TitanSMA User Guide

June 20, 2023

Strategic Intelligence Fueled by Science

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

Model Number	Part Number	Description
TSMA3	17197	Titan Strong Motion Accelerograph, Triaxial, ±4g, 3-ch 24-bit, 8GB Expandable Store

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

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Contents

1.0 About the TitanSMA

The TitanSMA is a strong motion accelerograph used for high precision observational and structural engineering applications, where scientists and engineers require exceptional dynamic range over a wide frequency band. The integrated digitizer and recorder facilitate both standalone and networked monitoring deployments.

1.1 Key Features

- Low noise floor, extremely low hysteresis, and industry leading dynamic range
- Precision timing with built-in GNSS or network timing PTPv2 (Precision Time Protocol), NTP (Network Time Protocol)
- Provides network timing to other Nanometrics instruments including other TitanSMA units, TitanEA or Centaur digital recorder
- Ultra low latency configurations as low as 0.25 seconds

- Local real-time processing and transmission of PGA[1] data
- Data retrieval via a removable **SD**[2]™ card or local Ethernet in MiniSEED and **ASCII**[3] file formats
- Continuous streaming of data to a central server, retrieved on demand or retrieved via a removable SD media card
- Real-time data streaming over Ethernet using SeedLink or Nanometrics Protocol (NP)
- Network integration of multiple sensors for event and trigger sharing
- Easy integration of state-of-health information into existing tools using low bandwidth SNMP communications (Simple Network Management Protocol)
- Intuitive Web Interface for device configuration and control via a Web browser over an Ethernet connection
- **LED**[4] indicators provide quick visual instrument status
- Internal 8 GB redundant storage (expandable up to 64 GB in TSMA3 models)
- Built-in calibration synthetic Sine and PRB waveform generation and waveform player
- User configurable onboard 3-D data rotation for orientation correction of Azimuth and tilt rotation

1.2 About Data Storage

Understanding how and where TitanSMA 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 SD card. Please contact techsupport@nanometrics.ca for more information.

1.2.1 Primary Media

TitanSMA 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

[1] Peak Ground Acceleration
[2] Secure Digital
[3] American Standard Code for Information Interchange
[4] Light-Emitting Diode

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 TSMA3— or later models.

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 TitanSMA 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 SD card as your secondary (removable) media, and configure continuous archiving. The 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 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 TitanSMA continuously records data in MiniSEED to the SD card and generates metadata records in StationXML format whenever there is a configuration change. You can also configure TitanSMA to archive events and SOH data to the SD card.

When the SD card is full, the TitanSMA continues recording data to its internal storage media, but stops writing data to the SD card. Any configured streamers are unaffected when the SD card is full. You can monitor the amount of space that data archiving consumes on your 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 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 TitanSMA. The table below describes a number of these options.

List of Cables and Accessories

Name	Part Number	Description
Cable - Ethernet	15228-xM	An Ethernet cable with a 4-pin, shell size 8 MIL-C-26482 G Series 1 connector on one end and an RJ-45 connector on the other end. Available in standard lengths of 1 m, 2 m, 3 m, 5 m, 10 m, 15 m, 20 m, 30 m, 50 m, and 100 m. In the part number, xM represents the length of the cable in meters.
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.
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 LMR-400 very low loss	12785-xM	LMR-400 very low loss RF coaxial cable. 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 TitanSMA.
GNSS cap	CON0278	Dust cap for GNSS connector port. NOTE: This optional accessory is required if a local GNSS antenna is not being used.

Name	**Part Number**	**Description**
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.

*****See About SD media cards.

2.0 Installation Tasks

The TitanSMA is for anchored or freestanding installations. At a high level, we recommend that you perform the following tasks to install a TitanSMA:

- Before field deployment (pre-installation)
    1. Insert an SD media card (optional)
    2. Choose a deployment option.
    3. Perform the initial configuration.
    4. Develop a grounding plan.
    5. Inspect connectors and O-rings.
- In the field (installation)
    1. Evaluate the installation site.
    2. Prepare the installation surface.
    3. Connect, place, and ground the device.
    4. Orient, level, and anchor (anchored installations only) the device.
- Before leaving the installation site (post-installation)
    - Monitor the LEDs and troubleshoot any errors that occur.
    - Record station information.

2.1 Before You Visit the Installation Site

Some planning and configuration tasks should be completed prior to deploying the TitanSMA in the field, specifically:

- Ensuring that your deployment has sufficient power supply.
- Choosing a deployment and data access option.
- Setting up the TitanSMA in a clean office or lab environment with network connectivity to perform pre-installation setup and configuration tasks.

2.2 Choose a Deployment Option

The TitanSMA 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 installed SD card), the TitanSMA continuously records data to internal storage. For more information, see About Data Storage.

2.2.1 Stand-alone Deployment

In a stand-alone deployment, a TitanSMA 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 to a FAT32 formatted, hot-swappable SD card, if an SD card is installed and if continuous archiving is configured by the user.

A technician must visit the TitanSMA 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 SD card has been lost or damaged.

2.2.2 Networked Deployment

In a networked deployment, a TitanSMA 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 TitanSMA can be configured to continuously write the time series data in MiniSEED format to a FAT32 formatted swappable SD card. See Format SD Card.

The field technician does not typically visit the TitanSMA 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.

2.2.3 Data Access Options

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

The TitanSMA 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 SD card when a technician is visiting the site).

Regardless of whether data is streamed and/or archived to a secondary removable media (SD card), the TitanSMA 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 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 TitanSMA 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 SD card or internal storage, see Data Recording and Retrieval in the specifications.

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

2.2.4 Use Cases: Deployment and Data Access

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

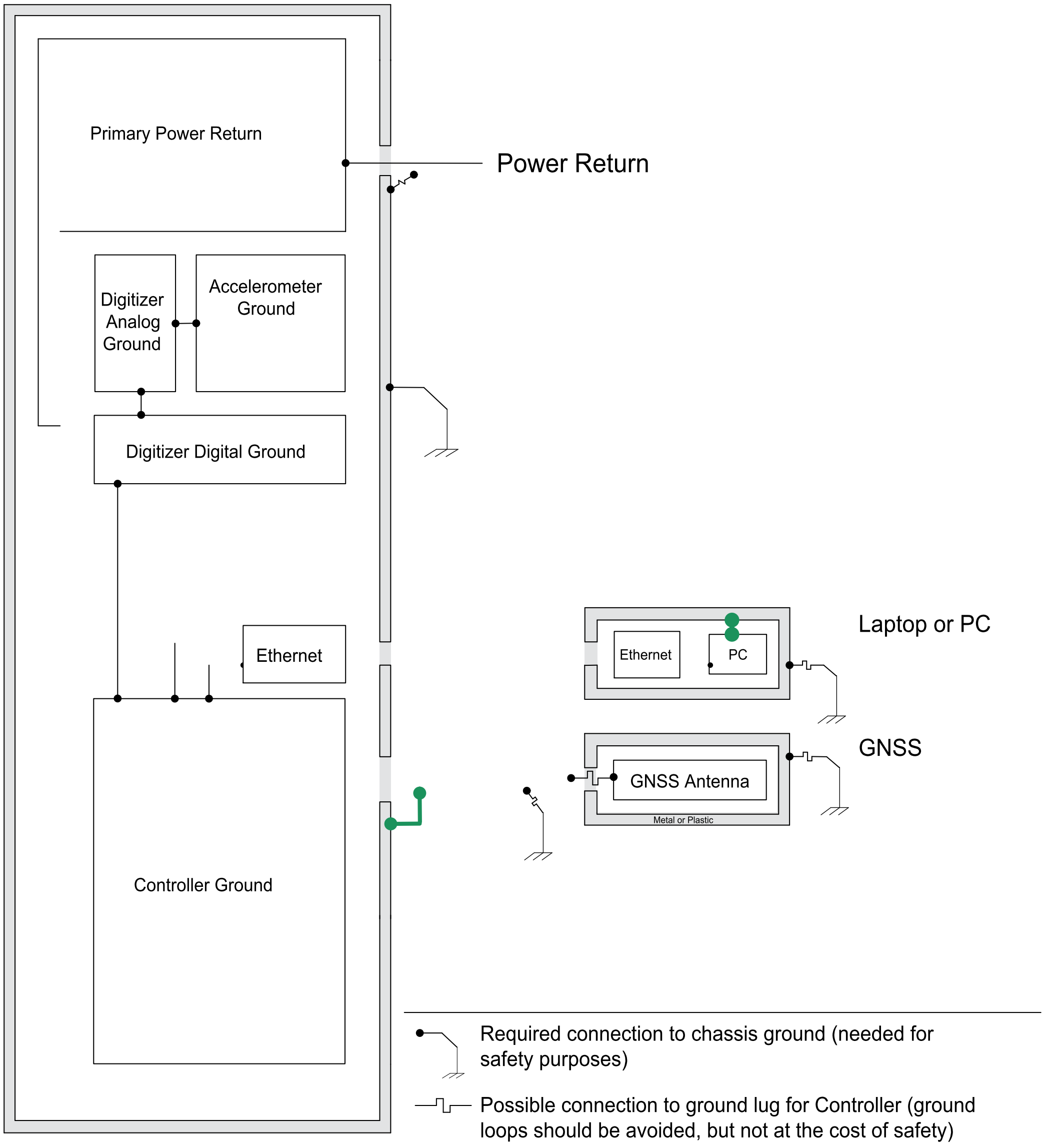
Deployment time-frame	Continuous data streaming required?	Data access option
Short-term (Temporary)	Yes	Streaming, using: • Wired Internet, cellular or satellite
	No	File transfer: • Removable media (SD card) • Internal storage via Ethernet (retrieve unit and bring to lab)
Medium-term (Semi-permanent)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

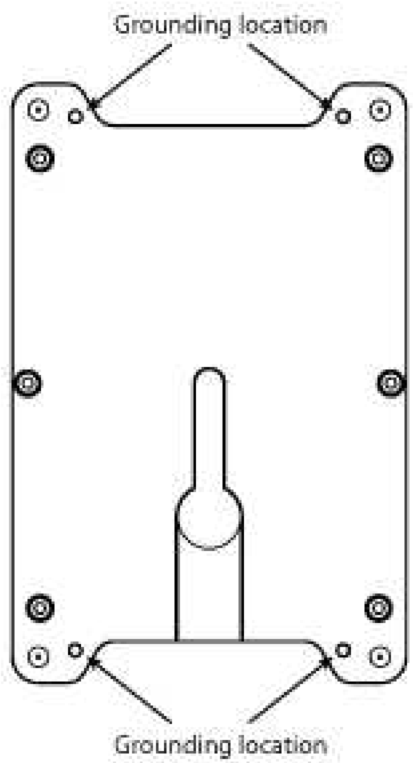
The power consumption of the TitanSMA varies with factors such as the GNSS receiver duty cycle and the activity of the Ethernet. Typical consumption is listed in the Power section of the technical specifications.

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 TitanSMA installation.



Primary power return is completely isolated from chassis, analog, and digital ground. Chassis (case) ground is connected to the analog ground of the digital recorder subsystem.

For the purpose of safety, the TitanSMA system chassis ground must be earthed. In most installations, for optimal performance, this should be done at one of the four grounding locations on the chassis, as shown in the following figure.



2.3.1 Power

The TitanSMA 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.

2.3.2 GNSS Antenna

The GNSS antenna is referenced to digital ground which has a single point connection inside the TitanSMA to analog ground which is in turn connected to TitanSMA chassis ground. If the TitanSMA 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 TitanSMA 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 TitanSMA grounding, the sensor grounding, power supply grounding, and local site grounding.

2.4 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 accelerometer, 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

2.5 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 14.

