Centaur

User Guide

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nanometrics

Listening to the Earth

This guide and the WebHelp apply to the following models of Centaur with firmware version 4.9:

Model Number	Part Number	Description
CTR4-3S	17954-31	Centaur Digital Recorder, 24-bit, 3 standard channels, 8 GB Expandable Store
CTR4-3H	17954-32	Centaur Digital Recorder, 24-bit, 3 high gain channels, 8 GB Expandable Store
CTR4-3A	17954-33	Centaur Digital Recorder, 24-bit, 3 standard channels, 8 GB Expandable Store, Authenticating
CTR4-3S-XC	17954-30	Centaur Digital Recorder, 24-bit, 3 std channels, 8 GB Expandable Store, Polar Environment
CTR4-6S	17954-61	Centaur Digital Recorder, 24-bit, 6 standard channels, 8 GB Expandable Store
CTR4-6H	17954-62	Centaur Digital Recorder, 24-bit, 6 high gain channels, 8 GB Expandable Store
CTR4-6A/S	17954-63	Centaur Digital Recorder, 24-bit, 6 standard channels, 8 GB Expandable Store, Authenticating
CTR4-6S/H	17954-64	Centaur Digital Recorder, 24-bit, 3 standard & 3 high gain channels, 8 GB Expandable Store
CTR4-6AS/H	17954-65	Centaur Digital Recorder, 24-bit, 3 standard & 3 high gain channels, 8 GB Expandable Store, Authenticating
CTR4-6S-XC	17954-60	Centaur Digital Recorder, 24-bit, 6 std channels, 8 GB Expandable Store, Polar Environment

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1.0 About the Centaur

The Centaur digital recorder is a portable geophysical sensing acquisition system that consists of a high-resolution 24-bit ADC, a precision GNSS-based clock, and removable storage capabilities. Its ease of use simplifies high performance geophysical sensing deployments in both remote and networked environments. Optimized for seismicity monitoring, the Centaur is also well-suited for infrasound and similar geophysical sensor recording applications requiring sample rates up to 5000 sps.

1.1 Key Features

- Intuitive Web interface
- Ultra-low noise floor for use with high performance sensors
- True 24-bit performance available in 3 or 6 channel configurations
- User selectable bit-depth from 24 to 31 bits per sample
- Sample rates of up to 5000 sps to support geothermal and/or passive seismic applications
- Data retrieval via a removable **SD**[1]™ card or Ethernet in MiniSEED file format
- Comprehensive, real-time data streaming over Ethernet using SeedLink, CD-1.1 or Nanometrics Protocol (NP)
- Records calibration signal generator output as fourth time series channel
- Precision timing with built-in GPS/GNSS or network timing using PTPv2 (Precision Time Protocol) or NTP (Network Time Protocol)

[1]Secure Digital

- Centaur can provide network timing to other Centaurs
- Advanced bandpassed triggering
- External State-of-Health (SOH) input that allows you to digitize up to 3 arbitrary, external analog signals for inputs such as temperature, barometric pressure, and similar slow moving signals (CTR2 and newer series models)
- Easy integration of state-of-health information into existing tools using low bandwidth SNMP communications (Simple Network Management Protocol)
- Acquisition and data management of high precision GNSS data (BINEX)
- Internal 8 GB redundant storage (expandable up to 64 GB in CTR3 series models)
- Rugged waterproof field enclosure rated to IP-68

The Centaur User Guide and WebHelp apply to all Centaur models.

1.2 About Data Storage

Understanding how and where Centaur stores data will help you plan and implement effective data access for your deployment.

In a networked deployment, in the unlikely event of both an internal media failure and a prolonged communications failure, it may be possible to recover some data from a continuous archive on the external SD card. Please contact techsupport@nanometrics.ca for more information.

1.2.1 Primary Media

Centaur continuously digitizes and records sensor data, measures and records state-of-health (SOH) data, and records configuration and log data in a proprietary database called the Store. The Store wraps when it is full and records over the oldest data. The frequency with which the Store wraps is shown in the Internal Storage section of the **Health** Page.

The Store is located on an internal flash media device which has standard capacity of 8 GB. This is expandable up to 64 GB in CTR3 series models or later by installing an internal SD card.

Data is recorded to the Store in Nanometrics Protocol (NP) format, but digitized sensor data can be streamed in SeedLink and NP formats for networked deployments, and/or archived to removable media in MiniSEED format. In addition, selected SOH channels are available in Steim compressed formats. For networked deployments using continuous streaming, the Store is used to back fill any data lost during transmission downstream.

Regardless of whether you deploy Centaur as a networked or standalone device, the internal storage acts as your primary media. You can retrieve data from internal storage from the **Maintenance** page.

1.2.2 Secondary (or Removable) Media

The most effective backup for your data is to use an external SD card as your secondary (removable) media, and configure continuous archiving. The external SD card is formatted as FAT32.

To ensure reliability, we strongly recommend that you use only SD cards that are provided by or recommended by Nanometrics. Other types of cards may be unreliable, which may lead to loss of data.

The external SD card serves two main functions:

1. Backup for the primary media for networked or standalone deployments.
2. Convenient data retrieval for standalone deployments.

When you enable continuous archiving, the Centaur continuously records data in MiniSEED to the external SD card and generates metadata records in StationXML format whenever there is a configuration change. You can also configure Centaur to archive events and SOH data to the external SD card.

When the external SD card is full, the Centaur continues recording data to its internal storage media, but stops writing data to the external SD card. Any configured streamers are unaffected when the external SD card is full. You can monitor the amount of space that data archiving consumes on your external SD card from the **Removable Media** section of the **Maintenance** page.

For standalone deployments, swapping out removable media is a more convenient way of harvesting data than downloading data from internal storage using a laptop and Ethernet cable. Data retrieval via external SD card swap or internal storage download is referred to as file transfer.

1.3 Cables and Accessories

Nanometrics offers optional equipment that can add convenience to the installation and use of your Centaur. The table below describes a number of these options.

List of Cables and Accessories

Name	Part Number	Description
Cable - Ethernet	CAB0013-xM	An Ethernet cable with RJ-45 connectors on both ends. Available in standard lengths of 1 m, 3 m, 5 m, 10 m, 20 m, and 30 m. In the part number, xM represents the length of the cable in metres.
Cable – Power	14983-xM	An unshielded 22 AWG power cable. Available in standard lengths of 3 m, 5 m, 6 m, 8 m, and 10 m. In the part number, xM represents the length of the cable in metres.
Cable - Centaur External SOH	17949-3M	Flexible cable that connects to Centaur models with Part Numbers 17954 and 17955. The cable provides three inputs for equipment (± 5 V range) with slow moving signals.
Cable - Seismowave MB3a to Centaur Digitizer, Ultra-Flex	18673-xM	Flexible cable that connects the 3-channel Centaur to a Seismowave MB3a microbarometer.
Cable - Seismowave MB3a & Gill GMX500 to Centaur Digitizer, Ultra-Flex	18674-xM	Flexible cable that connects the 3-channel Centaur to a Seismowave MB3a microbarometer and a Gill Instruments Maximet GMX500 with GPS Compact Weather Station. The cable has one connector on one end to connect to the Centaur Sensor port and 2 connectors on the other end to connect to the Seismowave MB3a microbarometer and the weather station.
Cable - Seismometer, Vaisala WXT536 (without heater) 8-pin Straight Con to Centaur Digitizer, PVC	20077-xM	Flexible cable that connects the 3-channel Centaur to a Vaisala Weather Transmitter WXT536. The cable has one connector on one end to connect to the Centaur Sensor port and one connector on the other end to connect to the weather station. This cable does not provide power to the WXT536 heater.
Cable - Seismometer, Vaisala WXT536 (with heater) 8-pin Straight Con to Centaur Digitizer,Power Breakout PVC	20148-xM	Flexible cable that connects the 3-channel Centaur to a Vaisala Weather Transmitter WXT536. The cable has 2 connectors on one end to connect to the Centaur Sensor port and an external power source for the weather station heater and one connector on the other end to connect to the weather station.
Waterproof Ethernet cable	19403-1M	1 meter RJ45 Ethernet cable with pre-installed waterproof shroud for use where waterproof connection is required. Shipped with Centaur
GNSS antenna cable RG-223 low loss	12030-xM	RG-223 low loss RF coaxial cable. Available in standard lengths of 10 m, 15 m, 20 m, 25 m, and 30 m. In the part number, xM represents the length of the cable in metres.
GNSS antenna cable	12785-xM	LMR-400 very low loss RF coaxial cable.

Name	Part Number	Description
LMR-400 very low loss		Available in standard lengths of 25 m and 50 m. In the part number, xM represents the length of the cable in metres.
GNSS bullet antenna kit	18869	GNSS Antenna (18771) With Mounting Bracket and Hardware
GNSS bullet antenna	18871	A 3.3 V thread-mount GNSS bullet antenna with a TNC connector.
GNSS patch antenna	18863	A 3.3 V GNSS patch antenna with a 5 m cable. Shipped with Centaur.
GNSS cap	CON0278	Dust cap for GNSS connector port. NOTE: This optional accessory is required if a local GNSS antenna is not being used.
Power supply	17236	Power supply with mains to 24 VDC. FOR INDOOR USE ONLY.
*****External SD Media Card	18023-xxGB	Secure Digital Media Card, Industrial Multi-level cell (MLC), pre-formatted with FAT32. Available in 16GB, 32GB, 64GB, 128GB and 256 GB capacities. In the part number, xxGB represents the storage capacity of the external SD card.
Internal memory storage media	18108-xxGB	Store Media, xxGB, SD card, Industrial MLC, Ext4, where xxGB represents the storage capacity of the internal SD card. Available in 32GB, 64GB, 128GB and 256GB capacities.
USB Wi-Fi Accessory Kit	17630	A kit containing a USB Wi-Fi dongle, O-ring, and Media Bay dome cover to connect Centaur over Wi-Fi. NOTE: The USB port is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

*****See About SD media cards.

2.0 Installation Tasks

At a high level, we recommend that you perform the following tasks to install a Centaur:

1. Insert an SD card in external media slot (optional).
2. Choose a deployment option.
3. Inspect Connectors and O-rings.
4. Perform the initial configuration.
5. Develop a grounding plan.
6. Connect and ground the device.

Before leaving the installation site (post-installation), monitor the LEDs and troubleshoot any errors that occur.

2.1 About SD Media Cards

Nanometrics tests with industrial-quality SD cards that have proven to be very reliable. SD cards are available in 16 GB, 32 GB, 64 GB, 128 GB and 256 GB capacities. If you prefer to supply your own SD cards, please contact technical support for information about SD cards that have been qualified by Nanometrics. See "Cables and Accessories" on page 15.

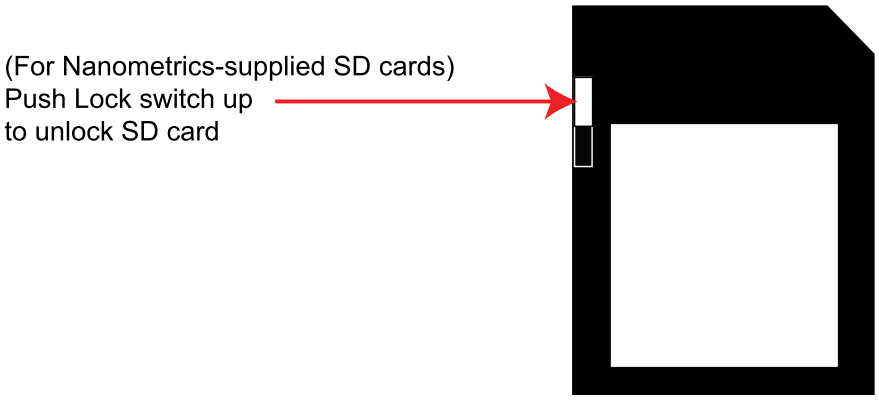
The Centaur supports both an internal SD card and an external SD card. See About Data Storage for more information. For information on replacing or installing the internal SD card, please contact Nanometrics Technical Support.

To ensure reliability, we strongly recommend that you use only SD cards that are provided by or recommended by Nanometrics. Other types of cards may be unreliable, which may lead to loss of data.

2.2 Write-protection on SD cards

To enable an external SD card for data archiving, make sure to unlock the SD card before you install it.

For the internal SD card, although you can lock or unlock the card, the Centaur will ignore the lock. Existing data on the internal SD card may be over-written.



2.2.1 Insert SD Card in External Media Slot

The Centaur can be configured to archive MiniSEED data, event data, SOH data, and StationXML to an external **SD**[1] card formatted as FAT32 that has been inserted into the external media slot on the Centaur. The event data can be archived in multiple industry-standard formats.

Before data archiving can be enabled, an unlocked SD card (formatted as FAT32) should be inserted into the external media slot on the Centaur. When properly inserted and ready for use, the Media LED will blink green and the Media Eject LED behind the media door will be solid red for 10 minutes (it will then turn off to save power). See Continuous Data Archive and Events Data Archive for instructions on enabling data archiving on the external SD card.

To ensure sufficient space on your external SD card, you can remove older time series data from your continuous archive. The safest method for transferring data from the external SD card is to connect it to your computer. Alternatively, you can use secure FTP and the client application of your choice to manage your continuous archive files.

2.2.2 Remove or Swap the External SD Card

Remove the External SD Card

To safely remove the external SD card, push and release the **Media Eject** button in the media bay, or click the **Eject** button in the **Removable Media** section on the Web Interface **Maintenance** page. Wait for the Media Eject LED to turn solid green, which indicates that it is safe to remove the card. This should take less than 15 seconds. If the external SD card is not removed within 10 minutes after it has

[1]Secure Digital

been prepared for safe removal and the LED turns solid green, the card will automatically be re-initialized by the software for use again and the LED will turn to blinking red.

To prevent data loss or corruption, the external SD card should never be physically removed while the Media Eject LED is blinking in any colour.

To prevent data gaps, insert the new unlocked external SD card within one hour of removing the old one.
After an external SD card is removed, and before the new one is inserted, the Centaur continues to digitize and buffers data internally. When the new external SD card is inserted, that buffered data is written to the SD card to achieve a continuous gap-free recording.

2.2.3 External SD Card Full or Corrupt

The status of the external SD card in use is indicated by the Media LED on the instrument, and on these Web Interface pages:

- Health > Storage section
- Maintenance > Removable Media section

If your external SD card is full or corrupt, the instrument continues recording data to its Store, but stops writing data to your external SD card. Any configured streamers are unaffected when the external SD card is full or corrupt.

External SD Card Troubleshooting

- If your external SD card is corrupt or damaged, you can try to repair it from the **Maintenance** page. You may also re-format the card. Repair and re-formatting of external SD cards is performed in the Removable Media section of the **Maintenance** page.
- The most effective way to retrieve data directly from the Centaur's **internal storage**[1] is by downloading it from the **Maintenance** page to your computer.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

- Individual archive files can also be downloaded from the **Download archive files** link from the **Maintenance** page.

2.3 Choose a Deployment Option

The Centaur can be deployed as a stand-alone device to record continuous data on removable media for extended periods of time or as a network device that allows data downloads, data streaming, and remote configuration changes while also recording data to the storage media.

Regardless of whether data is streamed and/or archived to removable media (an external SD card), the Centaur continuously records data to internal storage. For more information, see About Data Storage.

2.3.1 Stand-alone Deployment

In a stand-alone deployment, a Centaur is deployed as a "do-it-all" device. The recorded time series data is written in NP format to the Primary internal flash memory storage and written in MiniSEED format and StationXML format and recorded to the hot-swappable external SD card, if an external SD card is installed and if continuous archiving is configured by the user.

A technician must visit the Centaur in the field to retrieve the data, which is done by retrieving the removable media and replacing it with a new empty SD media card or by downloading data from the internal storage.

Downloading data from the Primary Internal Store is a slow operation and is generally done either for small amounts of data or when the swappable external SD card has been lost or damaged.

2.3.2 Networked Deployment

In a networked deployment, a Centaur is deployed as part of a network and the recorded time series data is written in NP format to the internal storage and also streamed over the network to a data acquisition server, such as Apollo Server, using either the SeedLink or NP streaming protocol. As an additional backup, the Centaur can be configured to continuously write the time series data in MiniSEED format to a FAT32 formatted swappable external SD card. See Format SD Card.

The field technician does not typically visit the Centaur in the field after it has been installed, but instead uses a Web browser to make any necessary configuration changes and receive the streamed data.

2.3.3 Data Access Options

Typically, the data access method you choose is influenced by the remoteness and duration of the deployment.

The Centaur can be deployed as a:

- Network device that allows data downloads, continuous streaming to a data acquisition server (such as Nanometrics' Apollo Server), and remote configuration changes.
- Stand-alone device to record continuous data on removable media for extended periods of time (accessed later via file transfer or retrieving the external SD card when a technician is visiting the site).

Regardless of whether data is streamed and/or archived to a secondary removable media (external SD card), the Centaur continuously records data to internal storage. For more information, see About Data Storage.

Continuous Streaming

Continuous data streaming is usually the preferred data access method for longer term deployments.

Continuous data streaming uses the Ethernet port communicating through a hard-wired network, or wireless options such as a cellular modem, Low Earth Orbit (LEO) modem, or VSAT communication system, such as Nanometrics' Libra II VSAT System.

File Transfer

File transfer is more common for short-to-medium term deployments when streaming is not possible or practical. You can remove the SD card from the external media bay and swap in a new SD card within one hour without causing any data gaps between the records on the two cards. Alternatively, you can connect to the Centaur via Ethernet to download the data stored in its internal flash memory.

Data Formats

Each data access method provides specific data recording formats.

For a list of available data formats you can use for file transfer from the external SD card or internal storage, see Recording (Continuous) and Recording (Events) in the specifications.

To view the data formats available for data streaming, see Data Streaming in the specifications.

2.3.4 Use Cases: Deployment and Data Access

The table below illustrates the typical use cases for deployment and data access.

Deployment time-frame	Continuous data streaming required?	Data access option
Short-term (Temporary)	Yes	Streaming, using: • Wired Internet, cellular or satellite
	No	File transfer: • Removable media (external SD card) • Internal storage via Ethernet (retrieve unit and bring to lab)
Medium-term (Semi-permanent)	Yes	Streaming, using: • Wired Internet, cellular or satellite
	No	File transfer: • Removable media (external SD card)
Long-term (Permanent)	* Yes	Streaming, using: • Wired Internet, cellular or satellite

* Streaming is normally required for permanent stations because file transfer is often impractical.

2.3.5 Perform the Initial Configuration

Each Centaur comes factory-configured with several default configuration settings. The factory configuration addresses the most common use cases for the Centaur and means that most devices will require minimal pre-installation configuration.

To check the configuration, you must connect the power, Ethernet, and GNSS cables and wait for the device to power up. Once started, you need to access the Web interface of the Centaur to verify or change the configuration.

You should ensure the following settings are configured to your needs prior to deploying the device in the field:

- Sample rate
- Sensor type
- Detector settings
- Ethernet settings
- Streamer settings (Networked deployment)
- Timing source settings
- Archiving to External SD card

2.4 Develop a Grounding Plan

The power consumption of the Centaur varies with factors such as the GNSS receiver duty cycle and the activity of the Ethernet. Typical consumption is listed in the Power section of the technical specifications.

The most appropriate grounding plan will depend on your application and the installation environment. Following is some general information you can take into account when planning grounding for a Centaur installation.

2.4.1 General Considerations

- Power — The Centaur power connector has 3 pins to allow the Centaur to conform to the site grounding system. You can connect the power return pin and ground, but combining grounding and power return in the same conductor limits the site grounding options. The recommended practice is to establish a single ground point for the station and ground everything to that point, which minimizes the chances of ground loops and signal noise created by the power system.

Applying excessive voltage to a peripheral for an extended period of time may damage the equipment. Therefore when designing the power system, take care when considering the voltage input demands of any attached peripherals to ensure that the voltage requirements are not exceeded.

- Peripheral power — The Centaur provides primary power to attached peripheral devices via the Sensor connectors. The Centaur monitors for over-current conditions and will automatically

switch off power to a peripheral if excessive current or a short is detected. The voltage provided to the Centaur is passed on to the attached peripherals. The current demand of each attached peripheral and the consequent voltage drop through the Centaur and peripheral cables should be taken into consideration when designing the power system to ensure that sufficient voltage is supplied to each peripheral.

2.5 Connect and Ground the Centaur

You will need the following items to set up and configure your Centaur:

- Power supply and cable*
- Ethernet cable*
- GNSS antenna and cable
- External SOH cable* if you want to record analog state-of-health (SOH) signals from other sensors
- Seismometer cable
- Computer, tablet, or smartphone with one of the following browsers installed: Chrome, Firefox or Safari

*Not included. See Cables and Accessories.

Connect the cables and ground the Centaur

Be sure to inspect cables for damage prior to connecting them. See "Preventative Maintenance of Connectors and O-rings" on page 26.

1. Connect the following cables to the Centaur:
   - Seismometer cable
   - Ethernet cable (if used)
   - External SOH cable (if used)
   - Power cable (apply power last)

You can make the Ethernet cable connection waterproof using the Ethernet cable P/N 19403-1M that is shipped with the Centaur.

To avoid ground loops, use either the chassis ground or the power cable to ground the Centaur chassis, not both. Using both methods to ground the chassis may cause a ground loop.

2. Ground the Centaur:
    a. Your Centaur ships with the grounding wire attached. If you must attach a new grounding wire, strip one end of the grounding wire and crimp the grounding lug around the grounding wire.
    b. Attach the grounding lug to the grounding hole using the M4x5 screw and the M4 washer. See the Top View of the Centaur for the grounding hole locations.
    c. Connect the other end of the grounding wire to a grounding point at the site.
3. Apply power. When you connect the power cable to the power source, the Centaur will power up immediately. It will take approximately 4 minutes for the device to completely start up. Data flow will begin approximately 2 minutes after power up. Note that the first time you start up after upgrading firmware will take an additional 2 minutes.

If the device fails to power up, the power supply voltage might be below the configured Power on threshold.

Next step: Log into the Web Interface.

2.6 GNSS Antenna

The GNSS antenna is referenced to digital ground which has a single point connection inside the Centaur to analog ground which is in turn connected to Centaur chassis ground. If the Centaur or attached sensor is grounded to earth, avoid making a second connection to earth ground at the GNSS antenna. If this is unavoidable, route the cables to minimize the area of the loop formed by the earth grounds and cables, as this loop behaves as an antenna to pick up noise and surge energy. If the Centaur and attached sensor are not otherwise grounded to Earth, connect the GNSS antenna to earth ground if possible.

In configurations that have long GNSS cables and lightning protection, an overall system design approach must be taken which balances the grounding requirements with the protection requirements. This approach requires an understanding of the Centaur grounding, the sensor grounding, power supply grounding, and local site grounding.

2.7 Power

The Centaur power connector has 3 pins to allow the instrument to conform to the site grounding system. You can connect the power return pin and ground but combining grounding and power return in the same conductor limits the site grounding options. The recommended practice is to establish a single ground point for the station and ground everything to that point, which minimizes the chances of ground loops and signal noise created by the power system.

2.8 Preventative Maintenance of Connectors and O-rings

Prior to each deployment, inspect the cable connectors and the O-ring on the media bay cover and replace them if necessary. Once greased and mated the connectors will be well protected and will not need to be serviced during the course of a field deployment. Similarly, once the media bay cover O-ring is greased and the cover is reinstalled on the digital recorder, the media bay will be well protected and will not need to be serviced during the course of a field deployment.

Prior to each deployment, the cable connectors and the media bay cover O-ring should be inspected and, if necessary, greased using the following guidelines:

- Inspect, grease and mate the connectors at a warm temperature (above -20ºC) prior to deployment if possible. (Below -20ºC connectors become stiff and cannot be mated. However, once mated connectors can be used to -40ºC or lower.)
- For standard temperature deployments, use Molykote 44, Molykote 111, or Dow Corning 111 grease
- For extremely low temperature deployments, (below -40ºC) use Molykote 33 or Uniflor 8911 grease

For the media bay cover O-ring:

- If the O-ring is dry, lightly stretch it to inspect for cracks. If cracks are present, discard the O-ring and obtain an equivalent replacement of the same size and material from any O-ring supply company.
- If an O-ring is missing or damaged, obtain an equivalent replacement of the same size and material from any O-ring supply company.

- If the O-rings are dirty, remove them gently with tweezers, wipe them clean without stretching them, re-grease and replace them. They should be greased with a small amount of the grease recommended above.

If you need to replace the O-ring, use one with the following specifications:

- **Material:** Buna-N
- **Size:** 1/8" Width x 1 3/4" internal diameter x 2" outside diameter
- **Hardness:** Durometer A 70

For the cable connectors, to apply the grease:

1. Apply a layer of grease to the end of the cable connector as follows:
    - If the connector is dry, apply a layer of grease approximately 2 mm thick.
    - If the connector is already wet (for example, in the field), apply a layer of grease approximately 8 mm thick.
2. To distribute the grease into the socket holes and onto the connector prongs, push together the two ends of the connector, then pull them apart again to verify that the grease has been distributed sufficiently.
3. Once the grease distribution has been verified, reconnect the ends and tighten the red locking sleeves to prevent the connectors from coming apart.

For more information, see the video, SubConn ® greasing and mating above water (dry mate), published by MacArtneyGroup (2013). Retrieved from https://www.youtube.com/watch?v=Vp_cbGtSsXI

3.0 Accessing the Web Interface

The Web Interface is where you can assess the status and health of your instrument, configure your sensor, view the waveform, and perform maintenance tasks, such as backing up your configuration settings and upgrading your firmware.

You can create a direct connection to your Centaur using a link-local IP address or you can create a network connection to the device.

3.1 The Summary page

When you first log on to the Web Interface for your Centaur the **Summary** page is displayed. Using a series of coloured status bars and status indicators, this page provides an at-a-glance view of the key device status information relating to the sensor mass positions, operating mode, timing, media, configuration and simplified waveforms allowing you to easily monitor the device during installation.

The **Time** section provides a high-level view of the status of the internal system clock, and an estimate of the clock's timing uncertainty. If GNSS timing is configured, this section also provides the number of GNSS satellites used by the GNSS receiver for time determination. You can also view this information in more detail from the Time section on the **Health** page.

The **Sensor** section provides a high level view of the mass position values and output mode for the sensor. The mass position thresholds are user configurable. See Sensor SOH for details.

Mass position bar graphs indicate the current value for each mass position and whether that value is within the acceptable ranges. Ranges are defined as follows:

- If the voltage falls within the green range of the configured SOH low threshold value, it is considered acceptable. No adjustments are required.
- If the voltage falls within the red ranges, the sensor is poorly aligned and needs to be mass centred. For sensors with remote mass centring capabilities, you can initiate this from the **Sensors** page.

If the selected sensor supports mode configuration, you can select the **Output** mode by clicking on the Period button without having to access the sensor **Control** page. Ensure that Long Period mode is selected before completing the installation.

The **Media** section quickly tells you whether an external archive SD media card is installed, the last time that the archive was written to and the size of the Internal Storage in the seismometer. In

addition, the Archive card bar will change from green to red when the external SD media card is at least 90% full. You can view more detailed information about the media from the Storage section on the **Health** page.

The **System** section indicates if the configuration has been committed. It also indicates the file name of the last configuration file uploaded to the device. A blank value indicates that no configuration has been uploaded. You can view detailed information about the configuration from the Firmware section of the **Maintenance** page.

Waveforms on the Summary page

As mentioned earlier, the **Summary** page also provides simplified waveforms allowing you to easily monitor the device during installation. Navigating to the Waveforms page gives you a more detailed view of these waveforms.

To ensure that waveforms are displayed correctly, make sure that you have installed one of the following browsers: Chrome version 16 or newer, Firefox version 11 or newer, or Safari version 7 or newer.

If you attempt to view waveforms on more than two Web Interfaces at the same time, the error message "An error occurred receiving waveform data" will be displayed.

For the 6-channel model, waveforms may not display on the **Summary** page if the Centaur is configured to have more than 6 active channels (primary and secondary channels combined). If you encounter this issue, proceed as follows:

1. Navigate to the **Waveform** page.
2. Click on the **Choose Channels** link located in the top left corner to access the Choose Channels window.
3. Select the channels that you wish to view and click **OK** to close the window.
4. Close and re-open the browser tab, OR navigate to the **Summary** page and refresh the browser.

The selected channels should now display on the **Summary** page.

3.2 Direct Connection to the Web Interface

For a direct connection between your instrument and a computer (with Chrome, Firefox or Safari installed), use the link-local IP address 169.254.33.33 (3 channel model) or 169.254.35.35 (6 channel

model) with a subnet mask of 255.255.0.0.

You can access the Centaur user interface over Wi-Fi using the optional USB Wi-Fi Accessory Kit (Nanometrics part number 17630). See "Cables and Accessories" on page 15.

> This feature is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

3.3 Network Connection to the Web Interface

1. Connect the Centaur to a DHCP-enabled network and allow it to automatically assign an IP address to the device.
2. Use Apollo Discovery, a Nanometrics application, to search the LAN for Nanometrics instruments and applications.

> Contact Nanometrics Support at http://support.nanometrics.ca to get Apollo Discovery. Apollo Discovery must be run on the same subnet as the devices you want to find.

3. Confirm that the serial number displayed on the Web interface matches your Centaur. If it does not, then you are connected to a different Centaur in your network.

> After connecting to the Centaur, either through the link-local address or via a DHCP-enabled network, you can configure a static IP address for your deployment.

3.4 Logging on to the Centaur Web Interface

When you first connect to the Web Interface, you are in view only mode. This mode allows you to view information about your instrument such as the status and health of your instrument, the connected sensors, events and waveforms. To edit the configuration, upload firmware, and perform maintenance tasks, you need to log on to your Web Interface.

1. From the upper right corner of the Web Interface, click **Log On**. The Log On dialog box will be displayed.
2. Enter the current admin account username and password.
3. Click the **OK** button. On the Web Interface, **admin** will display in place of Log On.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

3.5 About Passwords

For Nanometrics instruments, password authentication is used for more than one interface. To increase the security of the instruments, it is important to ensure that all of these default passwords are changed. Follow the links below for details on how to change each type of password:

- The root password is changed using an SSH client
- The calibration password is changed using an SSH client
- The admin password is changed from the Web Interface
- Setting a password for the Security Module

Before you begin, refer to the guidelines for creating a strong password.

3.5.1 Guidelines for creating a strong password

You should change the default passwords for all interfaces prior to deploying the Centaur. A strong password should:

- be a minimum of 8 characters long
- include a combination of upper and lower case letters
- include numbers
- NOT be based on dictionary words

If you require more information, there are several resources available on the Internet to help with the choosing and generation of strong passwords.

3.5.2 Changing the root password

After successfully logging in to the Centaur using an SSH client such as PuTTY, you can run the **passwd** command to change the root user's password:

1. If you do not have an SSH client such as PuTTY, download one from the Internet.
2. Launch the SSH client and connect to the instrument using the instrument's IP address and default port number 22.
3. If the connection was successful, a login screen will open. Log in to the instrument as the root user using the current root username and password.

> The factory defaults are username: **root**, password: **dolphin18**.

> To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

4. To change the root password, at the prompt, run the following command: **passwd**
5. Enter your new password. Passwords must be a minimum of characters 8 characters long and include a combination of upper and lower case letters and numbers. See Guidelines for creating a strong password.
6. Reenter your new password.
7. If you have not changed the calibration password from the factory default values, continue to step 4 in Changing the Calibration Password.

3.5.3 Changing the Calibration Password

The calibration user account and password allows you to upload a custom calibration file to the instrument. See "Uploading a custom calibration signal file" on page 223. You can change the calibration user password by logging in to the instrument as the root user using an SSH client such as PuTTY:

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

1. If you do not have an SSH client such as PuTTY, download one from the Internet.
2. Launch the SSH client and connect to the instrument using the instrument's IP address and default port number 22.
3. If the connection was successful, a login screen will open. Log in to the instrument as the root user using the current root username and password.

The factory defaults for the root user are username: **root**, password: **dolphin18**.
The factory defaults for the calibration user are username: **calibration**, password: **calibrate**.

4. To change the calibration password, at the prompt, run the following command:
   passwd calibration
5. Enter your new password. Passwords should be a minimum of 8 characters long and include a combination of upper and lower case letters and numbers. See "Guidelines for creating a strong password" on page 31.
6. Reenter your new password.
7. Close the SSH session.

3.5.4 Changing the admin password

The factory defaults for the admin user are username: **admin**, password: **admin**.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

After successfully logging in to the instrument's Web Interface, you can change the user's password from the admin menu:

1. From the upper right corner of the Web Interface, click on **admin** and select **Change password** from the list. The change password dialog box will be displayed. Passwords must be between 8 and 10 characters long and include a combination of upper and lower case letters and numbers. See "Guidelines for creating a strong password" on page 31.
2. Enter your **User name**, your **Old password**, and your **New password**.
3. Confirm your new password by entering it in the **Confirm new password** field.
4. Click the **OK** button. The dialog box will close and your password will be set to the new password.

3.6 Configuring instrument security

WARNING: You can become locked out of the instrument if the firewall is configured incorrectly. Only people with advanced working knowledge of Linux should attempt to configure a firewall for Nanometrics instruments.

In addition to changing instrument passwords, you can improve instrument security by configuring a firewall for your network using the `iptables` firewall utility for Linux. This utility allows you to specify which sets of IP addresses, IP networks and subnetworks can communicate with your Nanometrics instruments while blocking those that are not specified.

The Centaur includes a file for defining `iptables` rules and automatically applying them on startup. This file is located at `/etc/iptables.rules.user`. By default, the sample rules included in the file are disabled (commented out). You can edit this file to suit your specific needs, then reboot the Centaur to enable the functionality. If you have made any changes, you will also need to reconfigure the `/etc/iptables.rules.user` once firmware upgrade is complete as changes to the file are not preserved.

For guidance on configuring firewalls for Nanometrics instruments, please contact Nanometrics support at http://support.nanometrics.ca/. See https://linux.die.net/man/8/iptables for further information on the `iptables` firewall utility. For more information on configuring passwords, see "About Passwords" on page 31.

3.6.1 Using SSHGuard for added security

To improve the robustness against cybersecurity threats, SSHGuard (www.sshguard.net) is used to protect the secure shell from brute force attacks. Using `iptables` as a firewall, SSHGuard

automatically rejects connections from IP addresses that have been identified as a threat based on the configured banning level. By adjusting the settings in the `/etc/sshguard.conf` file you can modify SSHGuard configurations and corresponding banning levels to increase or decrease the level of security from cyber attacks. Keep in mind the following when configuring SSHGuard:

- By default, SSHGuard is configured with a moderate banning level which means:
    - The offender is typically banned after 3 failed attempts
    - Initially the offender is banned for 120 seconds. This duration increases by a factor of 1.5 each time a login attempt fails
- A `/var/log/authlog` file is created that contains a copy of the authentication related logs
- SSHGuard does not apply to the link local addressing
    - Care should be taken when using automated ssh access as incorrect credentials may lead to an extended lock-out period. For example in extreme cases, a site visit may be required to recover the unit. If a server is blocked, the web server for the User interface will not be available during the lock-out period
- An instrument reboot will reset the threat status of banned IP addresses
- If settings have been adjusted from the defaults, you will need to reconfigure the `/etc/sshguard.conf` file once firmware upgrade is complete as changes to the file are not preserved

4.0 Configuring Your Centaur

You can change the configuration settings for the Centaur by logging on using the admin user account, opening the Configuration menu, and selecting **Configuration**.

> To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

Once you have completed the configuration, click on the appropriate button as follows:

- Reset — Discard any unapplied changes and reload the current configuration settings.
- Apply — Implement changes before they are committed. The device will operate with the new settings but will discard them if it is restarted.
- Commit — Permanently save changes. Click this button within 1 hour of using the Apply command, otherwise the device will return to the previous configuration settings and any uncommitted changes will be lost.

> **As a fail-safe measure for instrument recovery.** In the case of a failed configuration operation, Centaur will automatically reboot and revert to the previously committed configuration 1 hour after the Apply command has been used if no Commit command is received.

4.1 Downloading/Uploading the Configuration

> Nanometrics recommends that you only use configuration files created with the current firmware version. Use of configuration files from other firmware versions may cause unexpected behaviour.

You can download the current configuration of the Centaur and save it as a backup in case you ever want to restore the settings of the Centaur to the current state or upload it to a different Centaur. The downloaded configuration file is in RDF Turtle format (see http://www.w3.org/TeamSubmission/turtle/).

If you do upload a configuration file, keep in mind that you might have to use Apollo Discovery to find the new IP address assigned to the device if the Ethernet mode changes from Static IP or Link-Local to DHCP.

Apollo Discovery is a Nanometrics command-line application that searches the LAN and returns the model number, serial number, IP address, and other information about the Nanometrics devices and applications that it finds.You can download Apollo Discovery from our support Web site: http://support.nanometrics.ca.

