Trident Digitiser

User Guide

Nanometrics Inc.
Kanata, Ontario
Canada

Trident Digitiser User Guide

The information in this document has been carefully reviewed and is believed to be reliable. Nanometrics, Inc. reserves the right to make changes at any time without notice to improve the reliability and function of the product.

This product uses the Java™ 2 Runtime Environment (J2RE) Standard Edition, which includes code licensed from RSA Security, Inc. Some portions licensed from IBM are available at http://oss.software.ibm.com/icu4j/

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Contents

List of Tables

Chapter 1 Getting Started

This section provides introductory information about the product and this manual, guidelines for checking the shipment, and technical support contact information.

1.1 About the Trident digitiser

The Trident 24-bit digitiser has 142 dB dynamic range, and programmable front end gain to support a wide range of sensor types. Trident can be used with a sensor having up to three channels, or six channels with two daisychained units. A partner product, such as the Cygnus VSAT or Janus-IP communications controller, supplies GPS timing and data communications.

Trident is easy to install and operate. The modular design and NMXbus connection to the partner products allows Trident to be installed in the sensor vault, requiring only a short sensor cable; the weather-sealed enclosure also allows Trident to be installed outdoors. The graphical user interface provides options for instrument configuration and monitoring, and sensor control and calibration, all from the central site.

1.2 Unpacking the shipment

Note The information in this section should be used in conjunction with system warranty information.

Open the shipment and check the contents for completeness against the packing slip. Visually inspect the equipment for any damage that may have occurred in transit. There is a configuration sheet containing specific configuration information for each Trident digitiser included in the shipment. If there are any problems with the shipment, please contact Nanometrics Support.

1.3 About this User Guide

This User Guide contains basic procedural information for installing, operating, and configuring the Trident digitiser, and general reference information. See also related documents, listed in section 1.3.1.

- Chapter 1, “Getting Started”, includes an introduction to the Trident digitiser and to this manual, guidelines for unpacking the shipment, and technical support contact information.
- Chapter 2, “Technical Description”, includes an overview of Trident function and features.
- Chapter 3, “Using the Trident”, includes information on installation, operation, maintenance, and configuration.
- Appendices:
  - Appendix A, “Specifications”
  - Appendix B, “Connectors”
  - Appendix C, “Cables”
  - Appendix D, “Filter Response”
  - Appendix E, “Sensor-Digitizer Interconnection”

1.3.1 Related documents

1.3.1.1 Configuration sheets

The configuration sheet lists the serial numbers of the parts shipped, the hardware configuration, and any calibration parameters associated with the hardware. The configuration described on the configuration sheet determines how the Trident will operate on the initial startup.

1.3.1.2 Software reference manual pages

- Nanometrics User Interface, for overview information on monitoring the operation and changing configuration parameters on an installed Trident and associated instruments
- Naqs (Naqs Server, Naqs Client), for data acquisition and monitoring

1.4 Technical support

Read the appropriate sections of this manual carefully before installing, operating, or configuring the Trident digitiser.

If you need technical support, please submit your request by email or fax. Include a full explanation of the problem and supporting data, to help us direct your request to the most knowledgeable person for reply.

email: support@nanometrics.ca

FAX: To: Support
+1 (613) 592-5929

Chapter 2 Technical Description

This section provides a brief description of the Trident digitiser functions and features.

2.1 Trident Overview

The Trident digitiser receives an analog signal from differential sensors and relays digitised data to an external comms controller instrument such as a Janus-IP or Cygnus VSAT, for transmission to the acquisition centre(s). Power, and timing, data communications, and configuration services are supplied via the NMXbus by an associated comms controller instrument.

The modular, rugged design allows Trident to be installed either in the sensor vault, requiring only a short sensor cable, or outdoors. The NMXbus allows two Tridents to be daisy-chained, for example to provide six-channel input, or to allow more than one sensor to share the same NMXbus.

Trident provides 24-bit resolution and a 142 dB dynamic range. Trident can digitise from one to three channels of data—or six channels with two daisychained units—with sample rates from 10 to 1000 sps. Software filters include a decimating Finite Impulse Response (FIR) filter which is required for low pass filtering of the data, and an optional Infinite Impulse Response (IIR) high pass filter to remove the DC offset from the data. The software programmable front-end gain supports a wide range of sensor types.

Configuration parameters are stored in flash memory. This is read on system initialization, to set values for parameters such as sample rate, front end gain, and timing resynchronization. The Nanometrics User Interface provides means for remotely monitoring and controlling digitiser and sensor operation. This includes options for operation monitoring, submitting new instrument configurations, upgrading Trident firmware and EPLD code, and sensor calibration and control. Trident and sensor state of health information that can be monitored through the UI includes mass position, and NMXbus data transmission statistics. (See also Chapter 3, “Using the Trident”.)

Trident can be used to deliver regulated DC power to some sensors. One of the sensor power output options listed below will have been specified for the Trident at the time the order was placed for the unit. (If a power output option was not specified, the first option is used.)

- Raw NMXbus voltage (9-36 V, depending on battery/charger)
- Dual ouput / low power (±12 V, 3 W)
- Single output / low power(+12 V, 3 W)
- Single output / high power (+12 V, 7 W)

Requirements for interconnecting Trident with high-performance sensors are described in Appendix E.

2.2 Timing

Trident uses high precision timing, supplied via the NMXbus by a TimeServer contained in a communications controller/transceiver instrument such as a Janus or Cygnus.

The TimeServer is essentially a GPS disciplined clock: the TimeServer system time is synchronized to UTC time provided by GPS. The TimeServer is able to provide time even when GPS signal reception is temporarily interrupted, by maintaining time with its internal clock. The user has the option to accept data acquired during gaps in GPS signal reception, and can make decisions using time quality information generated by the TimeServer.

Time-related messages carried on the NMXbus are the time, frequency error, time error, and accuracy. Timing-related information, such as time quality and GPS satellite tracking information, can be accessed through the user interface for instruments associated with the Trident (see the separate Nanometrics UI manual).

2.3 Data transmission

Trident sends digitised data via the NMXbus to a communications controller/transceiver instrument, such as a Janus or Cygnus, for transmission to the acquisition centre. For transmission over the communications link, data are compressed using a first difference compression algorithm, packetised into NMX packets, and are then sent with a CRC for error detection.

Each packet includes a comprehensive header which holds parameters such as the sequence number, time in long seconds, and the oldest packet available. Packets are stamped with UTC time, with time synchronization provided by the TimeServer. For transmission using IP, NMX packets are embedded into UDP packets prior to transmission.

In addition to being transmitted to the central site, each NMX packet can be stored in the comms controller memory if a corresponding ringbuffer is created. If the data are not received at the central station by the Naqs data acquisition software, a request is generated for retransmission (retransmission request is an optional setting). On the receipt of the retransmission request, the communications controller fetches the requested packet from its memory and queues it for transmission. The comms controller memory is a ringbuffer type, in which the oldest packet is continuously overwritten by the newest one.

The Trident and associated instruments generate state-of-health (SOH) messages which are sent to the NaqsServer software (using the UDP protocol) and to the user interface (using the TCP protocol). This SOH information can be used to simplify network maintenance. There are a number of configurable parameters for controlling the operation of the Trident digitiser, sensor, and associated instruments. These parameters can be accessed and edited through the user interface (see Chapter 3, “Using the Trident”, and the separate Nanometrics UI User Guide).

Chapter 3 Using the Trident

This section of the manual describes how to install, operate, configure, and maintain the Trident digitiser.

3.1 General precautions

- Back up the CD that is shipped with the system.
- Keep a record of all post-delivery changes made to the hardware and firmware.

3.2 Installation

Trident is typically installed in the remote site equipment vault or hut, using the mounting plate to secure the unit to a wall. The weather-sealed enclosure optionally allows Trident to be installed outdoors. Information about the Trident must be added to the Naqs station file for the instrument to be recognized in the acquisition network.

1. Purchase from Nanometrics or build NMXbus and sensor cables appropriate to your application. (Refer to Appendix B, “Connectors”, and Appendix C, “Cables”, for information on building NMXbus and sensor cables. See also Appendix E, “Sensor-Digitizer Interconnection”.)
2. Mount the Trident digitiser on the support hardware.
3. Plug the sensor and NMXbus cables into the appropriate connectors on the Trident.

   Trident can be used to deliver regulated DC power to the seismometer. Alternatively, connection to the seismometer should be made via a power insertion box, designed to carry through all other connections including all shields.

Caution The safety ground connection is carried through to the seismometer chassis via the sensor cable outer shield, therefore additional grounding of the seismometer chassis is not recommended.

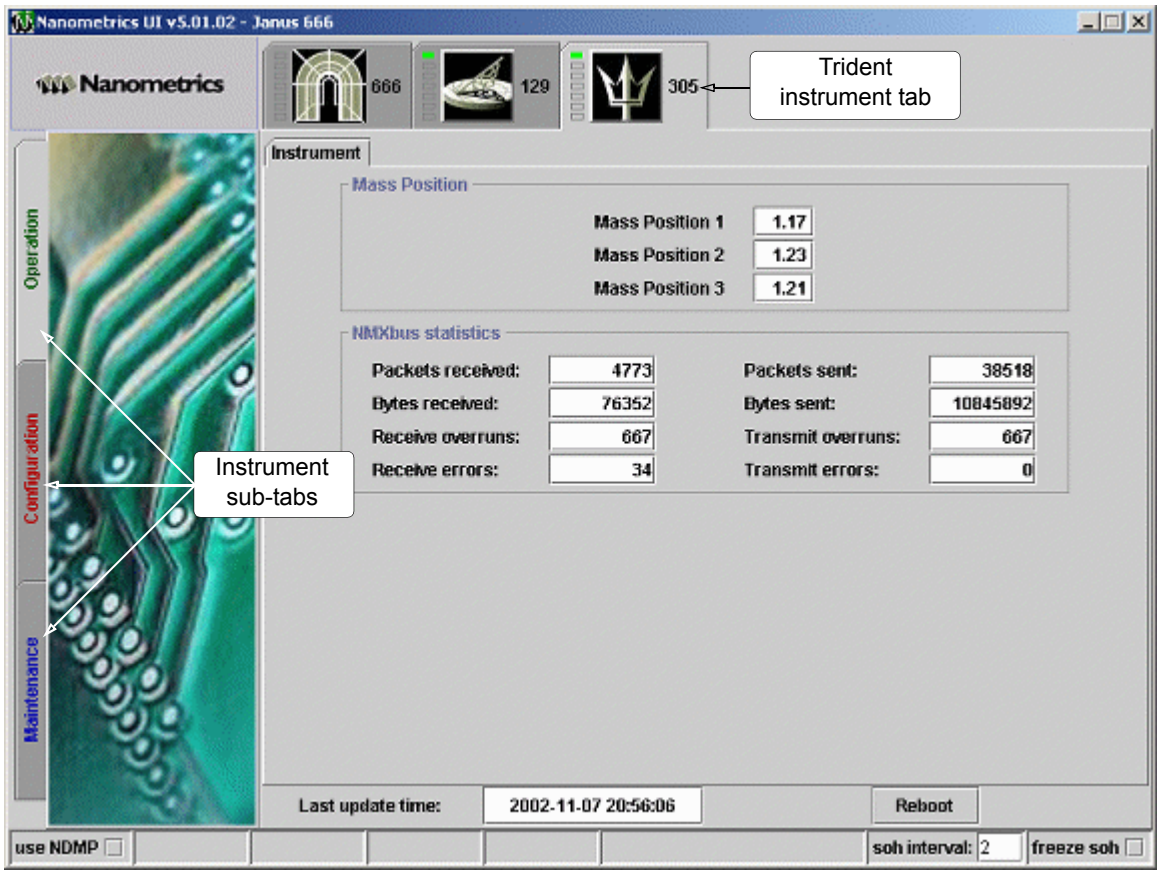
4. Safety ground the Trident: Safety ground should be made at the Trident case by connecting between the ground lug and earth ground in the equipment vault.

5. Ensure that the Trident is included in the Naqs station file (see the separate Naqs Server manual pages.)

3.3 Nanometrics UI

Most of the operation monitoring, configuration, and maintenance for Trident is done through the Nanometrics User Interface. Monitoring and configuration information is grouped in instrument sub-tab panels under the Trident instrument tab (Figure 3-1). See the separate Nanometrics UI manual for general information on using the Nanometrics UI and for detailed descriptions of the parameters.

Figure 3-1 Nanometrics UI example

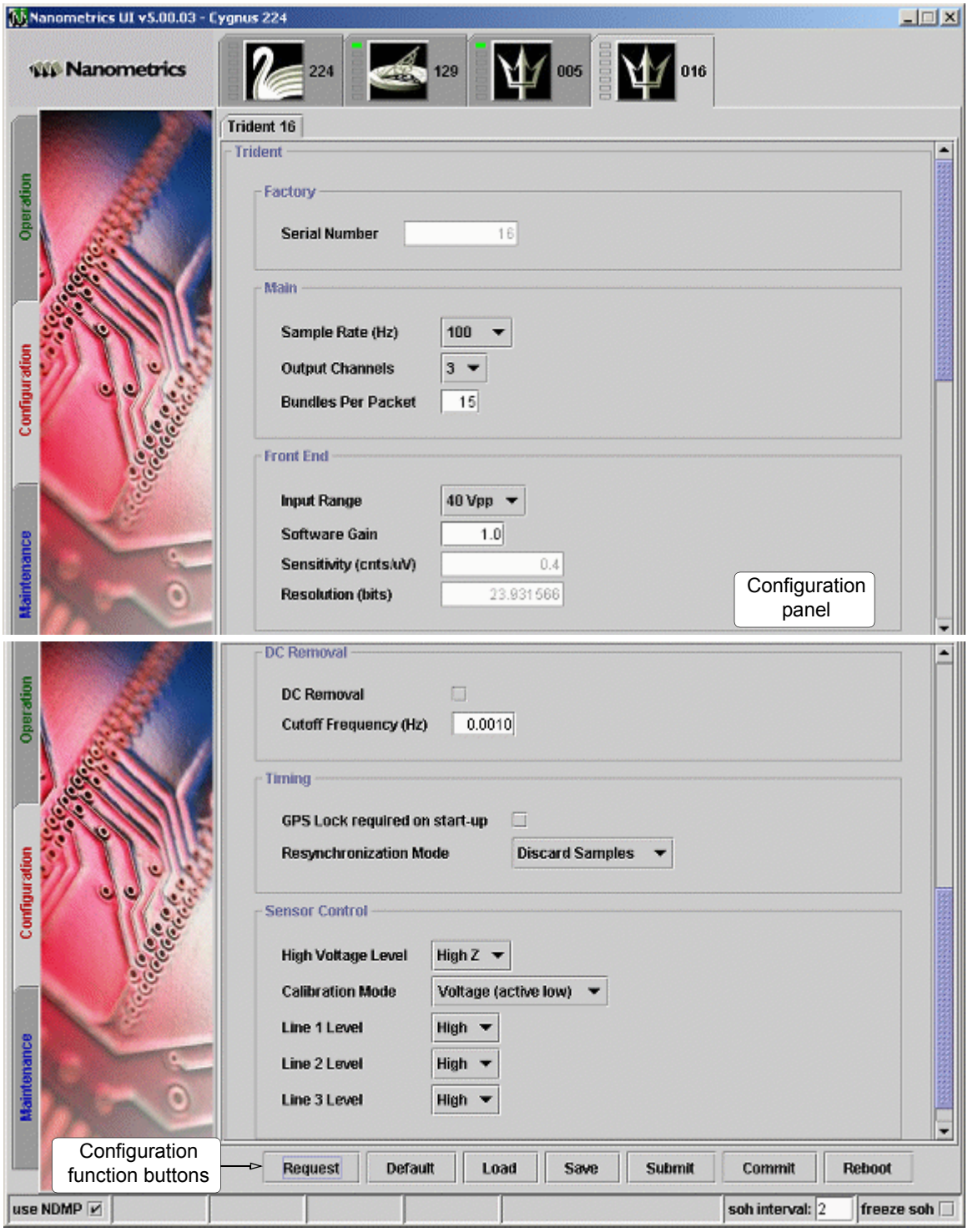


3.4 Operation Monitoring

Some of the state-of-health information for monitoring Trident operation is displayed in the Nanometrics UI, on the Operation sub-tab for the Trident instrument. This includes mass position and NMXbus statistics. Additional SOH information is available in the data stream, including internal temperature, and calibration in progress. (See also Table A-11, “Digitiser internal SOH specifications,” on page 26.)