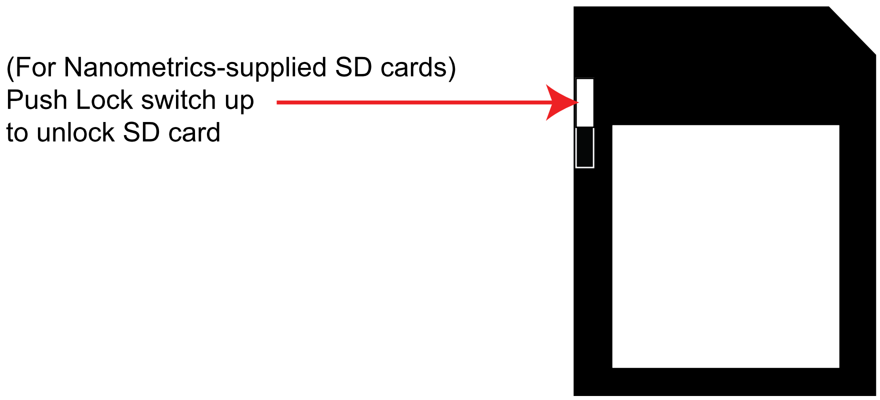
The TitanSMA supports both an internal SD card and an external SD card. See About Data Storage for more information. For information on replacing or installing the internal SD card, please contact Nanometrics Technical Support.

> ⚠ 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.

2.6 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 TitanSMA will ignore the lock. Existing data on the internal SD card may be over-written.



2.6.1 Insert SD Card

The TitanSMA can be configured to archive MiniSEED data, event data, SOH data, and StationXML to an **SD**[1] card formatted as FAT32. 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 media slot on the behind the media bay door of the TitanSMA . 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 SD card.

To ensure sufficient space on your SD card, you can remove older time series data from your continuous archive. The safest method for transferring data from the 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.

2.6.2 Remove or Swap the SD Card

Remove the SD Card

To safely remove the 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

[1]Secure Digital

Media Eject LED to turn solid green, which indicates that it is safe to remove the. This should take less than 15 seconds. If the 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 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 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 SD card within one hour of removing the old one. After an SD card is removed, and before the new one is inserted, the TitanSMA continues to digitize and buffers data internally. When the new SD card is inserted, that buffered data is written to the SD card to achieve a continuous gap-free recording.

2.6.3 SD Card Full or Corrupt

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

SD Card Troubleshooting

- If your 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 SD cards is performed in the Removable Media section of the **Maintenance** page.
- The most effective way to retrieve data directly from the TitanSMA'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.

2.7 Perform the Initial Configuration

Each TitanSMA comes factory-configured with several default configuration settings. The factory configuration addresses the most common use cases for the TitanSMA 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 TitanSMA 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
- Detector settings
- Ethernet settings
- Streamer settings (Networked deployment)
- Timing source settings
- Archiving to SD card

2.8 Perform a Tilt Test

A tilt test is an effective way to become familiar with the TitanSMA and how it records motion. The test involves holding the TitanSMA and rotating it while watching the **Mean** value for each channel in real-time on the Waveform page.

> To avoid clipping, the device should be in 2 *g* or 4 *g* mode when performing a tilt test.

2.9 Evaluate the Installation Site

When deciding where to install a TitanSMA, it is important to understand the expected range of motion at the site, ensure that the GNSS antenna will have a clear view of the sky, and to evaluate the available installation surfaces.

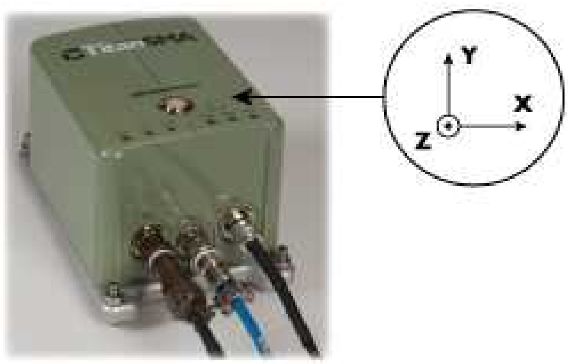
To achieve accurate measurements, it is recommended that you anchor each TitanSMA to a hard, unyielding surface, such as concrete, masonry, or metal, that is flat, level, and free of debris and obstacles. Anchoring the device to the installation surface is recommended because ground motion can cause an unsecured TitanSMA to shift and produce inaccurate measurements. Each TitanSMA is shipped with the necessary hardware to secure the devices to concrete, masonry, or metal surfaces.

Where less than 0.1 *g* of motion is expected, a TitanSMA can be placed freestanding on the installation surface. As with anchored installations, the installation surface for a freestanding TitanSMA should be flat, level, and free of debris and obstacles.

Next, ensure that there is a suitable location for mounting the GNSS antenna. The antenna must have a clear view of the sky and be within an acceptable distance for connecting the cable to the TitanSMA.

Finally, consider how the device will be oriented. Options include orienting the TitanSMA with the directions of the compass (north-south or east-west) or aligning it with the primary axis of the structure where it is being installed.

The table below shows the approximate values that you should see for each channel in various orientations.



Orientation	**X (*g*)**	**Y (*g*)**	**Z (*g*)**
X and Y arrows horizontal (device on its feet)	0	0	0
X arrow up (device on left side)	+1	0	-1
X arrow down (device on right side)	-1	0	-1
Y arrow down (device resting on media bay door)	0	-1	-1

2.10 What You Need for an Anchored Installation

You will need the following to properly orient, anchor, and level a TitanSMA on a concrete, masonry, or metal surface:

Item	Supplied by	Usage
Compass	Installer	To orient the TitanSMA to north-south or east-west
Drawing tools	Installer	To mark the installation surface
Hardware (anchor or bolt)	Nanometrics (included in the TitanSMA installation kit)	For concrete or masonry surfaces • One 1/4 in. masonry sleeve anchor bolt (complete with the washer and blue sleeve) with 11/64 in. head height For metal surfaces • One M6x25 hex bolt with M6 hex nut
3 mm hex screw-driver	Nanometrics (included in the TitanSMA installation kit)	For locking the levelling screws
Adjustable wrench or 10 mm wrench	Installer	For locking the levelling screws
Cables	Installer / Nanometrics	For part numbers and descriptions of cable options, see TitanSMA Optional Equipment. See Connectors and Pinouts for connector pinout tables and diagrams.
GNSS patch antenna	Nanometrics	For timing purposes

Item	Supplied by	Usage
Grounding wire	Installer	To connect the TitanSMA to the site ground • 10 AWG is recommended. • Cut the cable to length to remove excess and minimize voltage drop.
Grounding lug, M4	Installer	To ground the TitanSMA • The grounding lug must accommodate the gauge of the grounding wire used.
M4x5 screw and M4 washer	Nanometrics (included in the TitanSMA installation kit)	To attach the grounding lug to the TitanSMA

2.10.1 Prepare the Installation Surface

Perform the following steps to prepare the installation surface for installing and orienting the TitanSMA:

1. Select an installation location that is flat and level and ensure that it is clean and free of obstacles.
2. Determine the desired orientation of the TitanSMA, such as aligned with true north or in line with the primary axis of the structure.
3. If using a directional orientation, use the compass and drawing tools to draw a line on the concrete parallel to the selected orientation direction. If you are using a magnetic compass, account for the local magnetic declination when drawing the line.

   -OR-

   If aligning the TitanSMA along the primary axis of the structure, draw a line parallel to this axis.
4. Indicate the drilling location by marking the desired location on the orientation line.

   When adding this mark, ensure that there is a buffer of 20 cm around it that is free of obstacles and debris. The mark represents the centre point of the TitanSMA and is the location where the anchor or bolt that will hold the TitanSMA in place will be set into the surface.

2.10.2 Drilling Guidelines

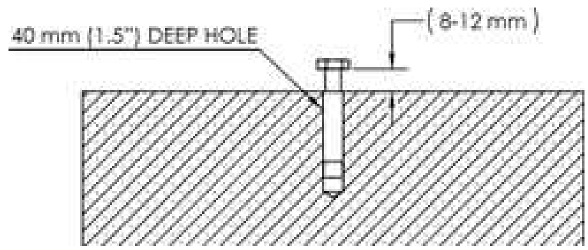
The following figures provide suggested drilling guidelines for hardware supplied by Nanometrics.

Concrete or masonry surface

Hardware: 1/4 in. masonry sleeve anchor bolt (Make sure to use the flat washer that is included with the anchor bolt.)

Drill bit: 1/4 in. concrete drill bit

Hole depth: 40 mm (1.5 in)

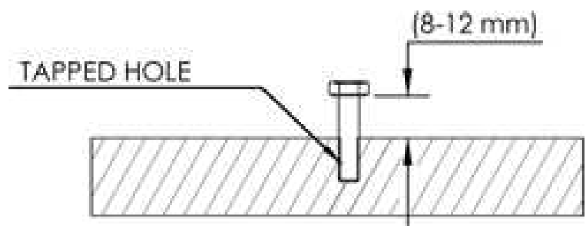


Metal surface, tapped hole

Hardware: M6x25 hex bolt

Drill bit: drill and tap for M6 thread

Hole depth: 20 mm drilled and tapped for M6 thread

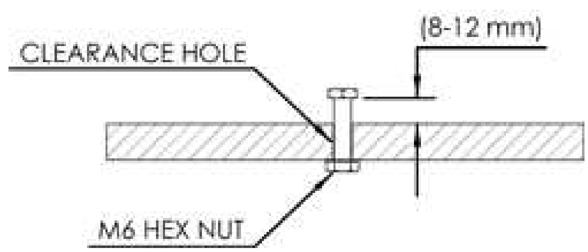


Metal surface, through hole

Hardware: M6x25 hex bolt

Drill bit: 6.5 mm or as desired for M6 clearance hole

Hole depth: through hole



2.10.3 Install and Anchor the TitanSMA

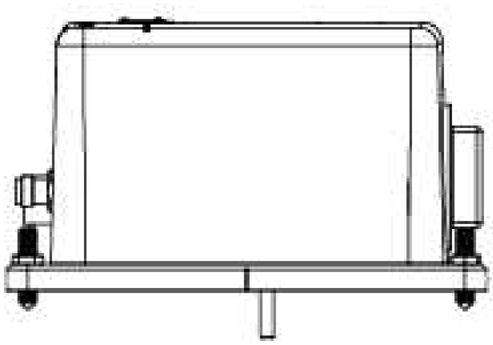
Perform the following steps to install and anchor a TitanSMA:

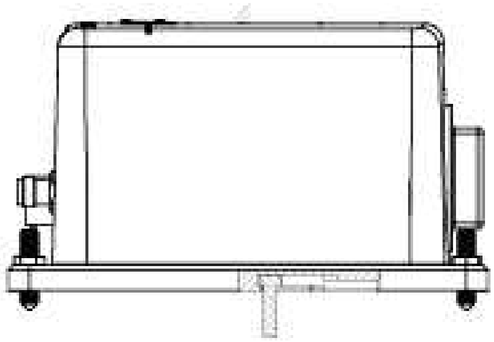
1. Mount the GNSS antenna so that it has a clear view of the sky.
2. Ensure the length of each cable is sufficient to
    - Connect to the accelerograph and its destination point (for example, the destination point for the power cable is the power source)
    - Allow for strain relief
3. Connect each cable to the TitanSMA but not to its destination point.
4. Select the anchor or bolt you will use to attach the TitanSMA to the installation surface.
5. Drill a hole at the drilling location marked on the installation surface.

    Use an appropriate drill bit for the surface type and the selected anchor or bolt. For more information, see Drilling Guidelines.
6. Clear **all** debris from the hole.
7. Insert the selected bolt into the hole. Ensure that the bottom of the bolt head is 8 mm to 12 mm above the surface.

> For masonry or concrete installations, ensure that the sleeve of the anchor bolt is flush with the installation surface. For more information, see the image for the sleeve anchor bolt in concrete or masonry in Drilling Guidelines.

8. Using the guide in the bottom of the TitanSMA, fit the TitanSMA over the head of the anchor or bolt. The images below show how the slot in the back of the TitanSMA fits over the head of the anchor or bolt set into the installation surface. For a full view of the back of the TitanSMA, see "Bottom View of the TitanSMA" on page 190.





