press **DOWN**. (See About Velocity-Corrected Fluid on page 4 for more information.)
The display reads **SELECT A FUNCTION**.
2. Press **TEST** or **PHYSIOLOGICAL** to select a waveform group.
The display shows a waveform.
3. Press **UP** or **DOWN** to select a waveform. (See Appendix A for graphs of waveforms.)
4. Press **EXECUTE** to start the motor.
5. To select a different waveform, you may press **UP** or **DOWN** at any time while the motor is running.
6. To reverse the direction of simulated flow, press **FLOW REV** at any time.
An arrow in the bottom right corner of the display indicates the flow direction.
7. To change functions (for example, to switch from physiological waveforms to constant speeds), press **ESCAPE**. The display reads **SELECT A FUNCTION**.

RS-232 INSTRUCTIONS

Introduction

The remote control software allows all of the same functions that are available from the front panel. It is primarily a serial communications feature for use with automatic testing equipment, but may be used by anyone wanting to control the phantom for standardized testing. It may be controlled by a laptop, desktop, or a process control computer.

To establish the link between the Doppler String Phantom controller and your computer, any common RS-232 communications program such as Pro-Comm Plus, Teraterm Plus, Microsoft Hyperterminal, etc., may be used. The communications program must be set to 9600, N, 8, 1. Use hardware flow control. If your computer does not have an RS-232 port, you can use an adapter available locally that will convert a standard USB port to RS-232.

Getting Started

To begin using the remote control feature:

1. Ensure the Doppler String Phantom controller is powered off (rear panel switch).
2. Plug the power cable into the **AC Receptacle** and into an AC power source. The label on the AC Receptacle indicates 120 volts. If using with 220 volts, use step down controller (Model 043-C, sold separately).
3. Plug the custom RS-232 cord (supplied with the Doppler String Phantom) into the **RS-232** receptacle on the back of the controller.
4. Plug the motor cable into the **Drive Motor** receptacle on the back of the controller.
5. Start the communications program.
6. Turn on the power on the controller (rear panel switch).

The following text should appear on your computer screen:

MARK 4 DOPPLER PHANTOM

MARK 4 MENU
C - CONSTANT SPEED
S - SET CONSTANT SPEED, CM/S
T - TEST WAVES
P - PHYSIOLOGICAL WAVES
U - UP KEY
D - DOWN KEY
E - EXECUTE KEY
Enter - EXECUTE KEY
R - REVERSE FLOW
Esc - ESCAPE KEY
^H - COMMAND MENU
^Z - RESTART PROGRAM
^L - LOCKOUT FRONT PANEL KEYS
^U - UNLOCK FRONT PANEL KEYS

SELECT H2O OR H2O/GLYCOL
FOR THE FLUID IN THE TANK
UP= H2O DOWN=H2O/GLYCOL

*

If this text does not appear check all connections and try again. When the text appears the system is ready to test.

Notes: When entering commands either upper or lower case may be used. Upper case is used in this manual for easier reading. Between each command wait until the controller responds that it's ready for the next command.

Accessing the Help Menu

The Help Menu (shown below) can be displayed at any time by entering <Ctrl>+H. The Help Menu is also displayed automatically upon power-up.

MARK 4 MENU
C - CONSTANT SPEED
S - SET CONSTANT SPEED, CM/S
T - TEST WAVES
P - PHYSIOLOGICAL WAVES
U - UP KEY
D - DOWN KEY
E - EXECUTE KEY
Enter - EXECUTE KEY
R - REVERSE FLOW
Esc - ESCAPE KEY
^H - COMMAND MENU
^Z - RESTART PROGRAM
^L - LOCKOUT FRONT PANEL KEYS
^U - UNLOCK FRONT PANEL KEYS

Selecting Velocities and Waveforms

Constant Speeds

The following example demonstrates how to generate various Doppler target velocities:

To create a constant flow at 52 cm/sec the following steps must be taken:

1. Turn the controller on or enter **<Ctrl> Z** to restart the program.
2. Issue **U** or **D** to select the type of fluid in the tank.
3. Issue **C** to select Constant speeds.
4. Issue **S52** to select a speed of 52 cm/sec.

Note: Only whole numbers are allowed for velocities.

Test Waveforms

To select a changing velocity profile such as a sine wave that ranges from -100 cm/sec to +100 cm/sec the following steps must be taken:

1. Turn the controller on or enter **<Ctrl> Z** to restart the program.
2. Issue **U** or **D** to select the type of fluid in the tank.
3. Issue **T** to select Test waves. The screen displays '100 Sine'.
4. To select a different waveform issue **U** to move up the list. Continue issuing **U** or **D** until the desired waveform is displayed.
5. Issue an **<Enter>** command to execute the selected waveform.

Human Waveforms

To select a human Doppler waveform such as the 'Common Carotid' waveform the following steps must be taken:

1. Turn the controller on or enter **<Ctrl> Z** to restart the program.
2. Issue **U** or **D** to select the type of fluid in the tank.
3. Issue **P** to select Physiological waves. The screen displays 'Common Carotid'.
4. To select a different waveform issue **U** to move up the list. Continue issuing **U** or **D** until the desired waveform is displayed.
5. Issue an **<Enter>** command to execute the selected waveform.

Flow Reversal

To reverse the flow direction of any constant speed or waveform first execute the desired speed or waveform and then issue an R. The target string will stop and then accelerate up to the desired speed or waveform in the opposite direction.

Setting up for Quality Control Testing

The following example demonstrates how to test ultrasound machines for Doppler accuracy at 100 cm/sec at the end of the manufacturing process.

1. Insert the ultrasound machine's probe into the holder on the tank.
2. Prepare the ultrasound machine to send Doppler data to the process controller machine. Enter the insonation angle to the process controller if not already done.
3. Turn on the Doppler phantom or issue a cold start with **<Ctrl> Z**.

4. Issue the following commands:

U

C (motor starts at 10 cm/sec)

S100

<Enter>.

5. The controller will increase the velocity from the initial 10 cm/sec to 100 cm/sec and hold. Read in the velocity data from ultrasound machine and compare to the phantom. This completes the procedure.

Locking the Settings:

To prevent the phantom settings from being changed at the front panel while operating via remote control, issue a **<Ctrl> L** command from the remote computer. To unlock the settings, issue a **<Ctrl> U** command. Unlocked mode is the default setting at startup and after restarting with **<Ctrl> Z**.