3.5 Configuration

Figure 3-2 Trident configuration window



The Nanometrics User Interface provides options for changing the Trident configuration. Most of the configuration settings can be viewed by a user with any level

of access, but changing the configuration requires tech access. This section contains information specific to Trident; see the separate Nanometrics UI manual for general information on using the UI, and for configuration options for partner instruments such as Janus or Cygnus.

The configuration window for a Trident (Figure 3-2 on page 9) includes a scrolling panel that provides access to configuration parameters, and a row of configuration function buttons.

The configuration panel provides options to view current settings and to edit some parameter values, for any Tridents connected to a comms controller partner instrument. (The UI obtains the configuration from the Trident, so the options that are visible may vary from the example shown in Figure 3-2.)

The function buttons allow a user with tech access to perform various actions, for example to restore a default configuration, or submit a new configuration to test before committing it to the instrument flash.

3.5.1 Configuration parameters

Note Trident uses NDMP protocol, therefore select this option when requesting data.

The configuration panel provides options to view current settings and to edit some parameter values for any Tridents connected to a comms controller partner instrument such as a Janus or Cygnus. The configuration parameters are grouped into six main sections:

- Factory
- Main
- Front End
- DC Removal
- Timing
- Sensor Control

3.5.1.1 Factory

The only parameter in the Factory section is Serial Number, which contains the serial number of the Trident digitiser. This value is read only.

3.5.1.2 Main

Table 3-1 Trident Main configuration parameters

Parameter	Description
Sample Rate (Hz)	The sampling rate on the sensor signal. • Options are: 10, 20, 40, 50, 100, 120, 200, 500, 1000. Default is 100. ▸ Select a sample rate from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Output Channels	The number of channels to output over the bus to the network terminal. • Options are: 0, 1, 2, 3. Default is 3. ▸ Select the number of output channels from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Bundles Per Packet	The number of bundles per packet for transmission from the instrument. • Valid range is 7 to 28. Default is 15. ▸ Type in a value to set bundles per packet. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence); a value that is outside the valid range displays as red text.

3.5.1.3 Front End

Table 3-2 Trident Front End configuration parameters

Parameter	Description
Input Range (V_{p-p})	The voltage range for the sensor input. The input voltage ranges represent the differential between the positive and negative signal inputs. For example, for the $40V_{pp}$ input range, the maximum input is +20V differential, with +10V on the positive signal input and -10V on the negative signal input. Similarly, the minimum input is -20V differential, with -10V on the positive signal input and +10V on the negative signal input. • Options are: 2, 4, 8, 16, 40. Default is $40V_{pp}$. ▸ Select an input voltage range from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Software Gain	Use this parameter to set the ADC front end gain, to attenuate or amplify the sensor input signal to a level that will optimise use of the digitiser dynamic range. • Valid range is 0.001 to 100. Default is 1.0. ▸ Type in a value for the software gain. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence); a value that is outside the valid range displays as red text.

Table 3-2 Trident Front End configuration parameters (Continued)

Parameter	Description
Sensitivity (cnts/µV)	Read only. Displays digitiser sensitivity in counts per microvolt, determined by the input voltage range and gain settings. **Input Range (V_{pp}) — Recommended Sensitivity (counts/µV)** 40 — 0.4 16 — 1 8 — 2 4 — 4 2 — 8 ▸ To obtain an updated value for the digitiser sensitivity, ensure that the option use NDMP is enabled, and then click Request.
Resolution (bits)	Read only. Displays the number of bits of resolution for the output. ▸ To obtain an updated value for the resolution, ensure that the option use NDMP is enabled, and then click Request.

3.5.1.4 DC Removal

Table 3-3 Trident DC Removal configuration parameters

Parameter	Description
DC Removal	This parameter defines whether the DC removal filter is used on data output over the bus into memory. • Default is no DC removal (option not checked) ▸ Click to enable ☑ or disable ☐ DC removal.
Cutoff Frequency (Hz)	The cutoff frequency for the DC removal filter • Valid range is 0.001Hz to 1.0Hz ▸ Type in a value to set cutoff frequency. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence); a value that is outside the valid range displays as red text.

3.5.1.5 Timing

Table 3-4 Trident Timing configuration parameters

Parameter	Description
GPS Lock required on start-up	This parameter defines whether GPS lock is required before the Trident starts digitising on startup. • Options are: Enabled, not enabled. Default is GPS lock not required (not enabled) ▸ Click to enable ☑ or disable ☐ GPS lock required on startup.

Table 3-4 Trident Timing configuration parameters (Continued)

Parameter	Description
Resynchronization Mode	This parameter defines how the Trident makes a time correction in its sample timing. Options are described in the section below, Selecting a Resynchronization Mode. • Options are: Discard Samples, Slow Coarse Lock, No UTC Alignment ▸ Select a resynchronization mode from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).

3.5.1.5.1 Selecting a Resynchronization Mode

Time errors are typically introduced because the TimeServer had to perform a time correction when its GPS relocked after a prolonged interval of free-running. The magnitude of the TimeServer time correction is dependent on the length of time the GPS was unlocked and the stability of the ambient temperature of the Timeserver.

Three resynchronization mode options are selectable from a drop-down list to configure how the Trident will behave when making a correction in its sample timing (Table 3-5). For all three modes, time errors between 1.25 µs and the time correction threshold are corrected by using the TIME (coarse lock) mode. The TIME mode will run the clock slightly off frequency until the time error is eliminated. The TIME mode is also used to correct the remaining time error after any time correction. The actual time error of the Trident from the Timeserver is always reported in the Trident PLL Status bundle.

Table 3-5 Resynchronization Mode options

Option	Description
Discard Samples	Discard Samples is the default resynchronization mode. A time correction is performed in a multiple of 100 µs when the time error between the Trident and Timeserver exceeds 66.7 µs. To preserve data quality, the FIR filters buffers are flushed of their samples and the FIR filtering is disabled for a few hardware samples, so that the first output sample occurs on a UTC aligned multiple of the output sample period. Advantages: • All output samples are UTC aligned. • Very low maximum time error (66.7 µs) between the Trident and Timeserver. • Very little time is spent in the TIME (coarse lock) mode, so that time error between the Trident and Timeserver is brought under 1.25 µs very quickly. Disadvantages: • Hardware samples are discarded during a time correction so the last sample before the time correction is not one sample period before the first sample afterwards. • A gap in data slightly larger than the FIR filter period is introduced. For example, when sampling at 100 Hz, the FIR filter period is 36254 hardware samples or 1.2084667 seconds; results in gaps of 1.21 seconds.

Table 3-5 Resynchronization Mode options (Continued)

Option	Description
Slow Coarse Lock	A time correction is performed in a multiple of the output sample period when the time error between the Trident and Timeserver is greater than 2/3 the output sample period. For example, for 100 samples per second, the time correction is performed in multiples of 10 ms when the time error exceeds 6.67 ms. Before digitizing has started, the time corrections are performed in multiples of 100 µs to minimize the time error. Advantages: • All output samples are UTC aligned. • Fewer time corrections are performed in this mode than any other because the threshold is much higher. • No hardware samples are discarded during a time correction, so that the last sample before the time correction is still exactly one sample period before the first sample afterwards. Disadvantages: • May require several hours in TIME (coarse lock) mode to slowly correct some time errors, especially when using low sample rates. • Time errors of up to 6.66 ms between the Trident and Time-server may occur when sampling at 100 Hz. • May not be suitable on an NMXBus with multiple Tridents where simultaneous sampling of all channels is required at all times.
No UTC Alignment	A time correction is performed in a multiple of 100 µs when the time error between the Trident and Timeserver exceeds 66.7 µs. When first starting to digitize, after power-on or after a reboot, the output samples are UTC aligned. The Trident can be rebooting via the user interface to restore the output samples to UTC alignment. Advantages: • Very low maximum time error (66.7 µs) between the Trident and Timeserver. • Very little time is spent in the TIME (coarse lock) mode, so that time error between the Trident and Timeserver is brought under 1.25 µs very quickly. • No hardware samples are discarded during a time correction, so that the last sample before the time correction is still exactly one sample period before the first sample afterwards. Disadvantages: • UTC alignment is not preserved after a time correction, there-fore the actual phase of the output samples in the output sample interval is not always the same. For example, when sampling at 100 Hz after performing a time correction of -1.1 ms, the first sample output in each second will be time stamped as xx.0089 rather than xx.0000. • Is not suitable for networks where simultaneous sampling is required.

3.5.1.6 Sensor Control

Table 3-6 Trident Sensor Control configuration parameters

Parameter	Description
High Voltage Level	The high voltage level for sensor control signals output. • Options are: High Z (open drain), +5 V, +12 V. Default is High Z. ▸ Select a high voltage level from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Calibration Mode	The sine calibration mode. The active high level is defined by control High Voltage Level (cannot be set to Voltage (active high) if control High Voltage Level is set to High Z). When calibrating a channel, the corresponding enable/return is set to this level. When not calibrating a channel, signal and enable/return are open. • Options are: Voltage (active low), Voltage (active high), or Current. Default is Voltage (active low). ▸ Select a calibration mode from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Line 1 Level	The control line level for line 1, independent of the other two control lines. Low outputs 0 V, high outputs the voltage that is set with the High Voltage Level parameter. • Options are: Low, High. Default is High. ▸ Select the line level from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Line 2 Level	The control line level for line 2, independent of the other two control lines. Low outputs 0 V, high outputs the voltage that is set with the High Voltage Level parameter. • Options are: Low, High. Default is High. ▸ Select the line level from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).
Line 3 Level	The control line level for line 3, independent of the other two control lines. Low outputs 0 V, high outputs the voltage that is set with the High Voltage Level parameter. • Options are: Low, High. Default is High. ▸ Select the line level from the drop down list. The current value displays as black text; a newly selected value displays as blue text (until the next Submit > Request sequence).

3.5.2 Configuration functions

Trident has seven instrument configuration functions:

- Request: Request current configuration information from Trident
- Default: Request the default configuration from Trident
- Submit: Submit an updated configuration to Trident
- Commit: Commit an updated configuration to flash on the Trident
- Reboot: Reboot theTrident

- Load: Load a configuration settings file from a local or network drive to the UI
- Save: Save the current configuration to a settings file on a local or network drive

If a configuration function fails, the user interface displays the error message generated by its communication function or sent by the network instrument.

Note Trident uses NDMP protocol, therefore select this option when requesting data.

3.5.2.1 Request

- Click Request to request the current system configuration from the network instrument. (For TimeServer and Trident instruments, and for some terminal configuration updates, select the use NDMP option to use the NDMP data protocol before requesting configuration information.) The UI updates the content in the panels upon receiving the configuration.

3.5.2.2 Default

- Click Default to request the default configuration values from the network instrument. Default configuration values are indicated in the parameter description tables in section 3.5.1.

3.5.2.3 Submit

- Click Submit to send a new configuration to the instrument. If the configuration is valid, the instrument sends a “submit OK” message and then starts to use the new configuration. The new configuration will not be permanent until the configuration is committed to flash. Use Reboot to restore the previous configuration if the newly submitted configuration is proven to be incorrect. Tech access only.

3.5.2.4 Commit

- Click Commit to request the instrument to write the current operating configuration permanently to the system flash memory. Tech access only.

3.5.2.5 Reboot

- Click Reboot to reboot the instrument. It may cause the loss of the current configuration if it is only in the system memory (not yet written into the flash). On rebooting, the instrument uses the configuration stored in the system flash memory. Tech access only.

3.5.2.6 Load

- Click Load to load a new configuration to the UI from a file on a local or network drive. This may be used to obtain a configuration which has been saved from another instrument. To change the configuration of the instrument, the

configuration must still be submitted using the “Submit” button. Tech access only.

3.5.2.7 Save

- Click Save to save the current instrument configuration to a file on a local or network drive.

3.6 Maintenance

Warning Do not power down the Trident during a firmware upload.