4.2 Configuration Reset

You can restore the Centaur to the factory default configuration settings by selecting **Reset configuration** from the Configuration dropdown menu on the Web Interface. This action will restore the configuration to the factory default settings, including network settings, but it will not delete existing data in the Store or on the SD Archive.

Restoring the instrument to the factory default configuration settings, allows you to reset the instrument to a known clean starting point which is useful for example, if you are redeploying an instrument.

If the network has already been configured for remote access, the instrument may become inaccessible.
Using the Configuration Reset feature will also reset the Web Interface credentials.

To reset the configuration:

1. Log onto the Centaur using the admin user account.
2. From the Web interface, click on the **Configuration** icon to access the drop-down menu and click on the **Reset configuration** menu item to display a prompt.
3. Click the **Reset configuration** button to reset the instrument configuration and cause the system to restart.

4.3 General Configuration Settings

Configuration title

This option allows you to configure a name for the configuration on your device. This is especially useful if you have deployed a system where multiple devices share a configuration file. This value will appear on the Web interface **Summary** page.

When you upload a configuration file, and the Configuration title is not set in the uploaded configuration itself, the system will automatically set the Configuration title to the filename of the uploaded configuration file.

Before downloading the configuration to be shared with other devices, either enter a name in the **Configuration title** field or ensure that the field is empty so that the configuration filename will be entered in the field when the configuration is uploaded to the other devices in the system.

System log verbosity

The level of detail of the system log:

- Info – All errors, warnings, and minimal system status information
- Verbose – All errors, warnings, and more detailed system status information
- Debug - All errors, warnings, and extensive system status information

You should only select **Verbose** or **Debug** as the logging level if you were instructed to do so by Nanometrics Technical Support. The larger number of log messages generated by both of these options may cause the system to slow down. Additionally, the larger log file size may cause older log files to be overwritten more quickly.

Retrieval mark

This feature is no longer supported.

Enable analytics sharing

When enabled, this option automatically shares instrument analytics data with Nanometrics including details about the system configuration and state-of-health including instrument configuration, software version, station and network names, and physical location. The collected information is not linked to your account or instrument serial number and does not identify you personally. In addition, the network cloud server does not preserve the source IP address of the data received nor are any passwords or IP addresses in the instrument configuration included in the data. This feature is enabled by default.

To opt-out of sharing instrument analytics, deselect this option.

4.4 Digital Signature on the Centaur CTR4 with Authentication

The Centaur digital recorder CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H) includes hardware authentication for digital signature of data. This use of digital signature focuses on the specific authentication requirements of CD-1.1-based data receivers to validate the authenticity of data received from Centaurs at remote stations.

If you have a Centaur digital recorder CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H), the Health page includes an Authentication section that will indicate the status of the features available with the CTR4-3A, CTR4-6A/S and CTR4-6AS/H including authentication and CD-1.1 channels and connection.

4.4.1 Setting a Password for the Security Module

To increase security, you can set a password for hardware authentication. This should be done before you enable digital signature authentication. This is an optional step.

1. Open the Configuration menu and navigate to **Data Streaming > CD-1.1 Streaming**.
2. In the **HSM PIN** field enter the password that you want to assign to the security module. The password should be a minimum of 6 characters long. If the entered PIN is less than 6 characters, a prompt will display requesting a longer PIN.
3. Click **Apply** and **Commit** to save the changes.
4. Click **Close** to close the Configuration menu and continue to Enabling Digital Signature.

The password will be set automatically when you initialize Authentication.

If the HSM PIN value does not match the value that was sent to the security module, the security module features will become inaccessible.
If you need to change the password, Please contact techsupport@nanometrics.ca for more information.

4.4.2 Enabling Digital Signature

To enable the digital signature of data you need to generate a keypair and a certificate request and then forward the request to your certificate authority (CA) for validation. Once you have received the certificate from your CA, you can complete the process.

1. On the Web Interface, navigate to the **Maintenance** page.
2. In the **Hardware Security Module** section, click **Initialize Hardware Security Module** to initiate the authentication security module so that the digital signature feature can be enabled.

> This step is only required when you first configure the CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

3. Click the **Generate Keypair** button. A dialog box will display.
4. Enter a **Slot Number**, select the **Keypair Type** from the drop-down list, then click the **Generate Keypair** button. The system will be unavailable while the keypair is generating. Once the keypair is complete the system will become available again. At this time you can continue with generating a certificate signing request.

> You can generate a keypair and generate a certificate signing request for up to 20 slots, however only 1 slot can be active at any one time.
> A slot can only contain one keypair. If the slot already contains a keypair, you must select the **Regenerate** button after selecting the Slot number. See Regenerating a keypair.
> Two types of keypairs are available. Select **ECDSA**, if you require a stronger encryption type.

5. In the **Hardware Security Module** section, select the Slot Number from the drop-down list and click the **Generate Certificate Signing Request** button to begin the certification request process. A prepopulated Certificate Request form will be displayed.
6. Click **Generate Certificate Signing Request**. A *.pem file will be downloaded to your computer.
7. Forward the *.pem file to your CA. (Contact your CA for specific instructions.) Once the CA has validated your certificate request, they will forward the certificate and an authentication number to you.
8. Once you have received the authentication number, access the Web Interface Configuration menu and navigate to **Data Streaming > CD-1.1 Streaming** and proceed as follows:
    a. Select the **Enable** check box.
    b. Enter the slot number in the **HSM slot ID** field.
    c. Enter the authentication number in the **Authentication key ID** field.

> The **HSM slot ID** must match the slot number for the keypair that you generated in step 4.

9. Click **Apply** and **Commit** to save the changes. At this time the CD-1.1 Authentication field on the **Health** page will display Active.

4.4.3 Regenerating a keypair

If you regenerate a keypair for a selected slot, you will also need to regenerate the certificate request and then forward the request to your certificate authority (CA) for validation. As part of this process you will receive a new authentication key ID to enter on the **Data Streaming > CD-1.1 Streaming** page. You should only regenerate a keypair if you are concerned about the current security of your system.

4.5 Configuring tamper switches on the Centaur CTR4 with Authentication

For the Centaur CTR4 series models with Authentication, you can define each external SOH channel as an open/close switch indicator from the CD-1.1 data streaming page. Typically, this feature could be used if the equipment includes a tamper switch installed on a vault door, for example. If a tamper switch is configured in this manner, the channel will display on the Web Interface on the **Health** page in the Authentication section and the status will display as open or closed. In addition, because of this configuration, the External SOH channel will automatically be configured as a switch. Any change in state will be reported by the associated SOH channel as mV in the Archives and for SeedLink streaming.

See External SOH Settings for details on configuring tamper switches for other Centaur models.

You can configure any number of the three external SOH channels to be open/close switch indicators, however for models CTR4-3A, CTR4-6A/S and CTR4-6AS/H, the External SOH channel 1 is reserved for the internal tamper switch.

1. To enable the tamper switches in CD-1.1 for models CTR4-3A, CTR4-6A/S and CTR4-6AS/H, navigate to **Data Streaming > CD-1.1 Streaming > Status**.
2. For the internal Centaur tamper switch, from the **Digitizing equipment open** drop-down, select **External SOH 1**. Note that although this switch is internal, an external loop back from SOH 1 to ground is required to enable the tamper function.

3. For external tamper switches, from the **Equipment housing open** or **vault door open** drop-down, select **External SOH 2** or **External SOH 3**. These external switches provide a loop back to ground to function.

4.6 Channel Naming

The channel names are used by the Centaur for two different purposes:

- Data Retrieval – The channel names are used in the file headings and default file names for all types of retrieved data. The names act as labels to help you identify the data. For more information, see "Retrieve Data from the Internal Storage" on page 162.
- Filtered Streaming – When you configure the Centaur to stream data, you have the option to define an SCNL-based filter to limit what channels are streamed. The Centaur refers to the channel names when it performs the filtering.

Centaur retains only the currently configured channel name. Historical naming information is not preserved.

When you make a query to retrieve data or to view a waveform from Centaur, make sure to use the channel name that is currently configured, not the channel name that was configured when the data was recorded.

To enable on-instrument channel naming, check the **Field naming** box located in the Data Streaming configuration window.

Network code

A two character alphanumeric code (the alpha characters must be uppercase) that represents the network that the Centaur belongs to.

Station code

A five character alphanumeric code that represents the station where the Centaur is located.

Location code

A two character alphanumeric code (the alpha characters must be uppercase) that represents the time series location of the Centaur. This value is superseded if a location code is explicitly included with a channel code.

This setting is optional.

Channel code (for Primary or Secondary sample rates)

A three character alphanumeric code (the alpha characters must be uppercase) that represents each of the primary and secondary data channels. Optionally, a two-character location code can be included before the channel code if a unique location code is required for each channel. (For example, 00.HHN where 00 is the location code and HHN is the channel code.) If the location code is specified with the channel code in this field, the value in the Location code field is overridden.

The two codes have to be separated by a dot (.).

SOH code

A two character alphanumeric code for the location and a three character alphanumeric code for the channel that represents the SOH for the Centaur.

The two codes have to be separated by a dot (.).

4.7 Communications

You can configure a Centaur for network access using an IP connection over an Ethernet connection.

4.7.1 Discovery

Enable discovery

Select this check box to allow the Centaur to periodically send out small multicast identification messages to other Nanometrics devices and applications on the network.

IP address

A valid multicast IP address.

Port number

The UDP port number used by the Centaur for discovery broadcasts.

4.7.2 Ethernet

Ethernet mode

The method that the Centaur uses to acquire an IP address for communications over the LAN.

By default, each Centaur ships in DHCP mode so it can automatically obtain an IP address in your network. If needed, you can also use the following Link-Local address: 169.254.33.33 (3 channel) or 169.254.35.35 (6 channel).

If you change this setting to another Ethernet mode (**Static IP** or **Link-Local**) and then change it back to **DHCP**, you can use Apollo Discovery to find the new IP address assigned to the device. You will need this new IP address to be able to commit the change you made to the Ethernet mode setting because the previous IP address will no longer work.

Apollo Discovery is a Nanometrics command-line application that searches the LAN and returns the model number, serial number, IP address, and other information about the Nanometrics devices and applications that it finds.

Go to Nanometrics support site (http://support.nanometrics.ca) to get Apollo Discovery. (Search for *Apollo Discovery Code*) You can also get the latest user guide and release notes from the support site. Note that Apollo Discovery must be run on the same subnet as the instruments that you want to find.

Static IP address

If the selected Ethernet mode is **Static IP**, enter the IP address to be assigned to the Centaur for the LAN.

Static subnet mask

If the selected Ethernet mode is **Static IP**, enter the subnet mask for the static IP address.

Static default gateway

If the selected Ethernet mode is **Static IP**, enter the default gateway address for the static IP address. If routing to remote networks is not required, this field may be left blank.

Primary DNS server

If the selected Ethernet mode is **Static IP**, enter an address for the primary DNS server. If DNS is not required, this field may be left blank.

Secondary DNS server

If the selected Ethernet mode is **Static IP**, enter an address for the secondary DNS server. If DNS is not required, this field may be left blank.

If the Primary DNS server is not configured or unresponsive, the Secondary DNS server address will be used.

Ethernet speed

This option allows you to reduce the power consumption of your Centaur and the device it is communicating with, such as a modem, by restricting the Ethernet speed that is used to communicate between devices during auto-negotiation. The default setting is **Auto**, which will attempt to use the maximum 100Base-T, if available.

To reduce the power consumption of your Centaur select **10BaseT** from the drop-down list. This typically reduces power consumption by more than 100 mW relative to 100Base-T.

4.7.3 Wi-Fi

Idle timeout [min]

The amount of time that the Wi-Fi connection can remain idle before the optional USB dongle is disabled. The default setting is 5 minutes with a maximum setting of 240 minutes (4 hours). See Wi-Fi Access to the Centaur for more information on accessing your Centaur using Wi-Fi.

This feature is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

4.8 Continuous Data Archive

The Centaur Continuous Data Archive feature allows you to continuously archive MiniSEED data, StationXML data and SOH data (optional) to a removable external SD card.

To enable this feature, in the Configuration menu, navigate to **Continuous Data Archive** and click **Enable continuous data archive**. To include SOH data, click **Include SOH archive**.

When continuous data archiving is enabled, the default configuration provides daily, per-channel MiniSeed archive files. Using the Archive period, MiniSEED output file, Archive channel list and SOH archive format filters you can specify the information to be archived. Additionally you can specify folder names and archive file names using the Archive directory pattern and Archive filename pattern options for MiniSEED data, and SOH archive directory pattern and SOH archive filename pattern options for SOH data.

Before you enable this feature, make sure that you have inserted an SD card (formatted as FAT32) into the external SD card slot behind the media bay door of the Centaur.

In addition to streaming data from the Centaur to a network application or device and archiving data to a removable external SD card, you can also retrieve time series and SOH data directly from the Centaur's **internal storage**[1] by downloading it from the Maintenance page to your computer. In addition, the Centaur implements a web service data download interface that enables access to data centres that support FDSN web services. See the Web Service data download interface API.

Enable continuous data archive

Select this check box to allow the Centaur to continuously write MiniSEED data and StationXML data files to the external SD card. Each file contains multiple 512-byte MiniSEED records of waveform data. You can specify what data to include in a file using the MiniSEED output files and Archive channel list options. See Archive directory pattern and Archive filename pattern for configuration guidelines.

Archive period [min]

Select the amount of data in minutes to be written to each file.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

The number of 512-byte MiniSEED records contained in each file is determined by the duration selected here.

MiniSEED output files

For sensor channels, you can select the number of output files to be generated for each archive period: one file per channel or one file per station. The **per sensor channel** option produces many small files. The **per station** option produces one large file.

MiniSEED SOH archive files are output as **per station** files. These MiniSEED SOH archive files are separate from the MiniSEED output files that are generated for sensor channels.

Archive channel list

This field allows you to create a filter to select which data to archive, by channel, using the SCNL (Station, Channel, Network, and Location) naming convention. Before you can filter the data, you need to configure the network, station, location, and channel codes. See the configuration setting guidelines for Channel Naming and raw TCP receivers Location and channel code.

The format for specifying SCNL elements in a filter is NN.SSSSS.LL.CCC, where NN is the network code, SSSSS is the station code, LL is the location code, and CCC is the channel code. The S, C, and N elements must be represented in the filter and each element must be separated by a dot (.). The L (Location) element is optional. Therefore, if the location code is not being used, then the format should be NN.SSSSS.CCC

Tips for creating filters

- use an asterisk (*) to represent one or more characters in a channel naming element. To include all available data, type an asterisk (*) in the **Archive channel list** field with no other characters.
- use an exclamation point (!) to exclude a network, station, location, or channel. The exclamation point always has to be placed before the SCNL element that should be excluded.
- to include SOH data in the filter, make sure that the selected **SOH archive format** is **MiniSEED**.

Examples:

a. For the channel list filter `XX.*.*.*`, data is archived for all of the channels in the XX network.
b. For the channel list filter `XX.*.*.*Z`, data is archived for all of the Z channels in the XX network.
c. A filter can be created for a specific channel. For example, for the channel list filter `XX.STN01.LO.HHZ`, data is archived for the specified channel.

d. For the channel list filter `!XX.*.*.*`, data is not archived for any of the channels in the XX network.
e. For the channel list filter `XX.*.*.*,YY.STN01.*.*`, data is archived for all of the channels in the XX network and all of the channels from STN01 in the YY network.

Archive directory pattern

Use this field to configure the pattern for naming the digitized time-series data archive directories. For example, based on the pattern `${Y}/${M}`, the resulting archive directory name for January 23, 2017 would be 2017/01.

You can also use SeisComP Data Structure conventions to configure the naming pattern. In this instance a commonly used pattern is `${Y}/${N}/${S}/${C}.D`, where D indicates that the data type is waveform. For example, based on this SeisComP Data Structure pattern, the resulting archive directory name for the HHZ channel of the centaur-6_3-0345 instrument would be 2017/XX/STN01/HHZ.D/

Configuration limitations. Keep in mind the following limitations when configuring the Archive directory pattern:

- If the selected **MiniSEED output files** option is **Per station**, `${C}` and `${L}` must be excluded from the pattern string.
- Optionally, you can add a leading and a trailing slash (/) to the archive directory pattern string. For example: `${Y}/${M}/${D}` and `/${Y}/${M}/${D}/` will result in the same output.
- Do not add dots (.) before or after a slash.
- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#` .
- You will get an error message if the **Archive directory pattern = SOH directory pattern** AND the **Archive filename pattern = SOH archive filename pattern**.
- The external SD cards limit the number of items that can exist in a folder to between 10 000 and 65 000 items depending on the length of the filename and the folder name. To reduce the number of items in a folder, it is recommended that you configure the directory using a time-based structure. For example, for hourly archive files use the directory pattern `${Y}/${M}/${D}` and for daily archive files use the directory pattern `${Y}/${M}`.

- Configure the directory pattern so that more than one item will exist in a single folder and so that all items will not be contained a small number of folders.

See "Archive pattern naming parameters" on page 52 for more parameter descriptions.

Archive filename pattern

Use this field to configure the pattern for naming the archived MiniSEED files. For example, based on the filename pattern `${N}.${S}.${L}.${C}_${ID}_${TIME}.miniseed`, an archived MiniSEED file may have the name XX.STN01.LO.HHZ_centaur-6_0345_20130912_073356.miniseed

You can also use SeisComP Data Structure conventions to configure the naming pattern. In this instance a commonly used pattern is `${N}.${S}.${L}.${C}.D.${Y}.${J}`, where D indicates that the data type is waveform.

Define date and time. To define the date and time you can use any of the following naming patterns in place of the default pattern `${TIME}`:

- `${Y}${M}${D}_${h}${m}${s}`
- `${Y}.${M}.${D}-${h}.${m}.${s}`
- `${Y}${J}_${h}${m}${s}`

Configure filename extension. The default filename pattern includes the extension `.miniseed`. To configure the filename extension to something other than the default you can

- replace the extension with something else. For example, replacing the extension name with **data** will give you the following pattern: `${N}.${S}.${L}.${C}_${ID}_${TIME}.data`
- remove the extension altogether. The resulting pattern will be `${N}.${S}.${L}.${C}_${ID}_${TIME}`

Configuration limitations. Keep in mind the following limitations when configuring the Archive filename pattern:

- If the MiniSEED output files option is set to **Per channel** you must include `${C}` in the pattern string.
- If the MiniSEED output files option is set to **Per station**
  - you must include `${S}` in the pattern string.
  - you must exclude `${C}` and `${L}` from the pattern string.
- Do not add dots (.) before or after a slash.

- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#`.

See "Archive pattern naming parameters" on page 52 for more parameter descriptions.

Include SOH archive

Select this check box if you want to archive SOH data files to the external SD card.

The SOH data files are separate files and they are stored in a folder called **soh**. See SOH archive directory pattern and SOH archive filename pattern for configuration guidelines.

SOH archive format

If **Include SOH archive** is checked, select the format for archiving the SOH files.

Archiving SOH data in the CSV format is time consuming and might impact the performance of the device.

SOH archive directory pattern

Use this field to configure the pattern for naming the SOH archive directories. For example, based on the pattern `${Y}/${M}/soh`, the resulting archive directory name for January 23, 2017 would be 2017/01/soh

You can also use SeisComP Data Structure conventions to configure the naming pattern. In this instance a commonly used pattern is `${Y}/${N}/${S}/${C}.S`, where S indicates that the data type is SOH. For example, based on this SeisComP Data Structure pattern, the resulting archive directory name for the SOH data for the centaur-6_3-0345 instrument would be 2017/XX/STN01/SOH.S/

Configuration limitations. Keep in mind the following limitations when configuring the SOH archive directory pattern:

- If the selected **SOH archive format** is **CSV**, the user-configured channel name defined by `${C}` will be replaced with a hard-coded name, for example `EnvironmentSOH`.
- If the selected **SOH archive format** is **MiniSEED**, all SOH channels are included in one file, per period.

- Optionally, you can add a leading and a trailing slash (/) to the archive directory pattern string. For example: `${Y}/${M}/${D}` and `/${Y}/${M}/${D}/` will result in the same output.
- Do not add dots (.) before or after a slash.
- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#` .
- You will get an error message if the **Archive directory pattern = SOH directory pattern** AND the **Archive filename pattern = SOH archive filename pattern**.
- The external SD cards limit the number of items that can exist in a folder to between 10 000 and 65 000 files depending on the length of the filename and the folder name. To reduce the number of items in a folder, it is recommended that you configure the directory using a time-based structure. For example, for hourly archive files use the directory pattern `${Y}/${M}/${D}` and for daily archive files use the directory pattern `${Y}/${M}`.
- It is recommended that you do not configure a directory pattern that uses a unique folder for each archive or that contains all archives in a small number of folders.

See "Archive pattern naming parameters" on the next page for more parameter descriptions.

SOH archive filename pattern

Use this field to configure the pattern for naming the archived SOH files. For example, based on the filename pattern `${N}.${S}.${L}.${C}_${ID}_${TIME}.miniseed`, an archived SOH file may have the name XX.STN01.LO.HHZ_centaur-6_0345_20130912_073356.miniseed

You can also use SeisComP Data Structure conventions to configure the naming pattern. In this instance a commonly used pattern is `${N}.${S}.${L}.${C}.S.${Y}.${J}`, where S indicates that the data type is SOH.

Define date and time. To define the date and time you can use any of the following naming patterns in place of the default pattern `${TIME}`:

- `${Y}${M}${D}_${h}${m}${s}`
- `${Y}.${M}.${D}-${h}.${m}.${s}`
- `${Y}${J}_${h}${m}${s}`

Configure filename extension. The default filename pattern includes the extension `.miniseed` To configure the filename extension to something other than the default you can

- replace the extension with something else. For example, replacing the extension name with **data** will give you the following pattern: `${N}.${S}.${L}.${C}_${ID}_${TIME}.data`
- remove the extension altogether. The resulting pattern will be `${N}.${S}.${L}.${C}_${ID}_${TIME}`

Configuration limitations. Keep in mind the following limitations when configuring the SOH archive filename pattern:

- If the selected **SOH archive format** is CSV, the user-configured channel name defined by `${C}` will be replaced with a hard-coded name, for example `environmental`.
- For MiniSEED format, you can configure ${L} and ${C} using the **SOH Code** field on the Channel Naming page. If configured, the value in the SOH code field will replace the ${L} and ${C} parameter values in the SOH archive filename pattern.
- If the selected **SOH archive format** is MiniSEED, all SOH channels are included in one file, per period.
- Do not add dots (.) before or after a slash.
- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#`.

See "Archive pattern naming parameters" below for more parameter descriptions.

Archive pattern naming parameters

The following parameters can be used when configuring filename or directory patterns.

- ${N} is the network name
- ${S} is the station name
- ${L} is the location name
- ${C} is the channel name
- ${ID} is the instrument ID
- ${TIME} is the start time for the data archive in YYYYMMDD_hhmmss format
- ${Y} is 4-digit year
- ${M} is 2-digit month
- ${D} is 2-digit day of the month
- ${J} is Julian day (day of the year)
- ${h} is 2-digit hour of the day

- ${m} is 2-digit minutes of the hour
- ${s} is 2-digit seconds of the minute

4.9 Data Streaming

You can configure the Centaur to **stream**[1] time-series data, SOH data, triggers, alerts, and raw data to one or more data acquisition servers, such as Nanometrics Apollo Server using NP protocol, or to third-party systems using the Centaur SeedLink server feature.

NP format data is streamed using a User Datagram Protocol (UDP) socket or Hypertext Transfer Protocol (HTTP/TCP). As an alternative to UDP NP Streaming, Centaur now supports WebSocket data streaming, that optionally, can be configured to use TLS encryption of streamed data. Note that WebSocket streaming requires a downstream Apollo Server running version 4.2.37 or later. Because WebSocket streaming is TCP-based, it is not recommended for use over Libra communications networks.

Quick Seismic Characteristic Data (QSCD20®) is a lightweight data calculation and transmission protocol that allows for the low latency calculation of ground motion data products at 1 second intervals derived from 20 sps data acquired from attached accelerometers, which is then automatically streamed to central facilities.

SeedLink data streaming is initiated by a SeedLink client requesting data from the Centaur, which then streams SeedLink data using Transmission Control Protocol (TCP).

If you have the Centaur CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H), you can configure data streaming using CD-1.1 Formats and Protocols for Continuous Data (CD-1.1) using TCP.

See the following topics for more information:

- General Data Streaming Settings
- CD-1.1 Streaming
- NP Streaming (UDP, HTTP & WebSocket)
- QSCD20 Streaming
- SeedLink Streaming

[1]The transfer of packets of data at a steady high-speed rate from the device to downstream devices and applications.

- Throttle
- Fragmentation

4.9.1 General Data Streaming Settings

Consistent latency

Check this box to enable this option to provide a more consistent data latency. Then, commit the change and restart the instrument. By default this option is not selected (disabled).

Considerations for using the consistent latency option

- Do not enable this mode if very low frames per packet or very high sample rates, or both, are specified in the digitizer channel configuration. Doing so will cause unreliable operation.
- Enabling this mode increases power consumption by 20 to 30 mW.

Field naming

Check this box to enable on-instrument channel naming. Data is streamed based on the SCNL names that are configure in the Channel Naming configuration window.

Libra compatibility streaming

Use this option to enable your Centaur to stream through a Libra satellite modem that is running a Libra II firmware version earlier than 2.5. This option uses the older Nanometrics Protocol version 2 (NP2) for compatibility with Libra which also disables streaming time status information in SEED blockette 1001. By default this option is not selected.

4.9.2 About CD-1.1 Streaming

If you have the Centaur CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H), you can configure data streaming using CD-1.1 Formats and Protocols for Continuous Data (CD-1.1). For 6-channel models that support Authentication, you can configure CD-1.1 streaming on either Sensor A or Sensor B or both to support multi-sensor or mixed sensor stations. Note that CD-1.1 streaming is only available for the primary channels. If additional digitizing is required for archiving or streaming, it must be configured on the secondary channels. The following describes the functionality and limitations when CD-1.1 is enabled:

- When Authentication is enabled, the data time series data is authenticated and encapsulated in CD-1.1 format
- Authentication can be enabled on a channel-by-channel basis from the primary digitizer channels for either Sensor A or Sensor B
- When Authentication is enabled, a maximum combined sample rate of 200 sps is supported (200 sps on Sensor A for a Centaur-3 model or a maximum of 100 sps on each of Sensor A and B for a Centaur-6 model)
- Digital weather station channels have a fixed sample rate of 1 sps
- The global CD-1.1 frame time length parameter is user configurable and applies to all channels
- When Authentication is enabled, all CD-1.1 channels will include the digital signature. See "Digital Signature on the Centaur CTR4 with Authentication" on page 39. The digital signature can be ignored if it is not required by the data consumer
- Canadian compression for CD-1.1 time series data
- Last-in-first-out (LIFO) backfill in case of an interrupted connection
- Implementation of the CD-1.1 frame header channel status field for continuous monitoring of key state of health parameters
- Authentication supports 1 or 2 destinations that are shared for all channels
- CD-1.1 can be enabled concurrently with Archiving to the external SD media
- CD-1.1 can be enabled concurrently with NP streaming
- SEEDLink streaming is not supported when CD-1.1 is enabled

4.9.3 CD-1.1 Streaming Configuration Parameters

This section describes the available parameters for configuring CD-1.1 streaming on the Centaur CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H).

To access these parameters, in the Configuration menu, navigate to **Data Streaming > CD-1.1 Streaming**.

Frame creator

Enter an identifier for the creator of the frame to a maximum of 8 alphanumeric characters

Station name

Enter a five character alphanumeric code that represents the station where the Centaur is located.

Station type

Select the type of station that is requesting the frame.

Frame time length [s]

Enter the amount of time to be included in each frame. For example, if you enter 10, then 10 seconds worth of data will be included in each frame. Typically this amount of time is configured to either 10 or 20 seconds.

When 8 or more channels in total (including Sensor A channels, Sensor B channels and weather channels) are configured, the Frame time length should be set to 20 seconds.

HSM PIN

This is an optional field that you can use to configure a password to increase the security for hardware authentication. This password must be configured before you enable CD-1.1 Streaming. See "Setting a Password for the Security Module" on page 39.

HSM slot ID

Enter the Hardware Security Module slot to use when signing frames. This slot must match the slot number that you used when you generated a keypair when Enabling Digital Signature.

If authentication has not been enabled, enter 0.

Authentication key ID

Enter the certification authentication number that you received from your CA as a result of generating a certificate signing request as part of Enabling Digital Signature. This key will also be included in the CD-1.1 trailer.

If authentication has not been enabled, enter 0.

4.9.4 CD-1.1 Destination Configuration Parameters

This section describes the available parameters for configuring destination addresses for CD-1.1 streams on the Centaur CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H). Up to

two destinations can be configured, enabling concurrent streaming.

To access these parameters, in the Configuration menu, navigate to **Data Streaming > CD-1.1 Streaming > Destination 1** or **Destination 2**.

Enable destination *n*

Select this check box to enable data streaming using CD-1.1 Formats and Protocols for Continuous Data.

If you intend to set a password for the hardware authentication security module, you must configure HSM PIN before selecting **Enable**.

Frame destination *n*

Enter an identifier for the destination of the frame to a maximum of 8 alphanumeric characters.

Destination address *n*

Enter a valid unicast IP address of the streaming destination in dotted decimal format.

Destination port *n*

Enter the port number where data packets are sent.

Enable throttle *n*

Enable throttle is selected by default. Uncheck this field if you do not want to limit the network transfer rate.

If you have a low-throughput link, the throttle configuration settings allow you to configure the maximum data output of the streamer.

Maximum throughput *n* [bps]

Maximum throughput bit rate (bps) allows you to specify the maximum output bit rate. The default maximum is 2056000 bps.

Maximum backfill days

Use this option to configure the maximum age, in days, of CD-1.1 frames that can be sent to a destination for frames that have not been transmitted or acknowledged.

- To limit each backfill request to a maximum number of days, enter a positive integer in the field. For example, if you enter 200 in the field, the maximum age of CD-1.1 frames that can be sent is 200 days old.
- To allow unlimited backfill, enter the value -1. (default value)
- To disable backfilling, enter the value 0.

4.9.5 CD-1.1 Status Configuration Parameters

Configure the key state of health parameters for CD-1.1 frames using the following parameters. To access these parameters, in the Configuration menu, navigate to **Data Streaming > CD-1.1 Streaming > Status**.

Minimum voltage [V]

When the power supply voltage falls below this value, the CD-1.1 status bit for 'main power failure' will be set. The status is included in the CD-1.1 Channel Status field for every channel subframe.

Maximum voltage [V]

When the power supply voltage exceeds this value, the CD-1.1 status bit for 'main power failure' will be set. The status is included in the CD-1.1 Channel Status field for every channel subframe.

Max clock differential [us]

When timing uncertainty exceeds this value, the CD-1.1 status bit for 'clock differential too large' will be set. The status is included in the CD-1.1 Channel Status field for every channel subframe.

Digitizing equipment open

Select the **External SOH 1** input channel to map to the digitizing equipment tamper switch. If enabled, the Authentication box on the **Health** page will indicate if the digitizing equipment is open or closed. In addition, the status is included in the CD-1.1 Channel Status field for every channel subframe.

Equipment housing open

Select the **External SOH 2** or **External SOH 3** input channel to map to the equipment housing tamper switch. If enabled, the Authentication box on the **Health** page will indicate if the equipment housing is open or closed. In addition, the status is included in the CD-1.1 Channel Status field for every channel subframe.

Vault door open

Select the **External SOH 2** or **External SOH 3** input channel to map to the vault door tamper switch. If enabled, the Authentication box on the **Health** page will indicate if the vault door is open or closed. In addition, the status is included in the CD-1.1 Channel Status field for every channel subframe.

4.9.6 CD-1.1 Primary and Weather channels Configuration Parameters

This section describes the available parameters for configuring primary channels and weather channels for CD-1.1 streaming on the Centaur CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H). To access these parameters, in the Configuration menu, navigate to **Data Streaming > CD-1.1 Streaming > Primary channels** or **Data Streaming > CD-1.1 Streaming > Weather channels**, then expand **Primary channel** or **Weather channel** to access the specific channel.

Enable

Select this check box to allow the channel data to be collected from the source and converted to CD-1.1 format.

Site name

Enter an alphanumeric code that is between three and five characters in length, to represent the site of the equipment.

Channel name

Enter a three character alphanumeric code (the alpha characters must be uppercase) that represents the data channel.

Location name

Enter a two character alphanumeric code (the alpha characters must be uppercase) that represents the time series location of the equipment. (Centaur or weather station).

Sensor type

For primary channels only, select the type of sensor that is connected to the channel from the drop-down menu.

Compression

Select the type of data compression for the channel from the drop-down menu.

Calibration factor

Use the Centaur calibration feature to determine the value to enter in this field. The default value is 1.0.

Calibration period [s]

1.0

4.9.7 NP UDP, NP HTTP and NP WebSocket Streaming Parameters

This section describes the available parameters for configuring NP UDP streaming, NP HTTP streaming or NP WebSocket streaming. Note that WebSocket streaming requires a downstream Apollo Server running version 4.2.37 or later. Because WebSocket streaming is TCP-based, it is not recommended for use over Libra communications networks.

You can configure a maximum of four streamers on an instrument.

When configuring streamers, note that settings such as sample rate, and frames per packet may affect the instrument's performance or may increase the bandwidth required for the configured streamer to function as expected.

Name

Enter a unique name for the streamer.

Enable

Check this box to enable the streaming of data. By default, this check box is not selected.

TLS enabled

For NP WebSocket data streaming, check this box to instruct the streamer to use Transport Layer Security (TLS) protocol when establishing WebSocket connections.

Stream primary time series

Select this option to stream primary time series data.

Stream secondary time series

Select this option if you have enabled secondary output on the Digitizer > Secondary Channels configuration menu.

Stream environmental SOH

Select this option to stream environmental SOH data. Environmental SOH for the Centaur includes the following data:

- Voltages
- Temperature
- Sensor SOH
- External SOH
- Timing information

Stream system SOH

Select this option to stream system SOH data to a downstream network management or monitoring tool. System SOH for the Centaur includes the following data:

- Internal storage statistics
- Data acquisition statistics

Stream triggers/events

Select this option to stream triggers and events. For **trigger**[1] settings, see also Trigger Detectors and Trigger Input Filters. For **event**[2] settings, see "Events " on page 85.

Stream alerts

Select this option to stream alerts generated by the Centaur for events such as start-ups, shut downs, and major errors.

Alert messages include a time stamp and a brief description. These messages are also displayed on the Health page.

Stream raw data

Select this option to stream raw data that comes from an external source. The raw data is inserted into an NP packet and streamed in the NP format.

Raw TCP Receiving must be configured and enabled before you can stream raw data.

Channel list

After you have selected the type of data you want the Centaur to stream, you have the option to use a filter to specify exactly which channels the Centaur streams.

The filter is a comma-separated list of the SCNL (Station, Channel, Network, and Location) names of the channels you want streamed. The network, station, location, and channel codes used in the SCNL list are defined in the Channel Naming settings and in the location and channel code settings of the raw TCP receivers.

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[1] A message generated by the device when the STA/LTA ratio for a channel goes above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.

[2] Seismic activity that is detected and declared by the instrument using a voting system and threshold values or STA/LTA trigger algorithms.

You can use an asterisk (*) to represent one or more characters in a channel name and an exclamation point (!) to exclude a network, station, location, or channel. The exclamation point always has to be placed before the SCNL element that should be excluded.

The format for specifying SCNL elements in a filter is NN.SSSSS.LL.CCC, where NN is the network code, SSSSS is the station code, LL is the location code, and CCC is the channel code. The S, C, and N elements must be represented in the filter and each element must be separated by a dot (.). The L (Location) element is optional. The L (Location) element is optional. Therefore, if the location code is not being used, then the format should be NN.SSSSS.CCC

Examples:

a. Data is streamed for all of the channels in the XX network XX.*.*.*
b. Data is streamed for all of the Z channels in the XX network XX.*.*.*Z
c. Data is streamed for the specified channel XX.STN01.LO.HHZ
d. Data is not streamed for any of the channels in the XX network !XX.*.*.*
e. Data is streamed for all of the channels in the XX network and all of the channels from STN01 in the YY network XX.*.*.*,YY.STN01.*.*
f. All SOH data is streamed for the XX network (if all SOH channels are called SOH) XX.*.*.SOH

If you do not want to filter the data, type an asterisk (*) into the box. A single asterisk means that all available data will be streamed.

Destination

A valid unicast IP address of the streaming destination in dotted decimal format.
-OR-
For NP UDP data streaming only, a valid **multicast** [1] IP address.

Port number

The destination port number used by the Centaur to stream data in the NP format.

If you are streaming to Apollo Server, ensure that the Apollo Server UDP receiver is configured to listen to this port number.

