# EuropaT Digitiser

## User Guide

**Nanometrics Inc.**
**Kanata, Ontario**
**Canada**

EuropaT Digitiser User Guide



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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**Release date** 2004-09-09

# Contents

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# Chapter 1 Getting Started

This section provides introductory information, guidelines for checking the completeness of the shipment and the condition of the shipped items prior to installation, and instructions on what to do if there are any problems with the shipment.

## 1.1 About the EuropaT digitiser

The EuropaT digitiser relays timestamped, error-corrected, (optionally) authenticated data to the acquisition centre. Communications with the acquisition centre can be via the built-in IP option, or via external options such as fixed frequency or spread spectrum radio, telephone modem, or fiber optic modem.

Multicast IP routing allows the EuropaT to forward continuous data to multiple acquisition systems simultaneously without requiring additional bandwidth. EuropaT is easy to install, and includes a graphical user interface—the Nanometrics UI—for configuration and monitoring.

## 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 EuropaT 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 and operating the EuropaT digitiser, and general reference information. See also related documents, listed in Section 1.3.1.

- Chapter 1, “Getting Started”, includes an introduction to the EuropaT digitiser and to this user guide, guidelines for unpacking the shipment, and technical support contact information.

- Chapter 2, “Technical Overview”, includes an overview of EuropaT features and hardware modules.
- Chapter 3, “Using the EuropaT”, includes installation and operation instructions, and maintenance guidelines.
- Appendices:
  - Appendix A, “Specifications”
  - Appendix B, “Connector Pinouts”
  - Appendix C, “Cable Drawings”
  - Appendix D, “Filter Response”
  - Appendix E, “Sensor-Digitiser Interconnection”

### 1.3.1 Related documents

#### 1.3.1.1 Configuration sheets

The as-shipped 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 EuropaT will operate on the initial startup.

#### 1.3.1.2 Software reference manual pages

- Nanometrics UI User Guide, for information on monitoring the operation and changing configuration parameters on an installed EuropaT and connected instruments
- Naqs (NaqsServer, Naqs Client), for information on data acquisition and monitoring options, such as information on defining instruments included in the data acquisition network

## 1.4 Technical support

Read the appropriate sections of this user guide carefully before installing or operating the EuropaT 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 Overview

This section provides a brief description of the EuropaT digitiser features and hardware modules.

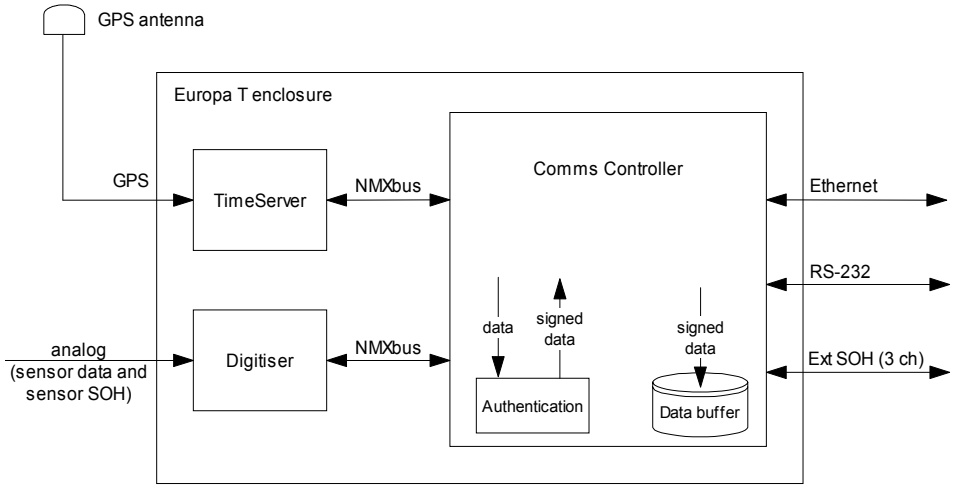
## 2.1 Overview

The EuropaT digitiser receives analog signals from differential sensors, and transmits digitised data to the acquisition centre(s). Data transmission can be via the built-in IP option, or external options such as RF, fiber optic, or dedicated telephone line. EuropaT provides a high precision timing subsystem and rigorous error correction for the data. EuropaT options include data authentication, central timing, and power supply to the sensor.

The three main modules of the EuropaT—Comms Controller, digitiser, and TimeServer—communicate through the internal NMXbus. Operation monitoring and some configuration of these internal bus devices can be done through the Nanometrics UI (see the Nanometrics UI User Guide).

Figure 2-1 is a block diagram of the hardware modules and data port options for a EuropaT digitiser with bus timing and data authentication.

**Figure 2-1** EuropaT block diagram



# 2.2 Timing

The EuropaT will be configured to use bus timing either derived from local GPS data acquired at the remote site, or central timing. In either case, timing is provided by the internal TimeServer, which is essentially a GPS disciplined clock; the TimeServer system time is synchronized to GPS time. Time-related messages carried on the NMXbus are the time, frequency error, time error, and accuracy. Time quality information and GPS status are displayed in the Nanometrics UI, under the [EuropaT] > Operation > GPS tab. TimeServer operation, configuration, and maintenance parameters are displayed in the panels under the [TimeServer] instrument module tab.

## 2.2.1 Local timing

With the local timing option, the TimeServer uses a built-in GPS engine.

## 2.2.2 Central timing option

With the central timing option, a central GPS unit is used to acquire and distribute the GPS clock signal to several remote site EuropaT digitisers. EuropaT units equipped with the central timing option accept these clock signals through the SOH/COMMS connector. The type of connection depends on the data transmission system that is used to carry the GPS signal from the central unit to the EuropaT. (See Table B-4, “SOH/COMMS connector pinout,” on page 21 for data options available with central timing enabled.)

# 2.3 Ports

For the EuropaT with local timing, ports include data ports (two serial ports, an Ethernet port, and three external state-of-health (SOH) channels) and factory configuration ports. The Nanometrics UI provides access to a subset of the port and channel configuration options.

- Serial port availability depends on the transport mode and timing option (see also Table 2-1):
  - For EuropaT with local timing, both serial ports can be configured for either unidirectional or full duplex communication. When sending data via serial port, one of the ports must be configured as an NMXP transmit port.
  - For EuropaT with central timing, serial port 1 is not available. Serial port 2 must be configured as an NMXP transmit port.
- Ethernet port: The Ethernet port supports email, FTP, and telnet IP protocols. The IP protocol used over the transmission link includes both UDP and TCP as data transfer layers.
- External SOH: The three SOH channels can be used to monitor external voltages, such as instrument temperature and battery voltage, typically related to environmental characteristics. Alternatively, other external signals can be connected, such as a vault tamper switch signal; see also Section 2.4.
- Comms Controller and TimeServer configuration ports: These configuration ports are available for factory configuration. (The Comms Controller configuration port can also be used for some operation monitoring; see Section 3.5.1 on page 12.)

**Table 2-1** Serial data port options

| Data Transport | Timing Mode | |
|---|---|---|
| | Local Timing | Central Timing |
| IP | serial port 1 or serial port 2 = any | serial port 1 = unavailable<br>serial port 2 = any |
| Serial | serial port 1 or serial port 2 = any = NMXP transmit | serial port 1 = unavailable<br>serial port 2 = NMXP transmit |

## 2.4 State-of-health channels

The EuropaT monitors analog state-of-health (SOH) channels—two internal and three external. The internal channels are used to monitor the input supply voltage and the internal temperature of the VCXO. Of the external channels, channels one and three are reserved for tamper switch monitoring, and channel two is available for user-defined applications. The reporting rate for SOH data to Naqs (Report interval) is an editable value in the Nanometrics UI.