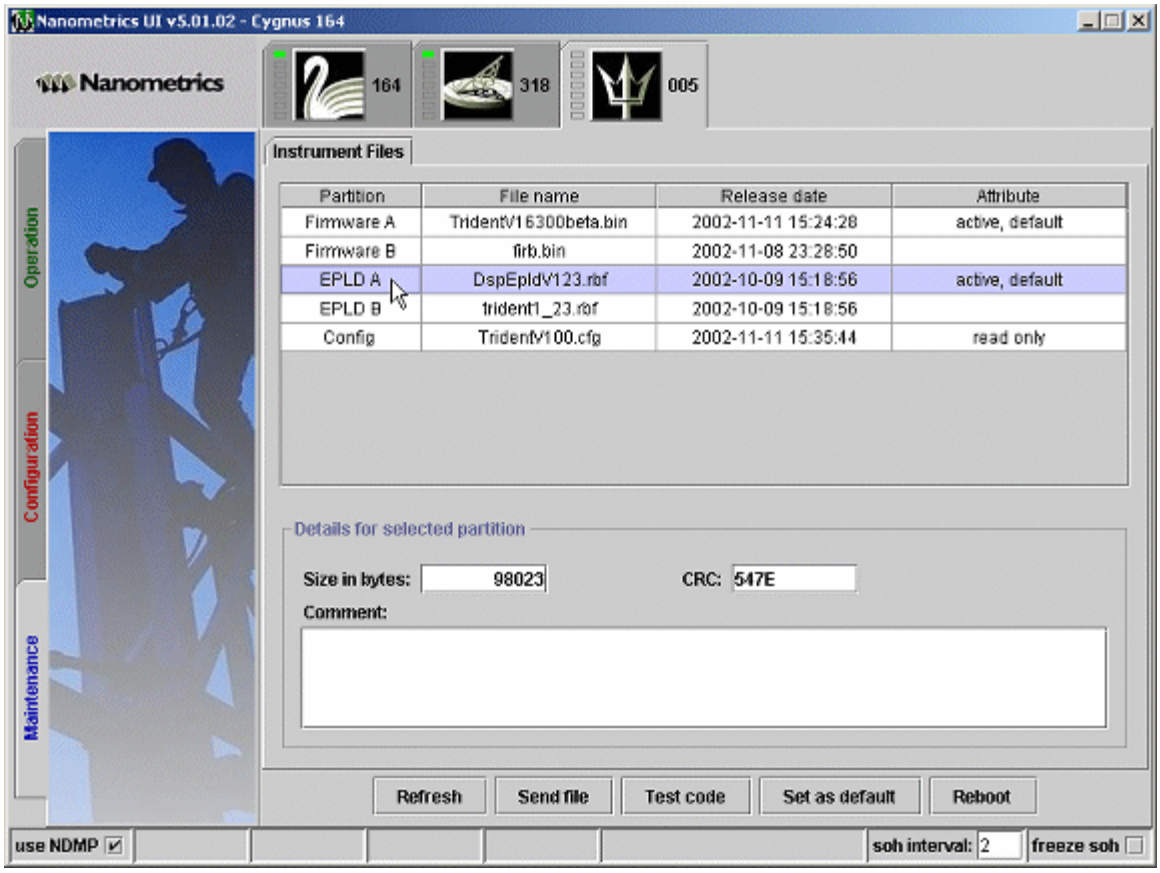
The Trident does not require scheduled maintenance. New firmware and EPLD code may periodically be available. Instrument files—including firmware, EPLD code, and saved configuration settings—can be uploaded to Trident using the Nanometrics UI.

3.6.1 Updating instrument files

The Instrument Files panel (Figure 3-3) is used for software updates to Trident. All text fields on this panel are read only. File information can be viewed and updated (refreshed) by all users; additional file management options are available to users with tech access.

Note Trident uses NDMP protocol, therefore select this option when sending or requesting data.

Figure 3-3 Maintenance > Instrument Files panel



3.6.1.1 Types of instrument files

Trident digitisers use three types of files:

- Config: Configuration settings for the Trident.
- Firmware: The executable code used by the Trident. Two instances of firmware can be stored.
- EPLD code: Program code for the Trident EPLD. Two instances of EPLD code can be stored.

3.6.2 Viewing file and partition information

Information about files and partitions can be viewed and updated by any user. The instrument tab selected at the run time indicates the instrument (with the model icon and serial number) currently connected to the Nanometrics UI, for example the Trident with serial number 005 shown in Figure 3-3.

3.6.2.1 View partition information

- View the Instrument Files table to see lists of file and partition information:
  - Partition. The type of the file on this partition.

- File name: The name of the file (if there is a file loaded).
- Release date: The date when the file was released or generated.
- Attribute: The attributes of the partition, which include:
  - active: the program is running and cannot be overwritten.
  - default: the program is set to be the default program that is run on reboot and cannot be overwritten.
  - read only: the configuration is read only; use the configuration tab to modify the configuration.
  - not valid, or invalid: either not supported by this instrument type, or is supported, but this partition does not currently have a file loaded.

3.6.2.2 View details for a selected file

- Click to select the file in the Instrument Files table to display details for the file loaded to the partition (for example, in Figure 3-3, partition EPLD A is selected):
  - Size (Bytes): The size of the file at the selected partition.
  - CRC: 16 bit CRC computed for the file. This value is recomputed and checked following file upload to verify the integrity of the file.
  - Comment: Descriptive comment, if entered when the file was uploaded to the instrument.

3.6.2.3 Update partition and file information

- Click Refresh to obtain the current system file information from the instrument, and to update the information displayed in the Instrument Files partition table and Selected file details section.

3.6.3 File management options

The file option buttons at the bottom of the Maintenance panel (Figure 3-3) provide a user with tech access options for managing network instrument files.

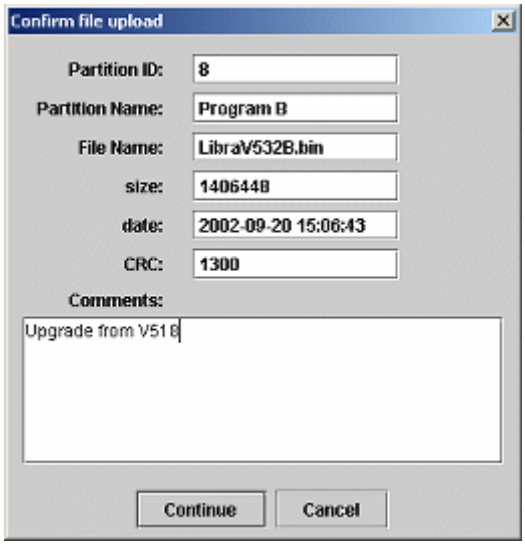
3.6.3.1 Upload files to network instruments

The Send file function uploads software from a local or network drive to an instrument.

1. In the Instrument Files table, click to select the partition for the file to be uploaded, and then click the Send file button at the bottom of the main window.
2. In the Open dialog box, select the file to upload. Double click the file name or click Open to load the file.
3. In the Confirm file upload dialog box (Figure 3-4), you can view the file information, and have the option to type in a comment about the file upload.
4. Click Continue to upload the file. (To exit without uploading the file, click Cancel.)

5. For versions prior to 5.02, in the main window click Refresh to update partition and file information.

Figure 3-4 Confirm file upload dialog box



3.6.3.2 Test new code

Use the test code function to reboot the Trident running the code in the non-default partition. After another reboot or power cycle the Trident will run code from the default partition.

3.6.3.3 Set the current program as the default

- To set the currently running program code as the default, click Set as default.

  Once set as the default, the file is used by the Trident on startup.

3.6.3.4 Reboot the Trident

Caution Rebooting may cause the loss of the current Trident configuration if the configuration is only submitted to the system memory but not yet written into the flash.

- To Reboot the Trident to the configuration stored in flash, click Reboot. The Trident will display a message that it is rebooting.

3.6.4 Troubleshooting

Some tests that may assist with troubleshooting are outlined below. If the Trident requires repair, send the unit back to Nanometrics. If you have any questions, contact Nanometrics support.

3.6.4.1 Ping

- Ping the LAN IP address of the comms controller instrument (for example, Janus or Cygnus) that is associated with the Trident. The IP address can be found in the instrument Configuration > Internet panel, and on the configuration sheet of the comms controller instrument.
  - Monitor the messages in the ping session window. The instrument should reply to the packets sent out from the computer.
- If the ping is not successful, then check:
  - The connections between the instrument and the computer.
  - That the IP address of the computer is in the same subnet as the IP address of the instrument LAN interface.
  - That you are pinging the correct IP address (the IP address of the LAN interface of the instrument in the configuration sheet).

3.6.4.2 Problems receiving data

Perform this test only after the ping test is successful.

- Start the Nanometrics UI. Under the Trident Operation tab, check whether the NMXbus packets sent is continuously increasing. If data are not being received, then check:
  - The connections between the data source, Trident, and comms controller instrument.
  - Whether the data source outputs data.

If these conditions are met and data are not being received, contact Nanometrics for support.

Appendix A Specifications

This section lists detailed specifications for the Trident digitiser, and summary specifications for the typical partner products.

A.1 Trident Specifications

A.1.1 Environmental

Table A-1 Environmental specifications

Parameter	Specification
Operating temperature	-20 to 55 degrees Celsius
Storage temperature	-40 to 85 degrees Celsius
Humidity	0 to 100%
Packaging	• Machined aluminum case, submersible IP-67 • Physical dimensions (cm) 30.0 x 13.2 x 4.0

A.1.2 Power

Table A-2 Power specifications

Parameter	Specification
Supply voltage	9 - 36 VDC (over NMXbus)
Power consumption	1.8 W typical, 100 sps continuous acquisition

A.1.3 Connectors

Table A-3 Connector specifications

Connector	Specification
NMXbus	4-pin MIL circular hermetic bayonet connector, male
Sensor	26-pin MIL circular hermetic bayonet connector, female

A.1.4 Sensor Inputs

Table A-4 Sensor input specifications

Parameter	Specification
Channels	3 (6-channel configuration achieved by daisy-chaining two units)
Sampling	Simultaneous
Maximum differential input voltage range	40 V_{p-p} differential (at gain=0.4)
Maximum single-ended voltage	±1.56 V, 3.12 V_{p-p}
Maximum common mode signal	±0.78 V
Input impedance	43 kΩ
Nominal sensitivity	1 count/microvolt (gain=1)
Gain selection	• Software-selectable 0.4, 1, 2, 4, 8 • Selectable sensitivity common for all 3 channels
EMC	EN55020, EN55011 FCC Part 15

A.1.5 Digitiser

Table A-5 Digitiser specifications

Parameter	Specification
Type	Proprietary high-order sigma-delta
Digital filter	140 dB attenuation at output Nyquist frequency
Filter type	Linear phase (consult factory for minimum phase filter options)

A.1.6 Performance

Table A-6 Digitiser performance specifications (100 Hz output sample rate)

Parameter	Specification
Shorted input noise (100 sps)	< 1 counts RMS (of 24 bits)
Dynamic range	142 dB typical (peak signal above shorted input level)

A.1.7 Data Output

Table A-7 Data output specifications

Parameter	Specification
Output channels	1, 2, or 3
Output sample rates	10, 20, 40, 50, 100, 120, 200, 500, 1000 sps
Optional DC removal filter	1 mHz to 1 Hz, first order

A.1.8 Timing

Table A-8 Timing specifications

Parameter	Specification
Source	The Trident obtains time and phase information from a Cygnus VSAT transceiver or Janus-IP communications controller via the NMXbus connection. NMXbus time is aligned to UTC using a digitally controlled VCXO clock disciplined by a GPS receiver.
Time accuracy	< 100 microseconds to UTC. Samples aligned on UTC second.

A.1.9 Sensor Calibration and Control

Table A-9 Sensor calibration and control specifications

Parameter	Specification
Calibration	Sine wave sensor calibration
Calibration enable	Three separate calibration enable lines
Mass centering	• Sensor mass centering on command • Mass position monitoring
Control lines	• Three additional control lines for mass centre, lock, unlock, short/long period • Control line outputs open drain, 0V, +5V, +12V

A.1.10 NMXbus

Table A-10 NMXbus specifications

Parameter	Specification
Prerequisite	NMXbus-compatible TimeServer or device containing a TimeServer, usually either a Cygnus satellite transceiver or Janus-IP communications controller
Additional channels	Two Trident digitisers can share the same NMXbus
Number of bus connectors	Two (to permit daisy-chaining)
Bus cable specification	Shielded twisted-pair
Termination	Automatic
Maximum bus length	150 m (subject to sensor power requirements and source voltage; see Table C-3 on page 32)

A.1.11 Instrument State-of-Health

Table A-11 Digitiser internal SOH specifications

Parameter	Specification
Temperature	Internal temperature (in Trident PLL Status Soh Bundle)
3 external inputs	Input voltage, commonly used for mass position
3 calibration active	Each bit indicates if calibration is in progress (in Extended Seismic Data Header)
Diagnostic SOH	A number of software diagnostic and statistical counts are also included as SOH messages; for example, Packets Sent.

A.1.12 Commands Supported

Table A-12 Digitiser commands supported

Command	Description
Calibrate	Initiates calibration sequence
Mass center	Initiates mass centering (STS-2 and CMG-3 series seismometers only)
Configuration	Get / change / save the current configuration; set default configuration
Software upload	Upload new DSP and EPLD firmware
Test code	Allows the user to test new code downloaded via the NMXbus
Reboot	Reboots the digitiser

A.2 Partner Product Specifications

The Cygnus VSAT transceiver and Janus-IP communications controller provide communications and timing support for the Trident digitiser.

A.2.1 Data Ports

Table A-13 Data ports

Parameter	Specification
NMXbus ports	Two
User serial ports	Two
Serial port drivers	Buffered serial; Command and control
Ethernet port	10-base-T
Storage capacity	12 MB

A.2.2 Timing Subsystem

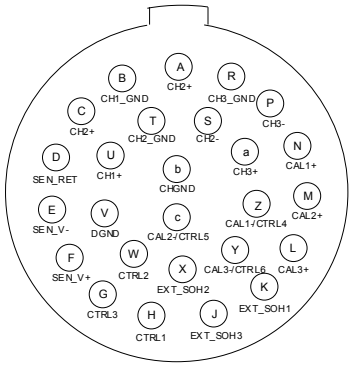
Table A-14 Timing subsystem specifications

Parameter	Specification
Type	UTC timed with digitally controlled VCXO clock disciplined by GPS receiver
Time accuracy	<100 µs to UTC, with GPS locked.
Internal oscillator	1 ppm
GPS receiver	12 channel
GPS antenna	External, active, 26 dB gain minimum
GPS antenna cable	3 m standard, 10 m optional

Appendix B Connectors

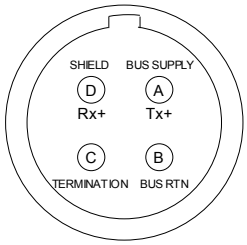
The Trident has three external connectors: a sensor connector and two NMXbus connectors (Figure B-1).

Figure B-1 Trident connectors



SENSOR

SOURIAU 851-07A16-26550-A7



NMXbus

SOURIAU 851-07A8-4P50-A7

The sensor connector on the Trident is a 26-pin male military circular type hermetic connector. The pinout is given in Table B-1.