Description of Commands Available Via RS-232

C	CONSTANT SPEED	Used to select constant velocity. Velocities must be whole numbers; decimal numbers are not allowed.
S	SET CONSTANT SPEED, CM/S	Used only when controller is already in constant speed mode. Issue an S command followed immediately by a whole number between 10 and 200, for example S52<Enter>. Decimal numbers are not allowed.
T	TEST WAVES	Used to access test waveforms.
P	PHYSIOLOGICAL WAVES	Used to access physiological waveforms.
U	UP KEY	Used to select water type in tank, move up in the menus and to increase constant speeds.
D	DOWN KEY	Used to select water type in tank, move down in the menus and to decrease constant speeds.
E	EXECUTE KEY	Used to select options currently displayed.
<Enter>		Same as EXECUTE button.
R	REVERSE FLOW	Used to reverse the direction of the Doppler target string in all modes.
Esc	ESCAPE KEY	Used to shut down motor driving the Doppler target string and go back to basic mode selection.
^H	HELP MENU	Used to display the list of available commands.
^Z	RESTART PROGRAM	Used to cancel and clear all entries and start over. This is equivalent to dropping power to the unit and turning it back on.
^L	LOCK OUT FRONT PANEL KEYS	Used to block all commands from front panel of controller. While in Lockout mode all buttons are ignored.
^U	UNLOCK FRONT PANEL KEYS	Used to allow commands to be entered from the front panel of the controller. This is the default startup condition.

MAINTENANCE INSTRUCTIONS

Making String Loops

Occasionally, string loops break and need to be replaced. You can order sets of 20 preformed loops from CIRS (*See Preformed String Loops for more information*) or make your own loops using these instructions. In general you want your string loop to have a small unobtrusive knot that will roll smoothly over the pulleys in the tank.

1. Set up two pins 15 3/16 inches (38.5 cm) apart. Push pins on a wooden measuring stick works well.
2. Form a loop of string around the pins. Any type of string will work but 3-0 surgical silk is recommended because of its ultrasound scattering properties.
3. Tie a knot to secure the loop and trim the ends to about 1/4 inch (6 mm) long.
4. Put a very small dot of super glue on the knot. The glue should not soak into the ends of the string and make them stiff.
5. After the super glue has dried roll the ends of the string between your fingers to separate the threads as much as possible.
6. Apply rubber cement to the knot and string ends allow it to dry slightly and then roll the knot between your fingers to form a smooth ball.

Ordering String Loops

You can order a pack of 20 preformed string loops made from 3-0 surgical silk. The Part number is 043SL. Please call for current prices.

Cleaning the Doppler String Phantom

The Doppler String Phantom is designed to be virtually maintenance-free. You can clean the controller and tank with a soft cloth dampened with water and mild detergent. Do not use disinfectants or solvent-based cleaners or sprays. Avoid using solvents because they could weaken the tank.

Calibrating the Doppler String Phantom

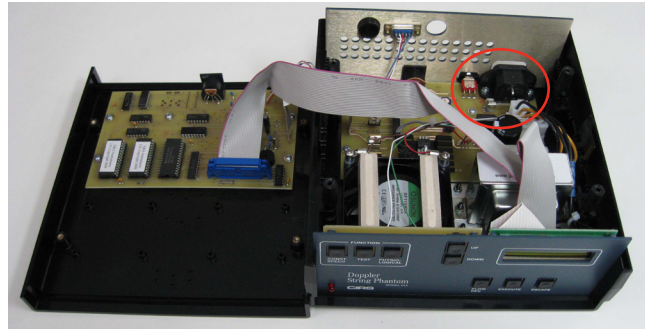
The Doppler String Phantom is computer-controlled so you don't need to make any adjustments. However, many customers choose to send their Doppler String Phantom back to CIRS each year for calibration certification. The string speeds are checked at a variety of settings, using instruments that are certified according to the National Institute of Standards and Technology (NIST). After verifying that the Doppler String Phantom is functioning correctly, CIRS provides a calibration certificate and a complete test report. Contact CIRS for more information regarding calibration service.

How to replace a fuse

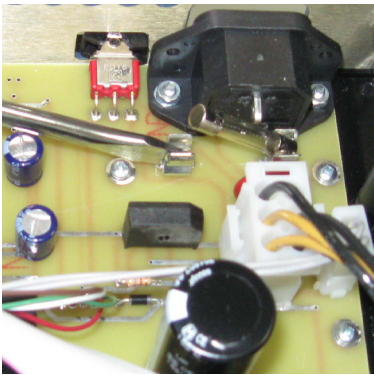
The Doppler String Phantom contains a fuse that may need to be replaced periodically. If the unit does not power up, first check the cord and power source. If all of the connections are properly in place then the fuse may need to be replaced.



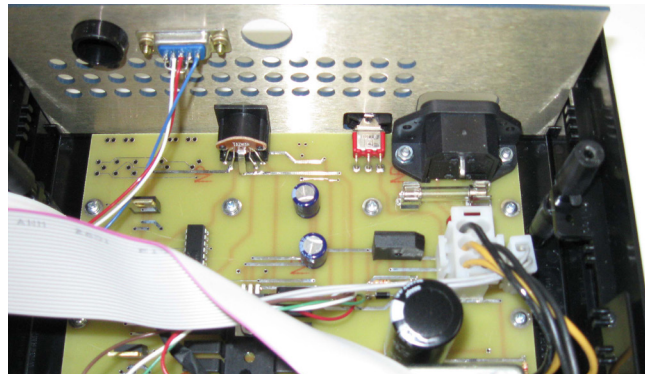
Unplug the unit from the power source and locate the 4 screws on the bottom of the controller. Remove these screws.



Open the controller. The fuse is found in the back, right side of the controller.



Use a screwdriver to flip up one end of the fuse and remove it.



Replace the fuse (2A 250V). Ensure fuse is properly seated and replace the top of the controller. Replace the screws into the bottom of the controller.

ACCESSORIES AND PARTS

Carrying Case

To protect your investment, the Model 043 comes standard with a foam-lined, rigid carrying case. The case is hermetically sealed and includes castors and a retractable handle for easy transport. The carrying case is highly recommended for customers who plan on travelling with or shipping their Doppler String Phantom.