**Caution** Do not short the +5V and ground wires of the vault tamper cable while it is connected to a powered EuropaT, as this will damage the Comms Controller.

- External SOH 1 is accessible through the SOH 1 connector and is used as a vault tamper switch monitor.

  The vault tamper switch cable comes with a three-pin connector at one end and three bare wires at the other to allow connecting a switch that meets the particular installation requirements. Opening the vault will move the SOH reading from 0 V to a high.
- External SOH 3 is used to monitor any tampering with the Europa digitiser enclosures. When the enclosure is opened, the SOH will change from 0 V to a high.

There are two calibration factors that need to be set for an external SOH channel. Both the calibration factor and offset parameters are set in the Nanometrics UI, in the Configuration > System > External SOH Calibration panel:

- The scale calibration factor is built from two constants. One is the sensitivity of the sensor. This might be expressed as “units” per volt. For example, with a temperature sensor, this might be set to 44 degrees Celsius per volt. The other constant is the actual sensitivity of the ADC, which is a factory setting. (To report the actual voltage on the connector use 0.1, 0.5, and 0.5 respectively for SOH channels 1, 2, and 3.)
- The offset is used to allow for the sensor not producing zero output volts when registering zero sensor measurement units. The offset is expressed in units appropriate to the sensor. For example, for a temperature sensor, the offset is expressed in degrees Celsius.

The appropriate scale and offset values for the internal SOH parameters are determined during the final test and are entered into the as-shipped configuration file. A hard copy of this file is shipped with the digitizer. The external SOH channels can be monitored from the central site, with either the Nanometrics UI or NaqsView software.

## 2.5 Data authentication option

The EuropaT equipped with the authentication option can securely send signed data on RS232 and 10-base-T Ethernet ports. Typically, two state-of-health channels are configured for vault and EuropaT enclosure monitoring, to increase security associated with data authentication (see Section 2.4).

The EuropaT digitiser uses an authentication card (token) integrated with the Comms Controller. The data are first assembled in 10-second CD1 format frames and signed using a key pair stored on the token. Following the signing process, the data are assembled into NMXP packets and sent to the acquisition computer. (NMXP is a Nanometrics proprietary data transmission protocol used in every Nanometrics seismic data acquisition system.) Each packet is compressed using a first difference compression algorithm and time stamped with UTC time.

## 2.6 Hardware modules

The EuropaT contains three main modules: the Comms Controller, TimeServer, and digitiser.

### 2.6.1 Comms Controller

The Comms Controller module receives data on the NMXbus and optionally on the serial port(s), and prepares the data 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 either internally or via a central timing system. For IP, NMX packets are embedded into UDP packets prior to transmission. For the EuropaT equipped with the data authentication option, data are signed before being packetized.

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. The data buffer has a 12 MB capacity. 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 receipt of the retransmission request, the Comms 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.

Each of the serial ports of the Comms Controller board can be configured using the Nanometrics UI to operate in one of six modes (see also the Nanometrics UI manual):

- NMXP transmit – The port transmits packets in Nanometrics format to NaqsServer, and receives command packets from NaqsServer.
- NMXP receive – The port receives data packets generated by a Nanometrics HRD-type digitiser and transmits command packets to the HRD.
- Serial receive (transparent operation) – The port receives serial data in any format and forwards the data to NaqsServer as Nanometrics format packets.
- Interactive – The port supports an interactive connection via Telnet.
- Console – The Comms Controller operation can be monitored via a test cable (Section C.1 on page 24). In this case information or data received on the serial port is not transmitted over the network.
- Internet – (For firmware v5.80 and higher, and UI v5.12 and higher.) The port is configured to carry data and commands via Serial Link Internet protocol (SLIP).

The Comms Controller generates equipment state-of-health (SOH) messages which are sent to the NaqsServer software (using UDP) and to the Nanometrics UI (using TCP).

### 2.6.2 TimeServer

The TimeServer module provides precise time for peripheral instruments and for the Comms Controller, and also controls data traffic on the NMXbus. Two instances of TimeServer firmware are maintained in flash memory, in order to support safe remote firmware upload capabilities.

Time marks are put on the NMXbus that define specific moments in time, and a long burst of bits provide means for precise time signal phase recovery (jitter reduction). The time marks occur 10 times a second. Every tenth time mark (signifying a second) is followed by a time message that contains the time to which the time mark corresponds. The message also contains a time quality indicator.

The TimeServer supervises data traffic on the bus, using a request-permit scheme. Critical timing information has priority over data messages. Timing-related information, such as time quality and GPS satellite tracking information, can be accessed through the Nanometrics UI.

TimeServer 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.

### 2.6.3 Digitiser

The three-channel digitiser module provides 24-bit resolution and a 142 dB dynamic range. The digitiser can digitise from one to three channels of data, with sample rates from 10 sps to 1000 sps. Software filters include a decimating FIR filter which is required for low pass filtering of the data, and an optional 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. See also Appendix D, “Filter Response” and Appendix E, “Sensor-Digitiser Interconnection”.

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 UI provides means for monitoring and controlling digitiser and sensor operation remotely. This includes options for operation monitoring, submitting new instrument configurations, upgrading digitiser firmware and EPLD code, and sensor calibration and control. Digitiser module and sensor state of health information that can be monitored through the UI includes mass position, and NMXbus data transmission statistics.

# Chapter 3 Using the EuropaT

This section of the user guide describes how to install, operate, and maintain the EuropaT digitiser.

## 3.1 General precautions

- Ensure that the power supply to the EuropaT is switched off before connecting or disconnecting the GPS antenna.
- 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

The EuropaT is typically installed in the remote site equipment vault or hut, using the optional universal mounting plate to secure the unit to a wall. The weather-sealed enclosure allows the EuropaT to be installed outdoors if required by the site design.

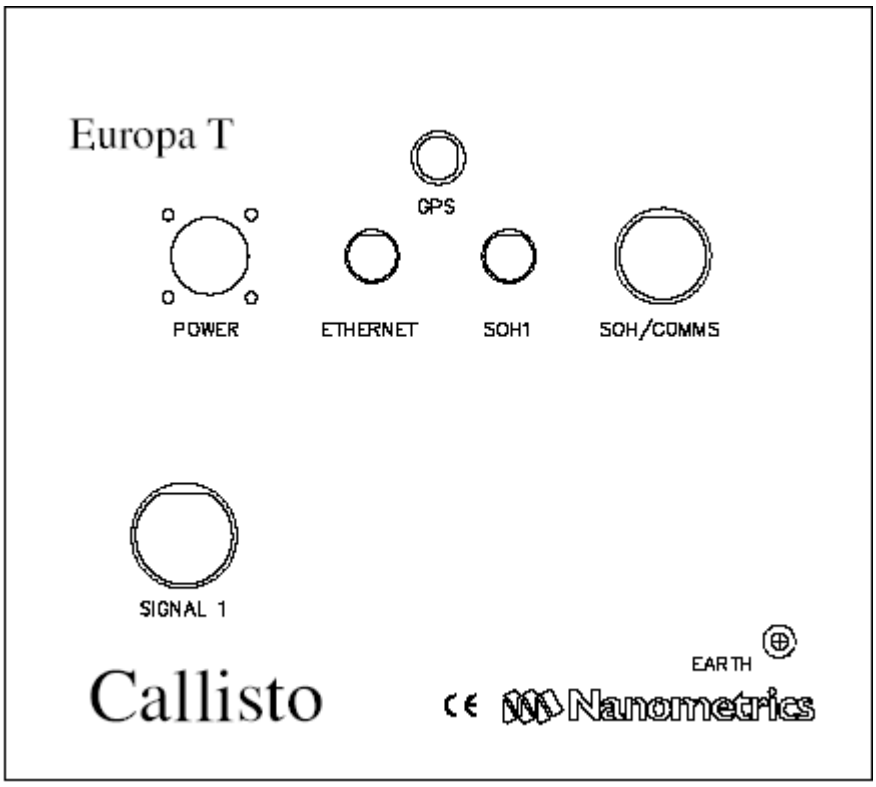
**Caution** Before installing the GPS antenna, ensure that (1) the power supply to the EuropaT is off, and (2) the antenna cable is properly secured to the antenna.