The two NMXbus connectors on the Trident are electrically and functionally equivalent, making daisy-chaining of Tridents possible. They are 4-pin military circular hermetic connectors. The pinout is given in Table B-2.

Table B-1 Sensor connector pinout

Pin	Name	Function	Type
U	CH1+	Channel 1 Input	±20V, differential
C	CH1-		
B	CH1_GND	Channel 1 Ground/Chassis	
A	CH2+	Channel 2 Input	±20V, differential
S	CH2-		
T	CH2_GND	Channel 2 Ground/Chassis	

Table B-1 Sensor connector pinout (Continued)

a	CH3+	Channel 3 Input	±20V, differential
P	CH3-		
R	CH3_GND	Channel 3 Ground/Chassis	
K	EXT_SOH1	State of Health Input Signal	±10V, single-ended
X	EXT_SOH2		
J	EXT_SOH3		
H	CTRL1	Control Signal Output	0V / 5V / 12V / open drain
W	CTRL2		
G	CTRL3		
N	CAL1+	Calibration Signal Output	±4.5V, output
M	CAL2+		
L	CAL3+		
Z	CAL1-/ CTRL4	Calibration Signal Return / Enable	Calibration signal return / 0V / 5V / 12V / open drain output
c	CAL2-/ CTRL5		
Y	CAL3-/ CTRL6		
F	SEN_V+	Power Supply for Sensor	Power +
E	SEN_V-		Power -
D	SEN_RET		Power Return
b	CHGND	Chassis	
V	DGND	Logic Ground	

Table B-2 NMXbus connector pinout

Pin	Name	Function
A	BUS_SUPPLY	Bus voltage (positive, IN or OUT) and bus signals
B	BUS_RTN	Bus return and bus signals
C	TERMINATION	Line termination sense
D	SHIELD	Bus cable shield
shell	CHASSIS	Trident chassis

Appendix C Cables

The cables required for the Trident digitiser are the NMXbus cable and the sensor cable. This section provides information for customers who choose to assemble these cables themselves.

C.1 NMXbus cable

Nanometrics provides an NMXbus cable kit which consists of two bus connectors and a shielded twisted pair wire (Table C-1), so that the bus cable can be cut to length and assembled on site. Table C-2 shows how to wire the connector pins. Table C-3 provides guidelines for maximum NMXbus cable length.

Caution Ensure that the connector shell in the completed cable is well isolated from the cable shield, because the NMXbus cable shield must not be connected to the Trident chassis.

Table C-1 NMXbus cable kit

Nanometrics part number	Manufacturer part number	Quantity	Description
WIR0158	BELDEN, 89272	Selectable length	Shielded twisted pair, 20 AWG, 78 Ω
CON0916	SOURIAU, 851-06JC8-4S-N50	2	Plug with backshell

Table C-2 NMXbus connector pin wiring

From			To			Wire				Run
Conn	Pin	Name	Conn	Pin	Name	Part	Colour	AWG	Length (mm)[a]	
P1	A	BUS_SUPPLY	P2	A	BUS_SUPPLY	W1	COPPER	20	*	1
P1	B	BUS_RTN	P2	B	BUS_RTN	W2	SILVER	20	*	1
P1	C	TERMINATION	P1	A	BUS_SUPPLY	W3		24	25	
P1	D	SHIELD	P2	D	SHIELD	W4	SHIELD		*	1
P2	C	TERMINATION	P2	A	BUS_SUPPLY	W5		24	25	

a. An asterisk (*) in this column denotes custom cable length; see also Table C-3.

Table C-3 Maximum NMXbus cable length[a]

Category	Power consumers	Maximum length (m)		
		12V nominal	15V supply	24V nominal
1	1 low-power sensor + 1 Trident	30	150	150
2	2 low-power sensors + 2 Tridents	15	110	150
3	1 high-power sensor + 1 Trident	10	80	150
4	1 low-power sensor + 1 high-power sensor + 2 Tridents	8	60	150
5	2 high-power sensors + 2 Tridents	5	40	100

a. with standard 20AWG cable

C.2 Sensor cable

Use a 26-pin military-style circular connector (e.g. Souriau 851-06JC-16-26P-N50) to connect to the Trident. Choose a sensor connector according to the manufacturer's instructions.

The cable should be a type with twisted shielded pairs and an overall braid shield. When designing the cable ensure that the braid shield makes continuous connection to the connector shells at each end. The inner shields should only be connected at the digitiser end of the cable. Unused shields should not be left floating, but need not be connected in any particular fashion. Check the cable after construction to ensure that the inner and outer shields are not shorted together.

Table C-4 shows typical connections for active and passive sensors.

Table C-4 Typical connections for sensors

Pin	Name	Typical Recommended Usage	
		Active Sensor	Passive Sensor
U	CH1+	Vertical differential output	
C	CH1-		
B	CH1_GND	Vertical channel inner shield (connect at digitiser end only)	
A	CH2+	North/South differential output	
S	CH2-		
T	CH2_GND	North/South channel inner shield (connect at digitiser end only)	
a	CH3+	East/West differential output	
P	CH3-		
R	CH3_GND	East/West channel inner shield (connect at digitiser end only)	

Table C-4 Typical connections for sensors (Continued)

Pin	Name	Typical Recommended Usage	
		Active Sensor	**Passive Sensor**
N	CAL1+	Vertical calibration input	Vertical calibration coil (CAL1±)
Z	CAL1-/ CTRL4	Vertical calibration enable (CTRL4)	
M	CAL2+	North/South calibration input	North/South calibration coil (CAL2±)
c	CAL2-/ CTRL5	North/South calibration enable (CTRL5)	
L	CAL3+	East/West calibration input	East/West calibration coil (CAL3±)
Y	CAL3-/ CTRL6	East/West calibration enable (CTRL6)	
K	EXT_SOH1	Vertical mass position output	Not used
X	EXT_SOH2	East/West mass position output	
J	EXT_SOH3	North/South mass position output	
H	CTRL1	Sensor enables such as: mass center, mass lock, mass unlock, symmetric outputs, short period response	Not used
W	CTRL2		
G	CTRL3		
F	SEN_V+	Sensor power supply input(s) and return	Not used
D	SEN_RET		
E	SEN_V-		
V	DGND	Logic ground: return path for calibration and enable signals	Not used
b	CHGND	Sensor chassis ground pin, connector shell and cable overall shield, connected at both ends of cable	

Appendix D Filter Response

D.1 Response Overview

Analog signals connected to the Trident are filtered using a first order low pass antialias filter before being sampled at 30kHz. This data is later low pass filtered and decimated, using a 3 to 4 stage FIR filter, to the output sample rate. Depending on the requested sample rate, different filters are used and a different number of filter stages are required. The output bandwidth will always be 0.4 x F sample out.

The low frequency response is also configurable using the DC removal IIR filter. With no filter the response is to DC. With the DC removal filter enabled it can be set to a number of predetermined frequencies.

D.2 System Filter Values

This section describes the transfer functions of the Trident components.

D.2.1 Analog Low Pass Antialias Filter

The analog antialias filter is a first order low pass filter.

D.2.1.1 Transfer Function

$$F(s) = \frac{A}{s \cdot r \cdot c + 1} \quad \text{(EQ 1)}$$

where

- $A = \frac{\alpha}{\beta + Z}$
- $r = \frac{1}{\frac{1}{\alpha} + \frac{1}{\gamma + Z}}$
- Z is the sensor impedance

D.2.1.2 Coefficients

- $c = 1.0 \times 10^{-8}$, $\alpha = 33600$, $\beta = 43250$, $\gamma = 9650$
- the complex frequency response is obtained by substituting $s = -j\omega$

D.2.2 Digital IIR High Pass Filter

The digital IIR high pass filter is used for the optional DC removal feature. DC removal, if used, is applied after the digital FIR filtering.

D.2.2.1 Transfer Function

$$y(n) = K \cdot [x(n) - x(n-1)] + F_1 \cdot y(n-1) \quad \text{(EQ 2)}$$

where

- *y(n)* is the current output sample
- *K* is the filter gain
- *x(n)* is the current input sample
- *x(n-1)* is the previous input sample
- F_1 is the filter coefficient
- *y(n-1)* is the previous output sample

D.2.2.2 Coefficients

The IIR filter is implemented as a first order IIR filter using the following coefficients calculated at runtime:

$$F_1 = \frac{1 - \left(\frac{\pi \cdot f}{F_S}\right)}{1 + \left(\frac{\pi \cdot f}{F_S}\right)} \quad \text{(EQ 3)}$$

$$K = \frac{1}{1 + \left(\frac{\pi \cdot f}{F_S}\right)} \quad \text{(EQ 4)}$$

where:

- F_S is the output sample rate
- f is the 3 dB corner frequency of the filter

The time constant (*TC*) of the filter can be calculated as follows:

$$TC = \frac{1}{2\pi \cdot f} \quad \text{(EQ 5)}$$

D.2.3 Digital FIR Low Pass Filters

The 3 to 4 stage digital FIR filter low pass-filters and decimates the data to the output sample rate.

D.2.3.1 Transfer Function

$$y(n) = \sum_{i=0}^{N-1} c(i) \cdot x(n-i) \qquad \text{(EQ 6)}$$

where:

- *y(n)* is the output sample
- *x(n-i)* is an input sample
- *c(i)* is a FIR coefficient
- *N* is the number of coefficients

D.2.3.2 Coefficients

Table D-1 shows the individual digital filter stages and associated decimation for each output sample rate, and the cumulative filter delay. The filter coefficient sets are listed by output sample rate for each stage in Table D-2 through Table D-32.

Table D-1 Digital filter stages and associated decimation for each output sample rate

Output Sample Rate	Filter Parameter	Stage				Cumulative Filter Delay (seconds)
		1	2	3	4	
10	# of Coefficients	213	177	113	223	6.172200
	Decimation	20	15	5	2	
20	# of Coefficients	165	187	113	223	3.104233
	Decimation	15	10	5	2	
40	# of Coefficients	177	71	113	223	1.547933
	Decimation	15	5	5	2	
50	# of Coefficients	203	245	223	—	1.194700
	Decimation	20	15	2	—	
100	# of Coefficients	165	187	223	—	0.604233
	Decimation	15	10	2	—	
120	# of Coefficients	59	69	113	223	0.515800
	Decimation	5	5	5	2	
200	# of Coefficients	173	95	223	—	0.303867
	Decimation	15	5	2	—	
500	# of Coefficients	123	65	223	—	0.123700
	Decimation	10	3	2	—	

Table D-1 Digital filter stages and associated decimation for each output sample rate (Continued)

Output Sample Rate	Filter Parameter	Stage				Cumulative Filter Delay (seconds)
		1	2	3	4	
1000	# of Coefficients	63	55	223	—	0.061033
	Decimation	5	3	2	—	

Note The following sets of digital FIR filter coefficients are symmetric, so only the first half of each coefficient set is listed. Coefficients are listed left to right in each table, as shown below:

[1st coefficient] [2nd coefficient] [3rd coefficient] [4th coefficient]
[5th coefficient] [6th coefficient] [7th coefficient] ...

Table D-2 10sps: Stage 1 FIR Filter Coefficients

+1.064907617486405e-009	+1.034453178307261e-009	+9.664113963958244e-010	+8.418348553462952e-010
+6.249258356490772e-010	+2.516549535268758e-010	-3.876703288067790e-010	-1.474331731295020e-009
-3.298806094223753e-009	-6.314136929531576e-009	-1.121016047230174e-008	-1.901483719775274e-008
-3.123022237999416e-008	-5.001196408074772e-008	-7.840265257259518e-008	-1.206307425175897e-007
-1.824880863208179e-007	-2.718002527084321e-007	-3.990046104754481e-007	-5.778515264232270e-007
-8.262437818926275e-007	-1.167228277378105e-006	-1.630152097364685e-006	-2.251991852378070e-006
-3.078860723061025e-006	-4.167691627856855e-006	-5.588087296214108e-006	-7.424318639540946e-006
-9.777441626027677e-006	-1.276748991862822e-005	-1.653568591925185e-005	-2.124659677792683e-005
-2.709014468801596e-005	-3.428336281447289e-005	-4.307177003589932e-005	-5.373021998545357e-005
-6.656306343787459e-005	-8.190344879132025e-005	-1.001115742094661e-004	-1.215716979621988e-004
-1.466877117031738e-004	-1.758770859167701e-004	-2.095630085718339e-004	-2.481645580520465e-004
-2.920847804659816e-004	-3.416965800307624e-004	-3.973263796728150e-004	-4.592355672882901e-004
-5.275998108837911e-004	-6.024864023037121e-004	-6.838298732466565e-004	-7.714062171413840e-004
-8.648061441093757e-004	-9.634078911739306e-004	-1.066350203188083e-003	-1.172506188408088e-003
-1.280458832741380e-003	-1.388479024791834e-003	-1.494506996192347e-003	-1.596138114719560e-003
-1.690613977896006e-003	-1.774819739131641e-003	-1.845288554367976e-003	-1.898213962743382e-003
-1.929470908861292e-003	-1.934645976577522e-003	-1.909077235596615e-003	-1.847903904417293e-003
-1.746125809244897e-003	-1.598672372460225e-003	-1.400480601239162e-003	-1.146581273096341e-003
-8.321922374960512e-004	-4.528174789654291e-004	-4.350325607132146e-006	+5.168210539300105e-004
+1.113707933547817e-003	+1.788617335426292e-003	+2.543052729685069e-003	+3.377621575812952e-003
+4.291952172227477e-003	+5.284622236434193e-003	+6.353101529129874e-003	+7.493710660214747e-003
+8.701597973949728e-003	+9.970736107327261e-003	+1.129393945504515e-002	+1.266290336317476e-002
+1.406826542043067e-002	+1.549968873126445e-002	+1.694596655060130e-002	+1.839514714878393e-002
+1.983467727077701e-002	+2.125156206983979e-002	+2.263253894652174e-002	+2.396426232227562e-002
+2.523349603555283e-002	+2.642730977791709e-002	+2.753327579770644e-002	+2.853966199622893e-002
+2.943561753119303e-002	+3.021134712629040e-002	+3.085827046415188e-002	+3.136916330916253e-002
+3.173827736108024e-002	+3.196143627177688e-002	+3.203610575514897e-002	

