Güralp Minimus, Minimus+, Fortimus, Certimus

Technical Manual

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Preliminary Notes

Proprietary Notice

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Cautions and Notes

Cautions and notes are displayed and defined as follows:

Caution: A yellow triangle indicates a chance of damage to or failure of the equipment if the caution is not heeded.

Note: A blue circle indicates a procedural or advisory note.

Manuals and Software

All manuals and software referred to in this document are available from the Güralp Systems website: www.guralp.com unless otherwise stated.

Conventions

Throughout this manual, examples are given of command-line interactions. In these examples, a fixed-width typeface will be used:

`Example of the fixed-width typeface used.`

Commands that you are required to type will be shown in bold:

`Example of the fixed-width, bold typeface.`

Where data that you type may vary depending on your individual configuration, such as parameters to commands, these data are additionally shown in italics:

`Example of the fixed-width, bold, italic typeface.`

Putting these together into a single example:

`System prompt:` **`user input with`** ***`variable parameters`***

Understanding the Manual

Manual structure

Thank-you for purchasing a Güralp Minimus, Minimus+, Certimus or Fortimus.

Güralp **Minimus** and **Minimus+** are a combined digitiser and advanced communications units. The Minimus provides four fully featured analogue input channels, whilst the Minimus+ increases this to a total of eight analogue inputs.

Güralp **Fortimus** is a digital, triaxial, strong-motion, force-feedback accelerometer.

Güralp **Certimus** is a digital, triaxial, broadband, force-feedback seismometer.

This manual is organised into two main sections.

- The first section is instrument-specific, and provides a general introduction to the instruments and their hardware. It shows how to set up your device and it advices on best practices to help with your deployment. The topics covered include:
  - System overview
  - System description
  - System set-up
  - Instrument and channel names
  - Installation
- The second section focuses on the instruments' firmware - called Dig. Dig is Güralp System's firmware for the Minimus and Minimus+ digitisers. Güralp's Fortimus and Certimus have an embedded Minimus digitiser and therefore run the same firmware. Within this second section of the manual, we provide instructions and describe features common to all the instruments running the Dig firmware, inclusive of the Minimus, Minimus+, Fortimus and Certimus.

Note: Minimus and Minimus+ units can be recognised by their serial numbers, which will be of the form MIN-XXXX or MINP-XXXX. Digitisers with serial numbers of the form MINL-XXXX are Minimus$_2$ or Minimus Lite units and run a different firmware, called Dig2. Although a lot of features are common to both Dig and Dig2, this manual is dedicated to Minimus/Minimus+ and other devices with an embedded Minimus digitiser (Fortimus and Certimus).

 	Minimus Minimus+	Minimus and Minimus+ both run Dig firmware. This is the correct document for these instruments.
 	Certimus Fortimus	Fortimus and Certimus each contain a Minimus digitiser which runs Dig firmware. This is the correct document for these instruments.
	Minimus$_2$ Minimus Lite	Minimus$_2$ and Minimus Lite runs Dig2 firmware. This is NOT the correct document for this instrument.

Note: For sake of brevity, instruments running the Dig firmware will be referred to as the *Minimus* throughout this document, but the instructions apply equally to the Minimus+, Fortimus and Certimus. Situations where instructions only refer to a specific instrument, or where they do not apply to one or more of them, this will be indicated.

Güralp Discovery Software

Güralp Discovery is our software application for configuration, control, state-of-health monitoring, waveform viewing and acquisition of instruments running the Dig firmware.

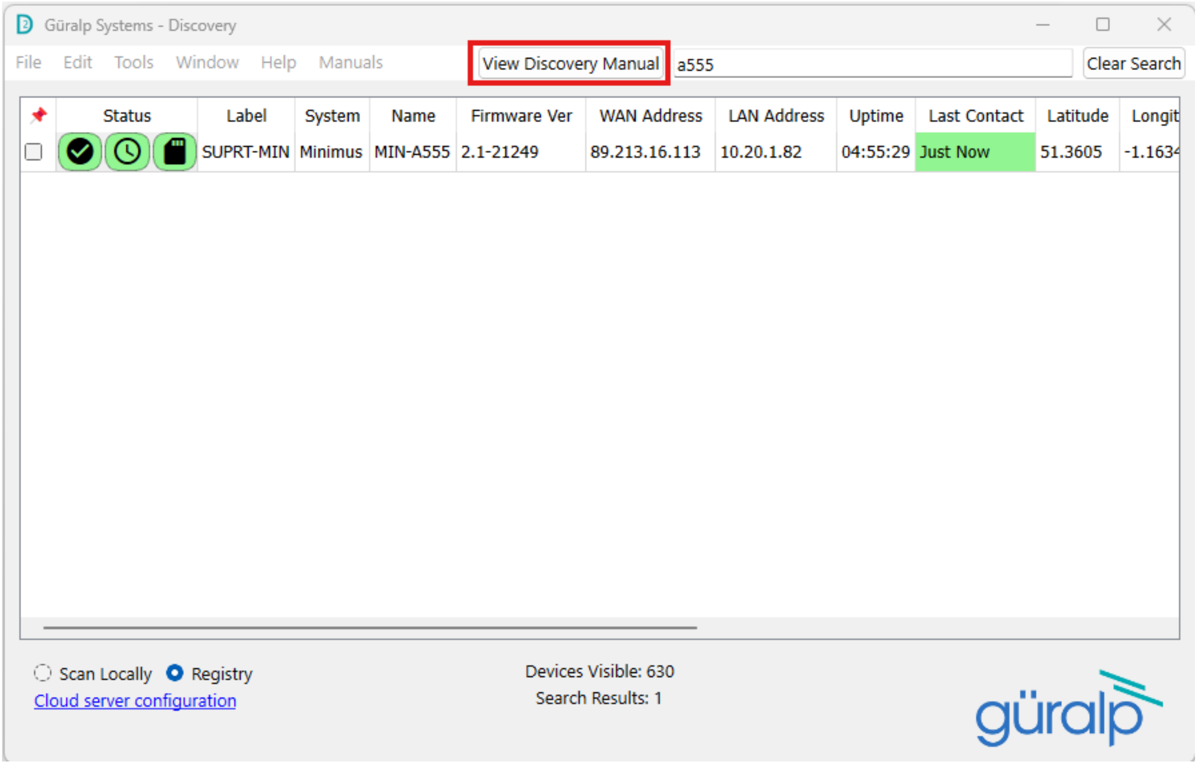
Discovery can be downloaded from the following link:

https://www.guralp.com/sw/download-discovery.shtml.

An important benefit of Discovery is that it allows users to identify their instruments' IP address on a LAN or via a cloud-based or organisational registry server, without the need for assigning a static IP address at the station.

Note: This document provides some information about Discovery, especially when related to the use of the Dig firmware, including firmware upgrades and configuration instructions.

However, full user instructions for Discovery are beyond the scope of this document. For full user information, please refer to Discovery's manual MAN-DIS-0001 (also accessible from Discovery's dashboard as in figure below).



Webpage Interface

Note: The Dig firmware is continuously improved to add new features, accommodate customers' requests, and refresh the webpage layout.

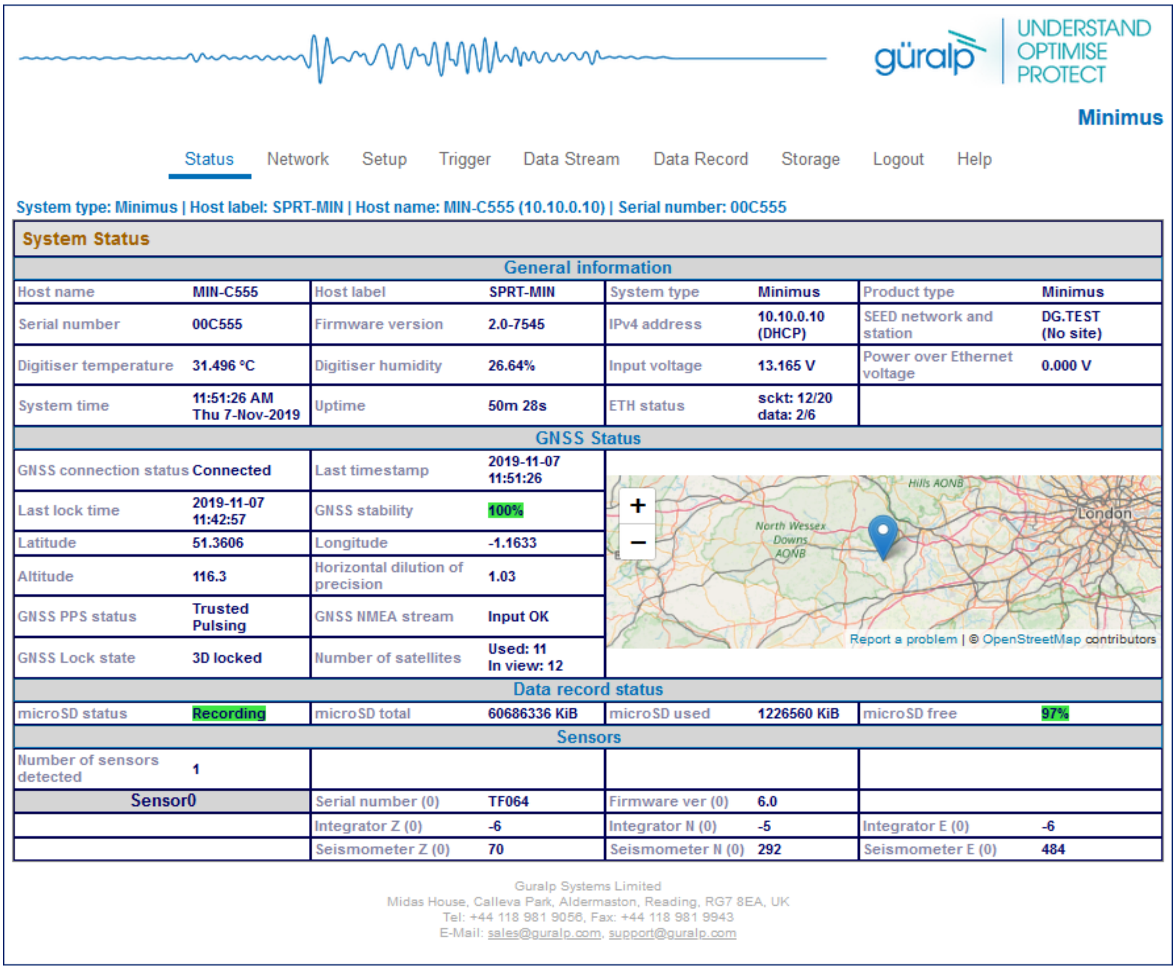
The design of your webpage may look slightly different from the examples shown in this document. The instructions are designed to be used with Dig versions 2.0 and upwards. If you encounter any problems, please email support@guralp.com for assistance.

If you read about features that you do not find available for your instrument, please read the Dig release notes: https://london.guralp.com/download/sw/release_MIN.shtml and consider upgrading your firmware with the instructions found in Section 2.17 .

Monitoring and configuration controls are accessible through the webpage interface, with options including:

- Sensor readings and instrument State of Health.
- Network configuration and authentication.
- Sensor, timing, and station configuration.
- Data streaming configuration.
- Local or networked data-storage configuration.
- Tools for secure access and download of data.

This document provides full user instructions about the webpage interface.



Güralp Scream! Software

Data from the Minimus and attached sensors can also be viewed and analysed using Güralp's Scream! software. Scream! is a software application for **S**eismometer **C**onfiguration, **RE**al-time **A**cquisition, and **M**onitoring.

Note: Full user instructions for Scream! are beyond the scope of this document. Please refer to the Güralp manual: MAN-SWA-0001 for full Scream user instructions.

Güralp GüVü Bluetooth App

The GüVü app provides monitoring and control of nearby instruments using the Bluetooth protocol. Full user instructions for the GüVü app can be found in Chapter 3.4 of this manual.

1 Part 1: Instrument-Specific Information

1.1 Minimus and Minimus+

1.1.1 System Overview

Thank you for purchasing a Güralp Minimus or Minimus+ digitiser.

This chapter describes the key components of a Minimus and Minimus+ system. The Minimus has four fully featured analogue input channels. The Minimus+ is physically wider, with an additional analogue sensor input connector, and provides eight fully featured analogue input channels.

Note: In this document, the symbol ⚠ is used to identify information that relates only to the Minimus+ and not to the Minimus. All other information relates to both units, unless obviously contradicted by a clause containing ⚠ .

1.1.1.1 Key Features

- 24-bit, four-channel (⚠ eight-channel) digitiser with nominal 2.44 µV/count sensitivity.
- Compact form, measuring just 134 × 99 × 45 mm (⚠ 134 × 139 × 45 mm) and weighing just 0.67 kg (⚠ 0.78 kg).
- Compatible with all analogue seismic sensors with a voltage output.
- Simultaneously accommodates one (⚠ two) triaxial sensor(s), one (⚠ two) infra-sound sensor(s) and a digital feed from a Radian post-hole or borehole instrument.
- Identification of IP addresses via Güralp Discovery software and a cloud-based or organisational registry server.
- Remote instrument and data management via Discovery.
- Bluetooth Android app for installation integrity checking.
- Low-latency mode for Earthquake Early Warning (<40 ms).
- Hot-swappable data storage with dual redundant microSD cards.
- GNSS time-synchronisation, compatible with Navstar (GPS), GLONASS, Galileo and BeiDou constellations. PTP is available for when GNSS is impractical.

1.1.1.2 Typical Applications

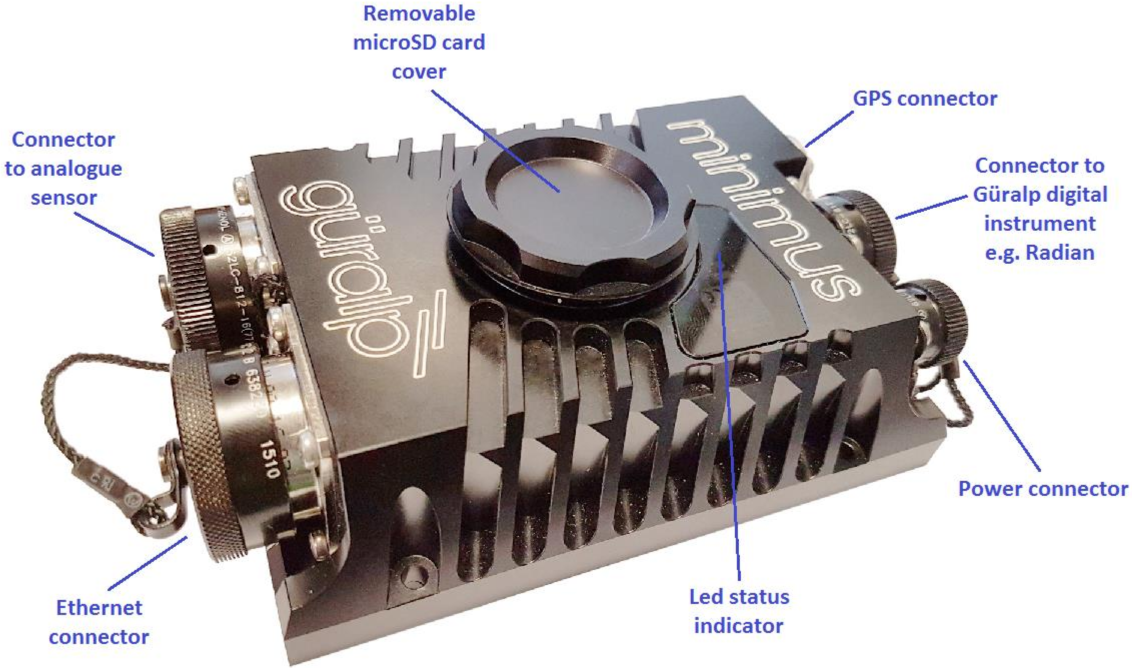
- Earthquake Early Warning systems.

- Volcanology.
- Multi-scale seismic networks.
- Structural health monitoring.
- Hydrocarbon exploration.
- Permanent reservoir monitoring.
- Induced seismicity detection.
- Explosion monitoring.

1.1.2 System Description

1.1.2.1 Güralp Minimus Digitiser

The Güralp Minimus is a combined digitiser and advanced communications unit. The Minimus acquires data from – and allows direct control (where appropriate) of – connected analogue instruments (*e.g.* Güralp Fortis, 3-series, 5-series, 40T and 6T sensors) and digital instruments (*e.g.* the Güralp Radian and Certis). The following diagram details the ports and features of a Minimus:



The Güralp Minimus functions as the Surface Interface Unit (SIU) for a Radian post-hole instruments in shallow depths of less than 100 metres.

⚠ The Minimus+ features an additional analogue sensor connector as shown below:

A full description of the operation, control and configuration of the Güralp Radian instrument via the Minimus is not within the scope of this manual; please refer instead to the Radian manual, MAN-RAD-0001.

Caution: Analogue sensors with true floating outputs connected to the Minimus must have their outputs ground-referenced using a greater than 100kΩ resistor.

1.1.2.2 LED Indicator

The Minimus has an LED indicator on the upper surface, which provides status and configuration information. More details can be found in Chapter 2.15.1.

1.1.2.3 Bluetooth Connectivity

The Minimus features Bluetooth connectivity, allowing sensor and state-of-health data to be monitored using the Güralp GüVü app (see Chapter 3.5) running on an Android mobile phone.

Bluetooth can be disabled via software to save processing power, but the hardware module cannot be switched off. BLE (Bluetooth Low Energy) technology is used to minimise the power requirement. The Bluetooth transmitter/receiver is in permanent standby mode and always ready to receive a connection from a phone or tablet.

1.1.2.4 Data Storage

The Minimus uses microSD (non-volatile) memory technology to store seismic data locally. The Minimus features two microSD cards to provide redundancy; this helps to protect your recorded data in the unlikely event of any corruption or problem with the memory cards. One card is internal and cannot be removed by the user; the other is hot-swappable and easily accessible from the top of the Minimus.

The Minimus is supplied with two microSD cards that are of equal storage capacity (*e.g.* two 16 GB cards).

Note: In order to ensure data integrity and security, Güralp only recommends the use of the supplied industrial-grade microSD cards.

Caution: When the external microSD card is removed, the internal card keeps recording data, unless recording is stopped using the Unmount Cards button (see Chapter 2.7.4). However, when the external card is re-connected, any data written to the internal card while the removable card was absent will be overwritten.

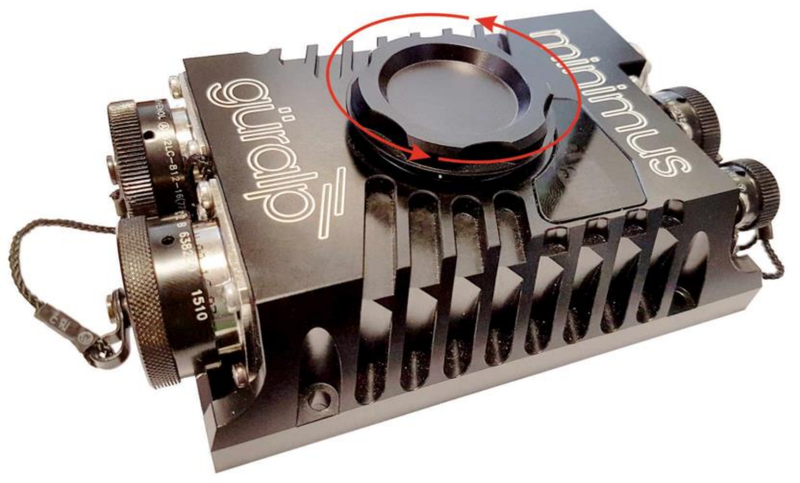
Starting from summer 2018, two designs of the card holder for the removable card became available. The following two sections describe how to change the card in the newer models and the original models.

Primary (Hot Swappable) microSD Card – New Style

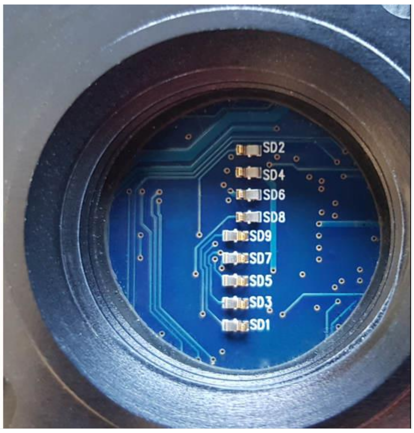
The upper surface of the Minimus has a waterproof screw-in card holder that is sealed by an O-ring.

To insert or replace a microSD card, proceed as follows:

1. Rotate the card holder in an anti-clockwise direction, unscrewing it from the body of the digitiser.



Caution: The card holder connects electrically to the Minimus via a series of slip -rings which ride on metal fingers in the main body of the digitiser:



It is very important that the slip-rings and the metal finger-contacts do not become damaged or tarnished. Take care not to touch either part. If a Minimus has had its card holder removed, do not leave it exposed to the elements. If a card holder is to be transported when it is not installed in a Minimus, enclose it in a protective bag or covering so that it cannot be scratched or contaminated.

2. The microSD card is accessible via the slot in the side of the card holder. Using a pair of tweezers, first push the card in gently and then release the pressure: the card will spring outwards a little. It can now be grasped and withdrawn.

3. To insert a new card, line it up with the slot as shown and push it gently into place. Once you feel the spring pressure, continue pushing until more resistance is felt and then release the pressure: the card will lock into place.

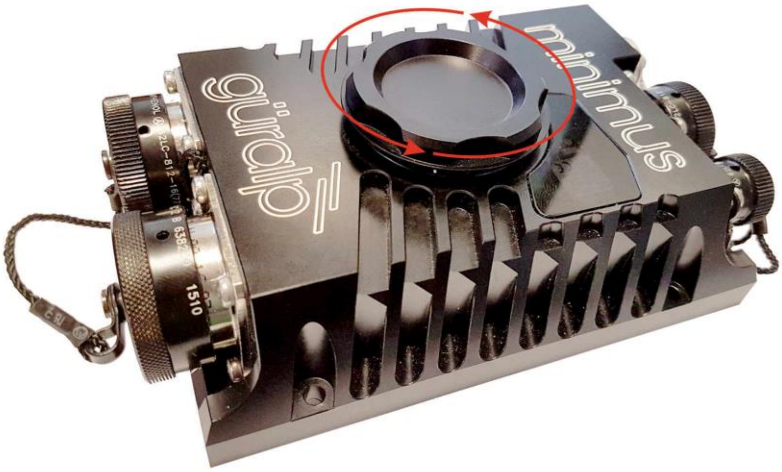
4. Finally, replace the cap and rotate clockwise until hand-tight. Do not over-tighten and do not use tools.

Primary (Hot Swappable) microSD Card – Old Style

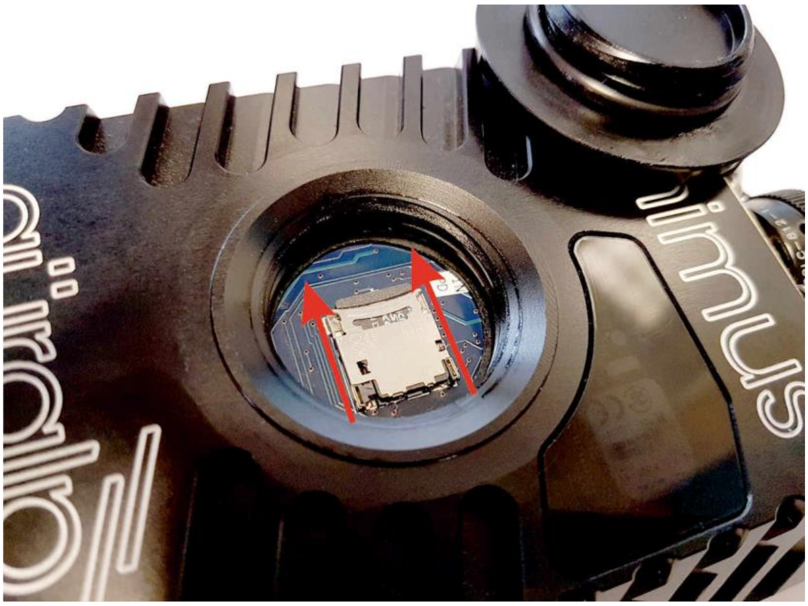
Early models of the Minimus had a different arrangement. The upper surface of the Minimus had a waterproof screw cap that is sealed by an O-ring. This protects the microSD card slot from the environment.

To insert or replace a microSD card in an older Minimus, proceed as follows:

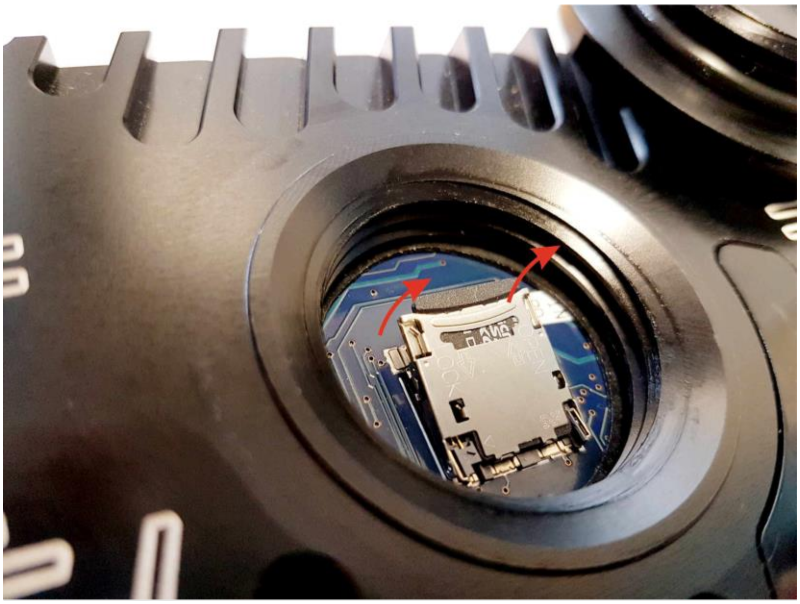
1. Rotate the cap in an anti-clockwise direction to reveal the microSD card slot. The microSD card is now exposed.



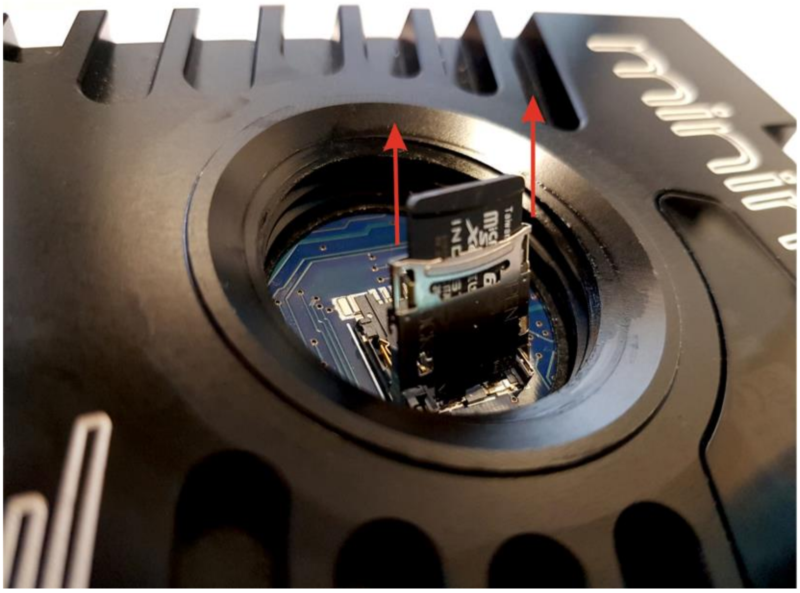
2. To make the microSD card slot accessible, use your finger to apply gentle pressure on the back of the card carrier until it slides into the open position.



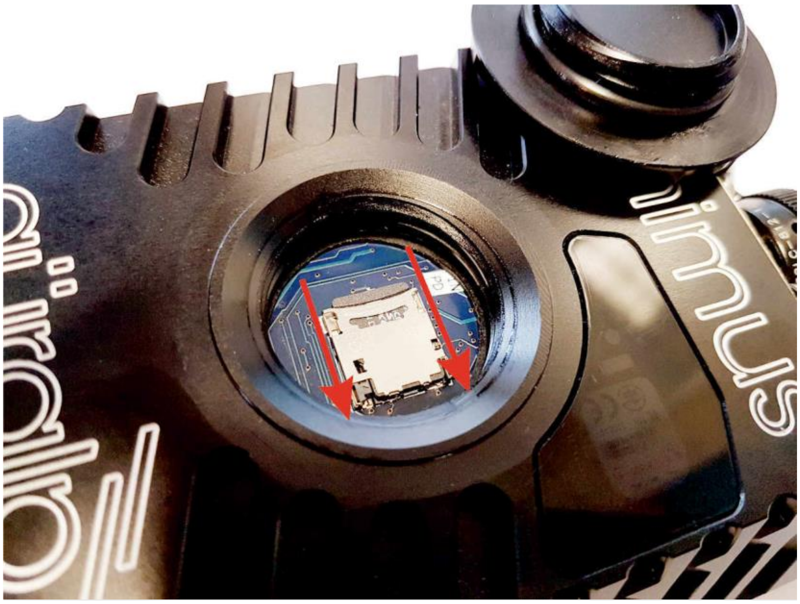
3. Gently lift the free end of the card carrier, which hinges at the other end, as shown.



4. You should now be able to insert/remove a microSD card. The replacement should be positioned so that the gold contacts on the microSD card will be facing downwards when the carrier is hinged back down.



5. Push the hinged carrier firmly down and slide it back into the seat.



6. Finally, replace the cap and rotate clockwise until hand-tight. Do not over-tighten and do not use tools.

Note: In order to ensure data integrity and security, Güralp only recommends the use of the supplied industrial-grade microSD cards.

Caution: When the external microSD card is removed, the internal card keeps recording data. However, when the external card is re-connected, any data written to the internal card while the removable card was absent will be overwritten.

Internal (Backup) microSD Card

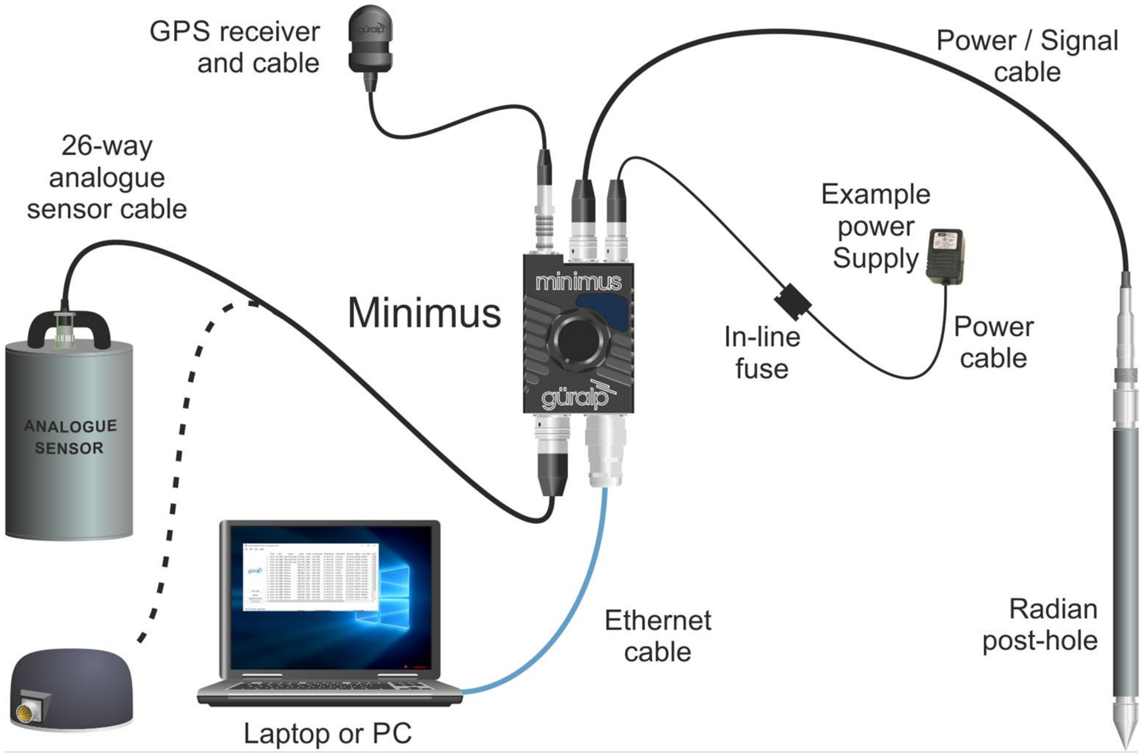
The second microSD card is factory-installed in a slot inside the Minimus.

Caution: The internal microSD card is not accessible by the user. Attempts to remove or replace it will void the Minimus' warranty.

1.1.3 System Setup

Güralp highly recommends exploring and gaining familiarity with the Minimus inside your lab before installation in an outdoors environment.

A typical setup for the Minimus connected to an analogue sensor (including an optional digital Radian post-hole instrument) is shown in the figure below:



To get started, connect the cables as shown in the figure above. Power up the Minimus using a power supply with a DC output of between 10 and 36 Volts. We recommend fitting an in-line 3.5 A anti-surge fuse in the positive power lead to protect the external wiring of the installation. The Minimus will, in turn, provide power to all connected instruments.

Caution: Observe the correct polarity when connecting the power supply. The red lead (from pin B) must be connected to the **positive terminal**, typically labelled "+", and the **black** lead (from pin A) must be connected to the **negative terminal**, typically labelled "-". An incorrect connection risks destroying the digitiser, the power supply and any connected instruments.

1.1.4 Instrument and Channel Names

The tables in this section are designed to inform users of the names and codes of the streamed and recorded channels. The first character of a miniSEED channel code represents the sample rate. The possible values are shown in the table below:

Code	Sample Rate
F	≥ 1000 Hz to < 5000 Hz
C	≥ 250 Hz to < 1000 Hz
H	≥ 80 Hz to < 250 Hz
B	≥ 10 Hz to < 80 Hz
M	> 1 to < 10
L	≈ 1

V	≈ 0.1 Hz
U	≈ 0.01 Hz
R	≥ 0.0001 Hz to < 0.001

Note: Throughout this section, the letter *n* in italic script is used to indicate the Sensor number, which is a small integer used to identify the signal source. This is always zero ('0') for the Minimus' own internal sensors and for the first analogue instrument (Sensor0).

For Minimus units, Sensors 1, 2, … 8 are external Radian instruments in a string sharing a digital connection. Sensor1 is the digital instrument closest to the Minimus.

For Minimus+ units, Sensor 1 is the second analogue sensor. Sensors 2, 3, … 9 are external Radian instruments in a string sharing a digital connection. Sensor2 is the digital instrument closest to the Minimus+.

1.1.4.1 Minimus Internal Sensors

The names of recorded seismic and accelerometer channels are suffixed with "A" or "B". This notation distinguishes between the two different sample rates that is possible to configure for each recorded channel. For example, the recorded streams *S0AccZA* and *S0AccZB* carry digitisations of the same signal, differing only in the sample rate. The below table shows the channels available from a Minimus with no external sensor attached.

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
MEMS accelerometer	1	Acausal	S0AccZ	0AXL10	S0AccZA	xN1
					S0AccZB	xN1
		Causal	S0AccelZLowLat	0AXL1C		xN1
	2	Acausal	S0AccN	0AXL20	S0AccNA	xN2
					S0AccNB	xN2
		Causal	S0AccelNLowLat	0AXL2C		xN2
	3	Acausal	S0AccE	0AXL30	S0AccEA	xN3
					S0AccEB	xN3
		Causal	S0AccelELowLat	0AXL3C		xN3
Magnetometer	1	Acausal	S0MagZ	0MAG10	S0MagZ	xF1
	2	Acausal	S0MagN	0MAG20	S0MagN	xF2
	3	Acausal	S0MagE	0MAG30	S0MagE	xF3
Input voltage		Acausal	S0Voltage	0VINP0	S0Voltage	xYV

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Power						
Humidity within the Minimus		Acausal	S0HumidA	0HUMA0	S0HumidA	xIO
Temperature	Precision temperature	Acausal	S0TemprA	0TMPA0	S0TemprA	xKO
	First derivative of temperature	Acausal	S0TemprD	0TMPD0		xKD
Internal Clock	Internal clock offset from GNSS	Acausal	ClkGpsOffset	0CGPSO	ClkGpsOffset	BEO
	Internal clock period difference from GNSS	Acausal	ClkGpsPeriod	0CGPSP	ClkGpsPeriod	BEF
	Internal clock DAC frequency pulling	Acausal	ClkDacFreqPull	0CVDAC	ClkDacFreqPull	BED
	Test internal clock drift	Acausal	ClkTestPbpS	0CTSTB	ClkTestPpbS	BEB
	Internal clock offset from PTP	Acausal	ClkPtpOffset	0CPTPO	ClkPtpOffset	BEP
	Delay MS	Acausal	ClkPtpDelayMS	0CPDMS	ClkPtpDelayMS	BEA
	Delay SM	Acausal	ClkPtpDelaySM	0CPDSM	ClkPtpDelaySM	BEB
	Mean path delay	Acausal	ClkPtpMeanPathDelay	0CPMPD	ClkPtpMeanPathDelay	BEC

1.1.4.2 Connected Analogue Instruments

Analogue Instruments connected to a Minimus have a standard set of codes pre-programmed. These are dependant on the type of instrument configured: a velocimeter will show with the prefix *VEL* whilst an accelerometer will show as *ACC*. The following table shows a full list of the values associated with each component of these sensors.

Minimus, Minimus+, Fortimus, Certimus

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	**Live stream name**	**Live Stream code**	**Data record name**	**Mini SEED channel code**
Analogue seismic sensor (velocimeter or accelerometer)	Vertical	Acausal	S*n*SeisZ	*n*VELZ0 *or* *n*ACCZ0	S*n*SeisZA	xHZ or xNZ
			S*n*SeisZ	*n*VELZ2 *or* *n*ACCZ2	S*n*SeisZB	xHZ or xNZ
		Causal	S*n*SeisZLowLat	*n*VELZC *or* *n*ACCZC	Se*n*SeisZLowLat	xHZ or xNZ
	North	Acausal	S*n*SeisN	*n*VELN0 *or* *n*ACCN0	S*n*SeisNA	xHN or xNN
			S*n*SeisN	*n*VELN2 *or* *n*ACCN2	S*n*SeisNB	xHN or xNN
		Causal	S*n*SeisNLowLat	*n*VELNC *or* *n*ACCNC	S*n*SeisNLowLat	xHN or xNN
	East	Acausal	S*n*SeisE	*n*VELE0 *or* *n*ACCE0	S*n*SeisEA	xHE or xNE
			S*n*SeisE	*n*VELE2 *or* *n*ACCE2	S*n*SeisEB	xHE or xNE
		Causal	S*n*SeisELowLat	*n*VELEC *or* *n*ACCEC	S*n*SeisELowLat	xHE or xNE
Auxiliary input		Acausal	S*n*SeisX	*n*AUXX0	S*n*SeisX	xDF
Analogue seismic sensor mass positions	Vertical	Acausal	S*n*IntZ	*n*VELM8	S*n*IntZ	xMZ
	North	Acausal	S*n*IntN	*n*VELM9	S*n*IntN	xMN
	East	Acausal	S*n*IntE	*n*VELMA	S*n*IntE	xME
Calibration Channel		Acausal	S*n*Calib	*n*VELC (or *n*ACCC)	S*n*Calib	xCA
Humidity within sensor enclosure		Acausal	S*n*HumidB	*n*HUMB0	S*n*HumidB	xIO
Pressure	Within sensor enclosure	Acausal	S*n*Pressure	*n*PRSR0	S*n*Pressure	xDI
	External	Acausal	S*n*ExtPressure	*n*PRSR1	S*n*ExtPressure	xDO
PLL clock offset		Acausal	S*n*PLLOffset	*n*PLLO0	S*n*PLLOffset	xYO

1.1.4.3 Connected Digital Instruments

Digital instruments can be attached to the Minimus in series. The lowest numbered instrument is the one which to the Minimus. On a Minimus, this will be shown as Sensor1. On a Minimus+, this will be shown as Sensor2. The following table shows the pre-configured channel names for each component:

Sensor	Comp	Data streaming			Data recording	
		Digital filter mode	**Live stream name**	**Live stream code**	**Data record name**	**MiniSEED channel code**
Seismometer (velocity or acceleration response)	Vertical	Acausal	S*n*SeisZ	*n*VELZ0 *or* *n*ACCZ0	S*n*SeisZA	xHZ *or* xNZ
			S*n*SeisZ	*n*VELZ2 *or* *n*ACCZ2	S*n*SeisZB	xHZ *or* xNZ
		Causal	S*n*SeisZLowLat	*n*VELZC *or* *n*ACCZC	S*n*SeisZLowLat	xHZ *or* xNZ
	North	Acausal	S*n*SeisN	*n*VELN0 *or* *n*ACCN0	S*n*SeisNA	xHN *or* xNN
			S*n*SeisN	*n*VELN2 *or* *n*ACCN2	S*n*SeisNB	xHN *or* xNN
		Causal	S*n*SeisNLowLat	*n*VELNC *or* *n*ACCNC	S*n*SeisNLowLat	xHN *or* xNN
	East	Acausal	S*n*SeisE	*n*VELE0 *or* *n*ACCE0	S*n*SeisEA	xHE *or* xNE
			S*n*SeisE	*n*VELE2 *or* *n*ACCE2	S*n*SeisEB	xHE *or* xNE
		Causal	S*n*SeisELowLat	*n*VELEC *or* *n*ACCEC	S*n*SeisELowLat	xHE *or* xNE
Digital seismic sensor mass position	Vertical	Acausal	S*n*IntZ	*n*INTZ0	S*n*IntZ	xMZ
	North	Acausal	S*n*IntN	*n*INTN0	S*n*IntN	xMN
	East	Acausal	S*n*IntE	*n*INTE0	S*n*IntE	xME
MEMS accelerometer	Vertical	Acausal	S*n*AccZ	*n*AXLZ0	S*n*AccZA	xNZ
					S*n*AccZB	xNZ
		Causal	S*n*AccZLowLat	*n*AXLZC		xNZ
	North	Acausal	S*n*AccN	*n*AXLN0	S*n*AccNA	xNN
					S*n*AccNB	xNN

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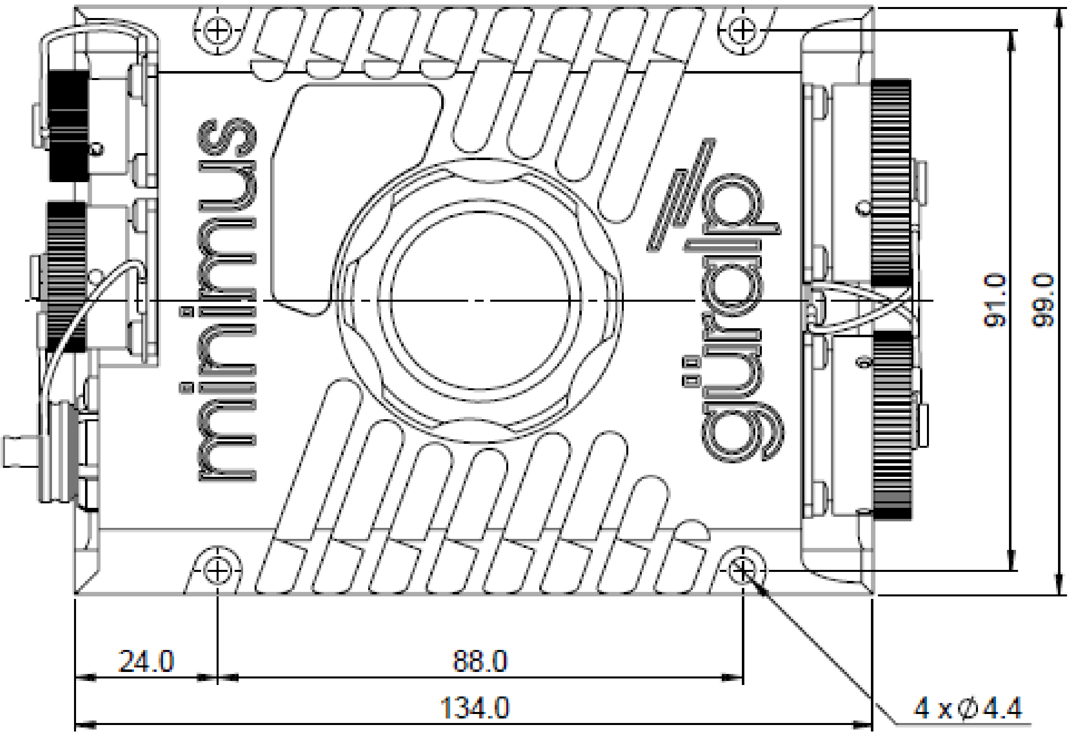
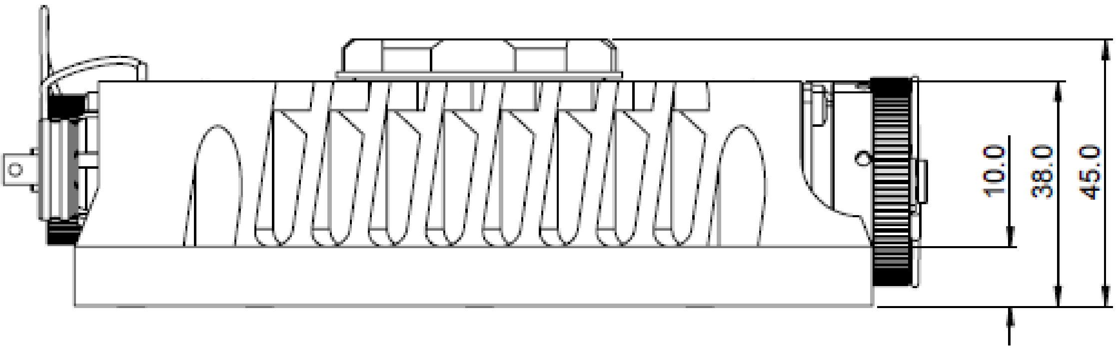
Sensor	Comp	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live stream code	Data record name	MiniSEED channel code
		Causal	S***n***AccNLowLat	***n***AXLNC		xNN
	East	Acausal	S***n***AccE	***n***AXLE0	S***n***AccEA	xNE
					S***n***AccEB	xNE
		Causal	S***n***AccELowLat	***n***AXLEC		xNE
Magnetometer	Z	Acausal	S***n***MagZ	***n***MAGZ0	S***n***MagZ	xFZ
	N	Acausal	S***n***MagN	***n***MAGN0	S***n***MagN	xFN
	E	Acausal	S***n***MagE	***n***MAGE0	S***n***MagE	xFE
	Yaw	Acausal	S***n***RotYaw	***n***ROTY0	S***n***RotYaw	xYY
	Pitch	Acausal	S***n***RotPitch	***n***ROTP0	S***n***RotPitch	xYP
	Roll	Acausal	S***n***RotRoll	***n***ROTR0	S***n***RotRoll	XYR
Temperature		Acausal	S***n***TemprB	***n***TMPB0	Sensor***n***TemprBRough	xKO
Humidity within sensor enclosure		Acausal	S***n***HumidB	***n***HUMB0	S***n***HumidB	xIO
Pressure	Within sensor enclosur e	Acausal	S***n***Pressure	***n***PRSR0	S***n***Pressure	xDI
	External	Acausal	S***n***ExtPressure	***n***PRSR1	S***n***ExtPressure	xDO
PLL clock offset		Acausal	S***n***PLLOffset	***n***PLLO0	S***n***PLLOffset	xYO
Sensor power		Acausal	S***n***Power	***n***PWR0	S***n***Power	xE0
Sensor input voltage		Acausal	S***n***Voltage	***n***VOLT0	S***n***Voltage	xE1

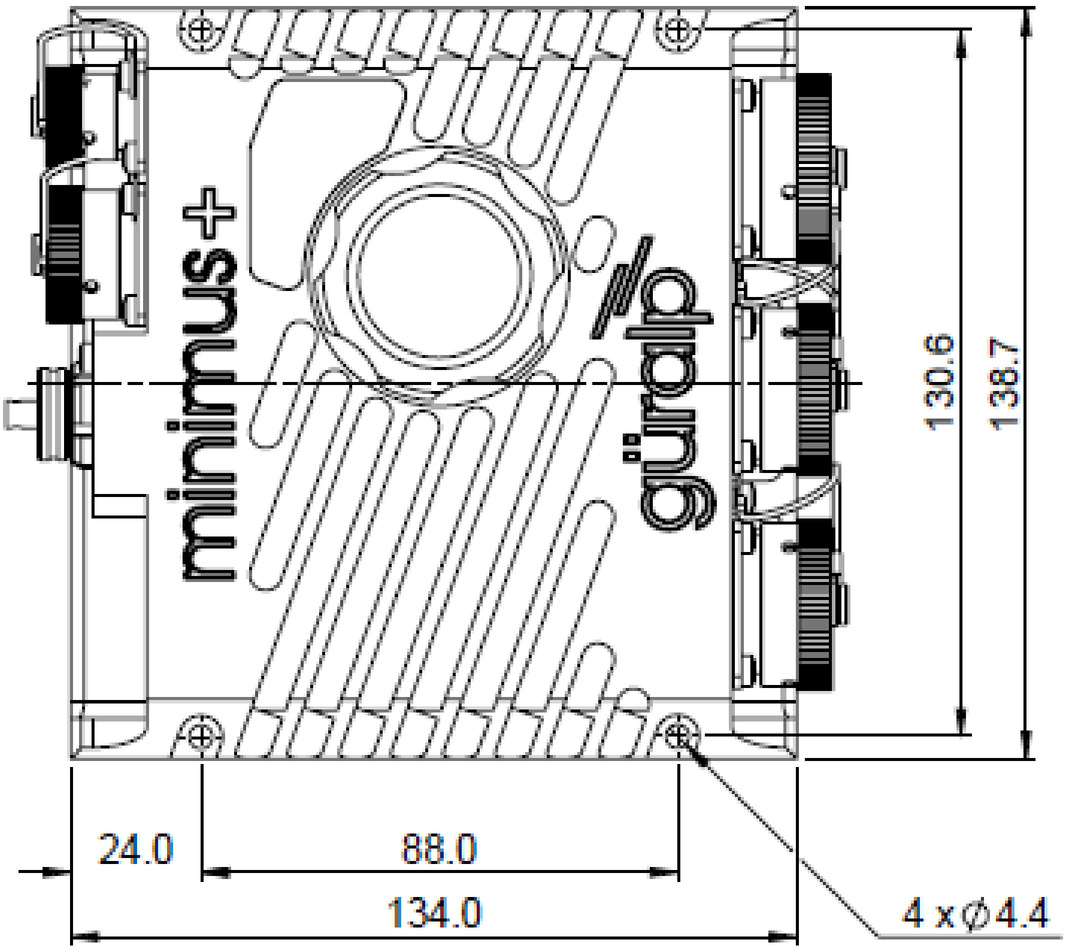
1.1.5 Technical Drawings

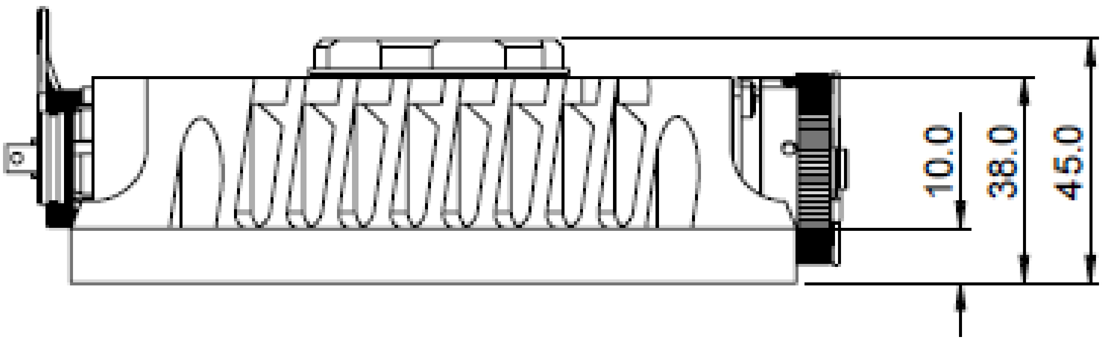
1.1.5.1 Minimus





1.1.5.2 Minimus+





1.2 Fortimus

1.2.1 System Overview

Thank you for purchasing a Güralp Fortimus digital accelerometer.

This section describes the key components of a Fortimus system. The Fortimus unit is the main, standard product in the system; other components and accessories are optional and can be purchased separately. Please check your order confirmation to see which components were purchased with your system.

1.2.1.1 Key Features

- Digital, three-axis, strong-motion, force-feedback accelerometer.
- Flat response to ground acceleration from DC to 315 Hz.
- Selectable gains for full-scale readings of ±4 g, ±2 g, ±1 g and ±0.5 g.
- 24-bit digitiser with a nominal sensitivity of 0.578 µV per count.
- Selectable sample rates from 1 sample per hour to 5000 samples per second.
- Data streaming in real-time using GCF (Scream!), GDI-link and SEEDlink.
- Compact form, measuring just 165 × 165 × 84 mm.
- Internal ±2 g MEMS accelerometer for orientation.
- Identification of IP address via Güralp Discovery software and, optionally, a cloud-based or organisational registry server.
- Remote instrument and data management via Discovery software.
- GüVü Android app for installation integrity checking via Bluetooth.
- Low-latency mode for Earthquake Early Warning (<40 ms).
- Hot-swappable data storage with dual redundant microSD cards.
- GNSS time-synchronisation, compatible with Navstar (GPS), GLONASS, BeiDou and Galileo constellations, with PTP available as an alternative time source.
- Touch-sensitive, 2.4 inch colour LCD for monitoring and control operations.

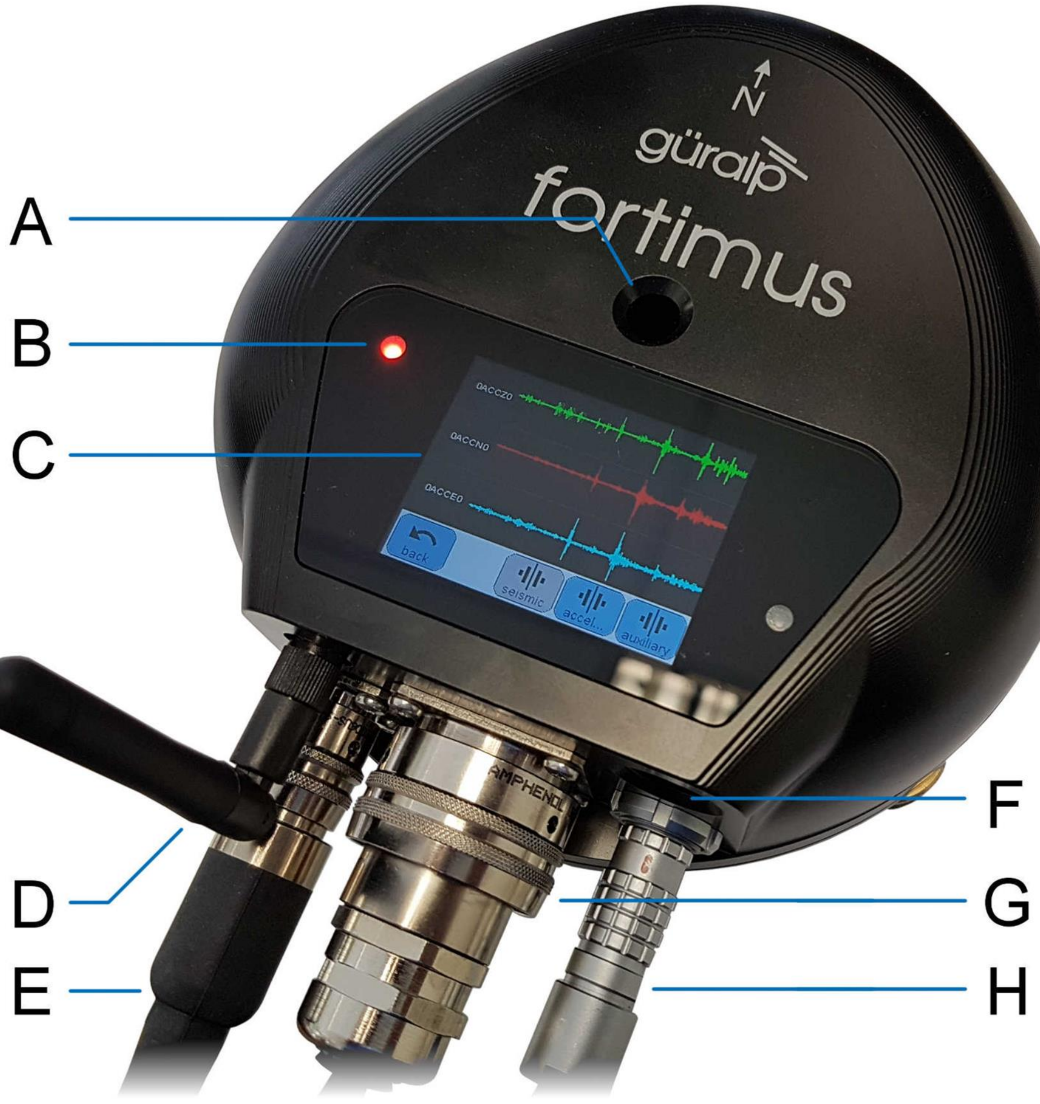
1.2.1.2 Typical Applications

- Earthquake Early Warning systems.
- Multi-scale seismic networks and arrays.
- Structural health monitoring (e.g. dams, industry, buildings).
- Surface and vault installation.
- Posthole deployment.

1.2.2 System Description

1.2.2.1 Güralp Fortimus Digital Accelerometer

The Güralp Fortimus is a Fortis triaxial accelerometer combined with a Minimus digitiser. The Minimus acquires data from and allows direct control of the Fortis analogue instrument.



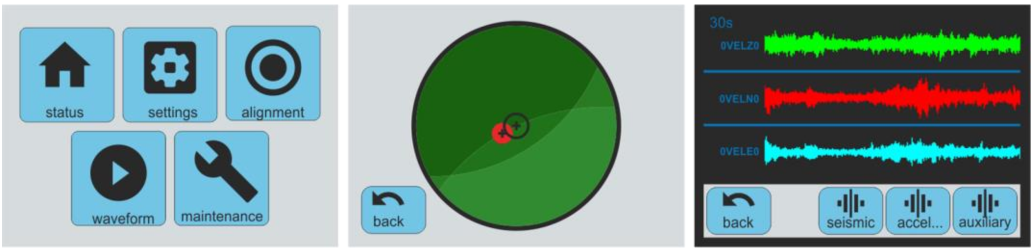
The labelled parts are:

A	Hole for a mounting bolt	**E**	Power connection
B	Status LED	**F**	Cover for SD card
C	Touch-screen display	**G**	Ethernet connection
D	WiFi antenna	**H**	GNSS connection

The hard-anodised aluminium casing protects the instrument from water, allowing it to be deployed in a range of environments. Installation is simple, using a single fixing bolt to attach the sensor to a hard surface. If required, you can also level the sensor using its adjustable levelling feet. An integrated digital bubble-level – available in the display menu – provides quick visual feedback during levelling.

1.2.2.2 Liquid Crystal Display

The Fortimus is equipped with a multi-touch sensitive, 2.4 inch, full colour LCD touch-screen which displays waveforms and a virtual instrument level. Its menu system allows control of instrument state of health, gain settings and network configurations.