[1]The first octet of a valid multicast IP address must be between 224 and 239, inclusive. Each of the last three octets can be any positive integer from 0 to 255.

ReTx strategy

Defines the manner in which requests to retransmit data are prioritized and processed.

- First-Come, First-Served – ReTx requests are processed in the order received.
- Oldest Data First, with Recent Data Threshold – ReTx requests are processed in chronological order based on the data time (oldest first) except for requests for data newer than the configured ReTx Recent Data Threshold, which are given highest priority.
- Disabled, discard request - instructs the Centaur to disregard all ReTx requests. ApolloServer will continue to request this missing data until its Store wraps and the missing data goes out of scope.
- Disabled, respond as not available - informs the Apollo Server that the Centaur no longer has the ReTx data, therefore Apollo Server will stop requesting the missing data. The data is still available in the Centaur Store and can be retrieved using either the Centaur Web interface or the FDSN dataselect API until it is eventually overwritten by newer data in the Centaur Store.

ReTx recent data threshold [min]

The time in which recent requests should be processed before the oldest requests are processed.

Configure this setting if you selected Oldest Data First, with Recent Data Threshold as the ReTx Strategy.

Multicast TTL (NP UDP streaming only)

If the streaming destination address is **multicast**[1], you can increase the Time-To-Live (**TTL**[2]) of the packets by specifying the number of networks (routers) that the packet must cross to reach the destination.

For example, if the packets have to cross five networks to reach the destination, you should set the Multicast TTL to 5.

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[1]The first octet of a valid multicast IP address must be between 224 and 239, inclusive. Each of the last three octets can be any positive integer from 0 to 255.

[2]Time-To-Live

All of the routers must support the Time-To-Live feature. In some cases, this feature might be disabled for security reasons (Denial-of-Service attack).

4.9.8 NP Throttle

If you have a low-throughput link, the throttle configuration settings allow you to configure the maximum data output of the streamer.

Enable throttle

Select this option to set the maximum data throughput of the NP streamer.

Maximum throughput [bps]

The maximum throughput in bits per second.

If you have enabled the Libra compatibility streaming option, configure the maximum throughput value to be 80 per cent of the Requested Throughput Value for the attached Cygnus. Refer to your Libra user guide for more information about Cygnus.

4.9.9 Fragmentation

This feature supports data paths with components that block packets larger than a particular threshold. For instance, if you are using a router that does not allow IP fragmentation, the fragmentation configuration settings allow you to configure the maximum packet size.

Enable fragmenting

Select this option to set the maximum allowable packet size. If enabled, packets larger than the configured threshold will be broken into smaller packets.

Fragment size [B]

The maximum packet size in bytes.

Include CRC

Select this option if you want a cyclic redundancy check performed on each fragment to verify that the data is not corrupted.

4.9.10 About QSCD20 data streaming

Quick Seismic Characteristic Data (**QSCD20®**[1]) streaming allows for the low latency calculation of ground motion data products at 1 second intervals derived from 20 sps data acquired from attached accelerometers, which is then automatically streamed to central facilities and includes the following features:

- QSCD20 is supported on 3-channel and 6-channel Centaur models.
- When QSCD20 data streaming is enabled, the data products are calculated at 1 second intervals from a dedicated 20 Hz digitizing sampling rate using a minimum phase decimation filter for the lowest latency. The resulting data products are expressed in units of acceleration (cm/s² or gal) and include:
    - Windowed Maximum, Minimum and Average (WMMA)
    - True Maximum, Minimum and Average (TMMA)
    - Maximum Value of each component (MEC)
    - Horizontal Peak Ground Acceleration (HPGA)
    - Total Peak Ground Acceleration (TPGA)
- The channel information is organized in the data packet by vertical (Z), North (Y), and East (X) directions respectively.
- QSCD20 streamed data products are identified by the SSSSS and LL components of the SCNL naming convention where SSSSS is the station code and LL is the location code, and by an orientation identifier designated as Z, N or E. Codes are based on SEED naming conventions.
- Sensor channels with the same station and location codes will be bundled together in a QSCD20 data packet.
- The QSCD20 data will contain zeros for the undefined components of uniaxial or biaxial sensors.
- QSCD20 streaming is supported when using any of Centaur's timing source configurations—GNSS, PTP, NTP and free-running. QSCD20 data packets are streamed once every second and

[1]Quick Seismic Characteristic Data (QSCD20®) from 20 sps data. QSCD20 is a region-specific streaming format. If your system requires QSCD20, contact customer support for more information.

are time-stamped with the time of the last sample considered for that data packet. Time-stamps are UTC-aligned.

- If timing uncertainty exceeds thresholds, such as if GPS signal is lost for an extended period, Centaur will continue to stream QSCD20 data, and the QSCD20 quality flag will identify the condition.

4.9.11 Configuring QSCD20 streaming

To enable **QSCD20®**[1] data streaming, configuration settings must be made to the **Sensor Library** page, the **Digitizer** page(s), and the **QSCD20 Streaming** page. Keep the following in mind:

- the connected sensors must be accelerometers, such as the Titan Accelerometer
- for a 2-component accelerometer, use channels 2 and 3 of the sensor connector
- for a 3-component accelerometer, use channels 2 and 3 for the horizontal components
- for either the 2-component or the 3-component accelerometer, both channels must be configured on the same sensor, for example Sensor A channel 2 and Sensor A channel 3 or Sensor B channel 2 and Sensor B channel 3
- for a 6-channel Centaur,
    - the <station>.<location> portion of the QSCD20 Channel codes for sensor A must be different from the <station>.<location> portion of the QSCD20 Channel codes for sensor B
    - the sensor A QSCD20 Channel codes are associated with Sensor A on the Sensor Library page and with the Digitizer A page. Similarly, the sensor B QSCD20 Channel codes are associated with Sensor B on the Sensor Library page and with the Digitizer B page

Proceed as follows to configure your Centaur for QSCD20 streaming:

1. Open the Configuration menu, navigate to the **Sensor Library** page and select the appropriate Titan sensor from the **Sensor** drop-down. To configure QSCD20 data streaming for an entire 6-channel Centaur, select a Titan sensor for **Sensor A** and **Sensor B**.

> QSCD20 streaming is only compatible with accelerometers. It cannot be enabled for other sensor types such as seismometers.

[1] Quick Seismic Characteristic Data (QSCD20®) from 20 sps data. QSCD20 is a region-specific streaming format. If your system requires QSCD20, contact customer support for more information.

2. To enable QSCD20 data streaming, navigate to the **Digitizer** page and select the **Enable continuous data products** check box. To configure QSCD20 data streaming for an entire 6-channel Centaur, enable continuous data products on the **Digitizer A** page and on the **Digitizer B** page.
3. To configure the Centaur to stream QSCD20 data, navigate to **Data Streaming > QSCD20 Streaming** and configure the following:
    a. Enter a **UDP source port** to specify where the QSCD20 originates.
    b. For each destination, enter a **QSCD20 destination**.
    c. To identify the sensor, navigate to the **QSCD20 Channel Codes** page and enter a code for each **Channel** in the format SSSSS.LL.<orientation> where SSSSS is the station code, LL is the optional location code, and <orientation> is the orientation identifier Z, N or E. NOTE: If a location code is not required, the 2 dots should separate the station code and orientation identifier. For example, SSSSS..<orientation>

    See QSCD20 Streaming Configuration Parameters for details.

4. Click **Apply** and **Commit** to save the configuration.
5. Click **Close** to close the configuration window and return to the main Centaur Web interface.

4.9.12 QSCD20 Streaming Configuration Parameters

A **QSCD20®**[1] data stream sends QSCD20 encoded packets to destination software capable of consuming QSCD20 data. The data is produced using the primary sample rate(s) of the digital recorder (s). This sample rate should be at least 100 sps for quality data. Data is streamed in one second packets with each packet timestamp containing the time of the last sample considered for that second of data. The timestamp is **UTC**[2] aligned.

QSCD20 is a region-specific streaming format. If your system requires QSCD20, contact customer support for more information.

[1]Quick Seismic Characteristic Data (QSCD20®) from 20 sps data. QSCD20 is a region-specific streaming format. If your system requires QSCD20, contact customer support for more information.
[2]Coordinated Universal Time

UDP source port

The port number on the streaming device used to stream QSCD20 data. The UDP source port is configurable to facilitate flexibility when passing packets through firewalls.

QSCD20 destination 1-5

Up to 5 destinations can be identified keeping in mind the following:

- The destination must include a valid unicast IP address in dotted decimal format, and the configured UDP source port. (For example, the syntax `<ip address>:<UDP source port number>` will result in a destination such as `10.14.2.20:9908`)
- The destination must have software that can read QSCD20 data.
- If the destination is entered incorrectly, an error message will be displayed.

QSCD20 Channel Codes, Channel *n*

The identifier for each sensor channel in the format SSSSS.LL.<orientation> where SSSSS is the station code, LL is the optional location code, and <orientation> is the orientation identifier Z, N or E.

- The station code, which identifies the seismic station, can be from 1 to 5 alphanumeric characters in length.
- The location code, which identifies the time series location of the Centaur, is optional and can be 1 or 2 alphanumeric characters.
- <orientation> is the orientation identifier Z, N or E.
- For each segment of the code, the alpha characters must be upper case and special characters are not valid.
- A dot must separate each segment of the code, for example SSSSS.LL.<orientation>
- If a location code is not required, the 2 dots should separate the station code and orientation identifier, for example, SSSSS..<orientation>
- For a 6-channel Centaur, enter a QSCD20 Channel code for each sensor channel. In this case the <station>.<location> portion of the QSCD20 Channel codes for sensor A must be different from the <station>.<location> portion of the QSCD20 Channel codes for sensor B.

4.10 Digitizer

The Centaur Digitizer has three or six time series data channels that are constantly digitizing data. The data from each of these channels is recorded and always written to the Primary Internal Storage, and is optionally written to the hot-swappable external SD memory card and/or streamed to central data repositories.

The settings for Digitizer A are for Sensor A, channels 1 to 3. The settings for Digitizer B are for Sensor B, channels 4 to 6.

You can capture data at two concurrent sample rates by enabling secondary output, and setting different sample rates on your primary and secondary channels. For example, you may wish to continually stream your data at a lower sample rate on primary channels and archive data to an external SD card at a higher sample rate on secondary channels.

You can also configure general settings for the Centaur Digitizer such as frames per packet on primary and secondary channels, as well as front end, input filter, and detector configuration settings.

See Maximum Archiving and Streaming Rates for further guidance on setting sample rates.

Enable continuous data products

Select this option to enable the streaming of continuous data products such as QSCD20 data (see also QSCD20 Streaming), and to summarize triggered events.

4.10.1 Maximum Archiving and Streaming Rates

The Centaur supports a maximum “aggregate sample rate” of 5010 Hz. This aggregate rate is the sum of the sample rates of the primary and secondary channels from all sensors, and can involve a combination of streaming and SD archiving.

If a SeedLink Server has been created, the supported maximum "aggregate sample rate" is reduced to 510 Hz. Exceeding this maximum "aggregate sample rate", whether the SeedLink server is enabled or disabled, may cause the Centaur to become overburdened, potentially resulting in waveform gaps.

For CTR4-3A, CTR4-6A/S and CTR4-6AS/H, when Authenticating is enabled, the supported maximum "aggregate sample rate" is 500 Hz. This aggregate rate can involve a combination of streaming over CD-1.1 and NP protocol as well as MiniSEED SD archiving. Note that SeedLink streaming is not supported when Authentication is enabled.

Examples:

- a Centaur with a sample rate of 5000 Hz archiving the primary channels and 10 Hz streaming the secondary channels has an aggregate rate of 5010 Hz and is supported.
- a Centaur with a primary rate of 100 sps that is being archived and also streamed simultaneously to two destinations has an aggregate rate of 300 sps and is supported.
- a Centaur with a sample rate of 500 Hz can have a SeedLink server configured.
- a 6-channel Centaur with Sensor A inputs sampled at 500 Hz and Sensor B inputs sampled at 50 Hz cannot have a SeedLink server configured.
- a 6-channel Centaur with both Sensor A and Sensor B inputs sampled at 2000 Hz and both secondary channels sampling at 1000 Hz has an aggregate rate of 6000 Hz and is not supported.
- a 3-channel authenticating Centaur (model CTR4-3A) with a sample rate of 10 Hz streaming CD-1.1 on the primary channels and 500 Hz MiniSEED archiving using the secondary channels has an aggregate rate of 510 Hz and is not supported.
- a 3-channel authenticating Centaur (model CTR4-3A) with a primary rate of 100 sps that is being archived and also streamed simultaneously through CD-1.1 and NP has an aggregate rate of 300 Hz and is supported.
- a 6-channel authenticating Centaur (model CTR4-6A/S or CTR4-6AS/H) with a primary rate on Sensor A of 100 sps streaming CD-1.1 with MiniSEED archiving, and a primary rate on Sensor B of 100 sps and NP streaming with MiniSEED archiving, has an aggregate rate of 400 Hz and is supported.

At higher sample rates, a larger frames per packet setting may be required. The Web Interface will indicate if the frames per packet setting is too low for a particular sample rate.

See Primary Channels and Secondary Channels for details on configuring your data channels. See Data Streaming for details on configuring data streaming.

4.10.2 Front End — Input range

The input voltage ranges represent the differential between the sensor positive and negative signal inputs in volts peak-to-peak. The maximum input range is 40 volts peak-to-peak. This represents the case of a differential input signal that at one peak has +10 V on the positive input and –10 V on the negative input (20 V peak). At the other peak, the differential input is –20 V for a peak-to-peak input

range of 40 V. The input range to Digitizer sensitivity mappings are provided in the **Digitizer Performance** section of the specifications.

- If you want to measure full-scale sensor activity, the input range of the digital recorder must be greater than or equal to the maximum output level of the sensor.
- If you want to measure very weak signals, you may wish to configure the input range of the digitizer to a lower level. This lowers the self-noise of the digitizer but also reduces the digitizer clip level. If strong events occur that exceed the configured range, these signals will be clipped.

Sensitivity for high-gain channels

Centaur models CTR4-3H, CTR4-6H, CTR4-6S/H and CTR4-6AS/H feature high-gain channel sets that provide a sensitivity that is 4 times higher than standard-gain channels and high-impedance inputs (1.7 MΩ) that are suitable for passive sensors. (Earlier high gain models also exist.)

Input range

To configure the input voltage range, from the drop-down list, select the differential range, peak-to-peak, based on standard or high gain channel connection to the sensor. For example, if you want an input range of 10 Vpp on a high gain channel, select 40 Vpp (standard gain) or 10 Vpp (high gain).

Refer to the " Data" section on the **Health** page to determine whether the channel pre-amp is high gain or standard gain. The **Input range** field will display the configured input voltage range.

Newly manufactured Centaur models that support high gain channels will ship with these features. For existing high gain Centaur models shipped prior to the release of version 4.6, contact Nanometrics for assistance with upgrading the firmware.

4.10.3 About Orientation correction

The Orientation Correction feature allows you to perform field data rotation to correct the sensor orientation for instances where the physical orientation of a deployed three-component geophysical sensor is different than what is desired, resulting in output X, Y and Z signals that do not represent the desired directions of sensitivity (typically East, North and Vertical). This feature can be used for the deployment of sensors such as a Trillium seismometer or a Titan accelerometer. For each sensor port, the **Health** page displays whether orientation correction is enabled or disabled.

Some typical examples where you would use the orientation correction option are described below.

Borehole azimuth correction

If a seismometer has been installed in a deep borehole, often there is no method for physically turning the seismometer to sit in the desired direction, for example X direction pointing East. The orientation correction feature allows you to correct the alignment of the seismometer by determining the degree of misalignment and then entering the azimuth correction using the Orientation Correction feature. Once these values are applied, the Centaur will perform a real-time re-orientation of the XYZ data to align with the configured angular rotation parameters. The resulting new X'Y'Z' output data will be as if the sensor had initially been physically oriented as desired.

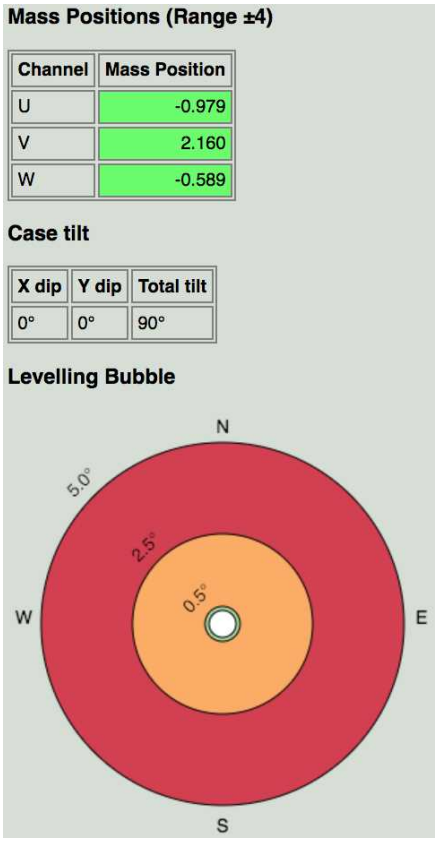
Determine the degree of misalignment using a method such as:

- **Surface seismometer referencing.** This method involves collecting a seismic data set from the downhole seismometer and a surface seismometer located at the wellhead. The downhole data set is correlated with the surface data set to determine the offset from north.
- **Rifle scope alignment.** This method involves mounting a rifle scope vertically pointing down the borehole. The rifle scope cross hair is focused on the north–south marking on the seismometer downhole. A reading of the rifle scope rotation relative to north is taken.

Sensor tilt correction

A sensor may be positioned so that its Z component is not actually vertical. For seismometers, this is necessarily constrained to be less than 1.5° to 2° for 120s instruments, but could be as much as 10° for Trillium Compact 20s models. This instrument tilt can be read using a virtual bubble level that is accessible from the seismometer Web Interface. For Titan accelerometers, this could be any angle as the accelerometer is capable of operating in any orientation (taking care that the operating range is selected so that a tilted or inverted sensor does not saturate). The angle of the X and Y axes relative to horizontal provide the measure of verticality: if the X/Y tilt angles are zero, Z is true vertical. The orientation correction feature allows the user to enter the X and Y tilt angles in degrees into the Centaur digital recorder Web Interface. The Centaur will rotate the data so that the new X' and Y' outputs have 0 tilt, which will bring Z' to true vertical.

Virtual bubble level for Sensor tilt correction



Vertical Titan output remapping

The vertical Titan model mounts on a vertical wall with the connector pointing downwards. This usually requires a unique cable to remap the Y output data (which is now vertical) to Z and vice-versa. The orientation correction feature allows you to use a standard cable and 90° clockwise rotation around the X axis to remap the output data.

Vertical Titan azimuth correction

A vertical Titan mounted to a wall cannot be readily oriented so that its X axis points East, unlike a horizontally mounted Titan that can simply be physically rotated about its mounting bolt. You can use the orientation correction feature to rotate the data about the Z axis to bring the X axis to true East.

4.10.4 Orientation Correction Configuration Parameters

This section describes the available parameters for configuring orientation correction. You can access these parameters by selecting **Digitizer**, then **Orientation Correction** in the Configuration menu.

Enable orientation correction

Select this check box to enable the orientation correction feature and view waveform data based on the values entered on this configuration page.

If you de-select the check box, any values entered on this page will be preserved, but ignored.

Sensor X-dip [deg]

Enter the required value (in degrees) to correct the downwards tilt angle of the sensor along the positive X axis. This value can be copied directly from the sensor Web Interface if available.

If no correction is required, enter 0.

Sensor Y-dip [deg]

Enter the required value (in degrees) to correct the downwards tilt angle of the sensor along the positive Y axis. This value can be copied directly from the sensor Web Interface if available.

If no correction is required, enter 0.

First, Second, or Third rotation axis

Select the rotation axis from the drop-down menu.

First, Second or Third rotation angle [deg]

Enter the rotation angle that is required to correct the orientation in a counter-clockwise direction. These rotations are performed sequentially after the Sensor X-dip and Sensor Y-dip tilt corrections.

For each rotation angle, if no correction is required, enter 0.

If you specify multiple rotations, each rotation is done in sequence and with reference to the result of the previous rotation. For example, if you first correct for a sensor tilted downward in the Y direction by 6 degrees, and then correct for azimuth by rotating 30 degrees counter-clockwise about

the Z- axis, the resulting Z-axis is with reference to the tilt-corrected reference frame, not the physical Z-axis of the tilted sensor. Likewise, the axis selected for each subsequent rotation is with respect to the new reference frame defined by the previous rotation.

4.10.5 Primary Channels

You can configure your sampling rate and set your frames per packet for your primary data channels.

If you are using a six-channel Centaur, you will need to configure your primary channel settings for both Digitizer A and Digitizer B.

See Maximum Archiving and Streaming Rates for further guidance on setting sample rates.

Primary output type *n*

Use this option to apply an anti-aliasing filter to decimate digitized data to the desired sample rate. Select the filter type from the drop-down list:

- **Linear phase** (also known as non-causal or acausal). Select this output type to enable a high-performance anti-aliasing filter with the flattest passband, most attenuated stopband, and no phase distortion.
- **Minimum phase** (also known as causal). Select this output type to significantly reduce signal delay (latency) of the anti-aliasing filters. Note that this output type has a somewhat reduced stopband attenuation performance than Linear phase. Its delay is frequency-dependent (not linear phase).
- **Disabled**. Select this option to turn off the output from this channel set.

The default output type is **Linear phase**. See "Decimation Anti-aliasing Filters" on page 197 in the Specifications section for more details.

1. The sample rates 80 Hz and 2000 Hz are not supported for **Minimum phase** filter types.
2. You can configure different output types for Primary channels and Secondary channels.

Primary sample rate *n* [Hz]

The number of samples per second produced from each analog sensor input signal. The default is 100 Hz (100 samples per second).

Primary sample encoding

Select the sample encoding for this channel group. The default is **Steim1**, which uses the algorithm described in the SEED reference manual. Select **Uncompressed, Steim1 format** to generate fixed duration packets and to reduce latency. Uncompressed, Steim1 format uses Steim1 format with fixed 4-byte differences, which disables compression.

Primary frames per packet *n*

The number of standard Steim data frames per packet for transmission and storage of the primary time series data. Smaller packets reduce the streaming latency, but will greatly increase the requirements for streaming throughput and data storage.

Primary bit depth

For Centaur CTR4 series models, you can increase the bit depth from the default 24 bits to up to 31 bits to provide additional bits of precision in the sensor time series output data.

To use this option, from the drop-down list, select the number of bits in the output data that is most appropriate for your application. Note that for each increment in bit depth digitizer sensitivity is doubled, data compression is reduced, and data volume is increased. The default setting is 24 bits.

Examples of bit depth usage:

- At a bit depth of 24 bits and a sample rate of 100 sps 24 bits, the Centaur self-noise is less than 1 count RMS.
- At lower sample rates, the self-noise decreases where useful signal information for very quiet signals can be masked by quantization noise.
- A bit depth of 28 might be preferred for samples rates of 10 sps or lower.
- The default bit depth is 24 bits, which is usually optimal for sample rates of 100 sps or higher since a greater bit depth increases the volume of data produced.

The selected bit depth will be reflected in the RESP, dataless SEED, and StationXML.

Primary digital gain

Enter a number between -100 and +100 with up to 3 decimal points of precision to specify the multiplication factor to be applied to the time series data keeping the following in mind:

- to attenuate the signal enter a value between 0.001 and 0.999
- to amplify the signal enter a value between 1.001 and 100
- to invert the signal enter a negative value

The default is 1.0 (no gain).

For example, if a specific site has a combined accelerometer + Centaur sensitivity of 0.8 counts/(nm/s²) and you want the stations in the network to have a sensitivity of 1 count/(nm/s²) you can set the digital gain in the Centaur to 1.25 to achieve the desired sensitivity.

The selected digital gain will be reflected in the RESP, dataless SEED, and StationXML.

Other Considerations or Limitations

- The effects of increasing the bit depth and changing the digital gain are cumulative; there is no check for too much total gain. For example, selecting a bit depth of 31 and a gain of 2 will cause outputs to clip for any signal that exceeds half the analog input range of the Centaur.
- To ensure that the data samples can be Steim1 encoded, all samples are automatically clipped at $\pm 2^{30}$ counts or more specifically the inclusive range [-1073741824 .. +1073741823]. The instrument will not provide an error message if the data is clipped.

4.10.6 Secondary Channels

If you want to capture data at two concurrent sample rates, you must enable the *Secondary output type*. You can also configure other signal processing settings for your secondary channels such as linear or minimum phase anti-aliasing filter type, or applying bandpass filtering.

If you are using a six-channel Centaur, you might want to configure secondary channel settings for both Digitizer A and Digitizer B.

See Maximum Archiving and Streaming Rates for further guidance on setting sample rates.

Secondary output type *n*

Use this option to apply an anti-aliasing filter to decimate digitized data to the desired sample rate. Select the filter type from the drop-down list. See "Primary output type n" on page 76 for options and details.

The default output type is **Disabled**.

You can configure different output types for Primary channels and Secondary channels.

Secondary sample encoding

Select the sample encoding for this channel group. The default is **Steim1**, which uses the algorithm described in the SEED reference manual. Select **Uncompressed, Steim1 format** to generate fixed duration packets and to reduce latency. Uncompressed, Steim1 format uses Steim1 format with fixed 4-byte differences, which disables compression.

Secondary sample rate *n* [Hz]

The number of samples per second produced from each analog sensor input signal. The default is 100 Hz (100 samples per second).

Secondary frames per packet *n*

The number of standard Steim data frames per packet for transmission and storage of the primary time series data. Smaller packets reduce the streaming latency, but will greatly increase the requirements for streaming throughput and data storage.

Secondary bit depth

For Centaur CTR4 series models, you can increase the bit depth from the default 24 bits to up to 31 bits to provide additional bits of precision in the sensor time series output data.

To use this option, from the drop-down list, select the number of bits in the output data that is most appropriate for your application. Note that for each increment in bit depth digitizer sensitivity is doubled, data compression is reduced, and data volume is increased. The default setting is 24 bits.

Examples of bit depth usage:

- At a bit depth of 24 bits and a sample rate of 100 sps 24 bits, the Centaur self-noise is less than 1 count RMS.
- At lower sample rates, the self-noise decreases where useful signal information for very quiet signals can be masked by quantization noise.
- A bit depth of 28 might be preferred for samples rates of 10 sps or lower.

- The default bit depth is 24 bits, which is usually optimal for sample rates of 100 sps or higher since a greater bit depth increases the volume of data produced.

The selected bit depth will be reflected in the RESP, dataless SEED, and StationXML.

Secondary digital gain

Enter a number between -100 and +100 with up to 3 decimal points of precision to specify the multiplication factor to be applied to the time series data keeping the following in mind:

- to attenuate the signal enter a value between 0.001 and 0.999
- to amplify the signal enter a value between 1.001 and 100
- to invert the signal enter a negative value

The default is 1.0 (no gain).

For example, if a specific site has a combined accelerometer + Centaur sensitivity of 0.8 counts/(nm/s^2) and you want the stations in the network to have a sensitivity of 1 count/(nm/s^2) you can set the digital gain in the Centaur to 1.25 to achieve the desired sensitivity.

The selected digital gain will be reflected in the RESP, dataless SEED, and StationXML.

Other Considerations or Limitations

- The effects of increasing the bit depth and changing the digital gain are cumulative; there is no check for too much total gain. For example, selecting a bit depth of 31 and a gain of 2 will cause outputs to clip for any signal that exceeds half the analog input range of the Centaur.
- To ensure that the data samples can be Steim1 encoded, all samples are automatically clipped at ± 2^{30} counts or more specifically the inclusive range [-1073741824 .. +1073741823]. The instrument will not provide an error message if the data is clipped.

4.10.7 Single channel devices and Centaur

Certain geophysical sensors such as a microbarometer are single channel devices, however the Centaur sensor infrastructure is grouped in 3-channel sets. To that end, once the single channel device is configured as the sensor, the Centaur applies the same settings to all of its channels. You can connect up to three single channel devices such as the microbarometer to one Centaur sensor port using an appropriate fan-out cable. This is useful for applications such as coherence testing or beamforming arrays. For cases where a single microbarometer is connected to the Centaur, the two

open channels will be digitized along with the desired microbarometer channel, but will of course have only noise. You can avoid streaming and/or archiving of any unused channels as desired.

4.10.8 Bandpass Butterworth Filters

This section describes the available parameters for configuring bandpass filters. You can access these parameters by selecting **Digitizer** then **Primary Channels > Primary Bandpass Filter** or **Secondary Channels > Secondary Bandpass Filter** in the Configuration menu.

High pass order

The order of the high pass filter applied to output data. The sum of the high and low pass orders must not exceed 5. Order of zero means no high pass filter is applied.

High pass frequency [Hz]

The 3 dB corner frequency of the selected high pass filter. The ratio of this corner frequency to the sample rate must be between 0.000001 and 0.499999.

Low pass order

The order of the low pass filter applied to output data. The sum of the high and low pass orders must not exceed 5. Order of zero means no low pass filter is applied.

Low pass frequency [Hz]

The 3 dB corner frequency of the selected low pass filter. The ratio of this corner frequency to the sample rate must be between 0.000001 and 0.499999.

4.10.9 Trigger Input Filters

The trigger input filter is a common band pass filter applied to the channel data prior to being processed by the **trigger**[1] **detectors**[2].

[1]A message generated by the device when the STA/LTA ratio for a channel goes above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.
[2]Algorithms applied to channels and used to declare seismic signals of interest

Trigger high pass order

The order of the high pass trigger filter.

Trigger high pass frequency [Hz]

The 3 dB corner frequency, in hertz, of the high pass trigger filter.

Trigger low pass order

The order of the low pass trigger filter.

Trigger low pass frequency [Hz]

The 3 dB corner frequency, in hertz, of the low pass trigger filter.

4.10.10 Trigger Detectors

The Centaur uses detectors combined with a voting system to declare an event. A detector is an algorithm that is applied to a channel and is based on either a configured threshold value or a configured **STA**[1]/LTA ratio. As soon as the channel detector detects that the threshold value or STA/LTA ratio has been exceeded, it generates a **trigger**[2] for that channel. When the Centaur sees this trigger, it counts how many **votes**[3] are assigned to the channel that generated that trigger:

- If the number of votes are equal to or higher than the configured number of required votes, an event is declared with the date and time from the trigger.
- If not enough votes were received from the trigger, then the Centaur waits for additional triggers for a configured period of time to allow for transmission latency.

---

[1] Short Term Average

[2] A message generated by the device when the STA/LTA ratio for a channel goes above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.

[3] The number of votes assigned to each channel that it can cast towards getting an event declared. The higher the number of votes, the greater the impact that the channel has on event declaration. To ensure proper event declaration, you should give zero votes to a channel that you do not want to affect the event declaration at all and a lower number of votes to channels at noisy stations.

- If not enough votes are received within the configured period of time, the triggers are discarded and no event is declared.
- If enough votes are received, an event is declared and written to the internal storage and posted on the **Events** page.

Event declaration can happen locally using only the channels of the Centaur or it can happen across a network between multiple devices if you enable the option to share triggers across a network.

Type *n*

Select the type of detector for the channel.

Votes *n*

The number of votes assigned to each channel that it can cast towards getting an event declared.

The higher the number of votes, the greater the impact that the channel has on event declaration. To ensure proper event declaration, you should give zero votes to a channel that you do not want to affect the event declaration at all and a lower number of votes to channels at noisy stations.

Trigger threshold *n* [counts]

The value that must be exceeded for the channel detector to generate a trigger for that channel.

Configure this setting if the selected detector type is **Threshold**.

Threshold hold off *n* [s]

The amount of time after a threshold has been exceeded that the channel detector will wait before it generates a trigger for that channel.

This setting can be used to ensure that multiple triggers are not generated if a threshold is exceeded several times in a very short period of time. Multiple triggers could result in the declaration of multiple events when really it is only one event.

Configure this setting if the selected detector type is **Threshold**.

STA time constant *n* [s]

The short term average time constant in seconds.

The time constant τ is related to the cutoff frequency f_c by $\tau = 1/(2\pi f_c)$.

Choose a value longer than a few periods of a typical expected seismic signal of interest, shorter than expected durations of events of interest, and not so short that excessive false triggers are generated by non-seismic noise spikes near the site.

Configure this setting if the selected detector type is **STA/LTA ratio**.

LTA time constant *n* [s]

The long term average time constant in seconds.

The time constant τ is related to the cutoff frequency f_c by $\tau = 1/(2\pi f_c)$.

Choose a value long enough to encompass at least several cycles of typical non-seismic, irregular noise for the site.

Configure this setting if the selected detector type is **STA/LTA ratio**.

Trigger on ratio *n*

The STA/LTA ratio above which the associated channel is triggered.

Choose a value low enough to be sensitive to events of interest but high enough to minimize false triggers.

Configure this setting if the selected detector type is **STA/LTA ratio**.

Trigger off ratio *n*

The STA/LTA ratio below which the associated channel trigger ends.

Latch LTA *n*

If you select this option, the LTA is held at the value when the channel triggered and is not updated while the channel is triggered.

If you do not select this option, the LTA continues to be calculated and updated while the channel is triggered.

In both cases, the trigger terminates either when the trigger off ratio is achieved or once the **Maximum duration** has expired.

Configure this setting if the selected detector type is **STA/LTA ratio**.

Maximum duration *n* [s]

The maximum duration of a trigger in seconds.

After this time period has expired, the trigger is ended even if the **Trigger off ratio** has not been achieved.

4.11 Events

The Centaur uses detectors combined with a voting system to declare an event. A detector is an algorithm that is applied to a channel and is based on either a configured threshold value or a configured **STA**[1]/LTA ratio. As soon as the channel detector detects that the threshold value or STA/LTA ratio has been exceeded, it generates a **trigger**[2] for that channel. When the Centaur sees this trigger, it counts how many **votes**[3] are assigned to the channel that generated that trigger. If the number of votes are equal to or higher than the configured number of required votes, an event is declared with the date and time of the trigger. If not enough votes were received from the trigger, then

[1]Short Term Average

[2]A message generated by the device when the STA/LTA ratio for a channel goes above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.

[3]The number of votes assigned to each channel that it can cast towards getting an event declared. The higher the number of votes, the greater the impact that the channel has on event declaration. To ensure proper event declaration, you should give zero votes to a channel that you do not want to affect the event declaration at all and a lower number of votes to channels at noisy stations.

the Centaur waits for additional triggers for a configured period of time to allow for transmission latency. If not enough votes are received within the configured period of time, the triggers are discarded and no event is declared. If enough votes are received, an event is declared and written to the internal storage and posted on the **Events** page.

Event declaration can happen locally using only the channels of the Centaur or it can happen across a network between multiple devices if you enable the option to share triggers across a network.

Coincidence window [s]

The window of time into which the trigger on times of the channels must fall in order for those channels to be included in the same event.

Required votes

The minimum number of votes required for the Centaur to declare a group of triggers as an event.

Maximum event duration [s]

The amount of time, in seconds, that the Centaur waits to see if the minimum number of required votes is met for event declaration. This wait time allows for transmission latency and any other delays that might occur.

The maximum event duration time should always be longer than the coincidence window duration.

Pre-event time [s]

The number of seconds of data archived before the event declaration time.

Post-event time [s]

The number of seconds of data archived after the event declaration time.

4.11.1 Events Data Archive

The Centaur Events Data Archive feature allows you to archive **event**[1] data and SOH data (optional) to a removable external SD card. The event data can be archived in multiple industry-standard formats. Using the MiniSEED output file, Archive channel list and SOH archive format filters you can specify the information to be archived. Additionally you can specify archive file names using the Archive filename pattern option for MiniSEED data, and the SOH archive filename pattern option for SOH data.

Before you enable this feature, make sure that you have inserted an SD card (formatted as FAT32) into the external SD card slot behind the media bay door of the Centaur.

> In addition to archiving event data to a removable external SD card, you can also manually declare an event on the **Events** page.

Enable events data archive

Select this check box to allow the Centaur to write event data to the external SD card. Each event data file is stored in a folder named for the day the event was recorded.

The folder location is **events/YYYY/MM/DD**.

You can specify what data to include in a file using the MiniSEED output files and Archive channel list options. See Archive filename pattern for configuration guidelines.

> If the **per channel** option is selected for the MiniSEED output files setting, then the channel name is also added to the name of the event data file before the YYYYMMDD_HHMMSS.

MiniSEED output files

Select the number of output files to be generated for each archive period: one file per channel or one file for all instruments.

The **per channel** option produces many small files, the **per station** option produces one large file.

[1] Seismic activity that is detected and declared by the instrument using a voting system and threshold values or STA/LTA trigger algorithms.

Format

Select the desired file format from the drop-down list to archive event data in that format. If the selected format is something other than MiniSEED, one archive file per channel will be created.