Table D-3 10sps: Stage 2 FIR Filter Coefficients

+1.274508037713854e-009	+3.998782762542515e-009	+1.024154282410265e-008	+2.260131975609668e-008
+4.482147327426093e-008	+8.183460736487531e-008	+1.396280457733333e-007	+2.247765750108437e-007
+3.434979804593919e-007	+5.000835626084475e-007	+6.945702915529181e-007	+9.195631536380137e-007
+1.156180237597563e-006	+1.369213636134487e-006	+1.501732190677942e-006	+1.469536132342558e-006
+1.156072180154469e-006	+4.086311791194063e-007	-9.631575963804799e-007	-3.185358645165066e-006
-6.513029984180443e-006	-1.121754953653928e-005	-1.756688863877204e-005	-2.579807834421872e-005
-3.608162845472528e-005	-4.847836564934252e-005	-6.289004605799169e-005	-7.900612977208145e-005
-9.625023005867442e-005	-1.137308825132404e-004	-1.302023173674668e-004	-1.440417372005855e-004
-1.532500772620555e-004	-1.554832182727657e-004	-1.481200182629544e-004	-1.283722284804781e-004
-9.343931225336277e-005	-4.070838456326049e-005	+3.200399879120903e-005	+1.261755255438299e-004

Table D-3 10sps: Stage 2 FIR Filter Coefficients (Continued)

+2.422790077247571e-004	+3.794766616276513e-004	+5.353282047932003e-004	+7.055367642667043e-004
+8.837591201708494e-004	+1.061507906179511e-003	+1.228172697716860e-003	+1.371184173455519e-003
+1.476340568373834e-003	+1.528308433157228e-003	+1.511300413745230e-003	+1.409921693519257e-003
+1.210164395473335e-003	+9.005162952909555e-004	+4.731374478641395e-004	-7.495331242320440e-005
-7.407496338188167e-004	-1.514260929538042e-003	-2.377724759513757e-003	-3.305103737040651e-003
-4.261935822939468e-003	-5.205595236681355e-003	-6.086004689576903e-003	-6.846818743370123e-003
-7.427073690811211e-003	-7.763272621360522e-003	-7.791846731533931e-003	-7.451907097887187e-003
-6.688176789325108e-003	-5.453973062220406e-003	-3.714095041860952e-003	-1.447465068324086e-003
+1.350627251190012e-003	+4.666819771776261e-003	+8.468634716747657e-003	+1.270419497334137e-002
+1.730276378362830e-002	+2.217613317169075e-002	+2.722084430537505e-002	+3.232117966910014e-002
+3.735282488611422e-002	+4.218705977144598e-002	+4.669530606909855e-002	+5.075383539601134e-002
+5.424842680203789e-002	+5.707876014276208e-002	+5.916233958966831e-002	+6.043776084683357e-002
+6.086716509748656e-002			

Table D-4 10sps: Stage 3 FIR Filter Coefficients

+3.624153237100989e-009	+1.470216688117767e-008	+2.924648074949182e-008	+1.675815859925242e-008
-9.459692996675541e-008	-4.005292369332425e-007	-9.373651758431229e-007	-1.530435241099631e-006
-1.645991491318222e-006	-4.078703649887408e-007	+3.030094105174225e-006	+8.685992078359400e-006
+1.476603465201467e-005	+1.713674632378615e-005	+1.012813500657534e-005	-1.072856062768063e-005
-4.439650993665008e-005	-8.029796768720772e-005	-9.761762240257018e-005	-7.094869060070728e-005
+1.692090641200780e-005	+1.585078223461214e-004	+3.094936499512948e-004	+3.912802093626145e-004
+3.155885036776064e-004	+2.919057865035819e-005	-4.362723697929486e-004	-9.354174279267205e-004
-1.228393916598020e-003	-1.061468695091633e-003	-2.939814743843771e-004	+9.756477540050195e-004
+2.352455381127647e-003	+3.215585281329135e-003	+2.933433563419905e-003	+1.171050910958822e-003
-1.829548430478970e-003	-5.145646443318352e-003	-7.361207758041045e-003	-7.056359496882652e-003
-3.467654576125640e-003	+2.935112705392162e-003	+1.024857149306014e-002	+1.551827984678943e-002
+1.570615959949202e-002	+8.987865329886645e-003	-4.081171672241476e-003	-2.004540408564930e-002
-3.303497648347430e-002	-3.628456170461448e-002	-2.430879726955251e-002	+4.958793846270522e-003
+4.884525267308668e-002	+1.000147740815335e-001	+1.480752985064006e-001	+1.823112272692678e-001
+1.947111255384850e-001			

Table D-5 10sps: Stage 4 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003

Table D-5 10sps: Stage 4 FIR Filter Coefficients (Continued)

+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-6 20sps: Stage 1 FIR Filter Coefficients

-4.047907827113435e-010	-1.390291410616280e-010	+6.728000500156772e-010	+2.757971531287775e-009
+7.546506865872195e-009	+1.766681105112393e-008	+3.769362981944433e-008	+7.523131717119556e-008
+1.424254208543815e-007	+2.579989942850785e-007	+4.499037171963720e-007	+7.586554657022834e-007
+1.241385823501068e-006	+1.976580337370245e-006	+3.069389218520029e-006	+4.657283633700868e-006
+6.915692774450531e-006	+1.006309584698377e-005	+1.436486680838168e-005	+2.013498922101177e-005
+2.773458889448483e-005	+3.756609353359231e-005	+5.006174380375990e-005	+6.566517495835717e-005
+8.480488904700095e-005	+1.078586692034099e-004	+1.351083708846758e-004	+1.666850740988706e-004
+2.025052991790280e-004	+2.421998676511588e-004	+2.850380044490719e-004	+3.298503862917036e-004
+3.749559835375441e-004	+4.180986428351539e-004	+4.564003231909406e-004	+4.863386265192439e-004
+5.037566477826840e-004	+5.039131041938723e-004	+4.815800932055991e-004	+4.311946010973558e-004
+3.470679930602060e-004	+2.236551558100188e-004	+5.588177435769922e-005	-1.604755031971873e-004
-4.283653814438088e-004	-7.490084037683738e-004	-1.121431576587110e-003	-1.542013055891304e-003
-2.004062154587584e-003	-2.497462335460076e-003	-3.008406043037227e-003	-3.519249945407228e-003
-4.008517211186400e-003	-4.451069724371900e-003	-4.818467626070565e-003	-5.079526362531964e-003
-5.201072726935362e-003	-5.148891537318578e-003	-4.888844032354756e-003	-4.388128318143293e-003
-3.616641856686609e-003	-2.548396677795745e-003	-1.162930346149744e-003	+5.533496934548342e-004
+2.605953436832241e-003	+4.991291898095885e-003	+7.695917735921711e-003	+1.069607652807879e-002
+1.395761185676819e-002	+1.743625403066915e-002	+2.107830656774628e-002	+2.482172719817530e-002
+2.859758195513501e-002	+3.233183282942656e-002	+3.594740243710946e-002	+3.936644413583802e-002
+4.251273389808217e-002	+4.531409175152301e-002	+4.770473629328503e-002	+4.962747602314526e-002
+5.103564612512176e-002	+5.189470870549539e-002	+5.218344796472771e-002	

Table D-7 20sps: Stage 2 FIR Filter Coefficients

+8.469229815375836e-010	+2.274220288025759e-009	+4.538950837882147e-009	+6.873790581886875e-009
+7.109040416947659e-009	+7.627841347268097e-010	-1.983009558282680e-008	-6.609942211224632e-008
-1.531137889126984e-007	-2.982494942275970e-007	-5.181519089662492e-007	-8.236355594832989e-007
-1.212476329485351e-006	-1.660554848844411e-006	-2.112474379324042e-006	-2.473531133129619e-006
-2.605619128003023e-006	-2.330133657562619e-006	-1.440980274917891e-006	+2.698043300278720e-007
+2.972713778558616e-006	+6.748858469608209e-006	+1.152961592827038e-005	+1.703543472209736e-005
+2.272479023143328e-005	+2.776698459480208e-005	+3.105368391399539e-005	+3.126302060212491e-005
+2.698613281584723e-005	+1.691886402482352e-005	+1.111764912365637e-007	-2.374558644778620e-005
-5.402671731357865e-005	-8.892267864716836e-005	-1.252819457239765e-004	-1.586044226011253e-004
-1.832358557248136e-004	-1.927980107782330e-004	-1.808635900860097e-004	-1.418501862256910e-004
-7.206699315303354e-005	+2.919375663577290e-005	+1.586654736525826e-004	+3.083858467014949e-004
+4.654216635228285e-004	+6.121982853786541e-004	+7.275470741759510e-004	+7.885115946319546e-004
+7.728577835233870e-004	+6.621229618182738e-004	+4.449259850407905e-004	+1.201613649467244e-004
-3.003694627769020e-004	-7.903605458595080e-004	-1.308874060360023e-003	-1.802020291776854e-003
-2.206618091924962e-003	-2.455790114635659e-003	-2.486192180752311e-003	-2.246311918537972e-003
-1.705031041178952e-003	-8.594632516121016e-004	+2.590111721915774e-004	+1.581566203839111e-003
+3.002498487966101e-003	+4.384141985044115e-003	+5.566316483085373e-003	+6.380002340389496e-003
+6.664402331430841e-003	+6.286042551189639e-003	+5.158141388519080e-003	+3.258199252425354e-003
+6.416820735977283e-004	-2.550179237628938e-003	-6.090064766937297e-003	-9.672703326103260e-003
-1.293168061123908e-002	-1.546424668939506e-002	-1.686255838709300e-002	-1.674898294478778e-002
-1.481246018868655e-002	-1.084255434379213e-002	-4.757782696764870e-003	+3.374886268966743e-003
+1.333182798532389e-002	+2.473737725852667e-002	+3.708164756536587e-002	+4.975069601283877e-002
+6.206696168821097e-002	+7.333684637153971e-002	+8.290151879402521e-002	+9.018659693370301e-002
+9.474635107447013e-002	+9.629848418816638e-002		

Table D-8 20sps: Stage 3 FIR Filter Coefficients

+3.624153237100989e-009	+1.470216688117767e-008	+2.924648074949182e-008	+1.675815859925242e-008
-9.459692996675541e-008	-4.005292369332425e-007	-9.373651758431229e-007	-1.530435241099631e-006
-1.645991491318222e-006	-4.078703649887408e-007	+3.030094105174225e-006	+8.685992078359400e-006
+1.476603465201467e-005	+1.713674632378615e-005	+1.012813500657534e-005	-1.072856062768063e-005
-4.439650993665008e-005	-8.029796768720772e-005	-9.761762240257018e-005	-7.094869060070728e-005
+1.692090641200780e-005	+1.585078223461214e-004	+3.094936499512948e-004	+3.912802093626145e-004
+3.155885036776064e-004	+2.919057865035819e-005	-4.362723697929486e-004	-9.354174279267205e-004
-1.228393916598020e-003	-1.061468695091633e-003	-2.939814743843771e-004	+9.756477540050195e-004
+2.352455381127647e-003	+3.215585281329135e-003	+2.933433563419905e-003	+1.171050910958822e-003
-1.829548430478970e-003	-5.145646443318352e-003	-7.361207758041045e-003	-7.056359496882652e-003
-3.467654576125640e-003	+2.935112705392162e-003	+1.024857149306014e-002	+1.551827984678943e-002
+1.570615959949202e-002	+8.987865329886645e-003	-4.081171672241476e-003	-2.004540408564930e-002
-3.303497648347430e-002	-3.628456170461448e-002	-2.430879726955251e-002	+4.958793846270522e-003
+4.884525267308668e-002	+1.000147740815335e-001	+1.480752985064006e-001	+1.823112272692678e-001
+1.947111255384850e-001			

Table D-9 20sps: Stage 4 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-10 40sps: Stage 1 FIR Filter Coefficients

-1.505962962619764e-010	-1.498864434953276e-010	-1.003114352411142e-010	+1.259463995744371e-010
+7.960451695184910e-010	+2.429826097389767e-009	+5.982544997374707e-009	+1.312757892786212e-008
+2.667805205372700e-008	+5.119490161176941e-008	+9.383677815944899e-008	+1.655130572685399e-007
+2.824033985862602e-007	+4.679036833418200e-007	+7.550463649832197e-007	+1.189420819154159e-006
+1.832583606329407e-006	+2.765897637017751e-006	+4.094671457151648e-006	+5.952385021026578e-006
+8.504687388082939e-006	+1.195273793146133e-005	+1.653534118667076e-005	+2.252920428425832e-005

Table D-10 40 sps: Stage 1 FIR Filter Coefficients (Continued)

+3.024653562249012e-005	+4.002911702265472e-005	+5.223793436414649e-005	+6.723746022952897e-005
+8.537376347669023e-005	+1.069457910959372e-004	+1.321694408673993e-004	+1.611344285464181e-004
+1.937544537908303e-004	+2.297117798746024e-004	+2.683980488962403e-004	+3.088539312739519e-004
+3.497110189143424e-004	+3.891401673183375e-004	+4.248112145966680e-004	+4.538695883396501e-004
+4.729356829883044e-004	+4.781329785920880e-004	+4.651506086952275e-004	+4.293454127561792e-004
+3.658873852657924e-004	+2.699508399385001e-004	+1.369515508045477e-004	-3.717234768200115e-005
-2.556407481231493e-004	-5.204813600606632e-004	-8.321601815404552e-004	-1.189207019513620e-003
-1.587853242030926e-003	-2.021701280200689e-003	-2.481447041803338e-003	-2.954677152845623e-003
-3.425762635913756e-003	-3.875869133321610e-003	-4.283101011280494e-003	-4.622792626947323e-003
-4.867954765909377e-003	-4.989877905201589e-003	-4.958886747251959e-003	-4.745232698266504e-003
-4.320102989381414e-003	-3.656717367713873e-003	-2.731476152982046e-003	-1.525117404310592e-003
-2.383639087218765e-005	+1.779682118927733e-003	+3.885368743620226e-003	+6.285059680983166e-003
+8.962016016969544e-003	+1.189070922779163e-002	+1.503690098284010e-002	+1.835803446437611e-002
+2.180394204064246e-002	+2.531786080272187e-002	+2.883773382245979e-002	+3.229776167772108e-002
+3.563015650334431e-002	+3.876704021700151e-002	+4.164242023074721e-002	+4.419417038407394e-002
+4.636594238533214e-002	+4.810893393369396e-002	+4.938344395179416e-002	+5.016015285223379e-002
+5.042107618011157e-002			