Preformed String Loops

You can order a pack of 20 preformed string loops made from 3-0 surgical silk. The Part number is 043SL. Please call for current prices.

Step Up and Down Transformer

CIRS offers a 220V step up/down transformer to be used with the Doppler String Phantom, when using outside of the USA. The Part number is 043-C. Please call for current pricing.

WARRANTY

All standard CIRS products and accessories are warranted by CIRS against defects in material and workmanship for a period as specified below. During the warranty period, the manufacturer will repair or, at its option, replace, at no charge, a product containing such defect provided it is returned, transportation prepaid, to the manufacturer. Products repaired in warranty will be returned transportation prepaid.

There are no warranties, expressed or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description on the face hereof. This expressed warranty excludes coverage of, and does not provide relief for, incidental or consequential damages of any kind or nature, including but not limited to loss of use, loss of sales or inconvenience. The exclusive remedy of the purchaser is limited to repair, recalibration, or replacement of the product at manufacturer's option.

This warranty does not apply if the product, as determined by the manufacturer, is defective because of normal wear, accident, misuse, or modification.

Non-Warranty Service

If repairs or replacement not covered by this warranty are required, a repair estimate will be submitted for approval before proceeding with said repair or replacement.

Returns

If you are not satisfied with your purchase for any reason, please contact your local distributor prior to returning the product. Visit <https://www.cirsinc.com/distributors/> to find your local distributor. If you purchased your product direct through CIRS, call Customer Service at 800-617-1177, email rma@cirsinc.com, or fax an RMA request form to 757-857-0523. CIRS staff will attempt to remedy the issue via phone or email as soon as possible. If unable to correct the problem, a return material authorization (RMA) number will be issued. Non-standard or "customized" products may not be returned for refund or exchange unless such product is deemed by CIRS not to comply with documented order specifications. You must return the product to CIRS within 30 calendar days of the issuance of the RMA. All returns should be packed in the original cases and or packaging and must include any accessories, manuals and documentation that shipped with the product. The RMA number must be clearly indicated on the outside of each returned package. CIRS recommends that you use a carrier that offers shipment tracking for all returns and insure the full value of your package so that you are completely protected if the shipment is lost or damaged in transit. If you choose not to use a carrier that offers tracking or insure the product, you will be responsible for any loss or damage to the product during shipping. CIRS will not be responsible for lost or damaged return shipments. Return freight and insurance is to be pre-paid.

With RMA number, items may be returned to:

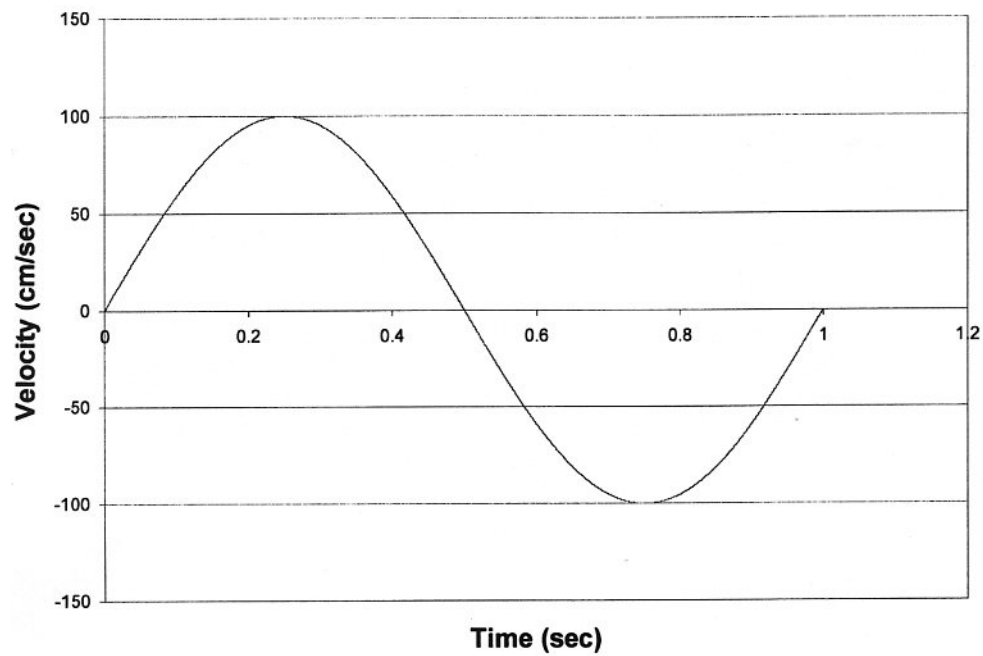
CIRS
Receiving
900 Asbury Ave,
Norfolk, Virginia, 23513 USA