Archive channel list

This field allows you to create a filter to select which data to archive, by channel, using the SCNL (Station, Channel, Network, and Location) naming convention. Before you can filter the data, you need to configure the network, station, location, and channel codes. See the configuration setting guidelines for Channel Naming and raw TCP receivers Location and channel code.

The format for specifying SCNL elements in a filter is NN.SSSSS.LL.CCC, where NN is the network code, SSSSS is the station code, LL is the location code, and CCC is the channel code. The S, C, and N elements must be represented in the filter and each element must be separated by a dot (.). The L (Location) element is optional. Therefore, if the location code is not being used, then the format should be NN.SSSSS.CCC

Tips for creating filters

- use an asterisk (*) to represent one or more characters in a channel naming element. To include all available data, type an asterisk (*) in the **Archive channel list** field with no other characters.
- use an exclamation point (!) to exclude a network, station, location, or channel. The exclamation point always has to be placed before the SCNL element that should be excluded.

Examples:

a. For the channel list filter `XX.*.*.*`, data is archived for all of the channels in the XX network.
b. For the channel list filter `XX.*.*.*Z`, data is archived for all of the Z channels in the XX network.
c. A filter can be created for a specific channel. For example, for the channel list filter `XX.STN01.LO.HHZ`, data is archived for the specified channel.
d. For the channel list filter `!XX.*.*.*`, data is not archived for any of the channels in the XX network.
e. For the channel list filter `XX.*.*.*,YY.STN01.*.*`, data is archived for all of the channels in the XX network and all of the channels from STN01 in the YY network.

Archive filename pattern

Use this field to configure the pattern for naming the archived MiniSEED files. For example, based on the filename pattern `${N}.${S}.${L}.${C}_${ID}_${TIME}.miniseed`, an archived MiniSEED file may have the name XX.STN01.LO.HHZ_centaur-6_0345_20130912_073356.miniseed

Define date and time. To define the date and time you can use any of the following naming patterns in place of the default pattern `${TIME}`:

- `${Y}${M}${D}_${h}${m}${s}`
- `${Y}.${M}.${D}-${h}.${m}.${s}`
- `${Y}${J}_${h}${m}${s}`

Configure filename extension. The default filename pattern includes the extension `.miniseed`. To configure the filename extension to something other than the default you can

- replace the extension with something else. For example, replacing the extension name with **data** will give you the following pattern: `${N}.${S}.${L}.${C}_${ID}_${TIME}.data`
- remove the extension altogether. The resulting pattern will be `${N}.${S}.${L}.${C}_${ID}_${TIME}`

Configuration limitations. Keep in mind the following limitations when configuring the Archive filename pattern:

- If the MiniSEED output files option is set to **Per channel** you must include `${C}` in the pattern string.
- If the MiniSEED output files option is set to **Per station**
  - you must include `${S}` in the pattern string.
  - you must exclude `${C}` and `${L}` from the pattern string.
- Do not add dots (.) before or after a slash.
- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#`.

See Archive pattern naming parameters for more parameter descriptions.

Include SOH archive

Select this check box if you want to archive SOH data files to the external SD card.

The SOH data files are separate files and they are stored in a folder called **soh**. The location of this folder is **YYYY/MM/DD/soh**.

SOH archive format

If **Include SOH archive** is checked, select the format for archiving the SOH files.

Archiving SOH data in the CSV format is time consuming and might impact the performance of the device.

SOH archive filename pattern

Use this field to configure the pattern for naming the archived SOH files. For example, based on the filename pattern `${N}.${S}.${L}.${C}_${ID}_${TIME}.miniseed`, an archived SOH file may have the name XX.STN01.LO.HHZ_centaur-6_0345_20130912_073356.miniseed

Define date and time. To define the date and time you can use any of the following naming patterns in place of the default pattern `${TIME}`:

- `${Y}${M}${D}_${h}${m}${s}`
- `${Y}.${M}.${D}-${h}.${m}.${s}`
- `${Y}${J}_${h}${m}${s}`

Configure filename extension. The default filename pattern includes the extension `.miniseed` To configure the filename extension to something other than the default you can

- replace the extension with something else. For example, replacing the extension name with **data** will give you the following pattern: `${N}.${S}.${L}.${C}_${ID}_${TIME}.data`
- remove the extension altogether. The resulting pattern will be `${N}.${S}.${L}.${C}_${ID}_${TIME}`

Configuration limitations. Keep in mind the following limitations when configuring the SOH archive filename pattern:

- If the selected **SOH archive format** is CSV, the user-configured channel name defined by `${C}` will be replaced with a hard-coded name, for example `environmental`.

- For MiniSEED format, you can configure ${L} and ${C} using the **SOH Code** field on the Channel Naming page. If configured, the value in the SOH code field will replace the ${L} and ${C} parameter values in the SOH archive filename pattern.
- If the selected **SOH archive format** is MiniSEED, all SOH channels are included in one file, per period.
- Do not add dots (.) before or after a slash.
- A space can be used if it is not followed by a slash or if it is not at the end of the configuration string. For example, where # represents a space `/#a/` is a valid configuration, the following are not valid configurations `/#/`, and `/a#/b#`.

See Archive pattern naming parameters for more parameter descriptions.

Archive pattern naming parameters

The following parameters can be used when configuring filename or directory patterns.

- ${N} is the network name
- ${S} is the station name
- ${L} is the location name
- ${C} is the channel name
- ${ID} is the instrument ID
- ${TIME} is the start time for the data archive in YYYYMMDD_hhmmss format
- ${Y} is 4-digit year
- ${M} is 2-digit month
- ${D} is 2-digit day of the month
- ${J} is Julian day (day of the year)
- ${h} is 2-digit hour of the day
- ${m} is 2-digit minutes of the hour
- ${s} is 2-digit seconds of the minute

4.11.2 Trigger/Event Sharing

The Centaur has the ability to send and receive **triggers**[1] and **events**[2] and from other devices via a multicast **UDP**[3]. The **votes**[4] associated with triggers received from other devices are used in the event detection and declaration process and the events received from other devices are displayed and downloadable on the **Events** page of the local device.

Share triggers

Select this option to enable trigger sharing.

If you enable this option, event declaration will happen both locally, using only the three channels of the local device, and across all of the devices in your network.

Share events

Select this option to enable events sharing.

If you enable this option, you can view and download the events received from other devices on the **Events** page of this device.

Multicast group

A valid multicast IP address.

All devices that share triggers and/or events have to use the same multicast IP address and port number.

[1]Messages generated by the instrument when the STA/LTA ratio for one or more channels go above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.
[2]Seismic activity that is detected and declared by the instrument using a voting system and threshold values or STA/LTA trigger algorithms.
[3]User Datagram Protocol
[4]The number of votes assigned to each channel that it can cast towards getting an event declared. The higher the number of votes, the greater the impact that the channel has on event declaration. To ensure proper event declaration, you should give zero votes to a channel that you do not want to affect the event declaration at all and a lower number of votes to channels at noisy stations.

Port number

The port number used by the Centaur to share triggers and/or events with other devices (send and receive)

> All devices that share triggers and/or events have to use the same multicast IP address and port number.

Multicast TTL

You can increase the Time-To-Live (TTL) of the trigger data packets by specifying the number of networks (routers) that the trigger data packets must cross to reach their destination.

For example, if the trigger data packets have to cross five networks to reach their destination, you should set the Multicast TTL to 5.

4.11.3 Event Data Products

You can configure the Centaur to calculate peak ground motion data products for any connected and configured accelerometer sensors When this feature is enabled, the Centaur calculates the **PGA**[1], **PGV**[2], and **PGD**[3] values for each declared event, writes the calculated values to the **internal storage**[4] with the event, and posts them on the **Events** page.

> The PGA reported by the Centaur is based on measurements of the acceleration in the two horizontal directions (north-south and east-west).

Enable events data products

Select this check box to allow the Centaur to calculate peak ground motion data products for each event.

---

[1]Peak Ground Acceleration

[2]Peak Ground Velocity

[3]Peak Ground Displacement

[4]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

You can view the calculated PGA, PGV, and PGD values on the Events page.

Source sensor port

Select the sensor port used to calculate the data products.

This option is only applicable to a Centaur with 6 channels (two sensor ports).

Source digitizer channels

Select the channels used to calculate the data products.

4.11.4 Configure Email Notifications for Declared Events

Centaur ships with three configuration template files that can be used to configure the automatic sending of email notifications when events are declared and completed. Once these files have been configured, two emails are sent automatically for each event. The first email is sent as soon as the event is declared and the second email is sent when the event has completed. The emails are sent to the email addresses specified in the configuration files.

The **SMTP**[1] client used by Centaur does not support the OAuth2.0 authorization protocol. Ensure that OAuth2.0 security measures are disabled on the account used as the destination email address.

Sample email

Example email subject line: NX.PVEA1 Event 2013-05-10T18:09:19.015Z
Example email body:
Event complete 2013-05-10T18:09:19.015Z (centaur-6_0104)
Maximum PGA 1.40693125E-1 g @ NX.PVEA1 (centaur-6_0104)

If Ethernet Mode is set to Static IP, email notifications require a Primary DNS to be configured.

[1] Simple Mail Transfer Protocol

See event detection and declaration for more information. You can also access the help by clicking **Help** in the upper-left corner of the Centaur web interface.

To configure the automatic sending of email notifications

1. Use the following commands to copy the three configuration template files that shipped with Centaur to /etc/nanometrics/config and remove the suffix (.template) from the copy:

   ```
   cp /usr/share/nanometrics/event-email/conf/event-email.conf.template
   /etc/nanometrics/config/event-email.conf

   cp /usr/share/nanometrics/event-email/conf/event-declared-
   email.conf.template /etc/nanometrics/config/event-declared-email.conf

   cp /usr/share/nanometrics/event-email/conf/event-complete-
   email.conf.template /etc/nanometrics/config/event-complete-email.conf
   ```

   The template files are called **event-email.conf.template**, **event-declared-email.conf.template**, and **event-complete-email.conf.template** and they are located in /usr/share/nanometrics/event-email/conf.

2. Modify the email server settings contained in **event-email.conf** so that they match the outgoing mail settings for your network and specify the email addresses of all intended recipients.
3. Modify the variables contained in **event-declared-email.conf** to determine the content of the event declared email notification (the first email that is sent).

   The first line of this file is the subject of the email and the other lines in the file are the body of the email. The available variables are as follows:

   - event_start — The time the event was declared
   - event_num_triggers — The number of triggers for the declared event
   - stationName — The SCNL information for the local device (the SCNL information for a device is configured in the Channel Naming settings)
   - instrumentID — The ID of the local device as shown at the top of the user interface of the device

4. Repeat step 3 for the variables in **event-complete-email.conf** to determine the content of the event completed email notification (the second email that is sent).

   The following variables are available for the event completed email notification in addition to the ones listed in step 3:

   - event_pga — The PGA of the local device, calculated after the post-event time has elapsed (see Configuration -> Events)
   - max_pga — The highest PGA value from the devices in a group, calculated after the post-event time has elapsed (see Configuration -> Events)
   - max_pga_instrumentID — The ID of the device with the highest PGA value
   - max_pga_stationName — The SCNL information for the device with the highest PGA (the SCNL information for a device is configured in the Channel Naming settings)

4.12 Power

If the power supply voltage is below the configured **Power on** threshold, the Centaur will not power up. If this happens, you can bypass the power supply threshold settings and force the Centaur to power up by pressing the **Force Power On** button behind the media bay door to override this threshold.

The voltage reported by the Centaur may be lower than the voltage supplied to the Centaur due to power cable losses as well as small voltage drops in protective circuitry inside the Centaur.

Power on [mV]

When the external power supply voltage rises above the Power on threshold, the Centaur powers up immediately.

If the current external power supply voltage is less than a newly committed **Power on** threshold, then the Centaur will not automatically power up the next time the power is disconnected and reconnected unless the **Force Power On** button behind the media bay door is pressed to override these thresholds.

Low voltage shutdown [mV]

When the external power supply voltage falls below the Low voltage shutdown threshold, the Centaur performs a safe shutdown.

If the current external power supply voltage is less than a newly applied **Low voltage shutdown** value, then the Centaur will automatically shut down. If not committed, the Centaur will revert to the previous Low voltage shutdown value.

Low voltage disconnect [mV]

When the external power supply voltage falls below the Low voltage disconnect threshold, the Centaur powers off immediately.

Set the disconnect to a value that will properly protect the battery for your power supply.

4.13 Raw TCP Receiving

You can configure the Centaur to acquire raw data from a TCP server using a TCP socket. For example, you can configure the Centaur to receive **BINEX**[1] data from a Trimble® NetR9 GNSS Reference Receiver.

You can create and configure raw data TCP receivers to acquire raw data. Once the raw data has been acquired, you can configure a streamer to stream the data to a data acquisition server. Before the raw data is streamed, it is inserted into an NP packet so that it can be streamed in the NP format.

Name

The name of the raw data TCP receiver.

Enable

Select this option to enable the raw data TCP receiver to receive data.

[1] BINEX is a binary exchange format for GPS and GNSS data. For more information on BINEX, see http://binex.unavco.org/binex.html.

Server IP address

The unicast IP address of the TCP server.

Port number

The number of the port used by the TCP server to stream data. The raw data TCP receiver acts as a TCP client and connects to this port and then the external device streams data to the Centaur.

For example, you configure this port number in the I/O Configuration settings of a Trimble® NetR9.

TCP socket timeout [s]

The maximum amount of time in seconds that the modem will wait for data from the TCP socket before disconnecting from the socket.

After the modem has disconnected from the socket, it will reconnect and wait for a response again.

Raw data type

Select the format of the raw data from the list.

Currently, the only available format is BINEX.

Make sure that the TCP server (for example, a Trimble® NetR9) is configured to stream data to the Centaur in the BINEX format.

Channel index

A number from 2001 to 2099 used to identify the raw data channel.

Each raw data TCP receiver should have a unique channel index number.

You only need to change this number if you are enabling more than one raw data TCP receiver on a single Centaur.

Raw packets per NP packet

The number of packets the Centaur waits for before it creates an NP packet.

Location and channel code

A three character alphanumeric code for the channel name.

-OR-

A two character alphanumeric code for the location and a three character alphanumeric code for the channel name, separated by a dot.

Example: L0.RAW

These codes are used for filtering the data that is streamed to a downstream device and should be unique for each raw data TCP receiver. For more information on filtering, see the description of the NP UDP/HTTP streamer Channel list configuration setting.

The station and network codes are defined by the Channel Naming configuration settings.

4.14 SeedLink Server

Centaur can be configured to act as a SeedLink server for a maximum of four SeedLink clients. (See http://www.iris.edu/data/dmc-seedlink.htm) Any time series data in the **internal storage**[1] of the Centaur can be converted into the 512-byte MiniSEED format and retrieved by SeedLink clients from the Centaur. Only one SeedLink server can be configured on a Centaur.

Channel names are used in the file headings and default file names of the data that is retrieved from the internal storage. These channel names act as labels and help the SeedLink clients identify the data. Before you enable a SeedLink server, ensure that you have configured the channel name settings.

The **maximum "aggregate sample rate"** that is supported when configuring a Centaur to act as a SeedLink Server is reduced to 510Hz. Exceeding this maximum "aggregate sample rate", whether the SeedLink server is enabled or disabled, may cause the Centaur to become overburdened which may cause gaps in the waveform. If a SeedLink Server exceeds the supported maximum aggregate sample rate, delete the SeedLink Server as described below before resetting the sample rate.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

A disabled SeedLink Server causes significant internal processing. To reduce the processing load and improve reliability, and to avoid problems such as gaps in the data, an unused SeedLink Server should be deleted.
To delete a SeedLink Server, click the **Delete** button, followed by the **Apply** and **Commit** buttons to save the change. Note that you need to reboot to stop extra data processing that is caused by the deleted SeedLink Server.

Name

The unique name of the SeedLink server.

Once you have configured the SeedLink server, its name will appear in the left pane of the Configuration dialog box, under the SeedLink server section of the tree. Select the name of the SeedLink server to edit its settings.

Enable

Select this check box to allow Centaur to stream data from this SeedLink server.

Clear this check box to disable this SeedLink server, stopping data acquisition from this source.

Port

The port number for the SeedLink server.

The SeedLink clients have to be configured to use this port number to acquire data from the Centaur SeedLink server.

Maximum backfill packets

Use this option to configure the maximum number of 512-byte SeedLink packets that the SeedLink interface will attempt to re-transmit in response to DATA requests.

- To limit each DATA backfill request to a maximum number of SeedLink packets, enter a positive integer in the field. For example, if you enter **200** in the field, the maximum number of packets that will be backfilled is 200.
  When a maximum number of packets is configured, the most recent historical data are provided so that there is no gap between the re-transmitted data and the real-time data.

- To allow unlimited backfill, enter the value **-1**.
- To disable backfilling, enter the value **0**.

You can configure a different limit for each configured SeedLink server.

The default is **-1** so that no limits are applied to SeedLink backfill requests.

Throttle

The throttle fields display under each SeedLink server added, allowing you to enable a throttle and to specify the maximum throughput bit rate:

- Enable throttle is selected by default. Uncheck this field if you do not want to limit the network transfer rate.
- Maximum throughput bit rate (bps) allows you to specify the maximum output bit rate. The default maximum is 2056000 bps.

4.15 Sensor Library

The Centaur ships with default sensor configurations that you can select as the configuration for Sensor A and Sensor B (6 channel model only). Default sensor configurations cannot be altered, however you can create a custom sensor configuration using one of 2 methods.

Each sensor configuration contains the mode, power, voltage, sensitivity, control line, calibration, and SOH settings for a sensor.

4.15.1 Creating a Custom Sensor Configuration

Use one of the following methods to create a custom sensor configuration.

1. In the Configuration menu, navigate to **Sensor Library**.

Using method 1 (add a new configuration)

2. Click on the **Add** button. A new **My Sensor** page will be created.
3. Configure the relevant parameter on each of the pages for configuring general sensor settings, Sensor Control Lines, Sensor SOH, and Auto Mass Centring.
4. Click **Apply** and **Commit** to save the changes.
5. Continue with other configuration tasks or click **Close** to close the Configuration menu.

Using method 2 (copy an existing configuration)

2. Select an existing default sensor configuration.
3. On the default configuration page, click on the **Copy** button. A new **My Sensor** page will be created with all of the configuration settings of the default sensor configuration.
4. Change the relevant parameter on each of the pages for configuring general sensor settings, Sensor Control Lines, Sensor SOH, and Auto Mass Centring.
5. Click **Apply** and **Commit** to save the changes.
6. Continue with other configuration tasks or click **Close** to close the Configuration menu.

4.15.2 General Sensor Settings

If you are creating a custom sensor, use the settings on this page for sensor configuration.

Sensor name

Enter a name for the sensor configuration.

SP/LP mode

Select the default operating mode of the sensor, whether short period (SP) or long period (LP). This is most often LP for broadband seismometers. The default value is LP.

XYZ/UVW mode

Select the default orientation of triaxial sensor signal outputs, whether XYZ (horizontal and vertical signals) or UVW (symmetric triaxial outputs). The default value is XYZ.

Most triaxial sensors, even those with internal symmetric triaxial seismometer topologies, provide XYZ outputs by default.

Needs power

Select this option if the sensor needs power (active sensors). Do not select it for passive sensors that do not require power. This option is selected by default.

Nanometrics smart sensor

Select this option if the sensor is a Nanometrics smart sensor (for example, Trillium Borehole, Trillium Posthole, or Trillium Compact). This enables Centaur to establish serial communications with the smart sensor and provide access to the sensor's Web Interface.

Response

Use this option to select the response for your Nanometrics smart sensor.

Sensitivity units

The type of physical measurement that the sensor is measuring and representing as a voltage output. Supported units include V/(m/s) (for velocity sensors), V(m/s^2) (for accelerometers), V/Pa (for pressure sensors), and V/V (for voltage output). This value will be incorporated into the system sensitivity displayed on the **Health** page and will be used to control the scaling shown on the **Waveform** page. Also, for accelerometers, the sensitivity is used to calculate the PGA, PGV and PGD values displayed on the **Events** page. Refer to your sensor manual for the appropriate value.

Sensitivity value

The sensitivity of the sensor being measured in volts per unit. Refer to your sensor manual for this value.

Channel *n* orientation

Select the orientation of the each sensor channel.

4.15.3 Sensor Control Lines

Use the settings on this page to configure the behaviour of the sensor control lines. The specific control lines that are available are determined by the sensor. Refer to your sensor manual for the appropriate sensor control line settings and values for your sensor. Specific control line settings are required to make some of the sensor controls available on the **Sensors** page.

To access these parameters, in the Configuration menu, navigate to **Sensor Library > *[Your sensor]* > Sensor Control Lines**.

Settings that are configured for **Assert (on) level, Deassert (off) level, Positive voltage level [V]** and **Pulse duration [s]** will be applied to all control lines for the selected sensor.

Assert (on) level

Use this option to select the voltage or impedance (High Z) that is required to activate the behaviours configured on the **Control line (pins)**. If you select **Positive**, then you must configure a Positive voltage level [V].

> The selected value for Assert (on) level and Deassert (off) level cannot be the same. For example: if Assert (on) level is configured as Positive, then Deassert (off) level must be configured as High Z or Zero.

Deassert (off) level

Use this option to select the voltage or impedance (High Z) that is required to deactivate the behaviours configured on the **Control line pins**. If you select **Positive**, then you must configure a Positive voltage level.

> The selected value for Assert (on) level and Deassert (off) level cannot be the same. For example: if Assert (on) level is configured as Positive, then Deassert (off) level must be configured as High Z or Zero.

Positive voltage level [V]

Use this option to select the voltage level required to activate or deactivate the configured control line behaviours. Configure this option if the setting for **Assert (on) level** or **Deassert (off) level** is Positive.

Pulse duration [s]

Use this option to configure the duration for the selected **Assert (on) level** and **Deassert (off) level**. This setting is required if one of the Control line (pins) is configured to Mass Centre, Mass Lock or Mass Unlock.

For example, if the selected control line (pin) is Mass Centre with an Assert (on) level of +5 V, a Deassert (off) level of Zero (volts), and a Pulse duration of 3 s; then the line will normally rest at Zero (volts) but rise to +5 V for 3 s to signal a Mass Centre command to the sensor.

Control line *n* (pin *n*)

You can configure the behaviour for up to 6 control lines for the sensor. The specific control lines that are available are determined by the sensor. Refer to your sensor manual for the appropriate sensor control line settings and values.

- To enable automatic mass centring Mass Centre, Mass Lock, or Mass Unlock must be selected on one control line. See Auto Mass Centring for configuration information and Control for sensor operation information. Mass Centre, Mass Lock and Mass Unlock can only be configured on one Control line pin.
- To configure operating modes, select SP/LP On=SP, SP/LP On=LP, XYZ/UVW On=XYZ or XYZ/UVW On=UVW. These settings must match the mode settings on the Sensor Settings page. SP/LP On=SP, SP/LP On=LP, XYZ/UVW On=XYZ or XYZ/UVW On=UVW can only be configured on one Control line pin.
- To configure calibration for current mode, select Ch 1 Cal Enable, Ch 2 Cal Enable, or Ch 3 Cal Enable. Ch 1 Cal Enable, Ch 2 Cal Enable, or Ch 3 Cal Enable can each be configured on one Control line pin.
- If the control line is unused, then the selected behaviour must be Unused Assert or Unused Deassert. The use of Unused Assert and Unused Deassert is unlimited.

4.15.4 Sensor SOH

Each sensor port on the Centaur has three mass position SOH inputs and, if enabled, the voltage levels of these inputs are recorded at the configured Internal SOH report interval and displayed on the **Sensors** page. The Sensor mass position SOH values are also included in the Environment SOH group, which you can download from the **Maintenance** page.

You can edit the Sensor mass position SOH settings for any custom sensor configurations that you create.

SOH enabled *n*

Select this check box to allow the Centaur to record the voltage level of the mass position SOH input and generate an SOH channel for this input.

SOH label *n*

Type a label for the mass position SOH input.

The name you enter here will appear on the **Sensors** page and in the Sensor section on the **Summary** page.

SOH monitor *n*

Select this check box if you want the status of this mass position SOH input to impact the overall status of the device.

This means that if a warning or error condition is reported for this mass position SOH input, it will be indicated in red on the **Health** page, **Sensors** page, and in the status bar at the top of each page. It will also be indicated by the Sensor LED on the Centaur.

SOH high threshold

An error condition is reported for the mass position SOH input when the SOH input voltage rises above the SOH high threshold value. This error condition is indicated in red on the **Health** page, **Sensors** page, and in the status bar at the top of each page. The Sensor LED on the Centaur blinks red when this error condition occurs.

A warning condition is reported for the mass position SOH input when the SOH input voltage rises above the SOH low threshold value and stays below the SOH high threshold value. This warning condition is indicated on the **Health** page, **Sensors** page, in the status bar at the top of each page. The Sensor LED on the Centaur blinks orange when this warning condition occurs.

SOH low threshold

No error or warning condition is detected for the mass position SOH input when the SOH input voltage is below the SOH low threshold.

4.15.5 Auto Mass Centring

You can configure the Auto Mass Centring options to initiate automatic mass centring when sensor mass positions reach off-centre thresholds.

You can set thresholds for delayed or immediate recentring (yellow and red thresholds respectively) and set the number of retries and retry intervals to achieve centred masses.

You must have a control line configured for Mass Centre and have at least one of the following thresholds enabled:

- Auto Centre on Yellow – The Centaur will initiate mass centring when any axis has been above the Yellow Threshold for more than the Yellow Holdoff Time. If all axes drop below the Yellow threshold during holdoff time, then the holdoff time is cancelled.
- Auto Centre on Red – The Centaur will initiate mass centring 1 minute after any axis exceeds the Red Threshold. You can configure the number of retries, as well as the configured retry interval. Retries will be attempted until all axes are below the yellow threshold or until the number of retries per Auto Centre have been executed.

Once configured, the **Control** section on the **Sensor** page will indicate that automatic mass centring is enabled.

Red threshold [V]

The minimum voltage level used to indicate that the mass position is out of range. Mass centring is initiated one minute after this level is crossed for any sensing element.

The threshold range is from negative to positive, for example 1 indicates a threshold range of -1 to +1.

Enter a number that is greater than or equal to 1 V.

If you use both the red and the yellow thresholds, ensure that you set the yellow threshold as the lower mass position limit and the red threshold as the higher mass position limit (red >= yellow).

Auto-centre on red

Select this option if you want the Centaur to initiate mass centring when the Red Threshold is crossed.

By default, this option is not selected.

Yellow threshold [V]

The minimum voltage level used to indicate that the mass position is marginal. Mass centring is initiated after the Yellow Holdoff Time has expired.

The threshold range is from negative to positive: for example, 1 indicates a threshold range of –1 to +1.

Enter a number that is greater than or equal to 1 V.

If you use both the red and the yellow thresholds, ensure that you set the yellow threshold as the lower mass position limit and the red threshold as the higher mass position limit (red >= yellow).

Auto-centre on yellow

Select this option if you want the Centaur to initiate mass centring when the Yellow Holdoff Time expires.

By default, this option is not selected.

Yellow holdoff time [h]

The number of hours the Centaur waits when any mass position voltage is higher than the yellow threshold but lower than the red threshold before initiating mass centring.

Enter a number between 0.1 and 72.

Retries per auto-centre

The maximum number of re-attempts the Centaur makes to centre the masses.

Enter an integer between 0 and 20.

Retry interval [min]

The length of time in minutes that the Centaur waits before trying to automatically centre the masses again.

Enter an integer between 30 and 60.

4.16 Weather Station

The weather station feature allows you to configure supported weather stations to communicate with the Centaur digital recorder. The following weather stations are supported:

- Gill Instruments Maximet GMX500 Compact Weather Station
- Gill Instruments Maximet GMX500 with GPS Compact Weather Station
- Gill Instruments Maximet GMX600 Compact Weather Station

- Gill Instruments Maximet GMX600 with GPS Compact Weather Station
- Vaisala Weather Transmitter WXT536 configured with or without heater

> The GPS functionality that is available on the GMX-500 with GPS and GMX-600 with GPS models is not required by Centaur. Therefore, to conserve power, when either of these models are the selected Serial Sensor, the GPS functionality of the weather station will be disabled.

When the weather station is enabled, the Centaur will acquire the data that is produced by the weather station, which will then be displayed on the **Sensors** page. The acquired weather data is automatically associated with State of Health (SOH) time series data for storage in store, archiving on external SD card, or for streaming using the following SEED channel codes:

- LDO: Outside barometric pressure
- LIO: Outdoor relative humidity
- LKO: Outside Environment temperature
- LWD: Wind direction
- LWS: Wind speed
- LRT: (For GMX600 and WXT536 units only) Total rain
- LRI: (For GMX600 and WXT536 units only) Rain intensity
- LYT: (For WXT536 units only) Total hail
- LYI: (For WXT536 units only) Hail intensity

For CD-1.1-enabled Centaur instruments, you can transmit weather data using the CD-1.1 standard by enabling any or all of LDO, LKO, LWD and LWS weather channels from the CD-1.1 Data Streaming option.

The Centaur's sensor port shares the RS-232 capability between the geophysical sensor and the connected weather station. This means that while the weather station is in use the serial port cannot be used by any connected geophysical sensors. In addition, the serial communication to the weather station requires the use of the sensor control lines 1 and 2 of the sensor port where it is connected.

4.16.1 Preparing the Weather Station for use with Centaur

To prepare the weather station to use with a Centaur proceed as follows:

1. Configure the weather station before connecting to the Centaur as follows:
    a. For the GMX500 and GMX600 weather stations, configure the weather station using factory default settings. See the *MaxiMet User Manual* for details (Doc. No. 1957-PS-001, July 2017).
    b. For the WXT536 weather station, configure the communication settings as follows:
        i. RS232 serial interface (C=2)
        ii. Baud rate: 19200 bps
        iii. Data bits: 8
        iv. Parity: none
        v. Stop bits: 1
        vi. Parameter locking disabled (H=0)
2. Connect the weather station to the Centaur using the appropriate cable, see "Cables and Accessories" on page 15.
3. Configure the weather station to communicate with the Centaur.
4. Select a weather station-compatible sensor that does not use sensor control lines 1 or 2, such as an infrasound sensor.

4.16.2 Configuring the Weather Station

To configure the weather station to operate through a Centaur:

1. Open the Configuration menu and navigate to the **Serial Sensor** option page.
2. Select the weather station from the **Sensor** dropdown menu.
3. If you are connecting the weather station to a 6-channel Centaur, select the **Sensor port** where the weather station is connected.
4. If the Centaur is CD-1.1-enabled, you can transmit weather data using the CD-1.1 standard as follows:
    a. Navigate to **Data Streaming** > **CD-1.1 Streaming**.
    b. Expand **Weather channels** and configure the parameters for each channel type as required—Wind speed, Wind direction, Temperature, and Pressure. See Weather Channels Configuration Parameters for details.

5. Click on **Apply**, then **Commit** to save the settings.

4.17 State of Health (SOH) Settings

SOH information can be saved to the internal store and external media archive as well as streamed using NP or SeedLink. In addition, for each external SOH channel, along with the channel name you can configure the channel to be an open/close switch indicator.

When archiving and streaming are enabled, you can use the following parameters to configure the reporting intervals and frames per packet for SOH channels.

Internal SOH report interval [s]

The SOH reporting rate of the internal SOH channels (for example, GNSS, time, and storage). Enter an integer between 60 and 3600. See SOH channels for further information on SOH channel codes and descriptions.

This parameter affects the age of the SOH data that is retrieved from the SOH API and SNMP.

Default: 60 s.

External SOH report interval [s]

The SOH reporting rate of the three external SOH inputs. Enter an integer between 1 and 3600. You can see voltage readings for connected equipment on the **Sensors** page, in the External SOH Inputs section.

Default: 60 seconds.

Frames per packet

Number of frames used in each SOH packet. Increasing the value will lower the overhead, but increase latency.

Enable SNMP

Select this check box to enable an SNMP v2c server listening on UDP port 161. See " About Simple Network Management Protocol (SNMP)" on the next page.

Default: Unselected.

4.17.1 External SOH Settings

Each external SOH port is sampled periodically based on the configured External SOH report interval. When the associated external SOH is configured as a switch, if the door is opened or closed, the change in state will be reported by the associated SOH channel as mV in the Archives and for SeedLink streaming. On the Web Interface on the **Sensors** page, a value greater than 150 mV indicates that the switch is open. For Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H, see Configuring tamper switches on the CTR4 with Authentication. For connection details see External SOH Input Pinout.

Use the following parameters to configure each External SOH channel. To access these parameters, in the Configuration menu, navigate to **State of Health (SOH)** and expand. Then click on the **External SOH** channel that you want to configure.

Name

For each External SOH channel, enter a name for the channel. This name will display on the **Sensors** page in the External SOH Inputs section.

Units

For each External SOH channel, to use the channel as an open/close switch, select **Switch** from the drop-down menu. If you select mV, the output units of the channel will display on the **Sensors** page in the External SOH Inputs section. The external switches must provide a loop back to ground to appear as closed.

4.17.2 About Simple Network Management Protocol (SNMP)

You can configure the Centaur to use Simple Network Management Protocol (SNMPv2c) SNMP GET operation to communicate state-of-health information in a standard format to enable remote monitoring using common network operations tools using the community string “public”. Supported fields are described in the Management Information Base (MIB) file. These supported fields are a subset of the information described in the "State of Health API" on page 176. The latest MIB file can be downloaded from Centaur using the address `/NMX_CENTAUR_SOH-MIB.txt`.

The following additional details also apply:

- Standard SNMP port UDP 161 is used for SNMP Managers communicating with SNMP Agents.
- Nanometrics' assigned private enterprise number (PEN) is 58765. This number, which is assigned by the Internet assigned numbers authority (IANA), becomes part of the SNMP object identifier (OID) that is used in the MIB.
- You can configure the **Internal SOH report interval** parameter as part of the "State of Health (SOH) Settings" on page 111. However, to maintain reasonably current SNMP values it is recommended that you use the default interval of 60 seconds when using SNMP.
- SNMPv1 and SNMPv3 are not supported.
- SNMP SET operation, traps, and viewing or setting configurations are not supported by Centaur.

4.18 Timing Source

The Centaur requires a timing source to timestamp samples relative to UTC. The timing source option allows you to specify the time reference for the internal clock of the instrument, which in turn timestamps the digitized data. Five timing source options are available to Nanometrics instruments—GNSS, GNSS over fiber, PTP, NTP, and free running. In most cases GNSS timing will be used since it is very accurate, and works independently of network connections or other time servers, but network timing options of Precision Time Protocol (PTPv2) and Network Time Protocol (NTP) can also be selected, as well as a free running clock, which by definition has a user defined time reference or no time reference. Independently of what time source the Centaur uses, it can also be configured to supply either PTPv2 or NTP network timing to other Centaur units.

Consider the following when selecting a time source for your Centaur:

Availability of equipment

- To use GNSS or GNSS over fiber as the configured time source, the instrument must have a GNSS antenna.

Installed location of the instrument

- GNSS is convenient, economical and very precise, and is a good option if the instrument is situated so that its GNSS antenna has a view of the sky. GNSS is therefore not suitable for subsurface applications such as mining, seismic stations in caves, submarine, and interior structural monitoring. In these instances, PTP, NTP or free-running can be used.

- GNSS over fiber is convenient, economical and very precise, and can be used if the instrument is buried underground and connected to the GNSS antenna located at the surface using fiber cable.
- PTP can be used where another Centaur on the local subnet can be configured as a PTPv2 network timing source. Typically this is a system with GNSS-derived timing, but it can also be a system that is deriving its timing from NTP or even free-running. This type of system can provide very good accuracy that approaches that of GNSS if the LAN is appropriately engineered. PTPv2 uses multicast, so the server and clients must be on the same subnet.
- NTP can be used instead of PTP where a PTP source is not available or practical. NTP is a simpler less precise protocol for synchronizing computers' time-of-day across the Internet, and it is not restricted to a single subnet. NTP can use any public NTP server on the Internet. Very good timing accuracy can also be achieved when a local Centaur acts as an NTP server for other Centaurs.

Importance of timing accuracy

- GNSS and GNSS over fiber provide the most accurate timing followed by PTP, then NTP and finally free-running.
- The importance of relative time synchronization versus absolute time accuracy is a consideration. For example, where it is important that a cluster of local stations have precisely matched relative timing but absolute agreement to UTC time is not as important, one unit can be configured to source its time from a remote NTP server or even free-run, then in turn serve PTP time (or even NTP time) to neighbouring stations.
- Free running can be used in situations where time may be set manually and allowed to run at the accuracy of the internal oscillator, with the time manually reset at intervals if necessary.

The remainder of this section provides some sample configurations as well as guidelines for configuring the different timing sources.