Table D-11 40 sps: Stage 2 FIR Filter Coefficients

-1.400229112626751e-008	-1.255059101059420e-007	-6.074920969991863e-007	-2.046866214509816e-006
-5.236352154040682e-006	-1.042765851663702e-005	-1.566514019930482e-005	-1.467138197420866e-005
+3.866902659757839e-006	+5.254916999823256e-005	+1.345446585325526e-004	+2.273284714444688e-004
+2.694088234873323e-004	+1.653886989731449e-004	-1.754205349151400e-004	-7.649911881343388e-004
-1.452110890908049e-003	-1.881640586034664e-003	-1.562382793320976e-003	-7.930602619475102e-005
+2.588434924594316e-003	+5.777668544095568e-003	+8.077697621925183e-003	+7.665307255267063e-003
+3.066021771572913e-003	-5.859562061045245e-003	-1.711851993111805e-002	-2.645966399092334e-002
-2.823533141430562e-002	-1.718374882271293e-002	+9.394698265041817e-003	+4.991072675811308e-002
+9.803477717651034e-002	+1.439398984224276e-001	+1.769958388062633e-001	+1.890346344400278e-001

Table D-12 40 sps: Stage 3 FIR Filter Coefficients

+3.624153237100989e-009	+1.470216688117767e-008	+2.924648074949182e-008	+1.675815859925242e-008
-9.459692996675541e-008	-4.005292369332425e-007	-9.373651758431229e-007	-1.530435241099631e-006
-1.645991491318222e-006	-4.078703649887408e-007	+3.030094105174225e-006	+8.685992078359400e-006
+1.476603465201467e-005	+1.713674632378615e-005	+1.012813500657534e-005	-1.072856062768063e-005
-4.439650993665008e-005	-8.029796768720772e-005	-9.761762240257018e-005	-7.094869060070728e-005
+1.692090641200780e-005	+1.585078223461214e-004	+3.094936499512948e-004	+3.912802093626145e-004
+3.155885036776064e-004	+2.919057865035819e-005	-4.362723697929486e-004	-9.354174279267205e-004
-1.228393916598020e-003	-1.061468695091633e-003	-2.939814743843771e-004	+9.756477540050195e-004
+2.352455381127647e-003	+3.215585281329135e-003	+2.933433563419905e-003	+1.171050910958822e-003
-1.829548430478970e-003	-5.145646443318352e-003	-7.361207758041045e-003	-7.056359496882652e-003
-3.467654576125640e-003	+2.935112705392162e-003	+1.024857149306014e-002	+1.551827984678943e-002
+1.570615959949202e-002	+8.987865329886645e-003	-4.081171672241476e-003	-2.004540408564930e-002
-3.303497648347430e-002	-3.628456170461448e-002	-2.430879726955251e-002	+4.958793846270522e-003
+4.884525267308668e-002	+1.000147740815335e-001	+1.480752985064006e-001	+1.823112272692678e-001
+1.947111255384850e-001			

Table D-13 40 sps: Stage 4 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006

Table D-13 40sps: Stage 4 FIR Filter Coefficients (Continued)

+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-14 50sps: Stage 1 FIR Filter Coefficients

-5.148550518595382e-010	-5.503820912979381e-010	-6.491469835668823e-010	-8.865288815038872e-010
-1.399221922781915e-009	-2.422496318486318e-009	-4.345305355272829e-009	-7.789157626500222e-009
-1.371850651030332e-008	-2.359197670717998e-008	-3.956554217369130e-008	-6.476064527003532e-008
-1.036120043643297e-007	-1.623115596246171e-007	-2.493664138454102e-007	-3.762895519282085e-007
-5.584424407389275e-007	-8.160481036123163e-007	-1.175391592699649e-006	-1.670221849045022e-006
-2.343364420811424e-006	-3.248548175767535e-006	-4.452440807740775e-006	-6.036877504769354e-006
-8.101254406972049e-006	-1.076504353239432e-005	-1.417036874611793e-005	-1.848456331599462e-005
-2.390260893347382e-005	-3.064933437085011e-005	-3.898122975503990e-005	-4.918771062347694e-005
-6.159164539641024e-005	-7.654894180437700e-005	-9.444697329088229e-005	-1.157016168220188e-004
-1.407526701419350e-004	-1.700574207276748e-004	-2.040821517253327e-004	-2.432913931823998e-004
-2.881347608325197e-004	-3.390312703167187e-004	-3.963510723169456e-004	-4.603946236656257e-004
-5.313693905413767e-004	-6.093642714409420e-004	-6.943220281269754e-004	-7.860101201839316e-004
-8.839904504707054e-004	-9.875886415477220e-004	-1.095863573389741e-003	-1.207578016406712e-003
-1.321171286591235e-003	-1.434734927072340e-003	-1.545992477890567e-003	-1.652284429099445e-003
-1.750559457205633e-003	-1.837373017977784e-003	-1.908894306824151e-003	-1.960922499297527e-003
-1.988913047742422e-003	-1.988014635863681e-003	-1.953117182423066e-003	-1.878911041180321e-003
-1.759957270637840e-003	-1.590768549674393e-003	-1.365900000455418e-003	-1.080048856064333e-003
-7.281615859470996e-004	-3.055467772264269e-004	+1.920082257011148e-004	+7.681191867270819e-004
+1.425687838159468e-003	+2.166788401167422e-003	+2.992560550287748e-003	+3.903111657751202e-003
+4.897431133469844e-003	+5.973319580442288e-003	+7.127335311084472e-003	+8.354760517743446e-003
+9.649589063106371e-003	+1.100453745840131e-002	+1.241108013677877e-002	+1.385950961579458e-002
+1.533902158843128e-002	+1.683782440019950e-002	+1.834327177570780e-002	+1.984201706769705e-002
+2.132018673157318e-002	+2.276357019547822e-002	+2.415782281605174e-002	+2.548867819820645e-002
+2.674216582698561e-002	+2.790482972222629e-002	+2.896394369133408e-002	+2.990771872806975e-002
+3.072549818901627e-002	+3.140793657415418e-002	+3.194715804040495e-002	+3.233689118043551e-002
+3.257257709387603e-002	+3.265144835188193e-002		

Table D-15 50 sps: Stage 2 FIR Filter Coefficients

-2.248424117774393e-008	-4.642643587439857e-008	-9.086824871372440e-008	-1.590206104387818e-007
-2.567909974188776e-007	-3.892381268506234e-007	-5.594755976256573e-007	-7.673527791484545e-007
-1.007906680622452e-006	-1.269830061004852e-006	-1.534060697224885e-006	-1.772617696662865e-006
-1.948003004053838e-006	-2.013491658270361e-006	-1.914283940575952e-006	-1.590138069648525e-006
-9.791911300655609e-007	-2.342015045344638e-008	+1.324585004333917e-006	+3.093646050624833e-006
+5.285216140869372e-006	+7.864428751619978e-006	+1.075165762546044e-005	+1.381553782516197e-005
+1.686843983717624e-005	+1.966547256150965e-005	+2.190799579264532e-005	+2.325259613478408e-005
+2.332605821155048e-005	+2.174674737429560e-005	+1.815211823472118e-005	+1.223172463043748e-005
+3.764362047295070e-006	-7.342600579662850e-006	-2.101423843770261e-005	-3.697254866283645e-005
-5.470785053408204e-005	-7.346080855720896e-005	-9.221872210762419e-005	-1.097294113743585e-004
-1.245353476668098e-004	-1.350297645882529e-004	-1.395351171504224e-004	-1.364028009897406e-004
-1.241311999388250e-004	-1.014973247366093e-004	-6.769543330312970e-005	-2.247431113985582e-005
+3.373647444408592e-005	+9.972202102469496e-005	+1.734102405389535e-004	+2.518433855177636e-004
+3.312024576230887e-004	+4.068920325346301e-004	+4.736901742853282e-004	+5.259645697748949e-004
+5.579517406433626e-004	+5.640915882999001e-004	+5.394046556118302e-004	+4.798947892116965e-004
+3.829556263718983e-004	+2.477558450261566e-004	+7.557581133606256e-005	-1.299326507476519e-004
-3.625908219795382e-004	-6.136667832837974e-004	-8.719984411103067e-004	-1.124279627356568e-003
-1.355514828795137e-003	-1.549638574359543e-003	-1.690284969189717e-003	-1.761681962109579e-003
-1.749634219296640e-003	-1.642548672797125e-003	-1.432448635539632e-003	-1.115916446683899e-003
-6.949016118759333e-004	-1.773317468296161e-004	+4.225322873453017e-004	+1.084047760917815e-003
+1.780486976533114e-003	+2.479703590402148e-003	+3.145174209250359e-003	+3.737400990478588e-003
+4.215639662954890e-003	+4.539896060021425e-003	+4.673114109423882e-003	+4.583460490679655e-003
+4.246597092124963e-003	+3.647823009057872e-003	+2.783964077500575e-003	+1.664890429221449e-003
+3.145516543008143e-004	-1.228565177570029e-003	-2.911627520058403e-003	-4.668344984598962e-003
-6.420566608774059e-003	-8.080567281826850e-003	-9.553967139544177e-003	-1.074319263670337e-002
-1.155135541901075e-002	-1.188639688191599e-002	-1.166532418172082e-002	-1.081834888780580e-002
-9.292733605030502e-003	-7.056155443227625e-003	-4.099408426816391e-003	-4.382895441187270e-004
+3.885455633584578e-003	+8.804213253621410e-003	+1.422564865741498e-002	+2.003491444518150e-002
+2.609786342299352e-002	+3.226516274457664e-002	+3.837716119862833e-002	+4.426932313959991e-002
+4.977801211465580e-002	+5.474638646804998e-002	+5.903015934972362e-002	+6.250297728148256e-002
+6.506118483744229e-002	+6.662776755658176e-002	+6.715529982825459e-002	

Table D-16 50 sps: Stage 3 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003

Table D-16 50sps: Stage 3 FIR Filter Coefficients (Continued)

+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-17 100sps: Stage 1 FIR Filter Coefficients

-4.047907827113435e-010	-1.390291410616280e-010	+6.728000500156772e-010	+2.757971531287775e-009
+7.546506865872195e-009	+1.766681105112393e-008	+3.769362981944433e-008	+7.523131717119556e-008
+1.424254208543815e-007	+2.579989942850785e-007	+4.499037171963720e-007	+7.586554657022834e-007
+1.241385823501068e-006	+1.976580337370245e-006	+3.069389218520029e-006	+4.657283633700868e-006
+6.915692774450531e-006	+1.006309584698377e-005	+1.436486680838168e-005	+2.013498922101177e-005
+2.773458889448483e-005	+3.756609353359231e-005	+5.006174380375990e-005	+6.566517495835717e-005
+8.480488904700095e-005	+1.078586692034099e-004	+1.351083708846758e-004	+1.666850740988706e-004
+2.025052991790280e-004	+2.421998676511588e-004	+2.850380044490719e-004	+3.298503862917036e-004
+3.749559835375441e-004	+4.180986428351539e-004	+4.564003231909406e-004	+4.863386265192439e-004
+5.037566477826840e-004	+5.039131041938723e-004	+4.815800932055991e-004	+4.311946010973558e-004
+3.470679930602060e-004	+2.236551558100188e-004	+5.588177435769922e-005	-1.604755031971873e-004
-4.283653814438088e-004	-7.490084037683738e-004	-1.121431576587110e-003	-1.542013055891304e-003
-2.004062154587584e-003	-2.497462335460076e-003	-3.008406043037227e-003	-3.519249945407228e-003
-4.008517211186400e-003	-4.451069724371900e-003	-4.818467626070565e-003	-5.079526362531964e-003
-5.201072726935362e-003	-5.148891537318578e-003	-4.888844032354756e-003	-4.388128318143293e-003
-3.616641856686609e-003	-2.548396677795745e-003	-1.162930346149744e-003	+5.533496934548342e-004
+2.605953436832241e-003	+4.991291898095885e-003	+7.695917735921711e-003	+1.069607652807879e-002
+1.395761185676819e-002	+1.743625403066915e-002	+2.107830656774628e-002	+2.482172719817530e-002
+2.859758195513501e-002	+3.233183282942656e-002	+3.594740243710946e-002	+3.936644413583802e-002
+4.251273389808217e-002	+4.531409175152301e-002	+4.770473629328503e-002	+4.962747602314526e-002
+5.103564612512176e-002	+5.189470870549539e-002	+5.218344796472771e-002	

Table D-18 100sps: Stage 2 FIR Filter Coefficients

+8.469229815375836e-010	+2.274220288025759e-009	+4.538950837882147e-009	+6.873790581886875e-009
+7.109040416947659e-009	+7.627841347268097e-010	-1.983009558282680e-008	-6.609942211224632e-008
-1.531137889126984e-007	-2.982494942275970e-007	-5.181519089662492e-007	-8.236355594832989e-007
-1.212476329485351e-006	-1.660554848844411e-006	-2.112474379324042e-006	-2.473531133129619e-006
-2.605619128003023e-006	-2.330133657562619e-006	-1.440980274917891e-006	+2.698043300278720e-007
+2.972713778558616e-006	+6.748858469608209e-006	+1.152961592827038e-005	+1.703543472209736e-005
+2.272479023143328e-005	+2.776698459480208e-005	+3.105368391399539e-005	+3.126302060212491e-005
+2.698613281584723e-005	+1.691886402482352e-005	+1.111764912365637e-007	-2.374558644778620e-005
-5.402671731357865e-005	-8.892267864716836e-005	-1.252819457239765e-004	-1.586044226011253e-004
-1.832358557248136e-004	-1.927980107782330e-004	-1.808635900860097e-004	-1.418501862256910e-004
-7.206699315303354e-005	+2.919375663577290e-005	+1.586654736525826e-004	+3.083858467014949e-004
+4.654216635228285e-004	+6.121982853786541e-004	+7.275470741759510e-004	+7.885115946319546e-004
+7.728577835233870e-004	+6.621229618182738e-004	+4.449259850407905e-004	+1.201613649467244e-004
-3.003694627769020e-004	-7.903605458595080e-004	-1.308874060360023e-003	-1.802020291776854e-003
-2.206618091924962e-003	-2.455790114635659e-003	-2.486192180752311e-003	-2.246311918537972e-003
-1.705031041178952e-003	-8.594632516121016e-004	+2.590111721915774e-004	+1.581566203839111e-003
+3.002498487966101e-003	+4.384141985044115e-003	+5.566316483085373e-003	+6.380002340389496e-003
+6.664402331430841e-003	+6.286042551189639e-003	+5.158141388519080e-003	+3.258199252425354e-003
+6.416820735977283e-004	-2.550179237628938e-003	-6.090064766937297e-003	-9.672703326103260e-003
-1.293168061123908e-002	-1.546424668939506e-002	-1.686255838709300e-002	-1.674898294478778e-002
-1.481246018868655e-002	-1.084255434379213e-002	-4.757782696764870e-003	+3.374886268966743e-003
+1.333182798532389e-002	+2.473737725852667e-002	+3.708164756536587e-002	+4.975069601283877e-002