The LCD features are described in detail in Chapter 2.13 .

1.2.2.3 LED Indicator

The Fortimus has an LED indicator on the upper surface, which provides status and configuration information. More details can be found in Chapter 1.1.2.2.

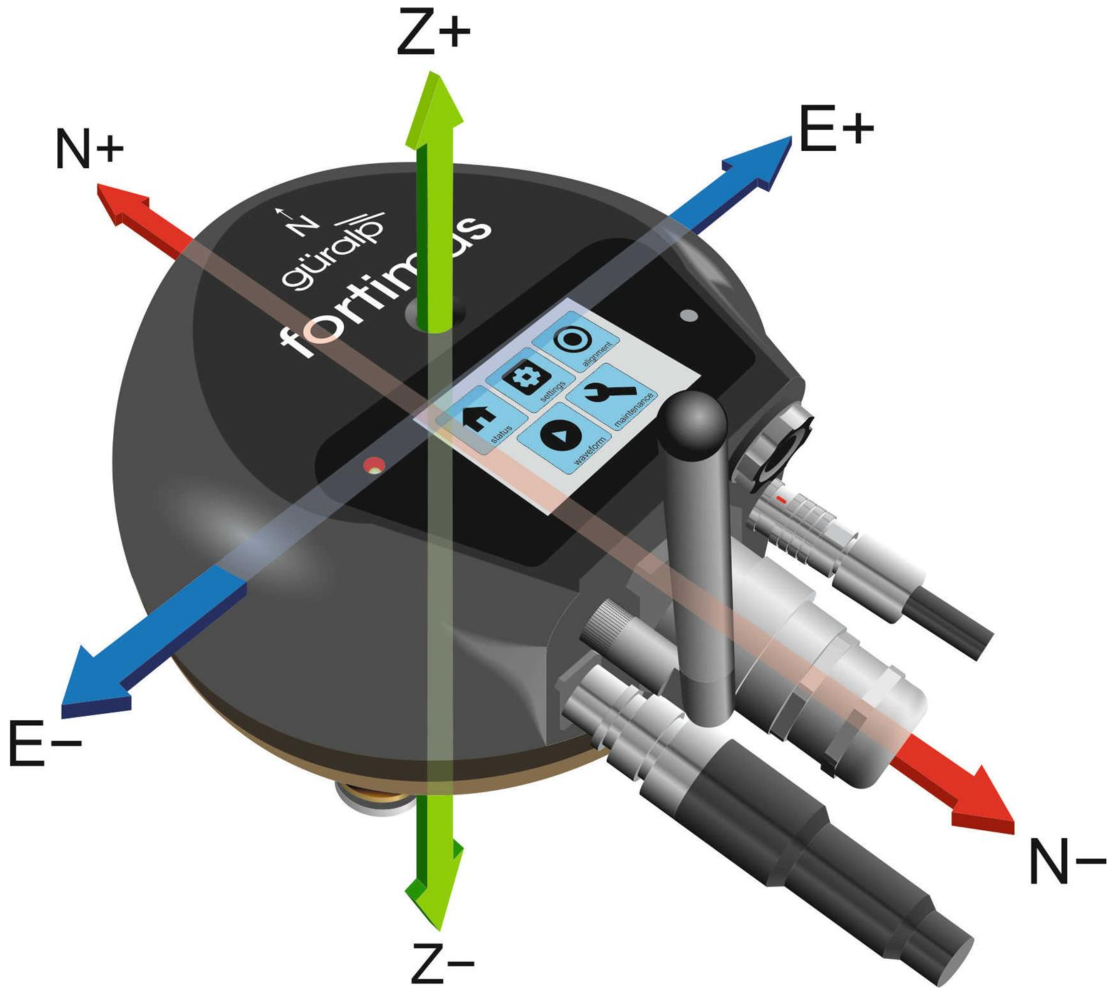
1.2.2.4 Bluetooth Connectivity

The Fortimus features Bluetooth connectivity, allowing sensor and state-of-health information to be monitored using the Güralp GüVü app running on an Android mobile phone or tablet. For full details and features of the app see Chapter 3.5 .

Bluetooth can be disabled via software to save processing power, but the hardware module cannot be switched off. BLE (Bluetooth Low Energy) technology is used to minimise the power. The Bluetooth transmitter/receiver is in permanent standby mode and is always ready to receive a connection from a phone or tablet.

1.2.2.5 MEMS Accelerometer

The Fortimus digital accelerometer is equipped with a triaxial Micro Electro-Mechanical System (MEMS) accelerometer with a measurement range of ±2 g. The three axes of sensitivity, Z, N and E, align with those of the main accelerometer outputs and are orientated as illustrated below:



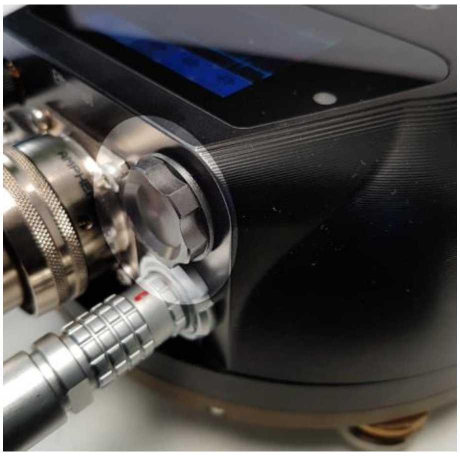
1.2.2.6 Data Storage

The Fortimus uses microSD (non-volatile) memory technology to store seismic data within the instrument. The Fortimus features two such microSD cards in order to provide redundancy; this helps to protect the recorded data in the unlikely event of any corruption or problem with the memory cards. One card is internal and cannot be removed by the user; the other is hot-swappable and easily accessible from the external SD card port.

The Fortimus is supplied with two microSD cards that are of equal storage capacity (e.g. two 16 GB cards).

Primary (Hot-Swappable) microSD Card

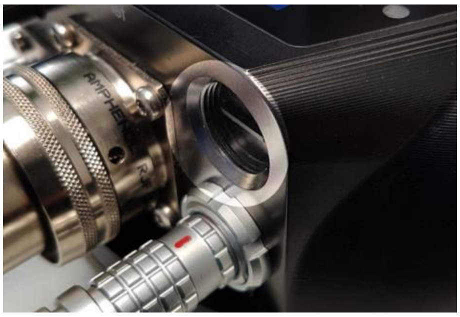
To remove the external microSD card, follow the steps below:



The microSD card is protected by a screw-in cap, located next to the Ethernet connector and above the GNSS connector

Remove the cap by unscrewing it anticlockwise, as shown.

Caution: Finger pressure is sufficient. Do not use tools.



The horizontal edge of the microSD card is now visible

The card slot has a spring lock: pushing the card firmly inwards locks it into place; a second push releases the card so that it can be withdrawn.

Lightly push the edge of the microSD card with a fingertip or a soft implement. Once the initial spring resistance has been overcome, release the pressure and the card will partially eject itself.

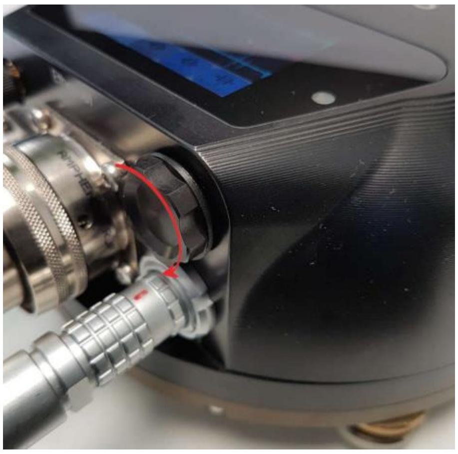
The card should now protrude enough that it can be grasped and withdrawn.

To replace the card, ensure any existing card has been remove, as shown previously, then follow the steps below:

Gently insert the replacement card into the slot with the logo facing upwards and the straight edge of the card on the left, as shown. The card must be perfectly horizontal in order to align properly.

Push the card gently into place until the pressure of the spring lock is felt. If it does not glide into place, remove the card, and start again. Do not force the card into position.

Check that the card is fully engaged by pressing lightly to unlock it and then pressing again to lock it. The card should be engaged firmly when locked and slide freely otherwise. Ensure the card is locked before proceeding.



Place the screw cap on the opening, taking great care to align the screw-thread correctly. Tighten the cap by screwing it in clockwise, as shown.

Caution: Finger pressure is sufficient. Do not use tools.

Note: In order to ensure data integrity and security, Güralp only recommend using the supplied industrial-grade microSD cards.

Caution: When the external microSD card is removed, the internal card keeps recording data, unless recording is stopped using the Unmount Cards button (see Chapter 2.7.4). However, when the external card is re-connected, any data written to the internal card while the removable card was absent will be overwritten.

Internal (Backup) microSD Card

The second microSD card is factory-installed in a slot inside the Fortimus.

Caution: The internal microSD card is not accessible by the user. Attempts to remove or replace it will void the Fortimus' warranty.

1.2.2.7 WiFi Connectivity

The Fortimus is provided with a Siretta Delta 7A omnidirectional antenna, suitable for both 2.4 GHz and 5.8 GHz networks.

The antenna connects directly to the Fortimus using an SMA connector. It can be removed and replaced with a high gain, directional antenna if required. To remove the antenna, grasp the knurled locking sleeve and turn anti-clockwise, as shown.

See Chapter **Error! Reference source not found.**for further details on how to configure the Fortimus to connect to a wireless network.

Note: It is not necessary to have the antenna fitted if wireless operation is not required.

1.2.3 System Setup

The Fortimus is delivered in an environmentally friendly, flat-packable, suspension packaging. The packaging is specifically designed for the Fortimus and should be re-used whenever you need to transport the instrument. Before unpacking, please inspect the case for any signs of damage and report defects to support@guralp.com. Unpack the equipment on a clean work surface. Within the package you will find: the Fortimus digital accelerometer, the pigtail power cable, the GNSS receiver and cable, the Ethernet cable and the fixing bolt.

Caution: Although the Fortimus is a strong motion instrument, it contains sensitive mechanical components which can be damaged by mishandling. If you are at all unsure about the handling or installation of the device, you should contact Güralp Systems for assistance.

- Do not bump or jolt any part of the sensor when handling or unpacking.
- Do not kink or walk on the data cable (especially on rough surfaces such as gravel), nor allow it to bear the weight of the sensor.
- Do not connect the instrument to a power source except where instructed.
- Never ground any of the output signal lines from the sensor.

Güralp highly recommends exploring and gaining familiarity with the Fortimus inside your lab before installation in an outdoors environment.

A typical set-up for the Fortimus is shown in the figure below:

To get started, connect the cables as shown in the figure above. Power up the Fortimus using a power supply with a DC output of between 10 and 36 Volts.

Caution: Observe the correct polarity when connecting the power supply. The red lead (from pin B) must be connected to the positive terminal, typically labelled "+", and the **black** lead (from pin A) must be connected to the **negative terminal**, typically labelled "**-**". An incorrect connection risks destroying the instrument, the power supply and any connected accessories.

1.2.4 Installation

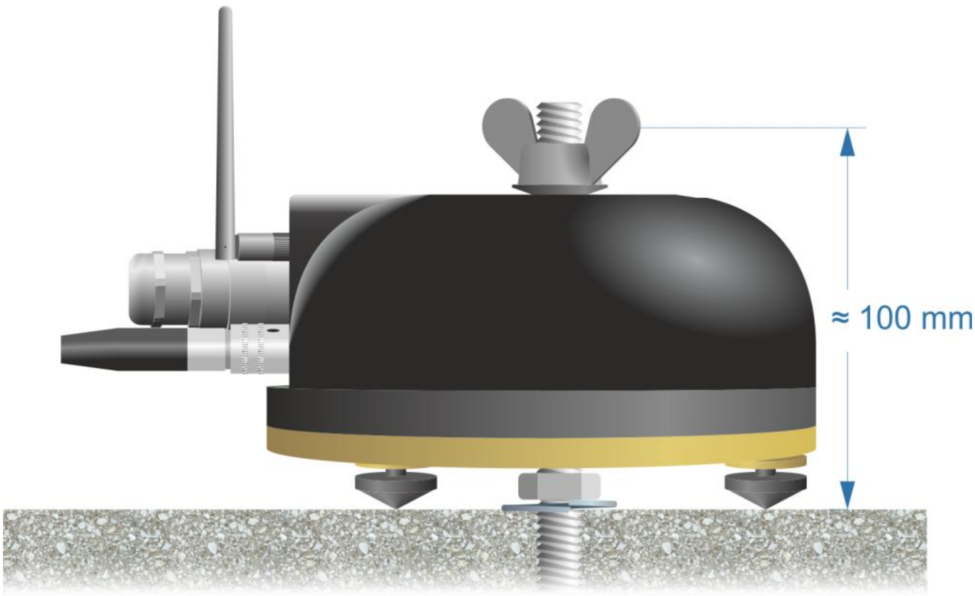
1.2.4.1 Permanent Installation

You will need a hard, clean surface such as a concrete floor, to install the Fortimus.

If you are in any doubt about how to install the sensor, you should contact Güralp Systems' Technical Support, via support@guralp.com.

1. Prepare the surface by scribing an accurate N/S orientation line and installing a grouted-in fixing bolt on the line, near the middle. An anchor terminating in a 6 mm or 8 mm ($^1/_4$ or $^5/_{16}$ inch) threaded stud is suitable.

The exposed thread should project approximately 100 mm (4 inches) above the surface. Significant excess length should be removed.



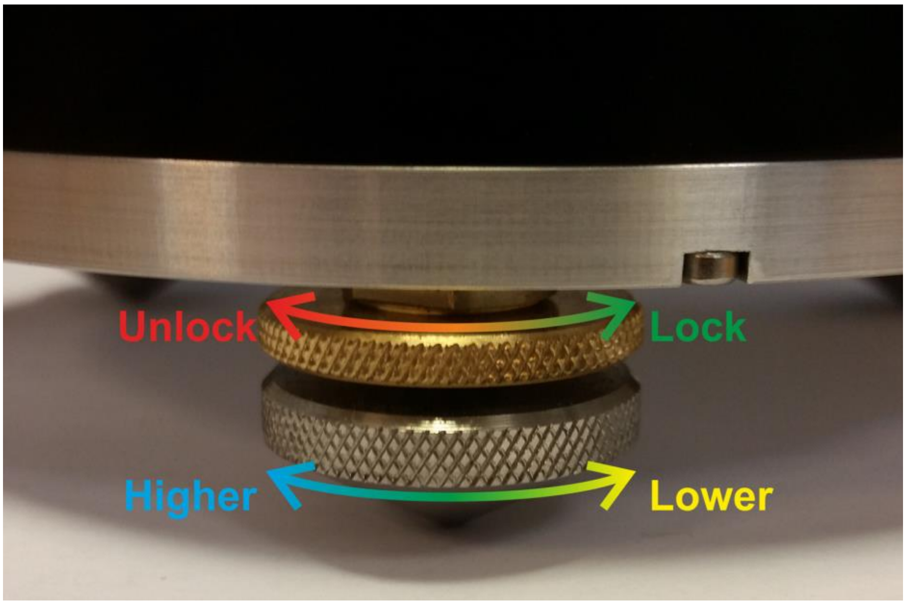
2. Place the Fortimus over the fixing bolt and rotate it to bring the scribed orientation line and Fortimus' pointers accurately into parallel alignment.

   For more accurate alignment, a long, thin rod or a length of stiff wire can be aligned with a slot machined into the base of the instrument. It can be held in place by hand or, if preferred, by inserting two 3mm screws into the threaded holes provided.

3. Connect all the cables as described in Chapter 1.2.3 and power on the Fortimus.
4. Touch the alignment button at the top right of the LCD screen: this will display the digital levelling tool

The red circle behaves like the bubble in a traditional bubble level, moving towards the highest edge of the instrument. The further from the centre it is, the more adjustment is needed.

5. Level the sensor, using its adjustable feet, until the red circle lies entirely within the inner circle of the indicator.



The feet are mounted on screw threads. To adjust the height of a foot, turn the brass locking nut clockwise (when viewed from above) to loosen it and rotate the entire foot so that it screws either in or out. When you are happy with the height, tighten the brass locking nut anti-clockwise to secure the foot.

6. Secure the instrument to the mounting stud using the conical washer provided and a wing nut.

Caution: Hand-tighten only, do not use tools.

The instrument is now installed and transducing ground motion.

1.2.4.2 Temporary Installations

The Fortimus is ideal for monitoring vibrations at field sites, owing to its ruggedness, high sensitivity and ease of deployment. Temporary installations will usually be in hand-dug pits or machine drilled holes. Once a level base is made, the Fortimus can be sited there and covered with a box or bucket. One way to produce a level base is to use a hard-setting liquid:

1. Prepare a quick-setting cement/sand mixture and pour it into the hole.
2. “Puddle” the cement by vibrating it until it is fully liquefied, allowing its surface to level out.
3. Follow the cement manufacturer's instructions carefully. Depending on the temperature and type of cement used, the mixture will set over the next 2 to 12 hours.
4. Install the sensor as above, then cover and back-fill the emplacement with soil, sand, or polystyrene beads.
5. Cover the hole with a turf-capped board to exclude wind noise and to provide a stable thermal environment.

If you prefer, you can use quicker-setting plaster or polyester mixtures to provide a mounting surface. However, you must take care to prevent the liquid leaking away by “proofing” the hole beforehand. Dental plaster, or similar mixtures, may need reinforcing with sacking or muslin.

1.2.4.3 Installation in Hazardous Environments

The fully enclosed, aluminium case design of the Fortimus makes it suitable for use in hazardous environments where electrical discharges due to the build-up of static charge could lead to the ignition of flammable gasses. To ensure safe operation in these conditions, the metal case of the instrument must be electrically bonded ('earthed') to the structure on which it is mounted, forming a path to safely discharge any static charge.

Where electrical bonding ('earthing') is required during the installation of a Fortimus, the central mounting hole that extends through the instrument should be used as the connection point. This is electrically connected to all other parts of the sensor case. Connection can be made by either a cable from a local earthing point terminated in an 8 mm ring tag or via the mounting bolt itself.

1.2.5 Instrument and Channel Names

The tables in this section are designed to inform users of the names and codes of the streamed and recorded channels present in the Fortimus. The first character of a miniSEED channel code represents the sample rate. The possible values are shown in the table below:

F	≥ 1000 Hz to < 5000 Hz
C	≥ 250 Hz to < 1000 Hz
H	≥ 80 Hz to < 250 Hz
B	≥ 10 Hz to < 80 Hz
M	> 1 to < 10
L	≈ 1
V	≈ 0.1 Hz
U	≈ 0.01 Hz
R	≥ 0.0001 Hz to < 0.001

1.2.5.1 *Environmental Channels*

Sensor	**Comp.**	**Data streaming**			**Data recording**	
		Digital filter mode	**Live stream name**	**Live Stream code**	**Data record name**	**Mini SEED channel code**
MEMS accelerometer	1	Acausal	S0AccZ	0AXL10	S0AccZA	xN1
					S0AccZB	xN1
		Causal	S0AccelZLowLat	0AXL1C		xN1
	2	Acausal	S0AccN	0AXL20	S0AccNA	xN2
					S0AccNB	xN2
		Causal	S0AccelNLowLat	0AXL2C		xN2
	3	Acausal	S0AccE	0AXL30	S0AccEA	xN3
					S0AccEB	xN3
		Causal	S0AccelELowLat	0AXL3C		xN3
Magnetometer	1	Acausal	S0MagZ	0MAG10	S0MagZ	xF1
	2	Acausal	S0MagN	0MAG20	S0MagN	xF2
	3	Acausal	S0MagE	0MAG30	S0MagE	xF3
Input voltage		Acausal	S0Voltage	0VINP0	S0Voltage	xYV
Digitiser power usage		Acausal	S0Power	0PINP0	S0Power	xYP

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Humidity	Relative within Minimus	Acausal	S0HumidA	0HUMA0	S0HumidA	xIO
	Within sensor enclosure	Acausal	S0HumidB	0HUMB0	S0HumidB	xIO
Pressure	Within sensor enclosure	Acausal	S*n*Pressure	*n*PRSR0	S*n*Pressure	xDI
	External	Acausal	S*n*ExtPressure	*n*PRSR1	S*n*ExtPressure	xDO
Temperature	Precision temperature	Acausal	S0TemprA	0TMPA0	S0TemprA	xKO
	First derivative of temperature	Acausal	S0TemprD	0TMPD0		xKD
Internal Clock	Internal clock offset from GNSS	Acausal	ClkGpsOffset	0CGPSO	ClkGpsOffset	BEO
	Internal clock period difference from GNSS	Acausal	ClkGpsPeriod	0CGPSP	ClkGpsPeriod	BEF
	Internal clock DAC frequency pulling	Acausal	ClkDacFreqPull	0CVDAC	ClkDacFreqPull	BED
	Test internal clock drift	Acausal	ClkTestPbpS	0CTSTB	ClkTestPpbS	BEB
	Internal clock offset from PTP	Acausal	ClkPtpOffset	0CPTPO	ClkPtpOffset	BEP
	Delay MS	Acausal	ClkPtpDelayMS	0CPDMS	ClkPtpDelayMS	BEA
	Delay SM	Acausal	ClkPtpDelaySM	0CPDSM	ClkPtpDelaySM	BEB
	Mean path delay	Acausal	ClkPtpMeanPathDelay	0CPMPD	ClkPtpMeanPathDelay	BEC
PLL clock offset		Acausal	S*n*PLLOffset	0PLLO0	S*n*PLLOffset	xYO

1.2.5.2 Accelerometer Channels

The names of recorded seismic and accelerometer channels are suffixed with "A" or "B". This notation distinguishes between the two different sample rates that is possible to configure for each recorded channel. For example, the recorded streams *S0AccZA* and *S0AccZB* carry digitisations of the same signal, differing only in the sample rate. The below table shows the channels available from a Fortimus.

Minimus, Minimus+, Fortimus, Certimus

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Analogue accelerometer	Vertical	Acausal	S0SeisZ	0ACCZ0	S0SeisZA	xNZ
			S0SeisZ	0ACCZ2	S0SeisZB	xNZ
		Causal	S0SeisZLowLat	0ACCZC	S0SeisZLowLat	xNZ
	North	Acausal	S0SeisN	0ACCN0	S0SeisNA	xNN
			S0SeisN	0ACCN2	S0SeisNB	xNN
		Causal	S0SeisNLowLat	0ACCNC	S0SeisNLowLat	xNN
	East	Acausal	S0SeisE	0ACCE0	S0SeisEA	xNE
			S0SeisE	0ACCE2	S0SeisEB	xNE
		Causal	S0SeisELowLat	0ACCEC	S0SeisELowLat	xNE
Calibration channel		Acausal	S0Calib	0ACCC0		xCA

1.3 Certimus

1.3.1 System Overview

Thank you for purchasing a Güralp Certimus digital Seismometer.

This section describes the key components of a Certimus system. The Certimus other components and accessories are optional and can be purchased separately. Please check your order confirmation to see which components were purchased with your system.

1.3.1.1 Key Features

- Digital, three-axis, weak-motion, force-feedback seismometer.
- Flat response to ground acceleration from 120s to 100 Hz.
- Standard gain equivalent to 2000V/ms-1.
- 24-bit digitiser with a nominal sensitivity of 0.2 µV per count.
- Selectable sample rates from 1 sample per hour to 1000 samples per second.
- Data streaming in real-time using GCF (Scream!), GDI-link and SEEDlink.
- Compact form, measuring just 175 × 175 × 95 mm.
- Internal ±2 g MEMS accelerometer for orientation.
- Identification of IP address via Güralp Discovery software and, optionally, a cloud-based or organisational registry server.
- Remote instrument and data management via Discovery software and/or WEB interface.
- Android app for installation integrity checking via Bluetooth.
- Low-latency mode for Earthquake Early Warning (< 40 ms).
- Hot swappable data storage with dual redundant microSD cards.
- GNSS time-synchronisation, compatible with Navstar (GPS), GLONASS, BeiDou and Galileo constellations, with PTP available as an alternative time source.
- Touch-sensitive, 2.4 inch colour LCD for monitoring and control operations.

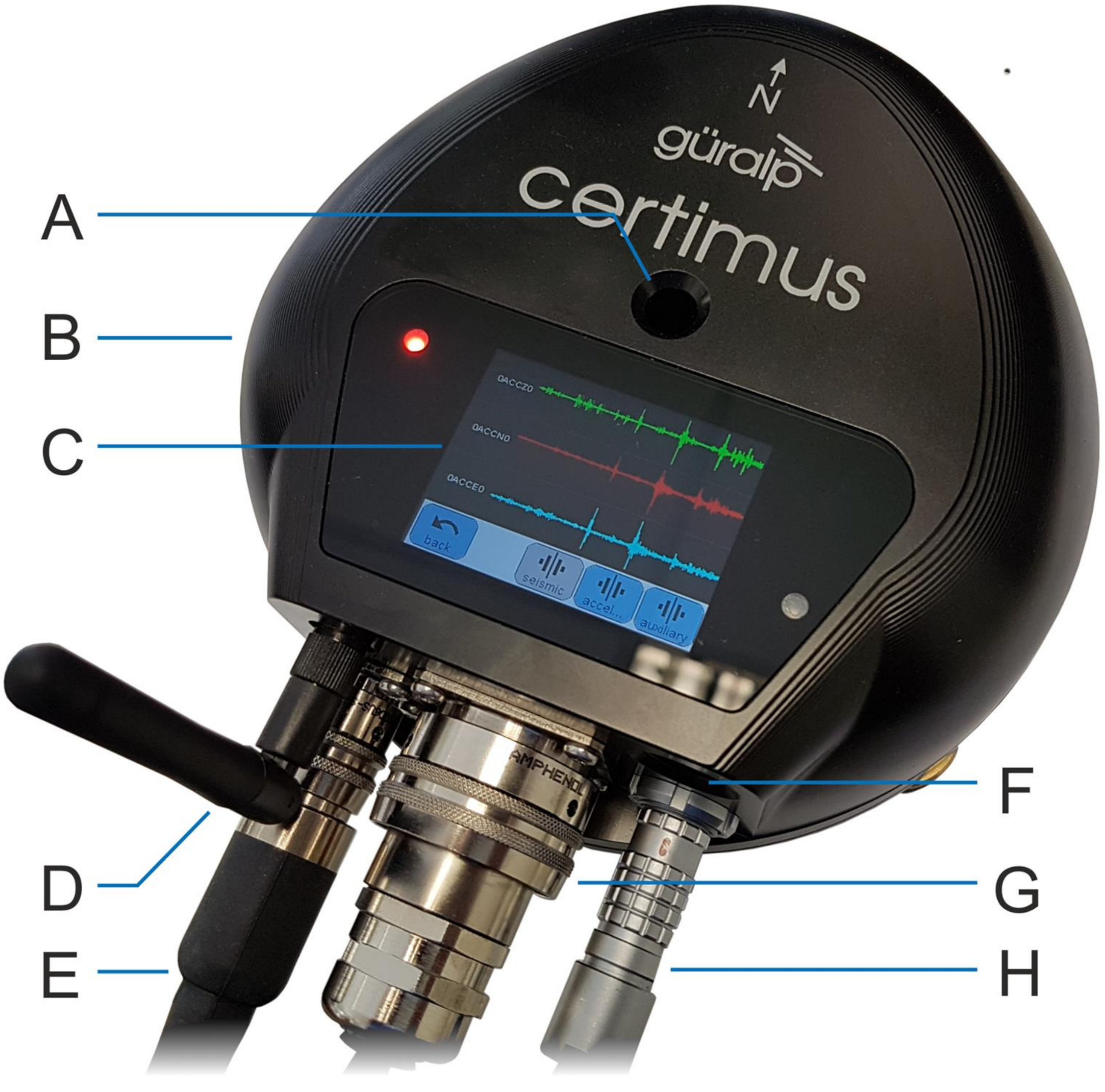
1.3.1.2 Typical Applications

- Earthquake Early Warning systems.
- Multi-scale seismic networks and arrays.
- Rapid response/aftershock study
- Surface and vault installation.
- Surface or buried deployment

1.3.2 System Description

1.3.2.1 Güralp Certimus Digital Seismometer

The Güralp Certimus is a broadband triaxial seismometer combined with a Minimus digitiser frontend. The Minimus acquires data from and allows direct control of the instrument.

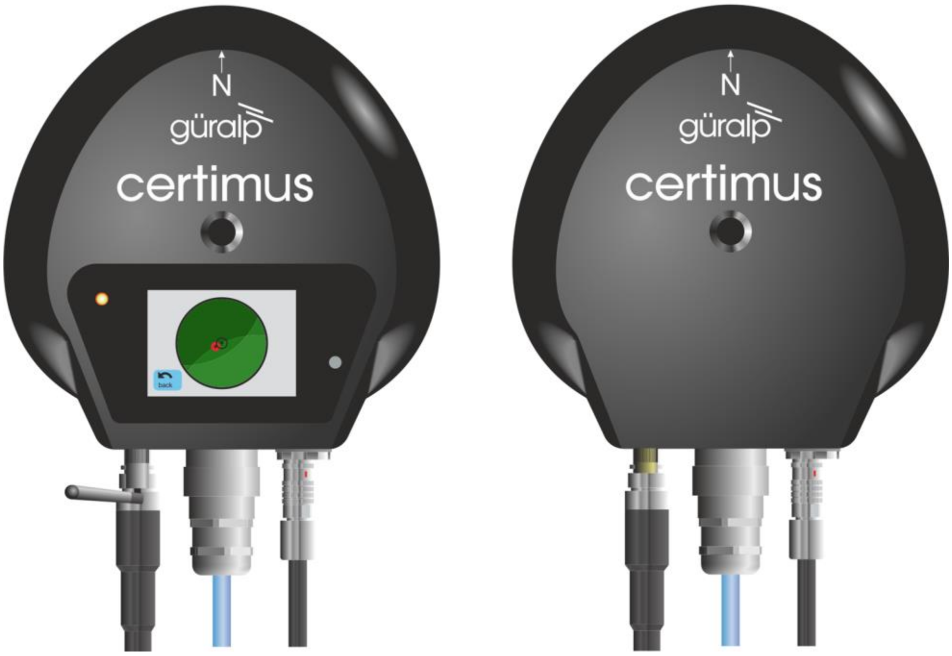


The labelled parts are:

A	Hole for a mounting bolt	**E**	Power connection
B	Status LED	**F**	Cover for SD card
C	Touch-screen display	**G**	Ethernet connection
D	WiFi antenna	**H**	GNSS connection

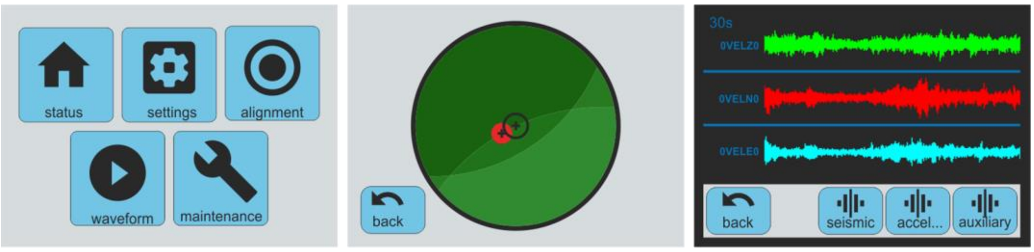
The hard-anodised aluminium casing protects the instrument from water, allowing it to be deployed in a range of environments. Installation is simple as the system will operate over a very wide range of angles. If required, you can also level the sensor using its adjustable levelling feet. An integrated digital bubble-level – available in the display menu – provides quick visual feedback during levelling. This is not essential for the operation of the sensor.

The Certimus is also available in a version without the LCD touch-screen, more suitable for direct burial.



1.3.2.2 Liquid Crystal Display

The Certimus is equipped with a multi-touch sensitive, 2.4 inch, full colour LCD touch-screen which shows waveforms and a virtual instrument level. Its menu system allows control of instrument state of health, gain settings and network configurations.



The LCD features are described in detail in Chapter 2.13 .

1.3.2.3 LED Indicator

The Certimus has an LED indicator on the upper surface, which provides status and configuration information. More details can be found in Chapter 2.15.1.

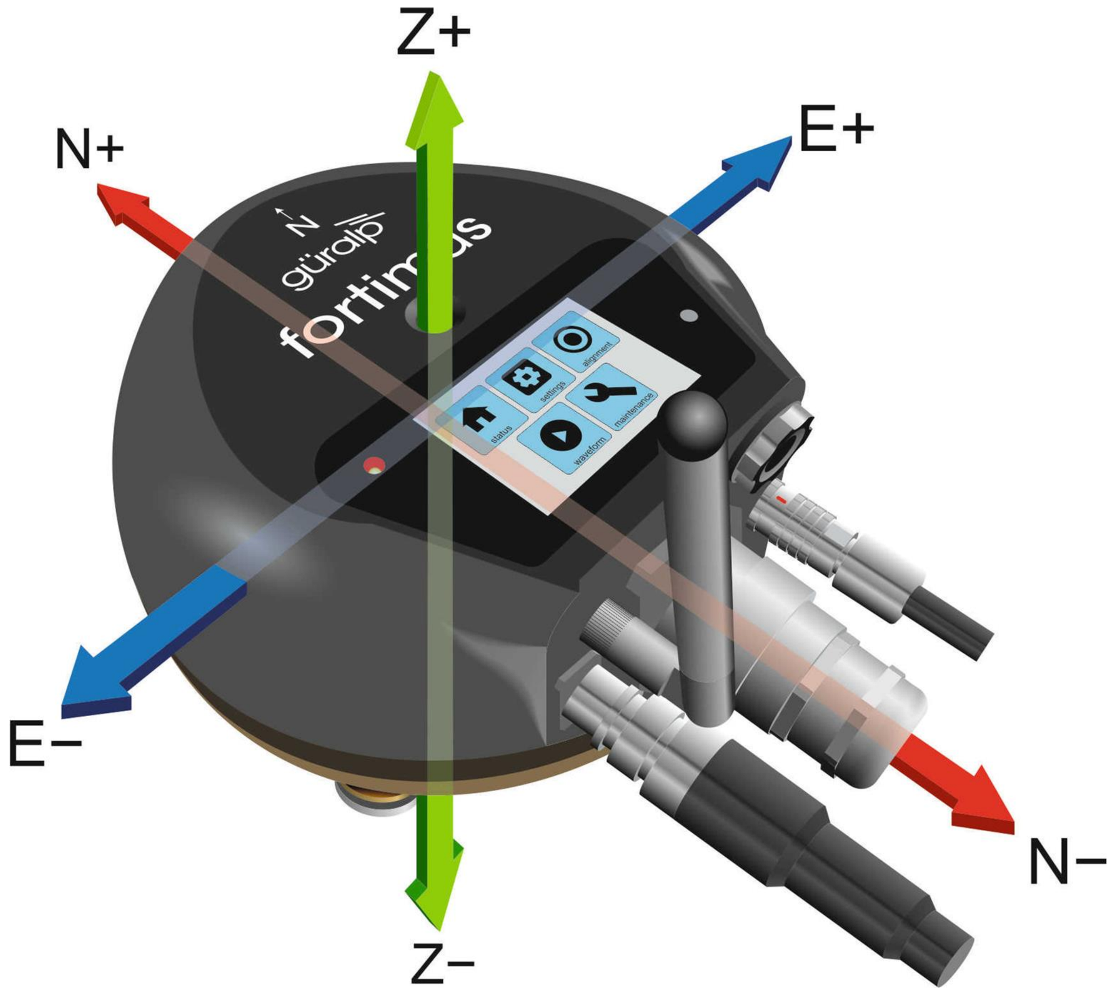
1.3.2.4 Bluetooth Connectivity

The Certimus features Bluetooth connectivity, allowing sensor and state-of-health data to be monitored using the Güralp GüVü app (see Chapter 3.5) running on an Android mobile phone or tablet.

Bluetooth can be disabled via software to save processing power but the hardware module cannot be switched off. BLE (Bluetooth Low Energy) technology is used to minimise the power requirement. The Bluetooth transmitter/receiver is in permanent standby mode and always ready to receive a connection from a phone or tablet.

1.3.2.5 MEMS Accelerometer

The Certimus digital seismometer is equipped with a triaxial Micro Electro-Mechanical System (MEMS) accelerometer with a measurement range of ±2 g. The three axes of sensitivity, Z, N and E, align with those of the main seismometer outputs and are orientated as illustrated below:



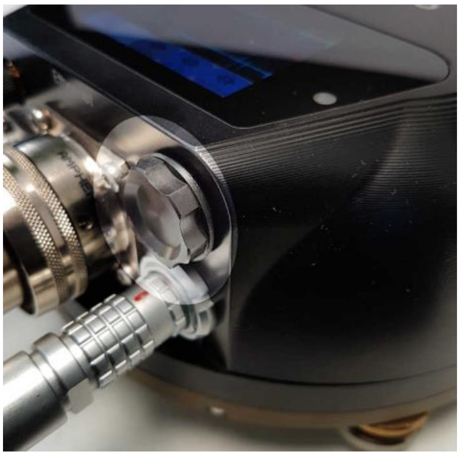
1.3.2.6 Data Storage

The Certimus uses microSD (non-volatile) memory technology to store seismic data within the instrument. The Certimus features two such microSD cards in order to provide redundancy; this helps to protect the recorded data in the unlikely event of any corruption or problem with the memory cards. One card is internal and cannot be removed by the customer; the other is hot-swappable and easily accessible from the external SD card port.

The Certimus is supplied with two microSD cards that are of equal storage capacity (e.g. two 16 GB cards).

Primary (Hot-Swappable) microSD Card

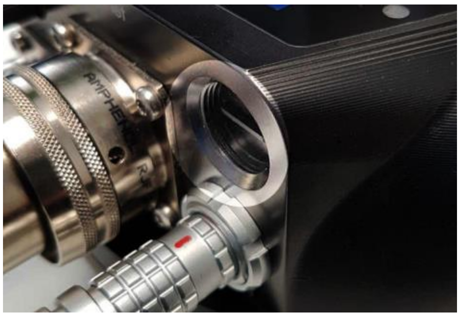
To remove the external microSD card, follow the steps below:



The microSD card is protected by a screw-in cap, located next to the Ethernet connector and above the GNSS connector

Remove the cap by unscrewing it anticlockwise, as shown.

> ⚠ **Caution:** Finger pressure is sufficient. Do not use tools.



The horizontal edge of the microSD card is now visible

The card slot has a spring lock: pushing the card firmly inwards locks it into place; a second push releases the card so that it can be withdrawn.

Lightly push the edge of the microSD card with a fingertip or a soft implement. Once the initial spring resistance has been overcome, release the pressure and the card will partially eject itself.

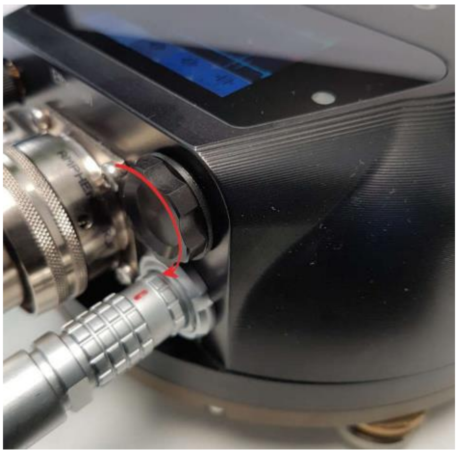
The card should now protrude enough that it can be grasped and withdrawn.

To replace the card, ensure any existing card has been removed , as shown previously, then follow the steps below:

Gently insert the replacement card into the slot with the logo facing upwards and the straight edge of the card on the left, as shown. The card must be perfectly horizontal to align properly.

Push the card gently into place until the pressure of the spring lock is felt. If it does not glide into place, remove the card, and start again. Do not force the card into position.

Check that the card is fully engaged by pressing lightly to unlock it and then pressing again to lock it. The card should be engaged firmly when locked and slide freely otherwise. Ensure the card is locked before proceeding.



Place the cap on the opening, taking care to align the screw-thread correctly. Replace the cap by screwing it in clockwise, as shown.

> **Caution:** Finger pressure is sufficient. Do not use tools.

Note: In order to ensure data integrity and security, Güralp only recommend using the supplied industrial-grade microSD cards.

Caution: When the external microSD card is removed, the internal card keeps recording data, unless recording is stopped using the Unmount Cards button (see Chapter 2.7.4). However, when the external card is re-connected, any data written to the internal card while the removable card was absent will be overwritten.

Internal (Backup) microSD Card

The second microSD card is factory-installed in a slot inside the Certimus.

Caution: The internal microSD card is not accessible by the user. Attempts to remove or replace it will void the Certimus' warranty.

1.3.2.7 WiFi Connectivity

The Fortimus is provided with a Siretta Delta 7A omnidirectional antenna, suitable for both 2.4 GHz and 5.8 GHz networks.

The antenna connects directly to the Certimus using an SMA connector. It can be removed and replaced with a high-gain, directional antenna if required. To remove, grasp the knurled locking sleeve and turn anti-clockwise, as shown.

See Chapter **Error! Reference source not found.**for further details on how to configure the Certimus to connect to a wireless network.

Note: It is not necessary to have the antenna fitted if wireless operation is not required.

1.3.3 System Setup

The Certimus is delivered in environmentally friendly, flat-packable, suspension packaging. The packaging is specifically designed for the Certimus and should be re-used whenever you need to transport the instrument. Before unpacking, please inspect the case for any signs of damage and report defects to support@guralp.com. Unpack the equipment on a clean surface. The package should contain the Certimus digital seismometer, the pigtail power cable, the GNSS receiver and cable, the Ethernet cable and the fixing bolt.

Caution: The Certimus is a precision seismic sensor. It contains sensitive mechanical components which can be damaged by mishandling. If you are unsure about the handling or installation of this device, you should contact Güralp Systems at support@guralp.com for assistance.

- Do not bump or jolt any part of the sensor when handling or unpacking.
- Do not kink or walk on the data cable (especially on rough surfaces such as gravel), nor allow it to bear the weight of the sensor.
- Do not connect the instrument to a power source except where instructed.
- Never ground any of the output signal lines from the sensor.

Güralp highly recommends exploring and gaining familiarity with the Certimus inside your lab before installation in an outdoors environment.

A typical setup for the Certimus is shown in the figure below:

To get started, connect the cables as shown in the figure above. Power up the Certimus using a power supply with a DC output of between 10 and 36 Volts.

Caution: Observe the correct polarity when connecting the power supply. The red lead (from pin B) must be connected to the positive terminal, typically labelled "+", and the **black** lead (from pin A) must be connected to the **negative terminal**, typically labelled "**-**". An incorrect connection risks destroying the instrument, the power supply and any connected accessories.

1.3.4 Installation

1.3.4.1 Permanent Installation

You will need a hard, clean surface such as a concrete floor, to install the Fortimus.

If you are in any doubt about how to install the sensor, you should contact Güralp Systems' Technical Support, via support@guralp.com.

1. Prepare the surface by scribing an accurate N/S orientation line and installing a grouted-in fixing bolt on the line, near the middle. An anchor terminating in a 6 mm or 8 mm ($^1/_4$ or $^5/_{16}$ inch) threaded stud is suitable.

The exposed thread should project approximately 100 mm (4 inches) above the surface. Significant excess length should be removed.

2. Place the Certimus on the surface and rotate it to bring the scribed orientation line and Certimus' pointers accurately into parallel alignment.

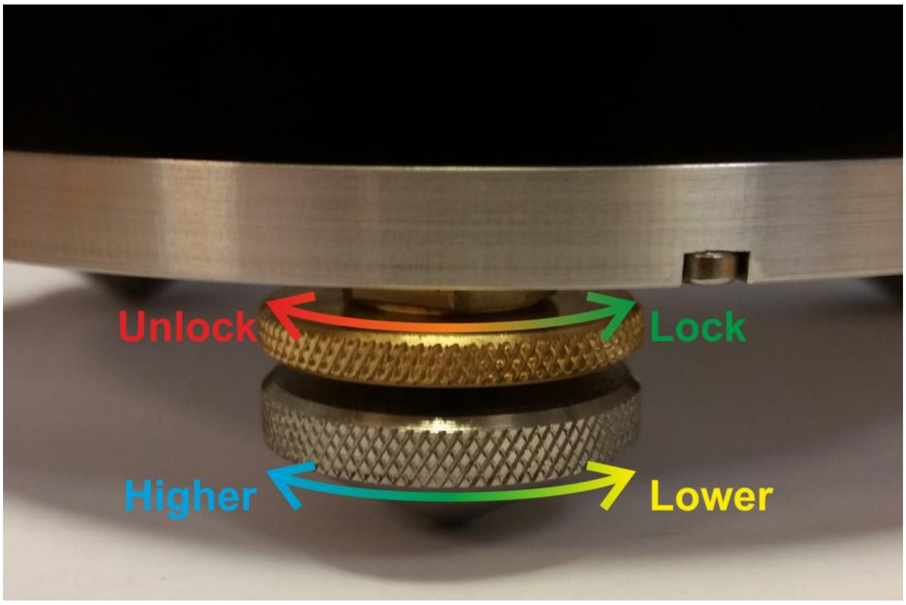
For more accurate alignment, a long, thin rod or a length of stiff wire can be aligned with a slot machined into the base of the instrument. It can be held in place by hand or, if preferred, by inserting two 3 mm screws into the threaded holes provided.

3. Connect all the cables as described in Chapter 1.3.3 and power on the Certimus.

4. Touch the alignment button at the top right of the LCD screen: This will display the digital levelling tool.

The red circle behaves like the bubble in a traditional bubble-level, moving towards the highest edge of the instrument. The further from the centre it is, the more adjustment is needed.

5. Level the sensor, using its adjustable feet, until the red circle lies entirely within the inner circle of the indicator.



The feet are mounted on screw threads. To adjust the height of a foot, turn the brass locking nut clockwise (when viewed from above) to loosen it and rotate the entire foot so that it screws either in or out. When you are happy with the height, tighten the brass locking nut anti-clockwise to secure the foot.

6. Secure the instrument to the mounting stud using the conical washer provided and a wing nut.

> ⚠ **Caution:** Hand-tighten only: do not use tools.

The instrument is now installed and transducing ground motion.

1.3.4.2 *Temporary Installations*

The Certimus is ideal for monitoring vibrations at field sites, owing to its ruggedness, high sensitivity and ease of deployment. Temporary installations will usually be in hand-dug pits or machine drilled holes. Once a level base is made, the Certimus can be sited there and covered with a box or bucket. One way to produce a level base is to use a hard-setting liquid:

1. Prepare a quick-setting cement/sand mixture and pour it into the hole.
2. “Puddle” the cement by vibrating it until it is fully liquefied, allowing its surface to level out.
3. Follow the cement manufacturer's instructions carefully. Depending on the temperature and type of cement used, the mixture will set over the next 2 to 12 hours.

4. Install the sensor as above, then cover and back-fill the emplacement with soil, sand, or polystyrene beads.

5. Cover the hole with a turf-capped board to exclude wind noise and to provide a stable thermal environment.

If you prefer, you can use quicker-setting plaster or polyester mixtures to provide a mounting surface. However, you must take care to prevent the liquid leaking away by "proofing" the hole beforehand. Dental plaster, or similar mixtures, may need reinforcing with sacking or muslin.

1.3.4.3 Direct Burial

The Certimus allows for deployment by burying it directly in the earth. This type of installation can be the simplest method, although, due to variations in ground types, means extra care needs to be taken to ensure the Certimus is protected from the elements and coupled stably with the ground. Güralp recommends that the Certimus is protected by placing it inside a plastic bag and covering with a sandbag before backfilling the hole with soil. The following list is Güralp's recommended best practices and not an exhaustive guide, if in doubt please contact support@guralp.com for advice on your site:

1. Dig a hole deep enough to reach a compacted surface, if this is not possible then compact the earth yourself, or place a concrete slab at the bottom to spread the load across the surface,

2. Connect the cables to the Certimus and place it inside a plastic bag, ensuring none of the cables are coiled inside and that the opening to the bag is not putting any pressure on to the cables themselves,

3. Place the Certimus in the hole so that the orientation to the north matches the pointer on the device as closely as possible,

4. Place the cables so that they're not coiled and not exerting any pressure on the Certimus ports,

5. Put a sandbag on top of the Certimus (this helps to protect it and provides better coupling to the ground)

6. Backfill the hole with substrate (earth or gravel), then compact the surface to ensure minimal subsidence,

1.3.4.4 Installation in Hazardous Environments

The fully enclosed, aluminium case design of the Certimus makes it suitable for use in hazardous environments where electrical discharges due to the build-up of static charge could lead to the ignition of flammable gasses. To ensure safe operation in these conditions, the metal case of the instrument must be electrically bonded ('earthed') to the structure on which it is mounted, forming a path to safely discharge any static charge.

Where electrical bonding ('earthing') is required during the installation of a Certimus, this can be done by using a ring tag on one of the screws mounting the power connector.

Alternatively, the negative connection of the DC in is connected to case internally.

1.3.5 Instrument and Channel Names

The tables in this section are designed to inform users of the names and codes of the streamed and recorded channels present in the Certimus. The first character of a miniSEED channel code represents the sample rate. The possible values are shown in the table below:

Code	Sample Rate
F	≥ 1000 Hz to < 5000 Hz
C	≥ 250 Hz to < 1000 Hz
H	≥ 80 Hz to < 250 Hz
B	≥ 10 Hz to < 80 Hz
M	> 1 to < 10
L	≈ 1
V	≈ 0.1 Hz
U	≈ 0.01 Hz
R	≥ 0.0001 Hz to < 0.001

Note: Throughout this section, the letter *n* in italic script is used to indicate the Sensor number, which is a small integer used to identify the signal source.

In a Certimus, this is zero ('Sensor0') for the channels related to the digitiser's state of health, clock information and battery status – where applicable. It is one ('Sensor1') for the seismometer's channels, such as velocity output, mass position channels, MEMS accelerometer channels, etc.

1.3.5.1 Sensor0 Channels

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Input voltage		Acausal	S0Voltage	0VINP0	Voltage_sd	xQV

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Power		Acausal	S0Power	0PINP0	Power_sd	xYP
Precision temperature		Acausal	S0TemprA	0TMPA0	S0TemprA	xKO
Internal Clock	Internal clock offset from GNSS	Acausal	ClkGpsOffset	0CGPSO	ClkGpsOffset	xEO
	Internal clock period difference from GNSS	Acausal	ClkGpsPeriod	0CGPSP	ClkGpsPeriod	BEF
	Internal clock DAC frequency pulling	Acausal	ClkDacFreqPull	0CVDAC	ClkDacFreqPull	BED
	Test internal clock drift	Acausal	ClkTestPbpS	0CTSTB	ClkTestPpbS	BEB
	Internal clock offset from PTP	Acausal	ClkPtpOffset	0CPTPO	ClkPtpOffset	BEP
	Delay MS	Acausal	ClkPtpDelayMS	0CPDMS	ClkPtpDelayMS	BEA
	Delay SM	Acausal	ClkPtpDelaySM	0CPDSM	ClkPtpDelaySM	BEB
	Mean path delay	Acausal	ClkPtpMeanPathDelay	0CPMPD	ClkPtpMeanPathDelay	BEC
Battery pack	External battery voltage	Acausal	BattVoltage_	BattVoltage_	BattVoltage_sd	LQV
	External battery current	Acausal	BattCurrent_	BattCurrent_	BattCurrent_sd	LYI
	External battery charge Volts	Acausal	BattChargeV_	BattChargeV_	BattChargeV_sd	AQQ
	External battery charge current	Acausal	BattChargeI_	BattChargeI_	BattChargeI_sd	LYQ
	External battery temperature	Acausal	BattTemp_	BattTemp_	BattTemp_sd	LYT
	External battery charge	Acausal	BattCharge_	BattCharge_	BattCharge_sd	LYC
	External battery power	Acausal	BatteryPower_	BatteryPower_	BatteryPower_sd	LYW

1.3.5.2 *Sensor1 (Broadband Seismometer) Channels*

The names of recorded seismic and accelerometer channels are suffixed with "A" or "B". This notation distinguishes between the two different sample rates that is possible to configure for each recorded channel. For example, the recorded streams *S0AccZA* and *S0AccZB* carry digitisations of the same signal, differing only in the sample rate. The below tables show the channels available from a Certimus.

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
Analogue broadband seismometer	Vertical	Acausal	S1SeisZ	1VELZ0	S1SeisZA	xHZ
			S1SeisZ	1VELZ2	S1SeisZB	xHZ
		Causal	S1SeisZLowLat	1VELZC	S1SeisZLowLat	xHZ
	North	Acausal	S1SeisN	1VELN0	S1SeisNA	xHN
			S1SeisN	1VELN2	S1SeisNB	xHN
		Causal	S1SeisNLowLat	1VELNC	S1SeisNLowLat	xHN
	East	Acausal	S1SeisE	1VELE0	S1SeisEA	xHE
			S1SeisE	1VELE2	S1SeisEB	xHE
		Causal	S1SeisELowLat	1VELEC	S1SeisELowLat	xHE
Calibration channel		Acausal	S1Calib	1VELC0		xCA

1.3.5.3 *Environmental Channels*

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
MEMS accelerometer	Vertical	Acausal	S1AccZ	1AXLZ0	S1AccZA	xNZ
					S1AccZB	xNZ
		Causal	S1AccelZLowLat	1AXLZC		xNZ
	North	Acausal	S1AccN	1AXLN0	S1AccNA	xNN
					S1AccNB	xNN
		Causal	S1AccelNLowLat	1AXLNC		xNN
	East	Acausal	S1AccE	1AXLE0	S1AccEA	xNE
					S1AccEB	xNE
		Causal	S1AccelELowLat	1AXLEC		xNE
Magnetometer	Vertical	Acausal	S1MagZ	1MAGZ0	S1MagZ	xFZ
	North	Acausal	S1MagN	1MAGN0	S1MagN	xFN

Minimus, Minimus+, Fortimus, Certimus

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
	East	Acausal	S1MagE	1MAGE0	S1MagE	xFE
Mass position	Vertical	Acausal	S1IntZ	1INTZ0	S1IntZ	xMZ
	North	Acausal	S1IntN	1INTN0	S1IntN	xMN
	East	Acausal	S1IntE	1INTE0	S1IntE	xME
STA/LTA parameters	STA	Acausal	S1STAZ	1LTAZ0	S1STAZ	xZ0
	LTA	Acausal	S1LTAZ	1STAZ0	S1LTAZ	xZ1
	Ratio	Acausal	S1RatioZ	1RatZ0	S1RatioZ	xZ2
Sensor rotation	Yaw	Acausal	S1RotYaw	1ROTY0	S1RotYaw	xYY
	Pitch	Acausal	S1RotPitch	1ROTP0	S1RotPitch	xYP
	Roll	Acausal	S1RotRoll	1ROTR0	S1RotRoll	xYR
Centring	Vertical	Acausal	S1CentringZ	1CENZ0	S1CentringZ	xE5
	North	Acausal	S1CentringN	1CENN0	S1CentringN	xE6
	East	Acausal	S1CentringE	1CENE0	S1CentringE	xE7
Input voltage		Acausal	S1Voltage	1VOLT0	S1Voltage	xE4
Digitiser power usage		Acausal	S1Power	1PINP0	S1Power	xYP
Humidity within sensor enclosure		Acausal	S1HumidB	1HUMB0	S1HumidB	xIO
Pressure within sensor enclosure		Acausal	S1Pres	1PRSR0	S1Pres	xDI
Temperature		Acausal	S1TemprB	1TMPB0	S0TemprB	xKO
Internal Clock DAC frequency pulling		Acausal	S1ClkDacFreqPull	1CVDAC	S1ClkDacFreqPull	BED
PLL clock offset		Acausal	S1PLLOffset	1PLLO0	S1PLLOffset	xYO

2 Part 2: Common Information

2.1 Unpacking

Our instruments are delivered in environmentally-friendly, flat-packable, suspension packaging. The packaging is specifically designed for these instruments and should be re-used whenever you need to transport the sensor. Please note any damage to the packaging when you receive the equipment and unpack on a clean surface.

Inside the box, you will find:

- The purchased item (Minimus, Minimus+, Fortimus or Certimus),
- The accessory package (optional) including:
    - An ethernet cable,
    - A compact GNSS receiver,
    - A power cable,
    - A diagnostic GNSS to serial cable adapter,
- The calibration documents in a yellow envelope (see Chapter 2.5.1.5).

Caution: The instruments contains sensitive mechanical components which can be damaged by mishandling. If you are at all unsure about the handling or installation of the device, you should contact Güralp Systems for assistance.

- Do not bump or jolt any part of the sensor when handling or unpacking.
- Do not kink or walk on the data cable (especially on rough surfaces such as gravel), nor allow it to bear the weight of the sensor.
- Do not connect the instrument to power sources except where instructed.
- Never ground any of the output signal lines from the sensor.

2.1.1 The Purchased Item

For more details about the item purchased please read the following chapters:

- 1.1. Minimus and Minimus+
- 1.2. Fortimus
- 1.3. Certimus

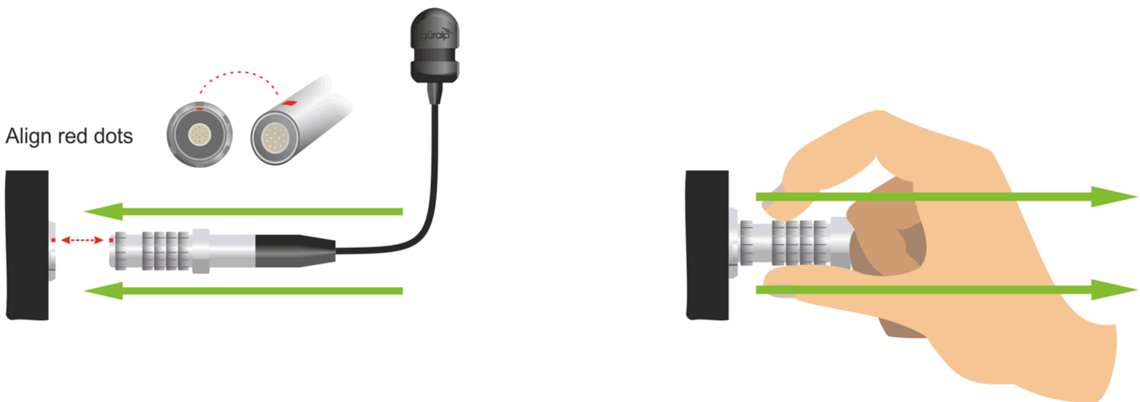
2.1.2 Ethernet Cable

The Ethernet connector allows the use of 100BASE-T or 1000BASE-T transmission over networks. The metal gland shell-type connector that connects to the device is IP68-rated and ensures consistent connection in harsh installation environments. At the other end of the Ethernet cable, there is a standard 8P8C modular jack (often called an RJ45) for attachment to all common networking devices (including: PC, laptop, router, switch, and modem).

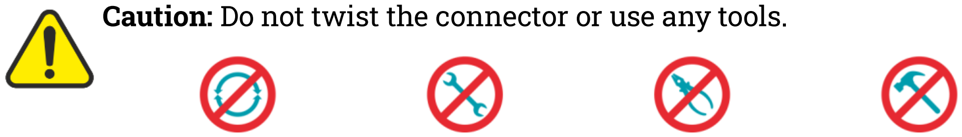
2.1.3 Compact GNSS Receiver and Cable

The new-generation compact GNSS receiver has an in-built antenna that supports the GPS (Navstar), GLONASS, BeiDou and Galileo satellite constellations.

The receiver comes with a black RS-422 cable that has an over-moulded 14-way LEMO connector. LEMO connectors use an innovative latching mechanism which is different to the bayonet connectors used elsewhere. To mate, simply line up the red marks – one on the chassis and one on the free connector – and gently push the connector into place until they latch together with a click. To disconnect (un-mate), grasp the outer sleeve of the connector and pull gently.