Product	Warranty Period
Model 043 - Doppler String Phantom	24 Months

APPENDIX A - GRAPHS OF WAVEFORMS

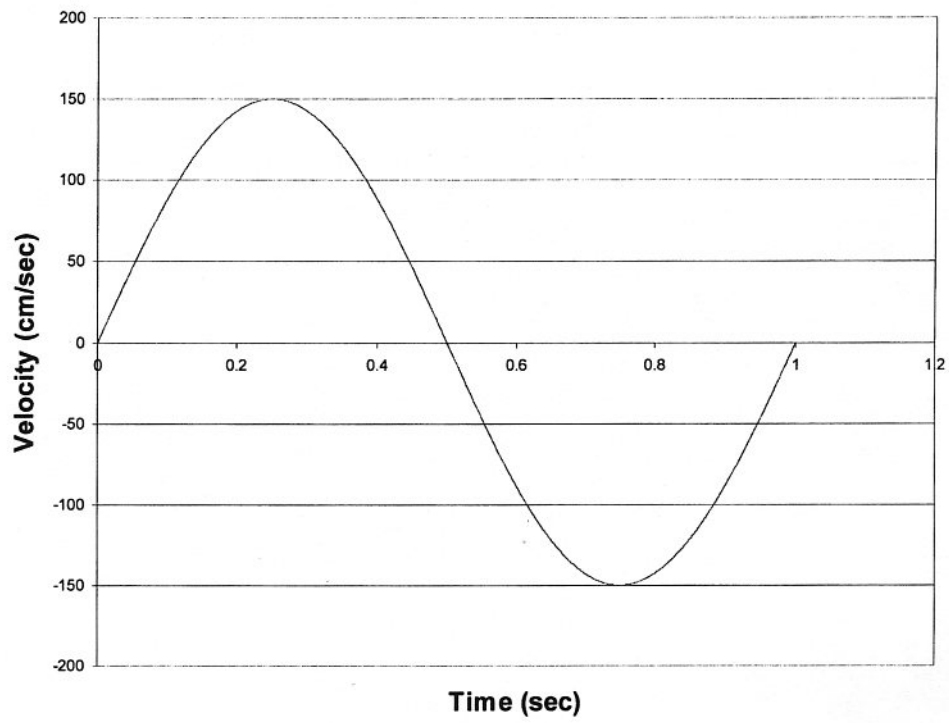
TEST WAVEFORMS

Sine Wave, 100 cm/sec



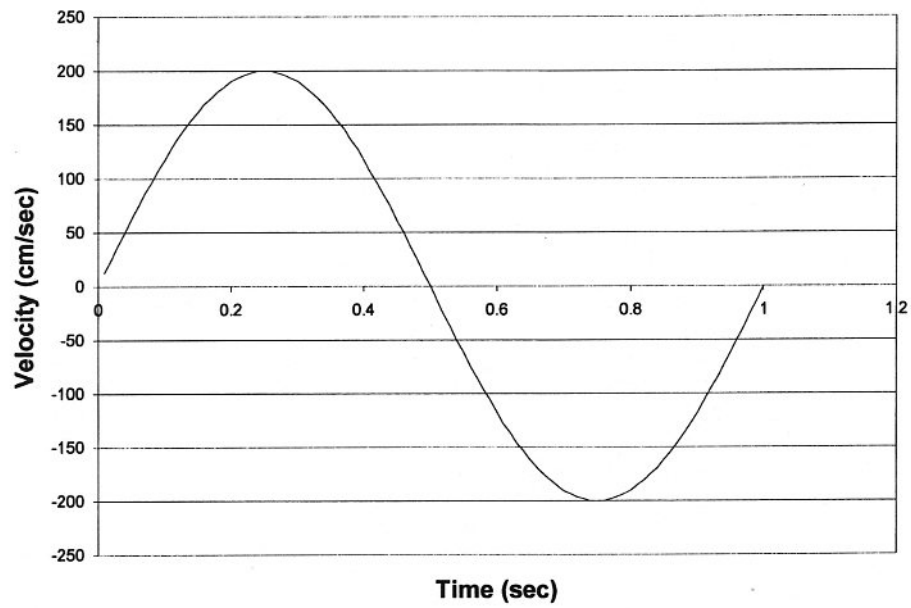
APPENDIX A - GRAPHS OF WAVEFORMS

Sine Wave, 150 cm/sec



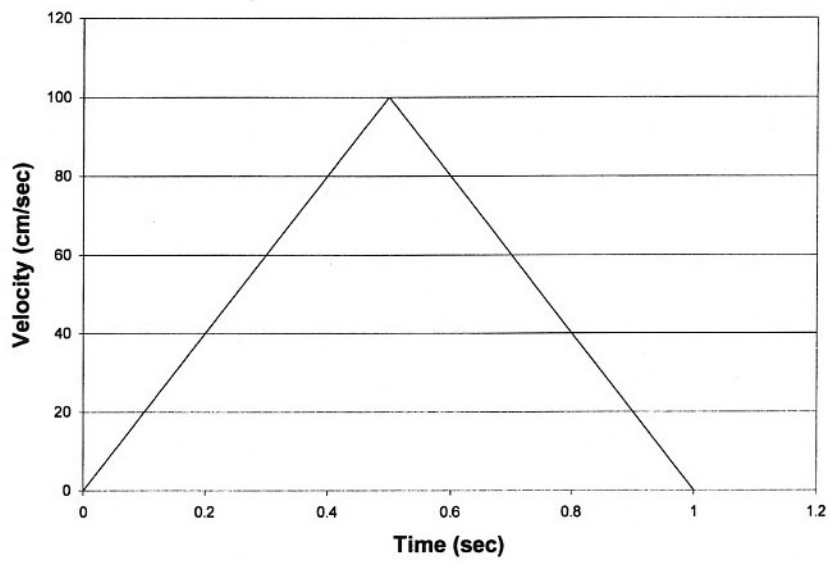
APPENDIX A - GRAPHS OF WAVEFORMS

Sine Wave, 200 cm/sec

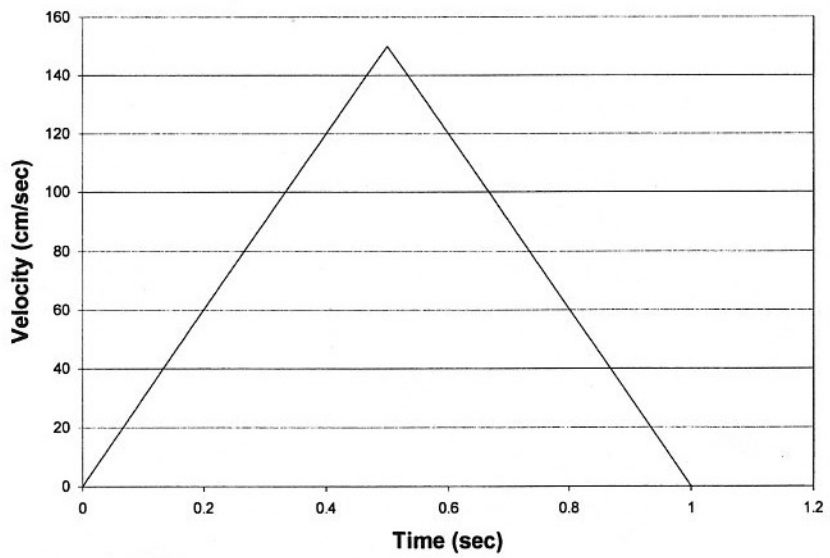


APPENDIX A - GRAPHS OF WAVEFORMS

Triangle Wave, 100 cm/sec

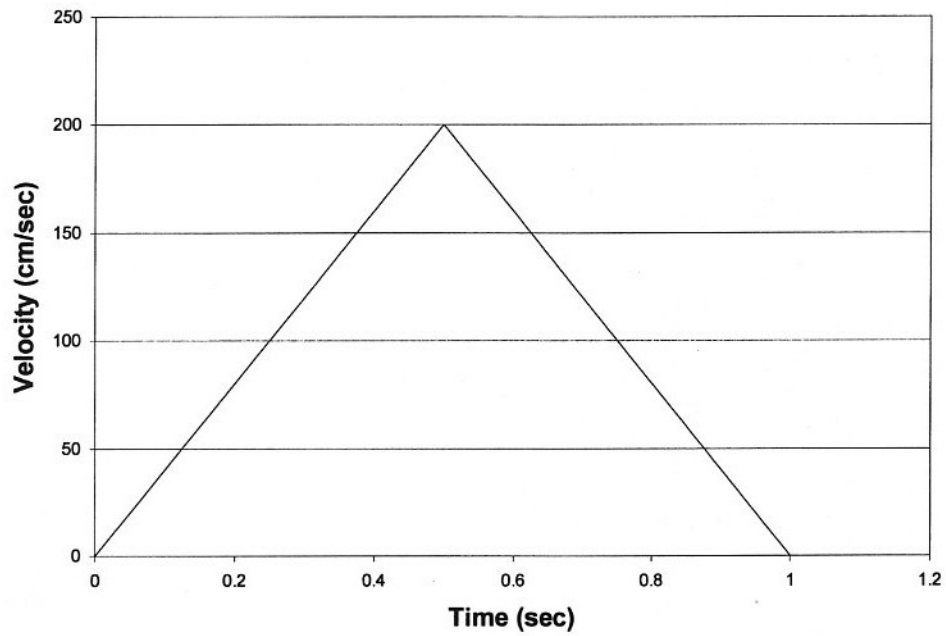


Triangle Wave, 150 cm/sec

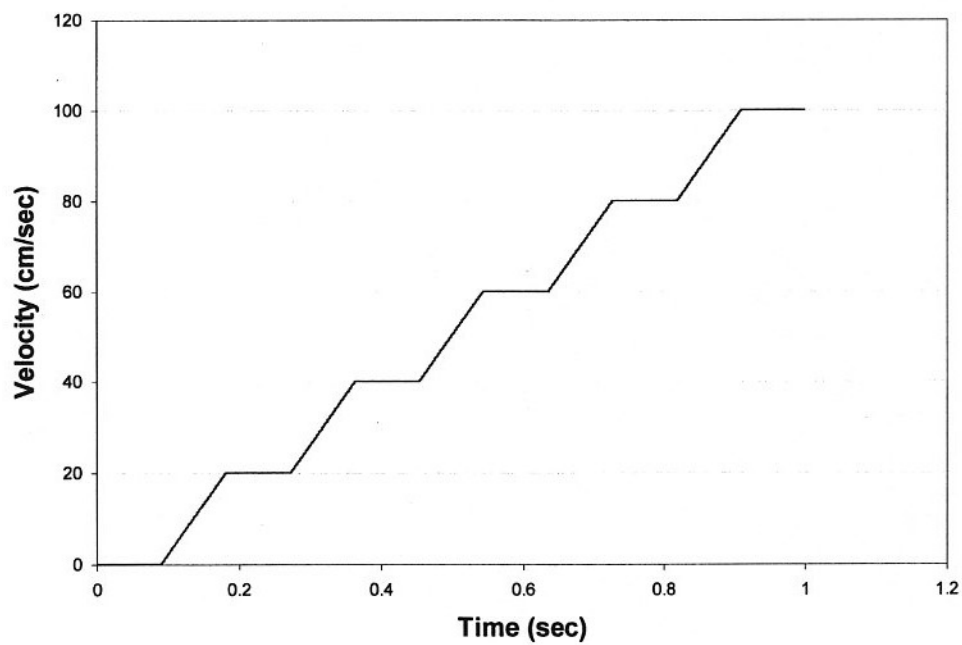


APPENDIX A - GRAPHS OF WAVEFORMS

Triangle Wave, 200 cm/sec



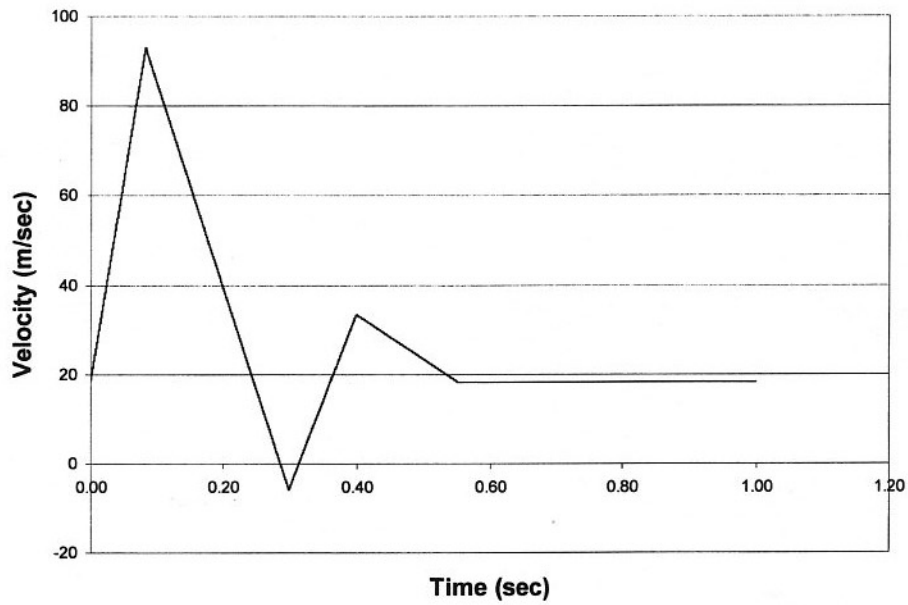