Table D-18 100 sps: Stage 2 FIR Filter Coefficients (Continued)

+6.206696168821097e-002	+7.333684637153971e-002	+8.290151879402521e-002	+9.018659693370301e-002
+9.474635107447013e-002	+9.629848418816638e-002		

Table D-19 100 sps: Stage 3 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-20 120 sps: Stage 1 FIR Filter Coefficients

+1.035954137727850e-008	+2.380715563670972e-008	+1.215287844369605e-007	+6.172676526658757e-007
+2.571918915092029e-006	+8.904631629860253e-006	+2.631544018920328e-005	+6.772048046339687e-005
+1.537474600982135e-004	+3.101772956392099e-004	+5.569243004121623e-004	+8.849267693883314e-004
+1.222095834531600e-003	+1.398922199638253e-003	+1.136096196340338e-003	+8.425031828590839e-005
-2.059035906704833e-003	-5.354157294749186e-003	-9.387696093571527e-003	-1.309153737935447e-002
-1.472662638912829e-002	-1.212621130824787e-002	-3.218564922601985e-003	+1.326626426974910e-002
+3.711431453572162e-002	+6.623396816708169e-002	+9.676901273444644e-002	+1.237877548669908e-001
+1.424107155595921e-001	+1.490567475532042e-001		

Table D-21 120 sps: Stage 2 FIR Filter Coefficients

-3.200801662364815e-009	-1.988439646433057e-008	-5.402910439495697e-008	-3.547032265328775e-010
+6.452688615155827e-007	+3.280814268787692e-006	+1.058986896003402e-005	+2.597279770902737e-005
+5.076968476801004e-005	+7.857946348675915e-005	+8.823298699088323e-005	+4.073539194744338e-005
-1.113268976328547e-004	-3.946869928122824e-004	-7.687326169762171e-004	-1.080568247436766e-003
-1.058650779949517e-003	-3.857227284916195e-004	+1.132148333669320e-003	+3.338236697125898e-003
+5.544662142675237e-003	+6.545367146237799e-003	+4.941769693002198e-003	-2.163436736430420e-004
-8.650542097071775e-003	-1.827152361006828e-002	-2.517602379478459e-002	-2.446009307559762e-002
-1.176902845944294e-002	+1.487007643807905e-002	+5.364033265254078e-002	+9.863398203828931e-002
+1.409934743174493e-001	+1.712727280104992e-001	+1.822634740405426e-001	

Table D-22 120 sps: Stage 3 FIR Filter Coefficients

+3.624153237100989e-009	+1.470216688117767e-008	+2.924648074949182e-008	+1.675815859925242e-008
-9.459692996675541e-008	-4.005292369332425e-007	-9.373651758431229e-007	-1.530435241099631e-006
-1.645991491318222e-006	-4.078703649887408e-007	+3.030094105174225e-006	+8.685992078359400e-006
+1.476603465201467e-005	+1.713674632378615e-005	+1.012813500657534e-005	-1.072856062768063e-005
-4.439650993665008e-005	-8.029796768720772e-005	-9.761762240257018e-005	-7.094869060070728e-005
+1.692090641200780e-005	+1.585078223461214e-004	+3.094936499512948e-004	+3.912802093626145e-004
+3.155885036776064e-004	+2.919057865035819e-005	-4.362723697929486e-004	-9.354174279267205e-004
-1.228393916598020e-003	-1.061468695091633e-003	-2.939814743843771e-004	+9.756477540050195e-004
+2.352455381127647e-003	+3.215585281329135e-003	+2.933433563419905e-003	+1.171050910958822e-003
-1.829548430478970e-003	-5.145646443318352e-003	-7.361207758041045e-003	-7.056359496882652e-003
-3.467654576125640e-003	+2.935112705392162e-003	+1.024857149306014e-002	+1.551827984678943e-002
+1.570615959949202e-002	+8.987865329886645e-003	-4.081171672241476e-003	-2.004540408564930e-002
-3.303497648347430e-002	-3.628456170461448e-002	-2.430879726955251e-002	+4.958793846270522e-003
+4.884525267308668e-002	+1.000147740815335e-001	+1.480752985064006e-001	+1.823112272692678e-001
+1.947111255384850e-001			

Table D-23 120 sps: Stage 4 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-24 200 sps: Stage 1 FIR Filter Coefficients

-4.362506220108750e-010	-1.806376451116416e-009	-5.570394776144358e-009	-1.438565196188544e-008
-3.295637947256818e-008	-6.910595136467388e-008	-1.351974812166871e-007	-2.499213997487419e-007
-4.404316319576105e-007	-7.447576664034625e-007	-1.214345110894767e-006	-1.916484003651231e-006
-2.936281628072127e-006	-4.377722173080341e-006	-6.363249425455480e-006	-9.031219018893644e-006
-1.253050991642668e-005	-1.701158506617340e-005	-2.261336249927899e-005	-2.944542166285249e-005
-3.756534261937042e-005	-4.695136269020378e-005	-5.747103928147660e-005	-6.884721727189637e-005

Table D-24 200 sps: Stage 1 FIR Filter Coefficients (Continued)

-8.062328835311143e-005	-9.213045884260119e-005	-1.024604566907290e-004	-1.104477393848633e-004
-1.146657308989088e-004	-1.134418328258946e-004	-1.048958370196779e-004	-8.700583403336131e-005
-5.770470299733258e-005	-1.500874890848986e-005	+4.282198036188565e-005	+1.170946708592686e-004
+2.084718760741516e-004	+3.167458041499561e-004	+4.406109467810773e-004	+5.774502548319454e-004
+7.231526444568223e-004	+8.719814767556627e-004	+1.016514513735156e-003	+1.147675456659802e-003
+1.254875311444148e-003	+1.326278362059338e-003	+1.349202425238514e-003	+1.310656377889152e-003
+1.198009886879690e-003	+9.997811537926220e-004	+7.065187636937218e-004	+3.117439541878291e-004
-1.870895590434082e-004	-7.876689608887009e-004	-1.481985597005660e-003	-2.255648076383899e-003
-3.087405267712509e-003	-3.948935724464110e-003	-4.804952725862425e-003	-5.613662944727127e-003
-6.327602002650539e-003	-6.894852362841282e-003	-7.260628906030117e-003	-7.369196124240714e-003
-7.166059317737823e-003	-6.600351775276087e-003	-5.627321980254949e-003	-4.210810695767793e-003
-2.325598488811593e-003	+4.049920848604366e-005	+2.884909393986904e-003	+6.189061272639760e-003
+9.917722222465147e-003	+1.401898110594868e-002	+1.842492232406818e-002	+2.305300233040384e-002
+2.780810631408575e-002	+3.258522823069956e-002	+3.727268423059304e-002	+4.175573972102439e-002
+4.592050559581340e-002	+4.965794112684497e-002	+5.286779084561585e-002	+5.546228122998397e-002
+5.736941044406934e-002	+5.853568053358436e-002	+5.892814561810381e-002	

Table D-25 200 sps: Stage 2 FIR Filter Coefficients

+6.153430295132828e-009	+3.530519327063935e-008	+1.089858214494524e-007	+2.142857295407477e-007
+2.256697716333727e-007	-1.682190850826297e-007	-1.414450788649266e-006	-3.770907100820789e-006
-6.660793923894316e-006	-7.962811040042683e-006	-3.899630850342331e-006	+9.603922277193346e-006
+3.362840827823712e-005	+6.183138898420558e-005	+7.748136498063315e-005	+5.581577095929406e-005
-2.520515934503081e-005	-1.665611915198329e-004	-3.294145372558157e-004	-4.289274408458540e-004
-3.543105868444424e-004	-2.029750670138214e-005	+5.622960580560747e-004	+1.229527426586142e-003
+1.664545040670753e-003	+1.488560016088282e-003	+4.394819913049908e-004	-1.418539563620706e-003
-3.558013639677270e-003	-5.035428581611710e-003	-4.783902856107047e-003	-2.105146950388155e-003
+2.811017086151542e-003	+8.594694156147317e-003	+1.286812435881155e-002	+1.297354635818739e-002
+7.110221727755215e-003	-4.505597263086766e-003	-1.896891727817149e-002	-3.093477238042327e-002
-3.392627187366533e-002	-2.242131236251002e-002	+5.943292375288421e-003	+4.887832338440840e-002
+9.933513218795276e-002	+1.470122062931602e-001	+1.811124481365914e-001	+1.934882509424306e-001

Table D-26 200 sps: Stage 3 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003

Table D-26 200 sps: Stage 3 FIR Filter Coefficients (Continued)

+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-27 500 sps: Stage 1 FIR Filter Coefficients

+3.687128668327759e-009	+1.988589997819086e-008	+7.034199836249336e-008	+1.981551146357140e-007
+4.792119292369644e-007	+1.033576482295382e-006	+2.032944112302389e-006	+3.697965251359757e-006
+6.277537895395675e-006	+1.000168084517540e-005	+1.500126073542470e-005	+2.119253056761970e-005
+2.813260153887296e-005	+3.486342885224429e-005	+3.977541911819388e-005	+4.053507381786698e-005
+3.413072429162836e-005	+1.709234599273666e-005	-1.406849924421359e-005	-6.217744677998088e-005
-1.284946686854785e-004	-2.116655632316000e-004	-3.066626157854046e-004	-4.039174825654819e-004
-4.888885632207030e-004	-5.423257955303867e-004	-5.414671700015274e-004	-4.623206105076822e-004
-2.830476383156453e-004	+1.172128556701199e-005	+4.260272234484851e-004	+9.477853191995096e-004
+1.544838112478128e-003	+2.162752610676306e-003	+2.725241782148576e-003	+3.137933978553986e-003
+3.295901551424277e-003	+3.094905995970230e-003	+2.445761095731593e-003	+1.290622555288920e-003
-3.805336330911445e-004	-2.515388644389134e-003	-4.989038131499888e-003	-7.600237496991304e-003
-1.007589772317286e-002	-1.208482969725210e-002	-1.326071106718158e-002	-1.323307351805670e-002
-1.166392378080628e-002	-8.286581953329937e-003	-2.942606160478644e-003	+4.387593765495640e-003
+1.356458584960782e-002	+2.428350823651835e-002	+3.608344175243675e-002	+4.837292074113681e-002
+6.047011291596699e-002	+7.165442981681870e-002	+8.122484949574002e-002	+8.855924630699395e-002
+9.316867606453692e-002	+9.474092531265110e-002		

Table D-28 500 sps: Stage 2 FIR Filter Coefficients

+7.906879610198613e-008	+2.324131181456852e-007	-2.773212822834928e-007	-2.578884454846203e-006
-4.462061570757843e-006	+2.840054550840448e-006	+2.426607976251553e-005	+3.582744254187091e-005
-1.510647510251522e-005	-1.343526843047522e-004	-1.825442777287194e-004	+5.512420004172292e-005
+5.346423500720257e-004	+6.892924901102732e-004	-1.538123336945688e-004	-1.681413493662007e-003
-2.092473772821497e-003	+3.471450087760466e-004	+4.429339585437376e-003	+5.387843229955970e-003
-6.551049401636806e-004	-1.022723777722751e-002	-1.231744148068455e-002	+1.055553777511986e-003
+2.174685894103925e-002	+2.646399758733937e-002	-1.471895785988979e-003	-4.643308275563292e-002
-6.022532548275477e-002	+1.791307862058360e-003	+1.346723647853785e-001	+2.726495000282411e-001
+3.314217853600064e-001			

Table D-29 500 sps: Stage 3 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003

Table D-29 500 sps: Stage 3 FIR Filter Coefficients (Continued)

-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003
+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Table D-30 1000 sps: Stage 1 FIR Filter Coefficients

+2.680854976635399e-008	+2.621807504749845e-007	+1.379843023444468e-006	+5.069548265907504e-006
+1.429380975697960e-005	+3.216090626380187e-005	+5.800148422397549e-005	+8.036492159490036e-005
+6.998844477239671e-005	-1.951802499589744e-005	-2.329892356228854e-004	-5.716295662189337e-004
-9.378336808238523e-004	-1.099915313503737e-003	-7.257858064354704e-004	+4.756533878558921e-004
+2.516234277838917e-003	+4.883922625154118e-003	+6.453534700234562e-003	+5.720159266924601e-003
+1.420576847482689e-003	-6.592321068530753e-003	-1.657547943894720e-002	-2.468446947332750e-002
-2.567756602308608e-002	-1.454237111676001e-002	+1.140977444786802e-002	+5.079517356947721e-002
+9.760642899463642e-002	+1.423377798040746e-001	+1.745994145142351e-001	+1.863593565358893e-001

Table D-31 1000 sps: Stage 2 FIR Filter Coefficients

+1.987935777749492e-007	+1.106136279359727e-006	+1.872564270474522e-006	-2.822938187551184e-006
-1.801762495946041e-005	-2.708240890860545e-005	+1.897264325952234e-005	+1.377321648742390e-004
+1.919252787600896e-004	-8.155059628113955e-005	-6.803289719184677e-004	-8.993755026035479e-004
+2.532831548553589e-004	+2.485114515984222e-003	+3.166611047172176e-003	-6.061190825988742e-004
-7.278794088595842e-003	-9.074381784058786e-003	+1.160719791137329e-003	+1.830473627571735e-002
+2.281387287432125e-002	-1.820819890113855e-003	-4.356198705011789e-002	-5.730081138457384e-002
+2.373355179260169e-003	+1.335128242801155e-001	+2.715583162433188e-001	+3.307428992695577e-001