1. Mount the EuropaT digitiser on the support hardware, and then connect the antenna, power, and data cables to the unit.

   All of the connectors are located on the front panel of the unit (Figure 3-1). The data and power cables can be connected while the power supply is on without causing damage to the equipment.

2. Ensure that the EuropaT is included in the Naqs station file (see the NaqsServer software manual pages.)

**Figure 3-1** EuropaT connector locations




## 3.3 Operation

Options for operation monitoring, instrument reconfiguration, and maintenance of the Europa T are accessible through the Nanometrics UI.

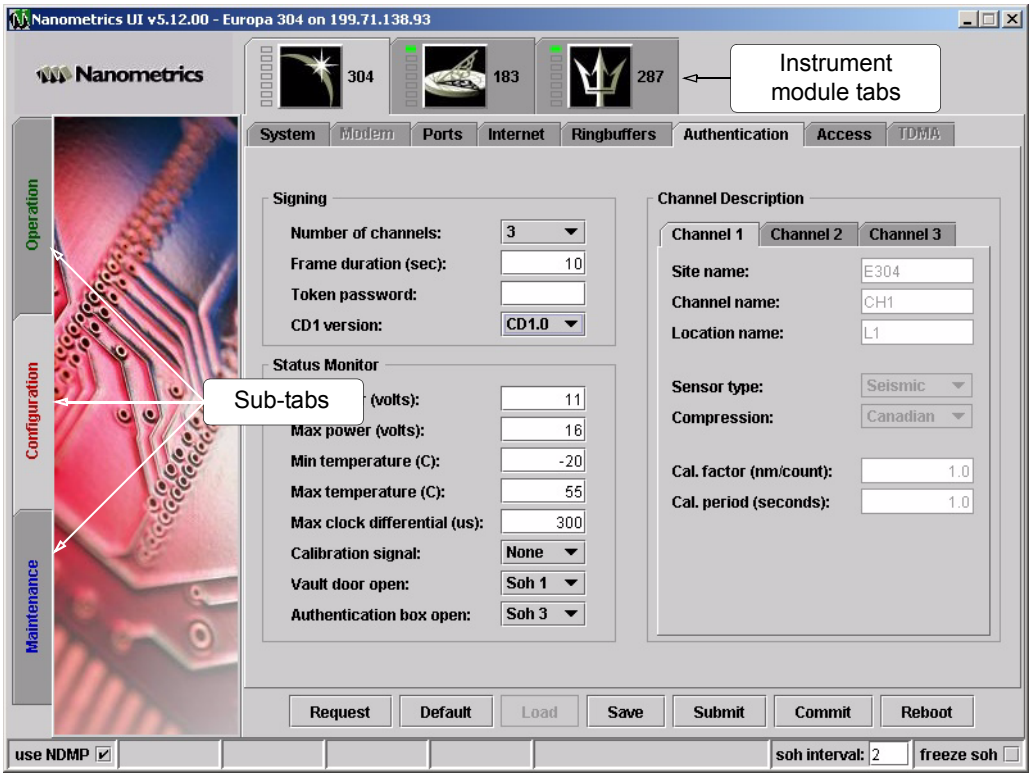
The instrument modules for the EuropaT—Comms Controller, TimeServer, and digitiser—are indicated in the Nanometrics UI by the icons shown in Table 3-1. Monitoring and configuration options for an instrument module are grouped in sub-tab panels under the main tab for that instrument module. For example, Figure 3-2 shows the environment SOH information for the Comms Controller module of the EuropaT.

See the Nanometrics UI User Guide for general information on using the Nanometrics UI and for detailed descriptions of operation monitoring, configuration, and maintenance parameters. For information on the EuropaT digitiser module, refer to sections about the Trident digitiser in the Nanometrics UI User Guide.

**Table 3-1** Instrument module icons for EuropaT

| Icon | Module |
|---|---|
|  | Comms Controller module |
|  | TimeServer module |
|  | Digitiser module |

**Figure 3-2** Nanometrics UI instrument tabs




## 3.4 Maintenance

**Warning** Do not power down the EuropaT during a firmware upload.

The EuropaT does not require scheduled maintenance. New firmware uploads may periodically be available; these can be uploaded to EuropaT using the Nanometrics UI. See the Nanometrics UI User Guide for instructions.

# 3.5 Troubleshooting

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

## 3.5.1 Monitor operation through the Comms Controller configuration port

The configuration port is an RS-232 port that can be used for monitoring the operation of the EuropaT. It is a three-pin port on the SOH/COMMS connector:

- TX: pin L
- GND: pin U
- RX: pin V

To access the port, connect the test cable to the SOH/COMMS connector of the EuropaT, and the Controller Config connector to the serial port of a computer. (See Section C.1, “Test/configuration cable,” on page 24 for information on building a test cable). The EuropaT operation can be monitored from a terminal emulator reading the COM port of the computer to which the EuropaT test cable is connected. The terminal emulator should be configured for 38400 Baud, 8 bits, no parity, and 1 stop bit (8N1), and no hardware or software handshaking.

## 3.5.2 Data communication

### 3.5.2.1 Ping

- Ping the LAN IP address of the EuropaT. The IP address can be found in the [EuropaT] > Configuration > Internet panel, and on the configuration sheet of the instrument.
  - Monitor the messages in the ping session window. The EuropaT should reply to the packets sent out from the computer.
- If the ping is not successful, then check:
  - All connections between the EuropaT and the computer.
  - That the IP address of the computer is in the same subnet as the IP address of the EuropaT LAN interface.
  - That you are pinging the correct IP address (the IP address of the LAN interface of the EuropaT as listed in the configuration sheet).

### 3.5.2.2 Ethernet port

Perform this test only after the ping test is successful.

- Start the Nanometrics UI. Under the [EuropaT] > Operation > Ports tab, check whether the number of received good packets is continuously increasing and the number of bad packets is stable. If data are not being received, then check:
  - The connections between the data source, Trident, and communications controller instrument.

- Whether the data source outputs data.

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

### 3.5.3 GPS

Start the Nanometrics UI. Under the [EuropaT] > Operation > GPS tab, monitor the activity on each GPS channel. The GPS should search and then track satellites on any of the channels. It needs to track at least one satellite in order to provide a good time reference for the EuropaT. Depending on the distance the EuropaT is from the previous location with a successful GPS lock, it may take several minutes for the PLL to be in Fine_Lock state.