4.18.1 Sample Timing Configurations

This section provides some examples of networks where there may be one or more instruments on the surface that can use GNSS and several instruments underground/sea that cannot use GNSS. All units are connected by Ethernet to a local network which may be connected to the Internet from which an NTP server is accessible (example: time.nrc.ca).

Example 1: GNSS server with PTP clients

In this scenario, all surface instruments have GNSS, with one or more of these units configured as an PTP server. All underground/sea instruments are PTP clients using the surface instruments as their source. All units must be connected to the same subnet. This is the best situation with an accurate local PTP server that minimizes network effects on timing accuracy.

The basic configuration instructions are as follows:

1. For all surface instruments, select **GNSS** or **GNSS over fiber** from the **Time source** drop-down list.
2. For one or more of the surface instruments, select **PTP** from the **Time sharing** drop-down list.
3. For all underground/sea instruments, select **PTP** from the **Time source** drop-down list.

Example 2: Free-running server and PTP clients

In this scenario, all of the instruments are connected via an Ethernet network on the same subnet, but none of them have access to remote NTP or GNSS. One of the underground/sea units is configured as Free running. This same underground/sea unit is also acting as a PTP server for the other instruments. This should provide excellent relative timing among the instruments because they are tracking the one local instrument PTP server.

The basic configuration instructions are as follows:

1. On one instrument, select **Free-running** from the **Time source** drop-down list, and select **PTP** from the **Time sharing** drop-down list.
2. On the other instruments, select **PTP** from the **Time source** drop-down list.

Example 3: GNSS server serving NTP clients

In this scenario, all surface instruments have GNSS, with one of these units configured as an NTP server. All underground/sea instruments are NTP clients using the surface instrument as their source. This is the best situation with an accurate local NTP server that minimizes network effects on timing accuracy.

The basic configuration instructions are as follows:

1. For all surface instruments, select **GNSS** or **GNSS over fiber** from the **Time source** drop-down list.

2. For one of the surface instruments, select **NTP** from the **Time sharing** drop-down list.
3. For all underground/sea instruments,
    a. select **NTP** from the **Time source** drop-down list.
    b. in the **NTP server address** field, enter the hostname or IP address of the surface instrument that is configured for Time sharing.

Example 4: All Centaur are NTP clients to an Internet NTP server

In this scenario, there are no surface instruments with GNSS that can act as NTP servers. All underground/sea instruments are NTP clients using the same remote NTP server as their source. This provides the most accurate absolute time available by NTP, but the relative timing of the instruments among themselves is no better than that of the NTP server.

The basic configuration instructions are as follows:

1. For all underground/sea instruments,
    a. select **NTP** from the **Time source** drop-down list.
    b. in the **NTP server address** field, enter the hostname or IP address of the remote NTP server.

Example 5: One NTP-timed Centaur serves NTP to the others

In this scenario, there are no surface instruments with GNSS that can act as NTP servers. One of the underground/sea units is an NTP client using a remote NTP server as its source. This same underground/sea unit is also acting as an NTP server for the other instruments. This should provide somewhat better relative timing among the instruments because they are tracking the one local instrument NTP server.

The basic configuration instructions are as follows:

1. For all underground/sea instruments, select **NTP** from the **Time source** drop-down list.
2. For one of the underground/sea instruments,
    a. select **NTP** from the **Time sharing** drop-down list.
    b. in the **NTP server address** field, enter the hostname or IP address the remote NTP server.
3. For the remaining underground/sea instruments, in the **NTP server address** field, enter the hostname or IP address of the underground/sea instrument that is configured for Time sharing.

4.18.2 Configuring GNSS timing

To configure GNSS timing on a Centaur, proceed as follows:

1. Open the Configuration menu and navigate to **Timing and Location.**
2. Select **GNSS** or **GNSS over fiber** from the **Time source** drop-down list.
3. Select either **Duty cycled** or **Always on** from the **GNSS power mode** drop-down list.

> **Duty cycled** is most often used because it saves significant power (about 400 mW) as it turns on the GNSS receiver only when needed to keep the system within 100 µsec of UTC time. **Always on** continually receives GNSS timing and keeps the system time to within 5 µsec of UTC time. See "Timing Accuracy" on page 204 for more information.

4. Optionally, in systems where one Centaur must provide network timing to other Centaurs, select **PTP** or **NTP** from the **Time sharing** drop-down list. If selecting **PTP**, be aware that only Centaurs on the same subnet as this Centaur will be able to receive the multicast PTP messages.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

4.18.3 Configuring PTP timing

To configure the Centaur to receive PTP network timing from another Centaur, proceed as follows:

1. Open the Configuration menu and navigate to **Timing and Location.**
2. Select **PTP** from the **Time source** drop-down list. Be sure there is at least one other Centaur on the same subnet that is configured to act as a PTP server.
3. Optionally, in systems where one Centaur must provide network timing to other Centaurs, select **PTP** or **NTP** from the **Time sharing** drop-down list. If selecting **PTP**, be aware that only Centaurs on the same subnet as this Centaur will be able to receive the multicast PTP messages.
4. To save the configuration, click the **Apply** button, then click the **Commit** button.

4.18.4 Guidelines for selecting an NTP server

When an instrument is running as an NTP Client, the accuracy of the instrument timing is affected by the quality of communications with the NTP Server and the accuracy of the NTP Server time.

When selecting a remote server, when possible choose a geographically close server with a low ping response time.

Use the following recommended order of preference when selecting an NTP Server:

1. Local stratum 1 server
2. Local stratum 1 server on a Nanometrics instrument. See Enabling a stratum NTP server.
3. Local stratum 2+ server
4. Local stratum 2+ server on a Nanometrics instrument. See Enabling a stratum 2+ NTP server.
5. Remote stratum 1 server
6. Remote stratum 2+ server

4.18.5 Configuring NTP timing on a Centaur

To configure the Centaur to receive NTP timing from another Centaur or any other NTP server, proceed as follows:

1. Open the Configuration menu and navigate to **Timing and Location.**
2. Select **NTP** from the **Time source** drop-down list.
3. In the **NTP server address** field, enter the hostname or IP address of the desired NTP server (which may be another Centaur). By default, the NTP server address is set to `pool.ntp.org`. This will automatically select a server based on geographical location determined by the source IP address.
   If you have selected another Centaur as the NTP server, be sure that the other Centaur is configured to act as an NTP server.
4. Optionally, in systems where one Centaur must provide network timing to other Centaurs, select **PTP** or **NTP** from the **Time sharing** drop-down list. If selecting **PTP**, be aware that only Centaurs on the same subnet as this Centaur will be able to receive the multicast PTP messages.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

4.18.6 Enabling a stratum 1 NTP server on a Centaur

IMPORTANT: An instrument that is configured to be an NTP Server will become publicly accessible.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

A stratum 1 NTP server derives time directly from a radio clock or some other highly accurate time source and then serves NTP time to network connected clients. In the case of Nanometrics instruments, GNSS is used as a highly accurate time source. To enable a stratum 1 NTP Server on an instrument, proceed as follows:

1. Open the Configuration menu and navigate to **Timing and Location.**
2. Select **GNSS** or **GNSS over fiber** from the **Time source** drop-down list.
3. To configure the best possible timing, select **Always on** from the **GNSS power mode** drop-down list.

To save power you can select **Duty cycled**, however the time will be slightly less accurate.

4. Select **NTP** from the **Time sharing** drop-down list.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

When configuring another Centaur as an NTP Client to connect to this instrument's NTP server use the server instrument's IP address or name as provided by the network's DNS.

4.18.7 Enabling a stratum 2+ NTP server on a Centaur

IMPORTANT: An instrument that is configured to be an NTP Server will become publicly accessible.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

A stratum 2+ server uses NTP as a time source and then serves NTP time to network-connected clients. To enable a stratum 2+ NTP Server on an instrument, proceed as follows:

1. Open the Configuration menu and navigate to **Timing and Location.**
2. Select **NTP** from the **Time source** drop-down list.
3. In the **NTP server address** field, enter the hostname or IP address of the NTP server from which this Centaur is to get its timing.
4. Select **NTP** from the **Time sharing** drop-down list to enable this Centaur to act as an NTP server for other Centaurs.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

When configuring another Centaur as an NTP Client to connect to this instrument's NTP server use the server instrument's IP address or name as provided by the network's DNS.

4.18.8 Timing Configuration Parameters

This section describes the available parameters for configuring a timing source. You can access these parameters from **Timing and Location** in the Configuration menu.

Time source

Select the source for internal timing from the drop-down.

- GNSS - Select this option if absolute time accuracy is important and if the instrument's GNSS antenna has a view of the sky. It is not suitable for indoor, underground or underwater installation unless a GNSS re-radiator device is used to broadcast GNSS signals near the instrument.
- GNSS over fiber - Select this option if absolute time accuracy is important as described by the GNSS option, but the GNSS antenna is attached using a fiber modem that does not draw current from the Centaur GNSS antenna connector.
- PTP - Select this option if absolute time accuracy is important, the instrument does not have GNSS access, and there is at least one other Centaur on the same subnet that is configured to act as a PTP server.
- NTP - Select this option to connect to a local NTP server (such as a Centaur configured to act as an NTP server), or to an Internet NTP server.
- Free running - Select this option to allow the instrument to run at the accuracy of the internal oscillator. This option allows you to manually set the instrument time and to manually reset the time at intervals.

The default setting is GNSS, otherwise, the default setting is PTP.

GNSS power mode

Select the power mode for the GNSS receiver.

- Duty cycled — Select this option from the drop-down to configure the GNSS to duty cycle automatically. In this instance, the GNSS receiver is switched on until the fine lock is reached in the system clock and then switched off until the estimated time uncertainty approaches 100 µs (500 µs if the temperature drops below -35°C). This is the most efficient setting for power consumption.

> If the GNSS is configured to **Duty cycled** the **Health** page will indicate a time error if the modelled uncertainty exceeds 1000 µs.
> Typical duty cycling on-time is 10%. However, it may be more frequent in environments with rapidly changing temperatures or with a poor GNSS satellite signal.
> When in **Duty cycled** mode, if the GNSS receiver does not lock after 15 minutes of turning on, it will turn off for 135 minutes before trying again. This is to avoid consuming more power than usual if the GNSS cannot lock due to the antenna being temporarily obscured, or if the temperature is outside the operating range.

- Always on — The GNSS is always on. This mode uses more power than Duty cycled, however it provides the most accurate timing.

> If the GNSS is configured to **Always on** the **Health** page will indicate a time error if the modelled uncertainty exceeds 1000 µs.

Second GNSS constellation

If the selected "Time source" is **GNSS** or **GNSS over fiber**, select a second constellation as a source from this drop-down list to increase the number of satellites that are used for timing acquisition. The primary GNSS timing source is always the GPS satellite constellation and is supplemented with the satellite constellation selected in this field.

> Note that enabling this option will increase power consumption.

NTP server address

Enter the hostname or IP address of the NTP server with which the Centaur time may be synchronized. Use this option in the following situations:

- to synchronize system time when the **Time Source** is set to **NTP**
- to automatically set time on startup if **Set time using NTP on startup** is enabled and if the **Time source** is set to **Free running**
- to manually set time when the **Time source** is set to **Free running** by clicking the **Set time using NTP** button on the Maintenance page

Set time using NTP on startup

If the **Time source** is Free running, check this option to enable the system time to synchronize with the configured NTP server when the Centaur starts up. If this option is selected, enter a value in the **NTP server address** field.

Time sharing

Select PTP or NTP from the drop-down to configure this device to be the time source for other devices in the network. Disabled indicates that this device is not acting as a time source.

4.19 Location Configuration

The geographical location of an instrument is determined automatically by GNSS or by configuring the location manually. In the following examples are examples in which it may be useful to manually configure the geographic location:

- GNSS coverage is unavailable and therefore the Centaur cannot determine its own location.
- The instrument's GNSS antenna is obscured or not attached; therefore the instrument cannot determine its own location.
- The GNSS antenna is located far enough from the instrument to warrant a separate location indicator.
- Your application requires that the geographical location of the Centaur remains fixed, for example if you are using the Centaur's location as an instrument or channel identifier. GNSS-derived locations vary slightly with time.

If a geo-location is manually configured by the user, it is displayed on the Web Interface, and also used as the geo-location in any Dataless SEED response files that are created by the Centaur.

This section describes the parameters for configuring the geographical location of your Centaur. You can access these parameters from **Timing and Location** in the Configuration menu. Once configured, these values are displayed in the **User-defined Location** area on the **Health** page.

Latitude [deg]

Use this option to specify an exact location for the Centaur if you do not wish to use the location determined by the GNSS time source or if GNSS is unavailable. Keep the following in mind:

- Specify the location in decimal degrees.
- Enter a positive value to indicate North.
- Enter a negative value to indicate South.
- If you specify the latitude for the instrument, you must also specify longitude and elevation.

Longitude [deg]

Use this option to specify an exact location for the Centaur if you do not wish to use the location determined by the GNSS time source or if GNSS is not available. Keep the following in mind:

- Specify the location in decimal degrees.
- Enter a positive value to indicate East.
- Enter a negative value to indicate West.
- If you specify the longitude for the instrument, you must also specify latitude and elevation.

Elevation [m]

Use this option to specify an exact location for the Centaur if you do not wish to use the location determined by the GNSS time source or if GNSS. Keep the following in mind:

- Specify the elevation in metres.
- If you specify the elevation for the instrument, you must also specify latitude and longitude.

5.0 Monitor the Status Indicator LEDs

The Centaur has the following status indicator LEDs that you can use to monitor the current status of the instrument and troubleshoot any problems that may occur. Indicator LEDs are located on the top of the Centaur and behind the media bay door.

External LEDs (on top of the Centaur):

- Overall Status
- Link
- Time
- Media
- Sensor A/B

Internal LEDs (located behind the Media Bay Door):

- Media Eject
- USB Eject

5.1 Overall Status LED

Off

The Centaur is powered off.

Solid red

Initial power-on.

Blinking orange

The Centaur is starting up and checking all of the internal systems.

Blinking green

The Centaur is operating properly.

Blinking red

There is a fault or condition that prevents the Centaur from operating properly. If none of the other LEDs indicate an error condition, check the Health page to determine the possible cause.

Possible problems could include the following:

- The GNSS receiver is not locked or the GNSS antenna is disconnected or shorted.
- The Data Archiving feature is enabled but the external SD card is missing, full, corrupt, or could not be prepared for use.
- Configuration changes have not been committed.
- The firmware status is not okay.
- The status of the **internal storage**[1] is not okay.
- The sensor input voltages or control settings are not okay.
- The internal storage failed and data is being temporarily written to the instrument's RAM. You will also see the Internal Storage Status listed as **Temporary Location** on the **Health** page.

  -OR-

  The Force Power On button was pressed to force the Centaur to bypass the power supply threshold settings and power up. Once the **Force Power On** button is pressed, the Power LED will change from solid red to blinking orange and then to blinking red.

5.2 Link LED

Off

No Ethernet cable is connected.

-OR-

The unit is powered off.

Solid green

Link established over the Ethernet cable, but there is no activity over the Ethernet link.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

Solid green with flicker

Link established over the Ethernet cable and data is being transmitted or received over the Ethernet link.

5.3 Time LED

Off

The Centaur is powered off.

Blinking orange

The timing system is initializing and attempting to acquire a lock to the time source. It will attempt to acquire a lock after the Centaur powers up.

Blinking green

The Centaur has synchronized to an accurate time.

Blinking red

The timing system is unable to synchronize to the time source. See SOH Time statuses for details of potential errors.

5.4 Media LED

Off

The Data Archiving feature is disabled and no events or data are being archived to the external SD card.

For more information, see Events Data Archive and Continuous Data Archive.

Blinking orange

Checking the status of the external SD card.

-OR-

The unit is in a transitional state as data archiving starts up or shuts down.

Blinking green

The external SD card is archiving data/ready to archive data.

Blinking red

The external SD card is corrupt, full or there is an error writing to the external SD card, and data archiving is enabled, or the card is being repaired or formatted, or is missing.

For more information, see Events Data Archive and Continuous Data Archive.

5.5 Sensor LEDs

The 3 channel model of the Centaur has one Sensor LED and the 6 channel model has two. In addition to the Sensor LEDs, you can also view information about the sensors on the **Health** and **Sensors** pages of the user interface.

Off

The unit is powered off or the unit is booting.

Blinking green

All three mass position values of a connected sensor are within the configurable SOH low threshold value.

Seismometer mass positions adjust very slowly. So if the sensor has been shifted from level, it will take many minutes for the Centaur to recognize that this has occurred. In the meantime, the LED will remain green.

Blinking red

There is an error condition that could prevent the sensor from operating properly.

Possible problems could include the following:

- At least one mass position value is outside the configurable SOH low threshold value. For example, if the configured SOH low threshold value is 2.5, a mass position value of -2.6 V or +2.6 V will cause an error condition.

- If the Sensor settings from the Configuration menu differ from the **Axis** and **Period** settings on the **Sensor** page, or the **Period** setting on the **Summary** page.

> The **Period** field is displayed only if the connected sensor supports the Long Period / Short Period setting.

5.6 USB Eject LED

> The USB Eject LED is not used on Centaur instruments and will always be off.

5.7 Media Eject LED

> The Centaur automatically detects the insertion of an external SD card and will start preparing it for recording.

Off

No external SD card is detected.

Blinking red

The external SD card has been inserted and it is being prepared for use.

-OR-

The button next to the external SD card has been pushed, or the Removable Media **Eject** button on the **Maintenance** page has been clicked, and the card is being prepared for safe removal. The Centaur will attempt to prepare the external SD card for safe removal. If files are still being archived to the external SD card after 2 minutes, the external SD card will return to the ready for use state and the LED will turn solid red for ten minutes and then turn off. If this happens, press the eject button to try again.

Solid red

The external SD card is ready to use or is being used and it is not safe to remove it.

It will turn from solid red to off after 10 minutes to save power.

Solid green

The button next to the external SD card has been pushed, or the Removable Media **Eject** button on the **Maintenance** page has been clicked, the card has been prepared for safe removal, and it is safe to remove the external SD card. If the external SD card is not removed within 10 minutes after it has been prepared for safe removal and the LED turns solid green, the card will be prepared for use again and the LED will turn to blinking red.

OR

There was an error writing to the external SD card.

6.0 Using the Web Interface

The Web Interface status bar, located at the top of the page, is visible from any page allowing you to quickly identify the specific device and its status and the available features based on the model number. Note the displayed model number should match the model number shown on the product label on the bottom of the unit. For example, the model number CTR4-6AS/H indicates that the model is a 6-channel version 4 Centaur with one standard gain and one high gain sensor port, that also supports data authentication on either port.

Once connected and your device is configured, you can use the Web interface to

- Monitor the status and health of your device.
- View the status of the sensor and perform several control functions.
- View and declare events.
- Calibrate connected sensors.
- View waveform data.
- Perform maintenance tasks.

6.1 Monitor the Status and Health of Your Instrument

In addition to monitoring the LEDs of your Centaur, you can also monitor the overall status and health of the device by viewing near real-time information on the **Health** page. Any problems are indicated in red. The last time the information was updated is shown in the lower-right corner of the page.

Each section on the **Health** page shows you the current state of health and status of your Centaur, grouped by component.

You can quickly check the health of the device from any page by looking at the status bar at the top of the page. The first section of the status bar displays both text and an icon to show the status of the device. 

6.1.1 Authentication

This section displays for the Centaur digital recorder CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H).

Digitizing Equipment

The status of the tamper switch for the digitizing equipment. If the channel is configured, Open or Closed is displayed depending on the status of the switch. If the switch is open the message is displayed in red indicating that this is an error state. See "Configuring tamper switches on the Centaur CTR4 with Authentication" on page 41.

Equipment Housing

The status of the tamper switch for the equipment housing. If the channel is configured, Open or Closed is displayed depending on the status of the switch. If the switch is open the message is displayed in red indicating that this is an error state. See"Configuring tamper switches on the Centaur CTR4 with Authentication" on page 41.

Vault Door

The status of the tamper switch for the vault door. If the channel is configured, Open or Closed is displayed depending on the status of the switch. If the switch is open the message is displayed in red indicating that this is an error state. See "Configuring tamper switches on the Centaur CTR4 with Authentication" on page 41.

CD-1.1 Connection *n*

For each CD-1.1 connection, the status of the connection and the frame destination. If you click on the information icon, additional CD-1.1 frame information will display.

CD-1.1 Authentication

The status of digital signature authentication on CD-1.1 frames. Active indicates that hardware authentication has been activated and that digital signature authentication has been configured.

6.1.2 Events

This section does not display on the Centaur digital recorder CTR4 with Authentication (models CTR4-3A, CTR4-6A/S and CTR4-6AS/H).

Most recent

The date, and Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV), and Peak Ground Displacement (PGD) of the most recent event.

Events archive

The status of the events archive and the external SD card.

The possible statuses are as follows:

- Not started — The following conditions will cause the Not started status to display. Note that the external SD card should not be removed while the Events archive state is Not started:
  - When events data archiving is already enabled, while archiving is starting up in response to an external SD card being recognized by the instrument.
  - When the instrument is ready to archive to the external SD card, while archiving is starting up in response to events data archiving being set to enabled.
  - Briefly, when archiving stops in preparation for the format, repair or ejection of an external SD card.
- Archive OK — The external SD card is archiving event data or is ready to archive event data and the last event was archived successfully.
- No archive media — The external SD card is missing or there is an error writing to the current external SD card. Insert an unlocked external SD card, disable the archiving of event data, or replace or reformat the current external SD card. If an external SD card is present and this error occurs, the error may be caused by the external SD card being write-protected. In this case remove the external SD card and unlock it before reinserting the it. See Write-protection on SD cards.
- Archive error — The archive is corrupted or another error has occurred. Replace or reformat the current external SD card.
- Archive full— The external SD card is full and no more event data can be archived. Replace the current external SD card or delete some of the archived data from the card.
- Disabled — The Centaur has not been configured to archive event data to a removable external SD card.

Trigger window

The window of time, in seconds, into which the Trigger on times of the channels must fall in order for those channels to be included in the same event.

Voting threshold

Each channel of the Centaur can cast a specified number of votes towards getting an event declared and the voting threshold is the minimum number of total votes required for it to declare an event.

You can configure the number of votes each channel casts towards getting an event declared and you can also configure the voting threshold. To ensure proper event declaration, you should give zero votes to a channel that you do not want to affect the event declaration at all and a lower number of votes to channels in noisy locations.

Trigger detectors

The trigger settings of Detector 1/Detector 2/Detector 3

The possible values are as follows:

- A hyphen (-) — This means that the detector is not enabled.
- A value in *g* — This is the configured threshold value.
- A value — This is the result of the configured STA/LTA ratio.

For more information on how to enable and configure detectors, see Trigger Detectors.

6.1.3 Device

System — Uptime

The time elapsed since the Centaur last powered up.

System — Streaming rate

The combined streaming packet rate of all of the enabled streamers.

System — Enabled streamers

The total number of enabled NP UDP and NP HTTP streamers.

System — Configuration

The status of the configuration settings.

If you have applied some changes to the configuration settings but not yet committed them, this value will be red. If you do not commit these outstanding changes before the next time the Centaur restarts or within an hour of making the changes, these changes will be lost.

As a fail-safe measure for instrument recovery. In the case of a failed configuration operation, Centaur will automatically reboot and revert to the previously committed configuration 1 hour after the Apply command has been used if no Commit command is received.

System — Firmware

The version of the active firmware.

If you see **testcode** as the value, this means that you have upgraded the firmware but not yet made it permanent by committing it. Go to the **Maintenance** page and click **Commit** in the Firmware section to commit the new firmware.

Environment — Power consumption

The amount of power consumed by the Centaur measured in watts.

The system current is shown in the tooltip.

Environment — Supply voltage

The voltage level being supplied to the Centaur by the power source.

Environment — Temperature

The internal temperature of the Centaur.

The internal temperature may be several degrees higher than the ambient temperature.

6.1.4  Storage

Media Card — Status

The status of the removable external media card.

The possible statuses are as follows:

- Ejecting — The external SD card is being prepared for safe removal from the device. (See Remove the SD Card for more information.)
- Formatting — The external SD card is being erased and reformatted with a new file system to prepare the external SD card for use. (See Format SD Card for more information.)
- Media error — The following conditions will cause the media error status to display. Repair, reformat, or replace the current external SD card:
  - The SD card is corrupted.
  - There is an error writing to the external SD card. This error may be caused by the external SD card being write-protected. In this case remove the external SD card and unlock it before reinserting it. See Write-protection on SD cards
- Media not present — The external SD card is missing from the device. Please insert an external SD card or disable the archiving of data (for more information, see Events Data Archive and Continuous Data Archive).
- Media OK — The external SD card is archiving data or is ready to archive data.
- Mounting — The inserted external SD card has been detected and is being prepared for use. (See Insert SD Card for more information.)
- Repairing — The file system on the external SD card is being repaired. This status may occur automatically if the card has become corrupt or damaged. (See Repair SD Card for more information.)
- Safe to remove — The external SD card has been ejected and is no longer in use. It is safe to remove from the device. Note, if the external SD card has not been removed from the device within 10 minutes, the state will change to Mounting.

Media Card — Continuous archive

The status of the continuous data archive.

The possible statuses are as follows:

- Not started — The following conditions will cause the Not started status to display. Note that the external SD card should not be removed while the Media Card — Continuous archive state is Not started:
    - When continuous data archiving is already enabled, while archiving is starting up in response to an external SD card being recognized by the instrument.
    - When the instrument is ready to archive to the external SD card, while archiving is starting up in response to continuous data archiving being set to enabled.
    - Briefly, when archiving stops in preparation for the format, repair or ejection of an external SD card.
- Archive OK — The external SD card is archiving data or is ready to archive data and the latest data was archived successfully.
- No archive media — The external SD card is missing or there is an error writing to the current external SD card. Insert an unlocked SD card, disable the archiving of data, or replace or reformat the current external SD card. If an external SD card is present and this error occurs, the error may be caused by the external SD card being write-protected. In this case remove the external SD card and unlock it before reinserting it. See Write-protection on SD cards.
- Archive error — The archive is corrupted or another error has occurred. Replace or reformat the current external SD card.
- Archive full — The external SD card is full and no more MiniSEED or StationXML data can be archived. Replace the current SD card or delete some of the archived data from the card.
- Disabled — The Centaur has not been configured to archive data files to a removable external SD card.

Media Card — Contains events

Indicates if the removable external SD card contains events.

Media Card — Percentage used

The percentage of the total space used of the removable external media card.

The total size of the removable external media card is shown in the tooltip.

Internal Storage — Status

The status of the Centaur's **internal storage**[1].

The possible statuses are as follows:

- Store recording — The internal storage is functioning correctly and recording data.
- Store reindexing — The index within the internal storage is being recalculated and synchronized with the actual data that is available. Reindexing may take up to 8 hours depending on how much data is in the internal storage. Data will continue to be generated during reindexing and will not be lost. You will not be able to perform any other operations that involve the internal storage until it has finished reindexing.
- Store not ready — The internal storage is not ready for recording because it is being resized, created, reformatted, or re-created.
- Not enough space — There is not enough free space in the internal memory to accommodate the intended full size of the internal storage. It will continue to operate normally with a reduced maximum capacity.
- No Store — The internal storage is corrupt or missing. Please contact Nanometrics Technical Support if you see this status.
- Store wrapping — The internal storage is functioning correctly and recording data but that the store has reached its maximum capacity and is now operating like a ring buffer. When this status occurs, it wraps around and records over the oldest data.

Internal Storage — Size

The size of the internal data store. This information is also displayed on the Summary page. Note that this reported size will be less than the total size of the internal media since some space is reserved for logs and other system files.

Internal Storage — Recording rate

The rate that packets are being written to the internal storage.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

6.1.5 Data

For 6-channel models, the name for each port includes the port identifier (A or B) and the pre-amp gain configuration. For example, for the 6-channel CTR4-6AS/H model, port A is displayed as **A - Standard Gain** and port B is displayed as **B - High Gain**. 3-channel models do not include the port identifier.

> Newly manufactured Centaur models that support high gain channels will ship with these features. For existing high gain Centaur models shipped prior to the release of version 4.6, contact Nanometrics for assistance with upgrading the firmware.

Primary Sample rate

The number of samples acquired every second, in hertz, by the Centaur for the primary channels.

Secondary sample rate

The number of samples acquired every second, in hertz, by the Centaur for the secondary channels (if enabled).

Primary Sensitivity

The system sensitivity for the primary output channels of each sensor. If the primary and secondary channels have the same bit depth and digital gain then their sensitivities will be the same. If the primary and secondary channels do not have the same bit depth and/or digital gain, the sensitivity for the secondary channels can be obtained by downloading the channel system response in RESP, dataless SEED or StationXML format from the **Maintenance** page.

Sensitivity is expressed in counts per m/s^2 for accelerometers such as the Titan or in counts per m/s for seismometers that provide an output proportional to velocity such as Trilliums.

> The sensitivity value that is displayed on the **Health page** may show a slightly different value than the sensitivity value displayed in the response file. For example, on the Health page the sensitivity value 3.01E8 cnt/(m/s) may be displayed as 2.989933E08 in the related response file. The slightly lower value that is shown in the response file reflects the slight attenuation that is due to the output impedance of the seismometer and the input impedance of the Centaur. The response file will contain a response stage that represents this adjustment.

Orientation correction

The status of the orientation correction feature for connected geophysical sensors. Enabled indicates that the orientation correction feature is being used and that the data has been adjusted according to the configured values.

Calibration

The status of calibration for connected sensors. If a calibration is running, this field indicates the time remaining.

Status

The overall status of the connected sensor or sensors (6 channel model). You can view more detailed information on the **Sensors** page.

Control

The status of the controls used to operate the sensors

A status of Unexpected means that one or more of the sensor control settings do not match the saved configuration settings for that sensor. For example, Unexpected is displayed if the XYZ/UVW Mode configuration setting for a sensor is set to **XYZ** but the sensor control is set to **UVW**. You can view more detailed status information for the sensor controls on the **Sensors** page.

Input range

The configured peak-to-peak input voltage range for the port. See "Front End — Input range" for configuration details.

6.1.6 Time

Status

The status of the internal system clock used to timestamp the data produced by the instrument.

The possible statuses are as follows:

- GNSS receiver needs update—The firmware running on the GNSS receiver needs to be updated. To resolve this message, run the "GNSS receiver firmware upgrade utility" on page 167.
- Time Init — The instrument has just powered up and it is attempting to synchronize its time to the configured time source.
- Time OK — The timing quality of the internal system clock is accurate to within the configured specification.
- Antenna short — If either GNSS or GNSS over fiber is the configured time source, the GNSS receiver has detected a short in the antenna.
- No antenna — If GNSS is the configured time source, the GNSS receiver has detected that the antenna is not connected or not drawing a current.
- Time Server Unreachable — The time source is configured to PTP or NTP and a network connection to the time source cannot be made.
- Time error — The time error status will be displayed for any of the following:
    - If either GNSS or GNSS over fiber is the configured time source,
        - the GNSS receiver is unlocked and it is past the initialization stage (the first 10 minutes after the instrument powers up),
        - and the modelled time uncertainty exceeds 1000 µs.
    - If PTP is the configured time source,
        - the configured PTP server is contactable and it is past the initialization stage (the first 90 seconds after the instrument powers up or reconfigured),
        - and the time uncertainty exceeds 1000 µs.
    - If NTP is the configured time source,
        - the configured NTP server is contactable and it is past the initialization stage (the first 5 minutes after the instrument powers up or reconfigured),
        - and the time uncertainty exceeds 5000 µs.

See also Timing Source.

If GNSS satellites are visible, the receiver in the instrument will typically lock and provide **UTC**[1] within one minute. If the instrument has been moved by 100 meters, it may require up to 3 minutes for the lock to occur and in some rare situations it may require up to 13 minutes under the following conditions:

[1]Coordinated Universal Time

- when the instrument powers up for the first time
- after the instrument has been shut down for a long period of time
- when the instrument has been synchronized to something other than GNSS and is now being synchronized to GNSS

The Timing status will be red until a stable UTC time has been obtained.

Uncertainty

An estimate of the time uncertainty of the internal system clock relative to its time source based on factors such as measurement error, clock drift, and temperature fluctuations, for example:

- If the configured time source is GNSS, GNSS over fiber, PTP, or NTP and it has good time, uncertainty is a function of the measurement error between the digitizer clock and the time source.
- If the configured time source is GNSS Duty cycled (and the GNSS is in the off cycle), or if the configured time source is Free running, or if the network time source is not providing good time, the digitizer clock is allowed to drift. In this instance, uncertainty will accumulate at a rate that is a function of temperature fluctuations and the duration of the drift.

For typical time uncertainty based on different time sources, see Timing Accuracy.

GNSS Location

The fields in this section describe the GNSS-derived geographical location of the GNSS antenna including earth location and elevation, and the number of GNSS satellites used to derive the location. GNSS latitude and longitude coordinates are derived using the World Geodetic System (WGS84) reference coordinate system.

Keep the following in mind:

- If the configured **Time source** is not GNSS or GNSS over fiber, the GNSS Location fields will not display.
- GNSS location indicates the location of the GNSS antenna, not the location of the instrument's internal receiver.
- When the GNSS signal is generated over a fiber link, this location can be several kilometers away from the instrument.

See "Timing Source" on page 113 for configuration information.

User-defined Location

The fields in this section describe the user-configured geographical location of the instrument using earth location and elevation.

If the location has not been configured by the user, the User-defined location fields will display "Not configured".

See "Location Configuration " on page 122 for more information.

GNSS satellites

If the configured time source is GNSS or GNSS over fiber, the number of satellites used by the GNSS receiver for position and timing calculation is displayed.

When the instrument starts up, its GNSS receiver needs to lock onto the signals from a minimum of four different satellites to calculate a three-dimensional positional fix, consisting of all three of latitude, longitude, and elevation. If less than four are visible, reposition the antenna so that it has good visibility of the open sky.

Earth location

The latitude and longitude of the GNSS antenna. These values are displayed under **GNSS Location** if GNSS or GNSS over fiber is the configured time source and under **User-defined Location** if Latitude, Longitude and Elevation have been configured.

Elevation

The elevation of the GNSS antenna. These values are displayed under **GNSS Location** if GNSS or GNSS over fiber is the configured time source and under **User-defined Location** if Latitude, Longitude and Elevation have been configured. GNSS uses the World Geodetic System (WGS84) reference ellipsoid / datum to define elevation. With this in mind, elevation is defined as the height above ellipsoid (as opposed to height above mean sea level).

6.1.7  Alerts

The Alerts section provides you with a list of recent system-related events such as start-ups, shutdowns, and configuration changes.

6.2 Monitor Sensor Operation

Use the **Sensors** page to view the mass positions for each connected seismometer, as well as voltage levels for external SOH inputs (if your Centaur has an external SOH input).

Additionally, you can manage some aspects of seismometer operation, and access the Web interface of a Nanometrics smart sensor on the **Sensors** page.

6.2.1 Seismometer Mass Position SOH

Each sensor port on the Centaur has three mass position seismometer SOH inputs and, if enabled, the voltage levels of these inputs are recorded at the configured SOH report interval and displayed on the **Sensors** page. The seismometer mass position SOH values are also included in the Environment SOH group, which you can download from the **Maintenance** page.

You can edit the Sensor SOH settings for any custom sensor configurations that you create and view the Sensor SOH settings for any of the default sensor configurations.

6.2.2 External SOH Inputs

If your Centaur has an External SOH input and you have connected sensors to record analog SOH signals (± 5V), you can see the external SOH values displayed on the **Sensors** page. The SOH input provides three external SOH channels that record voltage levels at the configured External SOH report interval.

External SOH values are included in the Environment SOH group, which you can download from the **Maintenance** page.

This only applies to Centaur models that have an external SOH input. This includes CTR2 series or later model types.

6.2.3 Control

Mass centring is a key function in the control section of the Sensor page. You can also temporarily toggle the axis mode from UVX to XYZ for debugging purposes.

You can control some aspects of sensor operation using the controls on the **Sensors** page. Specific control line settings are required to make some of the controls available and not all controls are available for all sensor types.

If one or more of the sensor control settings do not match the saved configuration settings for that sensor, the status of Unexpected will be displayed in the Data section of the **Health** page. For example, Unexpected is displayed if the XYZ/UVW Mode configuration setting for the sensor is set to **XYZ** but the sensor control is set to **UVW**.
Sensor mode (XYZ or UVW) is configured in **Configuration > Sensor Library**

See Calibrate Sensor for information on how to calibrate a sensor.

Name

Displays the model and serial number of the attached sensor.

Axis

The orientation of the sensor elements.

Control line settings:

- XYZ/UVW On=UVW
  -OR-
  XYZ/UVW Off=XYZ

UVW is the orientation for a symmetric triaxial seismometer.

Period

The operating mode of the sensor. (This applies to models of broadband seismometers that have a control line input that can enable short-period mode.)

The lower corner of the seismometer response can be changed from the normal long-period (LP) operating mode to a short-period (SP) response.