Caution: Do not twist the connector or use any tools.



2.1.4 Power Cable

Every device comes with a dedicated power cable with a standard military-specification bayonet connector on one end and bare ends at the other.

2.1.5 Diagnostic GNSS to Serial Cable Adapter

Every device comes with an adapter to connect the GNSS LEMO connector to a female nine-pin D-sub-miniature connector (DE9f), which can be used with a standard serial port to allow diagnosis and debugging of the instrument using a serial terminal emulator (see Section 3.5).

Note: This facility should rarely be required. It is primarily intended for use by the Güralp Support Team to help diagnose any problems with the device that may be experienced by the user.

A serial-to-USB converter (not supplied) may need to be used to connect to PCs or laptops that don't have a nine-pin serial connector.

2.2 Configuration Workflow (Quick-Start)

Note: Güralp strongly recommends exploring and familiarising yourself with the Minimus in a controlled environment, such as your lab or office, before deploying it in the field.

The steps below provide a high-level overview; detailed instructions can be found in the referenced chapters.

It is best to complete the instrument configuration prior to deployment, as suggested in the table below. However, if remote communication is set up, configuration can also be performed remotely during the deployment.

	Task	Description	Deployment Stage	Chapter
1	Access Web Interface	Connect and log in to the device. Basic networking configuration	Before	2.3
2	Choose Timing Option	Select GPS or PPT as timing source	Before	2.4
3	Set Up Device	If using Minimus/Minimus +, select connected analogue sensor and insert metadata. If using Fortimus or Certimus, configure full-scale and long-period corner, respectively	Before	2.5
4	Configure Data Streaming	Enable desired channels to stream and choose their sample rates	Before	2.6
5	Configure Data Recording	Enable desired channels to record to the SD cards and choose their sample rates	Before	2.7
6	Locate Metadata	Find and download metadata as Dataless SEED volume, RESP files or Station XML files	Before	2.8
7	Apply Transforms (Optional)	Choose if you want to apply any transforms to streamed and/or recorded channels	Before	2.8
8	Configure Triggers (Optional)	Choose EEW (Earthquake Early Warning) and triggers configuration	Before	2.10

9	Check Sensor Calibration (Optional)	Inject a calibration signal to check if your sensor is correctly calibrated	Before During	2.11
10	Automate Processes (Optional)	Enable scripting capabilities and upload scripts to automate repetitive procedures	Before	2.12
11	Enable Remote Connectivity (Optional)	Configure the device to be able to communicate with it remotely	Before	2.13
12	Apply Power-Save Modes (Optional)	Enable one of the available deployment modes to reduce power consumption	Before During	2.13.2
13	Monitor State of Health (SOH)	Monitor the SOH of your device	Before During After	2.15
14	Download Data	Download data either from the device's webpage (also remotely) or directly from the external SD card	Before During After	2.16
15	Upgrade Firmware	Perform a firmware upgrade via Discovery software	Before During After	2.17
16	Perform Mass Configuration (Optional)	Export configuration from device and upload it to other devices in the network via Discovery software	Before	2.18

2.3 Getting Started: System Setup and Network Configuration

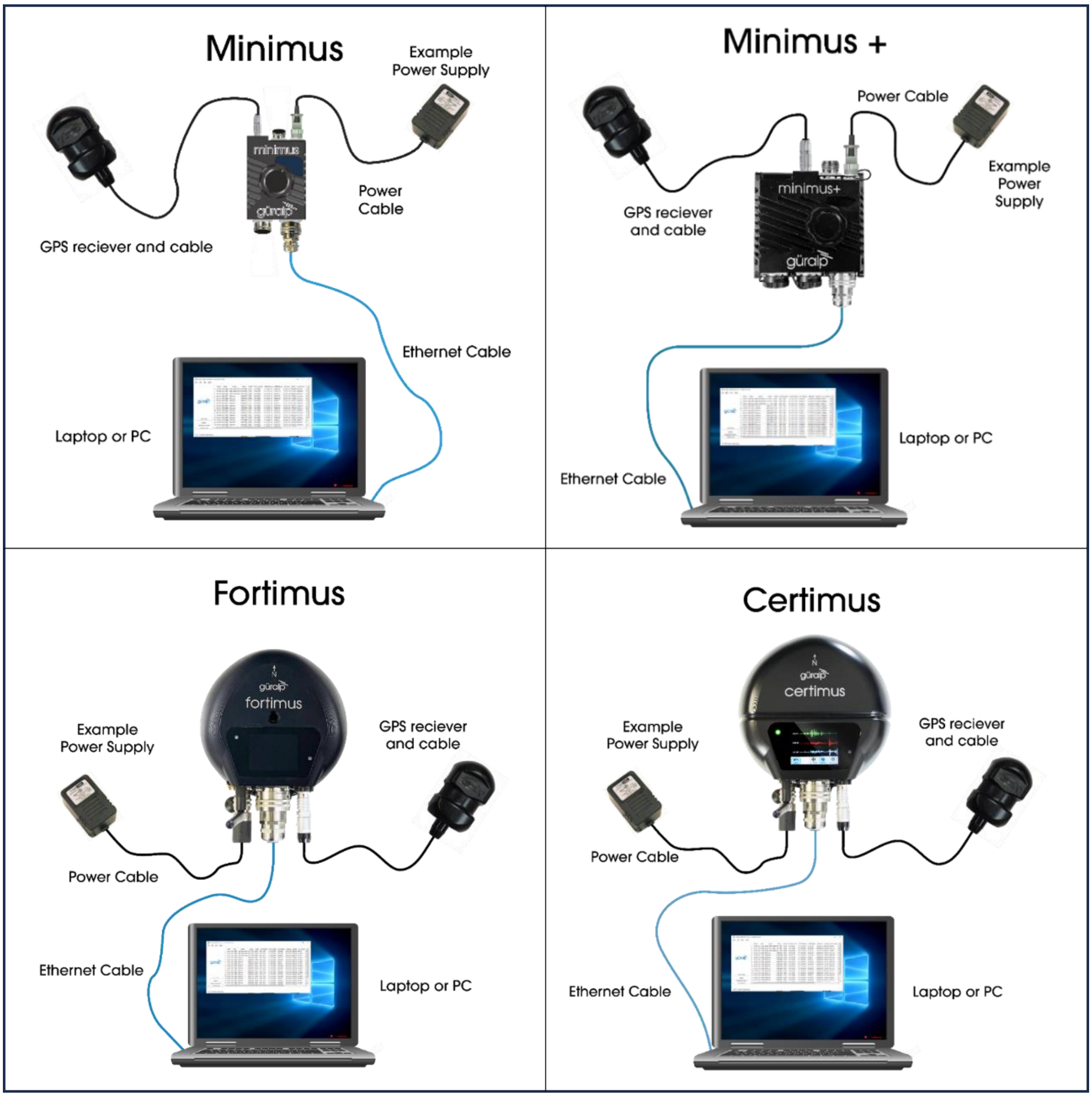
Note: For the sake of brevity, instruments running the DIG firmware (Minimus, Minimus+, Fortimus and Certimus) will be referred to as the *Minimus* throughout this document. Where instructions only refer to a specific instrument, or where they do not apply to one or more of them, this will be indicated.

To get started, connect the power cable to the power connector on the side of your device: this is a 4-pin plug, and the word "POWER" is printed below it. Power up the Minimus using a power supply with a DC output of between 10 and 36 Volts. We recommend fitting an in-line 3.5 A anti-surge fuse in the positive power lead to protect the external wiring of the installation. In the case of a Minimus or Minimus+ connected to analogue or digital sensors, the digitiser will, in turn, provide power to all connected instruments.

Caution: Observe the correct polarity when connecting the power supply. The **red** lead (from pin B) must be connected to the **positive terminal**, typically labelled "**+**", and the **black** lead (from pin A) must be connected to the **negative terminal**, typically labelled "**-**". An incorrect connection risks destroying the digitiser, the power supply and any connected instruments.

Once the Minimus is powered up, the LED will start blinking following the pattern described in Section 2.15.1. If your device has an LCD screen, this will turn on too.

Now, connect the Ethernet cable to the Minimus and directly into your laptop. Plug the GPS receiver into the 14-pin LEMO socket of the Minimus and, if possible, position the receiver close to a window. This will increase the chances to obtain a GPS lock. Your setup will look like in the figure below.



2.3.1 IP Address Configuration on PC or Laptop

If the Minimus is directly connected to a laptop or PC using the blue Ethernet cable, make sure that the laptop or PC is configured to obtain an IP address automatically.

With APIPA (Automatic Private IP Addressing), a laptop or PC can automatically configure itself with an IP address in the range `169.254.0.1` to `169.254.255.254`. The default subnet mask is `255.255.0.0`. By default, the Minimus uses DHCP (Dynamic Host Configuration Protocol) to acquire its network configuration. If a DHCP server is not found – as in the case of a Minimus connected directly to a laptop – it will acquire an IP address in the range `169.254.0.1`, meaning that the laptop and Minimus are in the same subnet.

Static addressing can be used if required, and more detailed will be provided in Section 2.3.4. However, configuring your laptop to obtain its IP address automatically and leaving the Minimus in DHCP mode (which is the default setting when it leaves the factory) is the easiest way to communicate with your device.

To configure the connection using APIPA, proceed with the following instructions.

2.3.1.1 On Linux

On your Linux computer, open the terminal and type the command:

```
sudo bash
```

Press the Enter key and provide the appropriate password. Then, enter the command:

```
ifconfig
```

to identify the Ethernet network interface to which the Minimus is connected. Once you have identified the correct interface, connect the Minimus, power it up and enter the commands:

```
ifconfig wlp2s0 down
ifconfig wlp2s0 up
```

replacing `wlp2s0` with the name of the appropriate interface on your PC.

Enter the command `ifconfig` again to verify that the IPv4 address of the Ethernet adapter is now included in the network `169.254.0.0/16` - *i.e.,* the address begins with `169.154.`...

```
wlp2s0  flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 169.254.139.29  netmask 255.255.0.0  broadcast 169.254.255.255
        ether 94:65:9c:ab:3c:9a  txqueuelen 1000  (Ethernet)
        RX packets 556837  bytes 722823565 (689.3 MiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 320424  bytes 42811910 (40.8 MiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

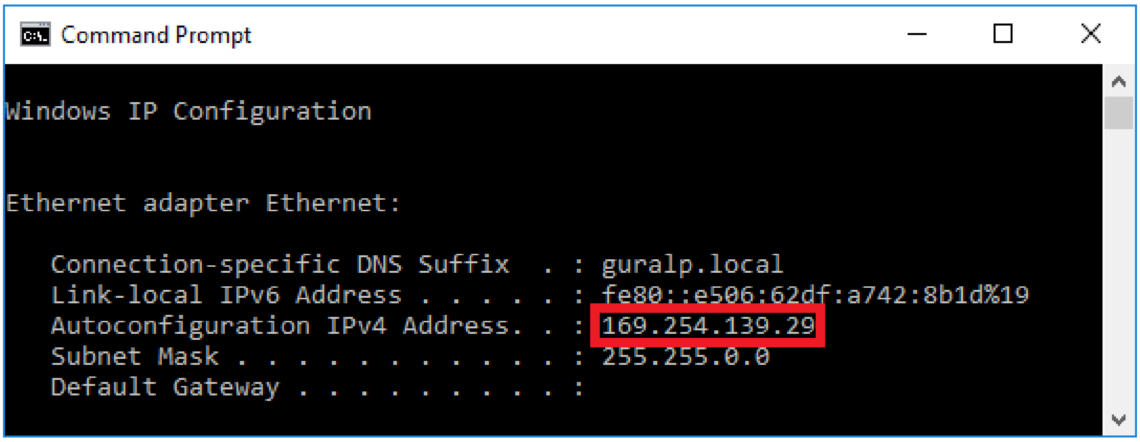
In the example above, the interface has been allocated address `169.254.139.29`, which is in the correct network.

2.3.1.2 On Windows

On a Windows computer, key Windows + R to open the "Run" dialogue, enter `ncpa.cpl` and press the Enter key.

Right-click on the network adapter which is connected to the Minimus and select Disable from the context menu. Right-click on the same adapter again and select Enable. Close the network settings window.

Key Windows + R and type **`cmd`**, then Enter key. This opens a command prompt. Type the command *`ipconfig`* and verify that the IPv4 address of the Ethernet adapter is included in network *`169.254.*.*`*.



In the example above, the interface has been allocated address `169.254.139.29`, which is in the correct network.

2.3.2 Your Device's IP address: Discovery

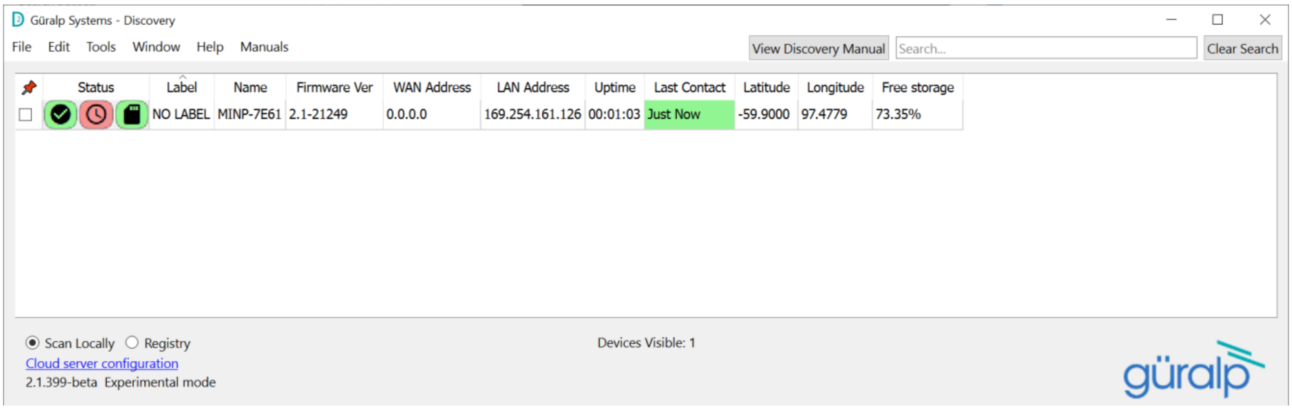
Once your laptop or PC is configured to obtain an IP address automatically, and the Minimus is powered up and connected to it using the blue Ethernet cable, you are ready to start communicating with your device. The first step is to find our the device's IP address.

If your device is provided with an LCD display (Certimus and Fortimus), its IP address appears on the Status page of the display.

If your device is not provided with an LCD display (Minimus and Minimus+), finding out its IP address is one of the first challenges. Güralp makes the process simple though the **Discovery** software: Discovery automatically finds and lists devices connected via local networks.

Note: Full user instructions for Discovery are beyond the scope of this document. For full user information, please refer to Discovery's manual MAN-DIS-0001.

If your laptop/PC and Minimus have been configured as detailed in Section 2.3.1 they will be on the same network and the Minimus will automatically appear in Discovery's main window within a few tens of seconds. Discovery's main window will look like the in figure below.



The Minimus IP address is listed under the "LAN address". In this case, the IP address is 169.254.161.126.

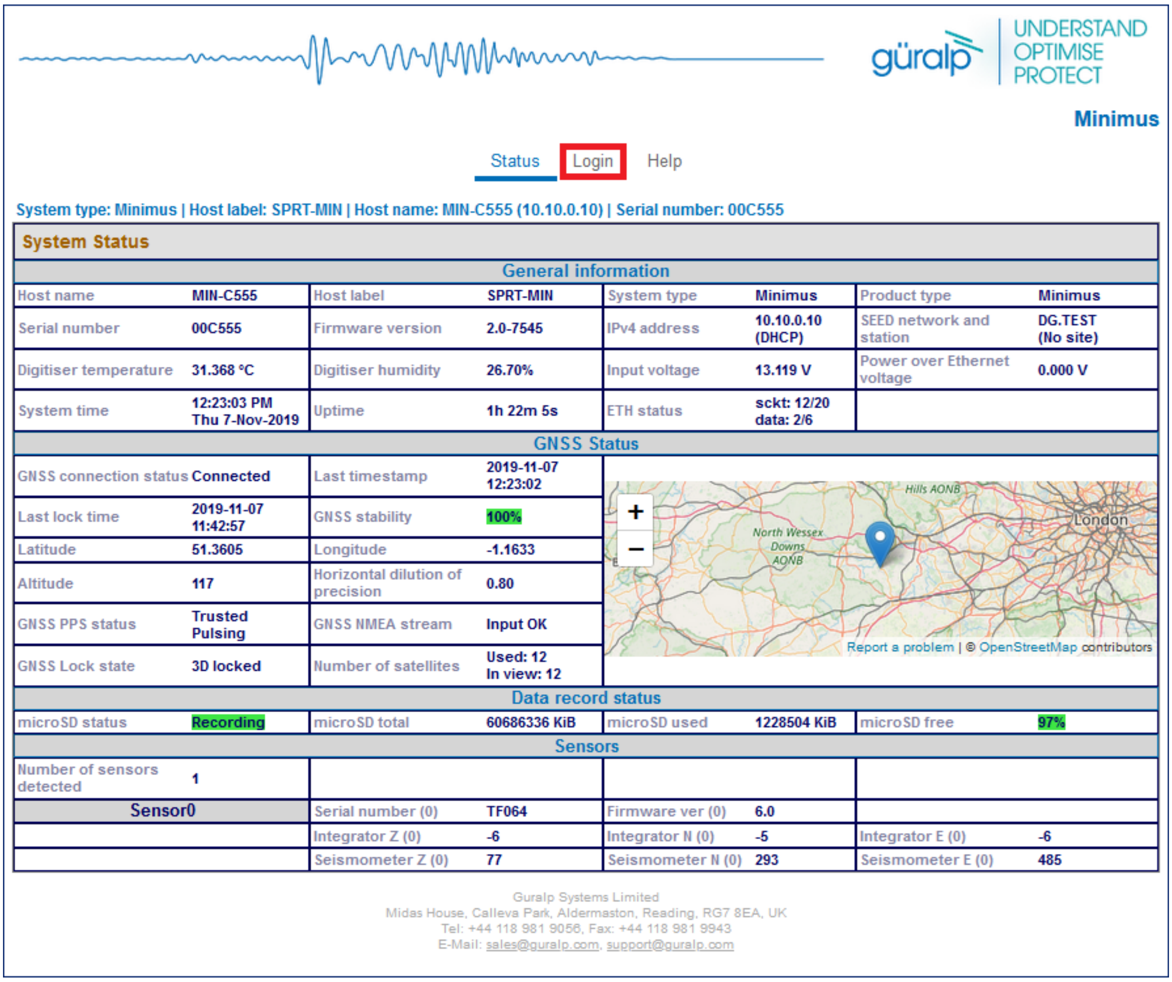
Once the device's IP address is known, system configuration and control are available from the webpage interface. This can be accessed:

- by selecting an instrument in Discovery, right-clicking its entry and selecting "View Web Page"
- by typing the LAN address of the instrument into any common web browser.

2.3.3 Web Page Interface Login

The web page interface can be protected by a username and password. There are two levels of access to the web page interface: user and administrator.

If the login is enabled (by default it is enabled), the web page interface will initially show a status display only.



General information							
Host name	MIN-C555	Host label	SPRT-MIN	System type	Minimus	Product type	Minimus
Serial number	00C555	Firmware version	2.0-7545	IPv4 address	10.10.0.10 (DHCP)	SEED network and station	DG.TEST (No site)
Digitiser temperature	31.368 °C	Digitiser humidity	26.70%	Input voltage	13.119 V	Power over Ethernet voltage	0.000 V
System time	12:23:03 PM Thu 7-Nov-2019	Uptime	1h 22m 5s	ETH status	sckt: 12/20 data: 2/6		
GNSS Status							
GNSS connection status	Connected	Last timestamp	2019-11-07 12:23:02				
Last lock time	2019-11-07 11:42:57	GNSS stability	100%				
Latitude	51.3605	Longitude	-1.1633				
Altitude	117	Horizontal dilution of precision	0.80				
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK				
GNSS Lock state	3D locked	Number of satellites	Used: 12 In view: 12				
Data record status							
microSD status	Recording	microSD total	60686336 KiB	microSD used	1228504 KiB	microSD free	97%
Sensors							
Number of sensors detected	1						
Sensor0		Serial number (0)	TF064	Firmware ver (0)	6.0		
		Integrator Z (0)	-6	Integrator N (0)	-5	Integrator E (0)	-6
		Seismometer Z (0)	77	Seismometer N (0)	293	Seismometer E (0)	485

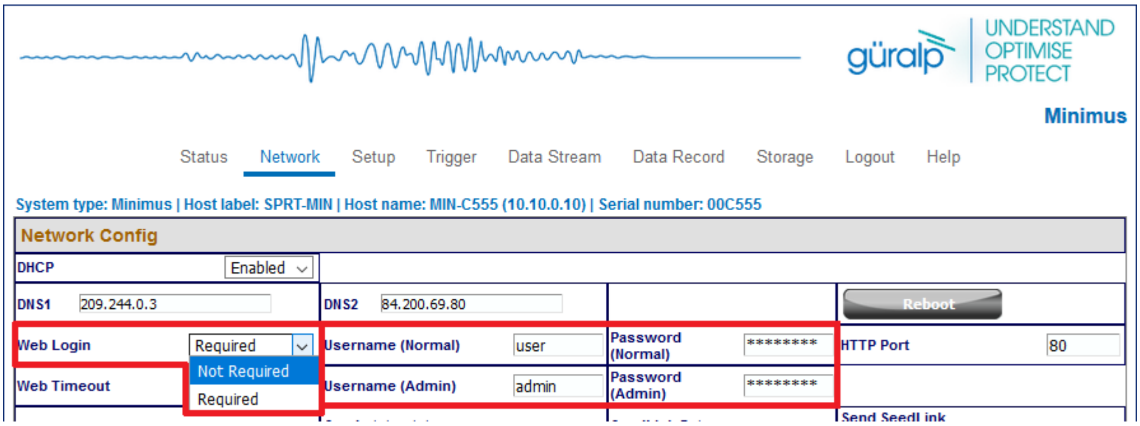
Clicking on Login opens the sign in box and allows you to type in a Username and Password to access the content of the web page interface.

Logging in with a user account unlocks basic configuration and control features to prevent advanced settings from being modified. The default username for a user account is `user` and the password is also `user`.

Logging in with the administrator account unlocks all the configuration and control features available on the Minimus web page interface. The default username for the administrator account is `admin` and password is also `admin`.

Note: For regular use and basic configuration changes, Güralp suggests logging in as `user`. Log in as `admin` only if necessary to unlock features only available in the administrator account.

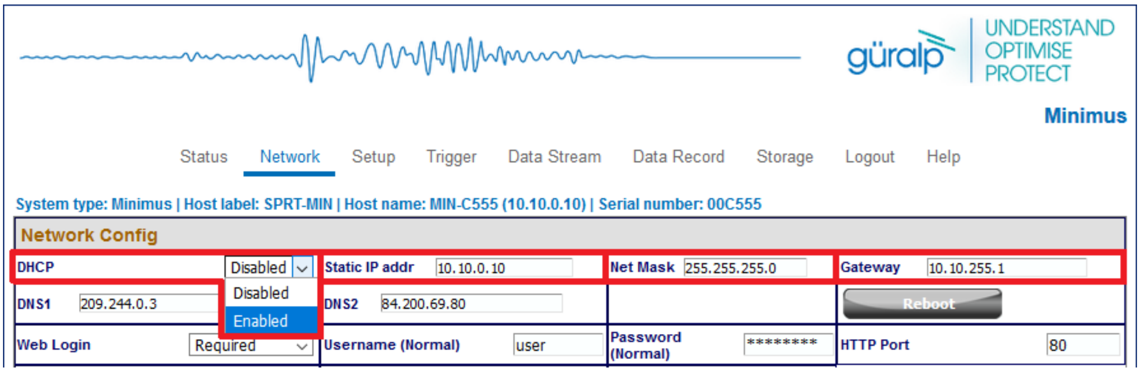
Once logged in as administrator, the Web Login drop-down menu in the Network tab makes it possible to disable the request for login every time the web page interface is accessed. The username and password for both user and administrator logins are configurable in the Network tab.



2.3.4 Network Configuration

As previously mentioned, by default the Minimus uses DHCP (Dynamic Host Configuration Protocol) to acquire its network configuration. This is the setting that Güralp recommends using, but static addressing can be used if required.

To configure static addressing, visit the Network tab of the instrument's web page interface. Next to the "DHCP" field is a drop-down box that allows you to change the mode from "Enabled" to "Disabled". In this mode, it is possible to specify the IP address, the Netmask and the address of the Gateway (default router), as shown:



Before any changes made here will take effect, the Minimus must be rebooted. To do this, click on the Reboot button.

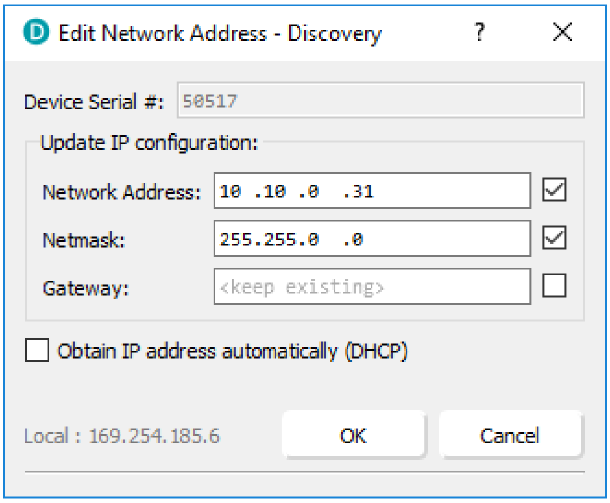
Note: By default, the static IP address assigned to each Minimus is unique and derived from the specific serial number of the device. These addresses are in the default network for link local (APIPA) addresses: `169.254.0.0/16` (in CIDR notation).

The first two octets of the address, therefore, are always *`169.254`*. The third octet is the equal to the last two characters of the serial number interpreted as a hexadecimal number and then converted into base 10. The forth octet is equal to the first two digits after the hyphen of the serial number, also converted from hexadecimal into base 10.

For example, if the serial number of the Minimus MIN-C555, the pre-assigned static IP address will be `169.254.`*`85.197`*, where:

- MIN-C5**55** ⇒ (5 x 16^1) + (5 x 16^0) = 85
- MIN-**C5**55 ⇒ (12 x 16^1) + (5 x 16^0) = 197

Network settings are also available in Discovery by right-clicking on the Minimus' entry in Discovery's main window and selecting Edit Network Address.



2.3.5 System Status

The Status tab of the web browser interface provides state-of-health information about the Minimus and connected instruments. These parameters are described as follows:

General Status

- **Host name**: The model of the device and the serial number;
- **Host label**: The customisable name of the Minimus system: this name can be changed from the Setup tab. It reflects how the Minimus appears in the list of instruments in Discovery's main window;
- **System type**: The name of the instrument, *e.g.* "Minimus";

- **Product type**: The type of the instrument, *e.g.* "Minimus";
- **Serial number**: The serial number of the Minimus;
- **Firmware version**: The DIG firmware version running on the Minimus;
- **IPv4 address:** the Static or Dynamic LAN IP address of the Minimus;
- **SEED network and station**: Network and Station SEED codes of the Minimus;
- **Digitiser temperature & Digitiser humidity**: The internal temperature and humidity of the Minimus;
- **Input voltage:** The input voltage supplied to the Minimus;
- **PoE (Power over Ethernet) voltage:** Optional PoE voltage supplied to Minimus+, Certimus and Fortimus (not applicable to Minimus);
- **System time**: The current internal system date and time from the Minimus;
- **Uptime**: The time the Minimus has been running since the last reboot or power up;
- **Restart Status**: Shows the number of Restarts and whether they were caused by Crashes (software reboot) or Power cycles;
- **ETH (Ethernet) status**: The number of total active TCP connection in use or used for data transmission;

GNSS Status

- **GNSS (Global Navigation Satellite System) connection status**: Shows whether the GNSS receiver is physically connected;
- **Last timestamp**: Shows the time when data was last received from GNSS.
- **Last lock time:** Shows when the first stable lock was made to the GNSS, since a significant timing drift or reboot;
- **GNSS stability:** The lock strength of the signal from GNSS;
- **Latitude**, **Longitude** and **Altitude:** Of the system, as provided by the GNSS receiver;
- **Horizontal dilution of precision:** The confidence level of precision data, based on satellite coverage, lower values mean better precision;
- **GNSS PPS (Pulses Per Second) status:** Benchmark for time synchronization with other sensors, will show if lock is trusted and the status of the pulses;
- **GNSS NMEA (National Marine Electronics Association) stream:** Shows if the NMEA data format is supported from the GNSS;
- **GNSS Lock state:** Shows as 3D or 2D based on the number of visible satellites, 4 satellites or greater will support 3D, fewer than this will result in 2D;
- **Number of satellites:** currently used and total in view of the receiver;

PTP Status (only visible if enabled)

- **PTP (Precision Time Protocol) state:** Shows the status of the PTP connection;

- **Last PTP timestamp:** The last time the PTP server sent data;
- **Last PTP lock time:** Time when first stable PTP lock was made since significant timing drift or re-boot.
- **PTP stability:** The stability of the clock in time accuracy;
- **Master IPv4 address**: The IP address of the PTP master server;
- **Master clock class:** Shows the source class of the clock;
- **Master clock accuracy:** How accurate the clock is to "true" time, the lower this value is the more accurate the reading will be;
- **Master time source:** Refers to the primary device or clock that provides the reference time for synchronization across the network;
- **Network path delay:** Shows the path delay measurement between the controller and responder clock;
- **Network jitter estimate**: Quality indicator measured in ns, refers to the variability in the time delay of network packets;
- **Network outliers:** Outliers typically refer to data points or measurements that significantly deviate from the expected or average values, these are calculated into a percentage value to give an impression of network integrity..

Data Record Status

- **micro SD status**: Shows if the primary card is recording;
- **micro SD total:** Shows the total storage capacity in KiB;
- **micro SD used:** Shows the current size of the data stored in KiB;
- **micro SD free:** Shows the percentage of space available on the card.

Sensors Status

- **Number of sensors detected:** Refers to the onboard sensors, this should show 1 for the Minimus, Fortimus and Certimus and 2 for the Minimus+;
- **Sensor0/1:** Shows the current output values from the onboard sensors in digital counts.

2.3.6 Configurable Codes

Discovery provides a number of flexible station metadata inputs. These are accessible from the Setup tab of the instrument's web page, in the "Digitiser Config" section.

Host Label and **Site Name** are only used in Discovery and appear in the list of instruments in the main window.

Station Code and **Network Code** are all standard metadata header values used by the miniSEED file format, which will be used as identifiers in locally-stored miniSEED files (see Section 2.16.5.1).

2.4 Timing Options

The Minimus system synchronises its sample clock using an attached GNSS receiver or, if that is not available, Precision Time Protocol (PTP). The currently supported GNSS systems are Navstar (GPS), GLONASS, BeiDou and Galileo.

Note: The GNSS can use only three different types of satellites simultaneously and GPS is always used, if available. The other two spots available can be either GLONASS, BeiDou or Galileo.

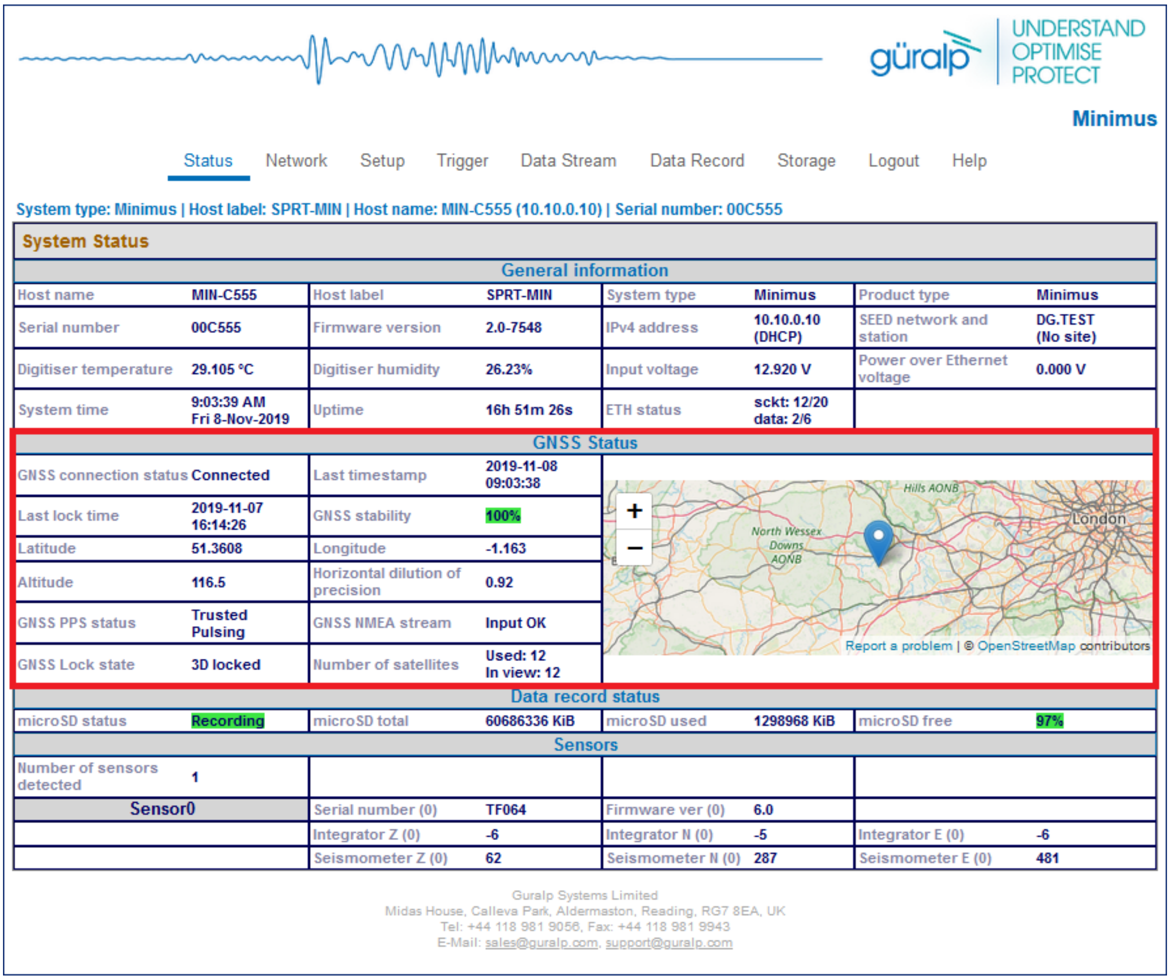
If visibility of the satellite constellation is available, this is the most accurate way to synchronise your digitiser. The accessory pack typically delivered together with instruments includes a combined GNSS antenna and receiver for this purpose.

2.4.1 GNSS

Information about the status of the GNSS receiver is available in the Status tab of the instrument's web page.

A number of GNSS reporting parameters are given, including:

- Connection status
- Last GNSS update (sync) & last GNSS lock date/time
- GNSS Stability:
  - 0% = no receiver connected;
  - 1% = receiver connected, but waking up (this can occur if the GNSS receiver has been moved a long distance since last power-up).
  - 2-99% = view of sky obstructed.
  - 100% = normal operation with clear view of sky
- Latitude, longitude, altitude
- Horizontal dilution of precision (quality of satellite fix due to position of satellites relative to receiver)
- GNSS PPS status
- GNSS NMEA streaming
- GNSS lock state (2D/3D)
- Number of available satellites (in use / in view)



General information							
Host name	MIN-C555	Host label	SPRT-MIN	System type	Minimus	Product type	Minimus
Serial number	00C555	Firmware version	2.0-7548	IPv4 address	10.10.0.10 (DHCP)	SEED network and station	DG.TEST (No site)
Digitiser temperature	29.105 °C	Digitiser humidity	26.23%	Input voltage	12.920 V	Power over Ethernet voltage	0.000 V
System time	9:03:39 AM Fri 8-Nov-2019	Uptime	16h 51m 26s	ETH status	sckt: 12/20 data: 2/6		

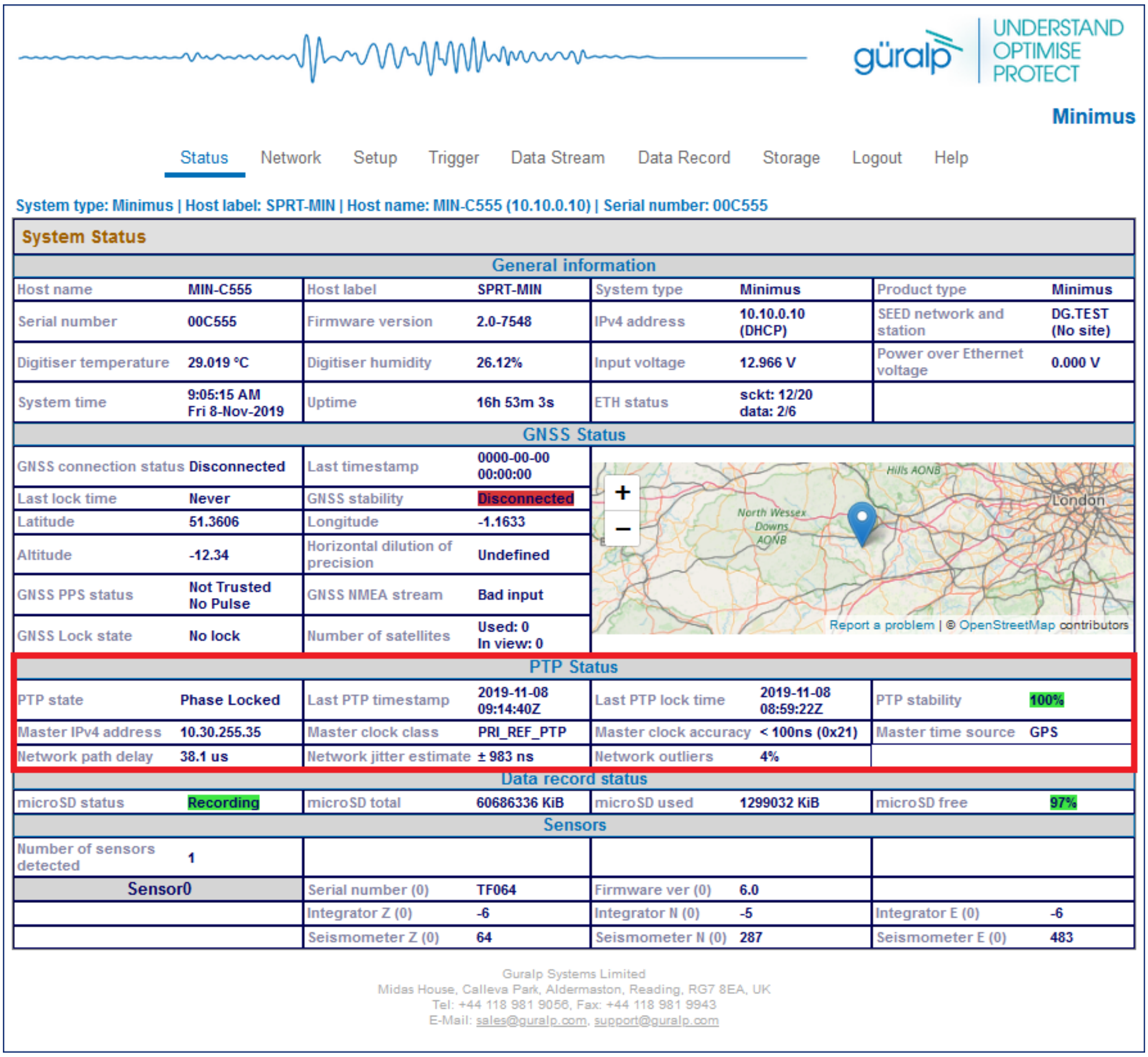
GNSS Status			
GNSS connection status	Connected	Last timestamp	2019-11-08 09:03:38
Last lock time	2019-11-07 16:14:26	GNSS stability	100%
Latitude	51.3608	Longitude	-1.163
Altitude	116.5	Horizontal dilution of precision	0.92
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK
GNSS Lock state	3D locked	Number of satellites	Used: 12 In view: 12

Data record status							
microSD status	Recording	microSD total	60686336 KiB	microSD used	1298968 KiB	microSD free	97%

Sensors							
Number of sensors detected	1						
Sensor0		Serial number (0)	TF064	Firmware ver (0)	6.0		
		Integrator Z (0)	-6	Integrator N (0)	-5	Integrator E (0)	-6
		Seismometer Z (0)	62	Seismometer N (0)	287	Seismometer E (0)	481

2.4.2 PTP (Precision Time Protocol)

The Minimus system supports timing provided through PTP. The IEEE 1588 Precision Time Protocol (PTP) is a network protocol which uses modified network hardware to accurately time-stamp each PTP packet on the network at the time of transmission, rather than at the time that the packet was assembled. If you do not have an existing PTP infrastructure, the simplest way to use PTP is to add a "grand-master clock" to the same network segment as the digitisers. A typical such clock is the Omicron OTMC 100, which has an integrated GNSS antenna and receiver which it uses as its own synchronisation source. PTP timing can be extended over up to 100 metres of Ethernet cable or longer distances when fibre-optic cable is used. PTP is significantly more accurate than NTP but generally requires specialised hardware support.

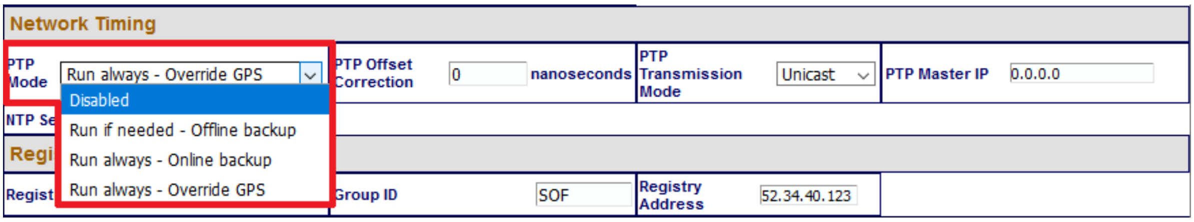


In the Status tab of the Minimus web page, a number of reporting parameters are given, including:

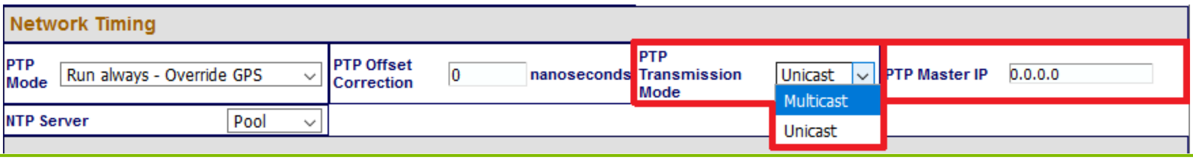
- PTP state
- Last PTP time-stamp and last PTP lock date/time
- PTP Stability:
  - Standby ⇒ PTP is running but timing is provided by GNSS;
  - No Master ⇒ PTP not available;
  - 1-100% ⇒ PTP locking process indicator. 100% indicates a time accuracy of better than 200 ns.
- Master IPv4 address
- Master clock class and accuracy
- Master time source
- Network path delay
- Network jitter estimate: quality indicator
- Network outliers

In the 'PTP Mode' section under the heading "Network Timing" there are four options:

- **Disabled** ⇒ PTP is never used (default settings).
- **Run if needed – Offline backup** ⇒ PTP is automatically enabled whenever the GNSS signal is lost. It is disabled while GNSS is available. This mode is used to minimise network traffic when GNSS is the primary timing source.
- **Run always – Online backup** ⇒ PTP is always running but GNSS is used as the primary timing source. This mode is useful for faster fall-back from GNSS to PTP timing and for validation that PTP is available.
- **Run always – Override GPS** = PTP is always running and takes priority over GNSS. This mode is useful in a system where PTP is the primary timing source, but GNSS may occasionally be connected for validation purposes.



PTP can be configured for multicast or unicast mode. In unicast mode, the server IP address must be specified. This is available as admin from the digitiser's web page in the Network tab.

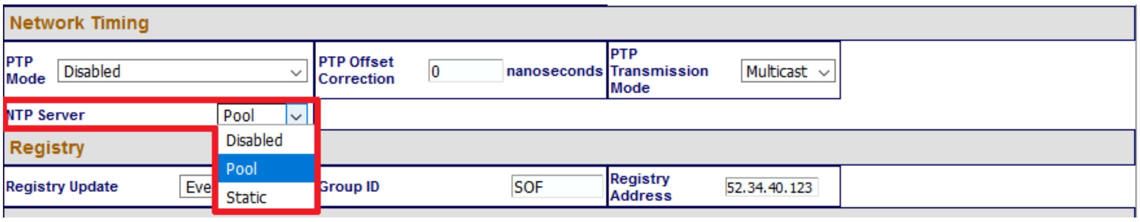


2.4.3 NTP (Network Time Protocol)

NTP is only used for setting the system's internal clock at boot-up and it is not used for sample timing. However, if neither GNSS and PTP are available, but NTP is locked and the sample clock's time is more than 5 seconds different from NTP's time, the sample clock will be adjusted (in a step-change) to NTP time.

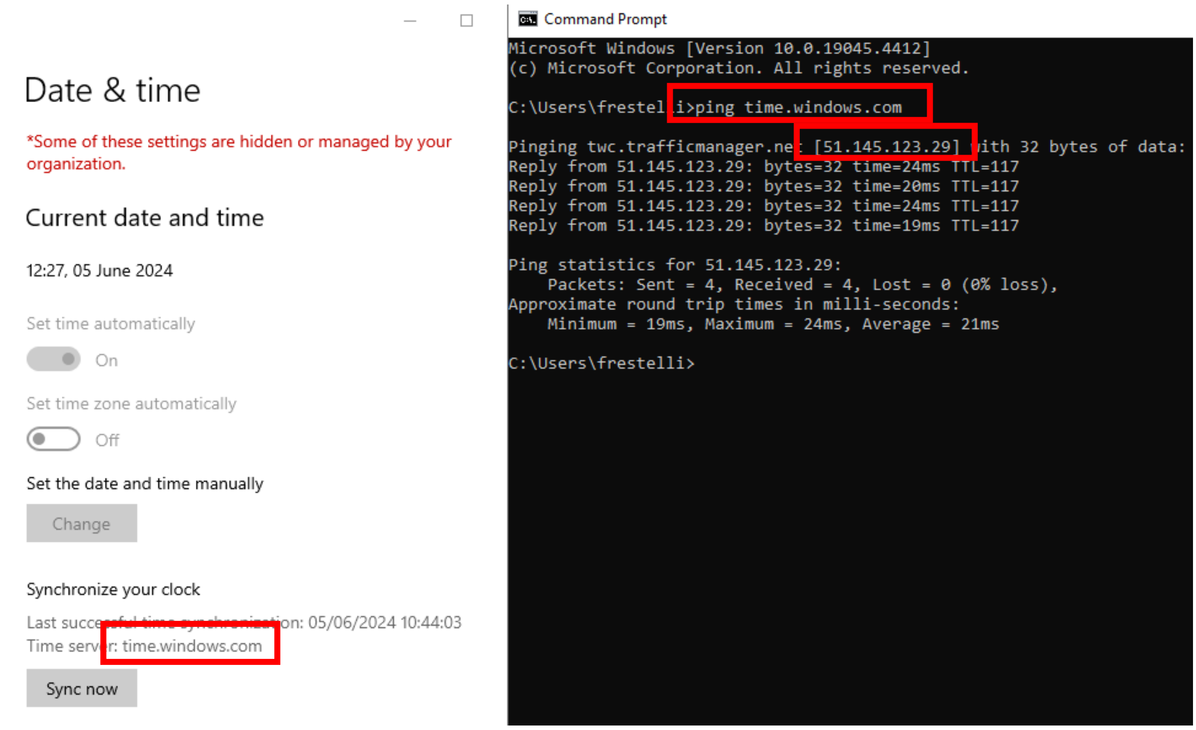
> **Note:** The precision provided by NTP is significantly lower than the precision provided by PTP and GNSS. Therefore, the time stamp provided by the NTP server should NOT be used to interpret seismic data.

By default, the NTP server option (located under the Network tab of the instrument's web page, when logged in as Admin) is set to "Pool" which uses the virtual server pool `pool.ntp.org`. This accesses a dynamic collection of networked computers that voluntarily provide moderately accurate time via the NTP to clients worldwide.



Alternatively, it is possible to specify the IP address of your preferred NTP server. To do this, select the “Static” option from the “NTP server” drop-down menu, which activates the “NTP IP Addr” setting, and enter the IP address of your NTP server here.

Typically, the name of your NTP server can be found in the Date & Time settings of your machine. After finding out the name of the server, its IP address can be discovered by pinging the NPT server, as in the figure below.



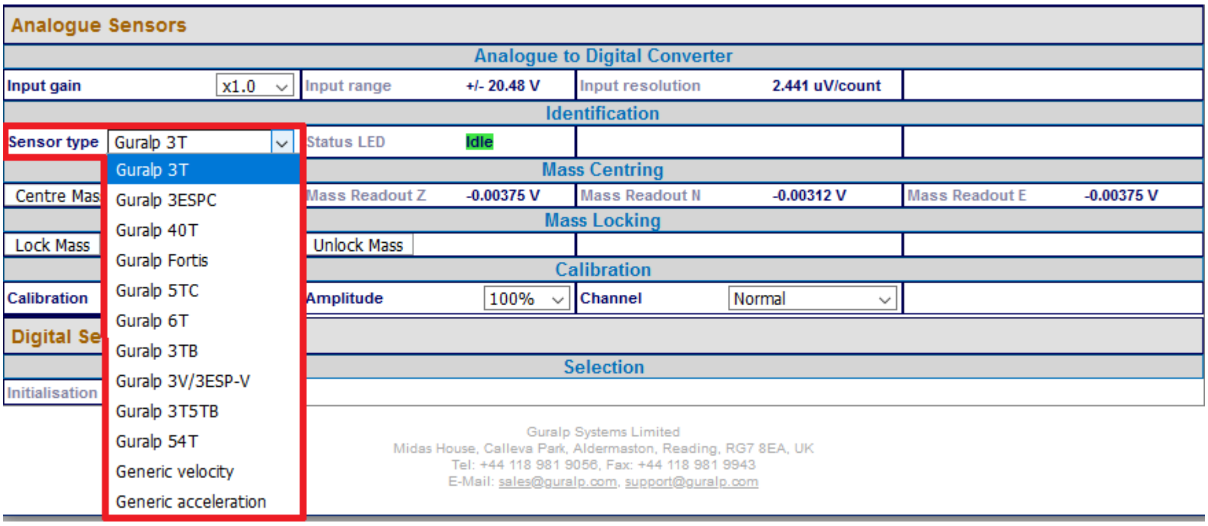
2.5 Configuration and Control

2.5.1 Connected Analogue Instruments (Minimus and Minimus+)

Note: This section is relevant to Minimus and Minimus+ only.

2.5.1.1 *Setting Instrument Type*

To select the analogue sensor type, open the webpage interface and navigate to the "Setup" tab, under the "Analogue Sensor" header, there is a drop-down box for "Sensor Type". The Minimus includes a choice of several Güralp sensors and accelerometers. If the sensor is not listed, select "Generic velocity" or "Generic acceleration", according to the instrument's sensor type.



A reboot is required after this change.

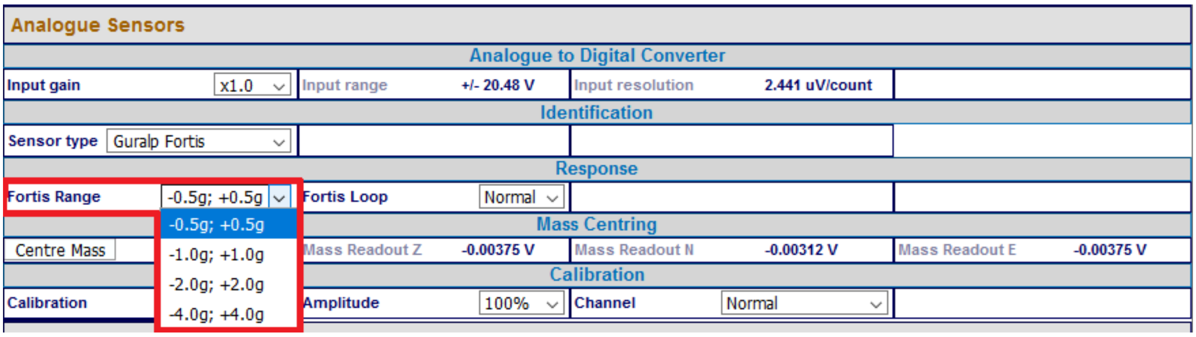
2.5.1.2 *Setting Full-Scale for Güralp Fortis*

The Güralp Fortis strong-motion accelerometer features a remotely switchable, full-scale option that can be controlled from inside Discovery. First, ensure that the physical gain switch on the underside of the Fortis is set to position "3" (as indicated by the engraving). See **MAN-FOR-0001** for more details.

To change the gain electronically, first, load the web page interface and navigate to the Setup tab, set the "Sensor Type" to "Güralp Fortis". Setting this option will then enable the "Fortis Range" control. Under the "Fortis Range" drop-drown box, select a full-scale setting (options: ±0.5g; ±1g; ±2g; ±4g), once the desired settings have been configured a Reboot will be required for these settings to take effect.

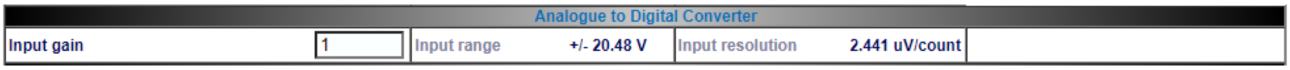
> **Note:** the sensitivity of Fortis is dependent on the full-scale. Make sure that the "Analogue Instrument Gain" setting in the Calibration Editor reflects the right full-scale option. More details in Section 2.5.1.5.

Setting the instrument type to "Fortis" will also change the miniSEED channel names to indicate that data is being recorded from an accelerometer, e.g. "H*N*Z".



2.5.1.3 Setting Digitiser Gain

The input gain can be controlled from the Setup tab of the web page interface using the "Input Gain" box. Güralp's recommended gain options are: ×1, ×2, ×4, ×8 and ×12, although any integer value can be entered here.



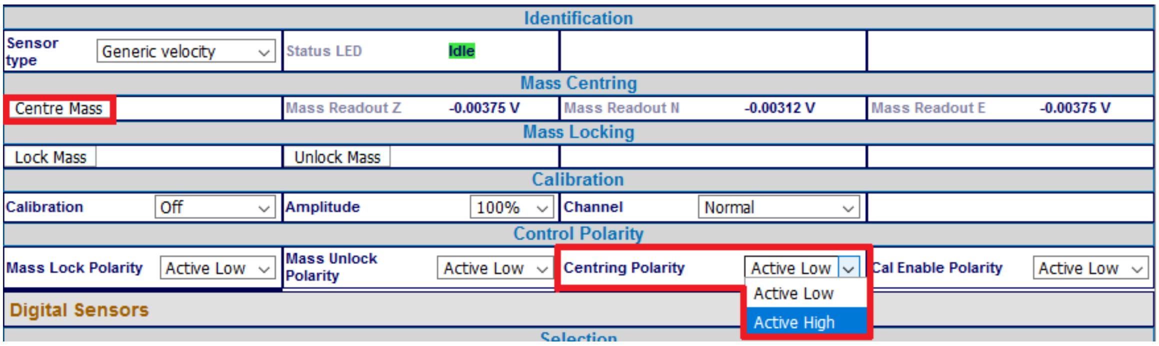
The input range and resolution update automatically when the gain is changed. The gain in the RESP and Dataless SEED files are updated automatically.

2.5.1.4 Mass Control

The Minimus can lock, unlock and centre the masses of connected Güralp instruments, where applicable.

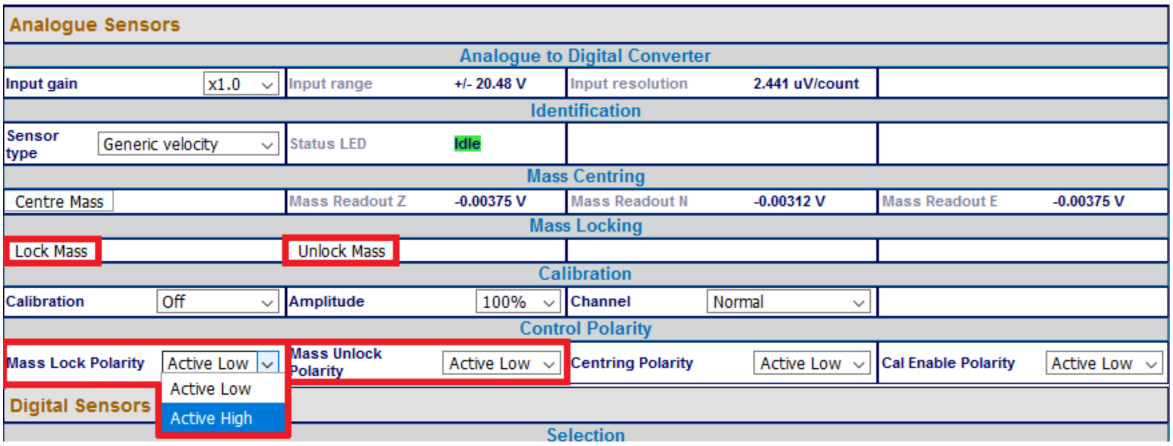
Mass Centring

Many broadband seismometers (*e.g.* Güralp 3T and 3ESPC) support remote/electronic mass centring. Mass centring can be controlled from the Setup tab of the web page using the Centre Mass button. Mass centring status and control can also be found by right-clicking on the instrument and selecting "Centring". Change the polarity of the control signal used for centring by using the drop-down menu "Centring Polarity" if necessary.



Mass Locking

Some seismometers require their masses to be locked before transportation. Mass locking can be controlled from the Setup tab of the web page using the Lock Mass and Unlock Mass buttons. Change the polarity of the control signals using the drop-down menu: "Mass Lock/Unlock Polarity", if necessary.



Note: The mass lock control buttons are not displayed unless the selected sensor type has a mass-locking mechanism.

2.5.1.5 Instrument Response Parameters

Calibration is a procedure used to verify or measure the frequency response and sensitivity of a sensor. It establishes the relationship between actual ground motion and the corresponding output voltage. Calibration values, or response parameters, are the results of such procedures.

Response parameters typically consist of a sensitivity or "gain", measured at some specified frequency, and a set of poles and zeros for the transfer function that expresses the frequency response of the sensor. A full discussion of poles and zeros is beyond the scope of this manual.

The gain for a seismometer is traditionally expressed in *Volts per* ms^{-1} and, for an accelerometer, in *Volts per* ms^{-2}. Other instruments may use different units: an electronic thermometer might characterise its output in mV per °C.

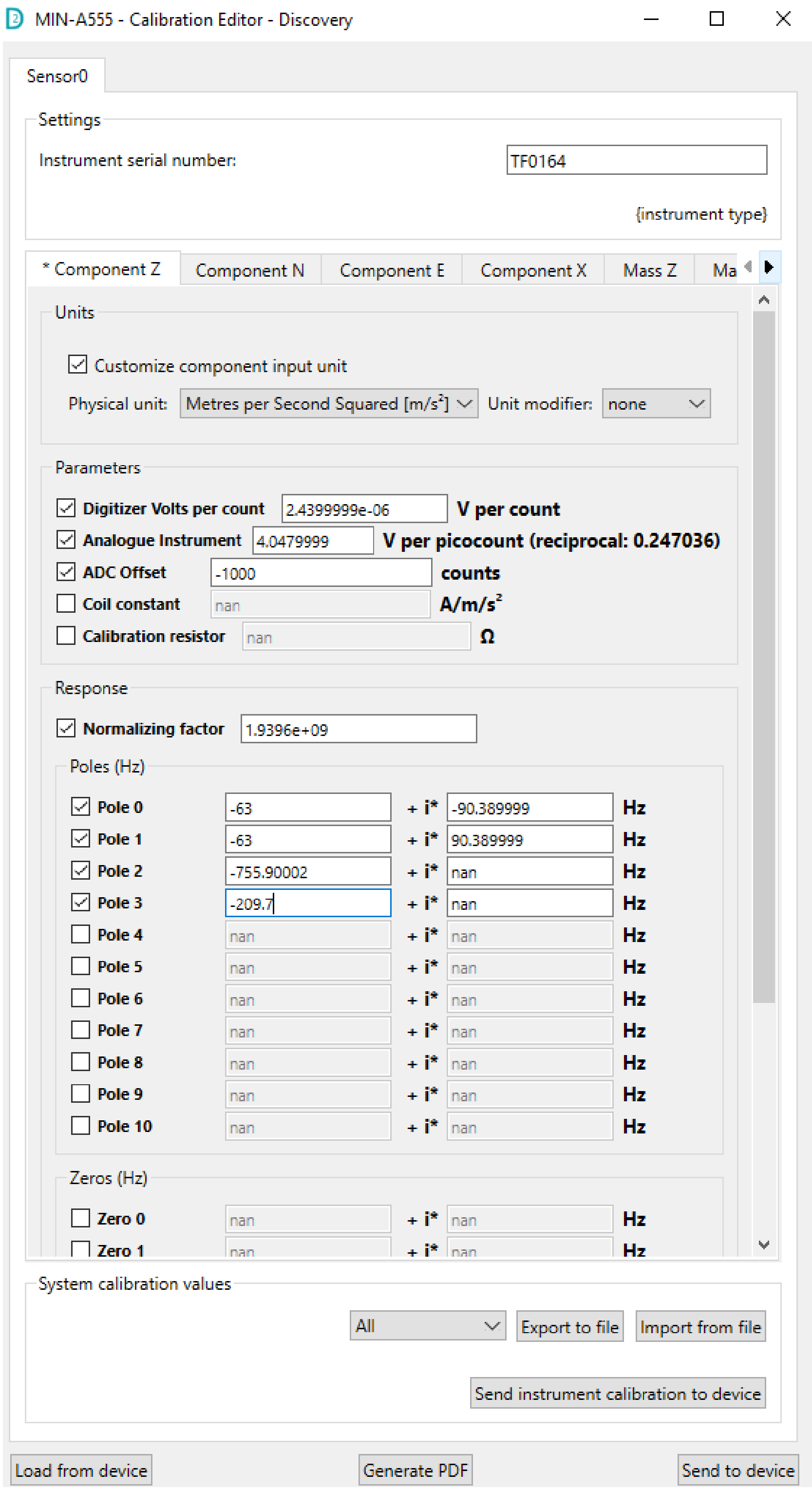
A calibration procedure is also used to establish the relationship between the input voltage that a digitiser sees and the output, in counts, that it produces. The results are traditionally expressed in *Volts per count*. Each Minimus is programmed at the factory so that it knows its own calibration values.

All Güralp sensors are fully calibrated before they leave the factory. The results are given in the calibration pack supplied with each instrument.

The Minimus requires analogue sensor calibration values to be input manually (*e.g.* Güralp Fortis, 3T, etc.).

To enter the calibration values for your analogue instruments, right-click the Minimus in Discovery's main window and select "Calibration" → "Edit Poles & Zeros".

Minimus, Minimus+, Fortimus, Certimus



This form has one tab for each seismic component, mass position and a calibration channel. The instrument's response values should be entered in here. These are:

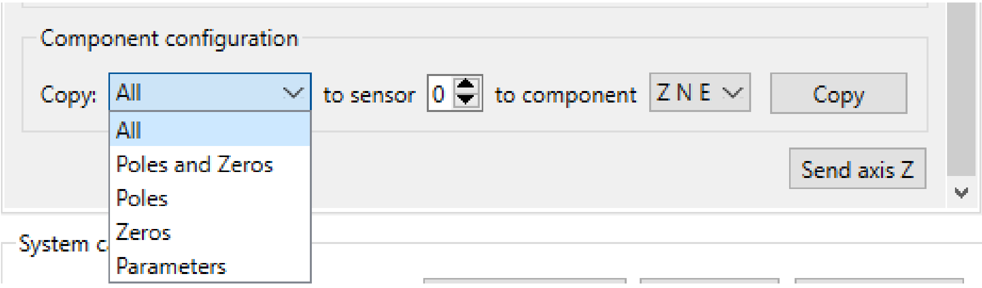
- The **Digitiser Volts per Count (VPC) –** the ratio between the input voltage and the digitised output value ("counts"). This field will be populated automatically with the correct value for this input channel of the Minimus.

- **Analogue Instrument Gain –** this specifies the output voltage of the seismometer per unit of ground motion, as measured at 1 Hertz. This information is normally provided on the calibration document that is shipped with the instrument. In the calibration document, this parameter is often referred to as “Velocity Output V/m/s” or “Acceleration Response V/m/s^2” depending on the analogue instrument. This value can vary slightly across the three components.
- The **ADC offset** is the quiescent output seen when digitiser input is zero. This field will be populated automatically with the correct value for this input channel of the Minimus.
- The **Coil constant** is the coil constant for the component being calibrated, in A/ms^{-2}, as given on the analogue sensor calibration sheet. This value is the same across all three components. This value is not relevant when Minimus is used with a Güralp Fortis accelerometer or Güralp Certis broad-band seismometer.
- The **Calibration resistor** is the value of the calibration resistor, in Ω, as given on the sensor calibration sheet. This value is the same across all three components. This value is not relevant when Minimus is used with a Güralp Fortis accelerometer or Güralp Certis broad-band seismometer.
- The **Normalising factor** specifies the value that the transfer function (as specified by the poles and zeros) must be multiplied by in order to provide unity gain at 1 Hz. This value is the same across all three components.
- The **Poles** and **Zeros** describe the frequency and phase response of the component. *They must be specified in Hertz.* This information is normally provided on a calibration document that is shipped with the instrument. If poles and zeros are not included in your calibration document, nominal values can be found here:: https://www.guralp.com/apps/paz/. This value is the same across all three components.

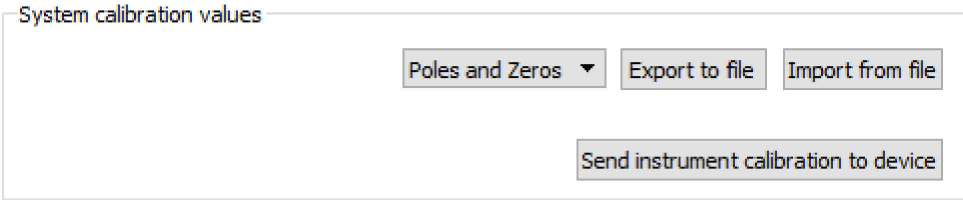
> **Note:** If the calibration document is lost, please visit the website to learn how to request a copy (https://www.guralp.com/customer-support).

The calibration parameters for one component can be copied to any other component of the same instrument, or other instruments. This is especially useful for poles and zeros because they are typically identical for all three components of all instruments in a class.

Within the “Component configuration” section, the “Copy:” drop-down box allows the selection of what to copy: poles and zeros, parameters, or All(tab dependant). The destination sensor can be set in the “to sensor” box and takes the numeric identity of the sensor as detected by the Minimus. Finally the specific components can be selected in the “to component” drop-down box. Click on the Copy button to copy and paste the selected values. Finally click on Send axis Z button to send the calibration values to the digitiser and save them permanently. Repeat this last step for the other axis. Note that Send axis Z only sends the calibration of the selected axis.



The overall system calibration parameters can be exported and saved in a file for future use by clicking on the Export to file button under "System calibration values".



The resulting filename will have the extension "`.conf`". Values from an existing calibration file can be imported using the Import from file button. The associated drop-down menu allows specification of what to import: poles and zeros, gains, or everything. Click on Send instrument calibration to device Send instrument calibration to device to send the calibration values to the digitiser and save them permanently.

Note: When using Minimus+, this action will only send the calibration of the selected sensor. Click on the Send to device button to send the complete calibration to the digitiser.

2.5.2 Connected Digital Instruments (Minimus and Minimus+)

Note: This section is relevant to Minimus and Minimus+ only.

For full details on configuring and controlling the Güralp Radian connected to the Minimus, please refer to the Radian manual.

For full details on configuring and controlling the Güralp Certis connected to the Minimus, please refer to the Certis manual.

2.5.3 Setting Long Period Corner (Certimus)

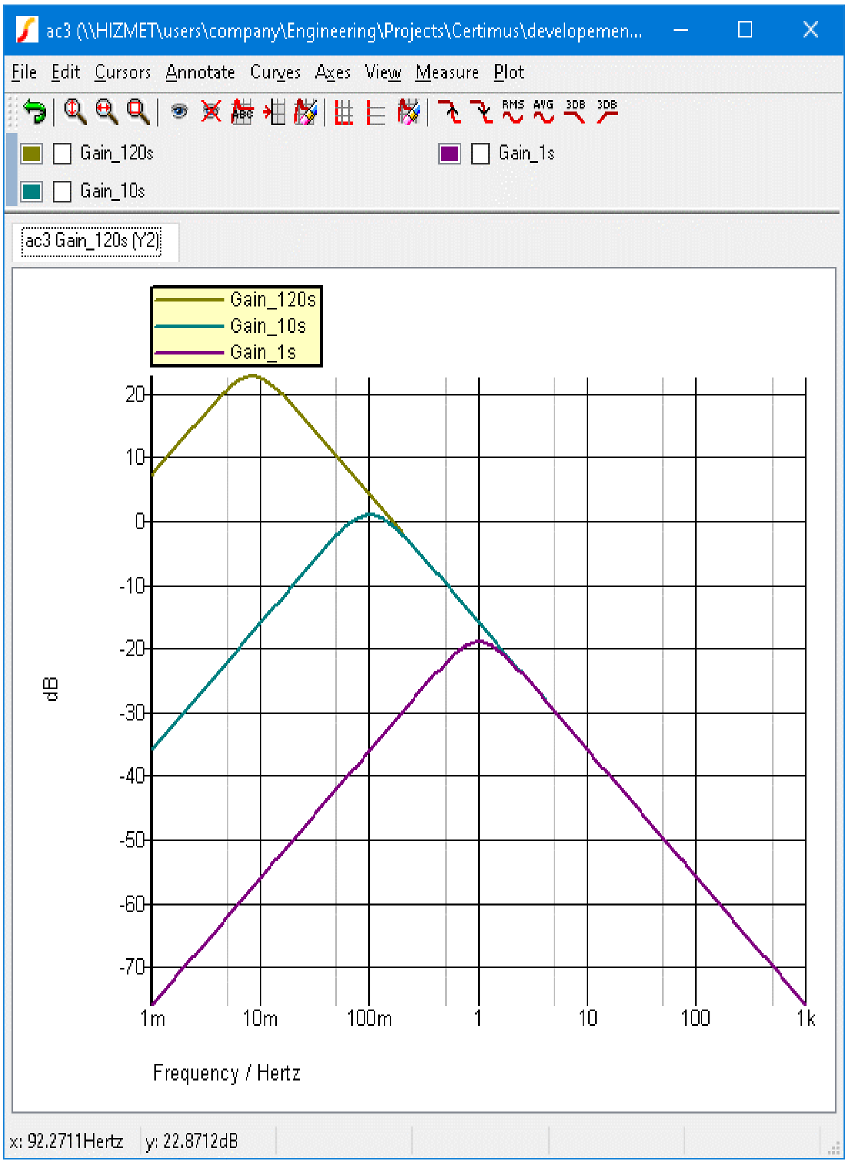
Note: This section is relevant to Certimus only.

The long period corner of the instrument can be set from the WEB setup page. The choices available are 1 second, 10 seconds or 120 seconds.

The clip level of the instrument varies with frequency. The highest gain of the instrument is at the long period corner frequency. The gain of the instrument steadily reduces as the frequency increases. The output is therefore considered to be proportional to the ground velocity.

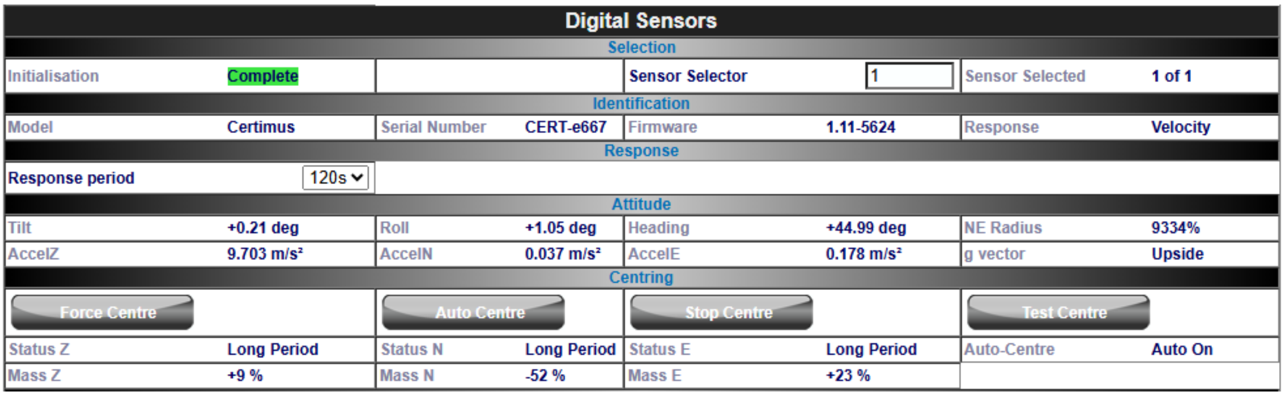
Changing the long period corner will have the effect of changing the instruments clip level. This can be helpful in an environment that is not stable – such as with large temperature variations between night and day or soft ground such as volcanic ash or water-logged ground. The instrument may tilt under these conditions, and a shorter period corner may help by avoiding repeated centring or clipping.

The graph below, shows the relative gain of the sensor against frequency for the 3 different long period corner settings.



The Fortimus seismometer automatically centres when it is powered up. To manually re-centre click on Force Centre button under the Digital Sensors section in the Setup tab.

The Automatic centring function can be disabled by clicking on Stop Centre. This is NOT normally recommended. The automatic centring operation is performed once the mass has moved beyond normal operating range. Failure to recentre at this point will result in compromised data.



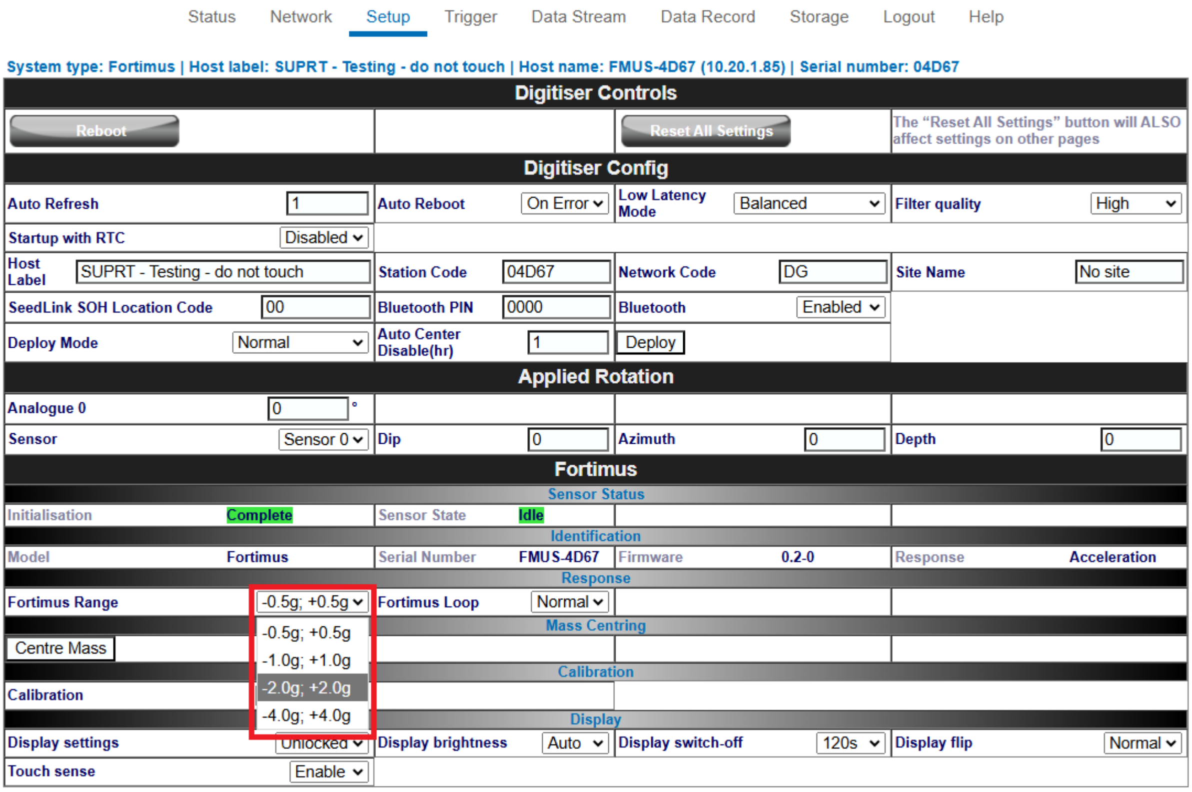
Digital Sensors							
Selection							
Initialisation	Complete			Sensor Selector	1	Sensor Selected	1 of 1
Identification							
Model	Certimus	Serial Number	CERT-e667	Firmware	1.11-5624	Response	Velocity
Response							
Response period	120s						
Attitude							
Tilt	+0.21 deg	Roll	+1.05 deg	Heading	+44.99 deg	NE Radius	9334%
AccelZ	9.703 m/s²	AccelN	0.037 m/s²	AccelE	0.178 m/s²	g vector	Upside
Centring							
Force Centre		Auto Centre		Stop Centre		Test Centre	
Status Z	Long Period	Status N	Long Period	Status E	Long Period	Auto-Centre	Auto On
Mass Z	+9 %	Mass N	-52 %	Mass E	+23 %		

2.5.4 Setting Sensor Gain (Fortimus)

Note: This section is relevant to Fortimus only.

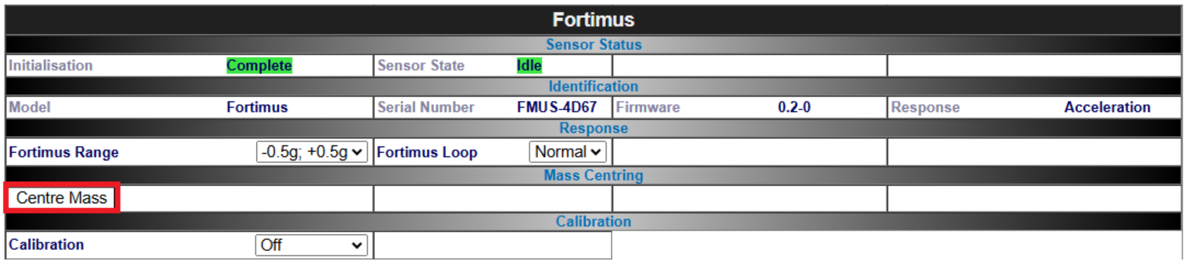
The Güralp Fortimus strong-motion digital accelerometer features a remotely-switchable gain option that can be controlled from inside Discovery.

The gain is settable in the Fortimus section in the Setup tab of the Fortimus web page. Under the "Fortimus Range", select a gain setting (options: ±0.5 g; ±1 g; ±2 g; ±4 g).



> **Note:** A reboot is required after this change.

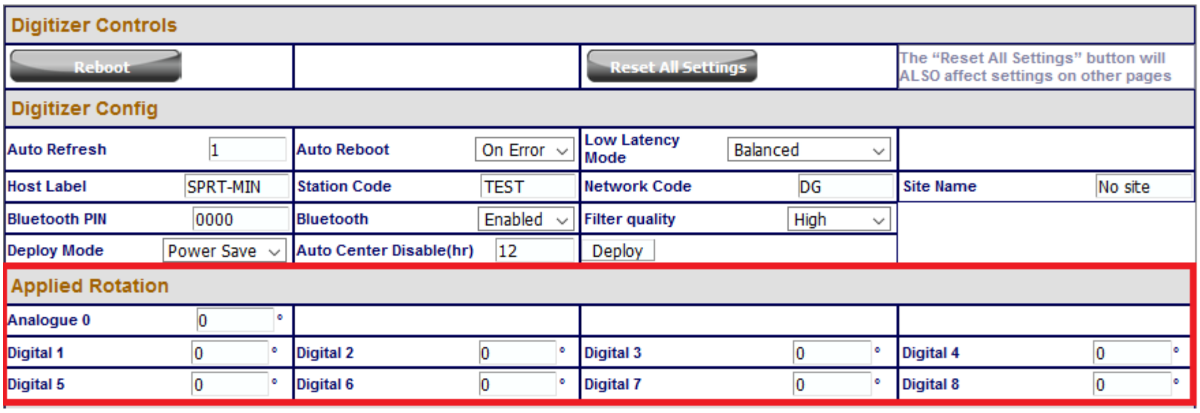
The Fortimus accelerometer automatically centres when it is powered up. To manually re-centre click on Centre Mass button under the Fortimus section in the Setup tab.



2.5.5 Sensor Orientation: Applied Rotation

A MATLAB extension for Scream! allows easy determination of the exact orientation of a sensor relative to a surface reference sensor (which can be accurately aligned magnetically or geographically. The procedure is explained at https://www.guralp.com/howtos/determining-sensor-orientation.shtml.

The Relative Orientation extension of Scream! provides a correction angle that can be entered into the Sensor Orientation section of the Setup tab of the Minimus web page.

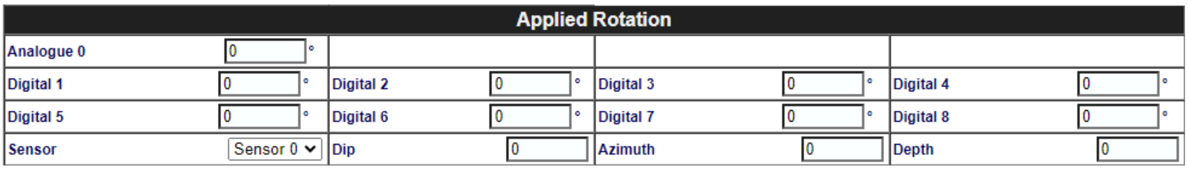


This feature can be applied to analogue seismometers, accelerometers and also to Borehole or Post-hole Radians, when installed with a vertical orientation.

Note: The input rotation is automatically applied to both transmitted and recorded data.

2.5.6 Instrument Installation Parameters

The Dip (tilt angle from vertical), Azimuth (tilt direction from North) and Depth of analogue or digital sensors connected to the Minimus can be set in the "Setup" tab of the web page interface in the section "Applied Rotation". The instrument to which the displayed parameters apply is selected using the drop-down menu.



Note: The orientation and depth are not applied to the data, the parameters are only saved in the Dataless SEED.

2.5.7 Output polarity

The polarity of output from each component of the instrument is as follows:

Direction of ground acceleration	Polarity of Z output	Polarity of N/S output	Polarity of E/W output
Upwards	**positive**	zero	zero
Downwards	**negative**	zero	zero
Northwards	zero	**positive**	zero
Southwards	zero	**negative**	zero
Eastwards	zero	zero	**positive**
Westwards	zero	zero	**negative**

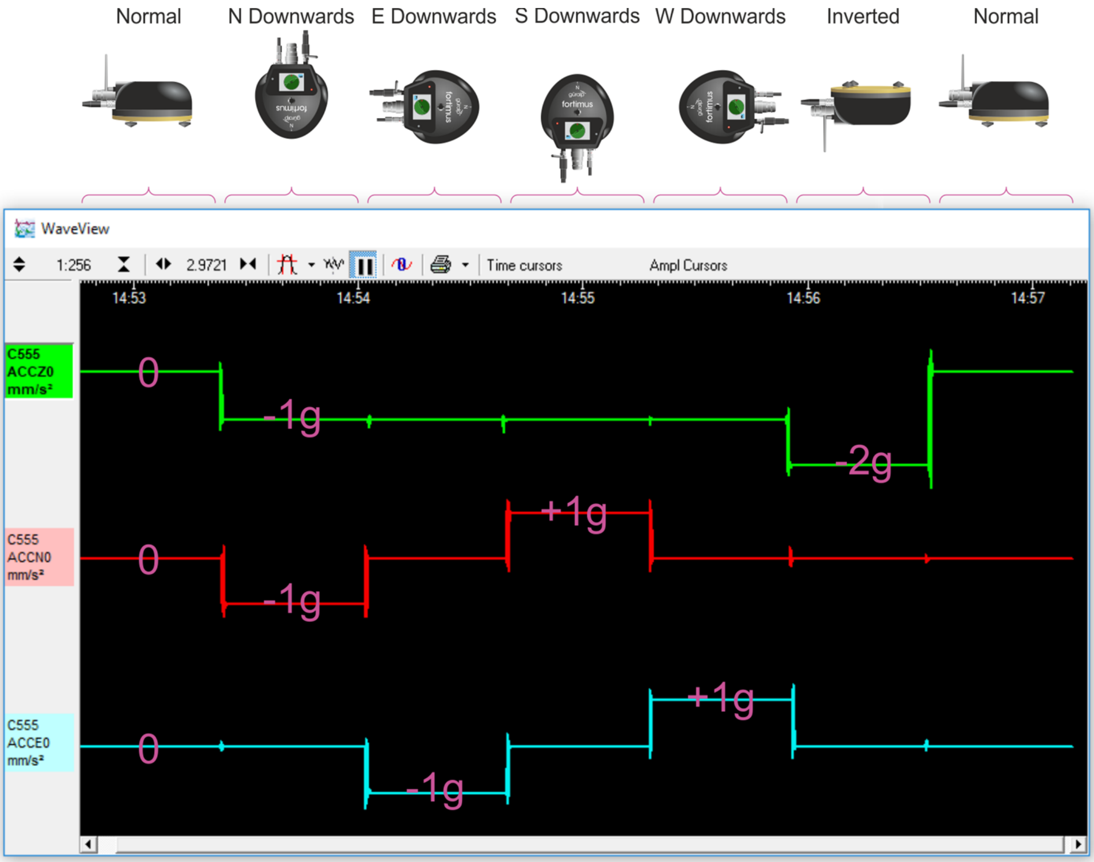
If the ground accelerates northwards, this moves the casing of the instrument northwards and the N-axis inertial mass is left behind. From the instrument's frame of reference, the mass appears to have been deflected southwards. The feedback system then needs to provide a balancing force to accelerate it northwards and this, by design, will result in a positive output signal from the N/S component.

If the instrument is mounted with the 'N' arrow pointing downwards, gravity will try and pull the inertial mass in the direction of the instrument's N-axis. The feedback system then needs to provide a balancing force to accelerate it upwards which, from the instrument's frame of reference, is now southwards. This is the opposite of the situation described above, so the output from the N/S component will now be negative.

The converses are also true: if the ground accelerates southwards, the instrument will produce a negative output signal from the N/S component and if the instrument is orientated with its 'N' arrow pointing upwards, it will produce a positive output signal from the N/S component

2.5.7.1 Example: Fortimus

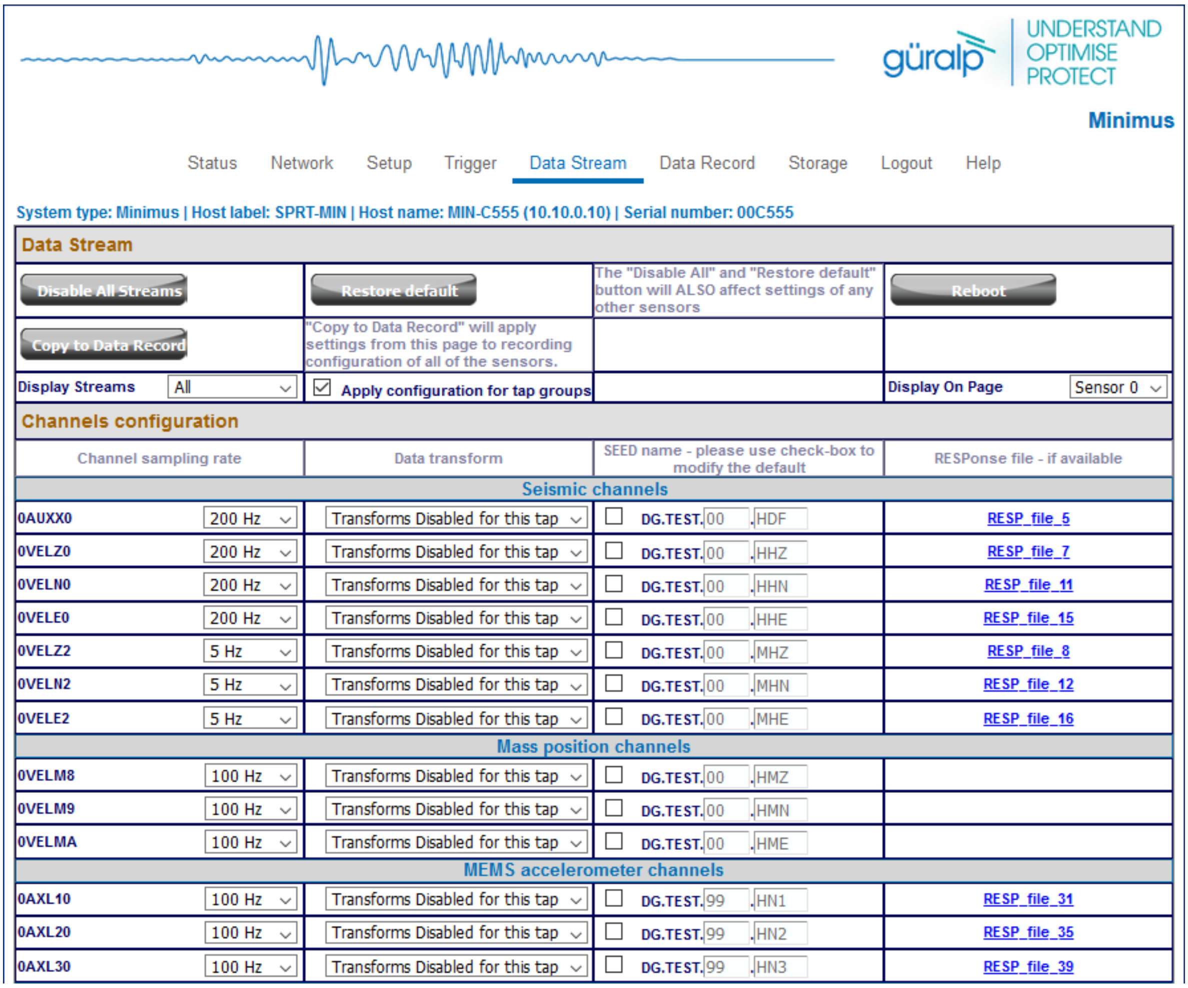
The polarity of the output signals with respect to acceleration can be demonstrated by selecting a sensitivity of 1g, 2g or 4g and orientating the instrument as shown in the diagram below.



2.6 Data Transmission

2.6.1 Data Stream Tab

The monitoring and configuration of transmitted data is handled using the Data Stream tab of the instrument's web page.



On this page it is possible to configure the transmitted channels for each of the connected instruments and sensors internal to the Minimus. A brief description of each channel is available by hovering the mouse cursor on the channel name.

Note: When changing a setting in the Minimus web page, ensure that you wait until the page refreshes before changing another setting. This allows time for the previous change to take effect.

The drop-down box named Display Streams found within the Data Stream section of the page filters out visible channels with options for All, Enabled Only and Disabled Only.

The option Apply configuration for tap groups automatically applies the same configuration to the three streams that belong to the same tap (*e.g.* 0VELZ0, 0VELN0, 0VELE0).

The drop-down box named Display On Page within the Data Stream section, allows you to view the sensors from different instruments connected to the Minimus, *e.g.* Sensor 1.

The Channel configuration section is divided into four columns:

- In the first column "Channel sampling rate", drop-down boxes are available for each channel to either select a sample rate or to exclude the channel from streaming by selecting the Disabled option (under the lowest sample rate available). All channels can be stopped from being streamed by clicking the Disable All button. The same configuration can be applied to recorded channels by clicking the Copy to Data Record button. The default channel configuration can be applied by clicking the Restore default button;
- in second column "Data transform", drop-down boxes are available for each channel to enable/disable transforms. Once a transform is enabled, the drop-down box will refresh allowing you to select the transform you want to apply;
- in third column "SEED name", Location and Channel SEED codes can be configured. Options are greyed out with default values applied, they can be edited by clicking on the checkbox at the start of the cell;
- in fourth column "RESPonse file" there are links to the RESP files associated to each of the seismic channels (see Section 2.8.2 for more details).

All streaming can be stopped by clicking the Disable All Streams button. The same configuration can be applied to recorded channels by clicking the Copy to Data Record button. Default channel configuration can be applied by clicking the Restore Default button;

Upon changing the sample rate, enabling a transform, or changing Location and Channel codes, the Minimus will need to be restarted for the changes to come into effect; this can be done by pressing the Reboot button. During the reboot, the LEDs will flash, displaying the starting-up sequence (see Section 2.15.1).

Once the Minimus has successfully rebooted, the full web browser display and controls will be available for use.

If transmitting data over a network with high latency and/or low throughput, such as when the device is connected wirelessly to a modem, be aware of not having the total samples per second too high as streaming performance will be degraded.

2.6.2 GDI-Link Protocol

The Minimus can transmit data using the GDI (Güralp Data Interconnect)-link protocol. GDI-link supports both push/pull of data from/to the Minimus. See Section 2.6.2.1 to configure a data push to one or more remote clients (*e.g.* NAM).

GDI-link provides a highly efficient, low latency method of exchanging data via TCP between seismic stations and data centres. The protocol allows state-of-health information to be attached to the samples during transmission. The topology can be many-to-one or one-to many. This means that a receiver can accept data from multiple transmitters and a single transmitter can send data to multiple receivers, allowing maximum flexibility for configuring seismic networks. GDI-link streams data sample-by-sample (instead of assembling them into packets) to minimise transmission latency.

A significant advantage of GDI-link is that it can stream data pre-converted into real physical units instead of just as raw digitiser counts, removing a requirement for receivers to be aware of calibration values.

For more information on GDI-link, please refer to Güralp manual **SWA-RFC-GDIL**.

2.6.2.1 GDI push (auto-connection)

A Minimus normally acts as a GDI server, where a client initiates a connection to pull data from it. This is the mechanism explained above and used when the GDI viewer in Discovery is launched (from the main menu, right click on the instrument, hover over "Live View" and select "GDI") .

The "GDI auto-connection" feature enables the Minimus to establish outgoing network connections to push data to one or more remote clients, such as Platinum systems or an Earthworm system running the `gdi2ew` plug-in.

Caution: Either configure the auto-connection on the Minimus OR the client to pull data from it. If the client is pulling data from the Minimus, leave the "GDI auto-connection settings" fields empty. Configuring both ends may cause problems.

To configure an auto-connection, login to the Minimus as admin, type either the IP address or the hostname of the target client, a colon (:) and the port number (*e.g.* *192.0.2.91:1566* or *affinity10.example.com:1566*), into any of the connection fields in the "Network" tab of the web page.

When auto-connection from a Minimus to a host is configured, the Minimus will attempt to open a connection to the host. If it fails, it will re-try every 60 seconds. A suitably configured host will accept the connection and the Minimus will then negotiate a link and start streaming data.

If the connection drops, the Minimus will attempt every 60 seconds to reconnect.

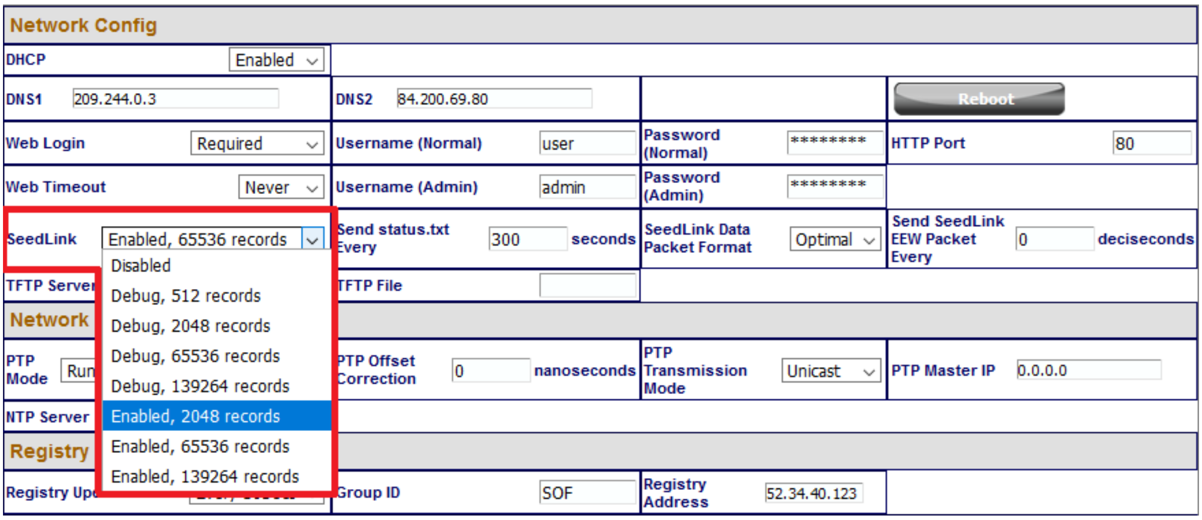
Note: The default port number for a GDI-link receiver is 1566. Push servers will normally connect to this port. The default port number for a GDI-link transmitter is 1565. Receivers wishing to pull data will normally connect to this port. See Section 0 for a list of the network ports used by the Minimus.

2.6.3 SEEDlink Protocol

The Minimus can act as a SEEDlink server to send miniSEED data packets over a network connection. The SEEDlink server is enabled by default but it can be disabled and re-enabled if desired. The server has a configurable back-fill buffer.

> **Note:** The Minimus SEEDlink back-fill implementation is packet-based.

When logged in as admin, the “Network” tab of the Minimus' web page allows the selection of the desired SEEDlink mode:



The choices are:

- “Enabled” - This is the normal operating mode. Choose between backfill buffer sizes of 2,048 records, 65,536 records or 139,264 records;
- “Disabled” - turns off the SEEDlink server; and
- “Debug” - this mode produces additional messages in the file `seedlink.log` (“Storage” tab) which may be helpful if trying to diagnose a problem. It is available with backfill buffer sizes as before and, additionally, a 512-record buffer.

> **Note:** As a general guide, we find that 139,264 records is normally sufficient to store around one day of triaxial, 100 sps data.

2.6.3.1 *Modified SEEDlink Protocol*

Standard SEEDlink has a fixed packet size of 512 Bytes and each miniSEED packet is completely populated with data before it is transmitted. Minimus supports a modified version of SEEDlink that allows the transmission of incomplete packets. This improves latency.

Note: The modified SEEDlink is only available for the low latency version of the main seismic channels. These are the equivalent of the standard seismic channels but are generated with causal low latency filters. In the Data Stream tab, they can be found in the "Low latency seismic channels" section.

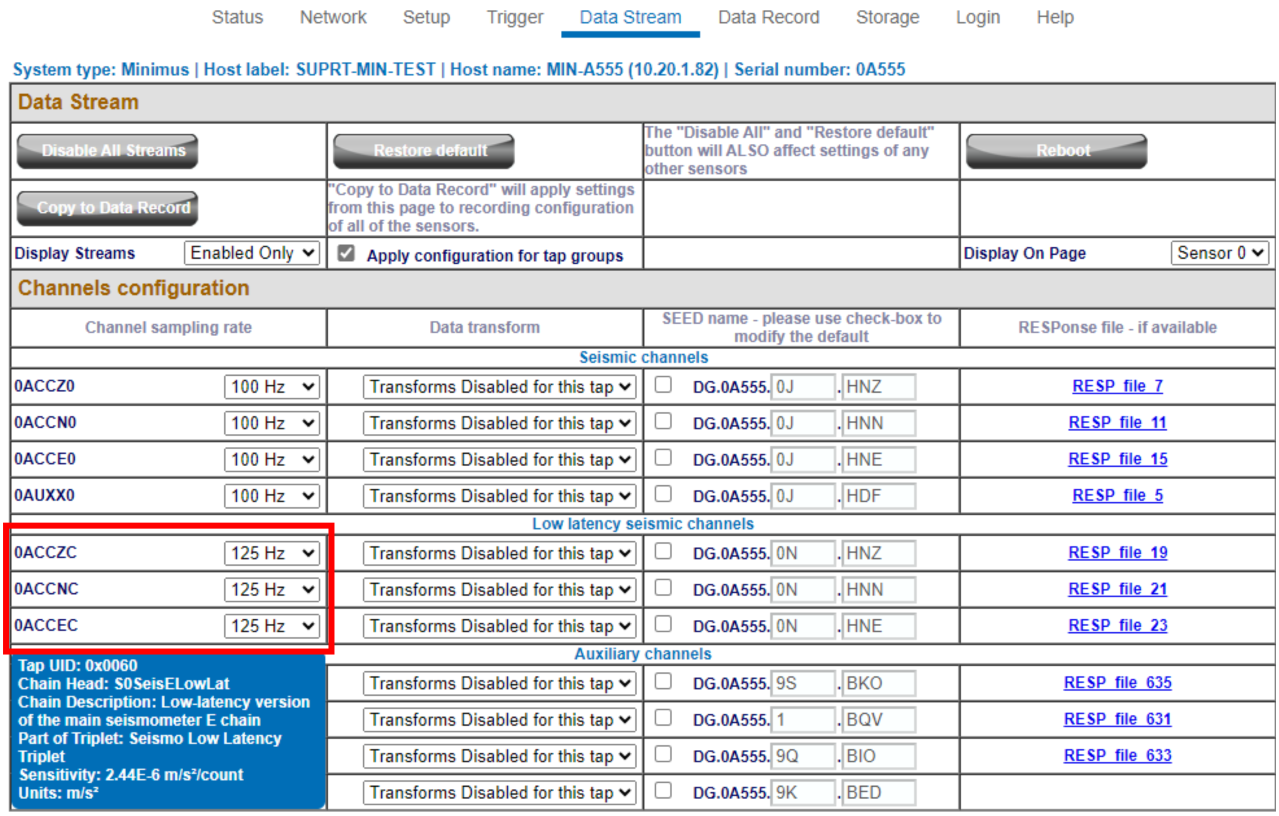
By default, only a single tap (sample rate) is available, and the channel name ends in "C", e.g. 0ACCZC or 0VELZC. To add an extra low latency channel tap, open the Minimus console from Discovery and type:

```
resource add extctaps n
```

with **n** the number of extra taps you wish to add. Following this command, the Minimus has to be rebooted. Type in the console:

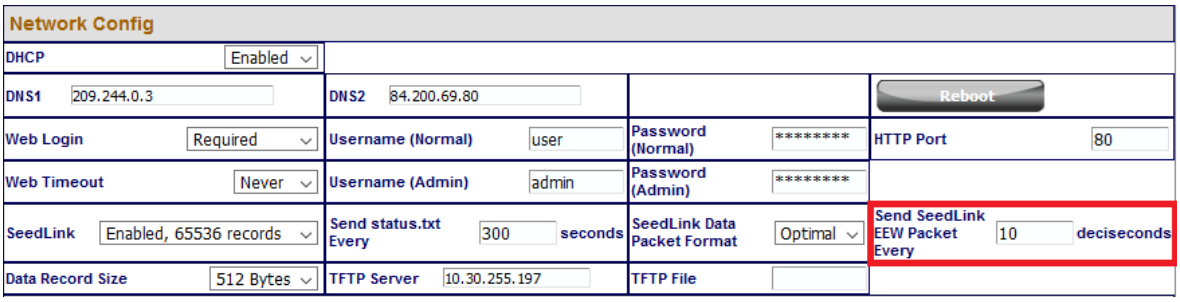
```
reboot
```

After the reboot, open the Minimus webpage, navigate to the Data Stream or Data Record tab, set "Display Stream" to "All" and the newly added channels will appear in the "Low latency seismic channels" section.

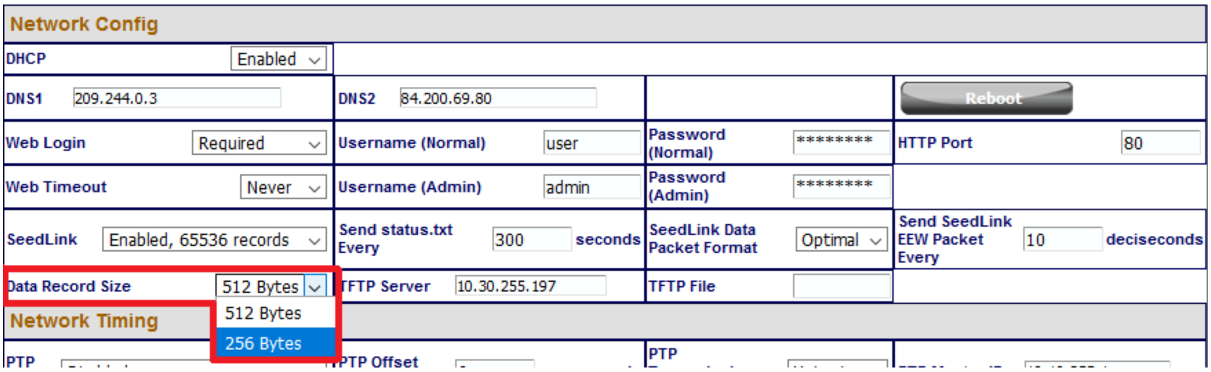


The user can specify the rate at which miniSEED packets must be transmitted. If populating complete packets would result in this rate not being achieved, incomplete packets are transmitted instead. The number of samples in each packet, therefore, depends both upon this setting and on the sample rate.

Log in as Admin and navigate to the “Network” tab of the Minimus web page, under the “SeedLink settings” title, look for “Send SeedLink EEW Packets Every” option and select the interval in deciseconds (1 decisecond = 100 ms or 0.1 seconds) between miniSEED packets. (



The modified SEEDlink protocol also allows the use of 256-byte records as an alternative to the standard 512-byte format. The “Data Record Size” drop-down menu on the “Network” tab of the Minimus web page controls this behaviour. This option becomes available only when the “Send SeedLink EEW Packets Every” is different than 0.



Note: Not all SEEDlink clients can accept 256-byte records. Consult your client's documentation if in doubt.

Using 256-byte packets instead of the standard 512-bytes is beneficial when transmitting incomplete packets. In fact, when incomplete packets are transmitted the miniSEED files will contain just a small amount of data while the rest of the file is empty (as the size of the packet is fixed). Reducing the packet size from 512 bytes to 256 bytes means that the resulting files would still contain all the data but the space they occupy in the SD card would be halved. If you are not recording data, or if you are not concerned about the space on the SD card, you can keep using the standard 512-byte packet size.

To test the SEEDlink server, Güralp recommends using the *slinktool* software for Linux, which is distributed by IRIS. For more information and to download a copy, see https://ds.iris.edu/ds/nodes/dmc/software/downloads/slinktool/.

To show a list of available miniSEED streams, issue the command:

slinktool -Q *IP-Address*

Which produces output like the following:

```
DG TEST 00 CHZ D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
```

```
DG TEST 01 HHZ D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 00 CHN D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 01 HHN D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 00 CHE D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 01 HHE D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 00 MHZ D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 00 MHN D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
DG TEST 00 MHE D 2016-09-13 10:42:18 - 2016-09-13 10:46:56
```

To print miniSEED data records of a single channel, run the following command:

slinktool -p -S *DG_TEST:00HNZ.D IP-Address*

Which produces the following output:

```
DG_TEST_00_HNZ, 412 samples, 100 Hz, 2016,257,10:43:42.000000 (latency ~2.9 sec)
DG_TEST_00_HNZ, 415 samples, 100 Hz, 2016,257,10:43:46.120000 (latency ~2.6 sec)
DG_TEST_00_HNZ, 416 samples, 100 Hz, 2016,257,10:43:50.270000 (latency ~3.0 sec)
DG_TEST_00_HNZ, 413 samples, 100 Hz, 2016,257,10:43:54.430000 (latency ~2.6 sec)
DG_TEST_00_HNZ, 419 samples, 100 Hz, 2016,257,10:43:58.560000 (latency ~3.0 sec)
DG_TEST_00_HNZ, 418 samples, 100 Hz, 2016,257,10:44:02.750000 (latency ~2.6 sec)
DG_TEST_00_HNZ, 415 samples, 100 Hz, 2016,257,10:44:06.930000 (latency ~3.0 sec)
```

The SEEDlink server on the Minimus also supports the use of the "**?**" character as a wild card within network, station, and channel codes. This allows you to request multiple streams using a single command.

> **Note:** Because the **?** character has special meaning to the shell, it is safest to quote this character with a preceding backslash ('\') when used in command arguments.

2.6.4 Scream! (GCF Format + Scream Protocol)

The Minimus can act as a Scream! Server and stream data by sending GCF (Güralp Compressed Format) packets over a network connection using the Scream! data-transmission protocol.

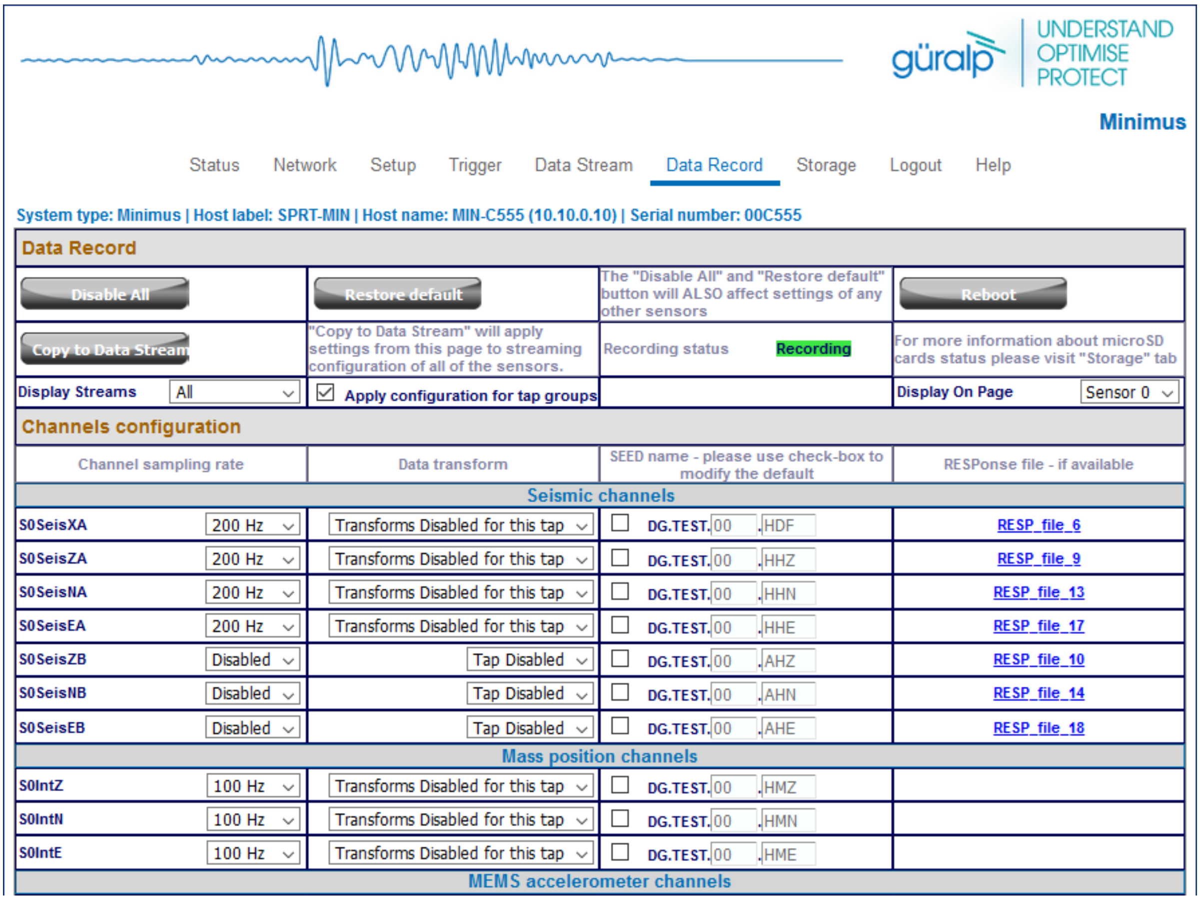
This is primarily intended to support Güralp's Scream! Software or any software that can communicate using the Scream! Protocol, including Earthworm.

For more information, please refer to Scream! manual: MAN-SWA-0001

2.7 Data Recording

2.7.1 Data Record Tab

The main panel of the Data Record tab from the web interface is shown here:



This page allows the user to configure the recording channels for each of the connected instruments and the sensors internal to the Minimus. A brief description of each channel is available by hovering the mouse cursor on the channel name.

> **Note:** When changing a setting in the Minimus web page, ensure that you wait until the page refreshes before changing another setting. This allows time for the previous change to take effect.

Under the Data Record header, look to the third row down for Display Streams, the drop-down box filters out the visible channels below with the following categories: All, Enabled Only and Disabled Only.

The next option to the right Apply configuration for tap groups has a checkbox that allows you to automatically apply the same configuration to three streams that belong to the same tap, *e.g.* S0SeisZA, S0SeisNA, S0SeisEA.

The last setting on this row Display On Page allows you to view the different instruments connected to this device, *e.g.* Sensor 1.

The next section titled Channels Configuration is divided into four columns:

- The left-most column "Channel sampling rate" contains a drop-down box for each available channel to either select a sample rate or to exclude the channel from recording by selecting the Disabled option (under the lowest sample rate available). All channels can be stopped from being recorded by clicking the Disable All button. The same configuration can be applied to real-time transmission channels by clicking the Copy to Data Stream button. The default channel configuration can be applied by clicking the Restore default button;
- In the second column "Data transform" there are drop-down boxes for each channel to enable/disable transforms. Once "Enable transform" is selected, the drop-down box will refresh allowing you to select the transform to apply.
- In the third column "SEED name", Location and Channel SEED codes can be configured. Cells contain default values and are unable to be edited unless the preceding checkbox is clicked.
- In the fourth column "RESPonse file", there are links to the RESP files associated with each of the sensor channels (see Section 2.8.2 for more details).

Upon changing the sample rate, enabling a transform, or changing the Location or Channel codes, the Minimus will need to be rebooted for the changes to come into effect; this can be done by pressing the Reboot button. During the reboot, the LEDs on the Minimus will flash, displaying the starting-up sequence (see Section 2.15.1).

Once the Minimus has successfully restarted, the full web browser display and controls will be available for use again.

2.7.2 Recording Status

MicroSD cards need to be specifically formatted to operate with the Minimus. The cards shipped with the Minimus are supplied pre-formatted.

Data is stored on the microSD cards in miniSEED format. Each channel is saved as a series of 128 MiB files. Instrument and station metadata (*e.g.* instrument response, coordinates, compression type etc.) are stored in "Dataless SEED" format (see Section 2.8.1 for more details).

The MicroSD card and data recording status can be monitored from the "SD Card control" & the "SD Cards Status" sections of the Storage tab.

The "SD Cards Status" section has two columns, the left-hand column provides details of the external (primary, removable) microSD card and the right-hand column shows the status of the internal (backup, fixed) card.

SD Cards status			
External microSD card present	PRESENT	Number of 128-MiB miniSEED files	461
External microSD card usable	USABLE	Internal microSD card usable	USABLE
External microSD card init count	1	Internal microSD card init count	1
External microSD card is primary microSD card	PRIMARY	Internal microSD card is primary microSD card	BACKUP
Primary microSD card is recording samples	RECORDING	Backup microSD card is recording samples	RECORDING

Fields of this panel indicate the state of the following:

- External micro SD card present: Whether a card is inserted into the external slot;
- External/Internal micro SD card Usable: Whether the card has been formatted correctly;
- Primary/Backup microSD card is recording samples: Shows if data is being recorded to the card;

Note: If the recording status of the cards is marked NOT RECORDING, clicking on Quickformat Cards or Fullformat Cards may solve the issue. Note that the quick format simply moves the write-pointer to the beginning of the recording space, hence overwriting any existing data. The full format, in contrast, erases all the existing data (and can take several hours).

2.7.3 MicroSD Card Re-Formatting

The card re-formatting process fills the card with 128 MiB files containing zeros. Each file is given a temporary, place-holder name. When data is written, these files are renamed and then over-written with the new data.

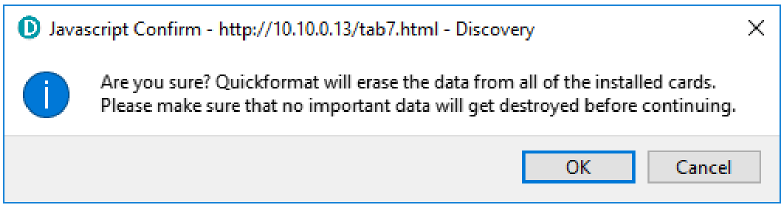
There are two methods for card reformatting: “Quick format” and “Full format”. The quick format mode should be used for pre-deployment tests (*e.g.* stomp/huddle tests) to ensure that the instruments are operating properly. This mode simply marks the existing files as empty without deleting their contents. Full formatting should be used prior to a long-term deployment to ensure that all headers are included and files are fully clean before writing.

The formatting process formats both fixed and removable cards, sequentially.

Note: A series of tests separated only by quick formats can leave some files with residual data in them. This is not normally a problem because a deployment will typically create data-sets longer than any test, over-writing any data remaining from the tests. The “miniSEED extractor” utility (see Section 2.16.6) can be used to remove the residual data if they cause any problems.

2.7.3.1 Quick Format

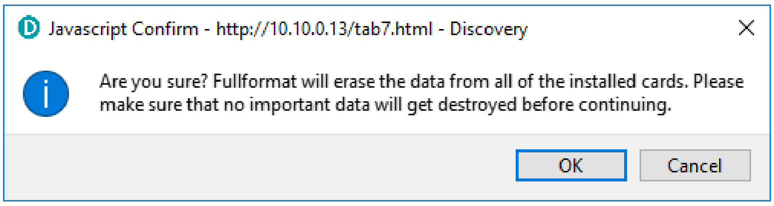
Ensure that the external microSD card is correctly inserted. Click the Quickformat Cards button in the “Storage” tab: a dialogue box will appear to confirm the formatting operation – click on OK button to continue.



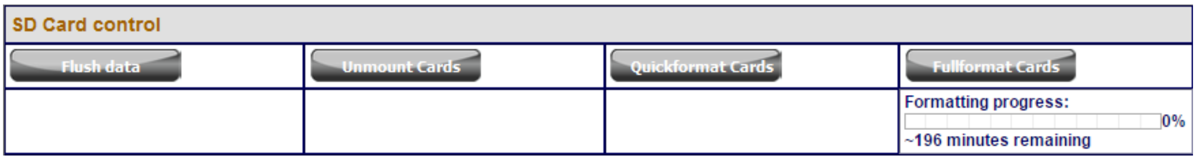
The instrument web page will refresh and return to the Status tab. The reformatting operation is now complete.

2.7.3.2 *Full Format*

Ensure the external microSD card is correctly inserted. Click the Fullformat Cards button in the Storage tab and a dialogue box will appear to confirm the formatting operation – click on the OK button to continue.



The process takes several hours: check the status countdown indicators on the top-right of Storage tab.



Caution: Do not remove or insert the external microSD card while formatting is taking place.

2.7.4 MicroSD Card Data Flushing and Unmounting

The Flush data button flushes data from the buffer into the microSD card storage. Perform a flushing before downloading data from the Storage tab or Seismic Event Table (see Section 2.10.5).

The Unmount Cards button flushes the data from the buffers into the microSD cards and interrupts the recording.

Caution: After unmounting the SD cards, the recording only restarts if a new card is inserted in the slot *and* the instrument is rebooted, or if a quick-format (or full-format) is performed.

2.8 Metadata

Minimus provides metadata in three different formats: Dataless SEED volume, RESP files and StationXML files. The three sections that follow describe where to find them.

2.8.1 Dataless SEED Volume

MiniSEED files do not contain detailed station metadata, but they represent a collection of raw data records (time-series data). The metadata – including network and station information, such as responses of the instruments and digitisers - are encoded in a file called "Dataless SEED file" .

The Dataless SEED file can be found in the Storage tab of the Minimus' webpage under "Auxiliary files". To download it, just click on its filename.

Auxiliary files

Filename	
DG_0E667.dataless	Dataless SEED file
fram.log	FRAM log file
Certis.xml	Certis StationXML
calvals.txt	SCREAM! calibration values
polezero.txt	SCREAM! zeros, poles and gains
calib.txt	Calibration text file
seedlink.log	Seedlink server log

The first component of the file name depends on the two-character Network code defined in the Setup tab, while the second contains the instrument's serial number. If, for example, the network code is `DG` and the Minimus' serial number is MIN-E667, the file is called `DG_0E667.dataless`.

The Dataless SEED file is also available by direct URL. Simply type into a web browser the IP address of the Minimus followed by the Dataless SEED filename, for example:

http://10.20.1.92/DG_0E667.dataless

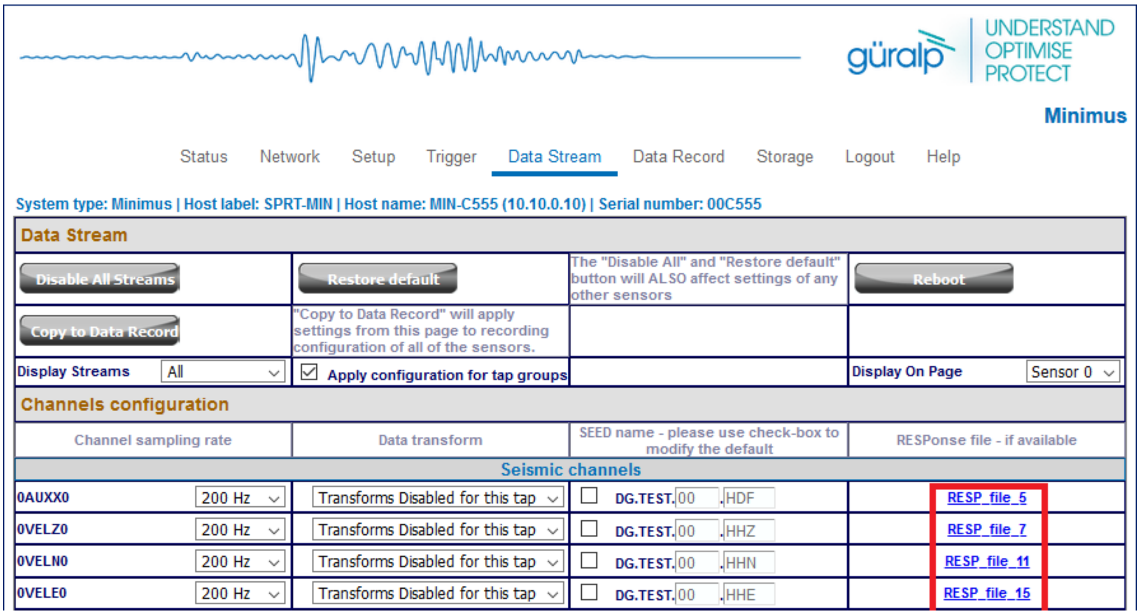
You can also use the `wget` command from the command line to download the Dataless SEED volume from the URL above. The command would look something like this:

```
wget http://10.20.1.92/DG_0E667.dataless
```

The Dataless SEED file is generated from the RESP files for each channel (see Section 2.8.2 below).

2.8.2 RESP File

The Dataless SEED file is created automatically by the Minimus and contains configuration data for all the available channels. The contents of the Dataless SEED file can be displayed in human-readable form for individual channels. These files are known as RESP, and they are accessible by clicking on the “RESP file” link of each channel in the Data Stream and Data Record tabs of the Minimus web page interface.

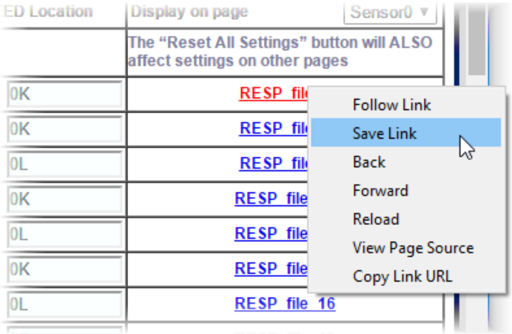


Clicking on a RESP file link produces a page like this:

```
#              << Guralp SEED response file builder v1.2-8615 >>
#
#              ======== CHANNEL RESPONSE DATA ========
B050F03     Station:     TEST
B050F16     Network:     DG
B052F03     Location:    0K
B052F04     Channel:     HNZ
B052F22     Start date:  2018,214,11:26:48
B052F23     End date:    No Ending Time
#              =======================================
#              +                  +-----------------------------------------+                  +
#              +                  |   Channel Sensitivity,  TEST ch HNZ    |                  +
#              +                  +-----------------------------------------+                  +
#
B058F03     Stage sequence number:                    0
B058F04     Sensitivity:                              2.131148E+05
B058F05     Frequency of sensitivity:                 1.000000E+00 HZ
B058F06     Number of calibrations:                   0
#
#              +               +---------------------------------------------+                  +
#              +               |   Response (Poles & Zeros),  TEST ch HNZ    |                  +
#              +               +---------------------------------------------+                  +
#
B053F03     Transfer function type:                   A [Laplace Transform (Rad/sec)]
B053F04     Stage sequence number:                    1
B053F05     Response in units lookup:                 M/S**2 - Acceleration in Metres Per Second Squared
B053F06     Response out units lookup:                V - Volts
B053F07     A0 normalization factor:                  3.022955E+12
B053F08     Normalization frequency:                  1.000000E+00
```

Right-click anywhere and select “Back” to return to the Minimus’ web page interface.

To save a RESP file, right click on the “RESP file” link and select Save Link:



> **Note:** RESP files are not available for channels that have a transform enabled, with the exception of the "EEW CAP Parameters – Observer" transform

In a similar way to the Dataless SEED files, the RESP files are also available by direct URL. Simply type in a web browser the IP address of the Minimus followed by the RESP filename, for example:

http://10.20.1.92/RESP_file_7.txt

You can also use the `wget` command from the command line to download the RESP file from the URL above. The command would look something like this:

`wget http://`*`10.20.1.92`*`/RESP_file_7.txt`

2.8.3 Station XML File

Seismic metadata is also available in XML format. The XML file can be found in the Storage tab of the Minimus' webpage as "Sensor0.xml". To download it, check the tick-box and click on "Download selected files".

☐	status.log	11869910	2024-09-05 09:23:05.000000000
☐	system.log	33825052	2024-09-05 09:28:19.000000000
☐	init.log	33554432	2024-08-31 07:05:58.000000000
☑	Sensor0.xml	1354917	2024-09-04 16:29:10.000000000
☐	Sensor1.xml	555723	2024-09-04 16:29:16.000000000
☐	data.xml	34059	2024-08-28 15:58:29.000000000
☐	table_of_events.bin	7168	2024-09-03 15:54:38.000000000

Download selected files

Also the XML files are available by direct URL. Simply type in a web browser the IP address of the Minimus followed by /sd and the XML filename, for example:

http://10.20.1.92/sd/Sensor0.xml

You can also use the `wget` command from the command line to download the XML file from the URL above. The command would look something like this:

`wget http://`*`10.20.1.92`*`/sd/Sensor0.xml`

An example XML file is shown in the figure below. Opening the XML file with a web browser allows you to view the structured data and expand/collapse blocks of information using the left-hand side angled arrows.

Not secure | 10.20.1.92/sd/Sensor0.xml

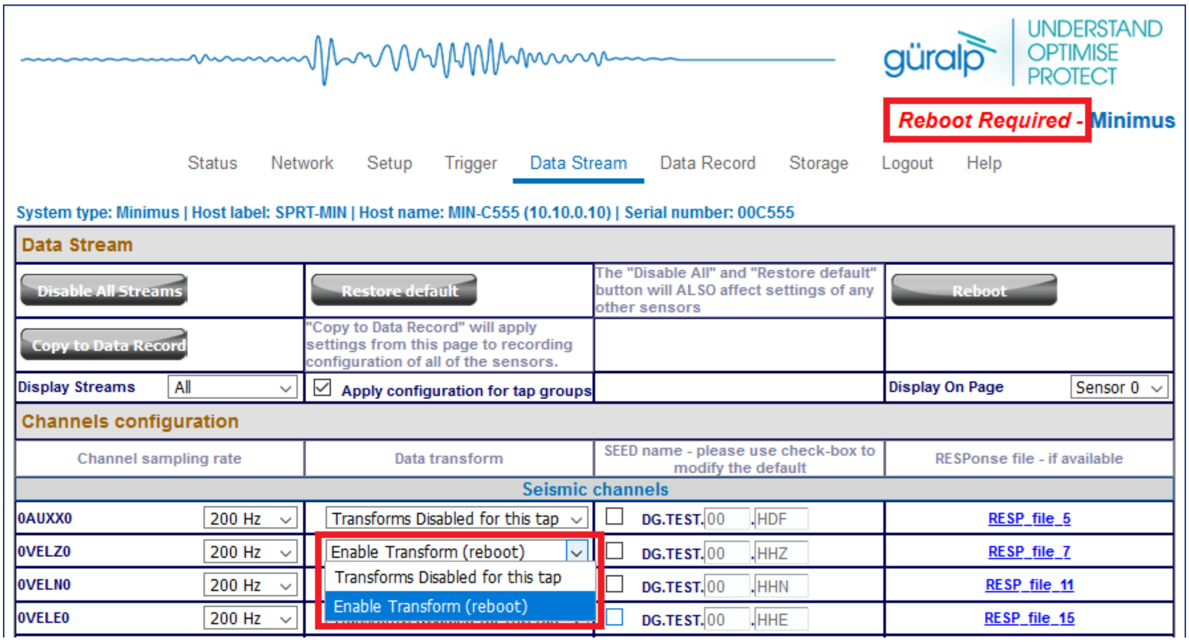
This XML file does not appear to have any style information associated with it. The document tree is shown below.