Most problems with GPS can be traced to a poorly placed antenna. If the GPS is not receiving well do the following:

- Reposition the antenna to a location with better visibility of the sky.
- Ensure that the antenna cable is not hanging from the antenna, but is secured with the U-bracket or a few tie wraps near the antenna to carry the weight of the cable.
- Check if another GPS will lock to satellites. If this GPS receiver does not lock it may mean that there is not enough GPS satellite coverage over the area at the time the test is being performed.

# Appendix A Specifications

## A.1 Environment/Operational

**Table A-1** Environment/operational specifications

| Parameter | Specification |
|---|---|
| Supply input voltage | 12 to 24VDC nominal (9 to 36VDC) |
| Power consumption | 6 to 7 Watts (configuration dependent) |
| Operating temperature | -20 to +55 degrees C |
| Humidity | 0 to 100% |

## A.2 Connectors

**Table A-2** Connector specifications

| Connector | Specification |
|---|---|
| Power | 3-pin MS connector |
| Ethernet | 4-pin MIL bayonet connector, female |
| SOH 1 | 3-pin MIL bayonet connector, female |
| GPS antenna | • TNC<br>• Supports an active antenna |
| SOH/COMMS | • 19-pin MIL bayonet connector, female<br>• Connector for the two serial ports, the two configuration ports, and the external state-of-health channels |
| Signal 1 | • 26-pin MIL bayonet connector, female<br>• Connector for the sensor |

# A.3 Ports

**Table A-3** Port specifications

| Port | Specification |
|---|---|
| User serial port 1 | • 1 external RS232 data port<br>• Available Baud rates: up to 38400<br>• Can be configured for either transparent full duplex serial or unidirectional; typically would be configured for full duplex.<br>• Not available for Europa T with central timing |
| User serial port 2 | • 1 external RS232 data port<br>• Available Baud rates: up to 38400<br>• Can be configured for either transparent full duplex serial or unidirectional; typically would be configured for unidirectional if local data buffering is required |
| External state-of-health | • Number of channels: 3 (CH1 = vault tamper switch; CH3 = EuropaT tamper switch; CH2 = user-defined)<br>• Data rate: 1 sample per minute<br>• Sensitivities:<br>  • Ch 1: ± 2VDC<br>  • Ch 2: ± 10VDC<br>  • Ch 3: ± 10VDC |
| Ethernet | 10Base-T port for on-site configuration and IP packet forwarding |
| Configuration | • 1 external RS232 data port, used for factory configuration<br>• Available Baud rates: up to 38400 |
| TimeServer configuration | • 1 external RS232 data port, used for factory configuration of the TimeServer<br>• Available Baud rates: up to 38400 |

**Table A-4** Europa T commands supported

| Command | Description |
|---|---|
| Configuration | Get / change / save / copy the current configuration |
| Software upload | Upload new DSP firmware |
| Test code | Allows the user to test new code downloaded via the NMXbus |
| Reboot | Reboots the Europa T |

# A.4 Authentication

- Signed data on RS232 port.
- Signed data on 10-base-T Ethernet port.

# A.5 Timing subsystem

**Table A-5** Timing subsystem specifications

| Parameter | Specification |
|---|---|
| Type | UTC timed with digitally controlled VCXO clock disciplined by GPS receiver |
| Time accuracy | ±20µs, relative to UTC |
| Frequency offset without GPS lock | ±4ppm maximum |
| GPS receiver | 12-channel |
| GPS antenna | External, active, 26dB gain minimum |
| GPS antenna cable | 3m standard, 10m optional |

# A.6 Digitiser module

**Table A-6** Sensor input specifications

| Parameter | Specification |
|---|---|
| Channels | 3 |
| Sampling | Simultaneous |
| Maximum differential input voltage range | 40$V_{p-p}$ differential (at gain=0.4) |
| Maximum single-ended voltage | ±1.56V, 3.12$V_{p-p}$ |
| Maximum common mode signal | ±0.78V |
| Input impedance | 43kΩ |
| Nominal sensitivity | 1 count/microvolt (gain=1) |
| Gain selection | • Software-selectable 0.4, 1, 2, 4, 8<br>• Selectable sensitivity common for all 3 channels |

**Table A-7** Digitiser performance specifications (100Hz output sample rate)

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

**Table A-8** Digitiser specifications

| Parameter | Specification |
|---|---|
| Type | Proprietary high-order sigma-delta |
| Digital filter | 140dB attenuation at output Nyquist frequency |
| Filter type | Linear phase |

**Table A-9** Data output specifications

| Parameter | Specification |
|---|---|
| Output channels | 1, 2, or 3 |
| Output sample rates | 10, 20, 40, 50, 80, 100, 120, 200, 250, 500, 1000 sps |
| Optional DC removal filter | 1 mHz to 1 Hz, first order |

**Table A-10** 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<br>• Mass position monitoring |
| Control lines | • Three additional control lines for mass centre, lock, unlock, short/long period<br>• Control line outputs open drain, 0 V, +5 V, +12 V |

**Table A-11** Digitiser module 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 active (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. |

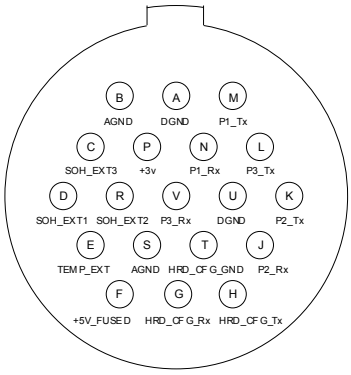
**Table A-12** Digitiser module commands supported

| 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 |

# Appendix B Connector Pinouts

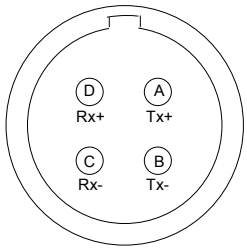
## B.1 Connector diagrams

**Figure B-1** Europa T connectors



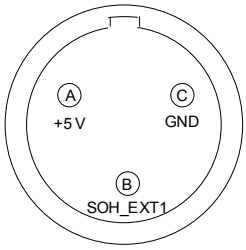

COMMUNICATIONS

SOURIAU 851-07A14-19S-N50



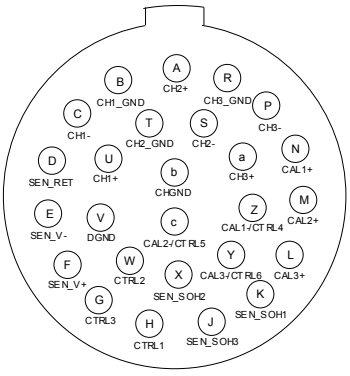

ETHERNET

SOURIAU 851-07A-8-4S-N50-A7



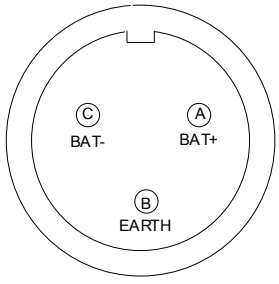

SOH 1

SOURIAU 851-07A8-34S50




SIGNAL 1

SOURIAU 851-07A16-16-26P-N50




POWER

CANNON CA-02L16-10P

# B.2 Pinouts

## B.2.1 Power

**Table B-1** Power connector pinout

| Pin | Signal name |
|---|---|
| A | BAT+ |
| B | EARTH |
| C | BAT- |

## B.2.2 Ethernet

**Table B-2** Ethernet connector pinout

| Pin | Signal name |
|---|---|
| A | Tx+ |
| B | Tx- |
| C | Rx- |
| D | Rx+ |

## B.2.3 SOH 1

**Table B-3** SOH 1 connector pinout

| Pin | Signal name |
|---|---|
| A | +5V |
| B | SOH_EXT1 |
| C | GND |

## B.2.4 GPS antenna

The GPS antenna connector is a standard female TNC bulkhead jack.