9. Ground the TitanSMA using the following steps:
   a. 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.
   c. Connect the other end of the grounding wire to a grounding point at the site.
10. To orient the TitanSMA, turn it so that its X directional marker is aligned with the line drawn on the installation surface.
11. Adjust the levelling screws until
    - The levelling bubble is in the centre of the black ring.
    - The levelling screws are extended to the maximum extent permitted by the anchor or bolt. As the levelling screws are turned into the surface, the TitanSMA is lifted away from it, creating a secure connection between the TitanSMA and the head of the anchor or bolt.

> For installations on concrete or masonry surfaces, over-tightening the levelling screws may pull the anchor or bolt out of the installation surface.

12. Lock each of the levelling screws by inserting the 3 mm hex screwdriver into the screw to stop it from rotating and using a wrench to firmly tighten the lock nut.

> Be sure to inspect cables for damage prior to connecting them. See "Preventative Maintenance of Connectors and O-rings" on page 22.

13. Strain relieve each of the cables to the installation surface.

> Tie-wraps with tie-wrap anchors or a heavy object are effective tools for achieving strain relief.

14. Connect each cable to its destination point and make sure that the cable runs from the strain relief to the TitanSMA are not under tension, kinked, or in compression.

> When you connect the power cable to the power source, the TitanSMA 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 Voltage reconnect threshold. For more information, see Troubleshooting Your Installation.

15. Ensure that the levelling bubble is still indicating that the device is level. If the device is not level, level it again.

2.11 What You Need for a Freestanding Installation

For lab testing or at sites where less than 0.1 *g* of motion is expected, a TitanSMA can be placed freestanding on the installation surface. The installation surface for a freestanding TitanSMA should be flat, level, and free of debris and obstacles.

To achieve accurate measurements, it is recommended that you anchor each TitanSMA to a hard, unyielding surface, such as concrete, masonry, or metal, that is flat, level, and free of debris and obstacles (see also Install and Anchor a TitanSMA).

When setting up a freestanding TitanSMA, you will use the fixed foot that is supplied with each TitanSMA to create a 3-foot installation that can be made level without securing the device to the installation surface.

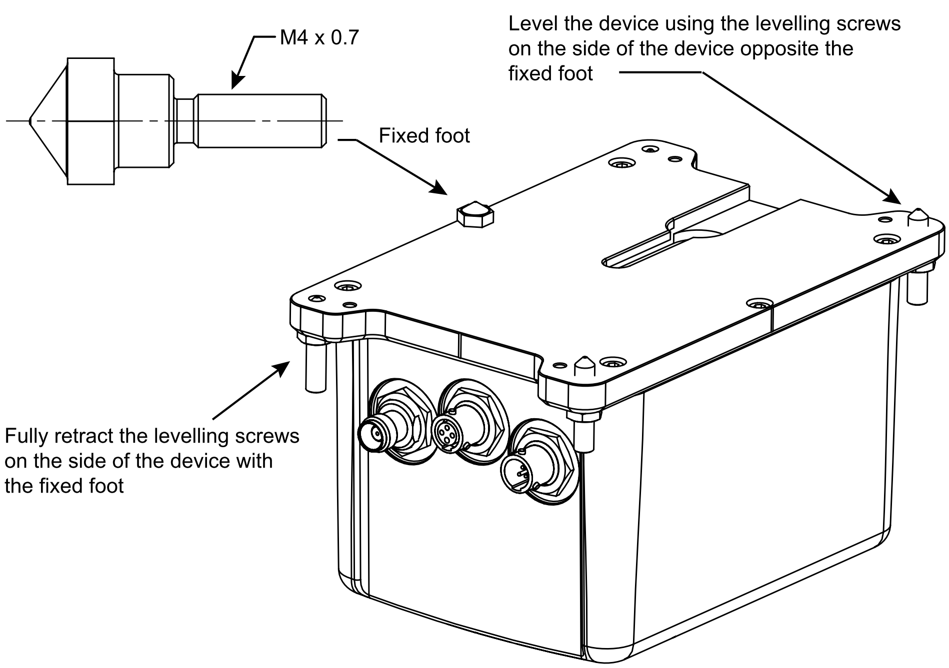
You will need the following to create a levelled and aligned freestanding installation of one or more TitanSMAs:

Item	Supplied by	Usage
Straightedge or equivalent	Installer	For alignment when setting up multiple devices.
Fixed foot	Nanometrics (included in the TitanSMA installation kit)	To act as a third foot for accurate levelling in installations where the device is not anchored to the installation surface.
3 mm hex screwdriver	Nanometrics (included in the TitanSMA installation kit)	For removing and replacing the screw in the base For locking the levelling screws

Item	Supplied by	Usage
Adjustable wrench or 10 mm wrench	Installer	For tightening the fixed foot For locking the levelling screws
Cables	Installer / Nanometrics	For part numbers and descriptions of cable options, see TitanSMA Optional Equipment. See Connectors and Pinouts for connector pinout tables and diagrams.
GNSS patch antenna	Nanometrics	For timing purposes

2.11.1 Install a Freestanding TitanSMA

Use the following figure as a reference when installing a freestanding TitanSMA:



Perform the following steps to perform a freestanding installation of one or more TitanSMAs:

1. Select an installation surface that is flat and level and ensure that it is clean and free of obstacles.
2. Ensure the length of each cable is sufficient to

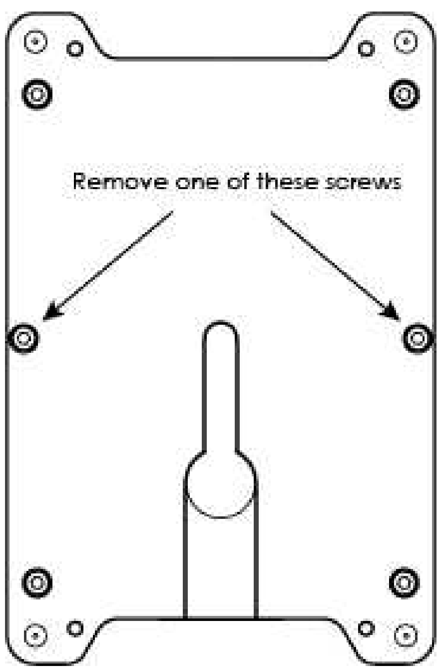
- Connect to the TitanSMA and its destination point (for example, the destination point for the power cable is the power source)
- Allow for strain relief

3. If you are setting up more than one device, place the straightedge (or equivalent, such as a line drawn on the installation surface) on your installation surface.

> If you are only setting up one TitanSMA, the orientation of the device does not matter. However, if you are setting up multiple devices, you should align all devices to the same reference point for data comparison purposes.

4. Mount the GNSS antenna(s), ensuring a clear view of the sky.
5. For each TitanSMA you are setting up

    a. Use the 3 mm hex screwdriver to remove one of the middle screws from the base plate of the TitanSMA. Retain the screw.



> When the freestanding installation is no longer needed, replace the screw in the base plate and tighten it to 22 in-lb.

    b. Insert the fixed foot into the empty screw hole and torque to 22 in-lb.
    c. Fully retract, but do not remove, the levelling screws on the side of the device where you installed the fixed foot.

d. If there are multiple devices, align each with the orientation line on the surface.
e. Connect each cable to the TitanSMA but not to its destination point.
f. Adjust the two levelling screws on the side opposite the fixed foot until the levelling bubble is in the centre of the black ring.
g. Lock the levelling screws so the device remains level by inserting the 3 mm hex screwdriver into one of the screws to stop it from rotating and using a wrench to firmly tighten the lock nut.

> Be sure to inspect cables for damage prior to connecting them. See "Preventative Maintenance of Connectors and O-rings" on page 22.

h. Strain relieve each cable to the installation surface.

> Tie-wraps with tie-wrap anchors or a heavy object are effective tools for achieving strain relief.

i. Connect each cable to its destination point and make sure that each cable run from the strain relief to the TitanSMA is not under tension, kinked, or in compression.

> When you connect the power cable to the power source, the TitanSMA 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 Voltage reconnect threshold. For more information, see Troubleshooting Your Installation.

j. Ensure that the levelling bubble is still indicating that the device is level. If the device is not level, level it again.

2.12 Post-installation Activities

At the installation site, these are activities you might want to perform:

- Monitor the LEDs for flashing red lights
- Verify your installation steps against the installation checklist

- Record the station information
- Troubleshoot, if necessary

After your installation is complete, you can access the Web interface to monitor the status and health of your TitanSMA remotely. You can quickly check the health of the device from any page by looking at the status bar at the top of the page.

2.12.1 Troubleshooting the Installation

To troubleshoot your installation, first ensure that you have completed the Installation Checklist.

Following are some problems that might occur in a TitanSMA installation with possible causes and solutions.

Spikes on the Horizontal Channels

The feet of the TitanSMA are not locked or properly tensioned against the anchor bolt.

There is something touching the sides of the TitanSMA.

Continuous Low Frequency Drift (Random or Periodic)

The TitanSMA is exposed to air drafts or large temperature changes. Install an insulating cover over the device.

Spikes on All Channels Simultaneously

Usually due to electrical system noise. For example, power supply noise from a battery charging circuit, or interference from a strong magnetic or radio source that is nearby.

Drift on Startup

A small amount of drift is normal as the TitanSMA is coming to equilibrium temperature. It should stabilize within 1 hour.

Does not Power On

The power supply voltage might be below the configured Voltage reconnect threshold. If the power supply voltage is below the configured threshold, the device will not power up.

To fix this problem, you can connect a power supply that is above the configured threshold or you can force the device to power up by pressing and holding the **Force Power On** button behind the media bay door until the Power LED turns on.

2.12.2 TitanSMA Installation Checklist

Use the following checklist to help you verify that you have completed all of the necessary steps in the installation of your TitanSMA.

	Installation surface is clear of debris.
	TitanSMA N direction is aligned to true north (accounting for the magnetic declination).
	TitanSMA is level.
	Levelling screws are extended and tensioned against the anchor bolt.
	Levelling screws are locked.
	Serial number is noted.
	Required cables are connected.
	GNSS antenna is attached.
	Cables are strain-relieved to the installation surface.
	Cables are not touching the TitanSMA case.
	X, Y, and Z channels are zeroed using the channel offset feature.
	SD card is installed (optional) and the media bay cover is closed.
	Power is on.
	Configuration is complete.
	The Status LED is blinking green and none of the values on the Health page are red (for more information, see Monitoring the LEDs).
	Ensure that seismic waveforms are displayed on the Waveform page.

2.12.3 Station and Device Information

Use the following table to record information about the installation and station. This information will be helpful in identifying changes to the station over time.

Station Information

Station code:	
Network code:	
Station address:	
Latitude-Longitude-Elevation:	
Station contact:	
Check-in with:	
Business hours:	
Directions:	
Keys needed:	Yes/No
Parking:	
Date of installation:	
Installation surface type:	
Secured to surface:	Yes/No
Description of installation site:	

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Device Information

Device type:	
Device location at site:	
Device serial number:	
Device IP address:	
Expected range of motion:	_____ *g* to _____ *g*
Device orientation:	Orientation of Z arrow __________ Orientation of Y arrow __________ Orientation of X arrow __________
Keys needed:	Yes/No
Device history:	
Inspection dates:	

Notes:

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 TitanSMA 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 TitanSMA 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 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 **Media** section quickly tells you whether an archive SD media card is installed, the last time that the archive was written to and the size of the Internal Storage in the accelerograph. In addition, the Archive card bar will change from green to red when the 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.

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 169.254.30.30.

3.3 Network Connection to the Web Interface

1. Connect the TitanSMA 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 TitanSMA. If it does not, then you are connected to a different TitanSMA in your network.

> After connecting to the TitanSMA, 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 TitanSMA 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 TitanSMA, 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

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 TitanSMA. 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 TitanSMA 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 TitanSMA, 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 195. 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 TitanSMA, 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 44.
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 TitanSMA, 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 44.
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 TitanSMA 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 TitanSMA 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 44.