```
<FDSNStationXML xmlns="http://www.fdsn.org/xml/station/1" schemaVersion="1.1">
  <Source>Guralp Certimus</Source>
  <Created>2024-06-10T13:19:59Z</Created>
 ▼<Network code="DG">
  ▼<Station code="0E667">
     <Latitude>51.360699</Latitude>
     <Longitude>-1.163408</Longitude>
     <Elevation>111.900002</Elevation>
   ▼<Site>
      <Name>No site</Name>
     </Site>
   ▼<Equipment>
      <Type>Instrument</Type>
      <Description>Certimus</Description>
      <Manufacturer>Guralp Systems Limited</Manufacturer>
      <Model>Certimus</Model>
      <SerialNumber>E667</SerialNumber>
     </Equipment>
   ▶<Channel code="BQV" locationCode="1">
     ...
     </Channel>
   ▶<Channel code="BYP" locationCode="1">
     ...
     </Channel>
   ▶<Channel code="BKO" locationCode="9J">
     ...
     </Channel>
   ▶<Channel code="BKO" locationCode="9K">
     ...
     </Channel>
   ▶<Channel code="AEO" locationCode="9M">
     ...
     </Channel>
   ▼<Channel code="AEF" locationCode="9K">
      <Description>9K.AEF</Description>
    ▼<Comment>
       <Value>S0/58983/1.5/0</Value>
      </Comment>
      <Latitude>51.360699</Latitude>
      <Longitude>-1.163408</Longitude>
      <Elevation>111.900002</Elevation>
      <Depth>0</Depth>
      <Azimuth>0</Azimuth>
      <Dip>0</Dip>
      <SampleRate>0</SampleRate>
    ▼<Sensor>
       <Type>Certimus</Type>
       <Description>Certimus instrument</Description>
       <SerialNumber>E667</SerialNumber>
      </Sensor>
    ▼<Response>
     ▼<InstrumentSensitivity>
        <Value>1000000000.000000</Value>
        <Frequency>1.000000</Frequency>
      ▼<InputUnits>
         <Name>s</Name>
         <Description>Time in Seconds</Description>
        </InputUnits>
      ▼<OutputUnits>
```

2.9 Transforms

The Minimus is capable of applying mathematical transforms to the streamed and recorded data. These include low-pass and high-pass filters, integration, differentiation, rotation, STA/LTA ratio etc.

When a transform is activated on a particular channel, the web page interface will update allowing the selection of the specific transform to be applied, from the same drop-down box. After rebooting the Minimus, the resulting streamed (or recorded, according to the chosen configuration) data output is automatically transmitted and/or recorded with the transform applied. The units of measure are re-calculated accordingly.

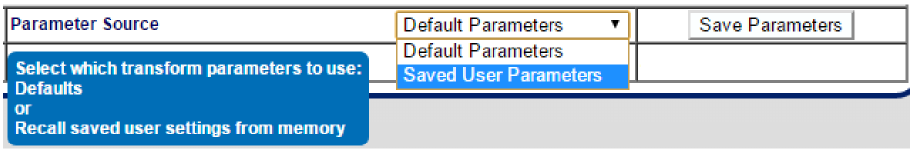


Transform functions are enabled or disabled from the Data Stream and Data Record tabs for each channel.

Note: To enable or disable a transform on any channel, it is necessary to reboot the Minimus. Transforms can be applied only on enabled channels.

Some transforms require parameters such as frequencies or coefficients. For these, the user can either use a fixed, default set, or create their own custom set.

To use customised parameters, visit the “Transform Parameters” tab and find the “Parameter Source” drop-down menu, select the “Saved User Parameters” option. Type in the required parameters and then click Save Parameters to store them. It is possible to reset the “Saved User Parameters” by clicking Save Parameters while “Default parameters” is selected, which will overwrite the customised parameters with the default values.

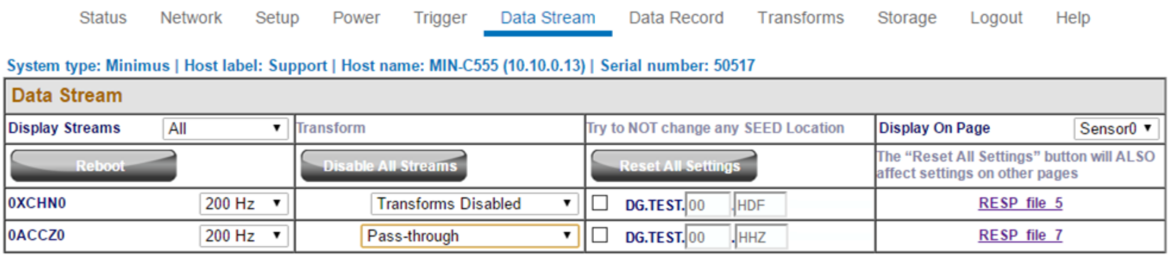


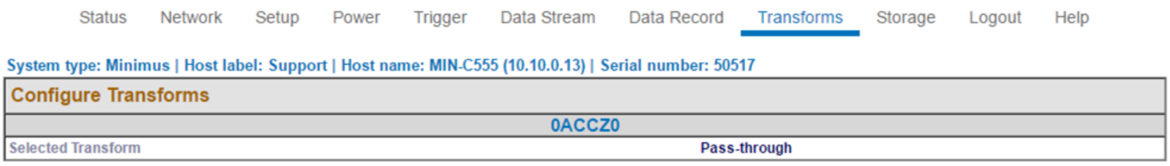
The various transforms are described in the following section:

Caution: The Disable All Streams button at the top of the Data Stream section does not disable *transforms* for all streams. It stops *transmission* of all streams, which may not be what you intend.

2.9.1 Pass-Through

This null transform simply outputs a copy of the input data, without applying any transform. It has no configuration parameters.

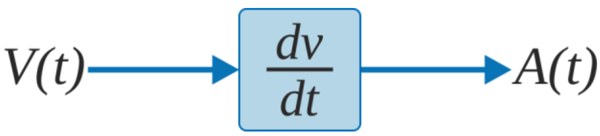


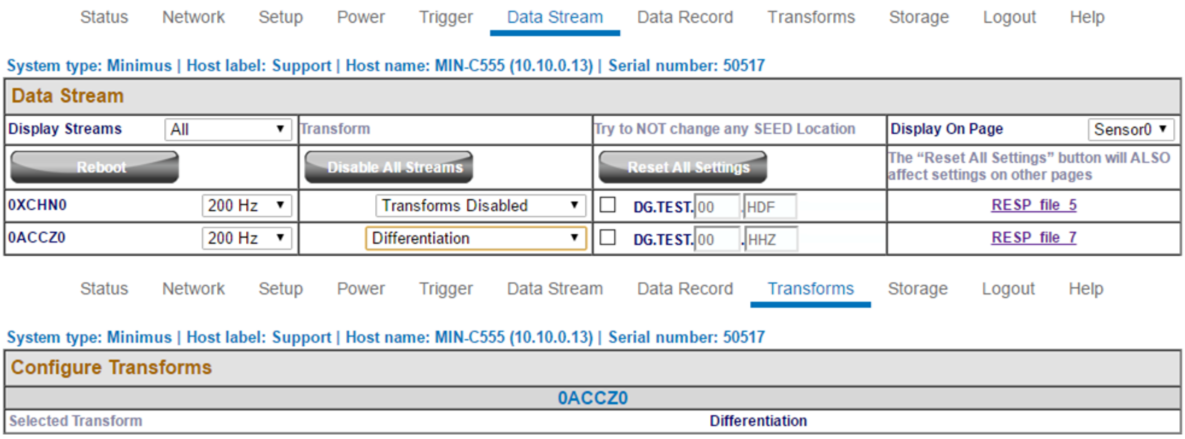


Note: This transform is selected by default when transforms are first enabled or when an invalid transform is selected. Do not use pass-through as a method of disabling transforms: instead, select "Disable Transforms for this tap" from the drop-down menu next to each stream on the "Data Streams" tab,

2.9.2 Differentiation

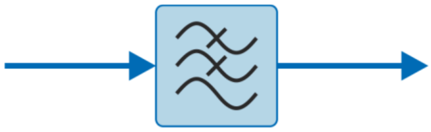
This transform differentiates the input data, for example if the input is a velocity (ms^{-1}) channel, the output will be acceleration (ms^{-2}). It has no configuration parameters.



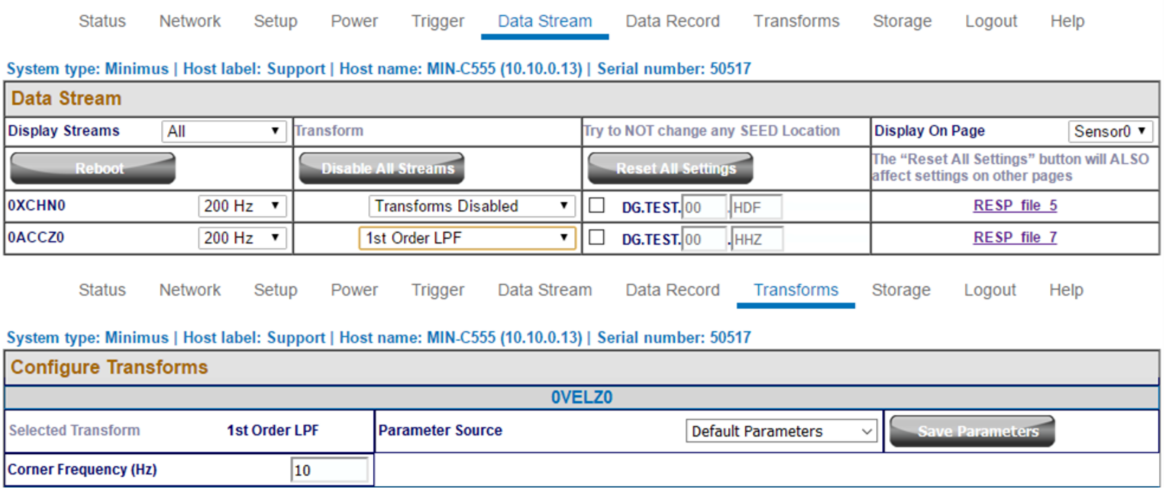


2.9.3 1st Order LPF

This transform applies a first-order low-pass filter to the input data.

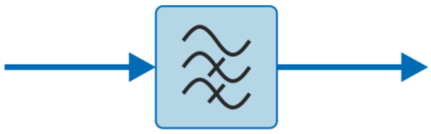


The single configurable parameter is "Corner Frequency": this specifies, in Hz, the frequency at which the output power is attenuated by -3 dB. Above this frequency, output power is attenuated by a further 6 dB per octave or 20 dB per decade.



2.9.4 1st Order HPF

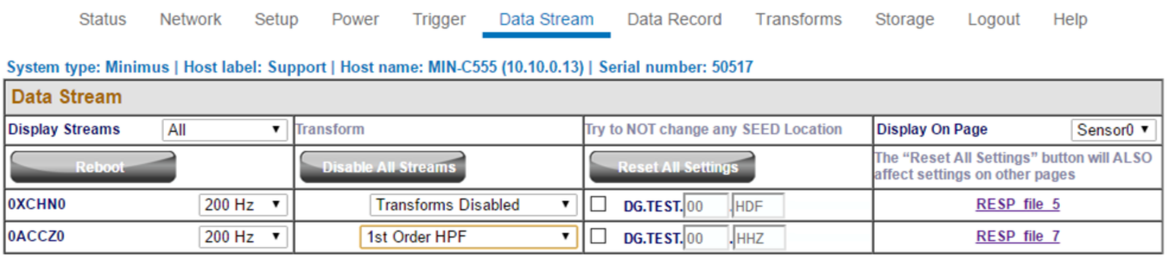
This transform applies a first-order high pass filter to the input data.

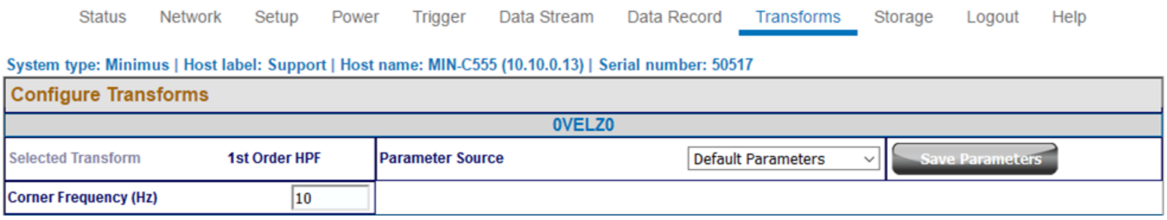


The output is the difference between a low-pass filtered copy of the signal and the unfiltered signal.

The single configurable parameter is "Corner Frequency": this specifies, in Hz, the frequency at which the output power is attenuated by -3 dB. Below this frequency, output power is attenuated by a further 6 dB per octave or 20 dB per decade.

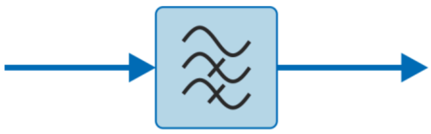
Note: The high-pass filter is implemented by subtracting the output of a low-pass filter from the unfiltered data:





2.9.5 1st Order Band/Notch Filter

This transform applies first-order band stop or Notch filter to the input data.

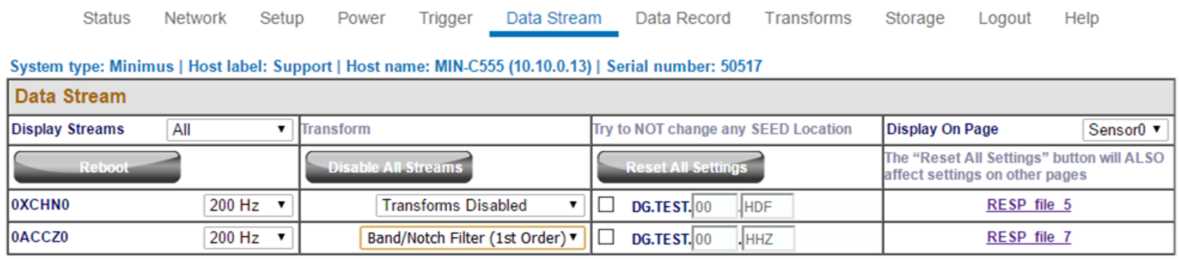


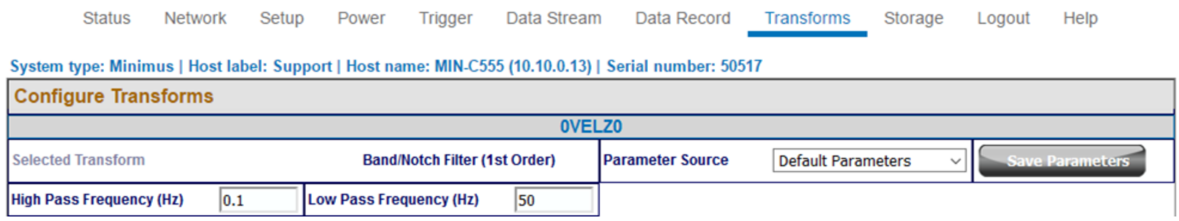
The band-stop filter is implemented as a configurable chain of two components:

A 1st order high pass filter (implemented using an LPF and a subtractor, as described in Section 2.9.4), to gradually attenuate low-frequency integrator drift.

A 1st order low pass filter (implemented as described in Section 2.9.3).

The configurable parameters are the "High Pass Frequency" (HPF corner frequency as defined in Section 2.9.4) and the "Low Pass Frequency" (LPF corner frequency as defined in Section 2.9.3).





2.9.6 2nd Order Biquad

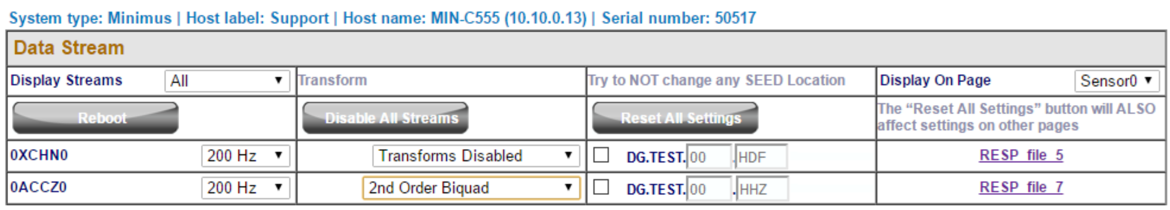
This transform applies a second-order bi-quadratic filter to the input data.

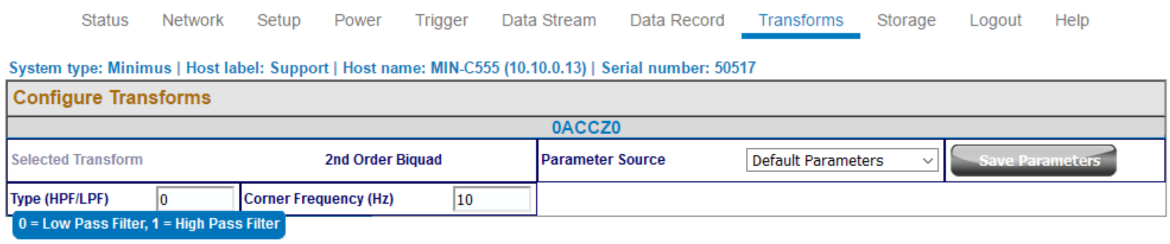
$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{a_0 + a_1 z^{-1} + a_2 z^{-2}}$$

The biquad filter is a second-order recursive linear filter, containing two poles and two zeros. In the Z-plane, the transfer function is the ratio of two quadratics in z, as shown.

The two configurable parameters are:

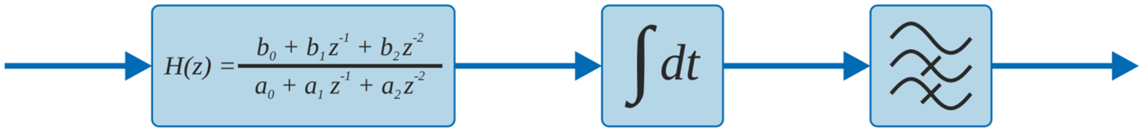
- "Corner Frequency": this specifies, in Hertz, the frequency at which the output power is attenuated by -3 dB; and
- "Type":
  - 0: low-pass mode; and
  - 1: high-pass mode.





2.9.7 Integration

This transform integrates the input data, e.g. if the selected channel unit is velocity (ms-1), the output produced is displacement (m).

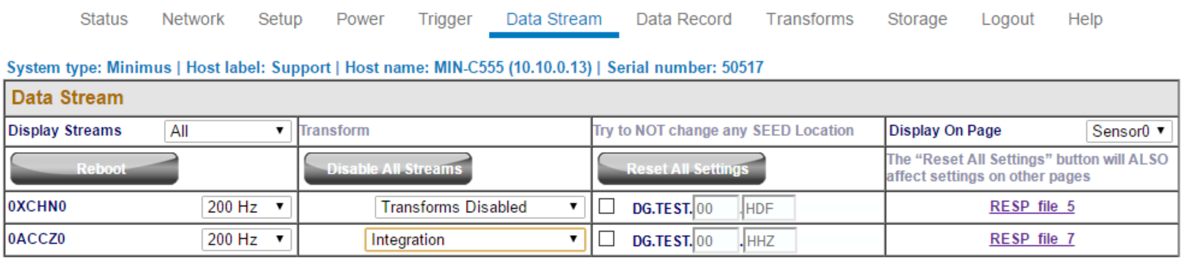


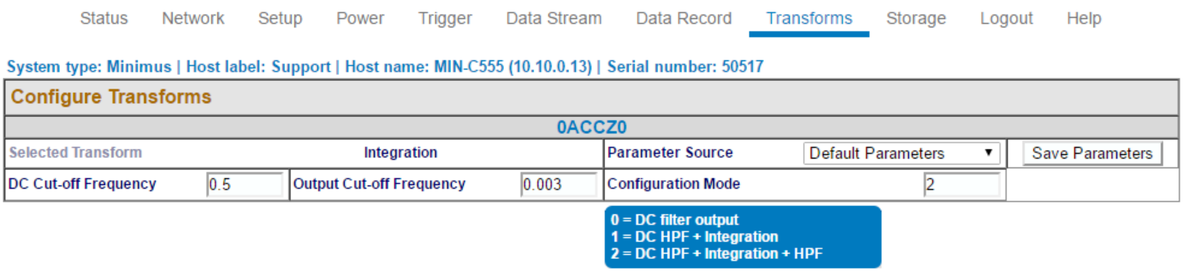
The integration transform is implemented as a configurable chain of three components:

- A DC filter (2nd order high-pass bi-quadratic) removes any DC component, which would cause the output to grow without limit;
- The integrator itself; and
- A 1st order high pass filter (implemented using an LPF and a sub-tractor, as described in Section 2.9.4), to gradually attenuate low-frequency integrator drift.

The configurable parameters are:

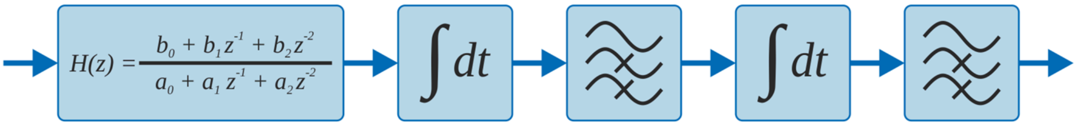
- "DC Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the initial high-pass filter;
- "Output Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the output high-pass filter;
- “Configuration Mode”, which configures how many elements of the chain are used. The options are:
  - Apply only the initial DC filter;
  - Apply the DC filter and the integrator; and
  - Apply the DC filter, the integrator and the output HPF.





2.9.8 Double Integration

This transform integrates the input data twice so, for example, if the selected channel is acceleration (ms^{-2}), the output produced is displacement (m).



Analogously to the single integrator, the double integrator applies an initial DC high-pass filter and then two further high-pass filters, one at the output of each integrator. The high-pass filters are implemented using an LPF and a subtractor

The configurable parameters are:

- "DC Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the initial high-pass filter;
- "Interstage Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the first integrator output high-pass filter;
- "Output Cut-off Frequency": this specifies the -3 dB (in Hertz) point for the second integrator output high-pass filter;
- “Configuration Mode”, which configures how many elements of the chain are used. The options are:

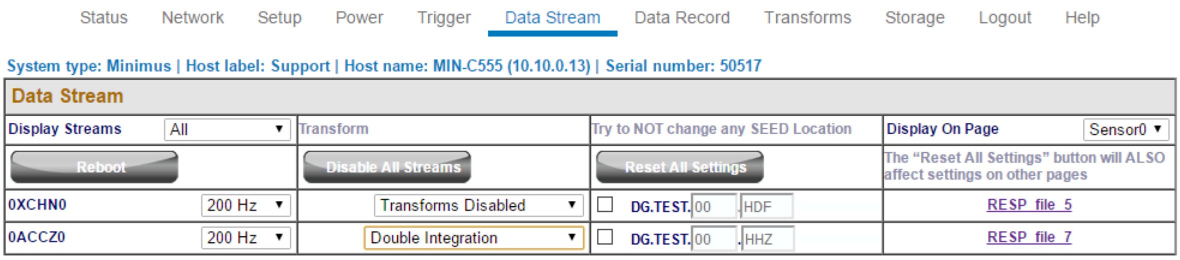
  0 Apply only the initial DC filter;

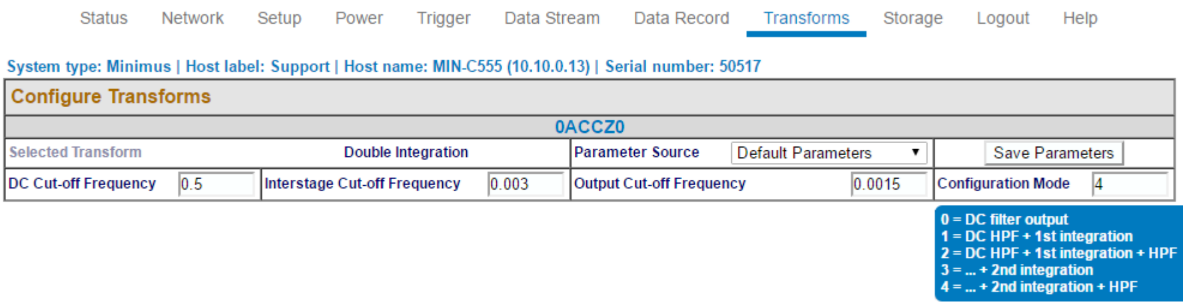
  1 Apply DC filter and first integrator;

  2 Apply DC filter, first integrator and interstage HPF;

  3 Apply DC filter, first integrator, interstage HPF and second integrator; and

  4 Apply DC filter, first integrator, interstage HPF, second integrator and second output HPF.



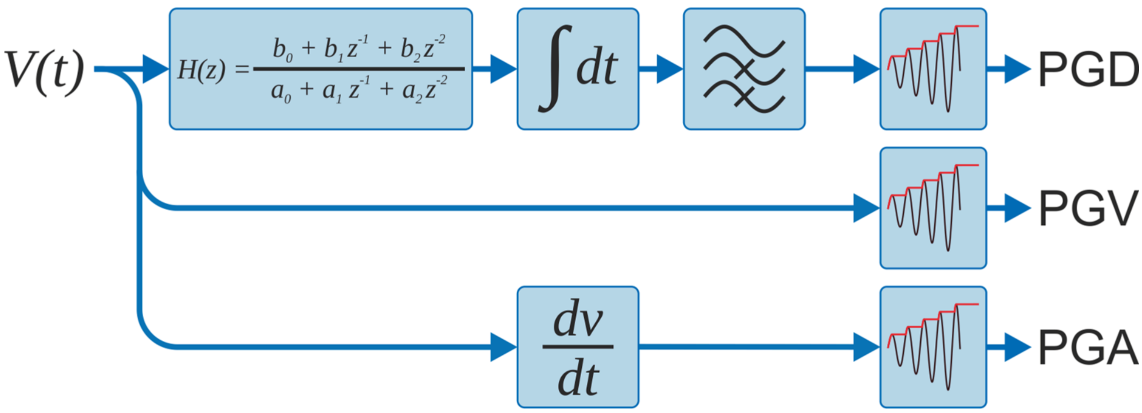


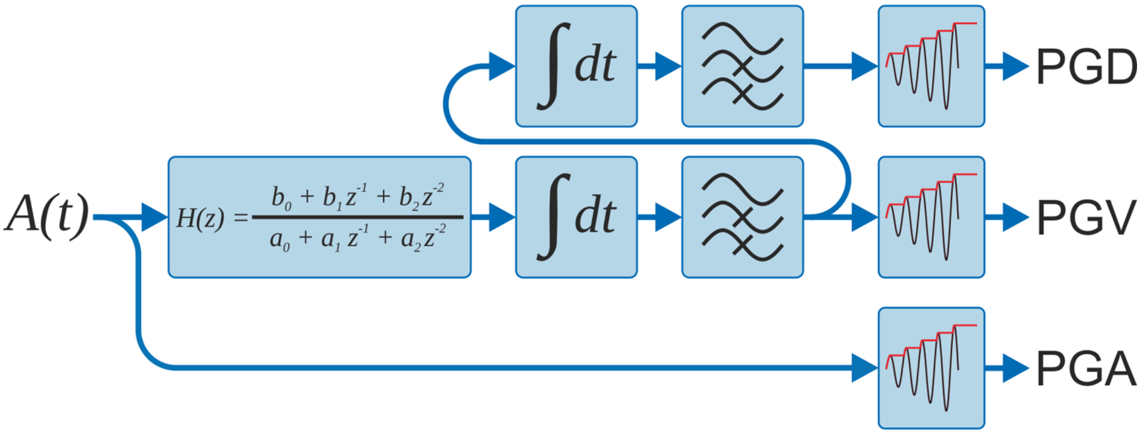
2.9.9 EEW CAP Parameters – Observer

When an EEW trigger occurs (or is simulated – see below), the peak ground motion values (Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV) and Peak Ground Displacement (PGD)) are calculated and automatically recorded over the selected time-window and subsequently transmitted as a CAP message (see Section 2.10.3 for more details). This transform allows the operator to directly observe the acceleration, velocity and displacement output on the real-time streams. It is available for use with both velocity and acceleration input signals.

> **Note:** The EEW parameter transform can work as an observer: doesn't necessarily modify the data streams on which it is applied.

The implementation of the transform differs, depending on whether the input stream represents velocity or acceleration data.





The high-pass filters are implemented using an LPF and a subtracter, as described in Section 2.9.4.

The configurable parameters are:

- "DC Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the initial high-pass filter;
- "Interstage Cut-off Frequency": this specifies the -3 dB point (in Hertz) for the first integrator output high-pass filter. This is only used when the input signal is acceleration;
- "Output Cut-off Frequency": this specifies the -3 dB (in Hertz) point for the sole (velocity input) or final (acceleration input) integrator output high-pass filter;
- "Window time": this specifies the duration, in seconds, of the time-window over which the peak values are reported;
- “Preview Mode”: the values to be shown in the output stream:

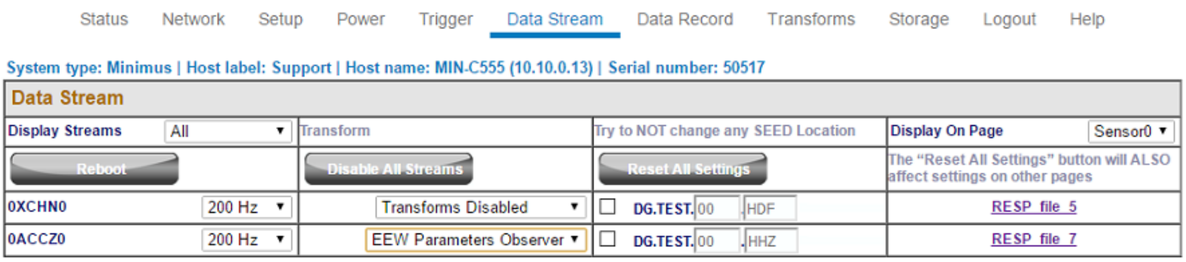
  0 unmodified original stream (acceleration or velocity);

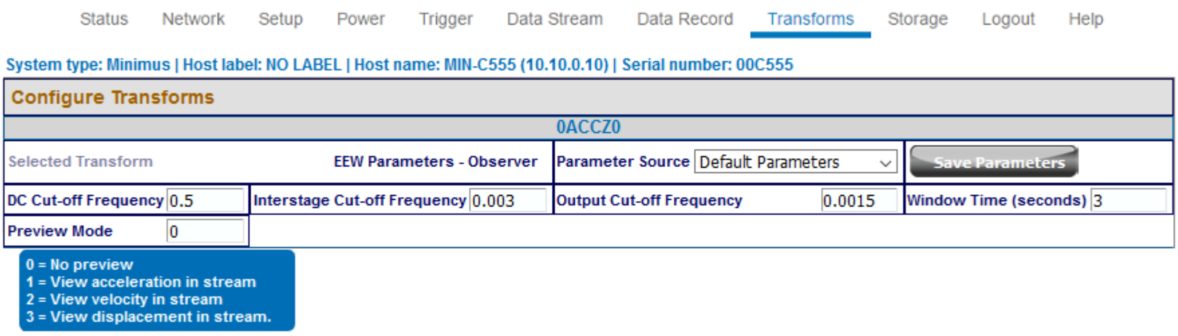
  1 acceleration;

  2 velocity; or

  3 displacement.

Note: Güralp recommend using the integration (Section 2.9.7) and double integration (Section 2.9.8) transforms to test the filter parameters, because the effect of the parameters will then be clearly visible in the transformed streams. Once suitable parameters have been determined, they can be copied to the “EEW CAP Parameter – Observer” transform.

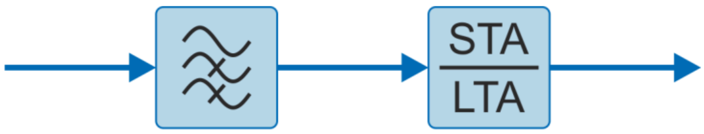




2.9.10 STA/LTA Ratio

The Earthquake Early Warning system (EEW) compares the ratio of a short-term average (STA) to a long-term average (LTA) in order to detect a "trigger" conditions. For more information see Section 2.10.1.1.

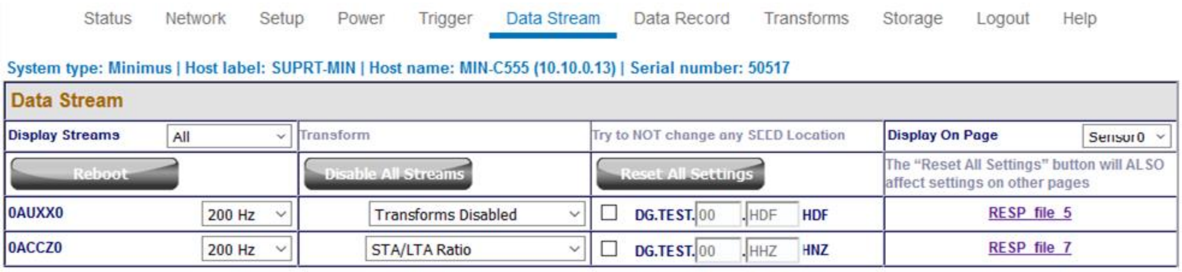
This transform is included to help determine parameters for configuring the EEW system. It does not affect the operation of the EEW system in any way. The transform calculates the ratio between the result of the Short Term Average filter and the Long Term Average filter. The input signal is passed through a high-pass filter which removes any DC offset.

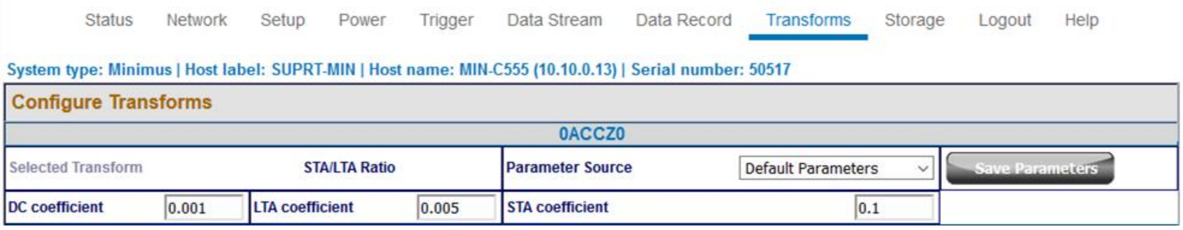


The configurable parameters are:

- "DC Frequency (Hz)": this specifies the corner frequency (-3 dB point) in Hertz for the initial high-pass filter;
- "STA Period (seconds)": this is the Short Term Average filter time period (the reciprocal of the corner frequency);
- "LTA Period (seconds)": this is the Long Term Average filter time period (the reciprocal of the corner frequency);

The high-pass filter is implemented using an LPF and a subtracter, as described in Section 2.9.4.

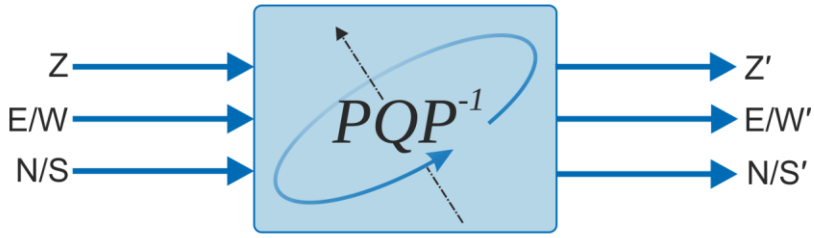




2.9.11 Rotation (Triplet)

This transform rotates three velocity/acceleration seismic components in space. Rotations are represented by unit quaternions (in preference to the more usual Euler angles: yaw, pitch and roll) because they are unambiguous and avoid the problem of gimbal lock.

Note: The rotation transform can only be applied if the transform is enabled on all three velocity/acceleration components of a single instrument at the same sample rate.



Any rotation in three-dimensional space can be represented as a combination of a unit three-dimensional vector, $\vec{u}$, which specifies the axis (and sense) of the rotation, and a scalar angle, θ, which specifies the amount of rotation

Güralp follows a North, East, Up convention when describing sensor orientation. Using this convention, we can represent $\vec{u}$ as [u,v,w] and use Pauli's extension to Euler's formula:

$$\mathrm{q} = \cos\left(\frac{\theta}{2}\right) + (u\mathrm{i} + v\mathrm{j} + w\mathrm{k})\sin\left(\frac{\theta}{2}\right)$$

to form a quaternion: $\mathrm{q} \equiv [a, b, c, d]$ where:

$$a = \cos\left(\frac{\theta}{2}\right), b = \sin\left(\frac{\theta}{2}\right)u, c = \sin\left(\frac{\theta}{2}\right)v \text{ and yes } d = \sin\left(\frac{\theta}{2}\right)w$$

For example, a perfectly- oriented sensor has a (null) rotation of $[1,0,0,0]$, where the sensor's Z, N and E axes align with the North, East and Up global axes.

A rotation of

$$\left[\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0,0\right]$$

represents a sensor that has been rotated 90° about its x axis to align the sensor's Z, N and E axes with global North, Down and East respectively.

Note: Clockwise rotations, when looking along an axis, are denoted as positive. This is generally known as the "right-hand rule" because, if you point your right thumb along the (directed) axis, your fingers will curl in a clockwise direction about it.

In the degenerate case of a simple rotation about a vertical axis (commonly used to correct data from a misaligned borehole instrument), the axis of rotation is vertical, so our unit vector is [0,0,1] (following the "North, East, Up" convention). To rotate by θ (where positive θ is clockwise when looking upwards), our quaternion should be:

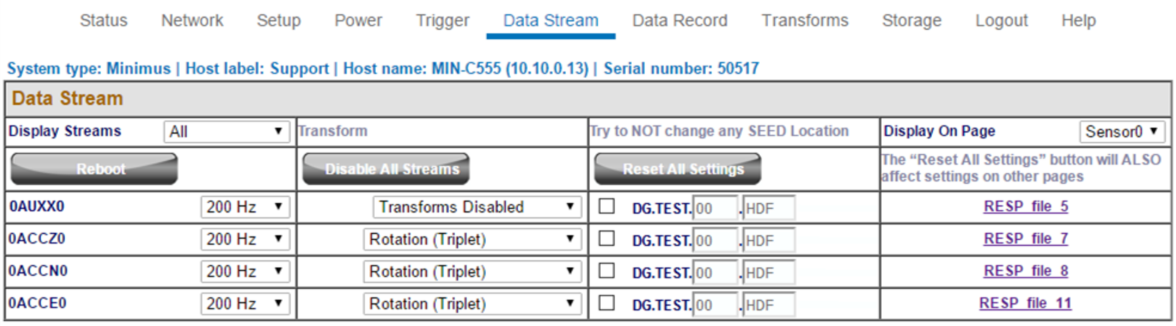
$$\mathrm{q} = \cos\left(\frac{\theta}{2}\right) + (0\mathrm{i} + 0\mathrm{j} + 1\mathrm{k})\sin\left(\frac{\theta}{2}\right) \equiv \left[\cos\left(\frac{\theta}{2}\right), 0,0, \sin\left(\frac{\theta}{2}\right)\right]$$

As a final check, note that

$$a^2 + b^2 + c^2 + d^2 = \cos^2\left(\frac{\theta}{2}\right) + 0^2 + 0^2 + \sin^2\left(\frac{\theta}{2}\right) = 1$$

which satisfies our requirement for a unit quaternion. The parameters to enter in the Configure Transforms fields are, therefore:

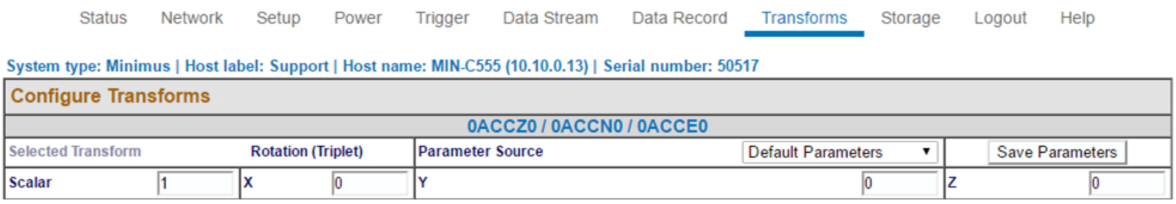
Scalar $\Rightarrow \cos\left(\frac{\theta}{2}\right)$, **X** $\Rightarrow 0$, **Y** $\Rightarrow 0$ and **Z** $\Rightarrow \sin\left(\frac{\theta}{2}\right)$



Status Network Setup Power Trigger Data Stream Data Record Transforms Storage Logout Help

System type: Minimus | Host label: Support | Host name: MIN-C555 (10.10.0.13) | Serial number: 50517

Data Stream						
Display Streams	All	Transform	Try to NOT change any SEED Location		Display On Page	Sensor0
Reboot		Disable All Streams	Reset All Settings		The "Reset All Settings" button will ALSO affect settings on other pages	
0AUXX0	200 Hz	Transforms Disabled	DG.TEST. 00	HDF	RESP_file_5	
0ACCZ0	200 Hz	Rotation (Triplet)	DG.TEST. 00	HDF	RESP_file_7	
0ACCN0	200 Hz	Rotation (Triplet)	DG.TEST. 00	HDF	RESP_file_8	
0ACCE0	200 Hz	Rotation (Triplet)	DG.TEST. 00	HDF	RESP_file_11	



Status Network Setup Power Trigger Data Stream Data Record Transforms Storage Logout Help

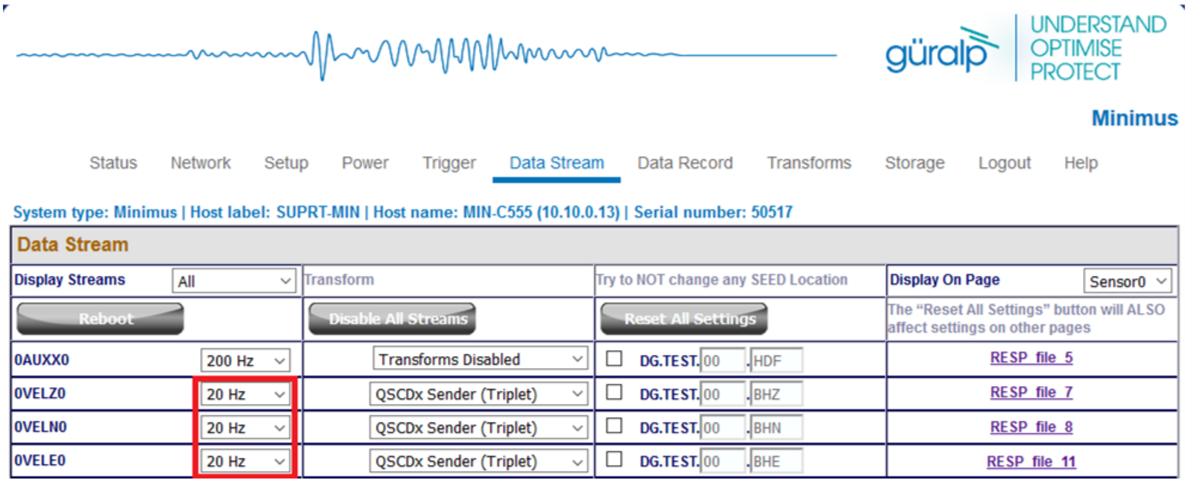
System type: Minimus | Host label: Support | Host name: MIN-C555 (10.10.0.13) | Serial number: 50517

Configure Transforms							
0ACCZ0 / 0ACCN0 / 0ACCE0							
Selected Transform	Rotation (Triplet)			Parameter Source	Default Parameters	Save Parameters	
Scalar	1	X	0	Y	0	Z	0

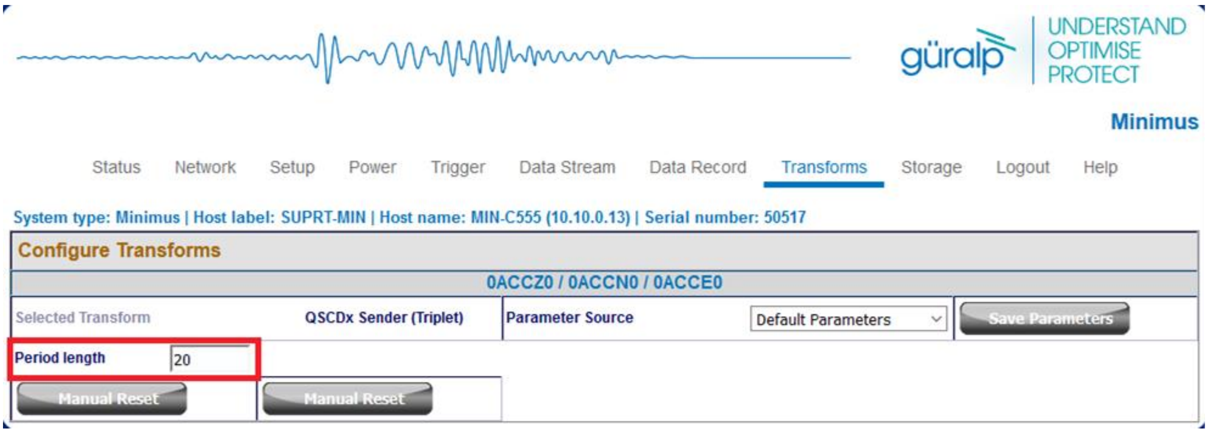
2.9.12 QSCD Sender (Triplet)

The QSCD protocol (Quick Seismic Characteristic Data) transmits values computed from the three triaxial streams of an instrument. One packet is transmitted every second so the number of samples in each packet is equal to the sample rate of the three input streams. Refer to Section 2.10.7 for more details about the QSCD protocol.

QSCD calculations are implemented using transforms and configured via the Data Stream tab of the Minimus web page. The three input channels must all be configured with the QSCD (triplet) transform. The transform is disabled if the sample rates of the input streams do not match.



In the "Transform Parameters" tab, the parameter "Period length" configures the number of samples to include in a QSCD packet. For example, QSCD20 requires the sample rate of the streams to be 20 samples per second so the "Period length" must be set to 20 (samples), to send a packet every second.

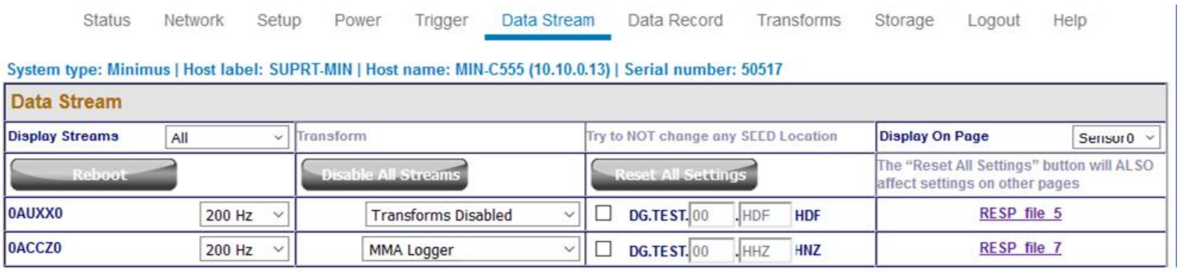


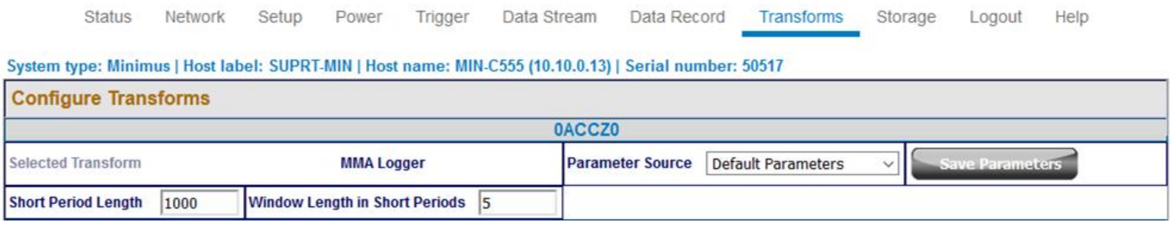
2.9.13 MMA Logger

The MMA logger transform is a function that periodically calculates and logs Maximum Minimum and mean (Average) values over a selected window of data.

The two configurable parameters are:

- "Short Period Length": this is the length of time between logging events expressed in samples, e.g. 200 samples when applied to a tap configured at 100sps produces an MMA calculation and logging every 2 seconds.
- “Window Length in Short Periods”: is the length of window over which the Max, Min and Average values are calculated, in terms of number of short periods.





2.10 Triggers

The Trigger tab is dedicated to Earthquake Early Warning settings. These are disabled by default because of the amount of processing resource – and hence, power – consumed by triggering calculations.

The Triggers section of the web page enables the user to configure the triggering system. The trigger Sources should be configured firstly because different configuration options are displayed for different source types. Once the source-specific settings are configured, the scores and destinations should be specified. Destinations can be shared between sources, allowing the creation of networks (directed graphs) of systems for distributed event detection.

The heart of the Earthquake Early Warning subsystem are the triggering algorithms: an STA/LTA (Short-Time-Average divided by Long-Time-Average) and a threshold algorithm.

The STA/LTA algorithm continuously calculates the average values of the absolute amplitude of a seismic signal in two simultaneous moving-time windows. The short time average (STA) is sensitive to seismic events while the long-time average (LTA) provides information about the current amplitude of seismic background noise at the site. When the ratio of STA to LTA exceeds a pre-set threshold value an event is “declared”.

The threshold algorithm, instead, declares the presence of an event when the raw data from the input passes above or below a pre-set threshold value.

2.10.1 Trigger Sources

The available sources for the trigger are listed below, along with the configurable fields available in each case.

1. **1st/2nd/3rd/4th Remote Source**: This setting is used for multiple-source triggering networks. The sources specified here are other Minimus based instruments, specified by the IP addresses configured in the “Remote Inputs” section:

Triggers configuration					
Source	1st Remote Source	Score	100	Destination	Disabled

The configurable fields in these cases are:

- Score: this assigns a value to the trigger. The score value is used when assessing multiple-source triggers simultaneously, where the total score value of all triggers can be set as a threshold variable of a destination. This value is ignored when a trigger is not configured to use multiple sources.
- Destination: this drop-down menu specifies the destination for the trigger. See Section 2.10.2 for more information.
- n^{th} Address: is the IP address of the remote source, *e.g.* another Minimus.

Sources	
	Remote Inputs
1st Address	

2 **1st/2nd/3rd/4th I/O Expander Input**: Select this option to use inputs from a connected Minimus 8 channel I/O Expander Module.

Triggers configuration					
Source	1st I/O Expander Input	Score	100	Destination	Disabled

The configurable fields in these cases are:

- Score: this assigns a value to the trigger. The score value is used when assessing multiple-source triggers simultaneously, where the total score value of all triggers can be set as a threshold variable of a destination. This value is ignored when a trigger is not configured to use multiple sources.
- Destination: this drop-down menu specifies the destination for the trigger. See Section 2.10.2 for more information.

3 **Tap Trigger *N*:** Chose between seismic or auxiliary Minimus channels among any of the active taps in the "Data Stream" and "Data Record" tabs.

Triggers configuration					
Source	Tap Trigger A [0ACCZ0]	Score	100	Destination	Disabled

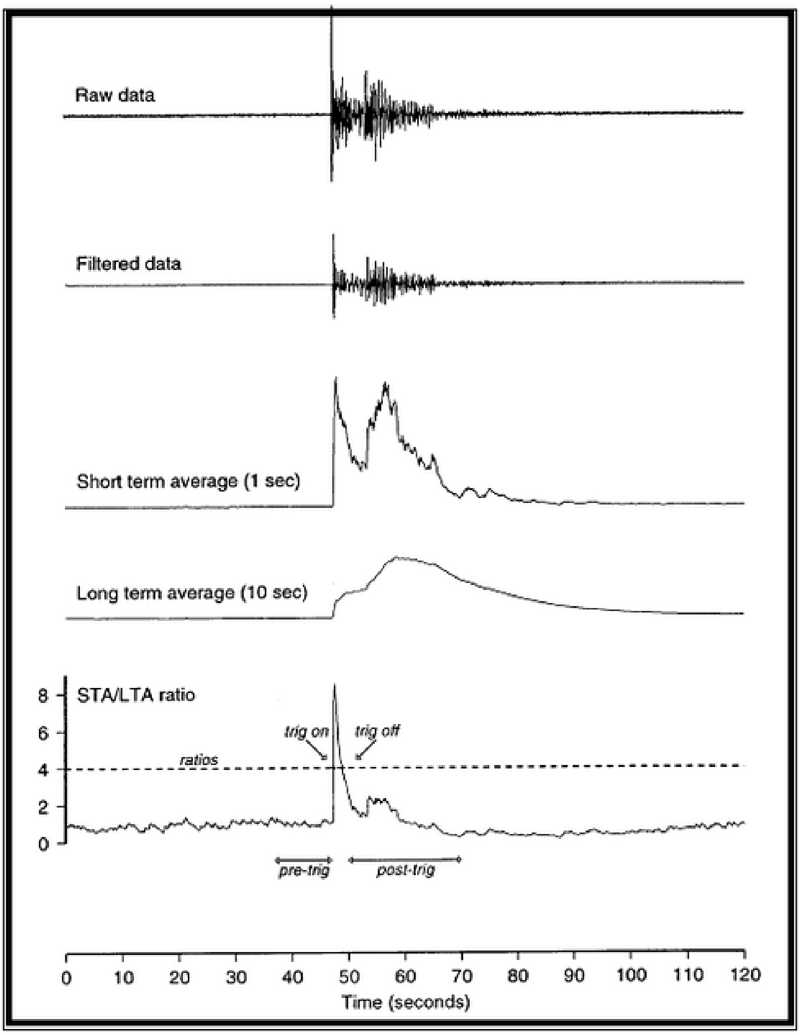
Note: Tap trigger is only an option if you've populated the Source field "Tap Trigger A" with a sensor and trigger value

The configurable fields for Tap Triggers are:

- Score: this assigns a value to the trigger. The score value is used when assessing multiple-source triggers simultaneously, where the total score value of all triggers can be set as a threshold variable of a destination. This value is ignored when a trigger is not configured to use multiple sources.
- Destination: this drop-down menu specifies the destination for the trigger. See Section 2.10.2 for more information.
- Sources: Sensor number: this drop-down menu selects which sensor's streams to use as input for the trigger algorithm.
- Sources: Tap: this drop-down menu allows selection of the stream to use as input for the trigger algorithm. The choice is between single taps, *e.g. 0VELZ0*, or triplets, *e.g. First Seismo Triplet*.
- Sources: Trigger type: this drop-down menu allows the use of either **STA/LTA** or **Threshold** algorithm.

2.10.1.1 STA/LTA Algorithm

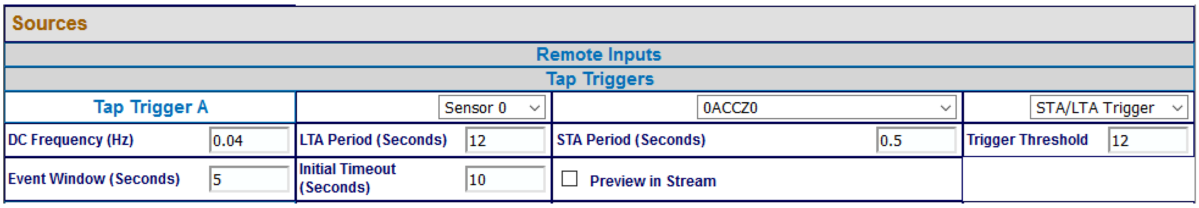
Averages of the modulus of signal amplitude are computed over two user-defined time periods, a short time average (STA) and a long time average (LTA), and the ratio of the two at each sample point is computed (STA/LTA). If this ratio exceeds a user-defined threshold, then a trigger is declared, and the system remains in a triggered state until the ratio falls below the defined threshold. The STA/LTA algorithm is used to remove the effects of varying background noise.



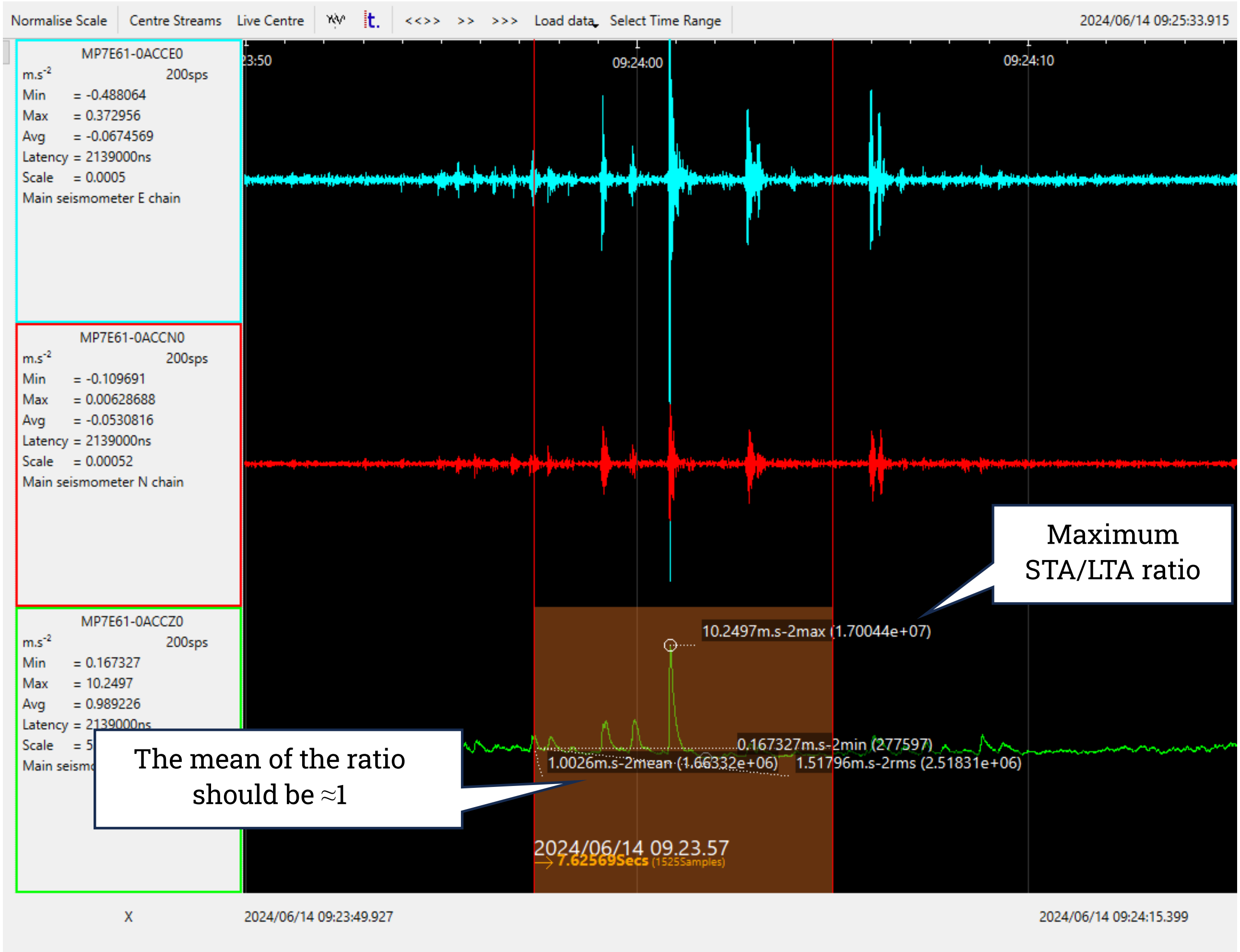
The purpose of taking a short term average, rather than triggering on signal amplitude directly, is to reduce the probability of triggering on spurious spikes or short duration transients, and to introduce some element of frequency selectivity into the triggering process. As a rule of thumb, the short term average should be set to the dominant frequency of the events the trigger is designed to catch.

The purpose of the long term average is to provide a measure of the variation in the background seismic noise, so it should be set to some value longer than the period of the lowest frequency seismic signal of interest. Obviously there is some element of trade-off in setting a value for the trigger ratio. Too high a value will result in events being missed, while too low a value will result in spurious non-seismic noise triggering the system producing false alarms. Determining an appropriate value in any given situation which maximises the number of seismic events detected while minimising the number of false alarms is a matter of experimentation.

The STA/LTA trigger algorithm includes the configuration of the following parameters:

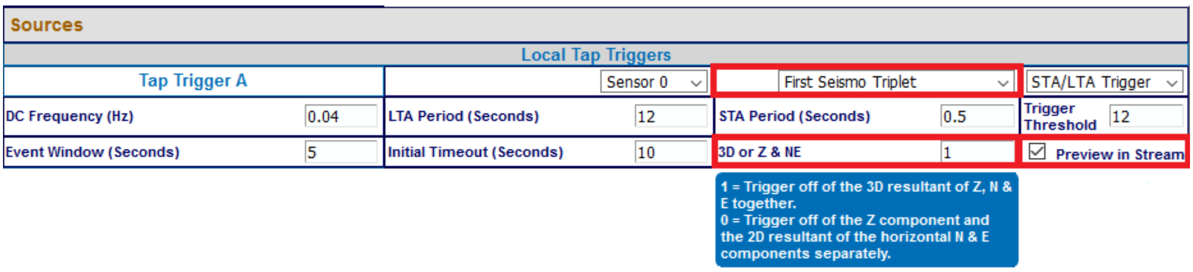


- “DC Frequency”: initial AC coupling HPF corner frequency;
- “LTA Period”: Long Term Average filter time period (1/corner frequency);
- “STA Period”: Short Term Average filter time period (1/corner frequency);
- “Trigger Threshold”: STA/LTA ratio level at which a trigger occurs;
- “Event Window”: After an event has been detected, subsequent crossing of the STA/LTA ratio threshold within the defined event window are treated as part of the same event and, therefore, not considered as a new trigger event;
- “Initial Timeout”: period of inactivity after the trigger function is initialised or changed to avoid false triggers.
- The “Preview in Stream” box enables the live streams to output the calculated trigger thresholds , *i.e.* the STA/LTA ratio. When a single stream is selected as source, the calculated STA/LTA ratio is shown in place of the original data.



When a triplet is selected as source, “3D or Z & NE” parameters are used to choose what type of preview to visualise.

For STA/LTA ratio trigger algorithm:



0 shows the STA/LTA ratio calculated on a 2D resultant vector of N and E components. The 2D STA/LTA ratio is shown in place of original E/W component. The Z component also shows the STA/LTA ratio calculated instead of the original seismic data. The N/S component shows normal seismic output.

1 shows the STA/LTA ratio calculated on 3D resultant vector of Z, N and E components. The STA/LTA ratio is shown on E/W component. Z and N/S components show their normal seismic output.

2.10.1.2 *Threshold Algorithm*

The threshold algorithm declares the presence of an event when the raw data input passes above or below a pre-set threshold value.

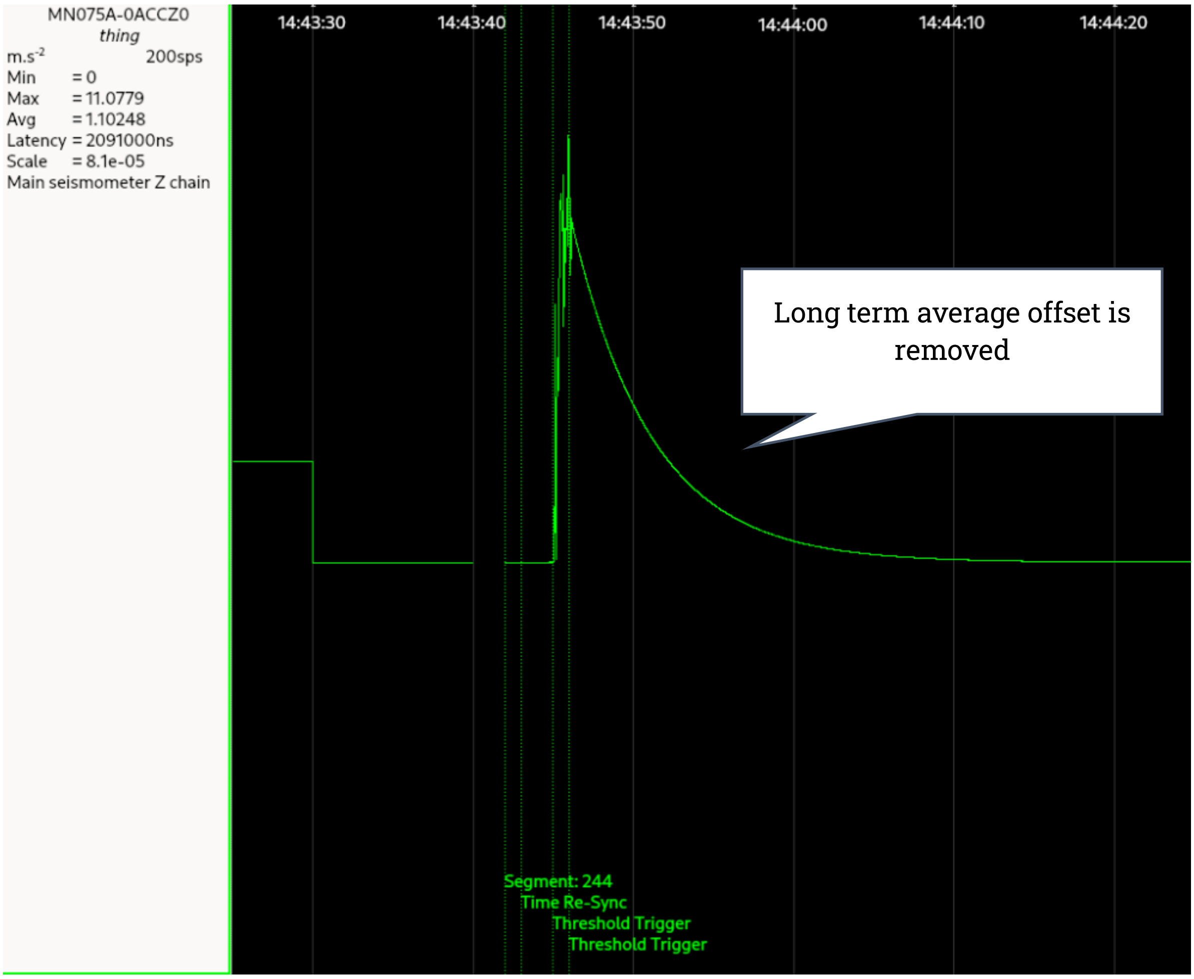
> **Note:** Since the threshold value has to be expressed in physical units, *e.g.* m/s^2, the right instrument response parameters have to be entered in the calibration editor when an analogue instrument (*e.g.* Fortis) is connected to a Minimus. Please see Section 2.5.1.5 for more details.

The threshold trigger algorithm includes the configuration of the following parameters:

Sources							
Remote Inputs							
Tap Triggers							
Tap Trigger A		Sensor 0		0ACCZ0		Threshold Trigger	
Absolute Mode	0	Low/High Mode	1	Threshold	10	Timeout	10
Hysteresis Percentage	10	☐ Preview in Stream					

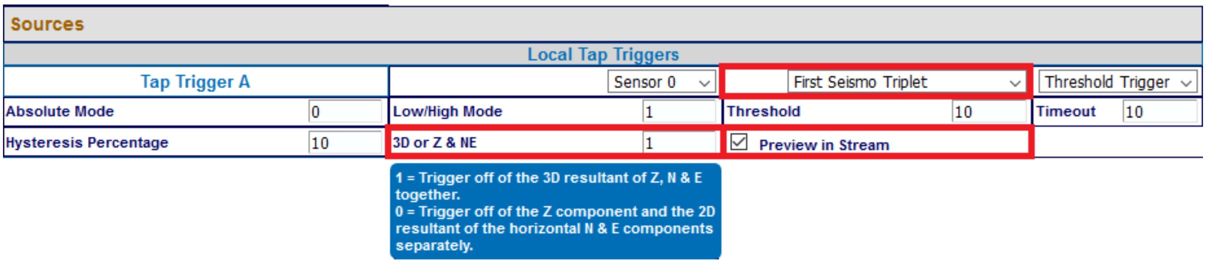
- "Absolute Mode": specifies if the threshold must act on the magnitude of the signal with a sign (+,-), options include:
  - 0 Real Values: the trigger will act on the standard response of the signal (positive or negative) against the given threshold
  - 1 Absolute Values: Will take the absolute value (only positive) of the signal to compare against the threshold;
  - 2 Absolute Values DC Filter: Takes the absolute value of the source signal minus the DC offset (long term average), before comparing against the trigger threshold, only works for non-triplet sources;
- "Low/High Mode": defines whether the threshold is exceeded when the signal passes below it, or above it, the option are:
  - 0 Triggers when the signal passes **below** the threshold, Low Mode;
  - 1 Triggers when the signal passes **above** the threshold, High Mode
- "Threshold": value of the threshold expressed in a physical unit, this option will be interpreted based on the type of sensor selected for the source tap, *e.g.* m/s^2;
- "Timeout": specifies the time to wait (in seconds), after crossing the threshold, before accepting a new event;
- "Hysteresis Percentage": defines the hysteresis point in terms of percentage of the threshold value, below or above the threshold. The hysteresis point is below the threshold for High Mode and above the threshold for Low Mode.
- "Preview in Stream": When "Absolute Mode" is set to 1 and a single stream is selected as a source, enabling the "Preview in Stream" box shows within the live stream (from Discovery's main menu, right click the instrument,

highlight “Live View” and select "GDI") the absolute value of the original signal. When “Absolute Mode” is set to 2 and a single stream is selected as a source, enabling the “Preview in Stream” box shows within the live stream the absolute value of the original signal after the removal of the DC Offset (long term average).



When a triplet is selected as source, “3D or Z & NE” parameters are used to choose what type of preview to visualise.

For the Threshold trigger algorithm:



0 shows the 2D resultant vector of N and E components. The 2D resultant is shown in place of E/W component. Z and N/S components show normal seismic output.

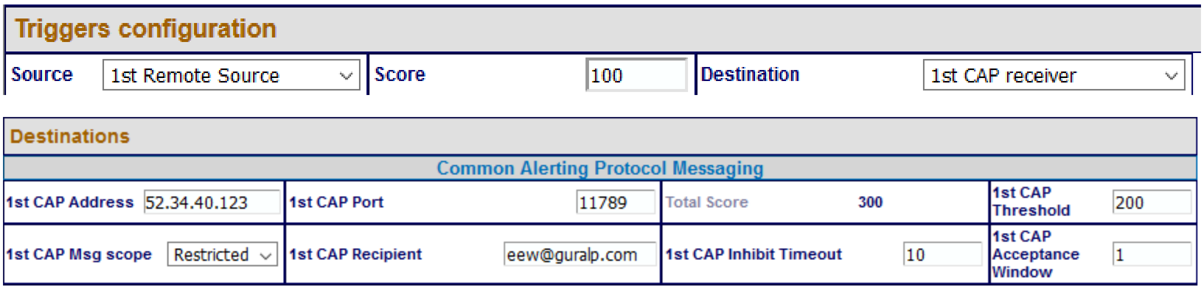
1 shows the 3D resultant vector of Z, N and E components. 3D resultant is shown in place of E/W component. Z and N/S components show normal seismic output.

2.10.2 Trigger Destinations

The options available form the various Destination fields are:

- **$1^{st}/2^{nd}/3^{rd}/4^{th}$ CAP receiver**: When a trigger is declared, the system will issue messages using the Common Alerting Protocol (for the full specification of this protocol, please refer to http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html).

This selection points to which of the four available CAP receivers the trigger information will be sent to, the CAP receivers can be configured as detailed below.



Various parameters control how the CAP message is created:

- n^{th} CAP Address: the IP address or Hostname of the CAP receiver;
- n^{th} CAP Port: the UDP port on which the CAP receiver is listening;
- Total Score: this is an information field, it displays an automatically-calculated total of the scores from all of the input sources that specify this as a destination;
- n^{th} CAP Threshold: The CAP threshold is used when multiple input sources subscribe to this destination, the score of each trigger is summed up and once it is equal to or greater than the threshold score, the events will be sent. Otherwise trigger threshold from the source configuration is used.
- n^{th} CAP Msg scope: This value is copied to the “scope” field of the CAP message, it allows the designation of CAP message to be Public, Private or Restricted;
  - Public: The CAP Receiver can send alerts to anyone
  - Restricted: The CAP Receiver is configured with a code to identify the groups it can send the alerts to
  - Private: The n^{th} CAP Recipient will be used as the only address the receiver can forward the alert to,
- n^{th} CAP Recipient: this value is copied to the “addresses” field of the CAP message, it is only required when the “n^{th} CAP Msg scope” is set to “Private”;

- n^{th} CAP Inhibit Timeout: Is the time the Minimus waits before sending a new CAP message if a new event is detected after a previous CAP message was sent;
- n^{th} CAP Acceptance Window: Subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window;

Common Alerting Protocol								
CAP Msg Expiry	300	seconds	CAP Msg Web URL	https://cap-validator.appspot.com	CAP Msg HMAC Key	secret		

- CAP Msg Expiry: This parameter determines the value used to populate the optional "expires" field in the CAP message. If required, it should be specified in seconds.
- CAP Msg Web URL: This parameter determines the value used to populate the optional "web" field in the CAP message. It should be a full, absolute URL for an HTML page or other text resource with additional or reference information regarding this alert.
- CAP Msg HMAC Key: A shared key used for signing the CAP message. All CAP messages generated by Minimus are signed. The user should set this key to a private value. The HMAC (High-based Message Authentication Code) digest can then be used to both authenticate the sender and validate the contents of CAP messages by anyone who is privy to the shared key. This prevents the generation of false, malicious CAP messages by a third party.

Note: EEW parameters (PGA, PGV and PGD values) are sent in the CAP message's body only if the "EEW parameter – Observer" transform is enabled on the source taps (see Section 2.9.9).

Note: Güralp Discovery software includes a CAP (Common Alerting Protocol) receiver. For detailed information about the Discovery CAP receiver, please refer to Discovery's manual (MAN-DIS-0001).

- **1st-8th I/O Expander Output**: Select this value to use outputs from a connected Minimus 8 channel I/O Expander Module. See MAN-MIN-1001 for more details.

Triggers configuration					
Source	Tap Trigger A [0VELZ0]	Score	100	Destination	1st I/O Expander Output

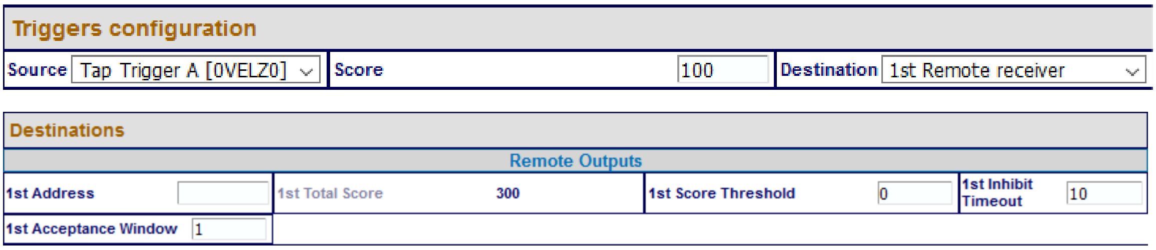
Destinations							
Relay Outputs							
1st Hold Time	1			1st Total Score	300	1st Score Threshold	200
1st Inhibit Timeout	10	1st Acceptance Window	1				

Various parameters control how the I/O Expander behaves:

- n^{th} Hold Time: Is the relay switch timeout in seconds. If configured to *0*: no timeout is used, otherwise the relay will be released after a specified number of seconds;

- n^{th} Total Score: This is an information field, it displays an automatically-calculated total of the scores from all of the input sources that specify this as a destination;
- n^{th} Score Threshold: this threshold is used when multiple input sources subscribe to this destination, the score of each trigger is summed up and once it is equal to or greater than the threshold score, the commands will be sent. Otherwise trigger threshold from the source configuration is used.
- n^{th} Inhibit Timeout: Is the time in seconds the Minimus waits before sending a new command to the I/O Expander, if a new event is detected after a previous command was sent;
- n^{th} Acceptance Window: Subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window (expressed in seconds).

- **$1^{st}/2^{nd}/3^{rd}/4^{th}$ Remote receiver:** This setting is used to consolidate multiple triggers to a single Minimus for it to act as a hub for triggering activity. The destinations specified here require a networked Minimus based instruments, specified by the IP address configured in the “Remote Outputs” section:



  - n^{th} Address: The IP address of the networked Minimus;
  - n^{th} Total Score: This is an information field, it displays an automatically-calculated total of the scores from all of the input sources that specify this destination;
  - n^{th} Score Threshold: : this threshold is used when multiple input sources subscribe to this destination, the score of each trigger is summed up and once it is equal to or greater than the threshold score, the message will be sent. Otherwise trigger threshold from the source configuration is used.
  - n^{th} CAP Inhibit Timeout: Is the time the Minimus waits before sending a new message, if a new event is detected after a previous message was sent;
  - n^{th} Acceptance Window: Subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window.

2.10.3 CAP Receiver

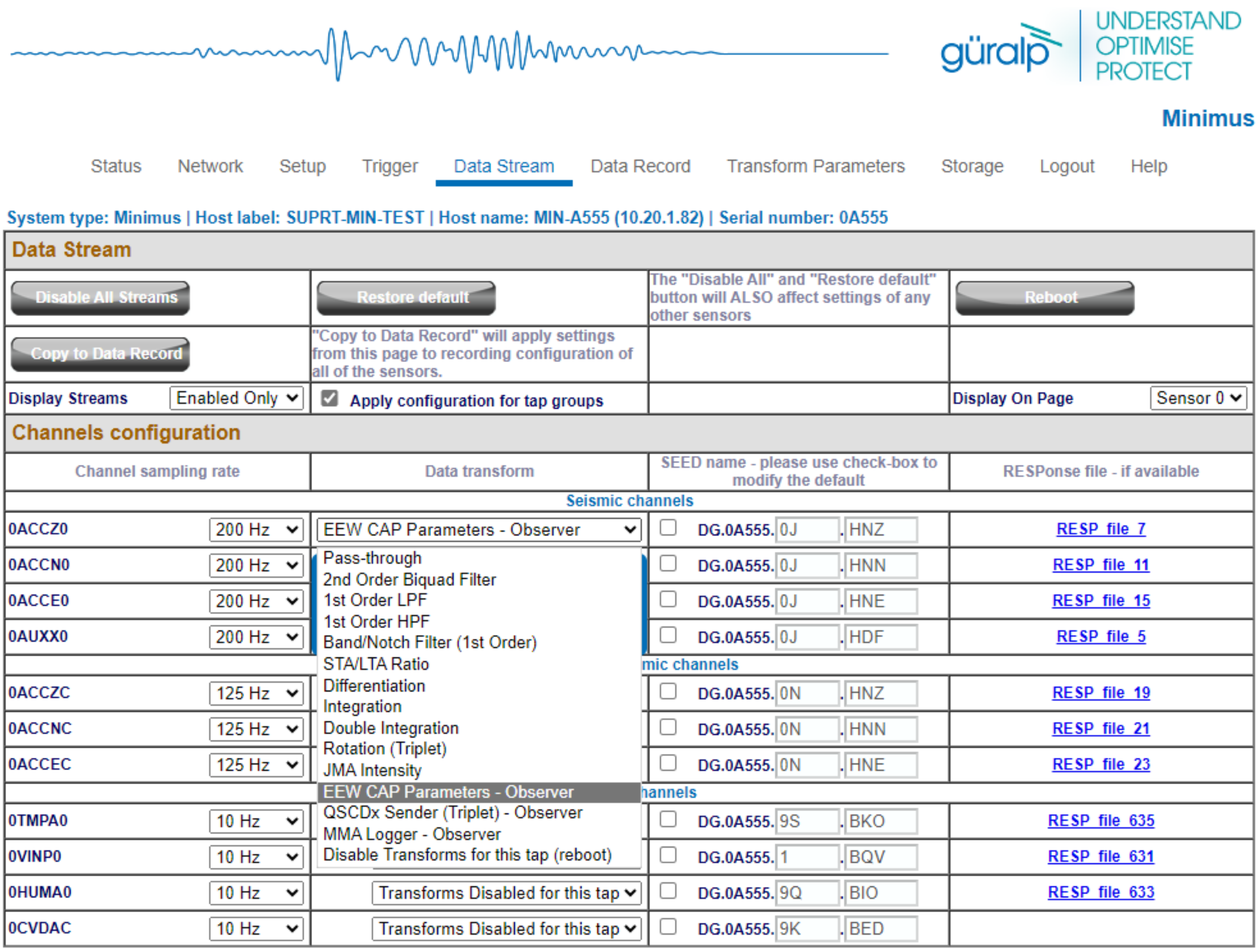
Güralp Discovery includes a CAP (Common Alerting Protocol) receiver. It listens on a specified UDP port for incoming CAP messages. When one arrives, it is displayed and plotted on a map. In addition, the receiver can open a TCP connection to the cloud-based registry server and display CAP messages that have been sent to the registry server.

Note: For more details about the Discovery built-in receiver and configuration of the registry server, please see Discovery's manual MAN-DIS-0001.

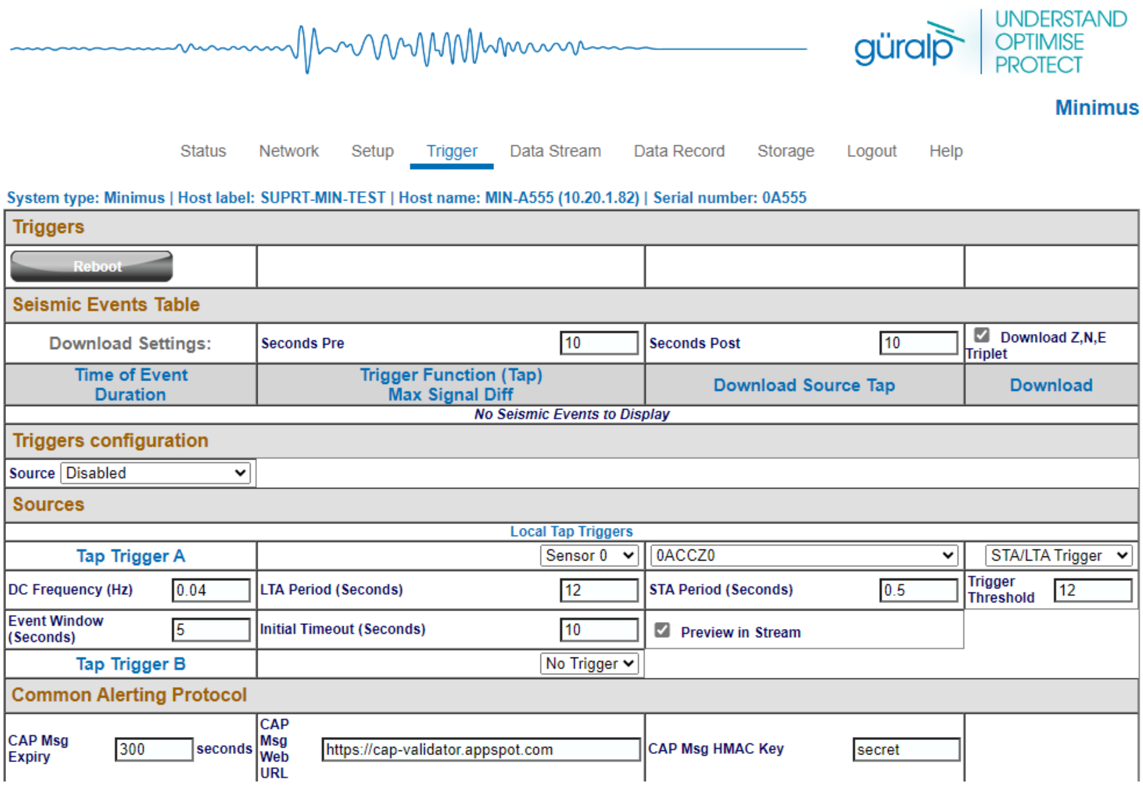
2.10.4 How to Configure a Trigger Step-By-Step

In this section is an example of how to configure a trigger. Specifically, the following steps allow you to configure an STA/LTA trigger on the vertical component of the main seismic channel (0ACCZ0) when the ratio exceeds 12. A CAP message is also sent to Discovery's CAP receiver (with the instance of Discovery open on a laptop with an IP address 10.20.1.69) when an event is detected. The CAP message contains information about the PGA (Peak Ground Acceleration), PGV(Peak Ground Velocity) and PGD(Peak Ground Displacement). A similar procedure should be followed to configure triggers with different characteristics.

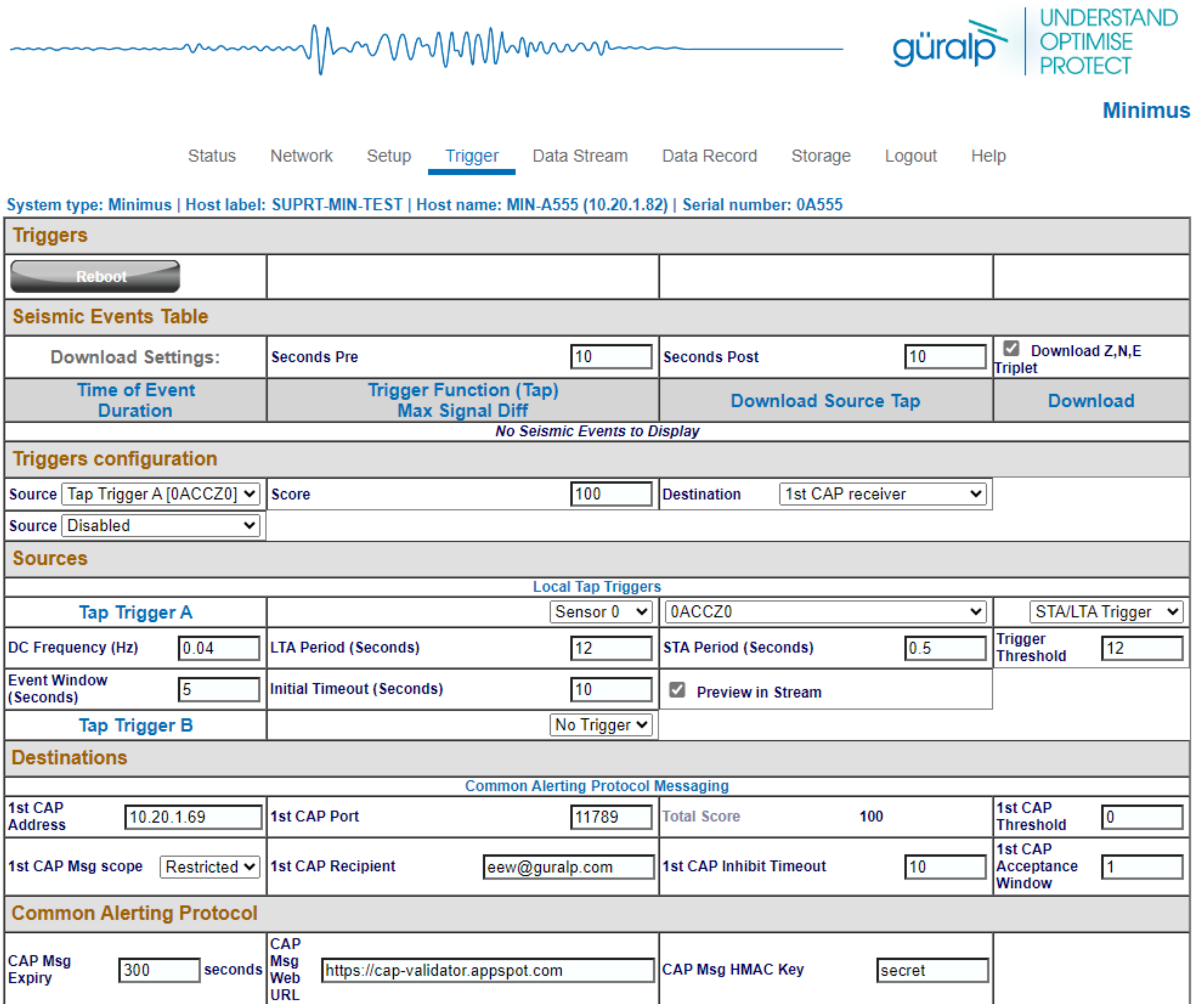
1. From the "Data Stream" tab enable the transform for channel 0ACCZ0. Once the page refreshes, from the same drop-down menu, choose "EEW CAP parameters - Observer" to receive PGA, PGV and PGD values in the CAP message. Reboot the device for the transform to be applied;
2. From the tab "Transform Parameters" configure the parameters for the transform. See Section 2.9.9 for more details;



3. From the “Trigger” tab, under “Sources” → “Tap Trigger A” use the drop-down menu to change from “No Trigger” to “Sensor 0”;
4. Use the drop-down menu to change from “Select Tap” to 0ACCZ0;
5. Use the drop-down menu to change from “No Trigger” to “STA/LTA Trigger”;
6. Configure the fields “DC Frequency”, “LTA period”, “STA period”, “Trigger threshold”, “Event Window”, “Initial Timeout”. In this example, “Trigger threshold” will be set to 12;
7. If you want to visualise these settings in the live data viewer, tick the box “Preview in Stream” (from Discovery’s main menu, right click the instrument, highlight “Live View” and select “GDI”) the live value of the STA/LTA will show instead of the normal 0ACCZ0 stream,



8. Under "Triggers configuration" use the drop-down menu to change from "Disabled" to "Tap Trigger A [0ACCZ0]";
9. Use the drop-down menu to change the destination to "1st CAP Receiver". A section towards the bottom of the page named "Destination" will now appear;
10. Type the IP address of the destination of the CAP message (in this example, 10.20.1.69, for you this will be the IP address of a device with Discovery installed or your own personal CAP Receiver) in the field "1st CAP Address". "1st CAP port" is set to 11789 by default, but this can be changed (if using the CAP receiver built into Discovery, it needs to match the port specified in Discovery);


güralp
UNDERSTAND
OPTIMISE
PROTECT
Minimus
Status Network Setup Trigger Data Stream Data Record Storage Logout Help
System type: Minimus | Host label: SUPRT-MIN-TEST | Host name: MIN-A555 (10.20.1.82) | Serial number: 0A555
Triggers
Reboot
Seismic Events Table
Download Settings:
Seconds Pre 10
Seconds Post 10
Download Z,N,E Triplet
Time of Event Duration
Trigger Function (Tap) Max Signal Diff
Download Source Tap
Download
No Seismic Events to Display
Triggers configuration
Source Tap Trigger A [0ACCZ0]
Score 100
Destination 1st CAP receiver
Source Disabled
Sources
Local Tap Triggers
Tap Trigger A
Sensor 0
0ACCZ0
STA/LTA Trigger
DC Frequency (Hz) 0.04
LTA Period (Seconds) 12
STA Period (Seconds) 0.5
Trigger Threshold 12
Event Window (Seconds) 5
Initial Timeout (Seconds) 10
Preview in Stream
Tap Trigger B
No Trigger
Destinations
Common Alerting Protocol Messaging
1st CAP Address 10.20.1.69
1st CAP Port 11789
Total Score 100
1st CAP Threshold 0
1st CAP Msg scope Restricted
1st CAP Recipient eew@guralp.com
1st CAP Inhibit Timeout 10
1st CAP Acceptance Window 1
Common Alerting Protocol
CAP Msg Expiry 300 seconds
CAP Msg Web URL https://cap-validator.appspot.com
CAP Msg HMAC Key secret

2.10.5 Seismic Event Table

The Minimus can generate a “Seismic Event Table”. This lists the events detected by the STA/LTA or Threshold trigger enabled on taps. It contains information about the time when the event occurred, the duration, the channel that generated the trigger and the peak magnitude of the event. The seismic data before, during and after the event are saved in miniSEED format and can be downloaded using links within the table. Events will populate the table only once they have an end point.

The table is located at the bottom of the “Trigger” tab in the Minimus web page.

Seismic Events Table			
Download Settings:	Seconds Pre 10	Seconds Post 10	☑ Download Z,N,E Triplet
Time of Event Duration	Trigger Function (Tap) Peak Magnitude (Time)	Download Source Tap	Download
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.50187 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.58626 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.27047 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.08352 m.s	S0AccNA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.74786 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.14463 m.s	S0AccNA	Request Event Data
Wed Aug 1 09:27:20 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.2666 m.s	S0AccNA	Request Event Data

The Minimus allows the download of event data in miniSEED format in a time range that is user selectable. The user can select how many seconds before and after the event detection to include in the miniSEED file.

Download Settings:	Seconds Pre 10	Seconds Post 10	☑ Download Z,N,E Triplet

The event table shows which of the components has caused the trigger and the user can chose to either download data related to that single component by deselecting the option “Download Z,N,E Triplet” or download data for all three components by leaving the option enabled.

Download Settings:	Seconds Pre 10	Seconds Post 10	☑ Download Z,N,E Triplet

The last column of the table contains links to downloaded and saved miniSEED files related to each event.

Time of Event Duration	Trigger Function (Tap) Peak Magnitude (Time)	Download Source Tap	Download
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.50187 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.58626 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:21:17 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.27047 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.08352 m.s	S0AccNA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL10) 0.74786 m.s	S0AccZA	Request Event Data
Thu Aug 2 12:20:46 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.14463 m.s	S0AccNA	Request Event Data
Wed Aug 1 09:27:20 2018 < 1 second	STA/LTA Trigger (0AXL20) 0.2666 m.s	S0AccNA	Request Event Data

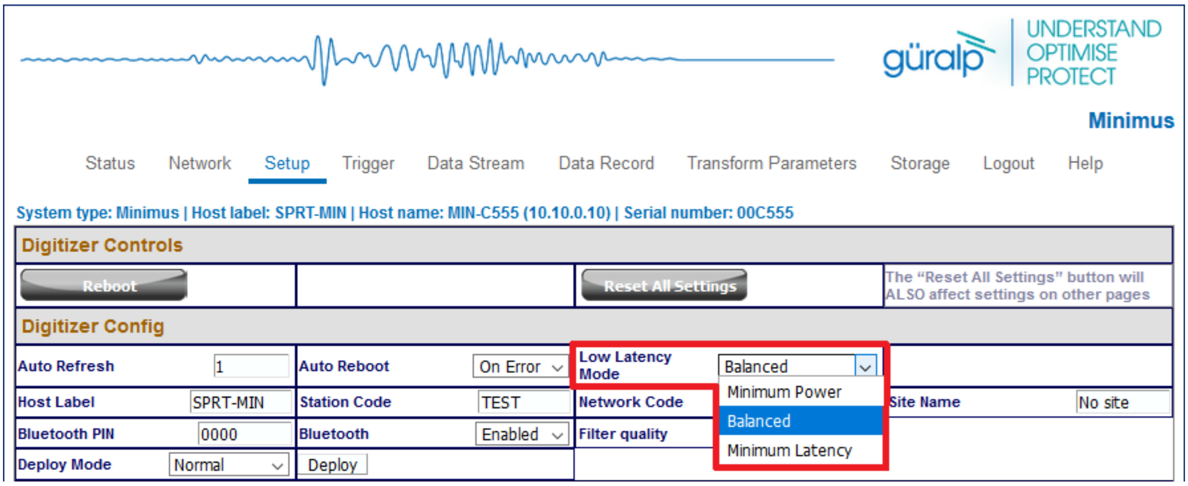
Note: The links produce downloadable miniSEED files if and only if the requested data is available in the microSD card. This depends on last flushing time and selected post event time. Use the Flush data button in the Storage tab to copy most recent data into the microSD cards (see Section 2.7.4).

2.10.6 Improving Latency

2.10.6.1 Low Latency Mode

In the Setup tab, the "Low Latency Mode" drop-down menu controls the processor workload that affects the power-consumption of Minimus. This control can be used to prioritise power-consumption at the expense of latency, to balance the two or to optimise latency regardless of the power consumption. Three settings are available:

- Minimum Power ⇒ slow processing / higher latency / low power consumption;
- Balanced ⇒ medium processing / medium latency / medium power consumption;
- Minimum latency ⇒ fast processing / lower latency / high power consumption;



2.10.6.2 EEW Packets

Typically, each miniSEED packet is transmitted once it is completely populated with data, with a fixed packed size of 512 Bytes. To improve latency when streaming data using the

SEEDlink protocol, a modified version of SEEDlink allows you to transmit packets which are not complete. The rate at which the miniSEED packets must be transmitted can be specified from the Network tab ("Send SeedLink EEW Packet Every", in deciseconds). The modified SEEDlink is only available for the low latency seismic channels (i.e. the main seismic channels generated with causal low latency filters).

For more information about the modified version of SEEDlink and how to use it, please see Section 2.6.3.

2.10.6.3 Considerations About Low Latency Channels

The Minimus performs an initial data sampling at a very high rate. Then, it down-samples the sensor data in a process called *decimation* to achieve the target value of the output (in Hz or seconds), where the maximum sample size gets divided by values of 2, 3, 4 or 5 to equal the sample rate value set for that channel. The higher the sample rate the more values will be stored within memory, impacting the overall capacity. However lower sample rates require larger time frames and more processing power which impacts the latency of the results within the Minimus.

Before each down-sampling stage, the high frequencies are removed using digital filters, to avoid aliasing. Digital filters can be *casual* (they only consider past samples to calculate the output value) or *acasual* (also consider future samples). The default filters on Minimus are acasual: they provide a more accurate transcription of the data but they can cause several seconds of additional latency. The low latency channels are specifically designed for EEW (Earthquake Early Warning) applications and use causal filters, which however distort the phase of incoming signal. Therefore, low latency channels are well suited for early warning systems, whilst the standard channels are better suited for identifying location and impact.

When discussing latency, unless specified, we are talking about the full stack of processes that occur from a sensor posting a value to the data packet being received by an end point. This is inclusive of network latency but worth noting that the choice of sensor output (in Hz or seconds) as discussed above, adds to this value. When designing a station it is recommended to take account of the bandwidth available for sending data as well as the output value of all sensors to calculate for a stable configuration.

2.10.7 QSCD

The Minimus can push data in QSCD format (**Q**uick **S**eismic **C**haracteristic **D**ata) to one or more clients, using outgoing network connections. This protocol is used for rapid transmission of essential earthquake data from seismic stations to monitoring centres.

To configure a connection, log into the web page interface as Admin, navigate to the “Network” tab and locate the “QSCD” section , as shown below. Type either the IP address or the hostname of the target client into any of the “Server” fields. This will push data using UDP port 9000, which is the default. If you wish to use a different port number, add a colon (':') and the port number to the end of the specification. For example, ***`192.0.2.91:9876`*** or ***`qscd.server.com:9876`***.

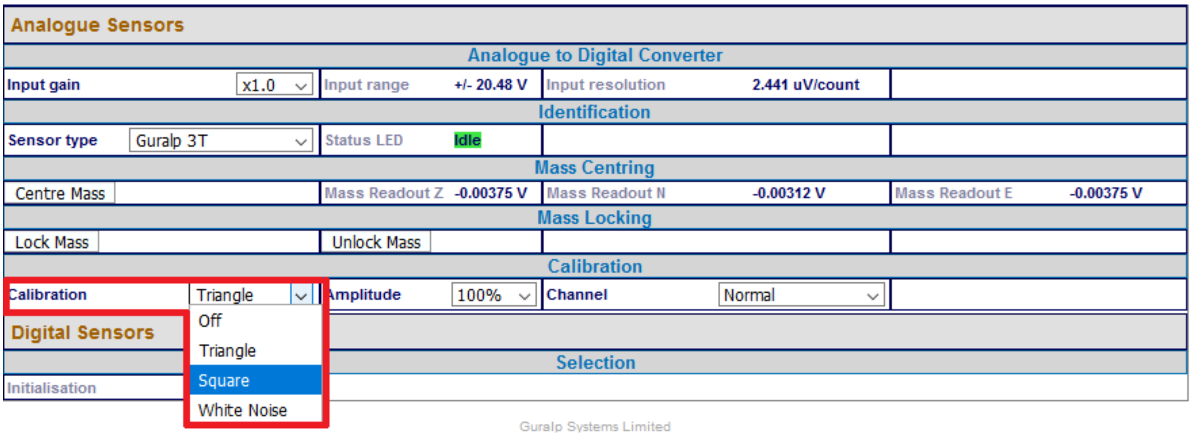
QSCD							
QSCD code sensor	Sensor 0	QSCD code	QSCD0				
Connection		Connection		Connection		Connection	

The Minimus does not automatically send all data when using the QSCD protocol. Channels to be transmitted must be selected (in Z/N/E triplets) and each channel passed through a QSCD transform. See Section 2.9.12 for details on how to configure this transform.

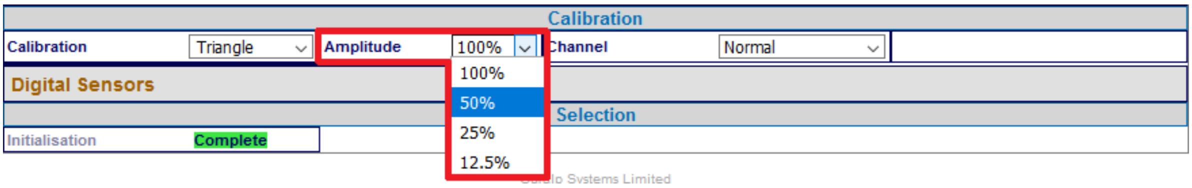
Use the “QSCD code sensor” drop-down menu to select the sensor and assign the desired QSCD code.

2.11 Injecting a Calibration Signal

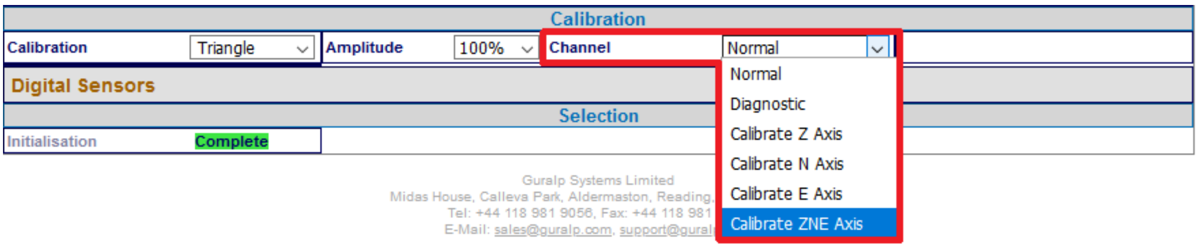
To check whether the Fortimus, Certimus or analogue sensor(s) connected to the Minimus are correctly calibrated, go to the Setup tab of the web page interface and use the "Calibration" drop-down box to choose between Triangle, Step, Sine Wave and White Noise signal to be injected into the sensor's feedback loop. There is a signal generator built into the system which can generate a number of different signals.



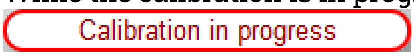
Adjust the calibration signal amplitude at 100%, 50%, 25% or 12.5% of the DAC's full range.



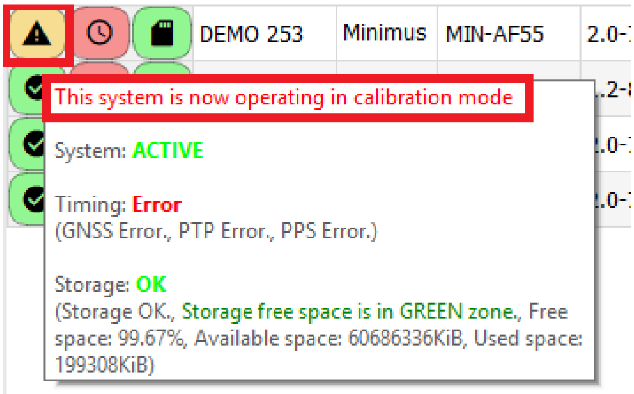
Finally, enable the calibration on all three axes of the selected analogue sensor.



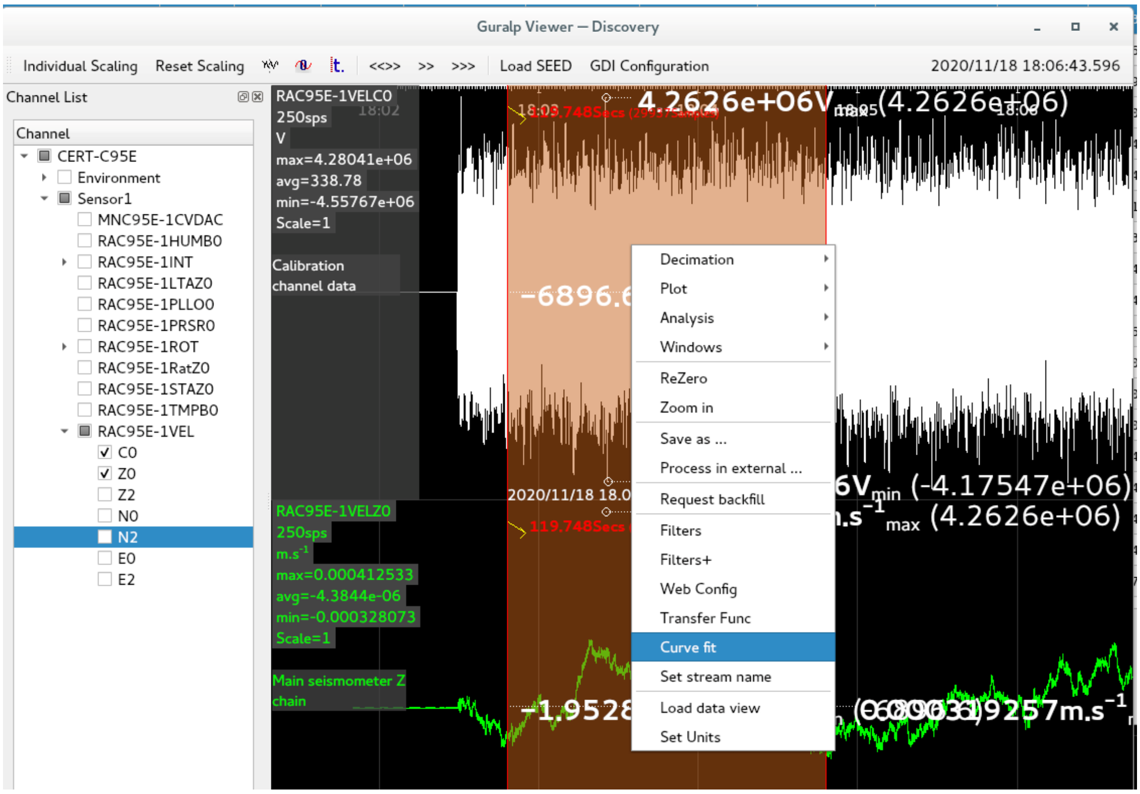
Note: The calibration channel, named nVELC0 (or nACCC0), produces an output if and only if the calibration is in progress.

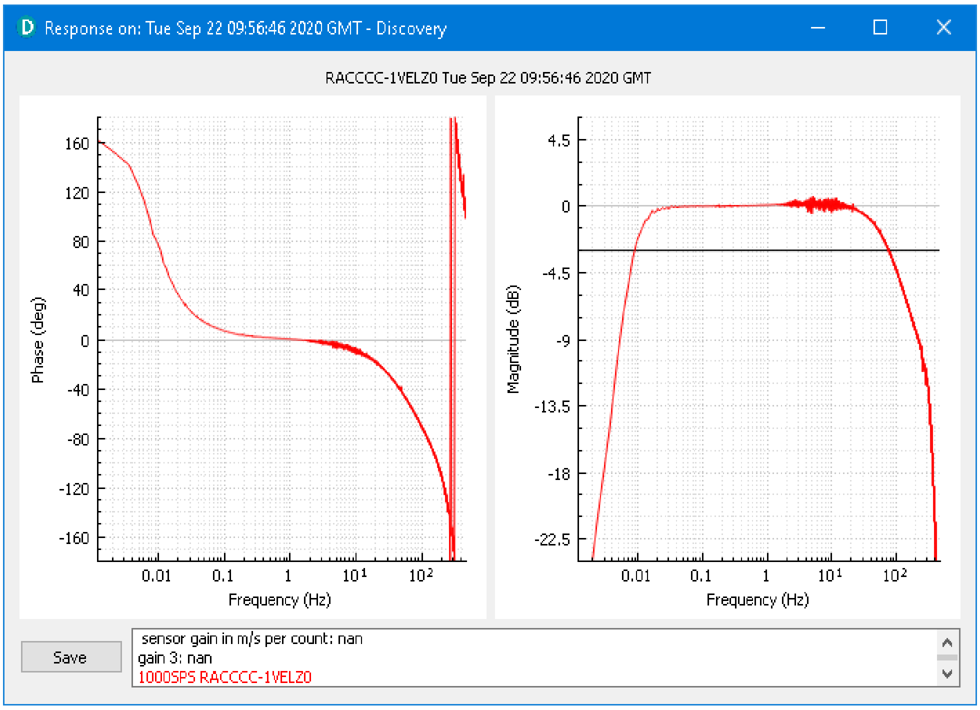
While the calibration is in progress, the webpage shows the warning message 

and Discovery flags the status icon in yellow.



Instrument response can be verified by exciting the instrument with a signal and measuring its response. For measuring the frequency response, Güralp recommends the use of white noise. This signal contains equal quantities of all frequencies. By looking at the frequency content of the instruments output, the transfer function of the instrument can be plotted. This plotting function can be performed in Discovery.




Response on: Tue Sep 22 09:56:46 2020 GMT - Discovery
RACCCC-1VELZ0 Tue Sep 22 09:56:46 2020 GMT
Phase (deg)
Frequency (Hz)
Magnitude (dB)
Frequency (Hz)
Save
sensor gain in m/s per count: nan
gain 3: nan
1000SPS RACCCC-1VELZ0

2.12 Scripting

The Minimus is capable of running a script file that contains commands to execute at specific dates and time. This can be used for operations such as scheduled instrument calibrations.

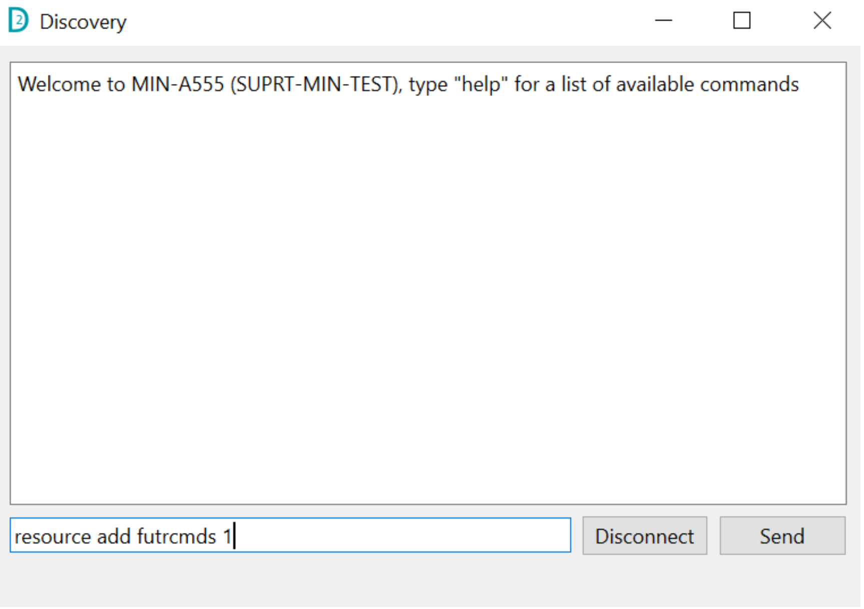
The script file is written on a computer as a .txt file. It is then sent to the digitiser as a file transfer from Discovery.

2.12.1 Enabling Scripting Capability

This capability needs to be enabled (once) on the digitiser. In order to do this, type the command below in the instrument's console:

`resource add futrcmds 1`

The console can be accessed from Discovery by right-clicking on the instrument's entry and selecting Console



2.12.2 Preparing the Script File

Typing "**`help`**" in the console shows all the possible commands along with a brief explanation. Any commands available on the digitiser console can be used. The list of commands to be executed on specific dates and time has to be written to a text file with the following format:

```
2024-06-17T18:30:33Z      example command 1
2024-06-17T18:30:50Z      example command 2
```

> **Note:** The circled space is the TAB character. Using spaces instead will not work.

Time has to be specified in UTC. Please refer to the “System time” that appears on the Minimus webpage.

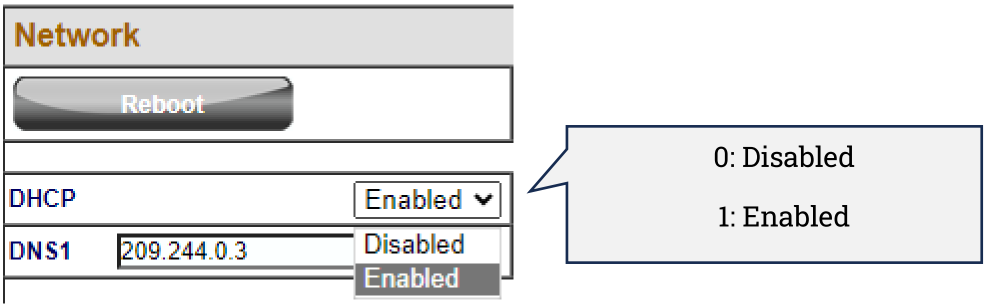
To edit the parameters present in the webpage, use the command “`var set`”. For example,

```
var set DHCP 1
```

enables DHCP. The number ‘1’ represents the enumeration of the pulldown list. Therefore,

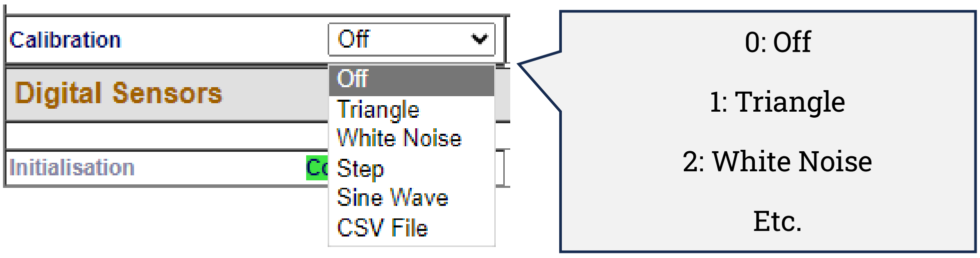
```
var set DHCP 0
```

would disable DHCP.



For Minimus+, where more than one sensors are available, specify on which sensor the command has to be executed by adding *“n:”* in front of the variable to change. For example, to enable white noise calibration signal generator on Sensor0 the command would be:

```
var set “0:Calibration” 2
```



As an example, the following text will create a single step calibration (positive, then negative step 11 minutes apart) on 2023-04-17 at 03:30 UTC.