## B.2.5 SOH/COMMS

**Note** In Europa T with central timing, user serial port 1 is not available.

**Table B-4** SOH/COMMS connector pinout

| Pin | Signal name | Function | |
|---|---|---|---|
| | | Bus timing | Central timing |
| A | DGND | Digital ground; common to pin U* | |
| B | AGND | Analog ground; common to pin S† | |
| C | SOH_EXT3 | External state-of-health channel 3 | |
| D | SOH_EXT1 | External state-of-health channel 1 | |
| E | TEMP_EXT | External temperature sensor | |
| F | +5V_FUSED | +5 V, fused, for external temperature sensor | |
| G | HRD_CFG_Rx | TimeServer configuration port receive | |
| H | HRD_CFG_Tx | TimeServer configuration port transmit | |
| J | P2_Rx | User serial port 2 receive | |
| K | P2_Tx | User serial port 2 transmit | |
| L | P3_Tx | Comms Controller configuration port transmit | |
| M | P1_Tx | User serial port 1 transmit | GPS 1 Hz pulse in |
| N | P1_Rx | User serial port 1 receive | GPS messages in |
| P | +3 V | Internal +3 V, not separately fused. Use only to check internal voltage. | |
| R | SOH_EXT2 | External state-of-health channel 2 | |
| S | AGND | Analog ground; common to pin B | |
| T | HRD_CFG_GND | Reserved | |
| U | DGND | Digital ground; common to pin A | |
| V | P3_Rx | Comms Controller configuration port receive | |

* Ports P1, P2, P3 are referenced to digital ground on pins DGND
† External temperature sensor and SOH are referenced to analog ground on pins AGND

## B.2.6 Signal 1

**Table B-5** Signal 1 connector pinout

| Pin | Name | Function | Type |
|---|---|---|---|
| U | CH1+ | Channel 1 input | ±20 V, differential |
| C | CH1- | | |
| B | CH1_GND | Channel 1ground/chassis | |

**Table B-5** Signal 1 connector pinout (Continued)

| Pin | Name | Function | Type |
|---|---|---|---|
| A | CH2+ | Channel 2 input | ±20 V, differential |
| S | CH2- | | |
| T | CH2_GND | Channel 2 ground/chassis | |
| a | CH3+ | Channel 3 input | ±20 V, differential |
| P | CH3- | | |
| R | CH3_GND | Channel 3 ground/chassis | |
| K | SEN_SOH1 | State of health input | ±10 V, single-ended |
| X | SEN_SOH2 | | |
| J | SEN_SOH3 | | |
| H | CTRL1 | Control signal output | 0 V / 5 V / 12 V open drain |
| W | CTRL2 | | |
| G | CTRL3 | | |
| N | CAL1+ | Calibration signal output | ±4.5 V, output |
| M | CAL2+ | | |
| L | CAL3+ | | |
| Z | CAL1-/CTRL4 | Calibration signal return/ enable | Calibration signal return/ 0 V / 5 V / 12 V 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 | Digital ground | |

# Appendix C Cable Drawings

- Test/configuration cable
- Tamper switch cable

# C.1 Test/configuration cable

**Figure C-1** Test/Configuration cable

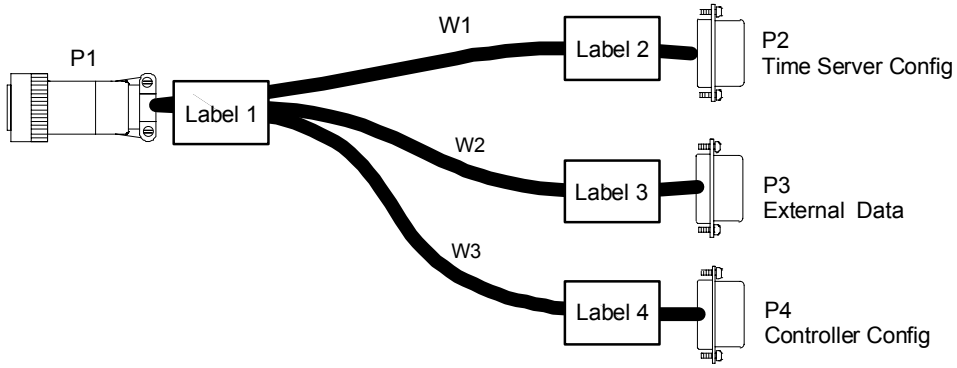



**Table C-1** Test/configuration cable parts

| Nanometrics part number | Manufacturer part number | Quantity | Description |
|---|---|---|---|
| WIR0058 | BELDEN, 8443-500 | 3 x 1.5m | 22 AWG, 3 conductor, unshielded |
| CON0907 | SOURIAU, 851-06JC14-19P-N50 | 1 | Plug, straight plug, shell 14, 19P |
| CON0011 | ESONIC, AMP DE09-S | 3 | Dsub 9-pin female |

**Table C-2** Test/configuration cable connector pin wiring

| From | | | To | | | Wire | Run |
|---|---|---|---|---|---|---|---|
| Conn | Pin | Name | Conn | Pin | Name | Colour | |
| P1 | H | HRD_CFG_Tx | P2 | 2 | Rx | green | 1 |
| P1 | G | HRD_CFG_Rx | P2 | 3 | Tx | red | 1 |
| P1 | T | HRD_CFG_GND | P2 | 5 | Gnd | black | 1 |
| P1 | K | P2_Tx | P3 | 2 | Rx | green | 2 |
| P1 | J | P2_Rx | P3 | 3 | Tx | red | 2 |
| P1 | A | DGND | P3 | 5 | Gnd | black | 2 |
| P1 | L | P3_Tx | P4 | 2 | Rx | green | 3 |
| P1 | V | P3_Rx | P4 | 3 | Tx | red | 3 |
| P1 | U | DGND | P4 | 5 | Gnd | black | 3 |

# C.2 Tamper switch cable

**Figure C-2** Vault tamper switch cable

**Table C-3** Vault tamper switch cable parts

| Nanometrics part number | Manufacturer part number | Quantity | Description |
|---|---|---|---|
| WIR0058 | BELDEN, 8443-500 | 2m | 22 AWG, 3 conductor, unshielded |
| CON0907 | SOURIAU, 851-06JC8-3AP-50 | 1 | Plug, straight plug, shell 8, 3AP with pressure gland |

**Table C-4** Vault tamper switch cable connector pin wiring

| From | | | Wire | Run |
|---|---|---|---|---|
| Conn | Pin | Name | Colour | |
| P1 | A | +5V | red | 1 |
| P1 | B | SOH_EXT1 | black | 1 |
| P1 | C | GND | green | 1 |

# Appendix D Filter Response

## D.1 Response overview

Analog signals connected to the digitiser module are filtered using a first order low pass antialias filter before being sampled at 30 kHz. 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 times the output sample rate.

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

## D.2 System filter values

This section describes the transfer functions of the digitiser module 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

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

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 3dB 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-38.