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 TitanSMA

You can change the configuration settings for the TitanSMA 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 TitanSMA, 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, TitanSMA 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 TitanSMA and save it as a backup in case you ever want to restore the settings of the TitanSMA to the current state or upload it to a different TitanSMA. 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 TitanSMA 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 TitanSMA 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 Accelerometer

The TitanSMA has a force balance triaxial accelerometer with a low noise floor, exceptionally low hysteresis, and a wide dynamic range. You can configure the mode and the channel offset for the TitanSMA accelerometer.

Mode

Select the mode in *g* for the horizontal and vertical channels.

The mode specifies the full scale range and sensitivity of the accelerometer.

Channel offset *n* [g]

Enter the offset of the channel in *g*. You can view the mean value on the Waveform page.

4.5 Channel Naming

The channel names are used by the TitanSMA 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 141.
- Filtered Streaming – When you configure the TitanSMA to stream data, you have the option to define an SCNL-based filter to limit what channels are streamed. The TitanSMA refers to the channel names when it performs the filtering.

TitanSMA 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 TitanSMA, 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 TitanSMA belongs to.

Station code

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

Location code

A two character alphanumeric code (the alpha characters must be uppercase) that represents the time series location of the TitanSMA. 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 TitanSMA.

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

4.6 Communications

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

4.6.1 Discovery

Enable discovery

Select this check box to allow the TitanSMA 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 TitanSMA for discovery broadcasts.

4.6.2 Ethernet

Ethernet mode

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

By default, each TitanSMA 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: 169.254.30.30.

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.

Apollo Discovery is part of Apollo Toolkit, which ships with TitanSMA. The Apollo Toolkit User Guide contains instructions for installing and using Disco.

Static IP address

If the selected Ethernet mode is **Static IP**, enter the IP address to be assigned to the TitanSMA 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 TitanSMA 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 TitanSMA select **10BaseT** from the drop-down list. This typically reduces power consumption by more than 100 mW relative to 100Base-T.

4.7 Continuous Data Archive

The TitanSMA Continuous Data Archive feature allows you to continuously archive MiniSEED data, StationXML data and SOH data (optional) to a removable 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 SD card slot behind the media bay door of the TitanSMA.

> In addition to streaming data from the TitanSMA to a network application or device and archiving data to a removable SD card, you can also retrieve time series and SOH data directly from the TitanSMA's **internal storage**[1] by downloading it from the Maintenance page to your computer. In addition, the TitanSMA 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 TitanSMA to continuously write MiniSEED data and StationXML data files to the 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

Select the number of output files to be generated for each archive period: one file per channel or one file per station. The **per 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 titanSMA_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 62 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_titanSMA_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 62 for more parameter descriptions.

Include SOH archive

Select this check box if you want to archive SOH data files to the 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 titanSMA_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_titanSMA_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

4.8 Data Streaming

You can configure the TitanSMA 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 TitanSMA 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, TitanSMA 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 TitanSMA, which then streams SeedLink data using Transmission Control Protocol (TCP).

See the following topics for more information:

- General Data Streaming Settings
- NP Streaming (UDP, HTTP & WebSocket)
- QSCD20 Streaming
- SeedLink Streaming
- Throttle
- Fragmentation

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

4.8.1 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 TitanSMA 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.

4.8.2 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 TitanSMA includes the following data:

- Voltages
- Temperature
- Sensor 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 TitanSMA 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 83.

Stream alerts

Select this option to stream alerts generated by the TitanSMA 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 TitanSMA to stream, you have the option to use a filter to specify exactly which channels the TitanSMA 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 TitanSMA 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 TitanSMA 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 TitanSMA no longer has the ReTx data, therefore Apollo Server will stop requesting the missing data. The data is still available in the TitanSMA Store and can be retrieved using either the TitanSMA Web interface or the FDSN dataselect API until it is eventually overwritten by newer data in the TitanSMA 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.

---

[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).

4.8.3 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.

4.8.4 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.

4.8.5 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:

- 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 TitanSMA'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, TitanSMA will continue to stream QSCD20 data, and the QSCD20 quality flag will identify the condition.

4.8.6 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

Proceed as follows to configure your TitanSMA 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.
2. To enable QSCD20 data streaming, navigate to the **Digitizer** page and select the **Enable continuous data products** check box.
3. To configure the TitanSMA 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 TitanSMA Web interface.

[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.

4.8.7 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.

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.

[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

- The location code, which identifies the time series location of the TitanSMA, 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>

4.9 Digitizer

The TitanSMA Digitizer has three 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 SD memory card and/or streamed to central data repositories.

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 SD card at a higher sample rate on secondary channels.

You can also configure general settings for the TitanSMA Digitizer such as frames per packet on primary and secondary channels, as well as 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.

4.9.1 Maximum Archiving and Streaming Rates

The TitanSMA supports a maximum “aggregate sample rate” of 2010 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 TitanSMA to become overburdened, potentially resulting in waveform gaps.

Examples:

- a TitanSMA with a sample rate of 2000 Hz archiving the primary channels and 10 Hz streaming the secondary channels has an aggregate rate of 2010 Hz and is supported.
- a TitanSMA 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 TitanSMA with both primary and secondary channels sampling at 2000 Hz has an aggregate rate of 4000 sps and is not supported.
- a TitanSMA with a sample rate of 500 Hz can have a SeedLink server configured.
- a TitanSMA with primary channels sampled at 500 Hz and secondary channels sampled at 50 Hz cannot have a SeedLink server configured.

> 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.

4.9.2 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). Orientation correction may also be used for azimuth correction, sensor tilt correction, and vertical Titan output remapping. 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.

Azimuth correction

If a sensor has been installed and there is no method for physically turning the sensor to sit in the desired direction, for example X direction pointing East. The orientation correction feature allows you to correct the alignment of the sensor by determining the degree of misalignment and then entering the azimuth correction using the Orientation Correction feature. Once these values are applied, the TitanSMA 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.

Sensor tilt correction

A sensor may be positioned so that its Z component is not actually vertical. The orientation correction feature allows the user to enter the X and Y tilt angles in degrees into the TitanSMA Web Interface. The TitanSMA will rotate the data so that the new X' and Y' outputs have 0 tilt, which will bring Z' to true vertical.

4.9.3 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.

4.9.4 Primary Channels

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

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

Primary output type

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 172 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 [Hz]

The number of samples per second produced from each analog sensor input signal. The default is 200 Hz (200 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

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.

4.9.5 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.

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

Secondary output type

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" on the previous page 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 [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

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.

4.9.6 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.

4.9.7 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].

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.

4.9.8 Trigger Detectors

The TitanSMA 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**[3]/LTA ratio. As soon as the channel detector detects that the threshold value or

---

[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

[3]Short Term Average

STA/LTA ratio has been exceeded, it generates a **trigger**[1] for that channel. When the TitanSMA sees this trigger, it counts how many **votes**[2] 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 TitanSMA 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 media card.

Event declaration can happen locally using only the channels of the TitanSMA 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.

---

[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]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* [*g*]

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.

4.10 Events

The TitanSMA 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 TitanSMA 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 the TitanSMA 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 media card.

Event declaration can happen locally using only the channels of the TitanSMA 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 TitanSMA to declare a group of triggers as an event.

---

[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.

Maximum event duration [s]

The amount of time, in seconds, that the TitanSMA 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.

4.10.1 Events Data Archive

The TitanSMA Events Data Archive feature allows you to archive **event**[1] data and SOH data (optional) to a removable 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 SD card slot behind the media bay door of the TitanSMA.

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

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

Enable events data archive

Select this check box to allow the TitanSMA to write event data to the 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.

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_titanSMA_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 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_titanSMA_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

4.10.2 Trigger/Event Sharing

The TitanSMA 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.

---

[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.

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.

Port number

The port number used by the TitanSMA 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.

4.10.3 Event Data Products

You can configure the TitanSMA to calculate peak ground motion data products When this feature is enabled, the TitanSMA calculates the **PGA**[1], **PGV**[2], and **PGD**[3] values for each declared event, writes the

[1] Peak Ground Acceleration

[2] Peak Ground Velocity

[3] Peak Ground Displacement

calculated values to the **internal storage**[1] with the event, and posts them on the **Events** page.

> The PGA reported by the TitanSMA 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 TitanSMA to calculate peak ground motion data products for each event.

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

Source digitizer channels

Select the channels used to calculate the data products.

4.10.4 Configure Email Notifications for Declared Events

TitanSMA 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**[2] client used by TitanSMA 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.

[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.
[2] Simple Mail Transfer Protocol

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 (titanSMA_0104)

Maximum PGA 1.40693125E-1 g @ NX.PVEA1 (titanSMA_0104)

> If Ethernet Mode is set to Static IP, email notifications require a Primary DNS to be configured.
> See event detection and declaration for more information. You can also access the help by clicking **Help** in the upper-left corner of the TitanSMA 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 TitanSMA 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)

4.11 Power

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

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

Power on [mV]

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

If the current external power supply voltage is less than a newly committed **Power on** threshold, then the TitanSMA 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 TitanSMA performs a safe shutdown.

If the current external power supply voltage is less than a newly applied **Low voltage shutdown** value, then the TitanSMA will automatically shut down. If not committed, the TitanSMA 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 TitanSMA powers off immediately.

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

4.12 Raw TCP Receiving

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

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

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.

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 TitanSMA.

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 TitanSMA 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 TitanSMA.

Raw packets per NP packet

The number of packets the TitanSMA 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.

4.13 SeedLink Server

TitanSMA 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

[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.

TitanSMA can be converted into the 512-byte MiniSEED format and retrieved by SeedLink clients from the TitanSMA. Only one SeedLink server can be configured on a TitanSMA.

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 TitanSMA 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 TitanSMA 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.
>
> **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 TitanSMA 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 TitanSMA 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.

4.14 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.

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.

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)" below.

Default: Unselected.

4.14.1 About Simple Network Management Protocol (SNMP)

You can configure the TitanSMA 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 155. The latest MIB file can be downloaded from TitanSMA 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 98. 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 TitanSMA.

4.15 Timing Source

The TitanSMA 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 TitanSMA uses, it can also be configured to supply either PTPv2 or NTP network timing to other TitanSMA units.

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

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 TitanSMA or another Nanometrics instrument such as aTitanSMA 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 another local TitanSMA, TitanEA or Centaur acts as an NTP server for the TitanSMA.

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.

4.15.1 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 TitanSMA 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 TitanSMA 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.

4.15.2 Configuring GNSS timing

To configure GNSS timing on a TitanSMA, 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 176 for more information.

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

4.15.3 Configuring PTP timing

To configure the TitanSMA to receive PTP network timing from another instrument, 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 Nanometrics instrument on the same subnet that is configured to act as a PTP server.
3. Optionally, in systems where one TitanSMA must provide network timing to other instruments, select **PTP** or **NTP** from the **Time sharing** drop-down list. If selecting **PTP**, be aware that only instruments on the same subnet as this TitanSMA will be able to receive the multicast PTP messages.
4. To save the configuration, click the **Apply** button, then click the **Commit** button.

4.15.4 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

4.15.5 Configuring NTP timing on a TitanSMA

To configure the TitanSMA to receive NTP timing from another instrument 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 TitanSMA or other Nanometrics instrument). 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 anotherNanometrics instrument as the NTP server, be sure that the other instrument is configured to act as an NTP server.
4. Optionally, in systems where one TitanSMA must provide network timing to other instruments, select **PTP** or **NTP** from the **Time sharing** drop-down list. If selecting **PTP**, be aware that only instruments on the same subnet as this TitanSMA will be able to receive the multicast PTP messages.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

4.15.6 Enabling a stratum 1 NTP server on a TitanSMA

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 TitanSMA, 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 instrument 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.

4.15.7 Enabling a stratum 2+ NTP server on a TitanSMA

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 TitanSMA, 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 TitanSMA is to get its timing.
4. Select **NTP** from the **Time sharing** drop-down list to enable this TitanSMA to act as an NTP server for other instruments.
5. To save the configuration, click the **Apply** button, then click the **Commit** button.

When configuring another instrument 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.