Changing to SP mode is useful when levelling the seismometer, allowing you to see the mass positions quickly respond to changes in tilt, or once the seismometer is levelled, to allow the mass positions to quickly settle. Be sure to leave the seismometer in long-period (LP) mode when recording seismic signals.

Control line setting:

- SP/LP On=SP
  -OR-
  SP/LP Off=LP

This option may not be available for all sensors.

Mass centre

Initiates automatic motorized re-levelling of the internal seismometer, and/or the re-centring of the masses.

Control line setting: Mass Centre

This option may not be available for all sensors.

Mass lock

Locks or unlocks all masses. Some non-Nanometrics broadband seismometers require the internal moving mass element to be locked to prevent damage during transport.

Control line settings (one control line for each setting):

- Mass Lock
  -OR-
  Mass Unlock

This option may not be available for all sensors, and is not required for Nanometrics seismometers.

Automatic mass centring

Indicates whether automatic mass centring is enabled or disabled. Automatic mass centring is disabled by default. You enable automatic mass centring in Configuration settings. For more information, see "Auto Mass Centring" on page 106.

The **Automatic mass centring** field is visible only if you have configured a control line for mass centring.

6.2.4 Nanometrics Smart Sensor - Discovery and Web Interface Access

After you connect a Nanometrics smart sensor (such as a Trillium Compact or a Trillium Posthole) to the Centaur and select it in the Sensor Library for Sensor A or B (6 channel model only), click the **Discover** button on the **Sensors** page to detect it and load the smart sensor details.

After it has been detected, you can access the Web interface of the Nanometrics smart sensor by changing the Serial setting to **A** or **B** and clicking the hyperlink in the name of the sensor.

Accessing the Web interface of a Nanometrics smart sensor through the Centaur can cause low levels of noise on the output signals of the sensor. When serial communication with the sensor is enabled, the Web Interface indicates a status error to alert the user to the potential for additional low-level noise. Disable serial communications when you have finished accessing the smart sensor Web Interface.

6.2.5 Serial Sensor

If a weather station is configured as the Serial Sensor, a Serial Sensor section will display on the **Sensors** page where you can view the sensor name, the time since the last update and a summary of the sensor readings. The Summary portion contains the timestamp from the sensor GPS, wind speed, wind direction, temperature, pressure and humidity. These values are refreshed every 5 seconds. See Configuring the Weather Station for further details.

6.3 Event Detection and Declaration

The channels of the Centaur continuously digitize time series data, which is recorded to the **internal storage**[1]. You can configure the Centaur to stream this time series data to another device or application and/or archive it on a removable external media card. You can also download it from the device using the options on the **Maintenance** page.

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

If you want the Centaur to detect and declare events in addition to continuously recording time series data, you have to enable a detector for one or more of the time series channels and assign a number of votes to all channels with enabled detectors. The Centaur uses the detectors combined with a voting system to declare an event. A detector is an algorithm that is applied to a channel and is based on either a configured threshold value or a configured STA/LTA ratio. As soon as the channel detector detects that the threshold value or STA/LTA ratio has been exceeded, it generates a trigger for that channel. When the Centaur sees this trigger, it counts how many votes are assigned to the channel that generated that trigger. If the number of votes are equal to or higher than the configured number of required votes, an event is declared with the date and time of the trigger. If not enough votes were received from the trigger, then the Centaur waits for additional triggers for a configured period of time to allow for transmission latency. If not enough votes are received within the configured period of time, the triggers are discarded and no event is declared. If enough votes are received, an event is declared and written to the internal storage and posted on the **Events** page. If configured, the time series data for the event is also written to a removable external media card.

Event declaration can happen locally using only the channels of the Centaur or it can happen across a network between multiple devices if you enable the option to share triggers across a network.

You can view information about the declared events on the **Events** page, download them locally from devices in the network, and, if required, you can also manually declare an event. You can check the **Last updated** information in the lower-right corner to see the age of the data.

6.3.1 View and Manage Events

The **Events** page shows you the date and time of each **event**[1] recorded in the **internal storage**[2] as well as the peak ground motion data products, cause and source, and the number of **triggers**[3] for that event. It also shows whether the event has been archived to the removable external media or not. If the Centaur has been configured to automatically archive events to an external SD card, then all declared events will be on the external SD card as well as in the internal storage.

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[1] Seismic activity that is detected and declared by the instrument using a voting system and threshold values or STA/LTA trigger algorithms.

[2] The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

[3] Messages generated by the instrument when the STA/LTA ratio for one or more channels go above the configured trigger on ratio or when the configured threshold value is exceeded. Each trigger is assigned a number of votes (on the source device) that it casts towards getting an event declared.

Download Archived Events

You can download locally to your computer any event that has been archived to the removable external SD card. The available formats depend on the configuration for the events data archive. To download archived events, select the checkboxes next to the events you want to download and then click **Download**.

The archived events are downloaded locally in a compressed file (.zip) that contains all available formats.

> You cannot download events that are only stored in the internal storage on the **Events** page but you can retrieve data from the internal storage on the **Maintenance** page.
> You can download events locally by navigating to the **Events** page and clicking on the **SEED** icon located in the **Download** column.

> To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

Delete Archived Events

You cannot delete events that are only stored in the internal storage but you can delete any events that have been archived to the removable external SD card. You have two options for deleting events:

- You can select the checkboxes next to the events you want to delete and then click **Delete**.
  -OR-
  You can click the **Delete all event archives** button to delete all existing content on the external SD card.

> You have to be logged on using the admin user account to delete all of the event archives on the external SD card and you have to confirm that you want to do it since this action cannot be undone.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

6.3.2 Manually Declare Events

If you know that an **event**[1] occurred but for some reason it was not declared as an event (for example, not enough votes were cast to get an event declared or the voting threshold was set too high), you can manually declare an event on the **Events** page. The manual declaration is based on the historical data stored in the internal storage .

You have to log on using the admin user account before you can declare an event.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

The event will appear in the list of Events on the **Events** page as soon as you click **Declare Event**. You will be able to download it and view the peak ground motion products for the event as soon as it has been successfully retrieved from the internal storage. The **Source** column will help you distinguish automatically declared events from any that have been declared manually (user).

6.4 About Sensor Calibration

Measuring and analyzing a sensor's frequency response may be accomplished by applying an electrical test signal to a connected sensor to simulate ground motion. The form and parameters of the input function (single pulse, PRBS, swept sine, or random noise) will depend on the requirements of the particular software used and on the expected parameters of the sensor under test. Typically, calibration software will calculate the transfer function (amplitude gain and phase shift as a function of frequency) and fit poles and zeros to generate custom response metadata for the sensor being tested. For a high quality broadband sensor, these parameters typically remain stable over time, therefore, if the sensor initially meets manufacturer's specifications and has not suffered damage, then calibration

[1] Seismic activity that is detected and declared by the instrument using a voting system and threshold values or STA/LTA trigger algorithms.

is usually not required. That said, calibration can be a useful quality control check if it is suspected that the sensor may have become defective or damaged after multiple deployments. In addition, if the initial transfer function deviates from the nominal response, it is possible to perform a calibration verification to measure the actual response of the sensor.

The Centaur data recorder generates and outputs an analog signal using a 16-bit internal digital-to-analog converter (DAC). The DAC output is applied to the sensor for calibration purposes through the output pins on the sensor connector (one or more of SEN_CAL1/2/3 pins). To maximize the range of the 16-bit DAC, the Centaur automatically selects and applies the appropriate analog gain or attenuation before outputting the signal, based on the peak amplitude of the desired output signal selected by the operator. The Centaur CTR, CTR2 and CTR3 series models may generate signals of up to ±5 V amplitude. The Centaur CTR4 series models have an enhanced calibration output to enable calibration of a broader range of geophysical sensors including seismic and infrasound sensors. These enhancements include an increased voltage output range of up to ±10 V, a ±30 mA current source mode in addition to the voltage source mode, and improved accuracy and signal quality (see the specifications section for details). Note that when using current source mode for calibration, the calibration signal should be fed into the calibration coil of the individual sensor channels one at a time to avoid dividing the current into undefined proportions.

A synthetic waveform signal generator allows you to generate sine wave, step, and pseudo-random binary (PRB) signals on demand. Along with configuring the sine frequency or PRB pulse width, signal duration and amplitude, you can specify lead in and lead out silence intervals before and after the calibration waveform. You can also select and play a calibration file that contains any other desired digital time series waveform that you have previously uploaded to the Centaur, such as a swept sine wave, step function, random noise, or chained PRB sequence. For playback of calibration waveforms you must configure what gain to apply, the maximum signal duration, and the lead in and lead out silence intervals before and after the calibration waveform. Once calibration is configured, the sensor output can be viewed in the waveform display while it is simultaneously recorded for later analysis.

6.4.1 Calibrating a sensor

You can launch calibration actions manually from the **Waveform** page in the Centaur Web Interface or you can automate calibration using the Calibration API. The following list outlines the main end-to-end steps involved in sensor calibration:

1. Set up equipment for calibration.
2. Configure a calibration sequence using the Web Interface. You can also use the Calibration API **GET /options** request, which provides the calibration options.
3. Initiate a calibration sequence using the Web Interface, or by calling a Calibration API **PUT /calibrate** request.
4. Verify the status at any time during a calibration from the **Waveform** page or the **Health** page using the Web Interface, or by calling a Calibration API **GET /status** request.
5. Stop a calibration sequence using the Web Interface, or by calling a Calibration API **POST /stop** request.
6. Access calibration data.
7. Analyze the data. You can use the retrieved MiniSEED calibration data in your analysis software to determine system parameters such as corner periods, and poles and zeros of the transfer function of the sensor. To compare the measured system response for Nanometrics sensors, you can download the nominal response using the Instrument Response API.

For some Trillium Sensors, the sensor calibration response is the combination of the nominal ground motion frequency response and the calibration input circuit response. Please refer to the seismometer user guide for details.

6.4.2 Setting up equipment for calibration

To setup the equipment for calibrating:

1. Place the sensor in a quiet location (such as a lab) with protection from drafts and temperature change.
2. Level the sensor and allow it to settle. (For seismometers, settling may take anywhere from hours to days.)
3. Connect the Centaur to the sensor, thus connecting the sensor's calibration input and X, Y, Z outputs to the Centaur.
4. Identify the calibration signal amplitude from the signal source that produces a good signal-to noise ratio (SNR) without producing clipping or obvious distortion. (For example, 50% of full-scale at the seismometer outputs.) For velocity seismometers, the calibration signal amplitude may depend on frequency since typically, the calibration input of a seismometer produces an equivalent ground motion that is proportional to acceleration, not velocity.

5. Since sampling rates, sample duration and signal source capability may vary, you may wish to test upper and lower corners, and midrange of the sensor separately.

6.4.3 Configuring a calibration sequence

To configure the calibration sequence for your sensor using the Web Interface, proceed as follows:

> To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

1. Log on to your Centaur using the admin user account. See Logging On to the Web Interface.
2. Navigate to the **Health** page and verify that the sensor is properly connected and levelled. The **Data | Status** field should display *Sensor OK*. (If required, refer to the Sensor Library section of this guide or to the sensor user guide for information on sensor configuration and levelling.)
3. Navigate to the **Waveform** page.

> Before you begin a calibration sequence, make sure that no other calibrations are running. (The **Status** field on the **Waveform** tab should display Inactive.)

4. Select the calibration output source mode and signal type:
    a. For Centaur CTR4 series models, select the calibration output source **Mode** to be Voltage (V) or Current (mA). For all other models, the calibration output source is Voltage (V).
    b. Select a signal **Type**. (Sine, Step, Pseudo-Random Binary, or Playback).
5. Click **Configure** to access the configuration settings dialog box.
6. Choose which sensors and channels to calibrate:
    a. For a 6-channel Centaur, select **Sensor** A or B from the drop-down menu.
    b. From the **Channels** drop-down list, select which channels to calibrate as follows:
        - For Voltage mode, you can calibrate All channels at once, or one channel at a time.
        - For Current mode, you can only calibrate one channel at a time. This option is only available on the Centaur CTR4 series models.

For sensors that do not support single channel calibration, it is recommended that you select **All channels** for calibration. For these sensors, if you do select an individual channel the calibration signal may be applied to all sensor channels or to none of the sensor channels, depending on which channel is selected and on the sensor cable wiring.

7. Select any or all of the following options:

   a. Select the **Create event** check box to create calibration event MiniSEED files that capture the recorded output of the sensors. The duration of this calibration event is based on the duration of the signal file plus the pre-event and post-event times specified on the **Events** configuration page. (See Events) This event will be recorded on the removable SD media card if installed and Event Archiving is configured, as well as in the internal memory. The CTR4-specific captured channel will not be associated with this event but will be recorded.

   b. For all Trillium Seismometers or other symmetric triaxial sensors, select the **Assert UVW mode** check box to orient the sensor to UVW coordinates for the duration of the calibration. Once the calibration is completed, the orientation will revert to the previously configured orientation. If the sensor does not have control lines to set UVW mode, this option will be ignored.

   c. For CTR4 models only, select **Capture** to instruct the Centaur to record the calibration signal output. This allows you to download a time-stamped MiniSEED file of the known calibration signal that can be used to compare with digitized sensor output.
   Sensor A and B calibration recordings are assigned SCNL channel codes HCA and HCB respectively (network, station, and location codes are inherited from the Channel Naming configuration). These channels can be retrieved using the Web Service data download interface (FDSN-WS). They can also be inspected using the Data Availability API and the Calibration API, and are included in the continuous archive by default. Calibration channels are not streamed.

      Calibration capture sensitivity. The signal is captured with a sensitivity of 400 000 counts/volt or 100 000 000 counts/ampere depending on the calibration mode. These sensitivity values are fixed independent of the input range or bit depth or digital gain selected.

8. If you selected the Playback signal type, select the appropriate signal file from the **Filename** drop-down menu.

> **Using Playback Type**. You can use Playback to calibrate your sensor with a generated signal file, a prerecorded signal file or a calibration signal file that you have created. The duration of this type of calibration should be at least four times the longest period tested and the sample rate should be 6 to 10 times larger than the highest frequency tested. Files should be created and uploaded before you begin to configure the calibration using this method. See About calibration signal files.

9. Configure the desired signal characteristics. For Centaur CTR4 models, see Centaur CTR4 models - Signal characteristic configuration otherwise see Signal characteristic configuration for all other Centaur models

    - Note that PRB creates a broadband signal allowing the calibration verification of the entire passband with a single input signal, which is preferred for Trillium sensors. The following signal characteristics are recommended for Trillium 120s sensor models (**All channels** selected for calibration and **Assert UVW** option selected):

        - Mode: Voltage
        - PRB width: 20 ms
        - PRB amplitude: 0.075 Volts
        - Duration: 10 hours (36000 s is max duration)
        - Lead in: 5 s
        - Lead out: 5 s

      The following are the recommended digitizer settings for these calibration signal characteristics:

        - Sample Rate: 500 sps
        - Digitizer Sensitivity: 40 Vpp

10. Configure silence padding before and after the calibration signal. Enter a value between 0 and 3600 seconds in the **Lead In (s)** and **Lead Out (s)** fields.
11. Configure the calibration duration:
    a. For Sine, Step or PRB, enter a value for **Duration (s)** up to 36000 s (10 hours). The default duration is 300 s.

b. For Playback, to limit the file duration, enter a value that is less than the default duration. The default duration is the entire length of a selected calibration signal file.

12. Click on the **OK** button to close the Configuration settings dialog box and save the settings.

Centaur CTR4 models - Signal characteristic configuration

Mode	Type	* Amplitude (V or mA)	Frequency (Hz)	Pulse width (ms)	Gain	** Signal file
Voltage	Sine	±0.0025 to 10	0.001 to 1000	---	---	---
Voltage	Step	±0.0025 to 10	---	---	---	---
Voltage	PRB	±0.0025 to 10	---	1 to 10000	---	---
Voltage	Playback	---	---	---	*** ±0.0005 to 2	Select signal file
Current	Sine	±0.015 to 30	0.001 to 1000	---	---	---
Current	Step	±0.015 to 30	---	---	---	---
Current	PRB	±0.015 to 30	---	1 to 10000	---	---
Current	Playback	---	---	---	**** ±0.0005 to 1	Select signal file

* 1 V Amplitude corresponds to 1 V peak voltage and 2 V peak-to-peak voltage.
** The signal file must be present before you can configure the calibration sequence. See About calibration signal files.
*** A gain of 1.0 will output a 5 V signal for a full-scale value in the calibration signal file.
**** A gain of 1.0 will output a 30 mA signal for a full-scale value in the calibration signal file.

Signal characteristic configuration for all other Centaur models

Mode	Type	* Amplitude (V)	Frequency (Hz)	Pulse width (ms)	Gain	** Signal file
Voltage	Sine	±0.0025 to 5	0.001 to 1000	---	---	---
Voltage	PRB	±0.0025 to 5	---	1 to 10000	---	---
Voltage	Playback	---	---	---	*** ±0.0005 to 1	Select signal file
Voltage	Step	±0.0025 to 5	---	---	---	---

* 1 V Amplitude corresponds to 1 V peak voltage and 2 V peak-to-peak voltage.
** The signal file must be present before you can configure the calibration sequence. See About calibration signal files.
*** A gain of 1.0 will output a 5 V signal for a full-scale value in the calibration signal file.

6.4.4 Initiating a calibration sequence

Once the calibration sequence has been configured, proceed as follows to initiate the calibration:

1. Click the start calibration button ▶. It will take 20 to 30 seconds before calibration start is indicated on the Web interface. If an error is displayed indicating that the calibration failed to start, click the start calibration button again.

   While the calibration is running, the displayed status is Active, and the Start and End times for the calibration are displayed. In addition, Calibration time remaining is displayed on the **Health** page.

> Once calibration starts, a small signal offset might be generated for between 1 and 2 s as the calibration signal is driven precisely at the top of second.

2. If you selected the **Create Event** option, once the calibration is complete, you will be able to download the calibration event from the **Events** page. (A calibration event will display *Calibration @* in the **Cause @ Source** column.)

6.4.5 Stopping a calibration sequence

To stop an active calibration before it has completed:

1. Click the stop calibration button ■ . The calibration signal will stop after 5 seconds and the configured lead out silence padding will be ignored.
2. If you selected the **Create Event** option, once the calibration is complete, you will be able to download the calibration event from the **Events** page. (A calibration event will display *Calibration @* in the **Cause @ Source** column.)

6.4.6 Accessing calibration data

You can access the resulting calibration information using any of the following methods:

- If the **Create event** option was selected, you can:
  - View the calibration event from the **Events** page
  - Download the MiniSEED files directly from the **Events** page
  - Copy the MiniSEED files from the events directory of the removable SD card
- You can retrieve the calibration history by calling a Calibration API **GET /calibrate** request:
  - For CTR4 models only, if the **Capture** option was selected, you can download a MiniSEED file of the known calibration signal that can be used to compare with digitized sensor output.

    Calibration capture sensitivity. The signal is captured with a sensitivity of 400 000 counts/volt or 100 000 000 counts/ampere depending on the calibration mode. These sensitivity values are fixed independent of the input range or bit depth or digital gain selected.

  - Using the Web Service data download interface (FDSN-WS) API You can download from the Store, specifying the sensor channels and for CTR4 models, the recorded calibration signal (HCA or HCB), and the start and end times that were returned from the GET /calibrate call that corresponds to the calibration sequence of interest.

6.5 View Digitized Waveforms in Near Real Time

You can see the sensor signals being recorded by the Centaur in near real time by viewing the digitized waveforms on the **Waveform** page. One horizontal signal line is displayed for each channel of the Centaur on a data plot with a time scale.

> If you attempt to view waveforms on more than two Web Interfaces at the same time, the error message "An error occurred receiving waveform data" will be displayed.

If the sensor needs to be calibrated, you can also perform a sensor calibration from this page. See Sensor calibration.

6.5.1 View Waveform Data

The **Waveform** page shows a horizontal signal line, or trace, in near-real time for each channel of the Centaur. To ensure that waveforms are displayed correctly, make sure that you have installed one of the following browsers: Chrome version 16 or newer, Firefox version 11 or newer, or Safari version 7 or newer.

> If you attempt to view waveforms on more than two Web Interfaces at the same time, the error message "An error occurred receiving waveform data" will be displayed.

The trace is displayed with any DC offset removed, for ease of viewing when a large DC offset is present in the signal. (This is for display only and does not alter the signal that is actually recorded or streamed.) The traces all begin and end at the same time and the starting time is shown in the lower-left corner of the data plot with time increasing to the right. The current time scale is shown at the bottom of the data plots between the current time and the plus and minus buttons. You can click the plus and minus buttons to increase or decrease the time scale.

- Click the pause button at the bottom of the data plot or click any of the traces to pause the traces. The colour of the traces changes to blue when paused.
- Click the rewind or fast forward button or click and drag the cursor on a trace to move back and forward in time. The amount of data buffered will limit how far back in time you can go.

- The **SCNL**[1] and sample rate is shown in the upper-left corner of each trace plot as well as the mean, RMS, minimum, and maximum. You can use the mean value to configure the Channel offset setting.

6.6 Perform Maintenance Tasks

From time to time, you might have to perform simple maintenance tasks to ensure that your Centaur continues to operate correctly. These tasks include manually setting instrument time, upgrading the firmware, and retrieving time series, SOH, or response files from the Centaur's **internal storage**[2] or archives on the external SD card. You can perform these tasks on the **Maintenance** page as well as download log files, format or repair the external SD card, restart/shut down the Centaur, and reindex or re-create the Centaur's internal storage.

You have to be logged in with the admin user account to perform any of the tasks on the **Maintenance** page.

To increase the security of your network and to significantly reduce the risk of unauthorized access to your Centaur, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

You should only click **Shutdown** on the Maintenance page if you are in the same location as the Centaur because it is not possible to power it up remotely.

6.6.1 Setting Instrument Time

If the configured Time source is Free running, you can manually set the instrument time to a given value or perform a one-time synchronization of the Centaur time to a configured NTP server.

To manually set the instrument time:

1. Access the Web Interface for your Centaur and navigate to the **Instrument Time** section on the **Maintenance** page.

[1] Station, Channel, Network, Location names

[2] The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

2. Enter the date (yyyy-mm-dd) and time (hh:mm:ss)
3. Click the **Set time** button. The instrument time will be synchronized to the configured date and time. The instrument time will then free-run.

To set the instrument time by synchronizing to a configured NTP server:

1. Access the Web Interface for your Centaur and open the **Configuration** dialog box.
2. Select **Timing and Location** from the left pane. Make sure that **NTP server address** is configured.
3. On the Web Interface, navigate to the **Maintenance** page, **Instrument Time** section.
4. Click the **Set time using NTP** button. The instrument time will be set by synchronizing it once to the configured NTP server. The instrument time will then free-run.

See "Timing Source" on page 113 for information about configuring timing.

6.6.2 Upgrade Firmware

Before you upgrade the firmware on your Centaur, refer to the release notes for the specific firmware version for recommendations and special considerations.
The **Delete** button on the **Maintenance** page is used to delete the firmware installation package. The actual firmware will not be deleted. If a firmware installation package does not exist on internal storage, then the **Delete** button is disabled.

To upgrade or install your firmware, follow the procedure below:

1. Before you begin, go to Nanometrics support site (http://support.nanometrics.ca) to obtain the latest firmware upgrade package (.tgz file) and download it to your computer.
2. Access the Web Interface for your Centaur and navigate to the Firmware section on the **Maintenance** page.
3. If required, click the **Commit** button to make the active firmware permanent.

If the currently loaded firmware has already been committed the **Commit** button is disabled. You can also verify if the firmware is committed from the Device section on the **Health** page.

4. If the **Available firmware** field displays the version number of a previously uploaded installation package, click the **Delete** button to remove the installation package from your Centaur. If no installation package is present, the **Available firmware** list is disabled.

> Only one installation package can be present on the Centaur. The previous version must be deleted before you can upload the latest firmware installation package.
> Deleting a previously uploaded firmware installation package will not affect the operation of your Centaur.

5. Upload and commit the latest firmware to your Centaur:
   a. Click the **Choose file** button to select the new firmware installation package to upload to the Centaur.
   b. Click the **Upload** button. A message will be displayed if the upload is successful.
   c. Click the **OK** button to confirm the upload and select the release from the **Available firmware** list.
   d. Click the **Apply** button to temporarily install the firmware. Your upgrade must be applied before it can be committed. The progress of the installation is shown in the installation log.

      > This operation will take several minutes. The Centaur will restart automatically after it has completed installing the firmware. You should not navigate away from the **Maintenance** page until the Centaur has completed installing the firmware and the device has restarted.

   e. After the Centaur has restarted, navigate to the Firmware section on the **Maintenance** page and click the **Commit** button to ensure the newly upgraded firmware is installed.

> **As a fail-safe measure for instrument recovery.** In the case of a failed configuration operation, Centaur will automatically reboot and revert to the previously committed configuration 1 hour after the Apply command has been used if no Commit command is received.

6. The installation package is no longer required once the firmware has been committed to the Centaur. Click the **Delete** button to remove the firmware installation package from your Centaur.

Deleting the firmware installation package will not affect the operation of your Centaur.

6.6.3 Retrieve Data from the Internal Storage

In addition to streaming data from the Centaur to a network device and archiving data to the removable external SD card, you can also retrieve time series and SOH data directly from the Centaur's **internal storage**[1] by downloading it from the **Maintenance** page to your computer.

When you specify the date and time range of the retrieval, remember that the internal storage wraps around when it is full and records over the oldest data. The frequency with which the internal storage wraps is shown in the Internal Storage section on the **Health** Page.

Only one data retrieval request can be run from one Centaur at any time. Any subsequent retrieval requests will be processed when the current download has finished.

SOH floating point values, such as Sensor SOH Voltage, External SOH Voltage, Supply Voltage and Total Current that are included in downloaded data files are recorded with more digits of precision than necessary and do not reflect the actual precision of the measurement.

Retrieving MiniSEED Data from the Internal Storage

MiniSEED records that are downloaded from the **Maintenance** page within a single MiniSEED file are sequenced with a 6-digit number. Once this 1 million record limitation is reached, the numbering sequence will start over resulting in non-unique record numbers. Some tools may not be able to open a single file that contains more that 1 million records. Once you have selected which MiniSEED data to retrieve from internal storage, the Centaur will display an error message if it determines that the data retrieval request may exceed 1 million records.

Use the following recommendations to configure a data request that will download fewer than 1 million MiniSEED records in one file:

- Choose a different **Data file length** (One file is recommended)
- Select fewer channels for a data retrieval download

[1]The device writes all of the data it receives to its Primary Internal Storage. The internal storage works as a ring buffer and it wraps around when it is full and records over the oldest data.

- Decrease the **Time range** for data retrieval

The error message will disappear once the number of requested MiniSEED records falls below 1 million. Click on the **Download** button to retrieve the requested data.

6.6.4 Download Log Files

If required for troubleshooting purposes, you can view the system logs for your Centaur by clicking **Log files** in the **Download files** section on the **Maintenance** page. Once the log file is displayed, typically, you can save the system log as a *.txt file by right-clicking anywhere on the window. Note that this method is available if you use Nanometrics-recommended browsers. Other browsers may use a different method for saving.

6.6.5 Download Archive Files

If an external SD card is present and configured to archive continuous and/or event data, and SOH data, you can periodically download archive files.

From the **Maintenance** page, in the **Download Files** section, click **Archive files**.

The archive opens in a separate tab in your browser where you can select the files you wish to download.

The **.store** directory on the SD card is the file system reserved by the Centaur for backup storage. Do not delete the .store directory or modify files within the directory. The best way to protect your data is to configure continuous archiving to your external SD card. For more information, see About Data Storage.

Continuous data are stored in directories labelled by date. Event data are contained in the **events** directory. If you have enabled SOH in either or both continuous and event archives, you will see an **soh** subdirectory in these archives.

Archive files can only be downloaded one file at a time using this method. As an alternative, you can download multiple files using secure FTP and an FTP client of your choice.

Unexpected Data in Archive Files

An unexpected power cut may cause a small amount of garbage data (approximately 32 kB) to be added to an archive file that is being written at the time of the power cut. This garbage data may appear as a series of '0's. If the SD archive media has been used previously, the data may appear as random values. This irrelevant garbage data may affect the readability of the resulting archive file by some software tools.

6.6.6 Download Channel Response Files

Response files allow you to access the transfer function response information for your instrument. These files, which describe the signal input/output response of a sensor and a digitizer, can be retrieved in dataless SEED, RESP (readable text), or StationXML format.

Note that dataless SEED and RESP files comply with SEED format version 2.4. For more information on SEED see (https://www.fdsn.org/media/_s/publications/SEEDManual_V2.4.pdf).

You can download response files from the following locations:

- For the current instrument configuration, including any attached Nanometrics seismometer, directly from your Centaur:
  - on the **Maintenance** page as described below, or
  - using the Instrument Response API.
- For a set of standard configurations:
  - From Nanometrics' customer support site at http://support.nanometrics.ca.
  - From the IRIS DMC Library of Nominal Responses for Seismic Instruments at http://ds.iris.edu/NRL/.

To download channel response data directly from the instrument:

1. From the **Maintenance** page, in the **Channel Response** section, select the desired file format from the **Choose response file format** drop down list.
2. Click the **Download** button. A zip file containing one response file for each channel will be downloaded to your browser's download location.

You can also use the Instrument response API to download overall instrument response.

Note that response files that are downloaded from the Centaur reflect the configuration of the Centaur at the that time the download is initiated, including SCNL, geo-location, and the response of

Nanometrics sensors that are shown on the Web Interface **Sensors** tab. The **Start-time** field is filled in with the time that the response creation request was made and the **End-time** field remains blank. Geo-location is included in the Dataless SEED format but not the RESP format, and uses the manually-configured geo-location if configured, otherwise the GNSS-derived geo-location if available.

Since the creation of the StationXML and the MiniSEED dataset are independent, it is recommended that you edit the start and end times in the StationXML to coincide with the corresponding MiniSEED dataset before importing the data into the analysis tool.

If the configured sensor response is undefined, for example if the configured sensor is a non-Nanometrics sensor, a unity sensor response will be used by default.

6.6.7 Removable Media

The **Removable Media** section on the **Maintenance** page provides:

- information about the status and the percentage of memory used on your external SD card.
- the ability to remotely re-format your external SD card in FAT32 format.
- a repair function that runs a file system check on your external SD card.

Nanometrics recommends that you attempt to Repair your external SD card before attempting to reformat it. The Format SD Card option should be used as a last resort as any previously saved data will be deleted from the external SD card when the card is reformatted.

Format SD Card

Format your external SD card by selecting FAT32 and clicking **Format** on the **Maintenance** page. Any data on your external SD card is permanently deleted and a new file system is set up for reading and writing data.

Repair SD Card

When you repair your external SD card by clicking the **Repair** button on the **Maintenance** page, Centaur runs a file system check on your external SD card and repairs the file system, if possible.

6.6.8 Perform Maintenance on the Internal Storage

Typically, you only need to perform internal storage maintenance tasks when instructed to do so by Nanometrics Technical Support for troubleshooting purposes. These tasks involve using Internal Storage Tools on the **Maintenance** page to reindex or re-create the data Store, which is located in internal storage media. For more information about internal storage, see About Data Storage.

Reindexing the Store

To reindex the Store, which is located on the internal storage media, click **Reindex** on the **Maintenance** page. The index within the Store is recalculated and synchronized with the actual data that is available. Reindexing might take a long time depending on how much data is in the Store. Data will continue to be generated during reindexing and will not be lost.

Re-creating the Store

To re-create the Store, click **Re-create** on the **Maintenance** page. All data in the Store is permanently deleted and a new Store is created.

In the event of internal storage failure

In the event of internal storage failure, the Status LED flashes red on the instrument and there will be a warning message on the **Health** page indicating that data is being written to a temporary location in RAM.

The backup Store in RAM is primarily used to backfill a limited amount of data lost during network outages for deployments using continuous streaming.

Any configured streamers are unaffected by internal storage failure.

What should I do?

- Contact Nanometrics Technical Support. Support staff will instruct you about your next steps, which may involve re-indexing or re-creating the Store, or replacing your flash storage media.

6.6.9 Restart/Shut Down a Centaur

Read the information in this topic carefully before you shut down or restart your Centaur from the **Maintenance** page.

Shut Down a Centaur

You should only click **Shutdown** on the Maintenance page if you are in the same location as the Centaur because it is not possible to power it up remotely.

Before initiating a system shut down, navigate to the **Health** page to verify the Internal Storage — Status. Initiating a system shutdown while the Store is being recreated can result in the Store being corrupted. If the Store has become corrupted, delete the Store and restart the Centaur to allow normal operation. Contact techsupport@nanometrics.ca for instructions on deleting the Store.

You should shut down a Centaur before you disconnect the power to avoid the possibility of a lengthy reindexing of the internal storage on restart.

When you click **Shutdown**, all data files are closed and saved and the Web server is shut down so that no data is lost when the power is disconnected. You can disconnect the power to the Centaur when all of the LEDs on the case have turned off.

Restart a Centaur

In general, you should only click **Restart** on the Maintenance page if instructed to do so by a Nanometrics representative for troubleshooting purposes. Recording and communications will be interrupted while the Centaur is restarting.

6.6.10 GNSS receiver firmware upgrade utility

This command line utility allows you to upgrade the GNSS receiver firmware if the Time Status field displays the message **GNSS receiver needs update**.

Use the following steps to run this command line utility:

1. Apply power to the Centaur and allow it to boot up completely.
2. Using an SSH client such as PuTTY, log on to your Centaur with your root login name and password.

3. To upgrade the GNSS receiver firmware and restore normal operation, run the commands
   - "`echo performance > /sys/devices/system/cpu/cpu0/cpufreq/scaling_governor`"
   - "`/usr/bin/nanometrics/upgrade_trimble_smt360.sh --default`"
   - "`reboot`"

In the unlikely event that the utility fails, run the command again.

Example of a successful upgrade

```
root@centaur-3-5003:~# /usr/bin/nanometrics/upgrade_trimble_smt360.sh --default
upgrade-trimble-smt360[2060]: Stopping applications for exclusive GNSS module
access and reduced load, a reboot will be required to restore normal operation
startstop: /usr/bin/appman is asking monit to perform the stop action on target
appman-all
I 15:47:50 main trimble-smt360-upgrader (1.0.0) Copyright (c) Nanometrics Inc.
2010-2019
I 15:47:50 main Built: Dec 3 2019 17:22:54
I 15:47:50 Upgrader Target is in remote download mode
I 15:47:50 Upgrader Upload of new firmware initiated
I 15:50:56 Upgrader Upgrade complete
I 15:50:56 Upgrader Target reset
I 15:50:56 main trimble-smt360-upgrader exiting (0)
upgrade-trimble-smt360[2411]: Factory reset target's EEPROM
```

7.0 Application Program Interfaces (APIs)

The following HTTP-based APIs are available for the Centaur.

- Data Availability API
- FDSN-WS Data Retrieval API
- State of Health API
- Instrument Response API
- User Authentication API
- Calibration API
- QSCD20 Retrieval API

Syntax

- Unless indicated otherwise, the APIs use HTTP GET requests to retrieve information.
- Requests consist of a path followed by a set of zero or more parameters. The first parameter in the set is prefixed with "?". Each subsequent parameter is prefixed with "&".
  Format: `path?first_parameter&next_parameter&next_parameter&...`
  Example using 2 parameters: `/api/v1/bands/availability?dataSource=centaur-6__0007&type=timeseries`
- Unless indicated otherwise, all parameters are optional. Optional values are given in the format {a|b}. The curly braces and vertical bar indicate the options and are not part of the API request.
- Note that APIs where all parameters are optional require the use of at least one parameter to return data.
- The use of ***bold-italics*** indicates the default value of an optional parameter.

7.1 Data Availability API

The Data Availability API provides the means for custom scripts and applications to retrieve data availability information from Centaur. Requested data is defined by selecting a path to determine the data source (band or channel). The data is further defined by selecting data source, data type and time option parameters. The response data is provided in JSON format and indicates ranges of time for which contiguous data is available on the instrument's primary, internal media.

Paths

Use the following path to return data from a device using the bandId/instrumentID parameter.

`/api/v1/bands/availability.json`

Use the following path to return data from a device using the channels parameter.

`/api/v1/channels/availability.json`

`.json` is part of the path. If you specify any parameters, you must remove `.json` from the API request.

Parameters

type

Use this parameter to specify data type.

Format: `type={`***`all`***`|soh|timeSeries}`

Select

- `all` to return all data types.
- `soh` to return only State of Health data.
- `timeSeries` to return only timeSeries data.

Example snippet: `type=all`

bandId/instrumentID

Use this parameter to specify a band or instrument data source.