**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 | — | |
| 80 | # of Coefficients | 165 | 63 | 497 | — | 0.638233 |
| | Decimation | 15 | 5 | 5 | — | |
| 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 | — | |

**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 | |
| 250 | # of Coefficients | 187 | 73 | 223 | — | 0.243100 |
| | Decimation | 15 | 4 | 2 | — | |
| 500 | # of Coefficients | 123 | 65 | 223 | — | 0.123700 |
| | Decimation | 10 | 3 | 2 | — | |
| 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** 10 sps: 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 |
| +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 |

**Table D-5** 10sps: Stage 4 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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-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 |

**Table D-6** 20sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +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 |
| +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 |

**Table D-10** 40sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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** 40sps: 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** 40sps: 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** 40sps: 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 |

**Table D-13** 40sps: Stage 4 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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 |

**Table D-14** 50sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +3.072549818901627e-002 | +3.140793657415418e-002 | +3.194715804040495e-002 | +3.233689118043551e-002 |
| +3.257257709387603e-002 | +3.265144835188193e-002 | | |

**Table D-15** 50sps: 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** 50sps: 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 |

**Table D-16** 50sps: Stage 3 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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-17** 80sps: 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** 80 sps: Stage 2 FIR filter coefficients

| | | | |
|---|---|---|---|
| +1.921168309799045e-008 | +2.234011506473452e-007 | +1.270800278820590e-006 | +4.897774231965315e-006 |
| +1.427423756566222e-005 | +3.294039728487237e-005 | +6.075583495015011e-005 | +8.643860747086018e-005 |
| +7.981115814811471e-005 | -8.082942540536886e-006 | -2.260050225397875e-004 | -5.787255391041039e-004 |
| -9.688789970852655e-004 | -1.158814398031802e-003 | -8.036459662262798e-004 | +4.039029920260099e-004 |
| +2.487712920264018e-003 | +4.934827336980802e-003 | +6.600744381302436e-003 | +5.945279957626037e-003 |
| +1.665594164348296e-003 | -6.412123390397003e-003 | -1.654311104661889e-002 | -2.484712609986934e-002 |
| -2.602102386243493e-002 | -1.498618577292422e-002 | +1.099177375346894e-002 | +5.053494966012143e-002 |
| +9.759647082071482e-002 | +1.425972154381203e-001 | +1.750642375166361e-001 | +1.869007659055685e-001 |

**Table D-19** 80 sps: Stage 3 FIR filter coefficients

| | | | |
|---|---|---|---|
| -8.489342142293113e-010 | +1.717100223577711e-008 | +1.371311143668353e-008 | +1.124697921895226e-008 |
| +2.149756060623480e-009 | -1.289776091205054e-008 | -2.963034262080455e-008 | -4.111726863078693e-008 |
| -3.991603475338417e-008 | -2.126594079191623e-008 | +1.378618817182284e-008 | +5.671400704665698e-008 |
| +9.255384338613683e-008 | +1.040543667301984e-007 | +7.817063214840865e-008 | +1.283534035461761e-008 |
| -7.871715601458936e-008 | -1.686323641038812e-007 | -2.212503116209754e-007 | -2.050541253817339e-007 |
| -1.063139367102373e-007 | +6.053902842833634e-008 | +2.508493765939709e-007 | +3.989400728051363e-007 |
| +4.379041256455915e-007 | +3.248976636218538e-007 | +6.351936261167088e-008 | -2.860959564246987e-007 |
| -6.162377278616608e-007 | -8.007234006586201e-007 | -7.377042760213998e-007 | -3.931554828268672e-007 |
| +1.712121928627280e-007 | +7.994644197375402e-007 | +1.278236280424732e-006 | +1.402594729579245e-006 |
| +1.052705988493510e-006 | +2.551892569971521e-007 | -7.964855070335048e-007 | -1.778320487334423e-006 |
| -2.326747290843963e-006 | -2.161795234864957e-006 | -1.203823448520114e-006 | +3.596804844819416e-007 |
| +2.090822520337753e-006 | +3.410884632863187e-006 | +3.780415420538409e-006 | +2.897851051349140e-006 |
| +8.489084870097168e-007 | -1.855446898131817e-006 | -4.385201705758399e-006 | -5.828737575602794e-006 |
| -5.499410518843847e-006 | -3.214460536159496e-006 | +5.575044397109514e-007 | +4.753426029541264e-006 |
| +7.990661750385515e-006 | +8.997844424379149e-006 | +7.075003671723471e-006 | +2.426476147051405e-006 |
| -3.769937123990292e-006 | -9.621919424205906e-006 | -1.306927574137197e-005 | -1.257079002778054e-005 |
| -7.713251152858139e-006 | +4.805012874805594e-007 | +9.695066950837269e-006 | +1.693284989342650e-005 |
| +1.944651497332028e-005 | +1.571676482998290e-005 | +6.144206032235328e-006 | -6.822680339453900e-006 |
| -1.924476383025478e-005 | -2.683586863888576e-005 | -2.637864951829109e-005 | -1.696305571511032e-005 |
| -5.995563089881093e-007 | +1.808442087871533e-005 | +3.307944920391419e-005 | +3.885776300612822e-005 |
| +3.230920534021631e-005 | +1.409844359798481e-005 | -1.109097796633712e-005 | -3.564612238133887e-005 |
| -5.124034037322001e-005 | -5.155894632369273e-005 | -3.467110510280661e-005 | -4.201523557374528e-006 |
| +3.123660240874874e-005 | +6.035882842298761e-005 | +7.269608813841884e-005 | +6.220691467090445e-005 |
| +2.980985559885369e-005 | -1.614031094396781e-005 | -6.182347475569181e-005 | -9.198009998454401e-005 |
| -9.486341094021906e-005 | -6.655334693143635e-005 | -1.311322244827910e-005 | +5.036702464994403e-005 |
| +1.038515840997645e-004 | +1.285250883810292e-004 | +1.131964387384733e-004 | +5.882004253097472e-005 |
| -2.057297717160582e-005 | -1.012122869221386e-004 | -1.565123239016234e-004 | -1.656308958892311e-004 |
| -1.209685217598967e-004 | -3.200165165909281e-005 | +7.618897291865717e-005 | +1.697219284012731e-004 |
| +2.163013063900979e-004 | +1.960728534638920e-004 | +1.093838253225470e-004 | -2.142611802504335e-005 |
| -1.573584662119432e-004 | -2.541067131778384e-004 | -2.762138882736559e-004 | -2.095983245493609e-004 |
| -6.814635247045366e-005 | +1.083492039142233e-004 | +2.649990148639018e-004 | +3.485772690042665e-004 |
| +3.252133337122347e-004 | +1.932467523421564e-004 | -1.342490341905193e-005 | -2.334344516476308e-004 |
| -3.957822999758246e-004 | -4.423678378900971e-004 | -3.481804534773504e-004 | -1.322958472249734e-004 |
| +1.447149265629660e-004 | +3.972380745038032e-004 | +5.406568385743859e-004 | +5.191932312471185e-004 |
| +3.265390549112922e-004 | +1.190958753397606e-005 | -3.316395783310149e-004 | -5.942078715065511e-004 |