4.15.8 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 TitanSMA 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 TitanSMA 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 TitanSMA or other Nanometrics instrument 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.

If the instrument has a GNSS receiver, 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 TitanSMA 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 TitanSMA 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.

4.16 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 TitanSMA 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 TitanSMA remains fixed, for example if you are using the TitanSMA'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 TitanSMA.

This section describes the parameters for configuring the geographical location of your TitanSMA. 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 TitanSMA 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 TitanSMA 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 TitanSMA 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 TitanSMA 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.

External LEDs:

- Overall Status
- Power
- Link
- Time
- Media
- Event

Internal LEDs:

- Media Eject
- USB Eject

5.1 Power LED

Off

The TitanSMA has no power.

Solid red -TO- Blinking orange

The TitanSMA is starting up (reverse sequence when shutting down).

Blinking green

The TitanSMA has power.

Blinking red

The Force Power On button was pressed to force the TitanSMA 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.

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 TitanSMA 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 TitanSMA powers up.

Blinking green

The TitanSMA 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

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

Blinking orange

Checking the status of the SD card.

-OR-

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

Blinking green

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

Blinking red

The SD card is corrupt, full or there is an error writing to the 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 Event LED

Off

No events recorded.

-OR-

No SD card detected.

Solid green

Checking SD card for events.

Blinking green

At least one event has been recorded to the SD card.

5.6 Overall Status LED

Off

The TitanSMA is powered off.

Solid red

Initial power-on.

Blinking orange

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

Blinking green

The TitanSMA is operating properly.

Blinking red

There is a fault or condition that prevents the TitanSMA 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 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.

  -OR-

[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 Force Power On button was pressed to force the TitanSMA 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.

5.7 USB Eject LED

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

5.8 Media Eject LED

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

Off

No SD card is detected.

-OR-

The SD card is ready for use or is being used for archiving so it is not safe to remove the card because data might be lost or become corrupted if removed while archiving data.

Blinking red

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

-OR-

The button next to the 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 TitanSMA will attempt to prepare the SD card for safe removal. If files are still being archived to the SD card after 2 minutes, the 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.

-OR-

The buttons next to the SD card and the USB device have been pressed and held for more than 6 seconds and then released to initiate a safe shutdown of the TitanSMA. Both LEDs will blink red while the TitanSMA is shutting down and then go off.

Solid red

The 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 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 SD card. If the 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 SD card.

6.0 Using the Web Interface

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

- Monitor the status and health of your device.
- 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 TitanSMA, 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 TitanSMA, 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. Status OK

6.1.1 Events

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 SD card.

The possible statuses are as follows:

- Not started — The following conditions will cause the Not started status to display. Note that the 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 SD card being recognized by the instrument.
  - When the instrument is ready to archive to the 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 SD card.
- Archive OK — The SD card is archiving event data or is ready to archive event data and the last event was archived successfully.
- No archive media — The SD card is missing or there is an error writing to the current SD card. Insert an unlocked SD card, disable the archiving of event data, or replace or reformat the current SD card. If an SD card is present and this error occurs, the error may be caused by the SD card being write-protected. In this case remove the 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 SD card.
- Archive full— The SD card is full and no more event data can be archived. Replace the current SD card or delete some of the archived data from the card.
- Disabled — The TitanSMA has not been configured to archive event data to a removable 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 TitanSMA 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.

6.1.2 Device

System — Uptime

The time elapsed since the TitanSMA 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 TitanSMA 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, TitanSMA 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 TitanSMA measured in watts.

> The system current is shown in the tooltip.

Environment — Supply voltage

The voltage level being supplied to the TitanSMA by the power source.

Environment — Temperature

The internal temperature of the TitanSMA.

The internal temperature may be several degrees higher than the ambient temperature.

6.1.3 Storage

Media Card — Status

The status of the removable media card.

The possible statuses are as follows:

- Ejecting — The SD card is being prepared for safe removal from the device. (See Remove the SD Card for more information.)
- Formatting — The SD card is being erased and reformatted with a new file system to prepare the 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 SD card:
  - The SD card is corrupted.
  - There is an error writing to the SD card. This error may be caused by the SD card being write-protected. In this case remove the SD card and unlock it before reinserting it. See Write-protection on SD cards
- Media not present — The SD card is missing from the device. Please insert an SD card or disable the archiving of data (for more information, see Events Data Archive and Continuous Data Archive).
- Media OK — The SD card is archiving data or is ready to archive data.
- Mounting — The inserted SD card has been detected and is being prepared for use. (See Insert SD Card for more information.)
- Repairing — The file system on the 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 SD card has been ejected and is no longer in use. It is safe to remove from the device. Note, if the 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 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 SD card being recognized by the instrument.
  - When the instrument is ready to archive to the 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 SD card.
- Archive OK — The SD card is archiving data or is ready to archive data and the latest data was archived successfully.

- No archive media — The SD card is missing or there is an error writing to the current SD card. Insert an unlocked SD card, disable the archiving of data, or replace or reformat the current SD card. If an SD card is present and this error occurs, the error may be caused by the SD card being write-protected. In this case remove the 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 SD card.
- Archive full — The 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 TitanSMA has not been configured to archive data files to a removable SD card.

Media Card — Contains events

Indicates if the removable SD card contains events.

Media Card — Percentage used

The percentage of the total space used of the removable media card.

> The total size of the removable media card is shown in the tooltip.

Internal Storage — Status

The status of the TitanSMA'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.

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[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.

- 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.

6.1.4 Data

Primary Sample rate

The number of samples acquired every second, in hertz, by the TitanSMA for the primary channels.

Secondary sample rate

The number of samples acquired every second, in hertz, by the TitanSMA for the secondary channels (if enabled).

Primary Sensitivity

The system sensitivity for the primary output channels of each sensor.

Sensitivity is expressed in counts per m/s^2.

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.

Sensor Mode

The mode for the horizontal and vertical channels of the TitanSMA in *g*.

6.1.5 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 146.
- 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:

- 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.

[1] Coordinated Universal Time

- 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 100 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 109 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).

6.1.6 Alerts

The Alerts section provides you with a list of recent system-related events such as start-ups, shutdowns, and configuration changes.

6.2 Event Detection and Declaration

The channels of the TitanSMA continuously digitize time series data, which is recorded to the **internal storage**[1]. You can configure the TitanSMA to stream this time series data to another device or application and/or archive it on a removable media card. You can also download it from the device using the options on the **Maintenance** page.

If you want the TitanSMA 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 TitanSMA uses the detectors combined with a

[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.

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 TitanSMA 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 TitanSMA 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 media card.

Event declaration can happen locally using only the channels of the TitanSMA 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.

6.2.1 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 media or not. If the TitanSMA has been configured to automatically archive events to an SD card, then all declared events will be on the 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 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 TitanSMA, 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 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 SD card.

> You have to be logged on using the admin user account to delete all of the event archives on the 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 TitanSMA, we recommend that you change all default passwords after you have logged on for the first time. See About Passwords.

6.2.2 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 TitanSMA, 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 and it will also be archived on the removable SD card if the TitanSMA has been configured to archive event data. The **Source** column will help you distinguish automatically declared events from any that have been declared manually (user).

6.3 About 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 instrument 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 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.

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

The TitanSMA generates and outputs an analog signal using a 16-bit internal digital-to-analog converter (DAC).

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 TitanSMA, 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 instrument output can be viewed in the waveform display while it is simultaneously recorded for later analysis.

6.3.1 Calibrating a sensor

You can launch calibration actions manually from the **Waveform** page in the TitanSMA 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.

6.3.2 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.
3. Identify the calibration signal amplitude from the signal source that produces a good signal-to noise ratio (SNR) without producing clipping or obvious distortion.
4. 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.

6.3.3 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 TitanSMA, 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 TitanSMA 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 a signal **Type**. (Sine, Step, Pseudo-Random Binary, or Playback). The calibration output source is Voltage (V).
5. Click **Configure** to access the configuration settings dialog box.
6. Sensor A and All channels are the only options for calibration.

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 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.
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. See Signal characteristic configuration.

    - Note that PRB creates a broadband signal allowing the calibration verification of the entire passband with a single input signal, which is preferred for Titan sensors. The following signal characteristics are recommended for Titan sensor models:

        - Mode: Voltage
        - PRB width: 10 ms
        - PRB amplitude: 4 Volts
        - Duration: 5 minutes (300 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: 1000 sps
- Gain: 4 *g*

10. Configure silence padding before and after the calibration signal. Enter a value between 0 and 30 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 300 s (5 minutes). 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.

Signal characteristic configuration

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.

6.3.4 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.)

6.3.5 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.)

6.3.6 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:
  - Using the Web Service data download interface (FDSN-WS) API You can download from the Store, specifying the sensor channels and the start and end times that were returned from the GET /calibrate call that corresponds to the calibration sequence of interest.

6.4 View Digitized Waveforms in Near Real Time

You can see the sensor signals being recorded by the TitanSMA in near real time by viewing the digitized waveforms on the **Waveform** page. One horizontal signal line is displayed for each channel of the TitanSMA 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.

6.4.1 View Waveform Data

The **Waveform** page shows a horizontal signal line, or trace, in near-real time for each channel of the TitanSMA. 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.

6.5 Perform Maintenance Tasks

From time to time, you might have to perform simple maintenance tasks to ensure that your TitanSMA continues to operate correctly. These tasks include manually setting instrument time, upgrading the firmware, and retrieving time series, SOH, or response files from the TitanSMA's **internal storage**[2] or archives on the SD card. You can perform these tasks on the **Maintenance** page as well as download log files, format or repair the SD card, restart/shut down the TitanSMA, and reindex or re-create the TitanSMA'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 TitanSMA, 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 TitanSMA because it is not possible to power it up remotely.

6.5.1 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 TitanSMA time to a configured NTP server.

To manually set the instrument time:

1. Access the Web Interface for your TitanSMA 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 TitanSMA 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 100 for information about configuring timing.

6.5.2 Upgrade Firmware

> Before you upgrade the firmware on your TitanSMA, 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 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 TitanSMA 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 TitanSMA. If no installation package is present, the **Available firmware** list is disabled.

> Only one installation package can be present on the TitanSMA. 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 TitanSMA.

5. Upload and commit the latest firmware to your TitanSMA:
    a. Click the **Choose file** button to select the new firmware installation package to upload to the TitanSMA.
    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 TitanSMA will restart automatically after it has completed installing the firmware. You should not navigate away from the **Maintenance** page until the TitanSMA has completed installing the firmware and the device has restarted.

    e. After the TitanSMA 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, TitanSMA 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 TitanSMA. Click the **Delete** button to remove the firmware installation package from your TitanSMA.

> Deleting the firmware installation package will not affect the operation of your TitanSMA.

6.5.3 Retrieve Data from the Internal Storage

In addition to streaming data from the TitanSMA to a network device and archiving data to the removable SD card, you can also retrieve time series and SOH data directly from the TitanSMA'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 TitanSMA 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, 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 TitanSMA 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.

6.5.4 Download Log Files

If required for troubleshooting purposes, you can view the system logs for your TitanSMA 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.

6.5.5 Download Archive Files

If an 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 TitanSMA 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 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.

6.5.6 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 directly from your TitanSMA:
  - 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 TitanSMA reflect the configuration of the TitanSMA at the that time the download is initiated, including SCNL, geo-location, and the response of both the digitizer and the accelerometer within the TitanSMA. 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.

6.5.7 Removable Media

The **Removable Media** section on the **Maintenance** page provides:

- information about the status and the percentage of memory used on your SD card.
- the ability to remotely re-format your SD card in FAT32 format.
- a repair function that runs a file system check on your SD card.

Nanometrics recommends that you attempt to Repair your 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 SD card when the card is reformatted.

Format SD Card

Format your SD card by selecting FAT32 and clicking **Format** on the **Maintenance** page. Any data on your 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 SD card by clicking the **Repair** button on the **Maintenance** page, TitanSMA runs a file system check on your SD card and repairs the file system, if possible.

6.5.8 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.