Format1: `bandId=instrumentId_SN/band/timeSeries1`

Example snippet: `/api/v1/bands/availability?bandId=centaur-6__0107/band/timeSeries...`

Format2: `dataSource={instrumentId_SN|NX.STN}`

Example snippet: `/api/v1/bands/availability?dataSource=centaur-6__0007&type=timeseries...`

Notes:

- Network.Station format only works with SEEDLink bands.
- Binder lookups are not performed.
- Multiple bandId parameters or instrumentID parameters are permitted.

channels

Use this parameter to specify a channel data source. Note that a binder is required.

Format: `channels={NX.STN.*}`

Example snippet:
`/api/v1/channels/availability?channels=XX.*.*.*&type=timeseries...`

Notes:

- Uses channel naming configuration in internal Binder.
- If this parameter is omitted, information for all available channels is returned.
- SOH channels return a modifier on the end of the channel name to differentiate between potentially different data that is available for different SOH types.
- Refer to “Channel list” in the Apollo Server User Guide for the format for specifying SCNL elements in a filter.

view

Use this parameter to trim returned data.

Format: `view=trimmed`

Example snippet: `view=trimmed`

Notes:

- Time ranges are trimmed to the time defined by the Time parameter.
- Sequence numbers are removed.

Time

Use this parameter to specify the ISO8601 time option.

Format: `{start|end}Time=yyyy-MM-ddTHH:mm:ss.sssZ`

Select:

- `start` to define the start time for retrieving data using the ISO8601 standard.
- `end` to define the end time for retrieving data using the ISO8601 standard.

Example snippet: `startTime=yyyy-MM-ddTHH:mm:ss.sssZ`

Notes:

- Milliseconds (.sss) are optional.
- Time is expressed in accordance with the ISO8601 standard.
- The Z indicates UTC (Zulu) time zone, non-UTC time zones are not supported.
- If you do not specify an end time, then it is assumed that the end time is the current time.

Millis

Use this parameter to specify the Milliseconds time option.

Format: `{start|end}Millis=#############`

Select:

- `start` to define the start time for retrieving data in Milliseconds.
- `end` to define the end time for retrieving data in Milliseconds.

Example snippet: `startMillis=1371686400000&endMillis=1371772800000`

Notes:

- Since 1970
- If you do not specify an end time, then it is assumed that the end time is the current time.

Nanos

Use this parameter to specify the Nanoseconds time option.

Format: `{start|end}Nanos=##################`

Select:

- `start` to define the start time for retrieving data in Nanoseconds.
- `end` to define the end time for retrieving data in Nanoseconds.

Example snippet: `startNanos=1371686400000000000&endNanos=1371772800000000000`

Notes:

- Since 1970
- If you do not specify an end time, then it is assumed that the end time is the current time.

Examples

This section provides examples of requests. Availability information for the requested data source and time period (or all if unspecified) is returned. The date and time in the returned data is in ISO8601 format, including nanoseconds. For instance, the combined date and time format is 2013-06-25T10:32.26.000000000Z.

Note that "ranges" in output indicate gaps in the data. Several ranges in an output could indicate a problem.

bandId/instrumentId

http://10.10.10.10/api/v1/bands/availability?type=timeseries&startTime=2013-06-21T12:00:00.000Z

http://10.10.10.10/api/v1/bands/availability?dataSource=centaur-6__0007&type=timeseries&startTime=2013-06-21T00:00:00Z

http://10.10.10.10/api/v1/bands/availability?dataSource=centaur-6__0007&type=timeseries&startMillis=1371686400000&endMillis=1371772800000

Trimmed example of the JSON data returned for bandId/instrumentId (... indicates where the data would continue)

```
{
      “availability”: [
            {
                  “id”: “centaur-6_0069/band/timeSeries1”, “ranges”: [
                        {
                              “startTime”: “2013-06-18T17:03:31.180000000Z”,
                              “endTime”: “2013-06-19T15:01:44.035000000Z”
                        },
                        {
                              “startTime”: “2013-06-19T15:01:59.350000000Z”,
                              “endTime”: “2013-06-19T22:27:50.760000000Z”
                        }
                  ]
            },
            {
                  “id”: “centaur-6_0069/band/timeSeries2”, “ranges”: [
                  ...
```

channels

http://10.10.10.10/api/v1/channels/availability?type=timeseries&startTime=2013-06-21T12:00:00.000Z

http://10.10.10.10/api/v1/channels/availability?channels=XX.*.*.*&type=timeseries&startTime=2013-06-21T00:00:00Z

http://10.10.10.10/api/v1/channels/availability?channels=!XX.*.*.*&type=timeseries&startMillis=1371686400000&endMillis=1371772800000

Trimmed example of the JSON data returned for channels (... indicates where the data would continue)

```
{
      “availability”: [
            {
                  “id”: “CI.ADO/BHZ”, “ranges”: [
                        {
                              “startTime”: “2013-06-18T17:03:31.180000000Z”,
                              “endTime”: “2013-06-19T15:01:44.035000000Z”
                        },
                        {
                              “startTime”: “2013-06-19T15:01:59.350000000Z”,
                              “endTime”: “2013-06-19T22:27:50.760000000Z”
                        }
                  ]
            },
            {
                  “id”: “CI.ADO/BHN”, “ranges”: [
                  ...
```

7.2 Web Service data download interface (FDSN-WS)

This web service interface allows you to download recorded time series sensor data and SOH data in MiniSEED format. The API is compliant with FDSN-WS Specifications version 1.1. See http://www.fdsn.org/webservices/FDSN-WS-Specifications-1.1.pdf for complete details.

The *fdsnws-dataselect* service currently supports the following methods:

- *query*
- *version*
- *application.wadl*

The following required parameters of *fdsnws-dataselect* service are supported:

- *starttime*
- *endtime*
- *network*

- *station*
- *location*
- *channel*

The following optional parameters are not supported at this time.

- *quality*
- *minimumlength*
- *longestonly*
- *format*
- *nodata*

Example snippet:

```
/fdsnws/dataselect/1/query?network=XX&station=S0001&location=*&channel=ZZZ&star
ttime=2015-05-20T18:21:00.000&endtime=2015-05-20T18:22:00.000
```

7.3 State of Health API

Use this API to retrieve the current status of all SOH channels on the specified instrument in JSON format. This API also allows you to share the information with other applications such as external reporting tools. For a listing of the SOH data that can be streamed via SEEDLink or downloaded in MiniSEED format, see "SOH channels in Steim compressed formats" on page 209.

Path

```
/api/v1/instruments/soh
```

Parameters

instrumentId

Use this parameter to specify the target instrument.

Format: `instrumentId=[instrumentId]`

Example snippet: `instrumentId=centaur-6__0242`

Notes:

- If you do not specify an instrument, the instrument will report its own SOH.

pretty

Use this parameter to retrieve the data in human-readable format.

Format: `pretty={true|false}`

Select:

- `true` to output the requested data in human-readable format.
- `false` to output the requested data in machine language.

Example snippet: `pretty=true`

SOH channels

SOH Channel Name	Description	Statuses	Units
config/commitState	Indicates whether or not the configuration has been committed. This is displayed on the **Health** page.	committed uncommitted	
controller/store/storePercentageUsed	The percentage of the total space available in the store that has been used.		percent-age
controller/store/storeRecordingStatus	The status of the internal Store. During regular operation the statuses “recording” and “wrapping” are returned. While the store re-indexes, the warning status “re-indexing” is returned. The remaining states are error or warning statuses.	recording wrapping re-indexing read only not ready no store not enough space temporary location	
dataArchive/status	The status of the continuous archiving feature. This is displayed on the **Health** page.	archive not started ok error media full media not present disabled	
dataArchive/status/events	The status of the event archiving feature. This is displayed on the **Health** page.	archive not started ok error media full	

SOH Channel Name	Description	Statuses	Units
		media not present disabled	
digitizer/sensor/status#_0	In the **Sensor Library**, for Sensor A, if the absolute value of any enabled and monitored sensor SOH is above the low threshold, the status “error” is returned, otherwise the status is “ok”.	ok error	
digitizer/sensor/status#_1	In the **Sensor Library**, for Sensor B, if the absolute value of any enabled and monitored sensor SOH is above the low threshold, the status “error” is returned, otherwise the status is “ok”.	ok error	
externalSoh/voltage#_1	The voltage recorded for the Channel 1 external SOH input. This is displayed on the **Sensors** page.		micro-Volts
externalSoh/voltage#_2	The voltage recorded for the Channel 2 external SOH input. This is displayed on the **Sensors** page.		micro-Volts
externalSoh/voltage#_3	The voltage recorded for the Channel 3 external SOH input. This is displayed on the **Sensors** page.		micro-Volts
gps/numberOfSatellites	The number of satellites used by the timing solution. If the GNSS receiver status is off as indicated by the GST SOH channel, the last known value is preserved. See "SOH channels in Steim compressed formats" on page 209 for further information on the GST SOH channel.		
instrument/earthLocation	The GNSS location of the instrument.		
instrument/systemInfo/firmwareStatus	Indicates whether or not the current firmware has been committed. If the firmware has not been committed, status “testcode” is returned. On the **Maintenance** page, the Commit button is disabled (grayed out) if the firmware has been committed.	ok testcode	
instrumentStatus	The highest status severity of the following channels is reported: • config/commitState • controller/store/storeRecordingStatus • dataArchive/status • dataArchive/status/events • digitizer/sensor/status#_0 • digitizer/sensor/status#_1 • instrument/systemInfo/firmwareStatus	ok warning error	

SOH Channel Name	Description	Statuses	Units
	• media/status/* (all media status channels) • powersupervisor/state • sensor/controlLines/state#_0 • sensor/controlLines/state#_1 • timeStatus The status is displayed on the web page in the top banner and is indicated by the Status LED on the instrument.		
media/freeSpace/removableSD	The space available on the external SD card. If the external SD card is not mounted, the value will be -1.		bytes
media/status/removableSD	The status of the external SD card. The statuses "repairing", "formatting", "mounting" and "ejecting" describe an action being performed on the external SD card.	ok error not present repairing formatting mounting ejecting ejected	
powerSupply/voltage	The supply voltage for the digitizer. This is displayed on the **Health** page.		Volts
sensor/controlLines/state#_0	For Sensor A, if the Control settings on the **Sensors** page match the settings configured in the Sensor Library for the selected sensor, "`expected`" will be returned, otherwise "`unexpected`" will be returned.	expected unexpected	
sensor/controlLines/state#_1	For Sensor B, if the Control settings on the **Sensors** page match the settings configured in the Sensor Library for the selected sensor, "`expected`" will be returned, otherwise "`unexpected`" will be returned.	expected unexpected	
system/current	The amount of current consumed by the system.		Amperes
systemSoftwareVersion	The current firmware version. This is displayed on the **Health** page.		
temperature	The internal temperature of the digitizer. This temperature may be several degrees higher than the ambient temperature.		degrees celsius
timeStatus	The status of the timing subsystem.	time ok time error time init free running	

SOH Channel Name	Description	Statuses	Units
		no PTP server no antenna antenna short	
timing/lastLockTime	Reports the last second that the instrument's internal clock was locked to the timing source. The internal clock is locked to the timing source when the status of the "timing/phaseLock" channel is "coarse lock" or "fine lock".		UTC time
timing/phaseLock	Indicates the GNSS Phase-lock loop (PLL) status of the instrument's internal clock.	no lock coarse lock fine lock free running	
timing/timeError	The difference between internal system clock and the selected timing source.		nano-seconds
timing/timeQuality	A heuristic time quality value.		percent-age
timing/timeUncertainty	An estimate of the time uncertainty of the internal system clock relative to its time source based on measurement error, clock drift, and temperature fluctuations.		nano-seconds

7.4 Instrument response API

Use this API to download overall instrument response of the Centaur and the attached Nanometrics sensors. The response is based on the current instrument configuration. For Centaur the sensor library contains response information for all Nanometrics sensors. See Download Channel Response Files for more details.

> If the configured sensor response is undefined, for example if the configured sensor is a non-Nanometrics sensor, a unity sensor response will be used by default.

By default a zip file containing individual channel responses is provided, but it is possible to request a single response file containing all non-SOH channel responses (see "Parameters" on the next page) Parameters section below).

Paths

Use the following path to return a StationXML file:
`/api/v1/responses/channels.xml`

Use the following path to return a dataless SEED file.
`/api/v1/responses/channels.dataless`

Use the following path to return an IRIS RESP file.
`/api/v1/responses/channels.resp`

Use the following path to return a JSON file.
`/api/v1/responses/channels.json`

Parameters

allInOne

Use this parameter to gather the responses for all channels into a single file for downloading.

Format: `allInOne={true|`**`false`**`}`

Select:

- `true` to return a single file containing data for all channels.
- `false` to return a single zip file that contains multiple files. Each file that is included in the zip file contains data for a single channel.

Example snippet: `allInOne=true`

7.5 User Authentication API

This API must be called before you can call the Calibration API to initiate a calibration for a specified sensor. To contact any authenticated API endpoint within Centaur, an authenticated session ID must be present within the HTTP cookies. This cookie is injected by the server after a successful credentials check against the login endpoint using the server-provided session key.

The expected sequence of actions to use authenticated endpoints is as follows:

```
GET /key
POST /login
... ( any authenticated actions ) ...
POST /logout
```

Endpoints

Each of these endpoints is at the root of the server's URL.

GET /key

A unique key is provided for each session that fetches this URL. Once the key is returned, the session ID is saved in a cookie to relate the same key to all future requests.

```
Response:
<string>
```

POST /login

The login endpoint accepts its parameters via custom HTTP headers as defined below.

```
Custom HTTP Headers:
X-NMX-USERNAME: <string>
X-NMX-PASSWORD: <string>
```

The password is encoded as an MD5 hash with the session key retrieved from the `/key` endpoint as such:

```
Password encoding:
MD5( MD5( <password> ) + key )
```

This endpoint responds with HTTP status codes to indicate success (`200`) or failure (`401`).

POST /logout

This endpoint only requires that the session ID cookie is still attached and will log out the associated session.

7.6 Calibration API

The Calibration API enables custom scripts or applications to initiate a calibration for a specified sensor. Through this API you can specify the desired parameters for the required calibration output signal type—file playback, or synthesized sine or PRB. In addition to voltage calibration waveforms that are available on all models, for the Centaur CTR4 series models, you can also specify current waveform calibration. The REST endpoints allow the Web Interface to work with the enhanced calibration system.

The Calibration API is locked down behind an authentication wall. To authenticate a session for use with the Calibration API, first you must call the User Authentication API. The sample *calibrate.py* script provides examples on how to create an authenticated session, and start and stop calibrations. You can download the script from http://[IPaddressofyourCentaur]/calibration/calibrate.py

Path

`/api/v3/calibration`

Endpoints

For expanded versions of the individual data structures, see REST JSON Data Structures.

GET /calibrate

Endpoint to fetch the settings and time of the last calibration or calibrations within a time range. When querying by time range calibrations may also be filtered by sensor.

Query Parameters:

- starttime
  - optional
  - start of time range to return calibration details for
  - ISO 8601 strict date (e.g. 2020-09-15T00:00:00Z)
  - must be paired with endtime parameter
- endtime
  - optional
  - end of time range to return calibration details for
  - ISO 8601 strict date (e.g. 2020-09-15T00:00:00Z)
  - must be paired with starttime parameter
- sensor
  - optional, defaults to ALL
  - valid values A, B, ALL
  - filter returned calibration details by sensor
  - must be paired with starttime and endtime parameters
- captured_signal_channel
  - the SCNL of the channel capturing the calibration signal if the "capture" option was selected when the calibration was run
  - attribute is null if the "capture" option was not selected
- primary_channels
  - a list of the SCNL codes for the primary channels being calibrated
  - if the configured "Primary Channels" output type is disabled, this attribute will be empty

    - See "Notes for Channel naming" below SCNL code semantics.
- secondary_channels is a list of the SCNL codes of the secondary channels being calibrated.
    - a list of the SCNL codes for the secondary channels being calibrated
    - if the configured "Secondary Channels" output type is disabled, this attribute will be empty
    - See "Notes for Channel naming" below for more information on SCNL code semantics.

Notes for Channel naming

The reported network, station, location, and channel (SCNL) codes are those that are in effect on the instrument at the time of calibration.

The FDSN-WS *dataselect* API requires the current SCNL of a channel to retrieve historical data. Therefore, if the SCNL codes have been changed in the instrument configuration since the calibration was run, the SCNL codes returned by the calibration history may no longer be usable for retrieval from the instrument using the FDSN-WS *dataselect* API. In this instance, use the channel names that are currently configured on the instrument and refer as needed to the "sensor" and "channel" parameters in the calibration object returned in the calibration history API.

HTTP Return Codes

- 200 - OK on success
- 204 - No Content on success that returns no data
- 500 - Internal Server Error on error

If no parameters are specified, this will return a <HISTORICAL_CALIBRATION> response:

```
{
       "calibration": <CALIBRATION>,
       "starttime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
       "endtime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
       "captured_signal_channel" : <string:NN.SSSS..CCC>,
       "primary_channels" : [<string:NN.SSSS.LL.CCC>,<string:NN.SSSS.LL.CCC>, ...],
       "secondary_channels" : [<string:NN.SSSS.LL.CCC>,<string:NN.SSSS.LL.CCC>, ...],
}
```

If parameters are specified, this will return a <CALIBRATION_HISTORY> response matching the query

```
{
       "history": [<HISTORICAL_CALIBRATION>, ...]
}
```

GET /status

Called to represent the current state.

This will return a <CALIBRATION_INFO> response:

```
{
	"calibration": <NULL> | <CALIBRATION>,
	"active": <boolean>,
	"starttime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
	"endtime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>
}
```

GET /options

Called to list calibration options.

Trimmed example of the JSON response (... indicates where the data would continue)

Response:

```
{
	"sensors": [
		{
			"name": <string>,
			"channel_count": <int>
		}, ...
	],
	"modes": [
		<string>, ...
	],
	"signal_types": [
		{
			"name": "playback",
			"files": [
				{
					"filename": <string>,
					"duration": <int:(seconds)>
				}, ...
			],
```

```
        "gain": [
                {
                        "magnitude": {
                                "min": <min_float>,
                                "max": <max_float>
                        },
                        "mode": <string:"voltage"|"current">
                }, ...
        ]
},
{
        "name": "sine",
        "amplitude": [
                {
                        "magnitude": {
                                "min": <min_float>,
                                "max": <max_float>
                        },
                        "mode": <string:"voltage"|"current">
                }, ...
        ],
        "frequency": {
                “min": <min_float:(Hz)>,
                "max": <max_float:(Hz)>
        }
},
{
        "name": "pseudo-random binary",
        "amplitude": [
                {
                        "magnitude": {
                                "min": <min_float>,
                                "max": <max_float>
                        },
                        "mode": <string:"voltage"|"current">
                }, ...
        ],
        "pulse_width": {
```

```
                        "min": <int:(milliseconds)>,
                        "max": <int:(milliseconds)>
                }
        },
        {
                "name": "step",
                "amplitude": [
                        {
                                "magnitude": {
                                        "min": <min_float>,
                                        "max": <max_float>
                                },
                                "mode": <string:"voltage"|"current">
                        }, ...
                ],
        }
    ],
    "capture_capable" : "true"
    "assert_UVW_capable" : "true"
}
```

PUT /calibrate

A JSON structure is PUT to this endpoint to initiate a calibration action. If a calibration is already in progress, an HTTP error response code is returned.

Sent:

```
<CALIBRATION>
```

Response:

```
{
    "status": 200 | 400 | 403 | 409,
    "calibration_info": <CALIBRATION_INFO>,
    "error": <string> | <NULL>
}
```

POST /stop

No data to send. This stops any active calibration.

Response:

```
{
	"status": 200 | 400 | 403 | 409,
	"calibration_info": <CALIBRATION_INFO>,
	"error": <string> | <NULL>
}
```

REST JSON Data Structures

```
<CALIBRATION_INFO> structure
	{
		"calibration": <NULL> | <CALIBRATION>,
		"active": <boolean>,
		"starttime": <NULL> | <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
		"endtime": <NULL> | <string:yyyy-MM-ddTHH:mm:ss.SSSZ>
	}

<CALIBRATION_HISTORY> structure
	{
		"history": [<HISTORICAL_CALIBRATION>, ...]
	}

<HISTORICAL_CALIBRATION> structure
	{
		"calibration": <CALIBRATION>,
		"starttime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
		"endtime": <string:yyyy-MM-ddTHH:mm:ss.SSSZ>,
		"captured_signal_channel" : <string:NN.SSSS..CCC>,
		"primary_channels" : [<string:NN.SSSS.LL.CCC>,<string:NN.SSSS.LL.CCC>,
...],
		"secondary_channels" : [<string:NN.SSSS.LL.CCC>,<string:NN.SSSS.LL.CCC>,
...],
	}

<CALIBRATION> structure
	{
		"sensor": <int>,
```

```
            "channel": <int:0=all>,
            "mode": <string:"voltage"|"current">,
            "create_event": <boolean>,
            "assert_uvw_mode": <boolean>,
            "capture": <boolean>,
            "signal": <SIGNAL>
      }
```

Notes for <CALIBRATION> structure

- For 3-channel instruments, the "sensor" parameter should be set to 0.
- For 6-channel instruments, the "sensor" parameter should be 0 or 1 where 0 maps to sensor port/digitizer A and 1 maps to sensor port/digitizer B.
- The “create_event” parameter is optional. It does not have to be enabled for calibration to be visible when using the **GET /Calibrate** call.
- If "assert_uvw_mode" is set, the calibrated sensor will be set to UVW mode for the duration of the calibration. This option will only work on Centaur with a sensor that has a `XYZ/UVW on=UVW` control line configured. Otherwise, the option is ignored.
- If "capture" is set, the calibration signal output to the sensor will be captured by the Centaur. "capture" can only be true if the capture flag is set on the GET /options endpoint.

```
<SIGNAL> structure
      {
            "signal_type": <string:"playback" | "sine" | "pseudo-random binary" |
"step">,
            "params": <SIGNAL_PARAMS>,
            "duration": <int:(seconds)>,
            "lead_in": <int:(seconds)>,
            "lead_out": <int:(seconds)>
      }
```

Notes for <SIGNAL> structure

Each signal type should be used with the corresponding <SIGNAL_PARAMS:[type]> structure, for example the "step" signal type should be used with <SIGNAL_PARAMS:step> structure.

```
<SIGNAL_PARAMS:playback> structure
      {
            "filename": <string>,
            "gain": <float>
```

```
        }

<SIGNAL_PARAMS:sine> structure
        {
                "amplitude": <float>,
                "frequency": <float:(Hz)>
        }
<SIGNAL_PARAMS:pseudo-random binary> structure
        {
                "amplitude": <float>,
                "pulse_width": <int:(milliseconds)>
        }
<SIGNAL_PARAMS:step> structure
        {
                "amplitude": <float>
        }
```

7.7 QSCD20 Retrieval API

This API allows you to retrieve **QSCD20®**[1] packets that have been streamed previously. The API can be run in a web browser using the path below, or with a web file retrieval utility such as `wget`.

The web browser or utility that is used to retrieve the data may prompt for a filename or may automatically select one. The file will contain the sequence of 120 byte QSCD20 packets without any additional framing. If an invalid request is made or if there is no data matching the request the result will be one of the following depending on the error and browser or utility:

- no file is produced
- an empty 0 byte file is produced
- an HTML formatted error message is produced

The data returned uses several parameters from the current configuration. Make sure that no changes were applied to the following parameters within the requested query interval. If any of these parameters have changed since the QSCD20 data was originally streamed, the QSCD20 data retrieved will not match the original streamed data.

[1] Quick Seismic Characteristic Data (QSCD20®) from 20 sps data. QSCD20 is a region-specific streaming format. If your system requires QSCD20, contact customer support for more information.

- sensor sensitivity
- digitizer front end input range
- QSCD20 channel codes

Path

`/api/v2/qscd20`

Required parameters

starttime

- inclusive start time of the QSCD20 data to be retrieved
- if available, the first packet retrieved will have this timestamp
- timestamp is to be expressed as an extended ISO8601 date and UTC time, YYYY-MM-DDThh:mm:ssZ

endtime

- exclusive end time of the QSCD20 data to be retrieved
- a packet with this timestamp will not be retrieved
- timestamp is to be expressed as an extended ISO8601 date and UTC time, YYYY-MM-DDThh:mm:ssZ

Optional parameter

sensor

- select which sensor data to retrieve
- describe using station.location notation to return the single set of QSCD20 packets where the station and location match the QSCD20 channel codes
- if this optional parameter is not specified, data for all QSCD20 sensors is retrieved

Example paths

This example retrieves all QSCD20 data from June 1, 2023 on centaur-6-1212

`http://centaur-6-1212/api/v2/qscd20?starttime=2023-06-01T00:00:00Z&endtime=2023-06-02T00:00:01Z`

This example only retrieves the QSCD20 data with station code "STATN" and location code "LO" from June 1st, 2023 on centaur-6-1212

```
http://centaur-6-1212/api/v2/qscd20?starttime=2023-06-01T00:00:00Z&endtime=2023-06-02T00:00:01Z&sensor=STATN.LO
```

8.0 Reference Information

This section contains the following reference information for Centaur.

8.1 Technical Specifications

Each Centaur model provides one or two three-channel banks of high performance 24-bit digitizers. Centaur models are designated as three- or six-channel. Three types of digital recorder banks are available: the Standard digital recorder with 40 Vpp inputs designed for both active-output instruments such as broadband seismometers as well as passive sensors, the High-Gain digital recorder with higher sensitivity and high input impedance designed to record signals from passive output sensors such as geophones, and the Standard digital recorder with Authentication capabilities. The six-channel Centaur may have one bank of each of standard and high-gain, both banks of the same type, or one bank of standard and one bank with Authentication configuration capability.

The specifications for the Centaur are listed in the following sections:

8.1.1 Sensor Inputs

Channels

One or two banks of 3-channel high-performance 24-bit digital recorders:

- standard-gain option: 3 or 6 standard-gain 40 Vpp input channels
- high-gain option: 3 or 6 high-gain, high impedance 10 Vpp channels
- mixed-gain option: One 3-channel bank of each type (standard-gain on Sensor A and high-gain on Sensor B)

Accuracy

Nominal gain accuracy within ±0.5%

Input Voltage Range

Standard-gain digital recorder models:

- 40 V, 20 V, 10 V, 4 V, 2 V, 1 V peak-to-peak differential, software selectable
- Single-ended input compatibility: Up to 20 V peak-to-peak (±10 V)

High-gain digital recorder models:

- 10 V, 5 V, 2.5 V, 1 V, 0.5 V, 0.25 V peak-to-peak differential, software selectable
- Single-ended input compatibility: Up to 5 V peak-to-peak (±2.5 V)

Input Impedance

40 kΩ for standard channels

1.7 MΩ for high-gain channels

8.1.2 Sensor Compatibility

Sensor Types

Broadband seismometers, short period geophones, and microbarometers

Control Lines

6 per sensor input - typically used for calibration enable, mass centre, mass lock/unlock, and selecting XYZ/UVW

Configurable logic level:

- High: 5 V, 12 V, open drain
- Low: 0, open drain

Configurable assert and de-assert behaviour is consistent across all control lines

Sensor Power

Supply power pass-through to sensor (9-36 VDC, 1A). Over-current and surge protected

Serial Interface

Supports digital management of Nanometrics sensors and connectivity to weather stations

8.1.3 Digitizer Performance and Capabilities

Sampling

Simultaneous on all 3 or 6 channels

Resolution

User selectable bit-depth from 24 to 31 bits per sample, 32-bit ADC sample architecture (Applicable to CTR4 models only).

Preamp Gain

The sensitivity in counts/uV changes if the selected bit depth is different than 24 bits (for CTR4 models) or if digital gain other than 1 is configured. Each increase in bit-depth resolution by 1 bit doubles the sensitivity. If a digital gain other than "1" is configured, the sensitivity is also multiplied by that digital gain.

Standard-gain digital recorder models and models with Authentication:				
Gain	**Gain (dB)**	**Input voltage range**	**Clip**	**Sensitivity (with 24 bit depth)**
1x	0 dB	40 Vpp	±20.97 V	0.4 counts/µV
2x	6 dB	20 Vpp	±10.48 V	0.8 counts/µV
4x	12 dB	10 Vpp	±5.24 V	1.6 counts/µV
10x	20 dB	4 Vpp	±2.10 V	4 counts/µV
20x	26 dB	2 Vpp	±1.05 V	8 counts/µV
40x	32 dB	1 Vpp	±0.524 V	16 counts/µV

High-gain digital recorder model:				
Gain	**Gain (dB)**	**Input voltage range**	**Clip**	**Sensitivity (with 24 bit depth)**
4x	12 dB	10 Vpp	±5.24 V	1.6 counts/µV
8x	18 dB	5 Vpp	±2.62 V	3.2 counts/µV
16x	24 dB	2.5 Vpp	±1.31 V	6.4 counts/µV
40x	32 dB	1 Vpp	±0.524 V	16 counts/µV
80x	38 dB	0.5 Vpp	±0.262 V	32 counts/µV
160x	44 dB	0.25 Vpp	±0.131 V	64 counts/µV

Digital Gain

0.001 to 100 high precision DSP gain permits choice of any digitizer gain

Sample Rates

1, 2, 5, 10, 20, 40, 50, 80, 100, 125, 200, 250, 500, 1000, 2000, and 5000 sps

Dual Sample Rates

A second sample rate can be selected from the sample rates above.

The maximum "aggregate sample rate" is 5010 Hz. For CTR4-3A, CTR4-6A/S and CTR4-6AS/H, when Authenticating is enabled, the supported maximum "aggregate sample rate" is 500 Hz. See Maximum Archiving and Streaming Rates.

Decimation Anti-aliasing Filters

Filter type

- Linear phase (also known as non-causal or acausal). Selectable for all samples rates.
- Minimum phase (also known as causal). Selectable for all samples rates except 80 and 2000 sps.

Attenuation performance

-140 dB (linear phase) or -120 dB (minimum phase) at output Nyquist, 0 dB at 80% Nyquist frequency

The complete specification for the decimation filters and other signal processing within the Centaur are available by downloading a SEED response file for the selected configuration. See Download Channel Response Files.

Anti-aliasing filter latency (in seconds)

Sample rate	Linear phase	Minimum phase
1	62.088	10.088
2	30.962	4.962
5	12.088	1.688
10	6.1722	0.9722
20	3.1042	0.5042
40	1.579	0.2479
50	1.1947	0.1547
80	0.6382	n/a
100	0.6042	0.0842

Sample rate	Linear phase	Minimum phase
125	0.5007	0.0847
200	0.3039	0.0439
250	0.2431	0.0351
500	0.1237	0.0197
1000	0.061	0.009
2000	0.0207	n/a
5000	0.0085	0.0013

Digital Filters

Low-pass and high-pass high-quality digital Butterworth filters, independently user configurable from first to fifth order with corner frequencies from 0.1 mHz to Nyquist. Sum of low- and high-pass filter orders acting on any given channel is 5 or less.

Different filters may be independently configured for primary and secondary sample rates and for the Sensor A and Sensor B channel banks on 6-channel Centaur instruments. This filter capability can be used for a wide variety of applications including DC removal.

Orientation Correction

User configurable onboard 3-D data rotation for correcting azimuth and tilt

Dynamic Range

142 dB @ 100 sps, 135 dB @ 500 sps (full-scale peak to RMA shorted-input noise)

Noise Floor (typical) — Shorted Input (RMS)

Standard-gain digital recorder models and models with Authentication:		
Sample rate (sps)	**@ 40 Vpp input range (µV)**	**@ 2 Vpp input range (µV)**
10	0.71	0.049
100	1.6	0.10
200	2.4	0.14
500	3.6	0.21
1000	5.0	0.25

High-gain digital recorder model:		
Sample rate (sps)	**@ 10 Vpp input range (nV)**	**@ 0.5 Vpp input range (nV)**
10	150	19
100	400	42
200	568	61
500	857	73
1000	1200	131

Cross-Talk

< -120 dB

Total Harmonic Distortion (THD_F)

< -95 dB

< 0.002%

8.1.4 Calibration

Signal Source

- 16-bit DAC with 30 ksps output
- Output analog bandwidth: 7.2 kHz

Calibration Mode

Voltage Mode

- 1% accuracy from ±10 V to ±5 mV
- Nominal output impedance: 52 Ω nominal
- Total harmonic distortion (THD) : <0.1% to 5 mV (typical)

Current Mode (CTR4 models)

- 1% accuracy from ±30 mA to ±30 µA
- Nominal output impedance: 52 kΩ
- Total harmonic distortion (THD) : <0.2% to 30 µA (typical)

Calibration Signal and Response Recording

- Calibration signal digitized as a fourth 24-bit channel available to be downloaded from the Store using the Web Service data download interface (FDSN-WS) API
- Calibration signal and the sensor response can be archived together as an event file

Waveforms

- Synthesized sine, step, and PRB signals
- Playback user defined calibration files
- User controllable amplitude, frequency, pulse width, duration, lead-in and lead-out silence

8.1.5 Data Authentication (for models CTR4-3A, CTR4-6A/S and CTR4-6AS/H only)

Digital Signature

Hardware authentication provides Elliptical Curve Digital Signature Algorithm (ECDSA P-256 SHA-256)

In addition authentication can be enabled

- for the CD-1.1 weather parameters when a digital weather station is connected to the RS-232 lines on a sensor port
- Sensor A or B or both

8.1.6 Recording (Continuous)

Formats

Recorded on external SD card: **MiniSEED**[1]

Internal Memory

8 GB flash memory (32, 64, 128 or 256 GB options available) for Centaur CTR3 series models or later)

Removable Media

External SD media card (formatted as FAT) up to 256 GB

To ensure reliable recording and data integrity, it is very important to use SD media cards qualified by or procured from Nanometrics.

8.1.7 Recording (Events)

Triggers

Bandpassed STA/LTA, threshold

[1]A version of SEED data which only contains waveform data. No station or channel metadata is included.

Captured Data

Recorded on external SD card: **MiniSEED**[1], **ASCII**[2] (COSMOS, SMC, Text)

Data Products

Peak Ground Motion (PGA, PGD, PGV) statistics calculated on the instrument

8.1.8 State-Of-Health (SOH) Inputs

This only applies to Centaur models that have an external SOH input. This includes CTR2 series or later model types.

Tamper Detection

Case tamper switch (CTR4-3A, CTR4-6A/S and CTR4-6AS/H models only) or 3 external switches via SOH connector

Channels

3 single-ended inputs, ±5V range, 50 kΩ input impedance

Sampling Interval

Configurable from 1 to 3600 seconds, non-simultaneous

Accuracy

18 bits effective resolution

8.1.9 Data Retrieval

File Transfer

Via Ethernet, optional Wi-Fi, or Ethernet-connected DSL, cellular, VSAT, and radio

---

[1] A version of SEED data which only contains waveform data. No station or channel metadata is included.

[2] American Standard Code for Information Interchange

Media Exchange

External SD card field-swappable during continuous recording with no loss of data if swapped within one hour

Response Metadata

Generate and download full digitizer/sensor response files in RESP or Dataless SEED or StationXML format, or access from the SD Archive Media in StationXML format.

8.1.10 Data Streaming

Continuous

Seismic data, data products and State-of-Heath data

Data Formats

SEEDLink or Nanometrics NP, QSCD20, CD-1.1 (for CTR4-3A, CTR4-6A/S and CTR4-6AS/H models only)

For model CTR4-3A, CTR4-6A/S and CTR4-6AS/H, when Authentication is enabled, SEEDLink is not supported.

Events

Triggered event data: email, secure file transfer, other options available

8.1.11 Timing - GNSS and Precision Network Timing

Timing System

Selectable time source:

- Internal DCXO clock disciplined to GNSS
- External PTPv2 (IEEE 1588-2008) high-precision timing source option
- External NTP timing source option

- Free-running timing source option that allows the instrument to run at the accuracy of the internal oscillator

Selectable time server. Can act as a time server, providing network timing to other devices:

- PTPv2 (IEEE 1588-2008) high-precision timing server option
- NTP timing server option

Timing Accuracy

* Time source	** Accuracy (typical)	*** Jamset threshold	Maximum slewing correction time (Approximate)
GNSS always-on	< 5 µsec	500 µsec	90 seconds
GNSS duty-cycled	< 100 µsec	500 µsec	90 seconds
PTP (LAN)	< 5 µsec	500 µsec	90 seconds
NTP (LAN)	< 100 µsec	20 msec	60 minutes
NTP (Campus)	< 300 µsec	20 msec	60 minutes
NTP (Internet)	< 2 msec	20 msec	60 minutes

* Time source **NTP (Campus)** describes multiple private subnets connected together.
** Accuracy for GNSS assumes an antenna with a clear view of the sky and good signal. For PTP or NTP, achieving the highest accuracy requires that users employ industry best practices when configuring their networks. For the best time accuracy, PTP aware switches and routers should be used between the Centaur receiving PTP time and the “master clock” time source.
*** A jamset is when the system determines that its internal clock is sufficiently different from the time source it is tracking, that it abruptly resets its time to match the source. This will cause a brief gap in recording as the anti-aliasing filters are flushed, and will also create apparent overlaps or gaps in the data depending on whether the new time is earlier or later than the old system time. The behaviour is as follows:

- below threshold, the system time slews to gradually adjust to source time, so that no gaps or overlaps are created
- above threshold, an abrupt time adjustment ("jamset") is applied

GNSS Receiver

Internal 14-channel GPS receiver (CTR1, CTR2, and CTR3 series models) or 32-channel GNSS receiver (CTR4 series models)

GNSS Constellations

GPS + select one of Beidou, Glonass, Galileo, QZSS

GNSS Power

Selectable: Always on, Duty cycled, or Off

8.1.12 Communications

Web-based UI

Supports standard PC, tablet, and mobile devices.