```
2023-04-17T03:28:00Z     var set "0:Calibration" 4
2023-04-17T03:28:20Z     var set "0:Lookup generator gain" 0
2023-04-17T03:28:40Z     var set "0:Channel" 5
2023-04-17T03:30:00Z     var set "0:Lookup generator gain"
1106247680
2023-04-17T03:41:00Z     var set "0:Lookup generator gain" 0
2023-04-17T03:47:00Z     var set "0:Channel" 0
2023-04-17T03:47:20Z     var set "0:Calibration" 0
```

Explanation:

`"0:Calibration" 4`

This command will set the signal type, in this example 4 will create a step on sensor 0. Other options include, sinewave, triangle wave and random noise. Note the script waits for 10 seconds before sending the next command.

`"0:Lookup generator gain" 0`

This will set the gain of the step to 0 volts, note the script waits for 10 seconds before the next command.

`"0:Channel" 5`

This switches the logic lines for the 'calibration enable' on all three components. Please note the script then waits 2 minutes before the next command to avoid any disruption to the analogue signals during the calibration cycle.

`"0:Lookup generator gain" 1106247680`

This will set the gain to 30% of maximum. The percentage on the webpage (e.g. 10) is a float. In the script though it has to be expressed in hexadecimal notation (preceded by the character *$*), or decimal. Some examples:

10% = $41200000 or 1092616192

20% = $41A00000 or 1101004800

30% = $41F00000 or 1106247680

`"0:Lookup generator gain" 0`

This will return the input signal to 0 volts. On a velocity sensor this is the equivalent of a negative step.

`"0:Channel" 0`

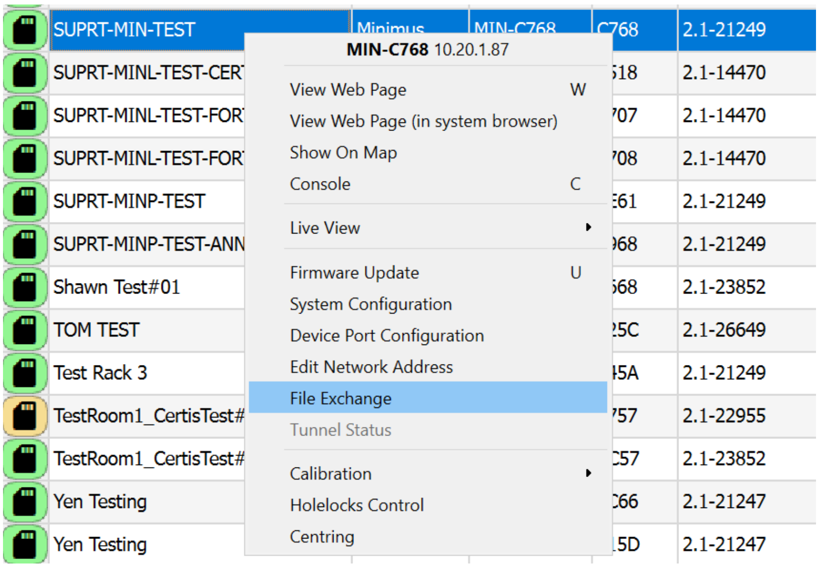
This switches off the logic lines of the 'calibration enable'.

`"0:Calibration" 0`

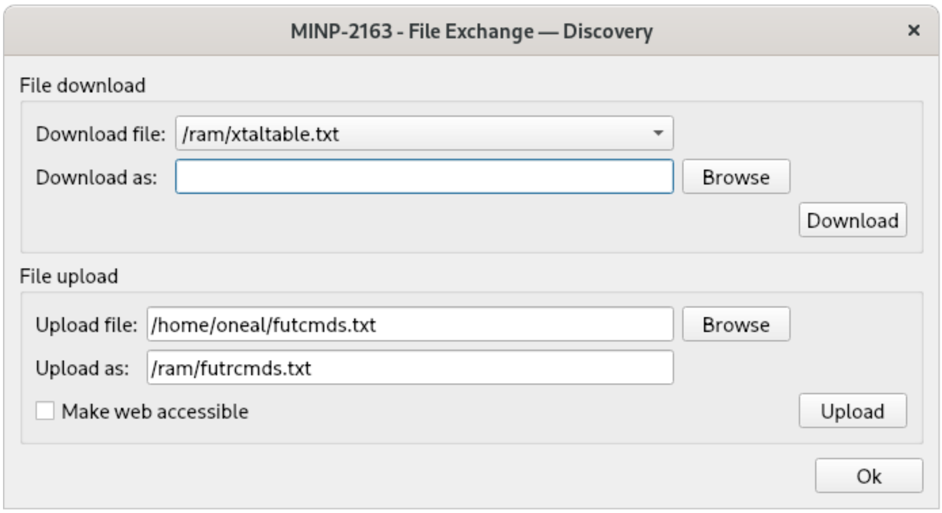
This command will switch off the DAC creating the calibration signal and stop the recording of the special calibration channel.

2.12.3 Sending a Script File

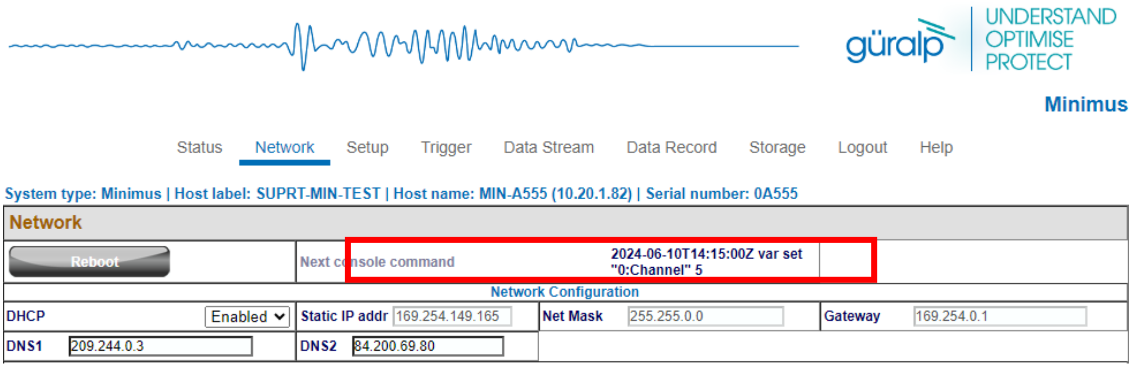
Once the text file with the list of commands is ready, it has to be uploaded in Discovery as a file transfer. To do this, right-click on the Minimus entry and select “File Exchange”.



From the “File Upload” box, browse for the text file previously prepared and in the field “Upload as” type exactly `/ram/futrcmds.txt`. Click on Upload.



If the file has been uploaded successfully, the next command due to be executed is displayed in the Network tab as shown below. If this does not show, reboot the instrument.



2.12.4 Status of the Script Running Process

To see the status of the process, type in the console:
`futrcmds show`

Keeping in mind that the date and time refer to the system time. To visualise the system time, type in the console:
`system time`

To remove the script and cancel queued up commands, type in the console:
`futrcmds clear`

Note: Sending a new script file replaces the existing queued up commands. The clear command removes the entire script.

2.13 Remote Connectivity

2.13.1 Registry Setup

Discovery can maintain a list of digitisers in a local or cloud-based registry, simplifying management of medium to large networks and removing the need for static IP addresses at telemetered stations. Registered digitisers appear in the selection list in the main screen, regardless of whether they are on the local network or not.

Administrators can create their own registry servers by installing a simple program on a server. The server itself must have a static IP address and be accessible to all connected Minimus units, as well as the PCs running discovery. Registry server's programs are currently available for Linux. Please contact Güralp technical support at support@guralp.com for details.

For administrators not wishing to install their own registry, Güralp provide a shared registry server in the cloud at `52.34.40.123` which customers are welcome to use.

52.34.40.123 *IP address of Güralp's Default Public Registry*

Registered digitisers must be assigned to groups, each of which has a Group Identifier. Instances of Discovery must also be configured with a Group ID and can only display registered digitisers from the matching group. This allows partitioning of large networks into smaller administrative domains. It also makes possible the simultaneous use of the Güralp shared registry server by multiple organisations.

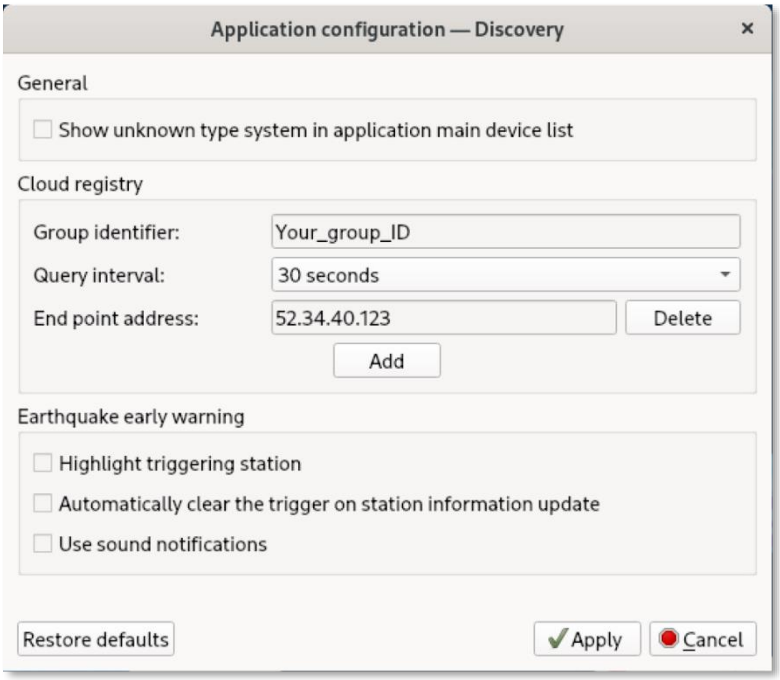
Note: The following instructions are to set up your Minimus with Güralp registry server. For instructions on how to set up your own registry server, please refer to Discovery's manual MAN-DIS-0001.

In order to use the Registry, you need to configure both the device and Discovery. Please follow these steps to set up your Registry.

- First, the address of the Registry Server and the chosen Group ID must be set individually for each participating device. To do this, first connect the device to the same network as a PC running Discovery (as explained in Chapter 2.3 . Then open the webpage and set Group ID and Registry address from the Network tab. To use the Güralp shared cloud server, enter **52.34.40.123** if not already there by default.
- Once you have set these values, the device must be rebooted before the changes will take effect.
- Last, open Discovery and click on Cloud server configuration at the bottom left of the main window. Enter the Group ID and server IP address in the relevant

fields ("Cloud registry group identifier" and "Cloud end point address", respectively) to match the ones entered in the device's webpage during the previous step. Click on Apply.

From Discovery's main window, click the Registry button and all devices configured with the same Registry server and Group ID will now appear in the main list.



2.13.2 Interacting with Remote Instruments

Beyond the information transmitted via Registry Servers, as outlined above, the functionality available for each instrument in Discovery depends upon network connectivity between the Discovery instance and the device.

In terms of configuring firewalls, the product manual provided for each Güralp device will outline the required open network ports for given functionality. Please see Chapter 3.1 for a list of the network port used by Minimus.

The most common and significant hurdle to communicating with remote devices is Network Address Translation (NAT). A number of solutions are here presented.

Right-clicking on the instrument row (on any column BUT the LAN address one) offers various functions that will all use the WAN (Wide Area Network) address to communicate with the instrument. So all will function as expected as long as ports are open.

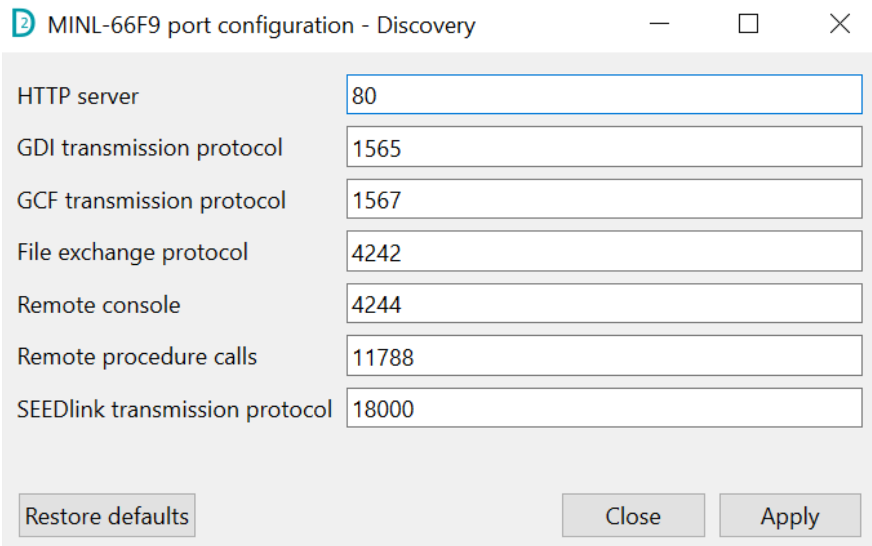
Right-clicking on the LAN address column forces the use of the LAN IP address to communicate with the device instead. This is therefore useful only if the device is in your local network.

2.13.2.1 Port Forwarding

In some cases, depending on networking equipment and topology, it may be possible to arrange the relevant device network ports to be forwarded by the WAN router. This allows direct connections to the remote device.

If a device is made available via port forwarding, users should initiate Discovery functionalities using the WAN address of the instrument. Where multiple network addresses are available for an instrument, it is possible to force Discovery to use the WAN address by selecting the WAN Address column of the device entry. Subsequent invocations either via the **Edit** menu or the right-click context menu will then utilise the WAN address. The WAN address is used by default when in Registry Mode.

It is common when port forwarding to remap port numbers away from the default internal device ports when presented to the WAN. Discovery allows for this by allowing for per device custom port numbers. Right-clicking on the instrument and selecting **Device Port Configuration** opens a window to change forwarding ports for an individual instrument.



2.13.2.2 Router/Gateway VPN

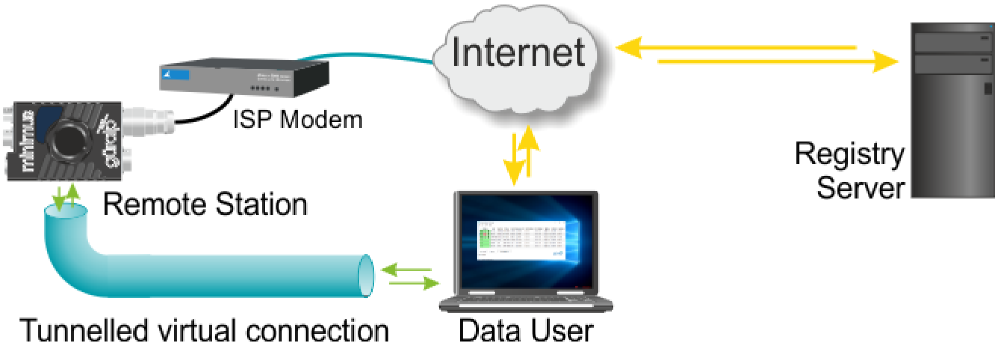
Some WAN routers include a VPN client feature which may allow remotely located instruments to appear as if they are on the same local network as the Discovery instance. Setting up a VPN is beyond the scope of this manual.

In some cases it is necessary to manually add devices which are accessible via a VPN, by selecting **Edit → Add Device**.

2.13.2.3 Güralp Discovery Tunnel

The easiest way to overcome firewall and NAT networking challenges with remote instruments is to use the Güralp Discovery Tunnel. By combining a Güralp device running DIG firmware with a Registry Server and Discovery, it is possible to maintain full connectivity with remote WAN connected instruments without any extra network configuration (beyond connecting the instrument to the WAN).

This feature allows all network traffic between a Discovery instance and instrument to be routed via a Registry Server, using only outgoing TCP connections from each end point (device and Discovery instance). In this way, full communication is possible through firewalls and NAT routers without special configurations or degrading network security.



To enable this feature, relevant Güralp devices should be assigned to a Registry server (as explained in Chapter 2.13.1) and the Tunnel Auto Connect setting should be enabled (see below). Where multiple Registry servers can be configured, the first Registry server slot should contain the tunnel enabled Registry server.

To allow connectivity via a Registry server, the tunnel option must also be enabled when starting the Responder service. For more details refer to the help information for Responder. Port 8190 TCP is used to make the connection to the remote registry server from the digitiser – so this outbound port must be permitted in any firewall rules.

Generally, all that is required is the enable of the tunnel connection within the instrument by ticking the Tunnel Auto Connect box from the webpage, under the Network tab.

Discovery Tunnel				
☑ Tunnel Auto Connect	Tunnel Status	Connected	Tunnel Protocol Version	2

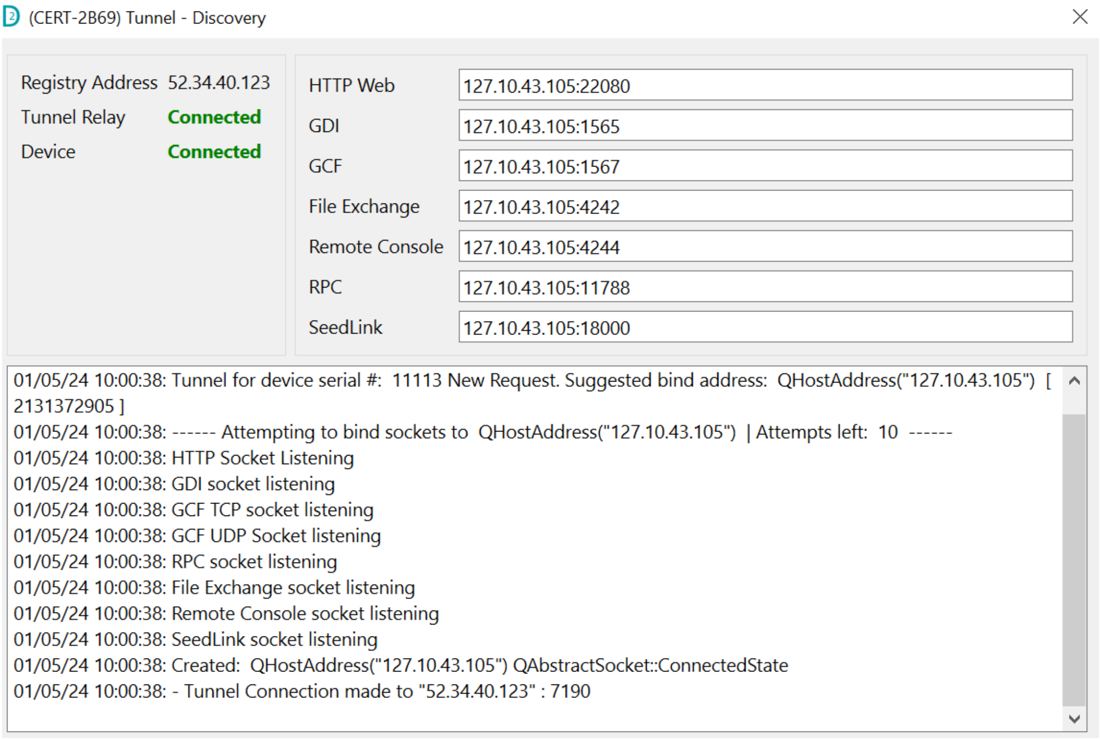
In Registry mode, the Discovery Main Window will display the tunnel availability of listed devices. If this column is not displayed, it can be enabled by selecting Window

→ Show → Tunnel Available. Devices connected to a tunnel-enabled Registry server will be indicated with "Available" in the Tunnel Available column.

Uptime	Last Contact	Latitude	Longitude	Tunnel Available
15days 14Hrs	Just Now	41.2938	-82.1524	Not Available
247days 3Hrs	Just Now	-30.8091	22.1089	Not Available
10days 15Hrs	Just Now	28.9985	-13.7498	Not Available
8days 21Hrs	Just Now	18.9832	-99.2380	Not Available
9days 4Hrs	Just Now	3.5349	-76.8709	Available
3days 7Hrs	Just Now	3.5357	-76.8695	Available
9days 4Hrs	Just Now	3.5354	-76.8689	Available
14days 0Hrs	Just Now	51.3609	-1.1632	Not Available
00:07:35	Just Now	51.3608	-1.1633	Not Available
191days 18Hrs	2024-04-30T21:30:50	41.5156	118.8553	Not Available
68days 16Hrs	Just Now	9.7799	-83.8415	Not Available
5days 13Hrs	Just Now	1.2078	-77.3588	Not Available
453days 23Hrs	Just Now	45.7559	5.4760	Not Available
15days 4Hrs	Just Now	10.2807	-84.9628	Not Available
11days 17Hrs	Just Now	0.0000	0.0000	Not Available

To utilise the tunnel connection, simply invoke a Discovery applet with the chosen device selected in Registry mode. Discovery will automatically default to using the tunnel network address for all communications with the instrument (unless the user specifically selects the WAN or LAN fields).

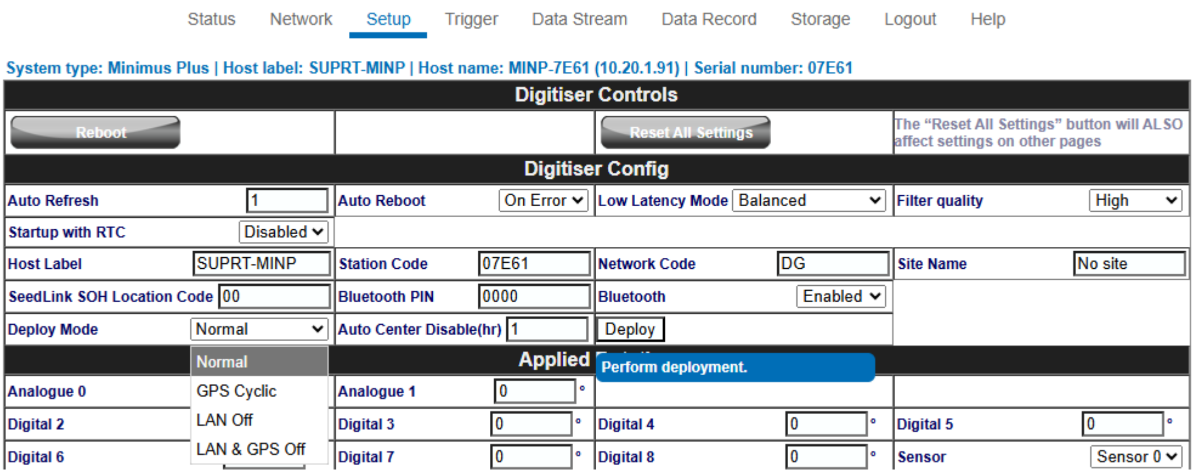
More information regarding the tunnel's operation is shown in the Tunnel Status applet available by right-clicking on the entry of a device whose tunnel is enabled. This provides detailed status and connection information for each tunnel connected device.


(CERT-2B69) Tunnel - Discovery
Registry Address 52.34.40.123
Tunnel Relay Connected
Device Connected
HTTP Web 127.10.43.105:22080
GDI 127.10.43.105:1565
GCF 127.10.43.105:1567
File Exchange 127.10.43.105:4242
Remote Console 127.10.43.105:4244
RPC 127.10.43.105:11788
SeedLink 127.10.43.105:18000
01/05/24 10:00:38: Tunnel for device serial #: 11113 New Request. Suggested bind address: QHostAddress("127.10.43.105") [2131372905]
01/05/24 10:00:38: ------ Attempting to bind sockets to QHostAddress("127.10.43.105") | Attempts left: 10 ------
01/05/24 10:00:38: HTTP Socket Listening
01/05/24 10:00:38: GDI socket listening
01/05/24 10:00:38: GCF TCP socket listening
01/05/24 10:00:38: GCF UDP Socket listening
01/05/24 10:00:38: RPC socket listening
01/05/24 10:00:38: File Exchange socket listening
01/05/24 10:00:38: Remote Console socket listening
01/05/24 10:00:38: SeedLink socket listening
01/05/24 10:00:38: Created: QHostAddress("127.10.43.105") QAbstractSocket::ConnectedState
01/05/24 10:00:38: - Tunnel Connection made to "52.34.40.123" : 7190

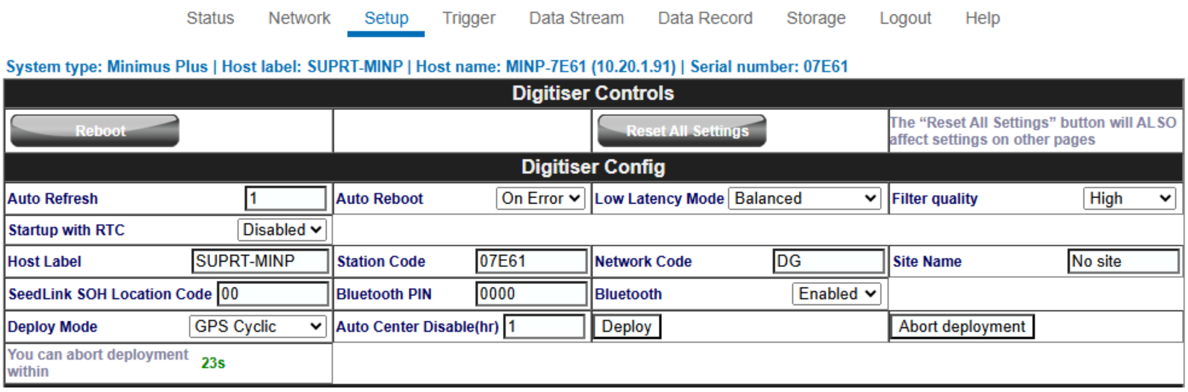
2.14 Deploy Modes

Minimus-based devices offers various power-save deployment modes depending on the instrument type. These can be: Disabled (no power-save mode enabled), GPS on + LAN off (SSM), GPS cyclic + LAN off, and GPS cyclic + LAN on. The power-save modes make several configuration changes to reduce the unit's power consumption.

The desired mode can be specified by logging into the web interface as admin, navigating to the Setup tab, under Digitiser Config and using the "Deploy mode" drop-down menu to select an option. The final step is to click on the Deploy button and confirm or cancel the operation from the pop-up window that appears.



Changes are not applied immediately. A thirty-second count-down will start before the system enters power-save mode. The screen updates and the Abort deployment button is now active.



You can cancel the operation before the countdown is complete by clicking the Abort deployment button.

To verify if a power-save mode is enabled, open the Minimus' console and type:

```
powersave status
```

If the output is a message saying "`power mode: Normal`", no power-mode is enabled.

2.14.1 GPS Cyclic + LAN On

When the Minimus is deployed in GPS cyclic power-save mode, the GPS interface remains off most of the time and is only switched on periodically to maintain a stable GPS lock.

Note: In order to function, the GPS cyclic power-save mode requires the internal clock DAC frequency pulling channel (0CVDAC) to be enabled.

To exit the GPS cyclic power-save mode, either:

- Click the Undeploy button on the webpage
- Use the GüVü Bluetooth app (see Section 3.5)
- Open the Minimus console from Discovery and type the command: `powersave off`
- Connect to the Minimus via a serial connection and type the command `powersave off`

The Minimus will reboot.

The user is advised to double-check that the power-save mode has been correctly removed by typing `powersave status` in the instrument's console. If the output is a message saying "`power mode: Normal`", no power-mode is enabled.

2.14.2 GPS on + LAN Off (SSM)

Note: This is the only power-save mode that has been proven to work with the Surface Storage Module (SSM).

When the Minimus is deployed in LAN off power-save mode, the LAN interface gets permanently switched off.

Caution: The LAN off power-save mode will disable the Ethernet module. You will not be able to continue to use the web interface.

To exit the LAN off power-save mode, either:

- Use the GüVü Bluetooth app (see Section 3.5)
- Connect to the Minimus via a serial connection and type the command `powersave off`
- Apply Power over Ethernet (PoE) if your instrument supports it. The application of PoE causes the system to boot in "Normal" mode.

The Minimus will reboot.

The user is advised to double-check that the power-save mode has been correctly removed by typing `powersave status` in the instrument's console. If the output is a message saying "`power mode: Normal`", no power-mode is enabled.

After the LAN off power-save mode is disabled, access to the webpage interface is possible.

2.14.3 GPS Cyclic + LAN off

This mode is a combination of the GPS cyclic power-save mode and the LAN off power-save mode. Both the Ethernet and GNSS modules are disabled, with the GNSS interface switching on periodically to maintain a stable GPS lock.

Caution: The GPS cyclic & LAN off power-save mode will disable the Ethernet module. You will not be able to continue to use the web interface.

To exit the GPS cyclic & LAN off power-save mode, either:

- Use the GüVü Bluetooth app (see Section 3.5)
- Connect to the Minimus via a serial connection and type the command `powersave off`
- Apply Power over Ethernet (PoE) if your instrument supports it. The application of PoE causes the system to boot in "Normal" mode.

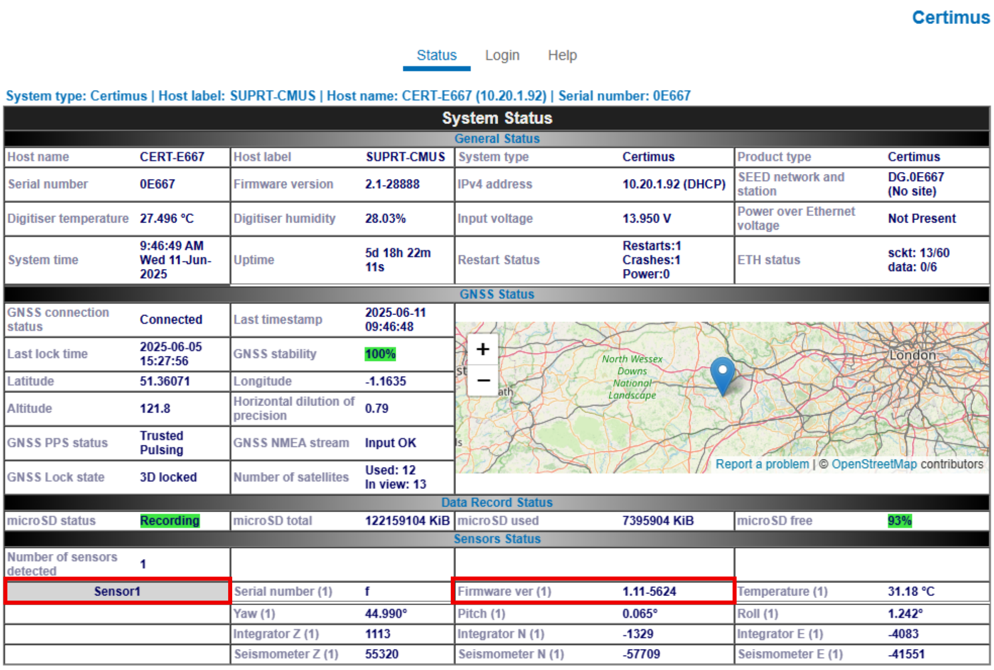
The Minimus will reboot.

The user is advised to double-check that the power-save mode has been correctly removed by typing `powersave status` in the instrument's console. If the output is a message saying "`power mode: Normal`", no power-mode is enabled.

After the GPS cyclic & LAN off power-save mode is disabled, access to the webpage interface is possible.

2.14.4 Ultra-Low Power (ULP)

Note: The Ultra-Low Power mode is only available for Certimus devices. In order to function properly, the Certimus must run Sensor1 firmware v. 1.12 or higher. The Sensor1 firmware and the Certimus firmware (DIG) are two different firmware packages. To find out your Sensor1 firmware, open the Certimus webpage and the information can be found at the bottom of the Status tab as in the screenshot below.



Certimus

Status Login Help

System type: Certimus | Host label: SUPRT-CMUS | Host name: CERT-E667 (10.20.1.92) | Serial number: 0E667

System Status							
General Status							
Host name	CERT-E667	Host label	SUPRT-CMUS	System type	Certimus	Product type	Certimus
Serial number	0E667	Firmware version	2.1-28888	IPv4 address	10.20.1.92 (DHCP)	SEED network and station	DG.0E667 (No site)
Digitiser temperature	27.496 °C	Digitiser humidity	28.03%	Input voltage	13.950 V	Power over Ethernet voltage	Not Present
System time	9:46:49 AM Wed 11-Jun-2025	Uptime	5d 18h 22m 11s	Restart Status	Restarts:1 Crashes:1 Power:0	ETH status	sckt: 13/60 data: 0/6
GNSS Status							
GNSS connection status	Connected	Last timestamp	2025-06-11 09:46:48	North Wessex Downs National Landscape London Report a problem | © OpenStreetMap contributors			
Last lock time	2025-06-05 15:27:56	GNSS stability	100%				
Latitude	51.36071	Longitude	-1.1635				
Altitude	121.8	Horizontal dilution of precision	0.79				
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK				
GNSS Lock state	3D locked	Number of satellites	Used: 12 In view: 13				
Data Record Status							
microSD status	Recording	microSD total	122159104 KiB	microSD used	7395904 KiB	microSD free	93%
Sensors Status							
Number of sensors detected	1						
Sensor1		Serial number (1)	f	Firmware ver (1)	1.11-5624	Temperature (1)	31.18 °C
		Yaw (1)	44.990°	Pitch (1)	0.065°	Roll (1)	1.242°
		Integrator Z (1)	1113	Integrator N (1)	-1329	Integrator E (1)	-4083
		Seismometer Z (1)	55320	Seismometer N (1)	-57709	Seismometer E (1)	-41551

To upgrade the Sensor1 firmware, please contact support@guralp.com.

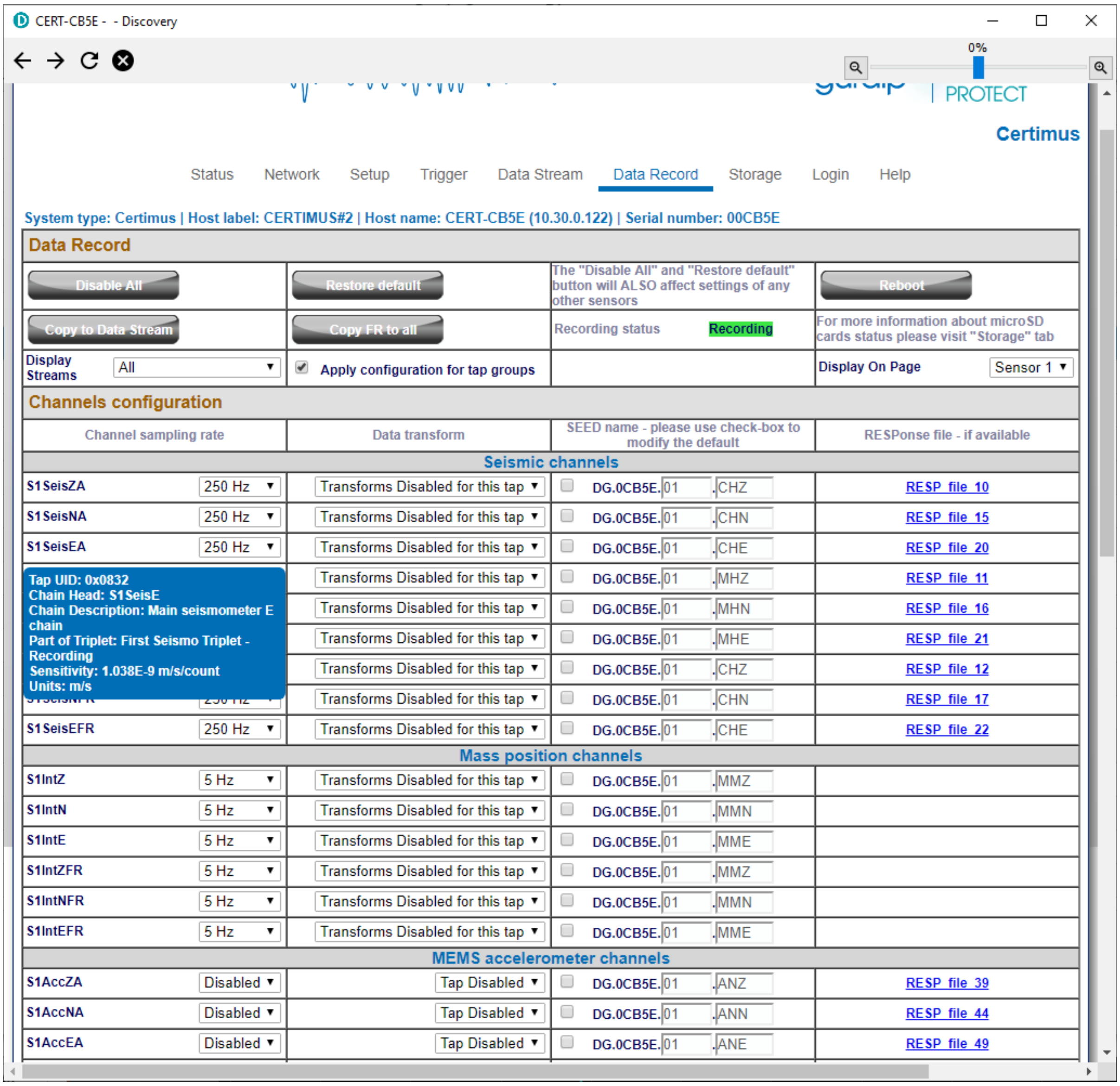
This mode achieves the lowest power consumption with some compromises in functionality. The sample rates and channels that are recorded are fixed: 250 Hz for the seismic channels and lower rates for other data. There are alternative taps (Fixed rate taps) that perform the decimation and record function which are marked as ".FR" in the Data Record tab.

The entire digitiser remains shutdown for the majority of the time so no Ethernet, web page or serial port are available. The system periodically wakes up (every 45 minutes) to copy data to the two SD cards.

The Data Record tab on the web interface shows both FR channels and the standard record channels. The FR channels are written during the wakeup cycles of the Ultra Low Power Save mode. The standard record channels are used whenever the system is full running. The two never overlap so enabling both FR and standard channels is normal practice. It is the choice of deployment mode that dictates which is used.

Caution: The ULP mode will disable the Ethernet module. You will not be able to continue to use the web interface. Once deployed in ULP mode the full digitiser will not power up other than to offload data periodically.

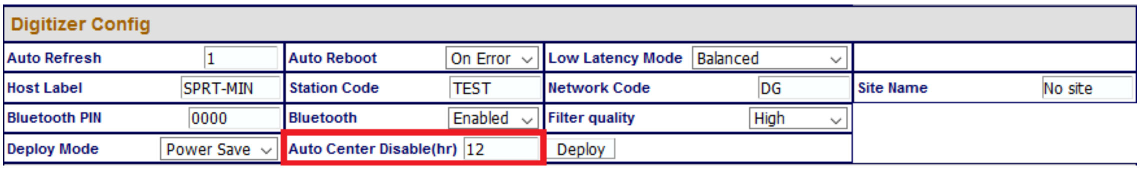
To switch a system out of ULP mode, power must be applied over the Ethernet connection (PoE). The application of PoE causes the system to boot in full mode. Access to the web page is possible at this point so the power modes can be reset.



2.14.5 Special Cases

2.14.5.1 *Maris Deployment*

"Power Save" mode temporarily disables auto-centring of a connected Maris digital sensor, so that it is not continually re-centring while being lowered to the sea floor. When this mode is selected, the “Auto Centre Disable (hr)” input field appears. Use this to specify the length of time before auto-centring is re-enabled.



Note: Güralp recommend a value of 10 to 12 hours to fully cover the entire deployment procedure.

2.15 Instrument's State of Health (SOH)

There are multiple ways of reporting and viewing the SOH data of an instrument. Many methods utilise the network features and can be scripted to pull the required data. SOH data is routinely written to the SD card at specific intervals and auxiliary channels can be enabled to capture or stream additional data. Below is a non-exhaustive list of the methods Güralp supports for viewing and extracting this data:

- Discovery: Güralp's proprietary tool to view and find networked devices, for a full list of features see the Discovery Manual;
- HTTP Request: data can be accessed directly from a networked device with an HTTP command that specifies the path to the required data (e.g. http://10.20.1.92/sd/`status.log`)
- Wget command: a Linux supported method for downloading the data utilising the http format above (e.g. `wget http://10.20.1.92/sd/ status.log`)
- User Generated Scripts: scripting languages such as bash or python can be used to automate the extraction and formatting of SOH data, scripts can also be set in discovery to allow ease of use for repetitive tasks (Discovery Manual section 4.3.6)
- Serial/Debug Port: by connecting directly to the device the user can run commands that return status information, a full list of commands can be viewed by running the command "help";
- GüVü App: Güralp's android smartphone app that can report SOH data via Bluetooth;
- Auxiliary Channels: by filtering "Display Steams" by "All" on the "Data Record" or "Data Stream" tabs, "Auxilliary channels" can be viewed and enabled to record/stream SOH data for devices such as Voltage and Temperature
- Device LED: for a manual approach, the LED on many Güralp devices can be used to detect certain errors and interpret the SOH of the device.

2.15.1 LED Indicator

Minimus, Minimus+, Certimus and Fortimus have an LED indicator on the upper surface, which provides status and configuration information.

This information is encoded in sequences of coloured flashes. In general, red flashes indicate that initialisation is in progress or that the instrument has encountered a problem, green flashes indicate normal operation and blue flashes show trigger activity. The various codes are:

One quick red flash followed by a one second pause: the removable microSD card is present in the Minimus' external slot, but no fixed microSD card is present inside the Minimus.

Two quick red flashes followed by a one second pause: the fixed microSD card is present inside the Minimus but no removable microSD card is present in the Minimus' externally-accessible slot.

Three quick red flashes following by a one second pause: both microSD cards are present but either the GNSS receiver is disconnected or the GNSS lock is not sufficiently accurate.

A green flash every four seconds: this is the standard operating heartbeat. GNSS and both internal and external microSD cards are present, which indicates that the Minimus can be successfully deployed and left to record data.

> **Note:** Depending on the digitiser's recent history, it can take up to ten minutes to reach this state after power-up.

1 blue flash: a trigger event has been detected.

2.15.2 Commands on the Debug RS232 Serial Port

The web page interface consists of named parameters with their respective values. There Name/Value pairs can be read and written from the serial debug port. This feature is offered specifically for the rarer applications where connectivity can only be provided by RS232 connection and not via the LAN (Local Area Network).

A group of commands are available under the name "var".

`var ?` - Lists available commands.

Some examples are reported below:

`var get "Digitiser humidity"` - Read contents of the named variable "Digitiser humidity"

`var get "Integrator Z (0)"` - Mass position of first sensor's vertical mass

`var get "Temperature (0)"` - Internal temperature of the device

2.15.3 HTTP State Of Health and Configuration Resources

Several files containing data can be downloaded from the Minimus' in-built WEB server when connected via LAN. These files can be used to check the running health of the Minimus as well as the configurations set for various components which could aid in troubleshooting problems or provide sanity checks for continued use.

2.15.3.1 ASCII Text Status

While normally status information gets written to the Status.log file every 20 minutes, you can request a status.txt file to be produced at any moment, which shows the status of the system at the moment of the request. To perform this action from any browser, enter the IP address of the Minimus followed by “/status,txt”, for example:

http://1.2.3.4/status.txt

Which will provide the following output:

Not secure 10.20.1.82/status.txt

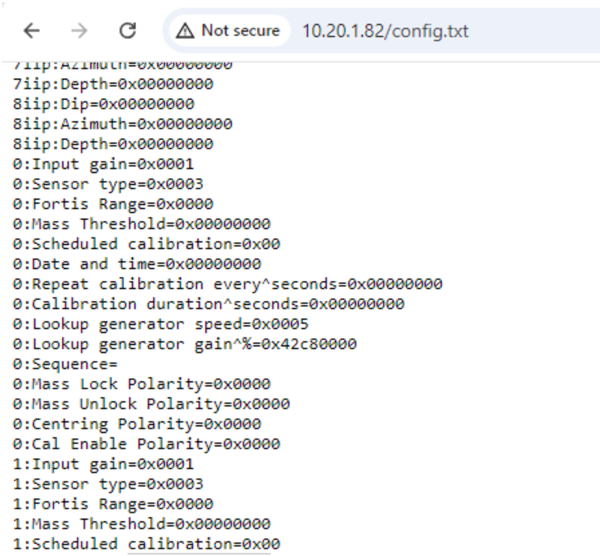
```
***** 2024-09-06 09:56:03 *****
Digitizer
        Host name:  MIN-A555
        Host label:  SUPRT MINIMUS FIXED
        System type:  Minimus
        SEED network:  DG
        SEED station:  0A555
        Site name:  No site
        Firmware version:  2.1-21249
        System boot time:  04.09.2024 16:23:03
        System uptime:  1d 17h 32m 58s
        Environment
                Temperature:  30.209 °C
                Relative humidity:  26.21%
        Power supply
                Input voltage:  14.389 V
                Power over Ethernet voltage:  0.796 V
        Network configuration
                IPv4 address:  10.20.1.82
                Subnet mask:  255.255.0.0
                Gateway:  10.20.255.1
                Mode:  DHCP
                MAC address:  00:50:C2:40:55:A5
                IPv4 sockets used:  13 out of 60
        GNSS status
                Status:  Locked
                Latitude:  51.3605
                Longitude:  -1.1635
                Altitude:  117.00 m
                Horizontal dilution of precision:  0.98
                Last timestamp:  2024-09-06 09:56:02
                Last lock time:  2024-09-04 16:28:56
                Stability:  100%
                Satellites used:  12
                Satellites in view:  12
                Clock quality:  Fine locked
```

2.15.3.2 System Configuration

To access the configuration values for various components associated with the Minimus, from a browser enter the IP address of the device, followed by “/config.txt”, for example:

http://1.2.3.4/config.txt

This returns name/value pairs of WEB interface parameters.



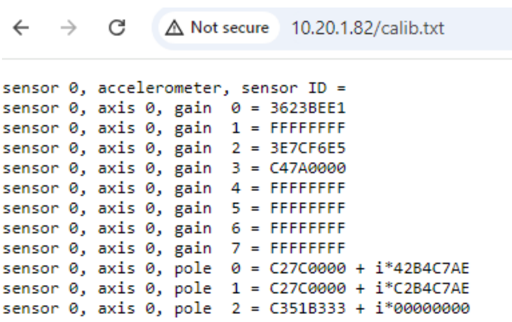

```
7iip:Azimuth=0x00000000
7iip:Depth=0x00000000
8iip:Dip=0x00000000
8iip:Azimuth=0x00000000
8iip:Depth=0x00000000
0:Input gain=0x0001
0:Sensor type=0x0003
0:Fortis Range=0x0000
0:Mass Threshold=0x00000000
0:Scheduled calibration=0x00
0:Date and time=0x00000000
0:Repeat calibration every^seconds=0x00000000
0:Calibration duration^seconds=0x00000000
0:Lookup generator speed=0x0005
0:Lookup generator gain^%=0x42c80000
0:Sequence=
0:Mass Lock Polarity=0x0000
0:Mass Unlock Polarity=0x0000
0:Centring Polarity=0x0000
0:Cal Enable Polarity=0x0000
1:Input gain=0x0001
1:Sensor type=0x0003
1:Fortis Range=0x0000
1:Mass Threshold=0x00000000
1:Scheduled calibration=0x00
```

2.15.3.3 Instrument Response

To view the calibration values set for instruments connected to the Minimus, from a browser enter the IP address of the device, followed by "/calib.txt", for example:

http://1.2.3.4/calib.txt

This returns the poles, zeros and gain values configured for instruments connected to the Minimus. Output values are shown in Hexadecimal format with 32-Bit single precision floats as specified by the IEE754 standard:

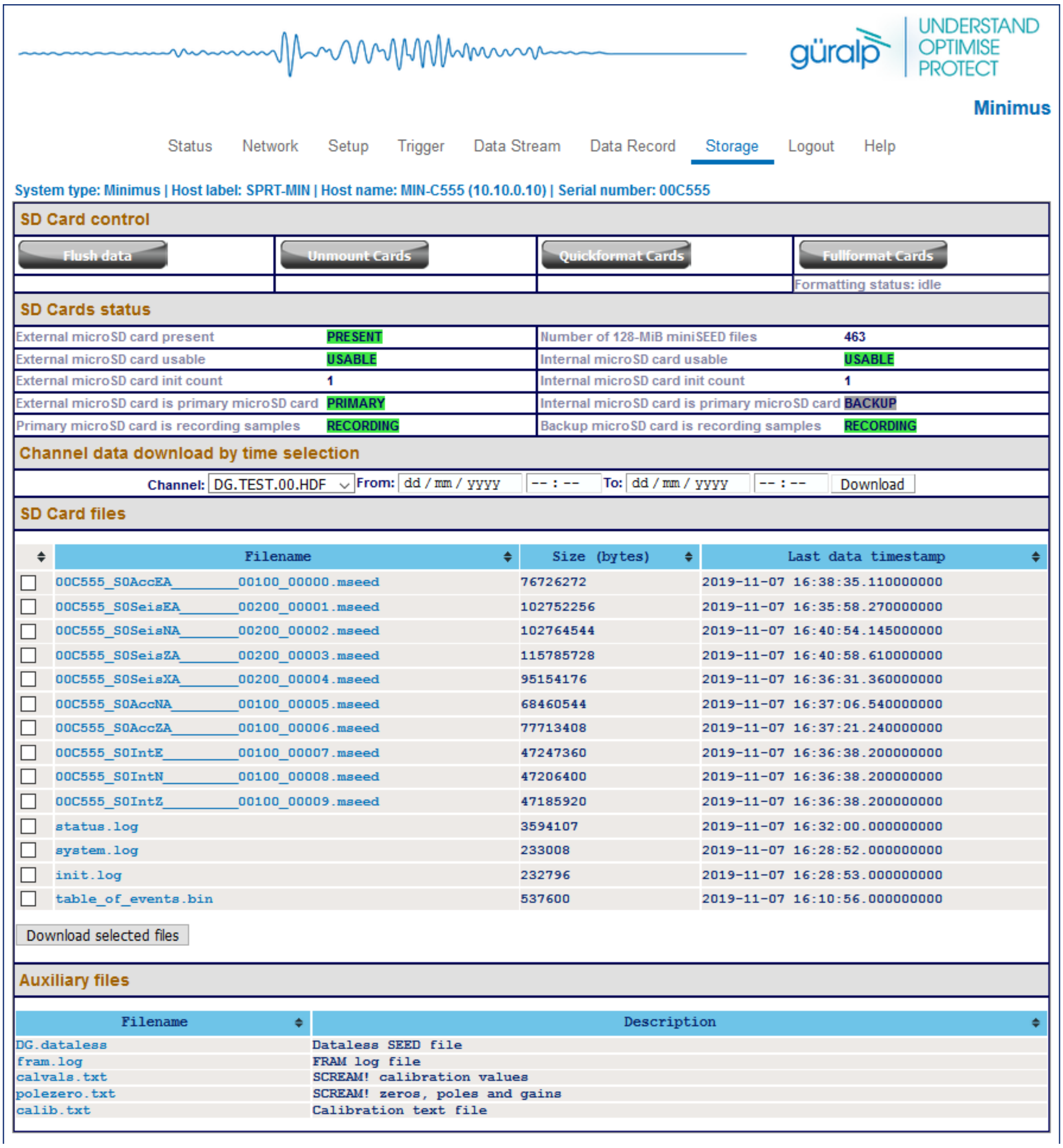



```
sensor 0, accelerometer, sensor ID =
sensor 0, axis 0, gain  0 = 3623BEE1
sensor 0, axis 0, gain  1 = FFFFFFFF
sensor 0, axis 0, gain  2 = 3E7CF6E5
sensor 0, axis 0, gain  3 = C47A0000
sensor 0, axis 0, gain  4 = FFFFFFFF
sensor 0, axis 0, gain  5 = FFFFFFFF
sensor 0, axis 0, gain  6 = FFFFFFFF
sensor 0, axis 0, gain  7 = FFFFFFFF
sensor 0, axis 0, pole  0 = C27C0000 + i*42B4C7AE
sensor 0, axis 0, pole  1 = C27C0000 + i*C2B4C7AE
sensor 0, axis 0, pole  2 = C351B333 + i*00000000
```

2.16 Data Download

2.16.1 Bulk Data Download via Webpage

The Storage tab of the web interface displays the miniSEED files stored on the microSD card:

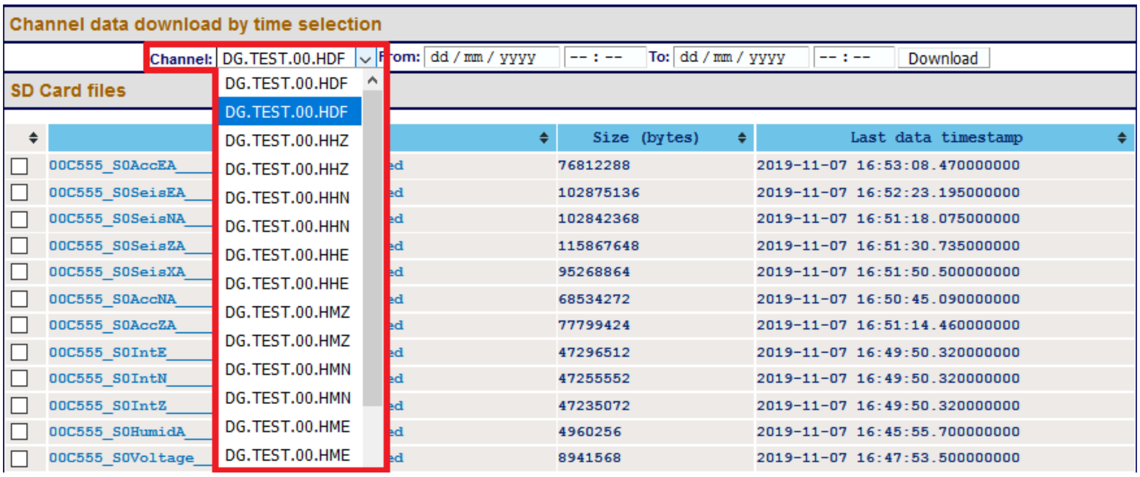


Single or multiple files can be downloaded simultaneously by ticking the check-boxes on the left of each link and clicking on Download selected files button.

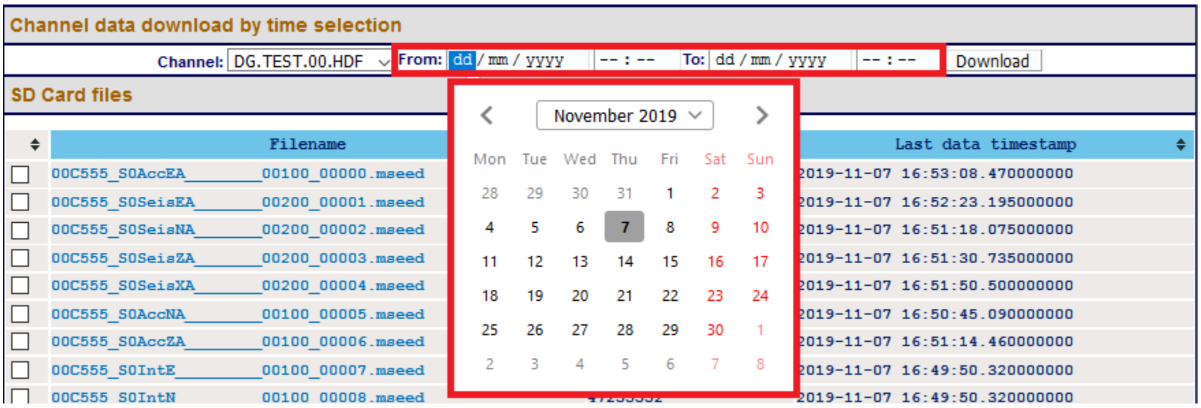
The microSD cards are formatted with empty files, which are filled with data as they become available. The filenames are also changed when the files are written on. Before they are written on, they are marked as "hidden" files, so that it is easier to see how many files contain data when looking at the contents of the card.

2.16.2 Time-Based Data Download via Webpage

From the Storage tab of the web interface, data for a single stream spanning a specific time-interval can be downloaded. To do this, start by selecting the desired stream from the drop-down menu:



Next select the start and end dates using the pop-up calendar, then the desired time range in 24 hour format :



Lastly, click the Download button to initiate a file transfer to your local device.

2.16.3 Bulk Data Extraction via Network

Files stored on the SD card can be downloaded using HTTP. The example bash script below can be used from a Linux PC or from the WSL shell on a Windows PC. The script extracts all files from the SD Card into a directory named after the date and the network address of the Minimus.