6.5.9 Restart/Shut Down a TitanSMA

Read the information in this topic carefully before you shut down or restart your TitanSMA from the **Maintenance** page.

Shut Down a TitanSMA

You should only click **Shutdown** on the Maintenance page if you are in the same location as the TitanSMA 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 TitanSMA to allow normal operation. Contact techsupport@nanometrics.ca for instructions on deleting the Store.

You should shut down a TitanSMA before you disconnect the power to avoid the possibility of a lengthy reindexing of the internal storage on restart. You can do this by clicking **Shutdown** on the Maintenance Page or by pressing and holding the USB and SD card buttons behind the media bay door and waiting until both the USB LED and the SD LED have turned off.

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 TitanSMA when all of the LEDs on the case have turned off.

Restart a TitanSMA

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 TitanSMA is restarting.

6.5.10 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 TitanSMA and allow it to boot up completely.
2. Using an SSH client such as PuTTY, log on to your TitanSMA 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@titansma-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 TitanSMA.

- Data Availability API
- FDSN-WS Data Retrieval API
- State of Health API
- Instrument Response 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=titanSMA__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 TitanSMA. 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=titanSMA__0107/band/timeSeries...`

Format2: `dataSource={instrumentId_SN|NX.STN}`

Example snippet: `/api/v1/bands/availability?dataSource=titanSMA__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=titanSMA__0007&type=timeseries&startTime=2013-06-21T00:00:00Z

http://10.10.10.10/api/v1/bands/availability?dataSource=titanSMA__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”: “titanSMA_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”: “titanSMA_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&starttime=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 185.

Path

`/api/v1/instruments/soh`

Parameters

instrumentId

Use this parameter to specify the target instrument.

Format: `instrumentId=`*`[instrumentId]`*

Example snippet: `instrumentId=titanSMA__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 185 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 TitanSMA and the attached Nanometrics sensors. The response is based on the current instrument configuration.

> 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 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. 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://[IPaddressofyourTitanSMA]/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
- 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>,
	"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"
}
```

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>,
            "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>,
            "capture": <boolean>,
            "signal": <SIGNAL>
      }
<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>
        }
```

7.6 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

[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.

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.