**Table D-19** 80sps: Stage 3 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -6.837042197468924e-004 | -5.573870447907194e-004 | -2.396968131501738e-004 | +1.805325801164908e-004 |
| +5.741605680953727e-004 | +8.108637226458248e-004 | +8.016250003125958e-004 | +5.309286669292171e-004 |
| +6.734677299357457e-005 | -4.525636060323498e-004 | -8.637696534249911e-004 | -1.024489805798179e-003 |
| -8.641284865868947e-004 | -4.114790132159574e-004 | +2.074505202085227e-004 | +8.034727303297920e-004 |
| +1.181297454169414e-003 | +1.202672399904207e-003 | +8.354246063055044e-004 | +1.714163452431991e-004 |
| -5.946224383655211e-004 | -1.221224342465902e-003 | -1.495427739574067e-003 | -1.303956552194977e-003 |
| -6.768875750662429e-004 | +2.122904196967447e-004 | +1.093221677367591e-003 | +1.679863721680560e-003 |
| +1.762256183248513e-003 | +1.279769069525491e-003 | +3.507920242039676e-004 | -7.536876386600520e-004 |
| -1.687773905307475e-003 | -2.137801883086991e-003 | -1.926110951501632e-003 | -1.077569385751387e-003 |
| +1.751650678819816e-004 | +1.453360980761200e-003 | +2.345273022915098e-003 | +2.537256806555168e-003 |
| +1.921645632359420e-003 | +6.449580189907357e-004 | -9.230197634307127e-004 | -2.294369930196776e-003 |
| -3.013162012381754e-003 | -2.804896936383007e-003 | -1.676920129201037e-003 | +6.578923354289615e-005 |
| +1.899970251254351e-003 | +3.239029451725284e-003 | +3.618389744780365e-003 | +2.853354498824235e-003 |
| +1.116788046128704e-003 | -1.093577554722676e-003 | -3.094736721923393e-003 | -4.226760023898465e-003 |
| -4.067171606130040e-003 | -2.582678772702303e-003 | -1.653479676492600e-004 | +2.465894279907724e-003 |
| +4.475476474110628e-003 | +5.172763725459088e-003 | +4.244247565760888e-003 | +1.879778053017540e-003 |
| -1.254715153597921e-003 | -4.199439915519540e-003 | -5.989745737683305e-003 | -5.966358504260334e-003 |
| -4.008787346902776e-003 | -6.118471437427009e-004 | +3.230007820316181e-003 | +6.306842498573601e-003 |
| +7.566775878689244e-003 | +6.465781903869351e-003 | +3.180292442911595e-003 | -1.395208176227164e-003 |
| -5.880596472423025e-003 | -8.815558629674206e-003 | -9.122043132063546e-003 | -6.481025748445776e-003 |
| -1.497271794218604e-003 | +4.416914880569452e-003 | +9.424755455446174e-003 | +1.181566122025388e-002 |
| +1.056379730201441e-002 | +5.719413599900255e-003 | -1.504481109228602e-003 | -9.004368976213420e-003 |
| -1.436517754907221e-002 | -1.559466037561772e-002 | -1.180092328375080e-002 | -3.599131497767827e-003 |
| +6.904013286826791e-003 | +1.658654594773472e-002 | +2.215329780090112e-002 | +2.113245372274378e-002 |
| +1.275128680085814e-002 | -1.573858816330951e-003 | -1.831147352137540e-002 | -3.248740696666503e-002 |
| -3.882770101574772e-002 | -3.310519224979664e-002 | -1.334960123186774e-002 | +1.940490864165034e-002 |
| +6.105826618788460e-002 | +1.051260815438986e-001 | +1.440328631552236e-001 | +1.707248067294749e-001 |
| +1.802205356189511e-001 | | | |

**Table D-20** 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 |

**Table D-20** 100sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +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-21** 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 |
| +6.206696168821097e-002 | +7.333684637153971e-002 | +8.290151879402521e-002 | +9.018659693370301e-002 |
| +9.474635107447013e-002 | +9.629848418816638e-002 | | |

**Table D-22** 100sps: 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 |

**Table D-22** 100sps: Stage 3 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +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-23** 120sps: 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-24** 120sps: 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-25** 120sps: 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 |

**Table D-25** 120sps: Stage 3 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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-26** 120sps: 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-27** 200sps: 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 |
| -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 |

**Table D-27** 200sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +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-28** 200sps: 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-29** 200sps: 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 |

**Table D-29** 200sps: Stage 3 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| -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** 250sps: Stage 1 FIR filter coefficients

| | | | |
|---|---|---|---|
| +8.021030126486040e-010 | +3.116465281322954e-009 | +8.900115387399319e-009 | +2.136146814812414e-008 |
| +4.570784023345887e-008 | +8.987454061363188e-008 | +1.653511290640104e-007 | +2.880143028736028e-007 |
| +4.788495859462893e-007 | +7.643930834336960e-007 | +1.176682162350611e-006 | +1.752462239372588e-006 |
| +2.531369521032817e-006 | +3.552811458666108e-006 | +4.851296667295614e-006 | +6.450038935287051e-006 |
| +8.352786690148797e-006 | +1.053400537573397e-005 | +1.292776921871672e-005 | +1.541599738000767e-005 |
| +1.781697664826134e-005 | +1.987542901447057e-005 | +2.125568121713784e-005 | +2.153973335069806e-005 |
| +2.023216363887429e-005 | +1.677380514750772e-005 | +1.056594338415373e-005 | +1.006375479843661e-006 |
| -1.246198150029029e-005 | -3.029015118851888e-005 | -5.275118835398751e-005 | -7.986000081114194e-005 |
| -1.112890756465557e-004 | -1.462857856040548e-004 | -1.835983647205234e-004 | -2.214188245058332e-004 |
| -2.573518756722413e-004 | -2.884191682702904e-004 | -3.111077216309345e-004 | -3.214701658867537e-004 |
| -3.152822824160907e-004 | -2.882602925636772e-004 | -2.363364525664862e-004 | -1.559868966166114e-004 |
| -4.460053997650746e-005 | +9.912750037842685e-005 | +2.747997277641338e-004 | +4.799437567234438e-004 |
| +7.096935698296908e-004 | +9.565568674128922e-004 | +1.210301216066353e-003 | +1.457989889701200e-003 |
| +1.684194060772773e-003 | +1.871401247451172e-003 | +2.000630731882190e-003 | +2.052255296633008e-003 |
| +2.007015534185219e-003 | +1.847198806192423e-003 | +1.557940464429397e-003 | +1.128591117168111e-003 |
| +5.540815297725676e-004 | -1.637928057539577e-004 | -1.015251361450041e-003 | -1.981658010139670e-003 |
| -3.034982229904094e-003 | -4.137665265566254e-003 | -5.242950206338383e-003 | -6.295715632909457e-003 |
| -7.233828789220752e-003 | -7.990007176426315e-003 | -8.494148392339482e-003 | -8.676058538571006e-003 |
| -8.468481339745442e-003 | -7.810305072536729e-003 | -6.649804237083092e-003 | -4.947759193738214e-003 |
| -2.680291017135879e-003 | +1.587485239945302e-004 | +3.555980255831438e-003 | +7.477421931622852e-003 |
| +1.186823250844216e-002 | +1.665333935431844e-002 | +2.173897011228853e-002 | +2.701506644905470e-002 |
| +3.235851157027770e-002 | +3.763705973498812e-002 | +4.271381658749089e-002 | +4.745208632226936e-002 |
| +5.172037756453186e-002 | +5.539734599110489e-002 | +5.837644917231717e-002 | +6.057009828070978e-002 |
| +6.191311190166436e-002 | +6.236530823420591e-002 | | |