Stepped Ramp



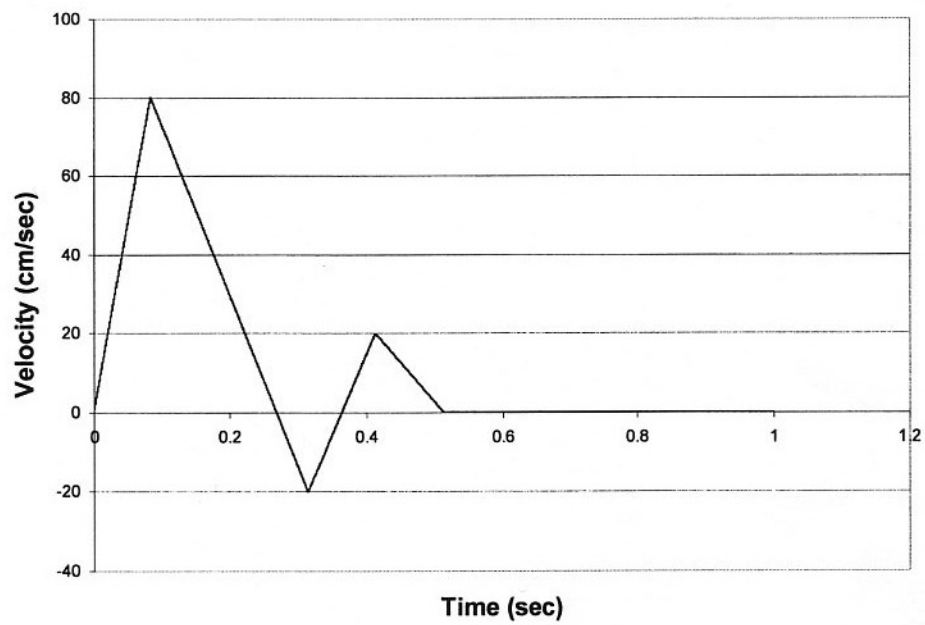
APPENDIX A - GRAPHS OF WAVEFORMS

PHYSIOLOGICAL WAVEFORMS

Adult Common Carotid

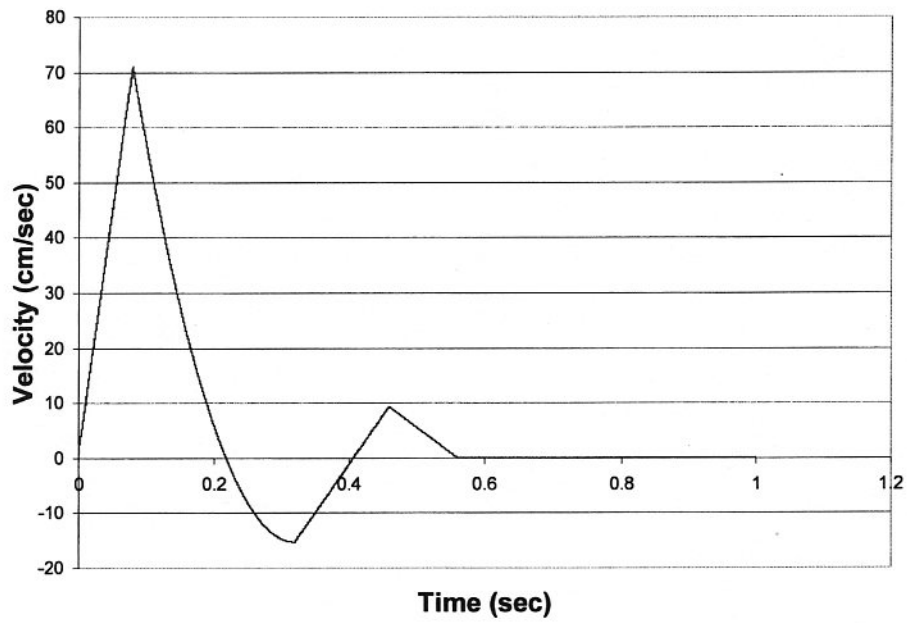


Adult Aortic



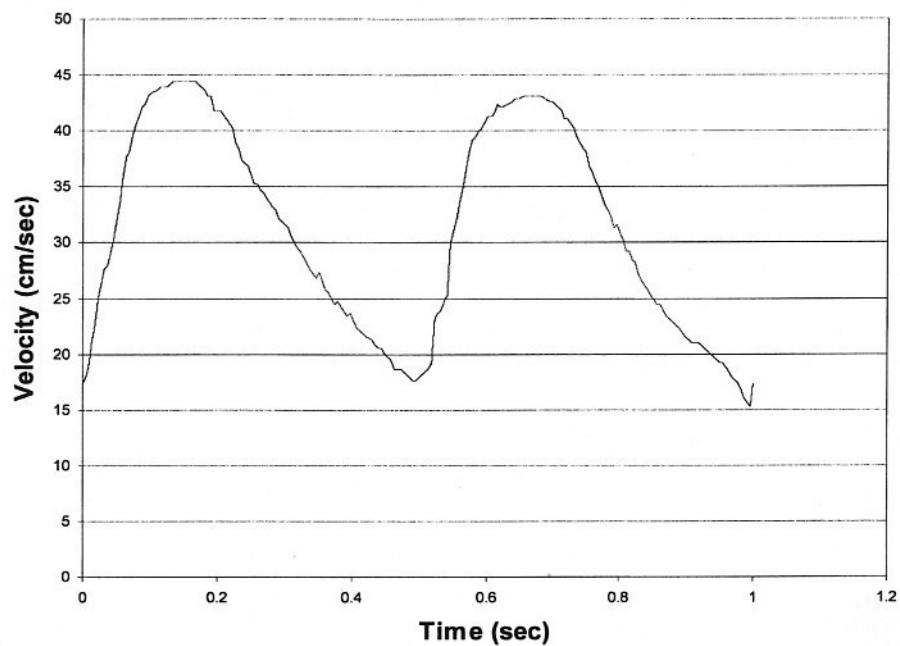
APPENDIX A - GRAPHS OF WAVEFORMS

Adult Femoral

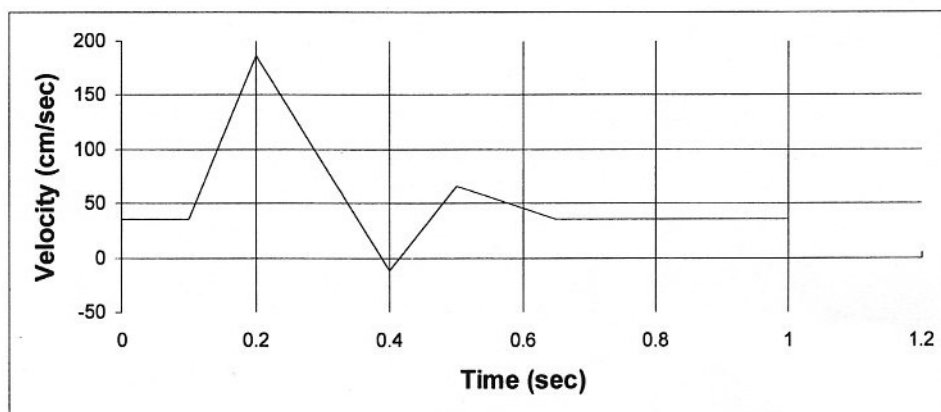


APPENDIX A - GRAPHS OF WAVEFORMS

Pediatric Umbilical

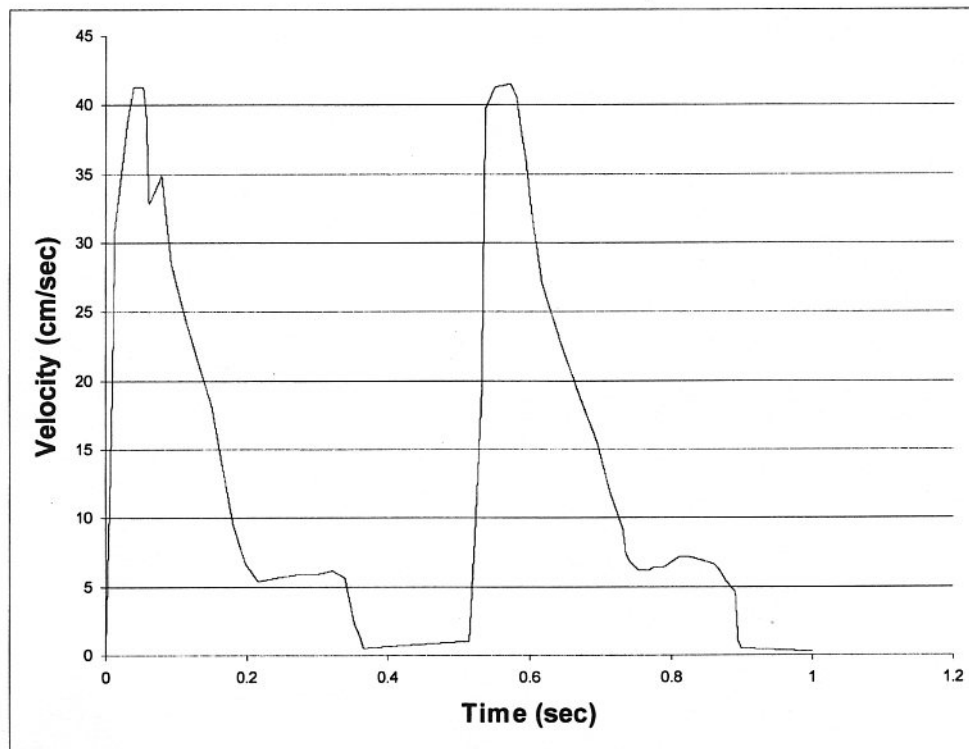


Stenotic Common Carotid



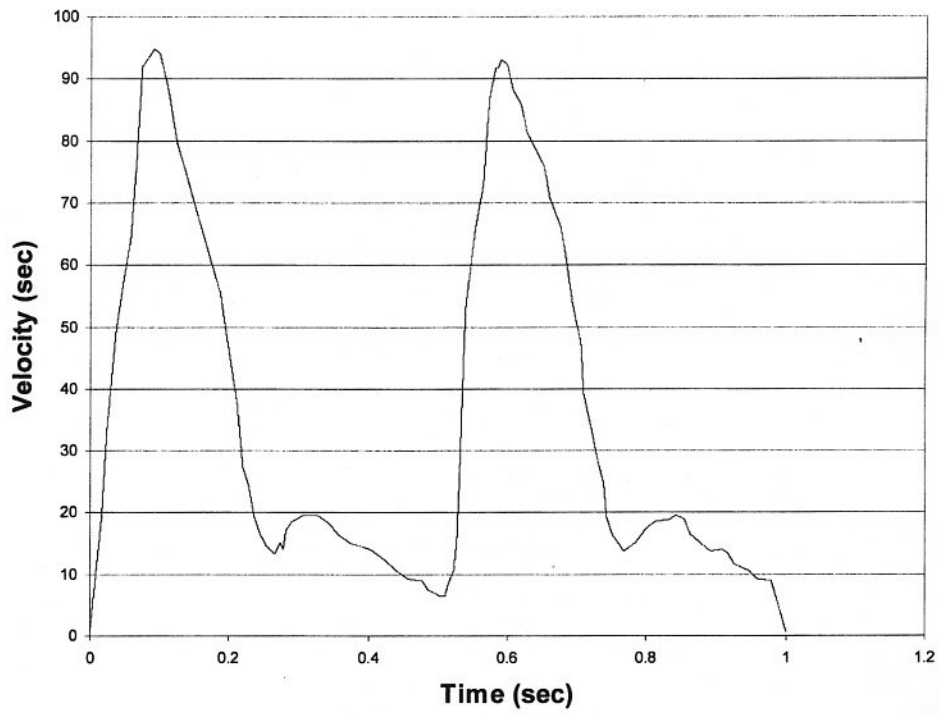
APPENDIX A - GRAPHS OF WAVEFORMS

Pediatric Renal



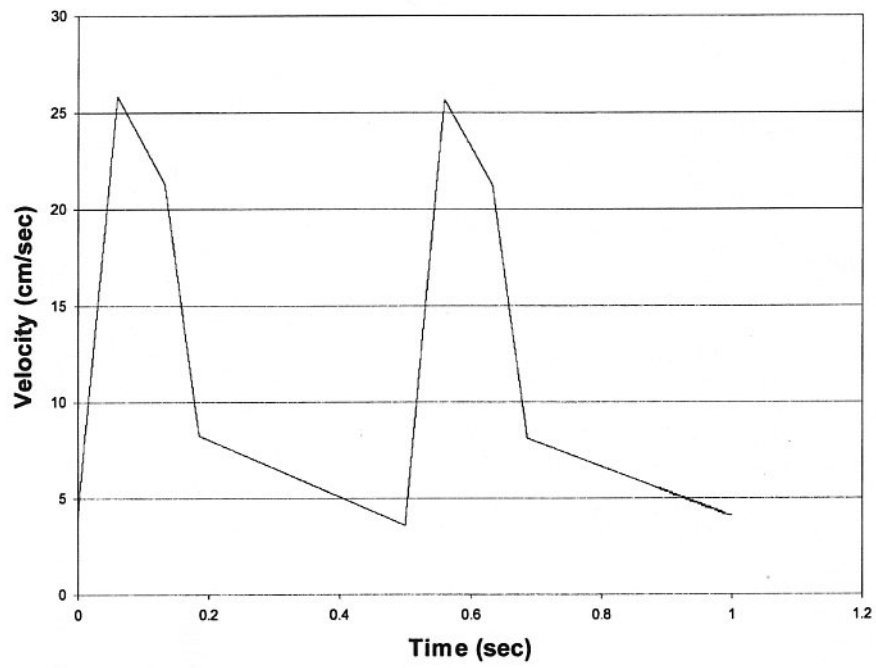
APPENDIX A - GRAPHS OF WAVEFORMS

Pediatric Ductus Arteriosus



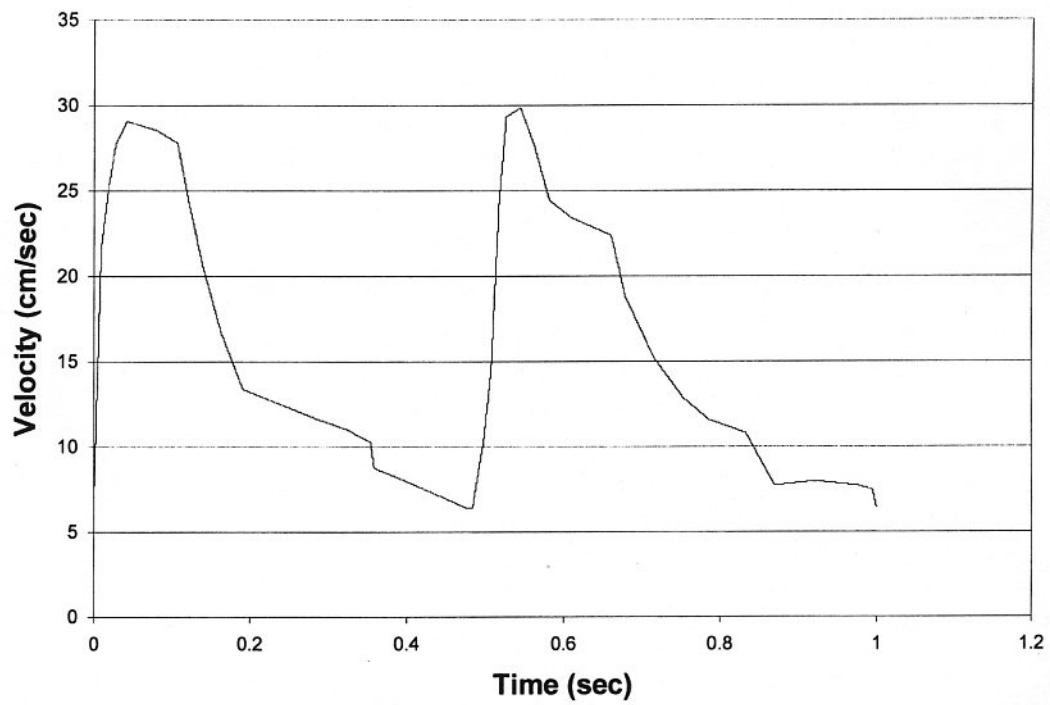