- 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 titansma-1212

```
http://titansma-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 TitanSMA.

8.1 Technical Specifications

The specifications for the TitanSMA are listed in the following sections:

8.1.1 Accelerometer Technology

Topology

Triaxial, horizontal-vertical

Feedback

Force balance with capacitive displacement transducer

Centering

Electronic offset zeroing via user interface

8.1.2 Accelerometer Performance

Full-scale Range

Electronically selectable range: ±4 *g*, ±2 *g*, ±1 *g*, ±0.5 *g*, ±0.25 *g*, ±0.125 *g* (nominal)

Bandwidth

DC to 430 Hz

Dynamic Range (Integrated RMS)

166 dB at 1 Hz over 1 Hz bandwidth, 155 dB, 3 to 30 Hz

Offset

Electronically zeroed to within ±0.005 *g*

Non-linearity

Less than 0.015% total non-linearity

Hysteresis

Less than 0.005% of full-scale

Cross-axis Sensitivity

Less than 0.5% total

Offset Temperature Coefficient

Horizontal sensor: 60 μ*g*/°C, typical

Vertical sensor: 320 μ*g*/°C, typical

8.1.3 Digitizer Performance and Capabilities

Channels

3 internal X, Y, and Z axes

Type

True 24-bit ADC per channel, simultaneous sampling

Sensitivity

2, 4, 8, 16, 32, and 64 digitizer counts per µg, ±1%

Sample Rates

1, 2, 5, 10, 20, 40, 50, 80, 100, 125, 200, 250, 500, 1000, and 2000 sps

Dual Sample Rates

A second sample rate can be selected from the sample rates above.

The maximum "aggregate sample rate" is 2010 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 TitanSMA 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

Sample rate	Linear phase	Minimum phase
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
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. 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)

8.1.4 Calibration

Digital Calibration (Waveform files)

- Synthesized sine, step, and PRB signals
- Playback user defined calibration files

8.1.5 Data Recording

Formats

MiniSEED[1]

Internal Memory

8 GB flash memory (32, 64, 128 or 256 GB options available) for TitanSMA version 3 (TSMA3) or later)

Removable Media

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.

8.1.6 Events

Triggers

Bandpassed STA/LTA, threshold

Trigger Selection

Independent threshold or STA/LTA ratio for each channel

STA/LTA Trigger

Configurable STA, LTA, LTA latching, trigger and de-trigger thresholds

---

[1] A version of SEED data which only contains waveform data. No station or channel metadata is included.

Trigger Votes

User set votes assigned by channel, transmitted via IP multicast

Threshold Trigger

Selectable from 0.01% to 100% of full scale

Data Products

Peak Ground Motion (PGA, PGD, PGV) statistics calculated on the instrument

Sa (0.3, 1, 3 Hz)

8.1.7 Data Retrieval

Data Retrieval

Direct download via Ethernet; Media exchange via SD card

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.

8.1.8 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 TitanSMA 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

32-channel GNSS receiver

GNSS Constellations

GPS + select one of Beidou, Glonass, Galileo, QZSS

GNSS Power

Selectable: Always on, Duty cycled, or Off

8.1.9 Communications

Web-based UI

Supports standard PC, tablet, and mobile devices.

Provided via onboard Web server

Used for:

- State-of-health, waveform, and sensor monitoring
- Viewing event information and downloading events
- Calibration, configuration, and maintenance

Interfaces

10/100 Base-T Ethernet (To reduce power consumption, the Ethernet speed can be set to 10 Base-T.)

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®

8.1.10 Power

Power Supply

9-36 V DC isolated input

Protection

- Reverse-voltage and over-voltage protected
- Self-resetting over-current protection

Battery Manager

User-configurable low voltage shutdown and restart thresholds

8.1.11 Power Consumption

2.0 W quiescent, no Ethernet, duty-cycled GNSS (nominal)

Use the following approximate guidelines for determining the power usage for your TitanSMA:

- 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 -45°C for Polar Certified devices.

> TitanSMA Model TSMA3 has approximately 100 mW lower power consumption than the approximate values listed in this section.

Isolation

Supply power is isolated from signal ground

Grounding

Predrilled holes (4) for M4 X 5 grounding lug screw

Low/High Voltage Disconnect

Software configurable

8.1.12 Connectors

External

Power:

- 3-pin, shell size 8
- MIL-C-26482 G Series 1
- Recommended mate: MS3116J8-3S

Ethernet

- 4-socket, shell size 8
- Insert position W
- MIL-C-26482 G Series 1
- 10/100 Base-T
- Recommended mate: MS3116J8-4PW

GNSS

- TNC female
- Recommended mate: TNC male

USB

- USB 2.0 type A, female
- Recommended mate: USB 2.0 type A, male

Internal

SD card slot

Status LEDs

Power, Ethernet, Timing, Media, Event notification, overall Status

8.1.13 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)

Shock

100 *g* half sine, 5 ms without damage, 6 axes

No mass lock required for transport

Ingress Protection

Rated to IP68 at 2 m for 72 hours when connectors mated or capped

Humidity

0 to 100%

8.1.14 Physical Characteristics

Housing

Aluminum

Surface resistant to corrosion, scratches, and chips

Weight

2.6 kg

Size

Length: 180 mm

Width: 118 mm

Height: 102 mm (without levelling screws)

Mounting

Single bolt keyhole mount

Levelling

- Integrated bubble level
- Adjustable locking levelling screws (4)
- Optional fixed-foot for three-foot freestanding installations (included with installation kit)

8.2 Performance

Sensitivities

Frequency Response

Self-noise

8.2.1 Sensitivities

The sensitivities of the internal accelerometer are as follows, in digital recorder counts per μ*g*, ±1%:

Clip level (*g*)	Sensitivity(counts/μ*g*)
4	2
2	4
1	8
0.5	16
0.25	32
0.125	64

If ground motion exceeds the sensor clip level, the signal processing algorithms that limit the signal bandwidth to match the sample rate will sometimes produce values with magnitudes greater than the clip level. This is intentional and represents a better estimate of actual ground motion amplitude than the clipped signal would.

8.2.2 Frequency Response

The accelerometer sensitivity, poles, and zeros define the transfer function according to the following equation:

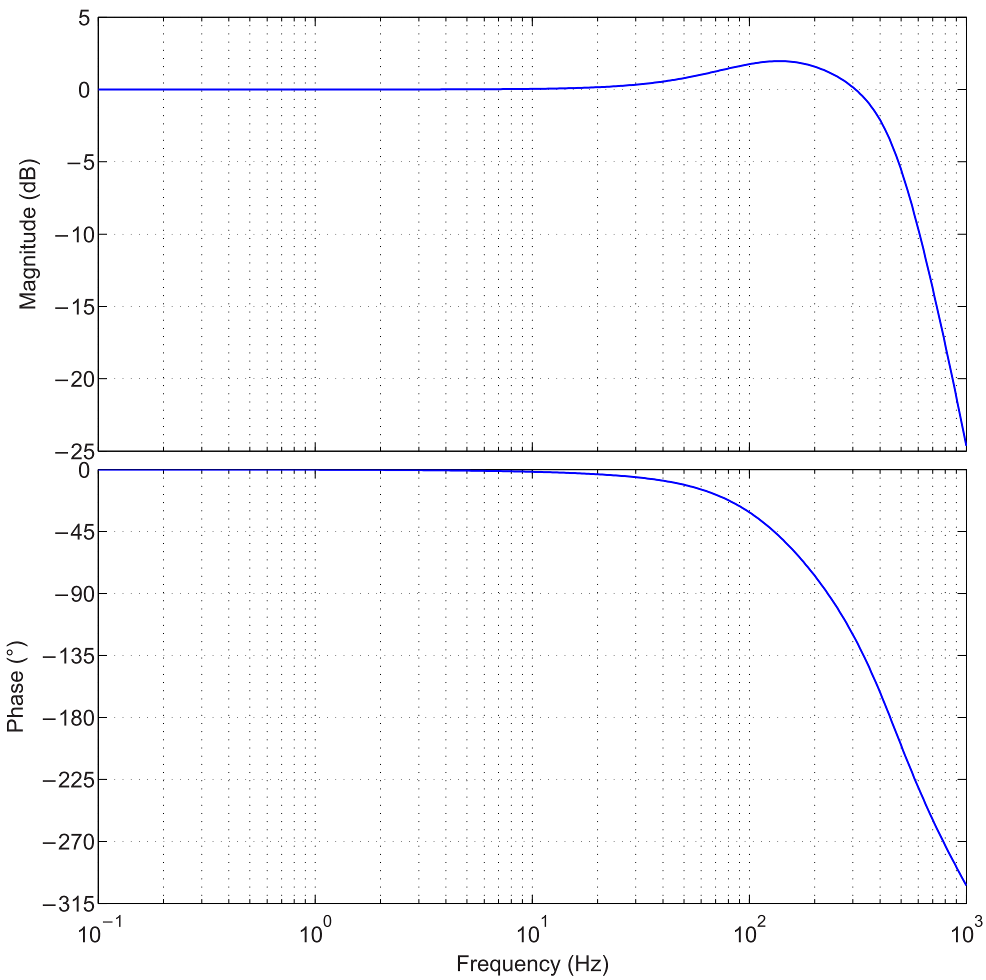
$$F(s) = S \cdot k \cdot \frac{\prod_n (s - z_n)}{\prod_n (s - p_n)}$$

Where the normalization factor is defined by the following equation and is given for informational purposes only.

$$k = \left| \frac{\prod_n (i2\Pi f_0 - p_n)}{\prod_n (i2\pi f_0 - z_n)} \right|$$

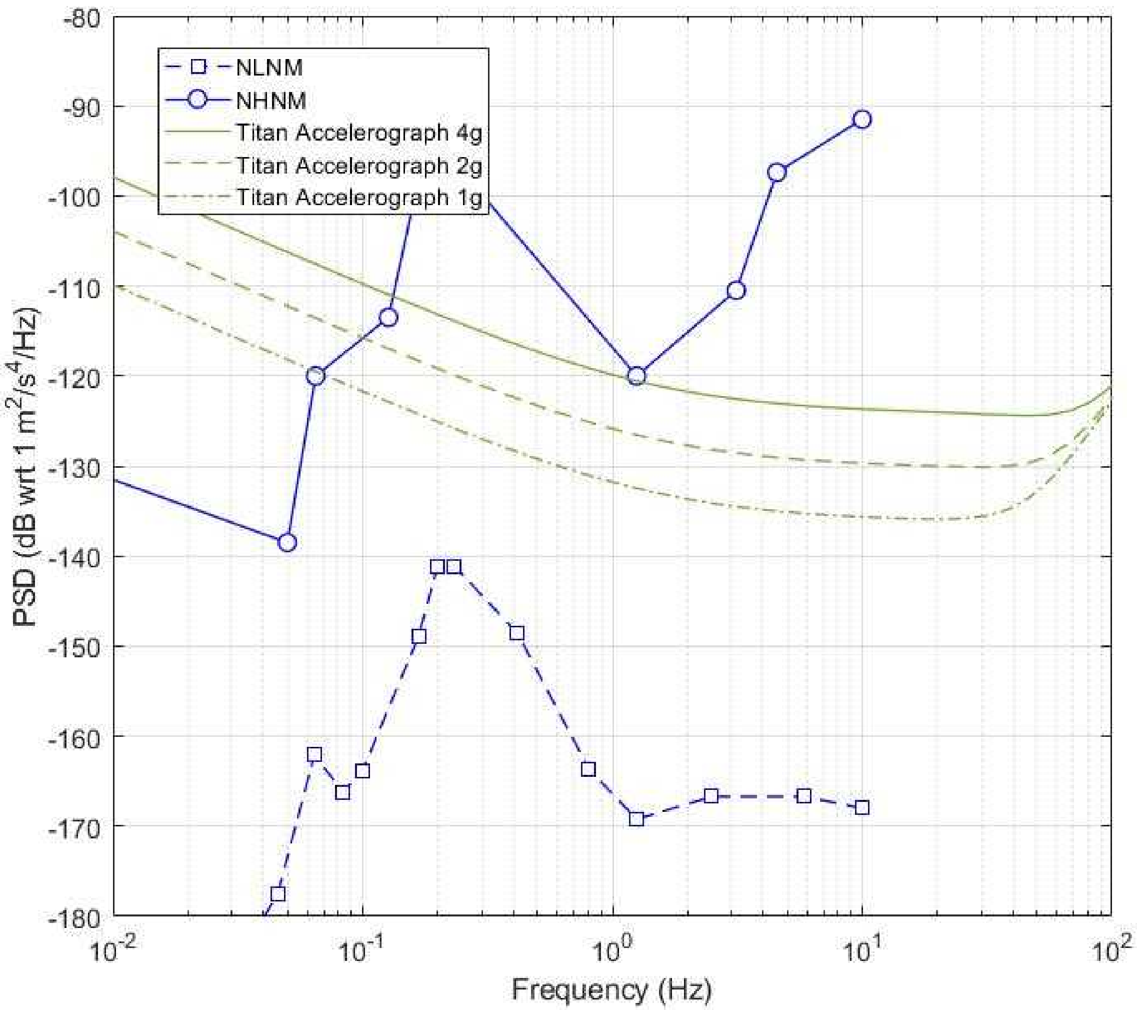
Titan accelerometer poles and zeros

Symbol	Parameter	Nominal Values	Units
z_n	Zeros	–515	rad/s
p_n	Poles	-977 ±328i –1486 ±2512i –5736 ±4946i	rad/s
k	Normalization factor	1.0077×10^{18}	$(rad/s)^5$
f_o	Normalization frequency	1	Hz



8.2.3 Self-Noise

The plot shows the typical self-noise for the TitanSMA. Two curves are included for reference: Peterson's[1] **NLNM**[1] and **NHNM**[2]. The noise floor shown is the typical level of instrument self-noise assuming proper installation.



[1]Jon Peterson, *Observations and Modeling of Seismic Background Noise, Open-File Report* 93-322 (Albuquerque, New Mexico, U.S. Department of Interior Geological Survey, 1993).

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[1]New Low-noise Model

[2]New High-noise Model

8.3 SOH channels in Steim compressed formats

The TitanSMA 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. Note that the External SOH and Sensor SOH do not apply to the TitanSMA. 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	
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

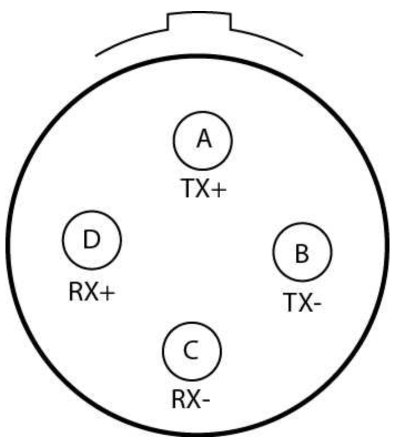
Code	Description	Units	Notes
			• < 70% indicates that the system has an estimated time error of > 200 µs. The 70% will decrease by 1% for each hour of free running • 0% indicates that the system has never locked or has been free running for more than 70 hours To provide real-time time quality SOH data, 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.
VCO	VCO control voltage (for timing oscillator)	raw DAC counts	
VDT	Digitizer system temperature	millidegrees Celsius	
VEC	Digitizer system current	milliamps	
VEI	Input system voltage	millivolts	
VM1 VM2 VM3	Sensor SOH channels 1 to 3	microvolts	This value represents mass position. • VM1 = W axis • VM2 = V axis • VM3 = U axis
VPB	Digitizer buffer percent used	0.1%	This value is typically 100% once the buffer is full.

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.

- Ethernet
- Power connector

8.4.1 TitanSMA Ethernet Connector Receptacle and Pinout



Connector type:

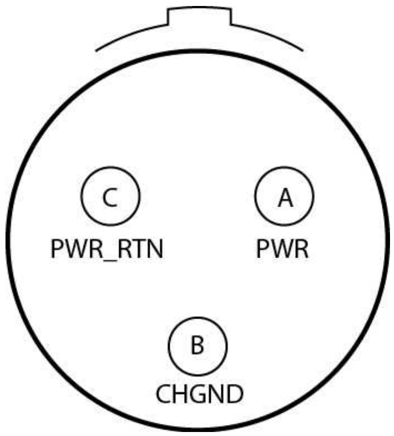
- 4-socket, shell size 8
- Insert position W
- MIL-C-26482 G Series 1
- 10/100 Base-T

Recommended mating connector:

- MS3116J8-4PW

Pin	Name	Function
A	TX+	Ethernet MTL-3 Transmit +
B	TX-	Ethernet MTL-3 Transmit –
C	RX-	Ethernet MTL-3 Receive –
D	RX+	Ethernet MTL-3 Receive +

8.4.2 TitanSMA 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

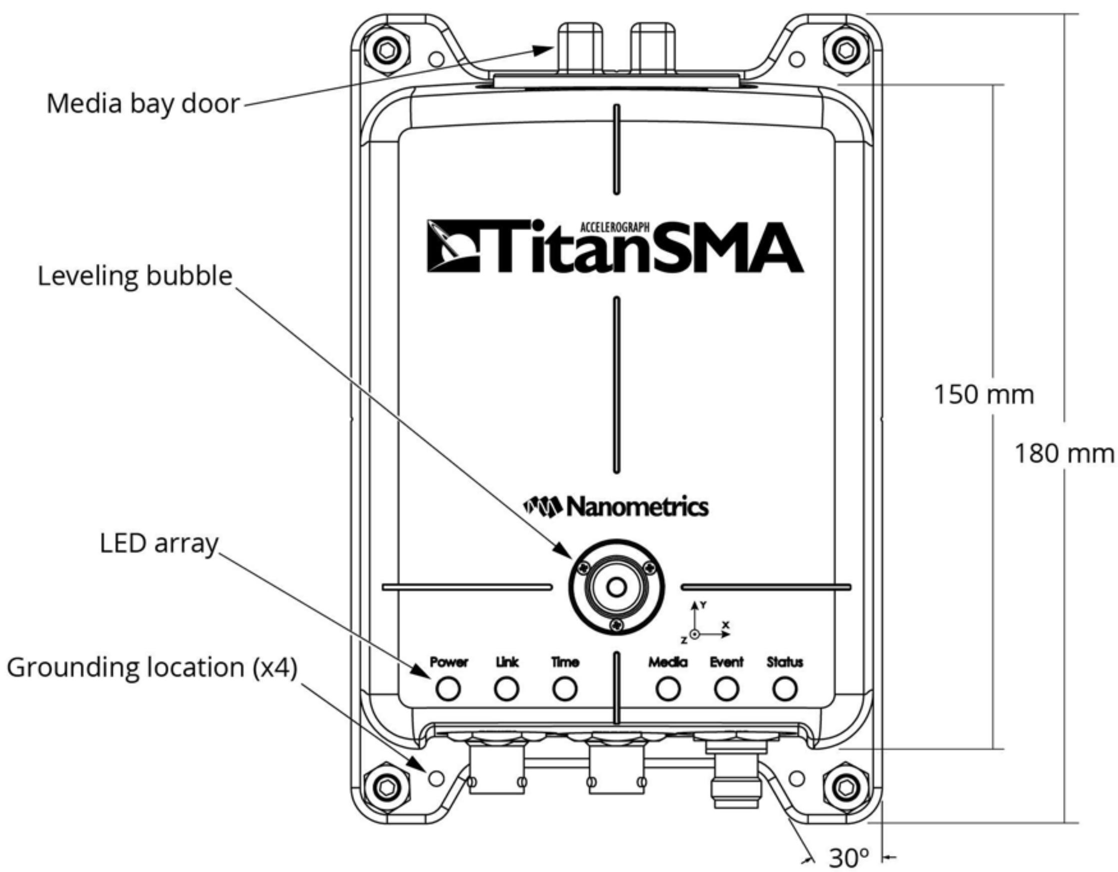
Pin	Name	Function
A	PWR	Raw (battery) power in (9 V to 36 V DC)
B	CHGND	Internal connection to chassis ground
C	PWR_RTN	Raw power return

8.5 Physical Features and Dimensions

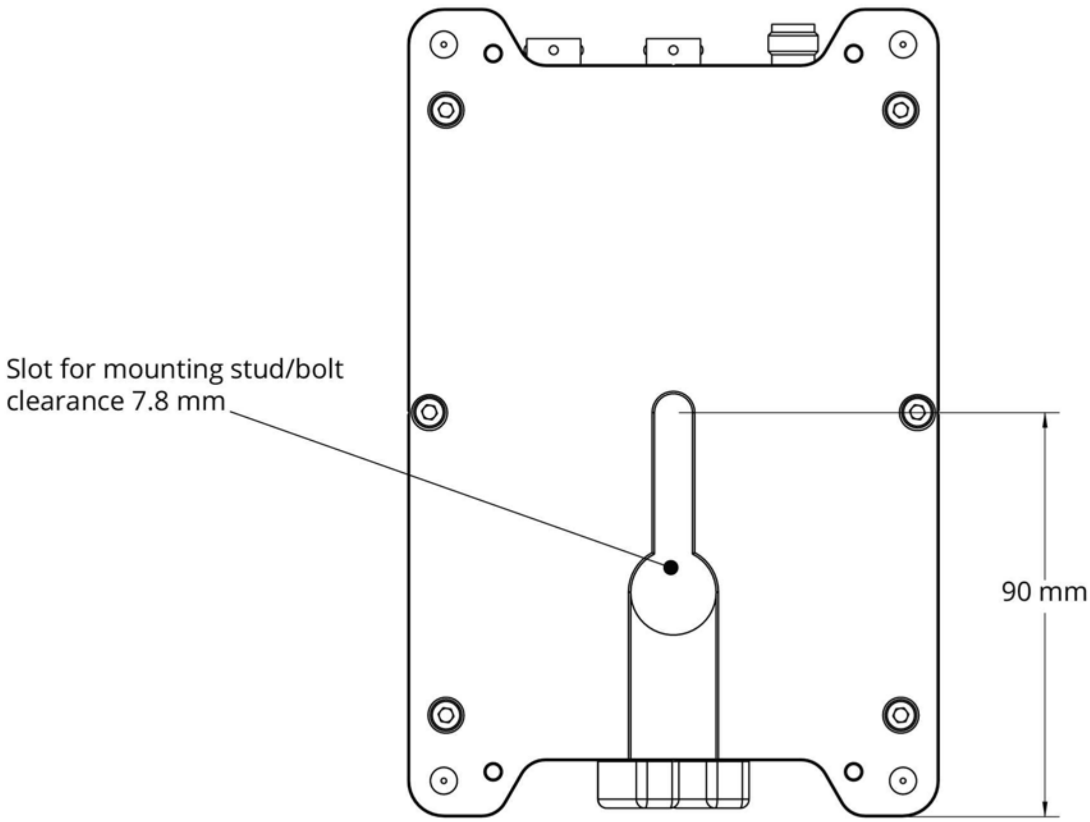
Refer to the following figures to view the features and dimensions. Dimensions are in millimeters unless otherwise stated.

- Top View
- Bottom View
- Side View
- View of External Connectors
- View of Open Media Bay Door

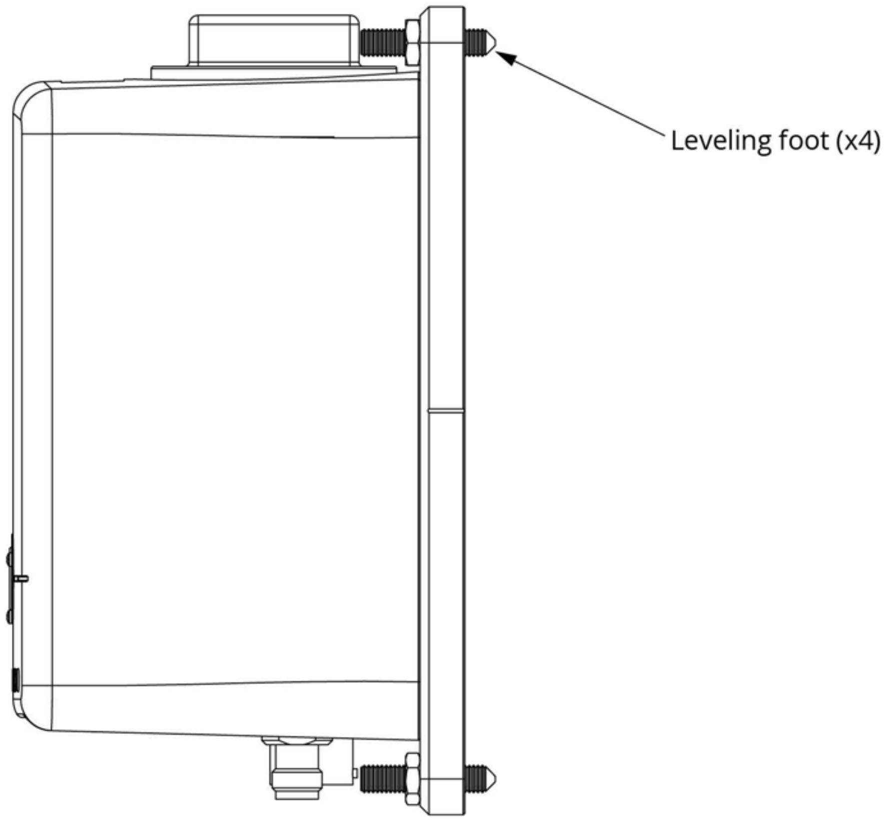
8.5.1 Top View of the TitanSMA



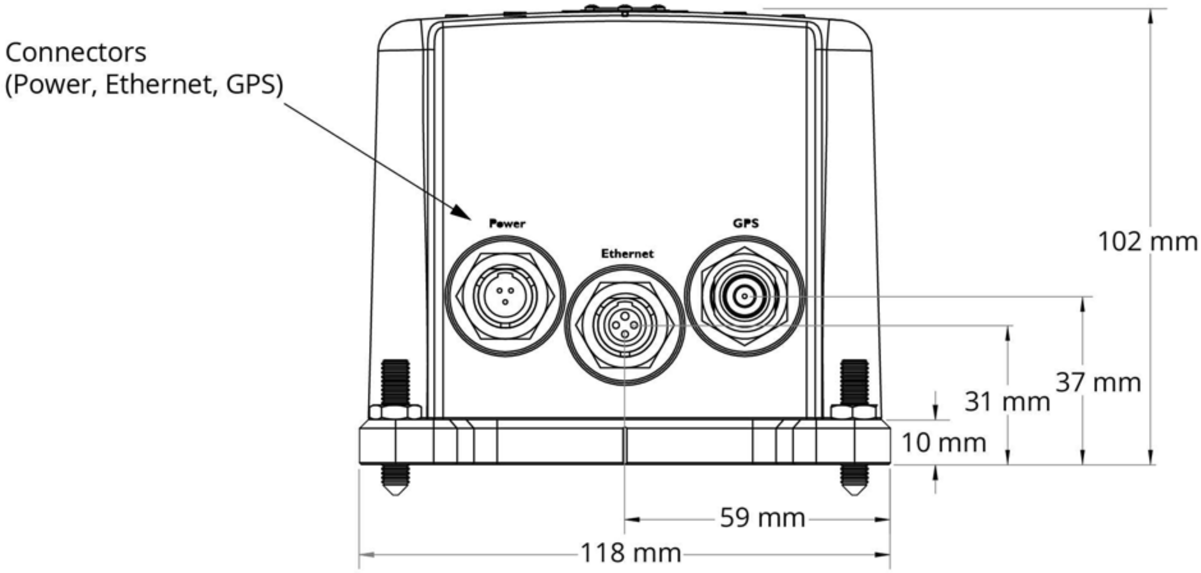
8.5.2 Bottom View of the TitanSMA



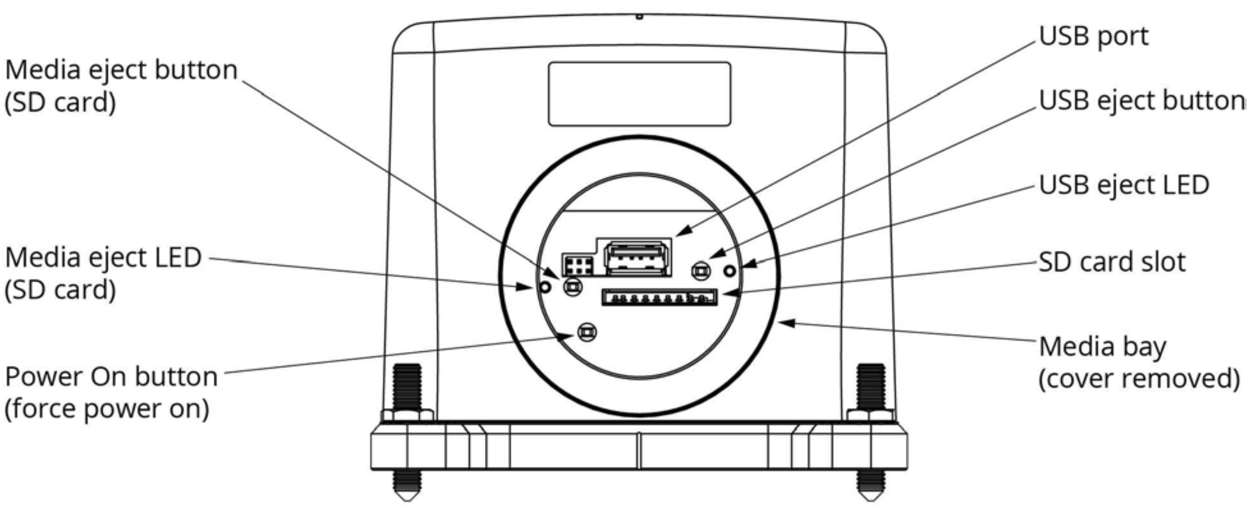
8.5.3 Side View of the TitanSMA



8.5.4 View of the TitanSMA External Connectors



8.5.5 View of the TitanSMA Open Media Bay



8.6 About calibration signal files

You can calibrate your TitanSMA 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 TitanSMA. 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.

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 TitanSMA.

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 TitanSMA.

Create a custom PRB calibration file

The sample Python script provided on the TitanSMA 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://IPaddressofyourTitanSMA/calibration/create_calibration_signal.py
2. Run the script, specifying the following parameters:
   - equipment type (accelerometer)
   - signal type (sine or step)
   - the duration in seconds
   - the amplitude in *g*
   - 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 TitanSMA.

Custom calibration files with a combined maximum size of 50 MB can be uploaded to your TitanSMA. 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 TitanSMA
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 TitanSMA because it will be overwritten during the upgrade process.

8.7 Configuring OpenVPN® on TitanSMA

This section describes how to configure OpenVPN® on TitanSMA instruments running firmware version 4.9.0 or newer.

Configuring the TitanSMA 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 TitanSMA instruments keep in mind the following:

- Once VPN is enabled from the TitanSMA 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 TitanSMA 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 (TitanSMA) 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 TitanSMA.

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
```