Table D-32 1000 sps: Stage 3 FIR Filter Coefficients

-2.487704073631181e-010	+4.737439758869627e-009	+1.240318920913107e-008	+2.184229963813306e-009
-2.973504470949853e-008	-2.774098397333487e-008	+4.823500641306028e-008	+9.048519725175742e-008
-4.377201937731960e-008	-2.029250639003875e-007	-2.932509742660224e-008	+3.576771181845490e-007
+2.380755516575443e-007	-5.050541265325251e-007	-6.566606160434081e-007	+5.295136199801142e-007
+1.333026564739420e-006	-2.353908661900860e-007	-2.234558255777740e-006	-6.431886720336236e-007
+3.178847859642279e-006	+2.391893663270882e-006	-3.766425715549474e-006	-5.213130996570269e-006
+3.343878835698979e-006	+9.069842337901537e-006	-1.034202665666667e-006	-1.349476353372010e-005
-4.128203067878262e-006	+1.740813571972671e-005	+1.293246945424367e-005	-1.901116086317058e-005
-2.559820150658931e-005	+1.583846664297833e-005	+4.129854219272497e-005	-5.051361531234260e-006
-5.769433718028819e-005	-1.597343340345311e-005	+7.062319519353707e-005	+4.876211902966221e-005
-7.411825064261423e-005	-9.265601046647684e-005	+6.092805886715002e-005	+1.437041528677315e-004
-2.365713142641937e-005	-1.938176534863781e-004	-4.346068390483575e-005	+2.305286005770023e-004
+1.422997430119745e-004	-2.376966240860235e-004	-2.684195404303642e-004	+1.974200184015998e-004
+4.089861668732694e-004	-9.322642224777145e-005	-5.416667040038034e-004	-8.565059594353358e-005
+6.351458753935074e-004	+3.394235438661822e-004	-6.517938478495219e-004	-6.531622837118695e-004
+5.527339849418497e-004	+9.935334284260212e-004	-3.051329942536734e-004	-1.308020364817281e-003
-1.089866761415155e-004	+1.527642392221839e-003	+6.836461053210791e-004	-1.573807813969138e-003
-1.381190291127471e-003	+1.369316440666299e-003	+2.127841145429655e-003	-8.527391469852445e-004
-2.814325561899974e-003	-5.435980978213282e-006	+3.302926411211769e-003	+1.187235385529431e-003
-3.441492859559195e-003	-2.615018460333554e-003	+3.083861131922053e-003	+4.145541224298037e-003
-2.114932740796397e-003	-5.572668686252893e-003	+4.775431526676058e-004	+6.640170511329856e-003

Table D-32 1000 sps: Stage 3 FIR Filter Coefficients (Continued)

+1.802537521879636e-003	-7.064640192213203e-003	-4.597380817112646e-003	+6.566940317484810e-003
+7.666904141149428e-003	-4.908950080892368e-003	-1.066028889600873e-002	+1.931063619415937e-003
+1.312888066219805e-002	+2.414871264176499e-003	-1.454757748158677e-002	-8.042475439797359e-003
+1.433728095680021e-002	+1.472206237002311e-002	-1.187358886084607e-002	-2.208894932833420e-002
+6.451059640865893e-003	+2.966939534975369e-002	+2.871718562712786e-003	-3.692218906488918e-002
-1.777634564159653e-002	+4.329151455872206e-002	+4.248360716585619e-002	-4.826484520071661e-002
-9.280869043016983e-002	+5.142858357174776e-002	+3.137773586587529e-001	+4.474858173759422e-001

Appendix E Sensor-Digitizer Interconnection

The purpose of this section is to point out the critical requirements when connecting high-performance sensors to high-resolution digitizers. The case of connecting a Trillium seismometer to a Trident digitizer is considered in detail.

Note Trident is designed for best dynamic range performance when used with sensors having differential outputs. See section E.5 on page 58 for information on Trident operation with single-ended inputs.

E.1 Circuit Description

E.1.1 Digitizer

High-resolution digitizers will always have differential input circuits, however they will differ in their input impedance, RF suppression and common-mode rejection. It is also important to determine whether or not the power supply is isolated.

The Trident input stage has an input impedance of 43 kΩ and minimum 110 dB of common-mode rejection over a range of approximately ±0.78 V with respect to the case. The front end is designed with excellent RF suppression so that with properly-designed cables, Trident can be operated in the presence of radios and cell phones. The Trident power supply is completely isolated from the rest of the electronics and the case.

Trident also provides state-of-health inputs and control, calibration and sensor power outputs.

E.1.2 Sensor

High-performance active seismometers will always have differential output stages. Other active sensors will sometimes have single-ended output stages. Passive seismometers have an isolated output coil. Active sensor power supplies may or may not be isolated.

The Trillium output is a balanced differential output with a clip level of 16 V peak-to-peak and an output impedance of 100 Ω. The Trillium power supply is completely isolated from the rest of the electronics and the case.

Trillium also provides mass position outputs and a calibration input. Active-low inputs serve as calibration enables and to configure the output signals and frequency response.

E.2 Shielding

Sensor cables must be designed for good EMI shielding. This is most easily accomplished using double-shielded twisted-pair cable as shown in Figs. 1 and 2. We find the Belden 816x series of cables particularly suitable.

The twisted pairs provide magnetic shielding, an inner shield grounded at the digitizer provides good electric field shielding, and a continuous outer shield provides good high-frequency RF shielding. The outer shield must be earthed for safety.

E.3 Grounding

E.3.1 General Considerations

The digitizer and sensor cases must always have a low-resistance path to ground for safety. However, directly earthing both instruments will result in a ground loop. When the digitizer and sensor are far apart differences in ground potential will cause spurious signals to appear unless the loop is broken. The solution is therefore to either earth the digitizer case and isolate the sensor case or vice versa.

Usually the simplest solution is to earth the digitizer as shown in Figure E-1 and Figure E-2. An M4 screw is provided on the side of the Trident case for this purpose. Trillium has stainless steel adjustable feet which when mounted directly onto dry rock or concrete provide a high resistance to ground. In wet environments it may be necessary to mount the sensor on a plate of glass embedded in sand, or to choose to earth the sensor and isolate the digitizer case.

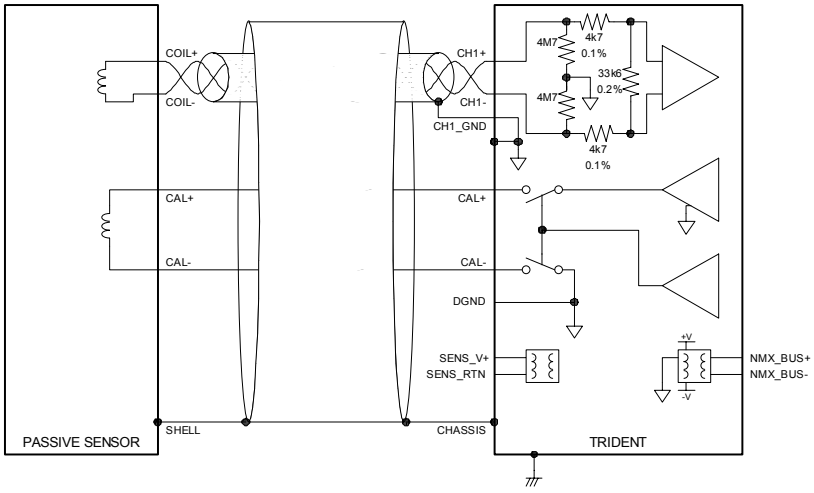
Some sensors may have no chassis connection at the connector. In this case the sensor and digitizer must be separately earthed.

E.3.2 Passive Sensors

For a passive sensor connect the output and calibration coils as shown in Figure E-1 and Table E-1.

In the wiring lists in this application note, P1 is the sensor connector and P2 is the digitizer connector. The “run” and “colour” columns are used to indicate which signals are paired together and how the shields are connected. In particular, “drain” means the drain wire of the foil shield of the twisted pair indicated in the run column and “braid” means the overall braided shield of the cable.

Figure E-1 Typical Passive Sensor Cable Design



Note that the 4.7 MΩ input resistors at the input of the Trident ensure that the common-mode voltage will be negligible.

Table E-1 Typical Passive Sensor Wiring List

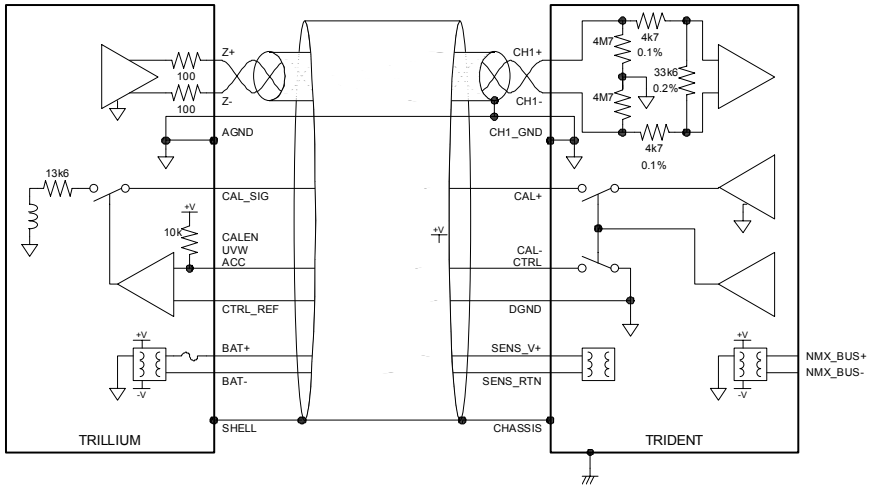
From			To			Colour	Run
Conn	Pin	Name	Conn	Pin	Name		
P1		COIL+	P2	U	CH1+	RED	1
P1		COIL-	P2	C	CH1-	BLK	1
			P2	B	CH1 GND	DRAIN	1
P1		CAL+	P2	N	CAL1+	WHT	2
P1		CAL-	P2	Z	CAL1-/CTRL4	BLK	2
P1		SHELL	P2	b	CHGND	DRAIN	2
P1		SHELL	P2	b	CHGND	BRAID	

E.3.3 Active Sensors

For an active sensor with a differential output a typical cable design is shown in Figure E-1. Note that, for simplicity, one channel only is shown and the mass position state-of-health connections have been omitted.

A typical wiring list is given in Table E-2. Pinouts given are for Trillium and Trident.

Figure E-2 Typical Active Sensor Cable Design



When either of the sensor or digitizer power supplies are isolated, there is nothing to constrain the common-mode voltage of the sensor outputs with respect to the digitizer ground. For optimal shielding performance the digitizer channel grounds are connected to the drain wires of the inner shields at one end of the cable only. Therefore it is of critical importance that the analog ground of the sensor (AGND) be separately connected to the analog ground of the digitizer (CH1_GND). The other two digitizer channel grounds (CH2_GND and CH3_GND) should only be connected to their respective sheild drain wires and not to AGND.

The control signal reference (CTRL_REF) serves as the reference voltage for all of the Trillium control signals (U_CALEN, V_CALEN, W_CALEN, UVW and ACC). This should be connected to the appropriate ground for the control signal outputs on the digitizer. In the case of Trident this is the digital ground (DGND).

Table E-2 Typical Active Sensor Wiring List

From			To			Colour	Run
Conn	**Pin**	**Name**	**Conn**	**Pin**	**Name**		
P1	L	Z+/W+	P2	U	CH1+	RED	1
P1	M	Z-/W-	P2	C	CH1-	BLK	1
			P2	B	CH1 GND	DRAIN	1
P1	N	Y+/V+	P2	A	CH2+	WHT	2
P1	A	Y-/V-	P2	S	CH2-	BLK	2
			P2	T	CH2 GND	DRAIN	2
P1	P	X+/U+	P2	a	CH3+	GRN	3
P1	B	X-/U-	P2	P	CH3-	BLK	3
			P2	R	CH3 GND	DRAIN	3

Table E-2 Typical Active Sensor Wiring List (Continued)

From			To			Colour	Run
Conn	Pin	Name	Conn	Pin	Name		
P1	T	CAL_SIG	P2	N	CAL1+	BLU	4
P1	U	W_CALEN	P2	Z	CAL1-/CTRL4	BLK	4
P1		SHELL	P2		SHELL	DRAIN	4
P1	J	V_CALEN	P2	c	CAL2-/CTRL5	YEL	5
P1	K	U_CALEN	P2	Y	CAL3-/CTRL6	BLK	5
P1		SHELL	P2		SHELL	DRAIN	5
P1	S	W_MP	P2	K	EXT_SOH1	BRN	6
P1	F	V_MP	P2	X	EXT_SOH2	BLK	6
P1		SHELL	P2		SHELL	DRAIN	6
P1	E	U_MP	P2	J	EXT_SOH3	ORG	7
P1	V	AGND	P2	B	CH1 GND	BLK	7
P1		SHELL	P2		SHELL	DRAIN	7
P1	H	BAT+	P2	F	SENS_V+	RED	8
P1	G	BAT-	P2	D	SENS_RTN	WHT	8
P1		SHELL	P2		SHELL	DRAIN	8
P1	D	UVW	P2	H	CTRL1	RED	9
P1	C	ACC	P2	W	CTRL2	GRN	9
P1	R	CTRL_REF	P2	V	DGND	DRAIN	9
P1		SHELL	P2	b	CHGND	BRAID	
P2	N	CAL1+	P2	M	CAL2+		
P2	M	CAL2+	P2	L	CAL3+		

E.4 Other Details

Some other factors to consider when designing sensor cables:

- Ensure that the cable length does not exceed sensor requirements for capacitive loading.
- Ensure that the peak current requirement of the sensor does not result in a voltage drop along the cable which takes the power supply voltage below the minimum required at the sensor.
- Ensure the cable is watertight.
- Check the cable electrically after assembly. In particular, ensure that the individual and overall shields are not shorted together unless so specified.
- Make sure cables are labeled with correct drawing numbers and revisions.
- Make sure the digitizer is configured so that the default states of the control lines put the sensor in the state you want it to be in. For example, for a Trillium in XYZ mode, all control lines should be open-drain high.

E.5 Trident operation with single-ended inputs

Trident is designed for best dynamic range performance when used with sensors having differential outputs. Over a limited voltage range common-mode signal components, such as unwanted noise induced into the input cable, are rejected by at least 100 dB. However, common-mode signals greater than ±0.78 V cause distortion. Maximum single-ended signal before distortion is:
2*maximum common-mode signal = 2*0.78 = 1.56 V.

E.5.1 Input range and gain for a single-ended signal

A single-ended signal can be considered as the sum of differential and common-mode signals.

Assume V_{cm} is the common-mode input (to both +ve and -ve terminals) and +Vdif/2 and -Vdif/2 are the differential inputs. If these are the components to a single-ended signal, and the -ve terminal is connected to GND return, then
Vcm +(-Vdif/2) = 0. Therefore, Vcm = Vdif/2.
At the +ve terminal, with V_{cm} +Vdif/2 referred to GND, the differential input is (V_{cm} + Vdif/2) - (V_{cm} +(-Vdif/2)) = Vdif.

Therefore, gain to a single-ended signal is the same for differential and the common-mode component is half of the single-ended input.