Used for waveform and state-of-health monitoring, configuration, maintenance, sensor management and calibration, downloading data and events.

Interfaces

10/100 Base-T Ethernet, Wi-Fi (optional), serial via USB (To reduce power consumption, the Ethernet speed can be set to 10 Base-T.)

The USB port is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

IP Addressing

Static IP, dynamic (DHCP), or link-local IP address

Protocols

WebSocket, UDP/IP (unicast/multicast), or HTTP-based data streaming, and Simple Network Management Protocol (SNMPv2c) for state-of-health monitoring

VPN

OpenVPN®

8.1.13 Local User Interface

Removable Media

SD card protected in waterproof media bay. Media eject button and LED ensures gap-free swapping

External Status LEDs

System status, Ethernet link, Time quality, Media card status, and Sensor A & B state-of-health

Buttons

Wi-Fi wake-up, media eject, system shutdown

8.1.14 Power

Power Supply

9-36 V DC isolated input

Protection

Electronic resettable fuse design, lightning surge, reverse battery and short circuit protection

Battery (External) Manager

User-configurable low voltage shutdown and restart thresholds

Grounding

Grounding lug screw and wire included

8.1.15 Power Consumption

Power consumption estimates are based on duty-cycled GNSS actively digitizing to internal store.

Typical power usage for each digital recorder type

- 3-channel standard digital recorder: 850 mW
- 6-channel standard digital recorder: 1.2 W

Use the following approximate guidelines for determining the power usage for your Centaur:

- (For the CTR4-3A, CTR4-6A/S and CTR4-6AS/H models) If Authentication is enabled, add 1.2 W to the above numbers.
- Add 0.2 W for every 3 high-gain channels
- If Ethernet is used and speed is set to 10Base-T, add 200 mW to the above numbers.
- If Ethernet is used and speed is set to 100Base-T, add 300 mW to the above numbers.
- If **GNSS power mode** is set to Always on, add 350 mW to the above numbers.
- Power usage increases at colder temperatures, up to 7% higher at -45ºC for Polar Certified devices.

8.1.16 Connectors

Sensor

- 26-pin, shell size 16, female
- MIL-C-26482 Series 1
- Recommended mate: Souriau 851-06A16-26P

Power

- 3-pin, shell size 8, male
- MIL-C-26482 G Series 1
- Recommended mate: Souriau 851-06JC8-3AS

Ethernet

- Watertight RJ-45 connector

USB

- USB 2.0 type A receptacle behind media bay door
- Recommended mate: USB 2.0 type A, male

The USB port is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

GNSS Antenna

- TNC (female) with 3.3 V supply for active antenna

State-Of-Health (SOH)

- 4-pin, shell size 8, female
- MIL-C-26482 Series 1
- Recommended mate: Souriau 851-06JC8-4PW

8.1.17 Environmental

Operating Temperature

-20ºC to +60°C (Standard Model)

-45ºC to +60ºC (Polar Certified Model)

Storage Temperature

-40ºC to +70°C (Standard Model)

-60ºC to +70ºC (Polar Certified Model)

Ingress Protection

Rated to IP68 at 2 m for 72 hours when connectors mated or capped

Humidity

0 to 100%

8.1.18 Physical Characteristics

Housing

Aluminum

Surface resistant to corrosion, scratches, and chips

Weight

2.1 kg (3-channel models CTR4-3H and CTR4-3S)

2.2 kg (3-channel model with Authentication CTR4-3A, 6-channel models CTR4-6S, CTR4-6H, and CTR4-6S/H)

2.4 kg (6-channel models with Authentication CTR4-6A/S, and CTR4-6AS/H)

Size

Length: 196 mm

Width: 137 mm

Height: 88 mm

8.2 SOH channels in Steim compressed formats

The Centaur stores selected SOH channels in Steim compressed formats. This data can be retrieved from the internal storage, streamed via SEEDLink or downloaded in MiniSEED format via the **Maintenance** page. For a full listing of the SOH channels that can be viewed using the SOH API, see SOH channels

Code	Description	Units	Notes
EX1 EX2 EX3	External SOH channels 1 to 3	microvolts	
GAN	GNSS antenna status		0=ok, 1=no antenna, 2=antenna short
GEL	GNSS elevation	meters	

Code	Description	Units	Notes
GLA	GNSS latitude	microdegrees	
GLO	GNSS longitude	microdegrees	
GNS	GNSS number of satellites used		The number of satellites used by the timing solution. If the GNSS receiver status is off as indicated by GST, the last known value is preserved.
GPL	GNSS PLL status		0=no lock, 1=coarse lock, 2=fine lock, 3=free running
GST	GNSS status		0=off, 1=unlocked, 2=locked
LCE	Absolute clock phase error	microseconds	The difference between the digitizer clock and the reference clock selected by the configured time source. If the time source is GNSS or GNSS over fiber, the LCE value will be 0 when the internal GNSS receiver is off or if the GNSS receiver is unlocked as indicated by the GST value.
LCQ	Clock quality		A heuristic time quality value that can be defined as follows: • 100% indicates that the system is fine locked • 90% indicates an estimated time error of < 100 µs (GNSS duty cycling, or coarse locked) • 70% indicates that the system is coarse locked or that it has an estimated time error of < 200 µs • < 70% indicates that the system has an estimated time error of > 200 µs. The 70% will decrease by 1% for each hour of free running • 0% indicates that the system has never locked or has been free running for more than 70 hours To provide real-time time quality SOH data, this value is also included in the SeedLink Blockette 1001 within each data block for each data channel. LCQ is also included in the header of each NP Packet.
LDO	Barometric Pressure	hectopascals	This value is provided when a weather station serial sensor is enabled.
LIO	Outdoor Relative Humidity	percentage	This value is provided when a weather station serial sensor is enabled. The value is the water vapor

Code	Description	Units	Notes
			present in air expressed as a percentage of the amount needed for saturation at the same temperature.
LKO	Outdoor Temperature	millidegrees Celsius	This value is provided when a weather station serial sensor is enabled.
LWD	Wind Direction	degrees	This value is provided when a weather station serial sensor is enabled. The value is degrees clockwise from north relative to the north alignment pointers on the serial sensor.
LWS	Wind Speed	centimeters per second	This value is provided when a weather station serial sensor is enabled.
LRT	Total Rain	micrometers	This value is provided when a weather station serial sensor is enabled.
LRI	Rain Intensity	micrometers per hour	This value is provided when a weather station serial sensor is enabled.
LYT	Total Hail	decihits per square centimeter	This value is provided when the Vaisala WXT536 with or without heater serial sensor is enabled.
LYI	Hail Intensity	decihits per square centimeter	This value is provided when the Vaisala WXT536 with or without heater serial sensor is enabled.
VCO	VCO control voltage (for timing oscillator)	raw DAC counts	
VDT	Digitizer system temperature	millidegrees Celsius	
VEC	Digitizer system current	milliamps	

Code	Description	Units	Notes
VEI	Input system voltage	millivolts	
VM1 VM2 VM3 VM4 VM5 VM6	Sensor SOH channels 1 to 6	microvolts	This value typically represents mass position. • VM1 to 3 for Sensor A SOH 1 to 3 • VM4 to 6 for Sensor B SOH 1 to 3 For Nanometrics seismometers: • VM1/VM4 = W axis • VM2/VM5 = V axis • VM3/VM6 = U axis Note that SOH channels 4 to 6 are only available on 6-channel Centaur models.
VPB	Digitizer buffer percent used	0.1%	This value is typically 100% once the buffer is full.

8.3 Wi-Fi Access to the Centaur

This feature is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

If you need to access the Web interface of a Centaur that is not connected via Ethernet to the Internet or a laptop, you can create a Wi-Fi connection to the device using the optional USB Wi-Fi Accessory Kit and access it using a Wi-Fi device.

The kit contains a USB Wi-Fi dongle that you can install permanently (using the O-ring and Media Bay dome cover supplied in the kit) or use temporarily depending on your needs. The Wi-Fi connection is only activated when the Wake button on the Centaur is pressed. Wi-Fi access to the Centaur is automatically disabled after the Wi-Fi connection has been idle for more than the configured idle timeout, or when the device is shut down or restarted. Wi-Fi access is also disabled when the USB eject button is pressed (used for safe removal of the dongle).

Wi-Fi Kit usage notes

1. Ideally, the USB Wi-Fi Accessory Kit should be used where there are no other competing Wi-Fi access points, namely access points that offer stronger signals than your computer or mobile device.

2. Accessing the Web interface of the Centaur over Wi-Fi can cause low levels of noise in the digitized data.
3. Ensure your Wi-Fi device is at least one metre from the Centaur to achieve reliable communications.

Perform the following steps to access the Centaur over Wi-Fi:

1. Remove the Media Bay cover.
2. Insert the USB Wi-Fi dongle and then press the Wake button to activate the Wi-Fi.

Once the Wi-Fi dongle is activated, the Wi-Fi can remain idle for up to 5 minutes before the connection disconnects. You can configure a different idle time by navigating to **Communications > Wi-Fi** on the Configuration menu. See Idle timeout for more information.

3. Select the Centaur wireless network on your Wi-Fi device and type the password **w1f1admin** to connect to it.

   The name of the wireless network is centaur-3_XXXX or centaur-6_XXXX, where XXXX is the serial number of the device.

4. Type **http://centaur** or **http://192.168.77.1** into your browser to access the Web interface of the Centaur.

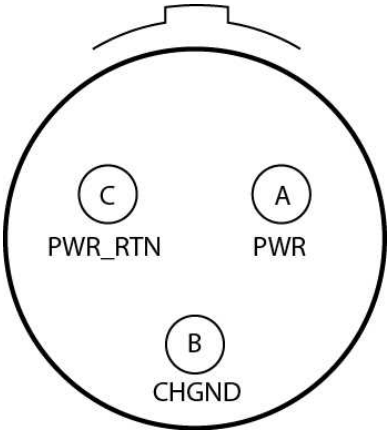
When you have finished accessing the Web interface, press the USB eject button and wait until the USB eject LED turns solid green before you remove the USB Wi-Fi dongle and replace the Media Bay cover. If you are installing the dongle permanently, you do not need to press the USB eject button but you do need to place the O-ring onto the Media Bay dome cover (both supplied in the USB Wi-Fi Accessory Kit) and screw the dome into the Media Bay slot to protect the Media Bay from the elements.

8.4 Connectors and Pinouts

This section does not include pinouts for industry standard connectors. See the Technical Specifications for the full list of connectors.

- Power connector
- Sensor connector
- External SOH Input Pinout

8.4.1 Centaur Power Connector Receptacle and Pinout



Connector type:

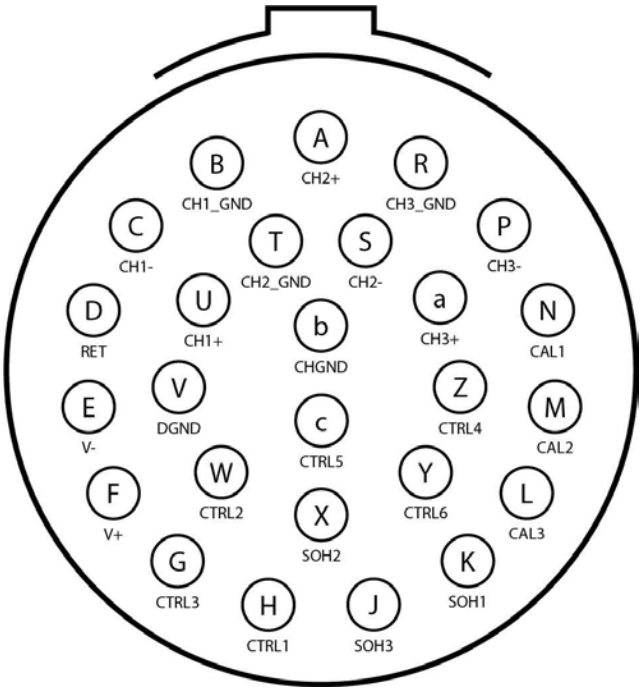
- 3-pin, shell size 8
- MIL-C-26482 G Series 1

Recommended mating connector:

- Souriau 851-06JC8-3AS

Pin	Name	Function
A	PWR	Raw (battery) power in (9 V to 36 V DC)
B	CHGND	Internal connection to chassis ground
C	PWR_RTN	Raw power return

8.4.2 Sensor Connector and Pinout



Connector type:

- 26-pin, shell size 16, female
- MIL-C-26482 Series 1

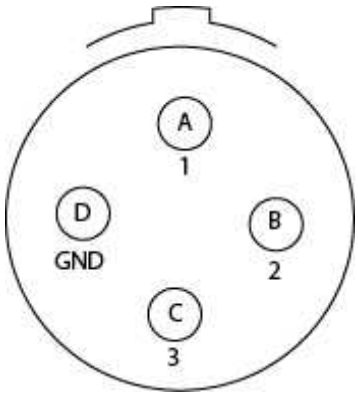
Recommended mating connector:

- Souriau 851-06A16-26P

Pin	Name	Function	Details
U	CH1+	Channel 1 input	40 V peak-to-peak differential for standard-gain digital recorder models
C	CH1-		10 V, peak-to-peak differential for high-gain digital recorder models
B	CH1_GND	Channel 1 ground/shield	Connected to shield ground
A	CH2+	Channel 2 input	40 V peak-to-peak differential for standard-gain digital recorder models
S	CH2-		10 V, peak-to-peak differential for high-gain digital recorder models
T	CH2_GND	Channel 2 ground/shield	Connected to shield ground

Pin	Name	Function	Details
a	CH3+	Channel 3 input	40 V peak-to-peak differential for standard-gain digital recorder models 10 V, peak-to-peak differential for high-gain digital recorder models
P	CH3-		
R	CH3_GND	Channel 3 ground/shield	Connected to shield ground
K	SOH1	Sensor state of health input signals	±10 V, single-ended Referenced to DGND
X	SOH2		
J	SOH3		
H	CTRL1	Sensor control signal outputs	0 V / 5 V / 12 V / high impedance Referenced to DGND
W	CTRL2		
G	CTRL3		
Z	CTRL4		
c	CTRL5		
Y	CTRL6		
N	CAL1	Sensor calibration signal outputs	±10 V single ended (CTR4 series models) ±5 V single ended (other models) Referenced to DGND in voltage mode
M	CAL2		
L	CAL3		
V	DGND	Digital ground	Digital ground
F	V+	Sensor power supply	Filtered, unregulated voltage
E	V-	Reserved for future use	
D	RTN	Sensor power return	Switched, overcurrent protected
b	CHGND	Chassis	

8.4.3 External SOH Input Pinout



Connector type (on chassis):

- 4-pin, shell size 8, female
- MIL-C-26482 Series 1

Required mating connector:

- MIL-C connector, 4-pin, shell size 8, male
- Souriau 851-06JC8-4PW

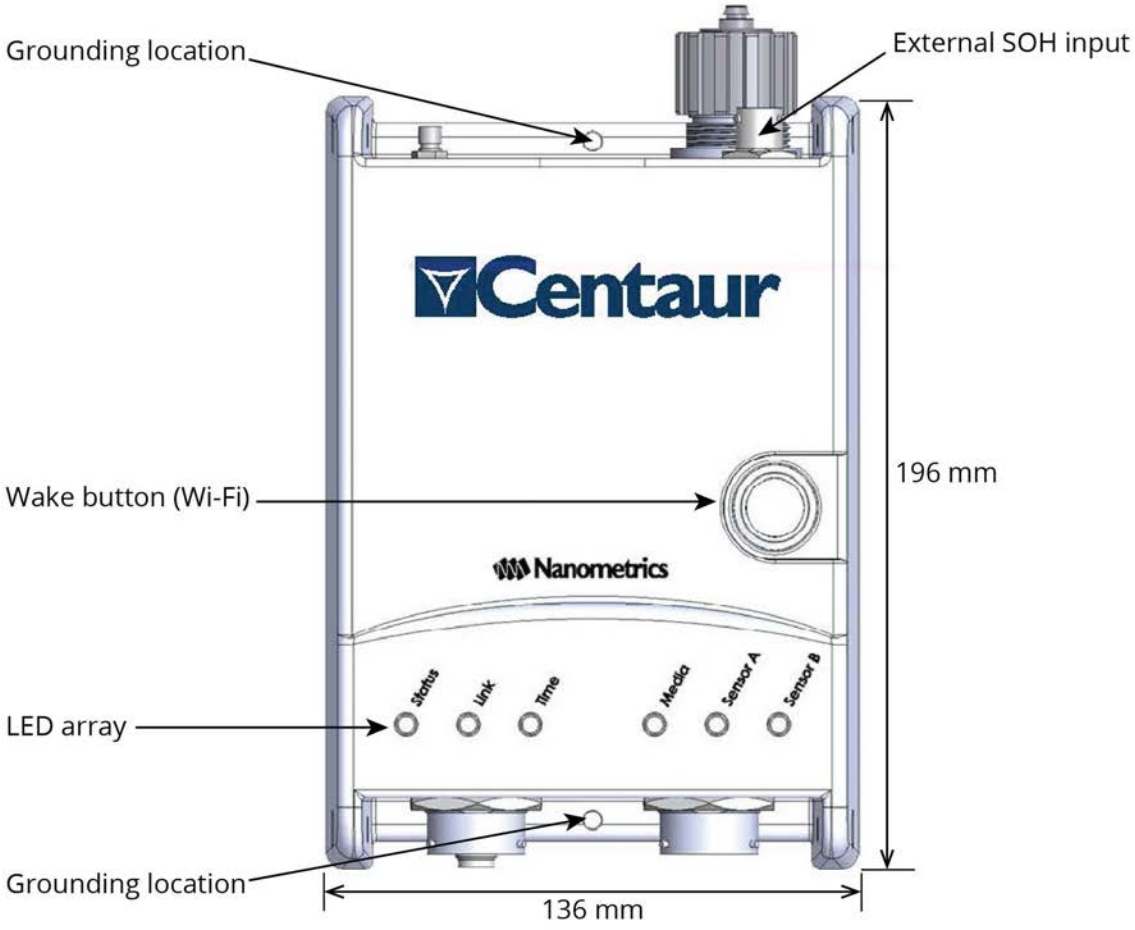
Pin	Name	Function
A	Channel 1	Channel 1 input
B	Channel 2	Channel 2 input
C	Channel 3	Channel 3 input
D	GND	Ground reference for SOH input

8.5 Physical Features and Dimensions

Refer to the following figures to view the features and dimensions. Dimensions are in millimeters unless otherwise stated.

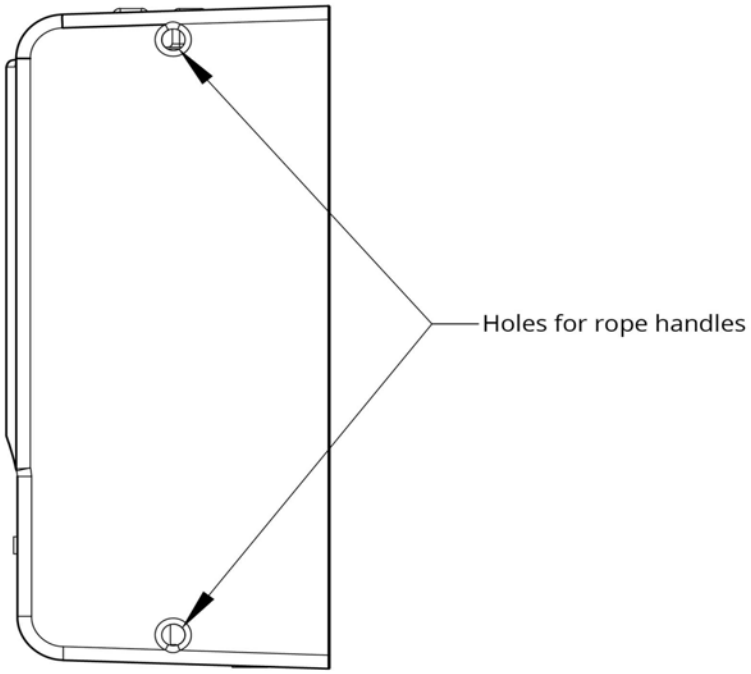
- Top View
- Side View
- View of External Connectors
- View of Open Media Bay Door

8.5.1 Top View of the Centaur

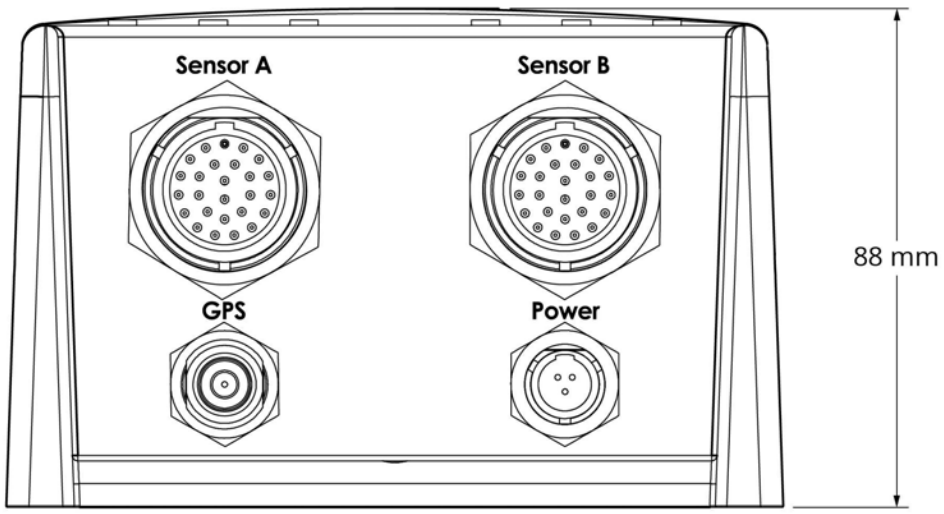


This only applies to Centaur models that have an external SOH input. This includes CTR2 series or later model types.

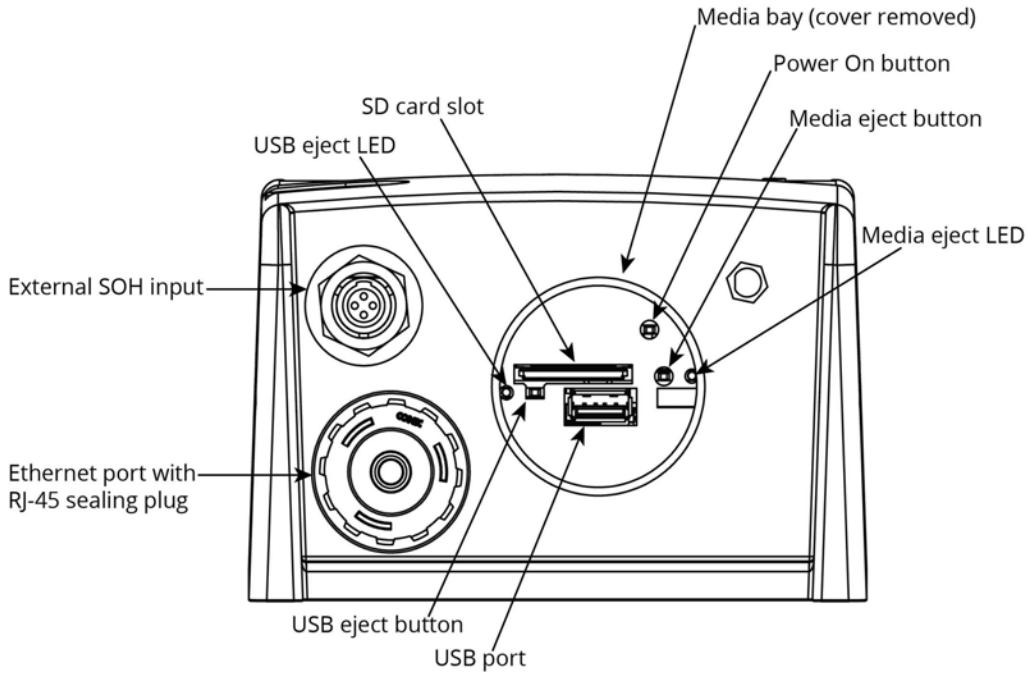
8.5.2 Side View of the Centaur



8.5.3 View of the External Connectors



8.5.4 View of the Centaur Open Media Bay



This only applies to Centaur models that have an external SOH input. This includes CTR2 series or later model types.

The USB port is not supported on Centaur models CTR4-3A, CTR4-6A/S and CTR4-6AS/H.

8.6 About calibration signal files

You can calibrate your Centaur with a generated signal or a prerecorded signal file, or you can create your own calibration signal file. Files should be created and uploaded before you begin to configure the calibration sequence.

8.6.1 Prerecorded calibration signal files

The following prerecorded calibration signal files are supplied with the Centaur. These files may be used to visually verify functionality and approximate sensitivity of the sensor by inspection of the output waveform:

- **Titan sine 2g 30s** generates a 1 Hz sine wave with 2 g amplitude lasting 30 seconds.
- **Titan step 0g to 2g 15s** generates a 0 g signal for 15 seconds followed by a positive 2 g step function lasting 15 seconds.
- **Titan prb 2g 10ms 5min** generates a 5 minute PRB sequence using 10 ms pulses with amplitude representing 2 g on a Titan accelerometer.
- **sine 5V 30s** generates a 1 Hz sine wave with 5 V amplitude lasting 30 seconds.
- **step 0V to 5V 15s** generates a 0 V signal for 15 seconds followed by a positive 5 V step function lasting 15 seconds.
- **prb 1V 20ms 10min** generates a 10 minute PRB sequence using 20 ms pulses and 1 V amplitude.
- **prb 1V 5s 150min** generates a 2.5 hour PRB sequence using 5 second pulses and 1 V amplitude.
- **prb 2V 5s 8hr** generates an 8 hour PRB sequence using 5 s pulses and 2 V amplitude.

8.6.2 Creating a custom calibration signal file

Although it is recommended that you use the prerecorded calibration signal files, you can create a custom calibration signal file either manually or using the sample Python script provided on the Centaur.

To manually create a custom calibration signal file, use the file format information below and any software that can export raw (headerless) audio files, such as Audacity®. Once you have created the custom calibration signal file, upload it to your Centaur.

Create a custom PRB calibration file

The sample Python script provided on the Centaur can be used as is or it can be customized to create a unique PRB calibration signal file, see *Nanometrics technical note 18895 Synthesized PRB Calibration Signal Sequence Implementation* for details.

Create a custom Sine or Step calibration file

To create a custom calibration signal file using the provided Python script, proceed as follows:

1. Download the script by entering the following in the browser address bar: http://IPaddressofyourCentaur/calibration/create_calibration_signal.py
2. Run the script, specifying the following parameters:
    - equipment type (seismometer)
    - signal type (sine or step)
    - the duration in seconds
    - the amplitude in V
    - a name for the output file
    - (recommended) meta option to create a metadata file (meta_file). The metadata file communicates the duration of the calibration file to the Web Interface.
    - (optional) the sine frequency in Hertz
3. Compress the calibration file using LZMA compression as implemented in the XZ Utils package.

- Files compressed using the obsolete LZMA Utils package will not be played correctly.
- GZIP or ZIP compression are also supported, however the resulting files are not as compact.
- XZ and BZIP compression are also possible, but not recommended.

4. Once the custom calibration signal file has been created, upload it and the optional meta_file to your Centaur.

Custom calibration files with a combined maximum size of 50 MB can be uploaded to your Centaur. If the files are uncompressed, 50 MB represents only 14 minutes of calibration time, however with compression several days of calibration may be saved.

Calibration file format information

Format	Uncompressed raw
Header	None
Encoding	Signed 16-bit integer
Byte order	Little-endian (In this order, the bytes of a multibyte value are ordered from least significant to most significant.)
Channels	1 (mono)
Sample rate	30 000 Hz
Output signal	The maximum output signal (+5 V) corresponds to the minimum value (-32 768)

meta_file format information

The meta_file must be named .meta_filename where filename matches the calibration signal filename, 2-line Linux text file

- file=[filename]
- durationMillis=[duration of calibration]

8.6.3 Uploading a custom calibration signal file

Once the custom calibration signal file has been created, you can upload it using an SSH-based file transfer protocol such as SFTP or SCP

File Transfer Protocol information

Protocol	SFTP or SCP
Host name	IP address of your Centaur
Port number	22
User name	calibration
Password	calibrate (default)
Upload location	/usr/share/nanometrics/calibration

You will have to re-upload your custom calibration signal file after you upgrade the firmware of your Centaur because it will be overwritten during the upgrade process.

8.7 Configuring OpenVPN® on Centaur

This section describes how to configure OpenVPN® on Centaur instruments running firmware version 4.9.0 or newer.

Configuring the Centaur instrument using OpenVPN allows you to establish secure connectivity across your network. Once OpenVPN is enabled, the instrument will only be accessible over the Internet from the Virtual Private Network (VPN) server and other devices on the same VPN. In addition, OpenVPN will remain active and all network traffic on this instrument will be routed through the VPN server.

When using VPN on Centaur instruments keep in mind the following:

- Once VPN is enabled from the Centaur Web Interface it will remain active.
- All network traffic on this instrument will be routed through the VPN server.
- The instrument will be accessible as follows:
    - Over the internet by the VPN server only
    - Over the VPN by other devices on the same VPN
    - Over a link-local Ethernet connection directly to a computer
- If the VPN becomes unavailable the instrument will be accessible locally using the link-local interface. The instrument will continue indefinitely to attempt to re-establish the VPN connection. Once the VPN becomes available again, the instrument will once again be accessible over the VPN.
- The instrument will be accessible at its non-VPN network address until the VPN starts successfully. Failure to establish a VPN connection may be the result of a misconfiguration on the instrument or inaccessibility of the VPN server.
    - In this instance, the Internet Protocol (IP) address that would be used to access the device over the Internet would be visible in the address bar rather than the VPN-facing IP address.
    - If the OpenVPN® server status is queried, an administrator would see that a client does not have an established connection.

Before you begin

- OpenVPN® must be enabled on your server (See OpenVPN website for details.)
- You need access to
  - a third-party key generation tool such as easy-rsa (to generate keypair and certificate)
  - a third-party Secure Copy Protocol (SCP) application such as FileZilla® (to copy the private key and certificates to the instrument)
  - a third-party Secure Shell (SSH) client such as PuTTY (to edit the `etc/openvpn/client.conf.user` file located on the instrument)

Generate an RSA key & certificate

The RSA key and certificate are used to ensure that all communication over the VPN is encrypted. The certificate also contains information that identifies the Centaur as the VPN client. To generate an RSA key & certificate:

1. Using your rsa key tool (for example, easy-rsa), generate a key and certificate for the VPN client (Centaur) keeping in mind the following:

   - Instrument keys should not be password protected.
   - A unique key and certificate should be generated for each VPN client.
   - Generate each certificate signing request (CSR) with a unique common name (CN).
   - Use the same Certificate Authority (CA) to sign certificates for all nodes on the VPN. Often, this CA would be hosted on a firewall or router that also hosts the VPN server.

   (See EasyRSA3-OpenVPN-Howto for instructions on using EasyRSA to generate a keypair and certificate.)

2. Change the names for the key and certificate files to:

   - [CA certificate] ca.crt
   - [instrument certificate] client.crt
   - [instrument private key] client.key

   This naming convention is required by the script that is used to launch OpenVPN on the Centaur.

Transfer key & certificate files to VPN client

Once the key & certificate have been created and the file names have been changed, the key and certificate need to be added to the VPN client as follows:

1. Access an SCP application such as FileZilla.
2. Transfer the key and certificate files to the `/etc/openvpn/keys` directory.

Modify instrument configuration file

To configure the instrument so that the VPN can be enabled from the Web Interface:

1. Log in to the instrument using an SSH client such as PuTTY.
2. Open the configuration file `/etc/openvpn/client.conf.user` and edit the remote option as follows:
   Change `remote my-server-1 1194` to `remote <server ip> <port>`
   Where `<server ip>` is the public-facing IP address of the VPN server, and `<port>` is the port used for OpenVPN® communication. (The default is 1194.)
3. Close the SSH session.

Instrument configuration file notes

- Multiple remote servers can be added if needed, however only one can be connected at any time.
- The default protocol setting is `proto tcp`. You can change the protocol to `proto udp` if your system requires it by adding the line proto udp to the bottom of the `/etc/openvpn/client.conf.user` file. Likewise, any default setting can be overridden by copying the setting to `client.conf.user`, and making your changes to the new entry.

Default client.conf.user file

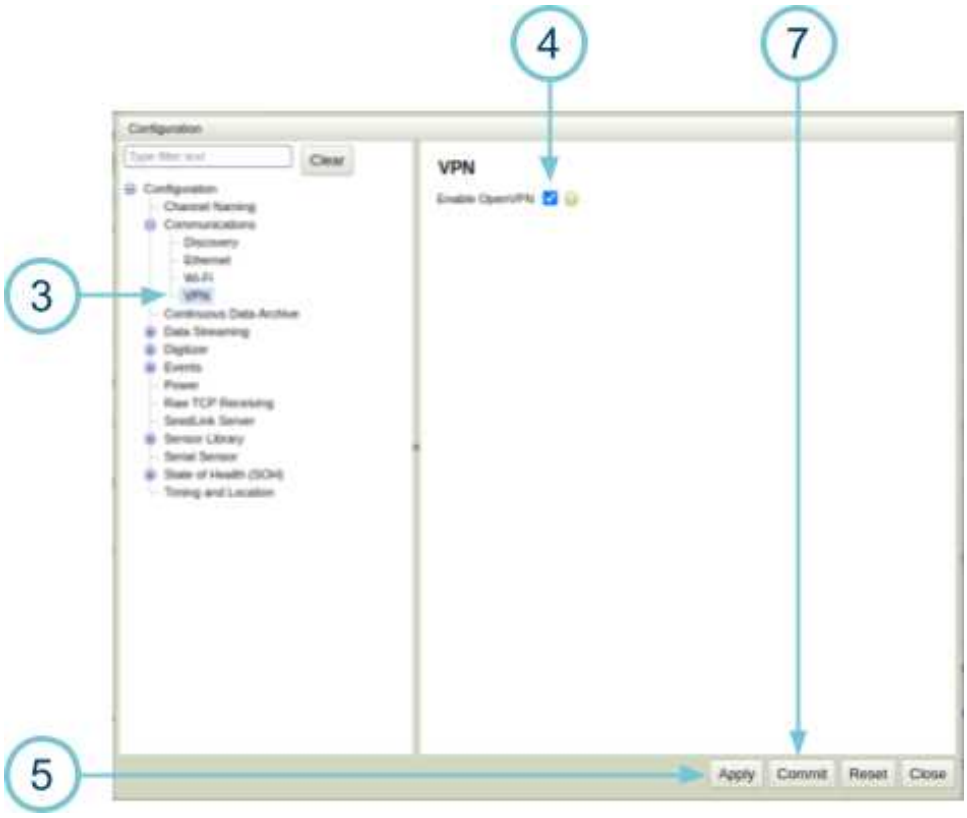
```
##############################################
# Persistent OpenVPN Configuration           #
#                                            #
# Use this file to add custom OpenVPN        #
# configuration settings, or to override the #
# defaults specified in client.conf.internal.#
# Any settings specified in this file will   #
# persist across firmware updates.           #
##############################################

# The hostname/IP and port of the server.
# You can have multiple remote entries
# to load balance between the servers.
remote my-server-1 1194
;remote my-server-2 1194
```

Enable OpenVPN® on Centaur

1. Log on to the Centaur Web Interface using your admin account username and password.
2. Open the **Configuration** menu.
3. In the left pane, navigate to **Communications | VPN**.
4. In the right pane, check the **Enable OpenVPN** box.
5. Click **Apply** to enable OpenVPN® on the instrument.
6. Connect the computer to the VPN, then connect to the instrument at the IP address given to the instrument by the OpenVPN server. A successful connection confirms that the VPN is active and all traffic on this instrument will be routed through the VPN server.

> **Setting up in a lab**
> Step 6 is not required if you are setting up in a lab using a local network connection for a future deployment. However, in this lab set-up use case, the VPN will not be active.

7. Click **Commit** to save the changes.



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