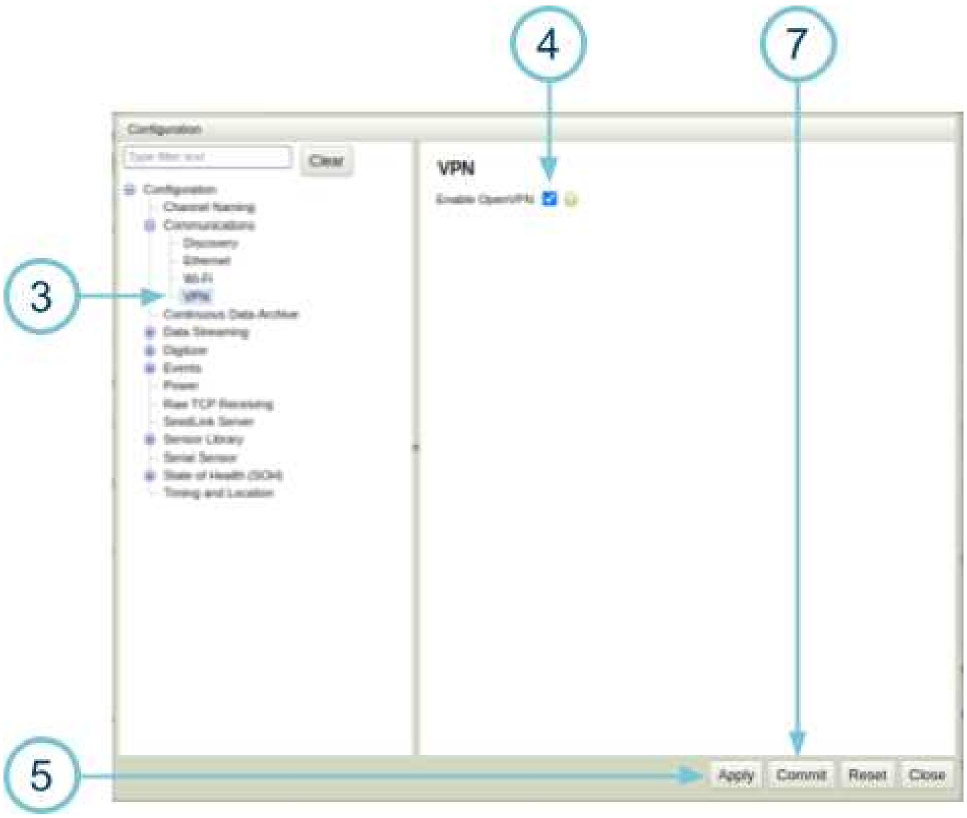
Enable OpenVPN® on TitanSMA

1. Log on to the TitanSMA 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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