**Table D-31** 250sps: Stage 2 FIR filter coefficients

| | | | |
|---|---|---|---|
| +2.013960040441461e-008 | +7.829905562730119e-008 | +3.556827360342027e-008 | -6.578952033153840e-007 |
| -2.838174976306336e-006 | -6.339604155665177e-006 | -7.579549248838519e-006 | +1.525421598222025e-006 |
| +2.867467179287802e-005 | +6.803611263639224e-005 | +8.621359082760767e-005 | +2.663318130002411e-005 |
| -1.488750181368265e-004 | -3.894078928286899e-004 | -5.096495482066918e-004 | -2.509025067986460e-004 |
| +5.148767179098934e-004 | +1.528343671862279e-003 | +2.058755951913143e-003 | +1.220083762433884e-003 |
| -1.317398112347203e-003 | -4.616151705880501e-003 | -6.423713155188930e-003 | -4.258895350566256e-003 |
| +2.633456984517682e-003 | +1.163030574425260e-002 | +1.691624644668013e-002 | +1.230146944514783e-002 |
| -4.243531326952775e-003 | -2.693880541814028e-002 | -4.237388278728672e-002 | -3.475587583921098e-002 |
| +5.613841562804873e-003 | +7.508120412217785e-002 | +1.552535727545412e-001 | +2.193593549586833e-001 |
| +2.438435444796746e-001 | | | |

**Table D-32** 250 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-33** 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-34** 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-35** 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 |
| -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-36** 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 |

**Table D-36** 1000 sps: Stage 1 FIR filter coefficients (Continued)

| | | | |
|---|---|---|---|
| +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-37** 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-38** 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 |
| +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-Digitiser Interconnection

The purpose of this section is to point out the critical requirements when connecting high-performance sensors to high-resolution digitisers. The case of connecting a Trillium seismometer to a Nanometrics digitiser—such as a Trident or a EuropaT—is considered in detail.

**Note** The Nanometrics digitiser is designed for best dynamic range performance when used with sensors having differential outputs. See Section E.5 on page 54 for information on digitiser operation with single-ended inputs.

## E.1 Circuit description

### E.1.1 Digitiser

High-resolution digitisers 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 Nanometrics digitiser 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, the digitiser can be operated in the presence of radios and cell phones. The digitiser power supply is completely isolated from the rest of the electronics and the case.

The digitiser 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 Figure E-1 and Figure E-2. We find the Belden 816x series of cables particularly suitable.

The twisted pairs provide magnetic shielding, an inner shield grounded at the digitiser 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 digitiser 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 digitiser 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 digitiser case and isolate the sensor case or vice versa.

Usually the simplest solution is to earth the digitiser as shown in Figure E-1 and Figure E-2. An M4 screw is provided on the side of the digitiser 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 digitiser case.

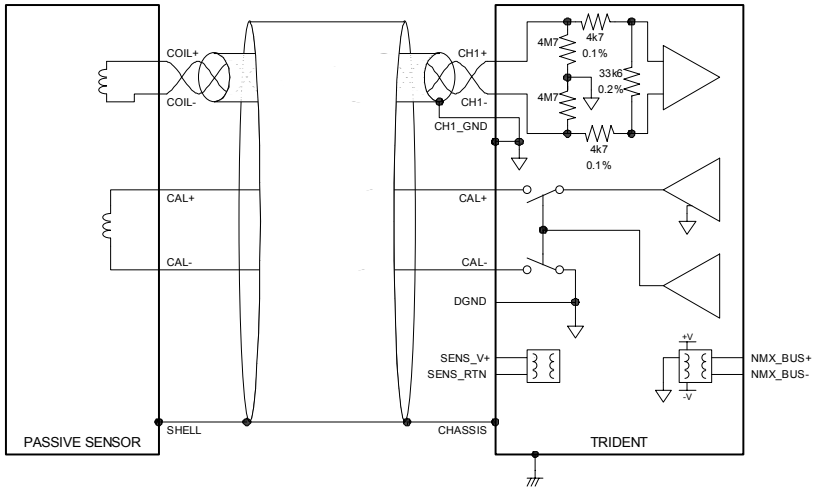
Some sensors may have no chassis connection at the connector. In this case the sensor and digitiser must be separately earthed.

## 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 digitiser 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 4.7MΩ input resistors at the input of the digitiser 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 | |

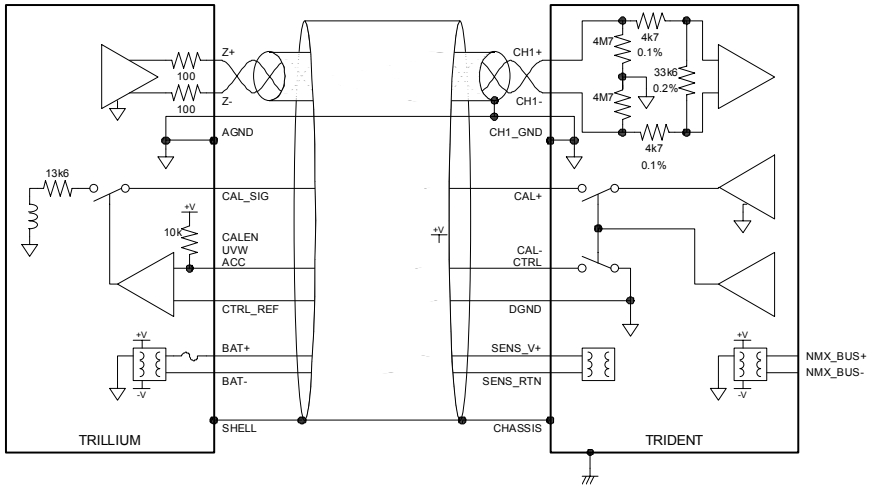
* Pinout will depend on the passive sensor that is selected.

## 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 the Nanometrics digitiser.

**Figure E-2** Typical active sensor cable design




When either of the sensor or digitiser power supplies are isolated, there is nothing to constrain the common-mode voltage of the sensor outputs with respect to the digitiser ground. For optimal shielding performance the digitiser 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 digitiser (CH1_GND). The other two digitiser channel grounds (CH2_GND and CH3_GND) should only be connected to their respective shield 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 digitiser. In the case of the digitiser 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 |
| P1 | T | CAL_SIG | P2 | N | CAL1+ | BLU | 4 |

**Table E-2** Typical active sensor wiring list (Continued)

| From | | | To | | | Colour | Run |
|---|---|---|---|---|---|---|---|
| Conn | Pin | Name | Conn | Pin | Name | | |
| 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 labelled with correct drawing numbers and revisions.
- Make sure the digitiser 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 Digitiser operation with single-ended inputs

The EuropaT digitiser 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 100dB. However, common-mode signals greater than ±0.78V cause distortion. Maximum single-ended signal before distortion is:
2*maximum common-mode signal = 2*0.78 = 1.56V.

## 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 $+V_{dif}/2$ and $-V_{dif}/2$ are the differential inputs. If these are the components to a single-ended signal, and the -ve terminal is connected to GND return, then
$V_{cm} + (-V_{dif}/2) = 0$. Therefore, $V_{cm} = V_{dif}/2$.
At the +ve terminal, with $V_{cm} + V_{dif}/2$ referred to GND, the differential input is
$(V_{cm} + V_{dif}/2) - (V_{cm} + (-V_{dif}/2)) = V_{dif}$.

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