APPENDIX A - GRAPHS OF WAVEFORMS

Pediatric Middle Cerebral



APPENDIX A - GRAPHS OF WAVEFORMS

Pediatric Descending Thoracic



Sample QA Form

(Example Page)

Doppler Mode Inspection

System Model _____ Serial # _____ Probe type _____

Sample Volume Registration (to string target)

√ = on target, or enter ± mm

√	√	√	√						
---	---	---	---	--	--	--	--	--	--

Date: 1/08 4/08 7/08 10/08

Color Registration (to string target)

√ = on target, or enter ± mm

√	√	√	√						
---	---	---	---	--	--	--	--	--	--

Date: 1/08 4/08 7/08 10/08

Directional Discrimination

color	√	√	√	√					
spectr	√	√	√	√					
audio	√	√	√	√					

Date: 1/08 4/08 7/08 10/08

Doppler Velocity Accuracy

(Continuous speed, angle corrected at 60 degrees to string target.)

√ = in spec, or enter velocity observed in cm/sec

200	√	√	√	19					
150	√	√	√	14					
100	√	√	√	√					
60	√	√	√	58					
30	√	√	√	√					

Date: 1/08 4/08 7/08 10/08

Doppler Velocity Accuracy

(Continuous speed, angle corrected at 45 degrees to string target.)

√ = in spec, or enter velocity observed in cm/sec

200	√	√	√	20					
150	√	√	√	15					
100	√	√	√	√					
60	√	√	√	62					
30	√	√	√	√					

Date: 1/08 4/08 7/08 10/08

APPENDIX B - SAMPLE QA FORM

Note: This page may be reproduced for customer use.

Doppler Mode Inspection

System Model _____ Serial # _____ Probe type _____

Sample Volume Registration (to string target)

√ = on target, or enter ± mm

--	--	--	--	--	--	--	--	--	--

Date:

Color Registration (to string target)

√ = on target, or enter ± mm

--	--	--	--	--	--	--	--	--	--

Date:

Directional Discrimination

color										
spectr										
audio										

Date:

Doppler Velocity Accuracy

(Continuous speed, angle corrected at 60 degrees to string target.)

√ = in spec, or enter velocity observed in cm/sec

200										
150										
100										
60										
30										

Date:

Doppler Velocity Accuracy

(Continuous speed, angle corrected at 45 degrees to string target.)

√ = in spec, or enter velocity observed in cm/sec

200										
150										
100										
60										
30										

Date:

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