```
#!/bin/bash
# Invoke with one argument: the network
# address of the Minimus

set -x

if [ "$#" -ne 1 ] ; then
  echo "Usage: $(basename $0) network_address"
```

```
  exit 1
fi

NET_ADDRESS=$1
DATE=$(date --iso-8601)
SAVEDIR = ${DATE}_${NET_ADDRESS}
echo Saving to $SAVEDIR

mkdir $SAVEDIR
cd $SAVEDIR
wget -rnp http://$NET_ADDRESS/tab9.html
cd ..

echo Done
```

2.16.4 Time Based Data Extraction via Network

The example Python script below will extract seismic data from the SD card based on a specified time interval. This is similar to the FDSN (International Federation of Digital Seismograph Networks) data archive retrieval service: https://www.fdsn.org/webservices/fdsnws-dataselect-1.1.pdf.

Channel names are as given on the "Data Record" tab of the web interface and the times are specified in UTC time format. The resulting file will be in miniSEED format.

> **Note:** The script forms an http request to the instrument in the form of: http://<<IP Address>>/data?channel=<<Channel>>&from=<<Unix Epoch Seconds>>&to=<<Unix Epoch Seconds>>, which for the example below, would appear as: http://192.168.254.101/data?channel=DG.TEST.01.CHZ&from=1740114000.0&to=1740117600.0

```
import os
import wget
from obspy import read, read_inventory, UTCDateTime
from obspy.signal import PPSD

######### Start of variable to set #############
sensor = "192.168.254.101"
channel = "DG.TEST.01.CNZ"
start = UTCDateTime("2025-02-21T05:00:00.0")
end = UTCDateTime("2025-02-21T06:00:00.0")
########### End of variables to set ###########

startUNIX = UTCDateTime(start).timestamp
#We use the 'start'&'end' to cut the data using Obspy
endUNIX = UTCDateTime(end).timestamp
# We use the 'startUNIX'&'endUNIX' to pull the
# data from the Minimus

#if os.path.exists(r"{0}\tt.mseed".format(temp)):
# See if temp file exists, if so delete.
#os.remove(r"{0}\tt.mseed".format(temp))

if os.path.exists(r"{0}_{1}_{2}.mseed".format(sensor, channel,
start)):
```

```
    os.remove(r"{0}_{1}_{2}.mseed".format(sensor, channel, 
start))

print(start)

print(r"http://{0}/data?channel={1}&from={2}&to={3}".format(senso
r, channel, startUNIX, endUNIX))
wget.download(r"http://{0}/data?channel={1}&from={2}&to={3}".form
at(sensor, channel, startUNIX, endUNIX), 
r"{0}_{1}.mseed".format(channel,startUNIX))
```

The following example in Bash allows you to extract from the SD card the three seismic components of a sensor for a given date over a specified time frame. It then combines the three components into an individual miniSEED file, whose name will include the network code, station code, start date and start time:

```
#! /bin/bash
# Invoke with one argument: the IP address. For example
./script_name 192.168.254.101

set -x

# enter your network details
net_code=DG
station_code=04D67
location_code=0L

#enter the sensor codes for the location targeted, found on the
Data Stream tab of discovery, the last 3 characters/values of the
SEED name (HNZ)
sensor_code1=HNZ
sensor_code2=HNN
sensor_code3=HNE

# choose the day
day=2024-04-28

# choose the start time in 24-hour format (e.g. 16 = 4pm)
start_hour=16

# choose the number of hours to include in the miniSEED file(e.g.
1 = 1-hour-long miniSEED)
step=1

utc=$(date --date ${day} +%s)
start_utc=$(expr $utc + 3600 \* ${start_hour})
end_utc=$(expr ${start_utc} + 3600 \* ${step})

echo $utc
echo $start_utc
echo $end_utc
```

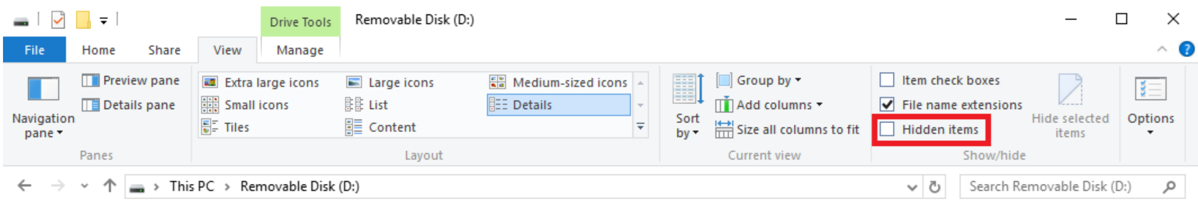
```
wget -v -Oz_component.mseed
http://$1/data?channel=${net_code}.${station_code}.${location_cod
e}.${sensor_code1}\&from=${start_utc}\&to=${end_utc}
wget -v -On_component.mseed
http://$1/data?channel=${net_code}.${station_code}.${location_cod
e}.${sensor_code2}\&from=${start_utc}\&to=${end_utc}
wget -v -Oe_component.mseed
http://$1/data?channel=${net_code}.${station_code}.${location_cod
e}.${sensor_code3}\&from=${start_utc}\&to=${end_utc}

# Convert from Unix timestamp to date and time
date_string=`date -d @${start_utc} +'%Y.%m.%d-%H.%M.%S'`


# In this example, the 3-components miniSEED file will be named
"DG.04D67-2024.04.28-16.00.00.mseed"
cat z_component.mseed n_component.mseed e_component.mseed >
${net_code}.${station_code}-${date_string}.mseed
```

2.16.5 Bulk Data Extraction from MicroSD card

To view files saved on the external microSD card, remove the card. Insert the card into a microSD card reader (external or in-built) on your PC/laptop. Within a few seconds, the card should appear as a removable disc drive.

A microSD card formatted for the Minimus contains many "hidden" files. They are created at format time with no contents and then renamed, unhidden and filled with data as required.

When viewing files in Windows Explorer, it may be helpful to configure your system so that "hidden" files are not shown. In Windows 10, this can be done by checking the “Hidden items” checkbox within the “View” ribbon of Windows Explorer.

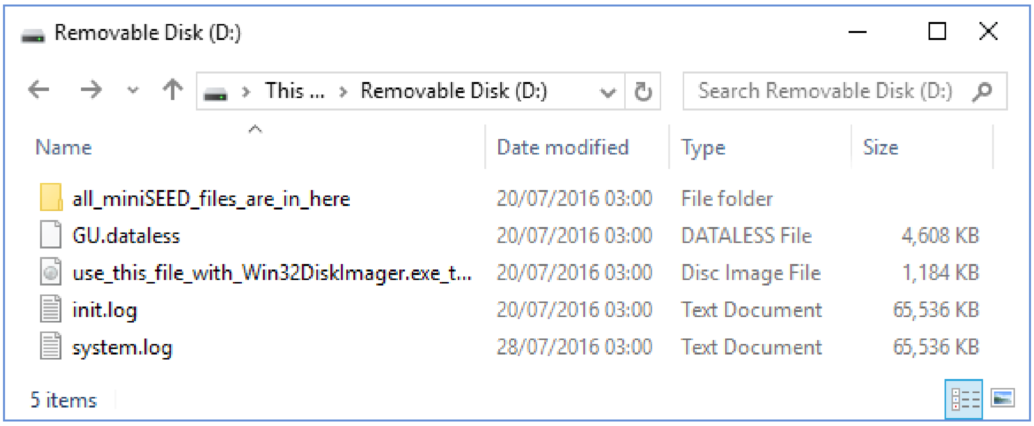


2.16.5.1 *The Contents of the MicroSD Card*

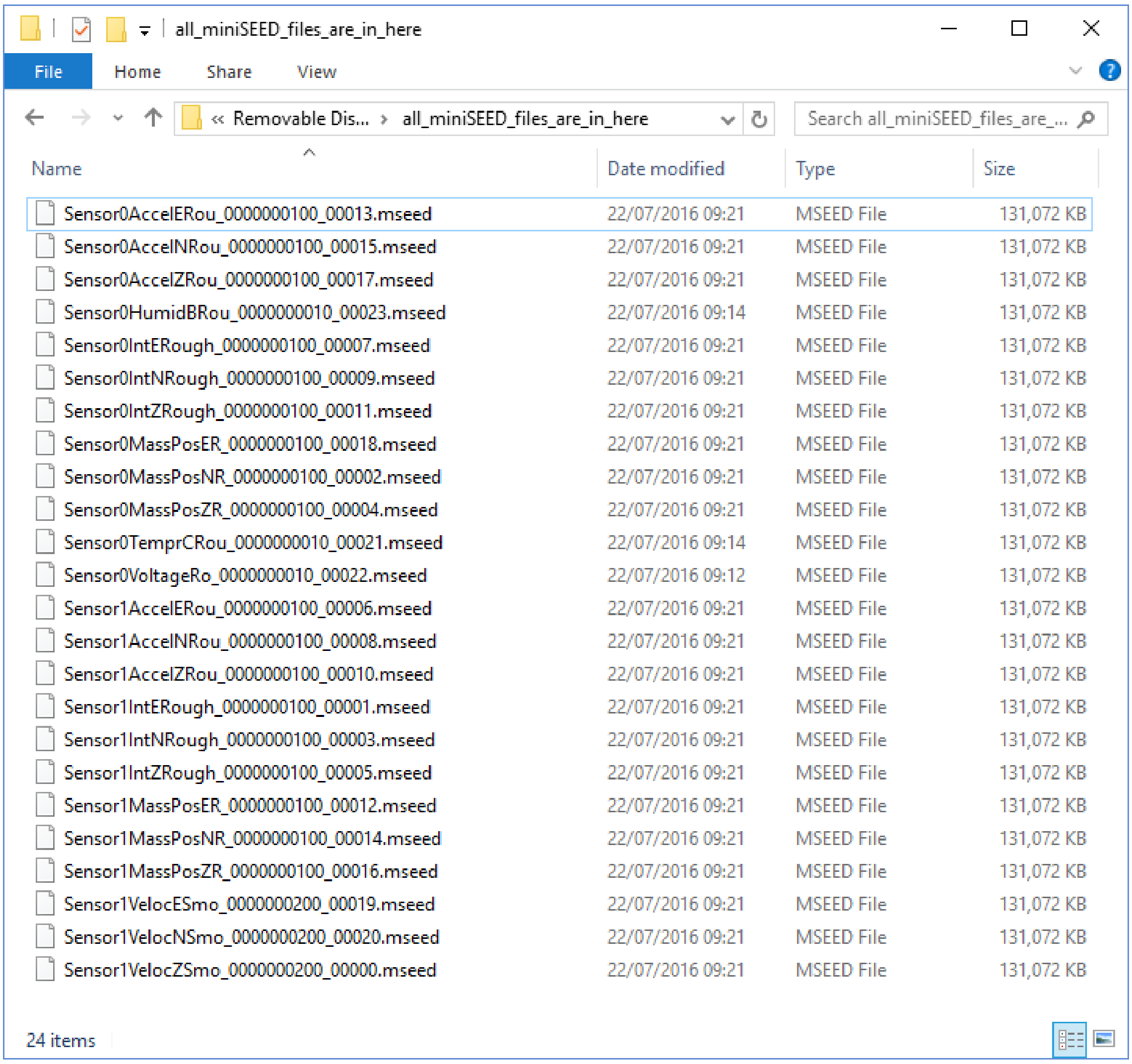
The root directory of the disc contains seven items:

- A file named `init.log`. This file contains the first 32 MiB of system log information since the card was last formatted;
- A file named `system.log`. This file contains the last 64 MiB of the system logs;
- A file named `status.log`. This file contains the last 32 MiB of system state of health information, which is updated every 20 minutes;
- A disc image file which Güralp technical support may ask you to use if you have problems with the card;

- A file named `table_of_events.bin`. This is a binary file that is used by the Seismic Events Table in the “Trigger” tab;
- A file with .dataless format. This contains meta data to be used in conjunction with the miniSEED files;
- A directory named `all_miniSEED_files_are_in_here`. Within this directory, there will be a miniSEED file for each recording channel. The file-name prefix is the same as the channel name description given in the “Data Record” tab. Each file is 128 MiB in size.



The typical contents of the `all_miniSEED_files_are_in_here` directory looks like this:



The filename consists of four components:

- The stream name, truncated to 16 characters

- The sample rate (in samples per second) as a ten-digit decimal number, left-padded with zeros;
- A number which functions as a counter to ensure unique filenames for all files. Each time a file is created, this number is incremented so that the next file to be created will use the next value; and
- The `.mseed` extension which identifies this as a miniSEED file.

The "Storage" tab also shows links to five auxiliary files, which are either saved in the Minimus' flash RAM or are dynamically generated:

- *<<SEEDnetwork>>*`.DATALESS` : This is a dataless SEED volume that contains metadata including instrument responses, coordinates, compression type and more. It is generated from the RESP files for each channel. The first component of the file name depends on the two-character Network code defined in the Setup tab. If, for example, this is `GU`, the file is called `GU.DATALESS`.
- `fram.log` : this is the FRAM log file. It is stored in FRAM.
- `calvals.txt` : this file contains calibration information in a format compatible with the Scream! software package. It is dynamically generated.
- `calib.txt` : this file contains calibration information with poles, zeros etc expressed in hexadecimal notation. It is stored in FRAM.
- `polezero.txt` : this file contains definitions of frequency responses in a format compatible with the Scream! software application. It is dynamically generated.

Auxiliary files

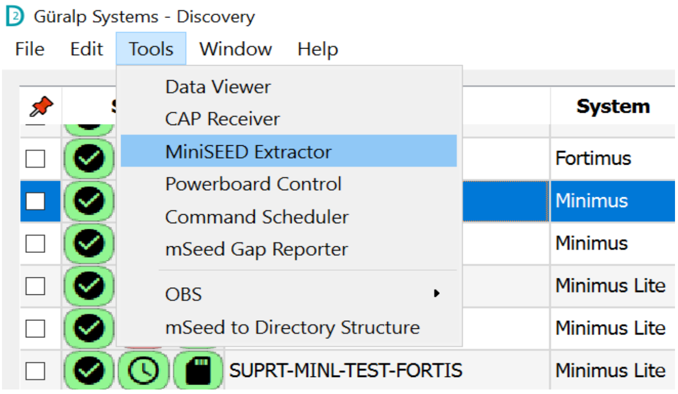
Filename	Description
DG.dataless	Dataless SEED file
fram.log	FRAM log file
calvals.txt	SCREAM! calibration values
polezero.txt	SCREAM! zeros, poles and gains
calib.txt	Calibration text file

2.16.6 Discovery Tool: MiniSEED Extractor

The miniSEED extractor is a tool available from Discovery and solves two problems:

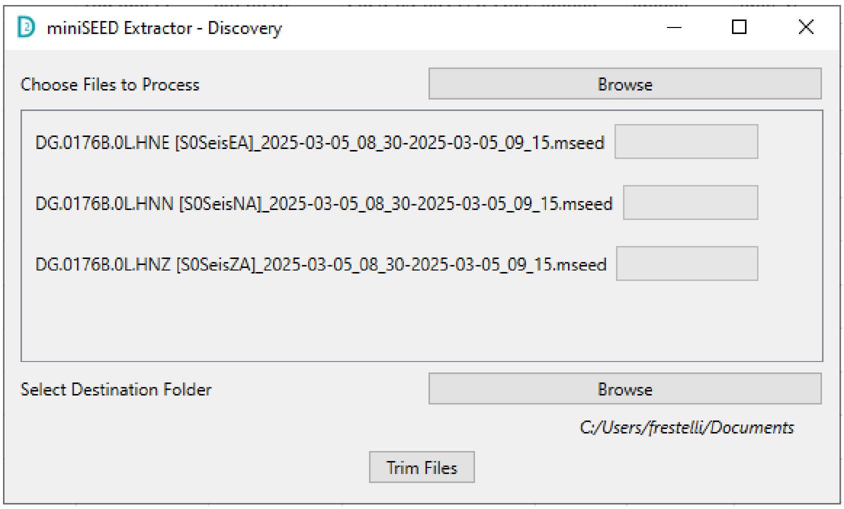
- When an SD card is quick formatted, each file is marked as unused but previously recorded data can remain within them. Subsequent recordings overwrite these files from the beginning but, if the previous recording had a longer duration, old data would remain in the files. When the files are copied from the SD card to a local device, the left over data can cause problems.
- The format used on the SD cards consists of fixed-length, 128 MiB files. Some recordings might not use all this space. When the files are copied from the SD card to a local device, the formatting can cause wasted disc space.

Minimus, Minimus+, Fortimus, Certimus



The miniSEED extractor reads miniSEED files on your PC and copies them to a selected destination folder, keeping track of the latest block timestamp as it goes. If it encounters either an unused block or a timestamp which is earlier than the previous one, it stops copying, truncating the output file at that point. This guarantees that each output file contains only blocks in time order and contains no wasted space.

To use the tool, select miniSEED Extractor from the Tools menu. Click the Top Browse button to select which files you wish to process and then the Bottom Browse button to select the folder into which you wish the output files to be written. Finally, click the Trim Files button to extract the valid data from the selected files into new files in the selected destination folder.

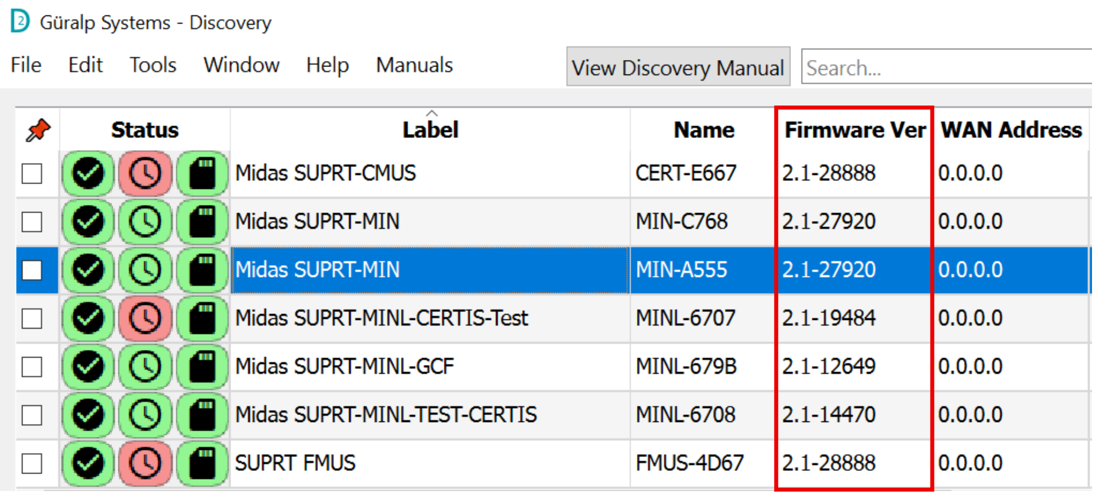


2.17 Firmware Update

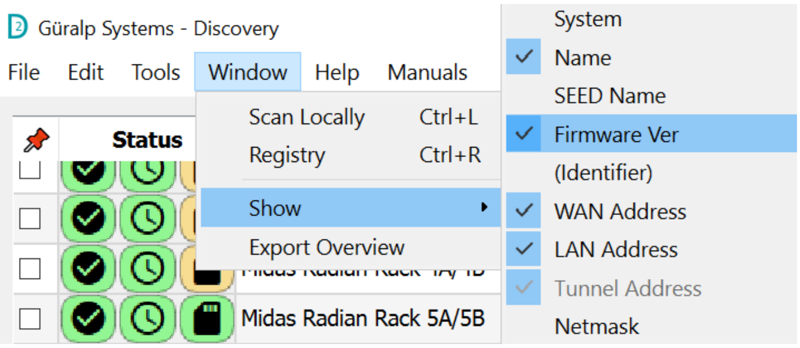
The DIG firmware is upgradeable. New releases appear regularly – either to add new features and, occasionally, to fix problems. Güralp recommends that the Minimus is regularly checked for availability of firmware updates and, *when convenient*, these updates should be installed.

2.17.1 Finding the Currently Installed Version

To determine the current firmware, open Discovery software and find the entry for your device on the main page. The firmware version is displayed, as highlighted below:



If the firmware version is not displayed, select Firmware Ver from the Show sub-menu of the View tab:



2.17.2 Upgrading the Firmware

The procedure below guarantees a straightforward upgrade and prevents any data loss or misconfiguration when upgrading from any firmware version 2.1.

Caution: Users upgrading from dig v2.0 or older may lose some or all digitiser configuration settings. We recommend that you save your current configuration before starting the upgrade process. Instructions to download your configuration can be found in Section 0. Once your configuration is saved, please proceed with the instructions below.

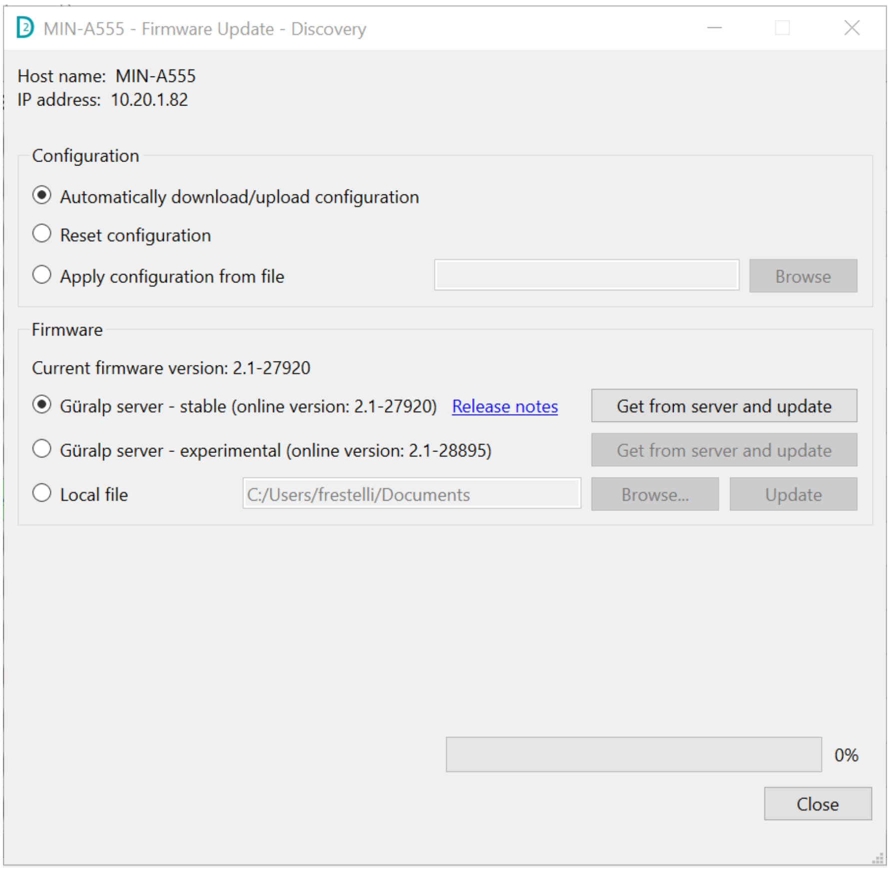
Caution: You should always back up and verify any data from your device's SD card before upgrading, in order to avoid any risk of data loss. See instructions below.

If you have any recorded data that you value, backup all files from Minimus microSD card:

1. Unplug the external microSD card from Minimus.
2. Plug the external microSD card into your PC.
3. Copy all files from the external microSD card into your PC.
4. Unplug the external microSD card from your PC.
5. Plug the external microSD card back into Minimus.

Once this is complete, to upgrade the Minimus:

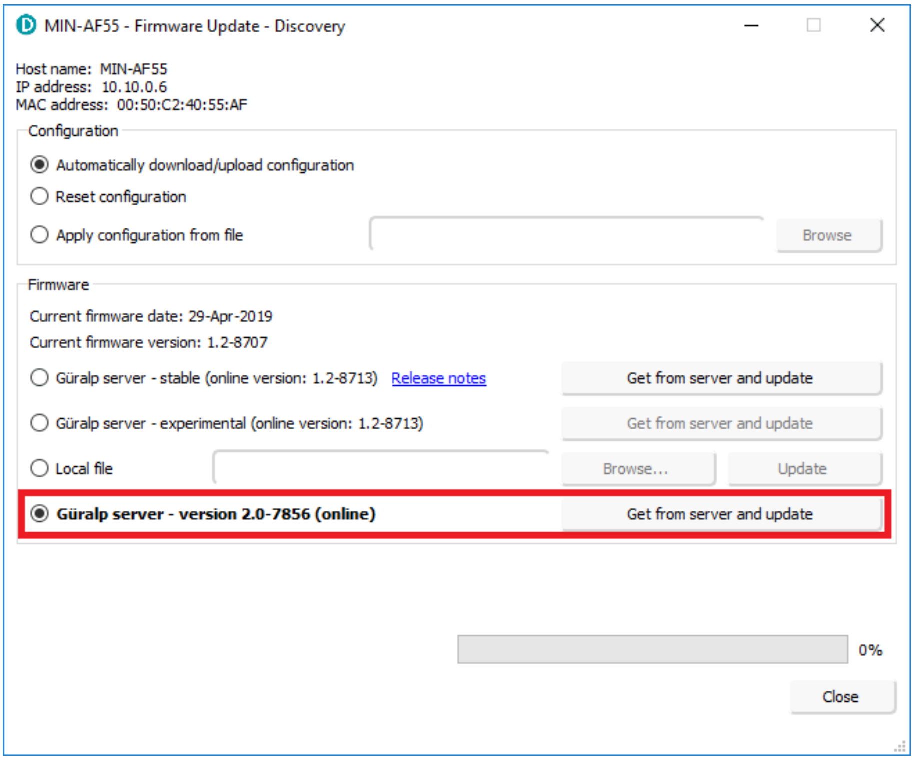
1. Run Discovery.
2. Right-click on the Minimus in Discovery main window and select "Firmware Update".
3. In the "Firmware Update" tab, select "Güralp server – stable (online version: 2.1-****)" to obtain the new firmware from the Internet via a local Ethernet connection. Click Get from server and update.



4. During the upgrade process, Discovery will remind you to backup the data on the SD cards before proceeding with the update. If any valuable data is backed up, then click Yes to continue.
5. Discovery will ask you if you want to save the Firmware binary file for future use – click Yes for future use, *e.g.* update other systems offline using same firmware file. Otherwise, proceed with No.
6. Discovery may ask to overwrite a temporary file on your PC – click Yes to allow it to do so.
7. Discovery will confirm through another dialogue box that the file download is complete. Click Yes to begin the firmware upload to the Minimus.
8. At the end of the uploading process, the dialogue box will ask to restart the Minimus. Click Yes to finalise the process.
9. A dialogue box will ask you if you want to upload the previous configuration. Click Yes to finalise the process.
10. When the configuration is uploaded, the Minimus needs to be restarted again. Confirm with Yes to the dialogue box.
11. The Minimus will re-boot and, during this process, the LED will rapidly flash white and power off for a few seconds.
12. Check that all indicators are green (*i.e.* nothing in red nor in yellow) in Discovery.
13. Go to the Status tab of the Minimus web page.

14. Check that your Minimus firmware version is as expected.
15. Check that nothing red or yellow shows up in the Status tab of the Minimus web page.

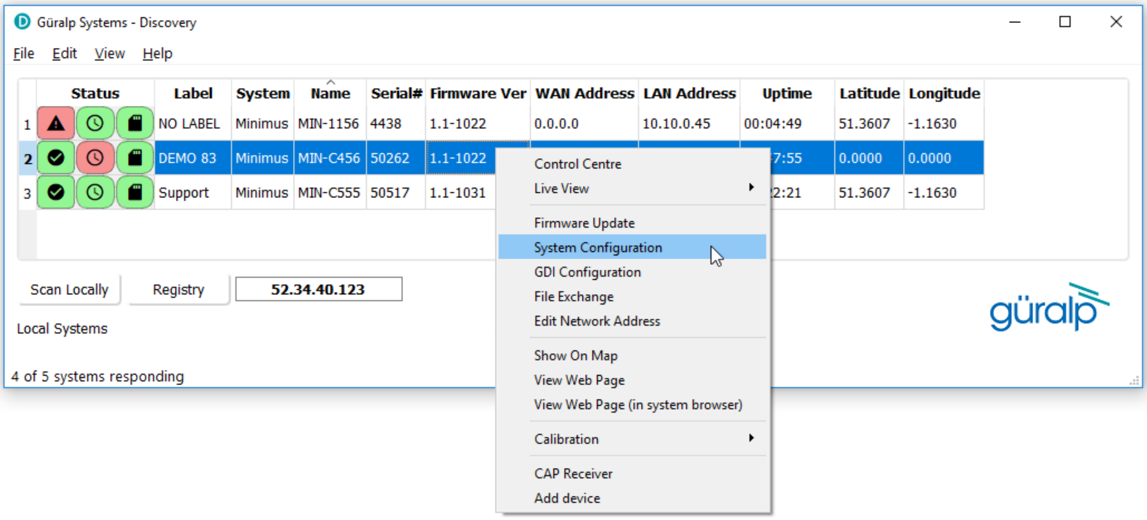
Caution: If updating from any release of v1.2 to v2.0, select the option "Güralp server – version 2.0-**** (online)" only. Do not use "Local file" option unless agreed case-by-case with *support@guralp.com*.



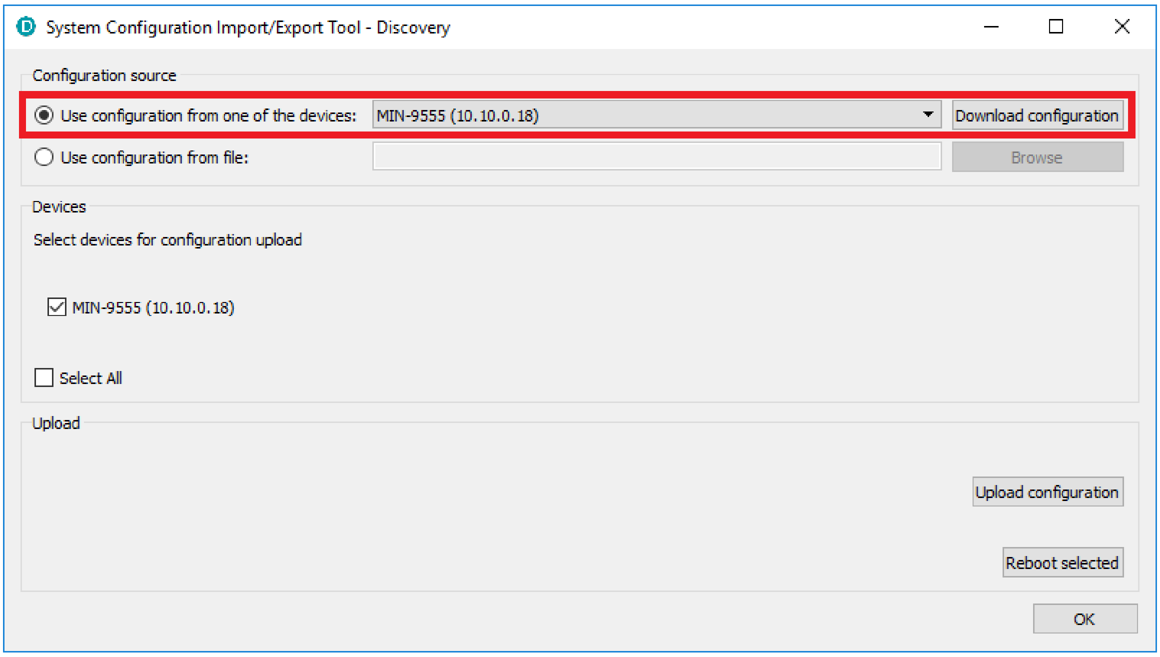
If updating from any release of below v1.2, contact *support@guralp.com* before proceeding.

2.18 Import / Export an Existing Configuration

Updating the Minimus' firmware can, occasionally, cause loss of configuration. We recommend that you export and save the current configuration before proceeding with an upgrade. This operation can be done through Discovery by right-clicking on the digitiser in the list and selecting "System Configuration" from the context menu:

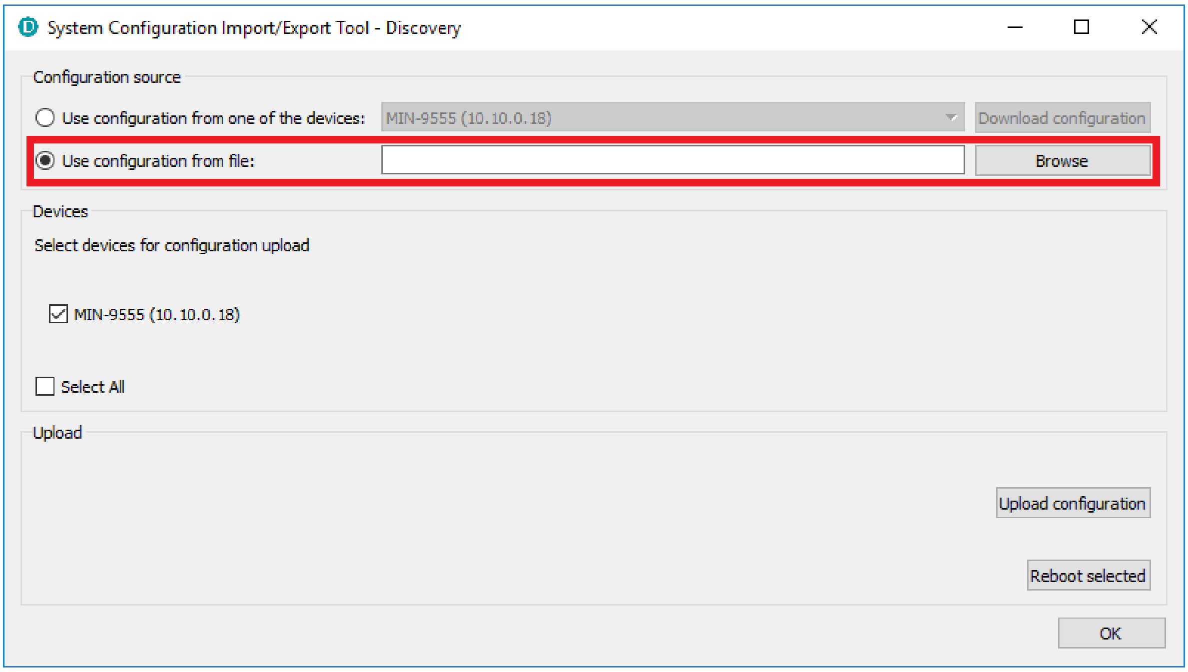


Select "Use configuration from one of the devices". If more than one device is available, select the one from which the configuration should be downloaded. Click the Download configuration button and browse to a suitable location (on your PC) into which to save the configuration file.



After the firmware update is successfully completed, the previous configuration can be imported, if required, by following the instructions below.

Right-click on the digitiser's entry in the Discovery list and select "System Configuration" from the context menu. Select the "Use configuration from file" option.



Select the configuration file from where it was saved in the File Explorer and confirm. Use the check-boxes to select the devices to which the configuration should be uploaded and click on the Upload configuration button.

Wait until the process finishes. To apply the new configuration, the unit has to be rebooted: the Reboot selected button can be used to perform the required system restarts.

Note: The configuration export and upload doesn't preserve the settings related to the applied transforms and to the analogue sensor type.

3 Part 3 - Appendices

3.1 Network Ports

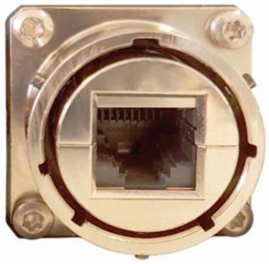
The following network ports are used by the Minimus:

Port	Layer 4 Protocol	Description
80	TCP	HTTP server
1565	TCP	GDI transmission protocol
1567	TCP/UDP	GCF transmission protocol
4242	TCP	File exchange protocol
4244	TCP	Remote console
11788	UDP	Remote procedure calls
18000	TCP	SEED-link transmission protocol
8190	TCP	Tunnel connection to server
7190	TCP	Tunnel Discovery to server

3.2 Connectors Pin-Outs

3.2.1 Ethernet

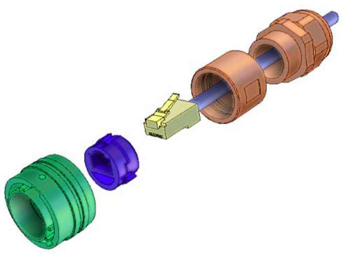
The image on the right is an Amphenol RJField-series 8P8C connector. It consists of a standard ISO 8877 8P8C modular socket (often called an RJ45) in a bayonet mounting compatible with MIL-DTL-26482 (formerly MIL-C-26482).



The wiring of a standard ethernet cable is shown below for configuration of different transmission types:

Pin	10BASE-T & 100BASE-TX	1000BASE-T
1	Transmit Data +	BI_DA+
2	Transmit Data -	BI_DA-
3	Receive Data +	BI_DB+
4	*not connected*	BI_DC+
5	*not connected*	BI_DC-
6	Receive Data -	BI_DB-
7	*not connected*	BI_DD+
8	*not connected*	BI_DD-

The 8P8C connector shown left accepts unmodified ISO 8877 8P8C modular connectors (often called RJ45 connectors or Ethernet “Cat 5/6” connectors).



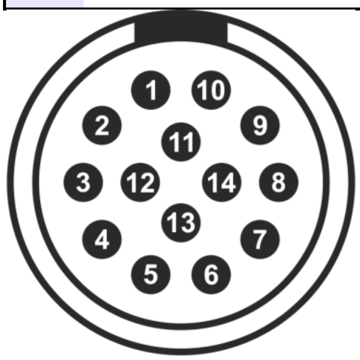
When used in hostile environments, a standard Ethernet cable can have a mating environmental shield (Amphenol part number RJF6MN) fitted.

3.2.2 GNSS/Serial

This is a 14-pin LEMO EEG.1K socket. Suitable mating connectors can be found in the LEMO FGG.1K.314 range.

- To engage the mating connector, line up the red marks and push firmly until you hear a click.
- To disengage, hold the mating connector by the knurled outer sleeve and pull steadily.

Pin	Function
1	Ground
2	*not connected*
3	Ground
4	Debug (serial) receive
5	Debug (serial) transmit
6	*not connected*
7	GNSS power
8	GNSS pulse-per-second signal – RS-422 positive
9	GNSS receive – RS-422 positive
10	GNSS transmit – RS-422 positive
11	GNSS transmit – RS-422 negative
12	*not connected*
13	GNSS pulse-per-second signal – RS-422 negative
14	GNSS receive – RS-422 negative



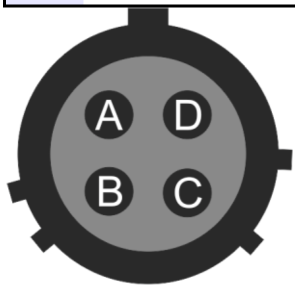
Wiring details for the compatible plug, FGG.1K.314. range, as seen from the cable end (*i.e.* when assembling).

3.2.3 Power

This is a standard 4-pin military-specification bayonet plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482).

s

Pin	Function
A	Ground
B	10-36 V DC input
C	*not connected*
D	*not connected*



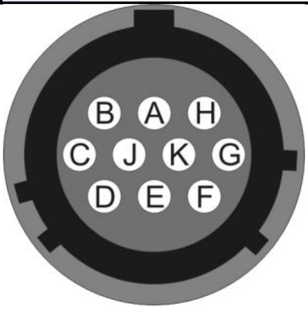
Wiring details for the compatible socket as seen from the cable end (i.e. when assembling).

3.2.4 Digital Port

Note: This connector is present only on Minimus and Minimus+.

This is a standard 10-pin military-specification bayonet sockets, conforming to MIL-DTL-26482 (formerly MIL-C-26482).

Pin	Function
A	Ground
B	Power
C	RS422 serial transmit – positive
D	RS422 serial transmit – negative
E	RS422 serial receive – negative
F	*not connected*
G	*not connected*
H	*not connected*
I	*not connected*
J	RS422 serial receive – positive



Wiring details for the compatible plug, ***-12-10P, as seen from the cable end (*i.e.* when assembling).

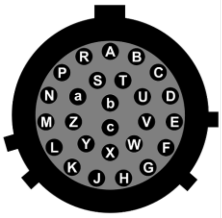
3.2.5 Analogue Port(s)

Note: This connector is present only on Minimus and Minimus+.

These are standard 26-pin male military-specification bayonet plugs, conforming to MIL-DTL-26482 (formerly MIL-C-26482).

Pin	Function	Pin	Function
A	Vertical Acceleration/Velocity – differential non-inverting input	**P**	Calibration signal (all channels)
B	Vertical Acceleration/Velocity – differential inverting input	**R**	Calibration enable – vertical channel
C	N/S Acceleration/Velocity – differential non-inverting input	**S**	Calibration enable – N/S channel
D	N/S Acceleration/Velocity – differential inverting input	**T**	Calibration enable – E/W channel
E	E/W Acceleration/Velocity – differential non-inverting input	**U**	Centre
F	E/W Acceleration/Velocity – differential inverting input	**V**	Aux sensor input – differential non-inverting (or single) input
G	Vertical mass positions	**W**	Unlock
H	*not connected*	**X**	Lock
J	N/S mass positions	**Y**	Logic – ground*
K	*BUSY* line	**Z**	Sensor RS232 transmit
L	E/W mass positions	**a**	Sensor RS232 receive
M	Auxiliary sensor input – differential inverting input	**b**	Power – ground*
N	Signal – ground*	**c**	Power – positive

* "Power – ground" and "Logic – ground" are connected together internally and also connected to the digitizer case.



Wiring details for the compatible socket, ***-16-26S, as seen from the cable end (*i.e.* when assembling).

3.3 LCD Display Menu

Note: This section is applicable to instruments with a LCD display. Both Certimus and Fortimus are available with or without LCD display. The LCD display is never present in Minimus and Minimus+ digitisers. In this section, both Certimus and Fortimus will be referred to as *Certimus*, for the sake of brevity.

The full colour LCD display shows the Certimus state of health, inclination and real-time output waveforms. It also allows configuration of the instrument as well as some control operations.

While the Minimus is booting up, it displays a white screen with the Güralp logo in the middle and a progress-bar at the bottom.

Once the Minimus has booted up completely, the LCD automatically displays the "status" page.

To move back to the main menu, touch anywhere in the screen and the main menu will be displayed.

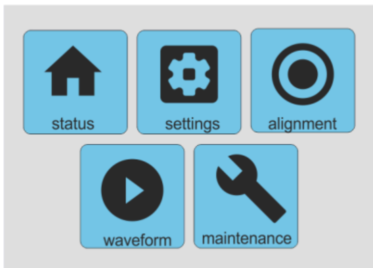
Note: When using the touch screen, keep your finger in place on each button for approximately half a second to ensure that your touch is registered. This delay helps prevent accidental triggering of menu functions.

The LCD's touch features can be disabled completely if desired: see Section 3.3.5.3 for details. The LCD behaviour can be configured in the Minimus web interface, see Section 3.3.6 for more details.

The complete LCD menu map is illustrated in Section 3.3.7.

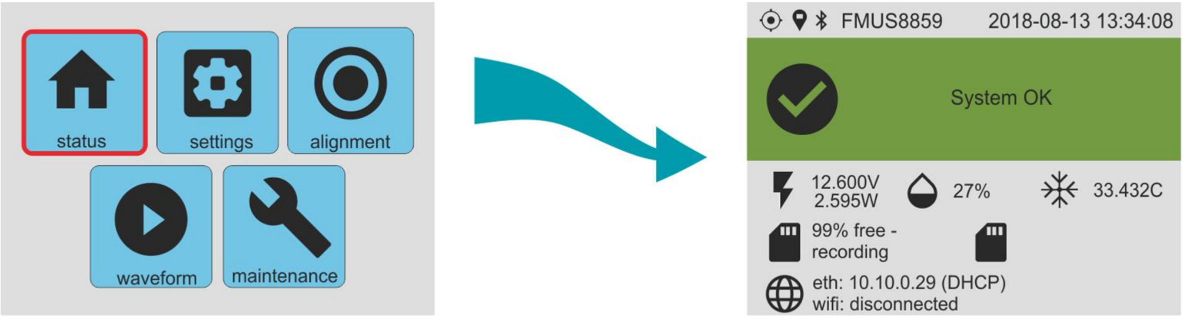
The main menu offers the following options:

- status
- settings
- alignment
- waveform
- maintenance



These are discussed in the following sections.

3.3.1 Status

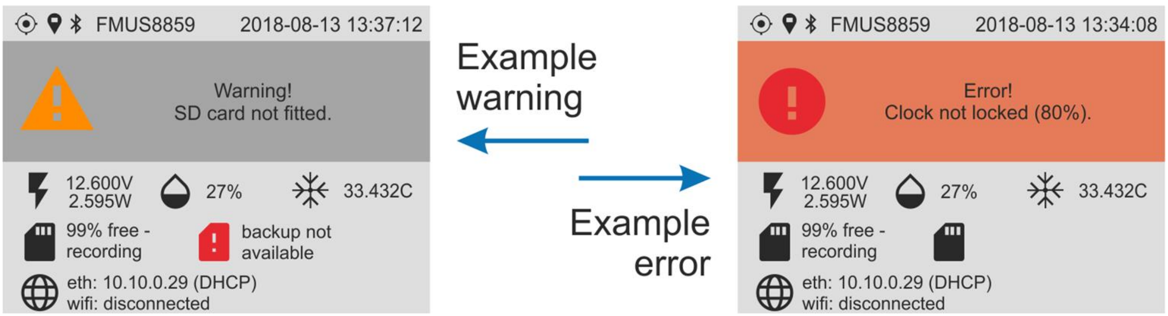


The “status” page shows information about serial number, Bluetooth status, time and date, GNSS/PTP status, input voltage and power, humidity, temperature, microSD cards recording status, IP address.

The top of the status display shows a series of icons:

These, from left to right, correspond to synchronisation, GNSS location, WiFi reception and Bluetooth status. The icon does not appear if the relevant service is disabled. If the service is enabled but in a fault condition (i.e. not connected or no GPS fix found), the icon is shown with a line through it.

Warning and errors are shown here when necessary. Warnings are shown with an amber triangle on a grey background, as shown on the left below. Errors are show with a red circle on an amber background, as shown on the right.

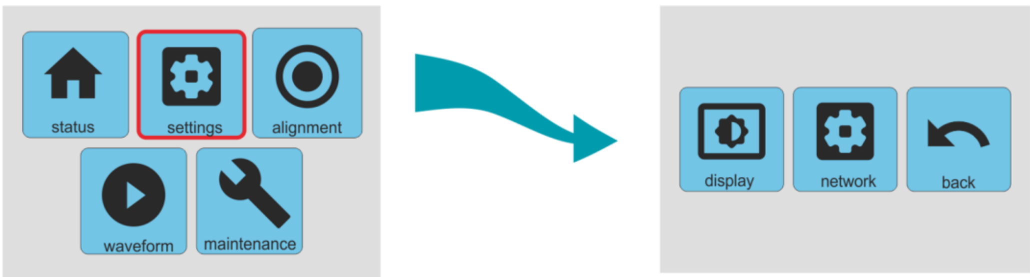


The messages that can be displayed are:

- Normal operation:
  - **System OK** : GNSS or PTP are locked, microSD cards are recording.

- Warnings:
  - **Warning! SD card not fitted** : At least one of the microSD cards is not recording.
  - **Warning! Waiting for PPS lock** : PPS signal is unstable.
- Errors:
  - **Error! Clock not locked (0%)** : GNSS quality is less than 95% and PTP is not available.
  - **Error! Clock not locked (PTP 0%)** : PTP quality is less than 80% and GNSS is not available.
  - **Error! Clock not locked (NTP only)** : GNSS quality is less than 95% and PTP quality is less than 80%.

3.3.2 Settings

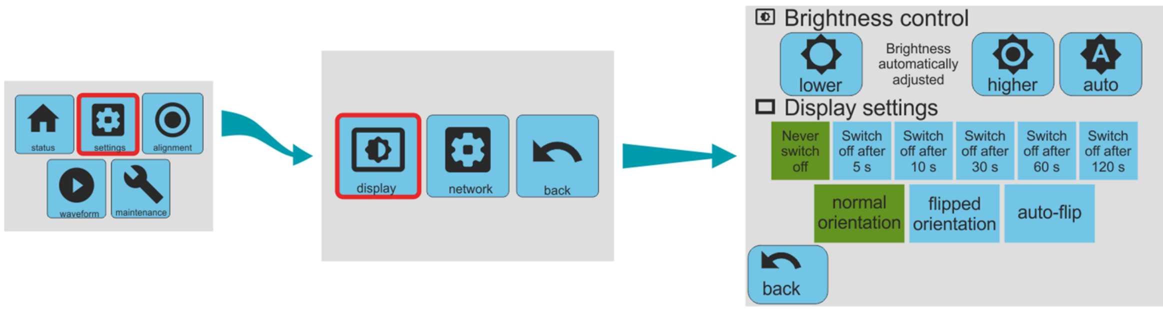


The "settings" menu offers the following options:

- display; and
- network.

These are discussed in the following sections.

3.3.2.1 *Settings → Display*



The "display" page allow control of brightness, the inactivity time-out and the orientation of the display.

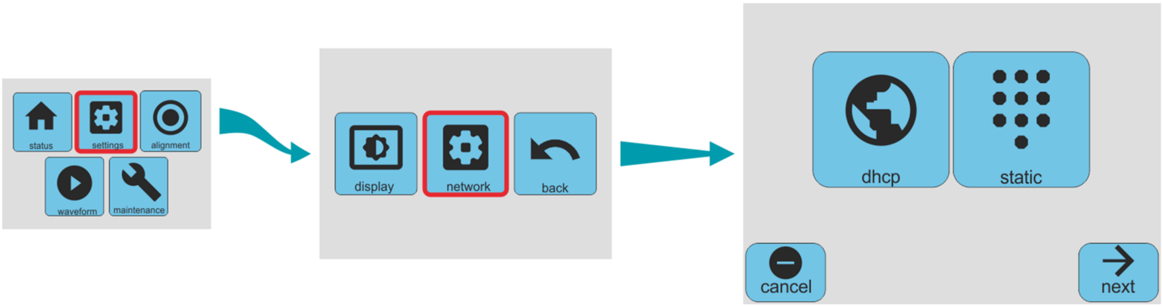
The brightness can be set to be adjusted automatically, based on the ambient light level, or manually adjusted with the "lower" and "higher" buttons.

The display can be set to stay on permanently (with a consequent increase in power consumption) or to automatically switch off after 5 s, 10 s, 30 s, 60 s or 120 s of inactivity. The currently-selected mode is indicated by the green background.

When the display has been switched off, it can be switched on again by touching and holding for a second.

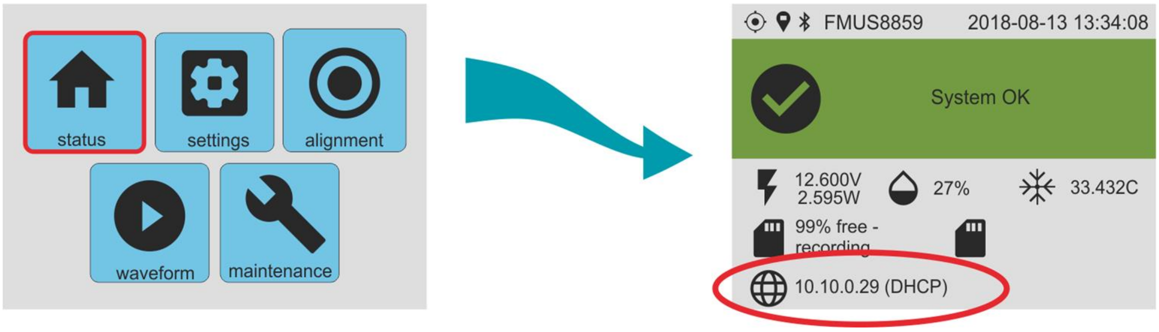
The orientation can be set to be normal or flipped. Selecting "auto-flip" will instruct the instrument to flip the display automatically based on attitude as determined by the internal MEMS accelerometer. The currently-selected mode is indicated by the green background.

3.3.2.2 Settings → Network

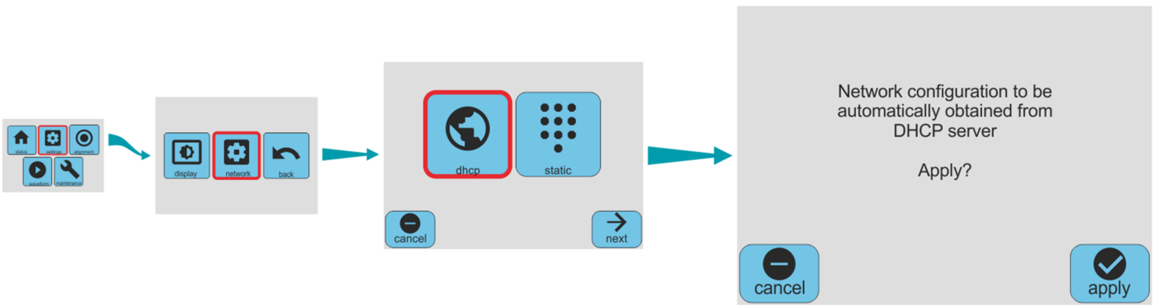


The network page allows you to choose between DHCP mode, where the networking parameters are set by an external DHCP server, or static mode, where the network parameters must be typed in manually.

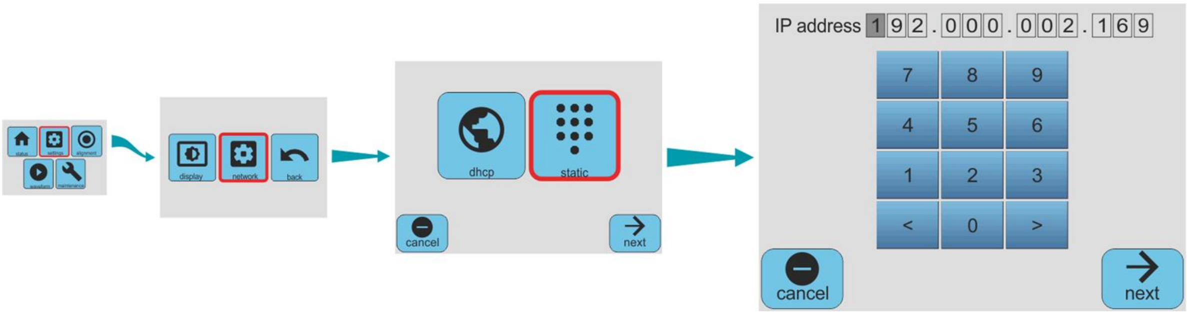
The current network mode is shown on the main status display:



If you select DHCP mode from the network page, you are asked for confirmation but no other configuration is required:

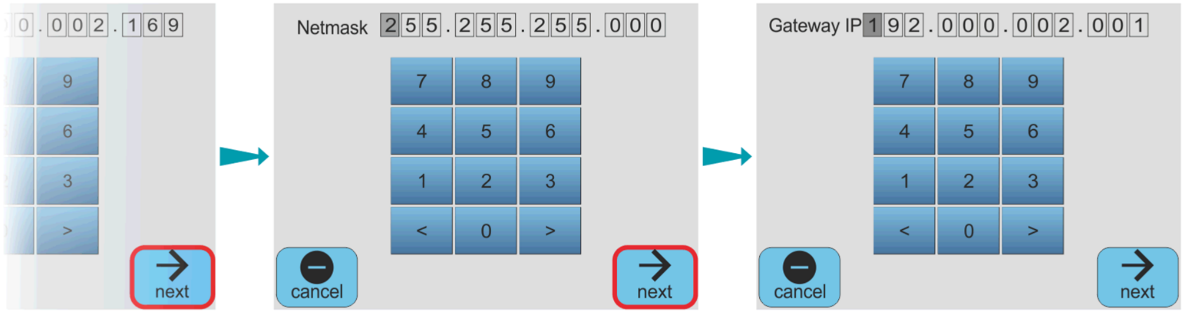


If you select static mode from the network page, you are prompted first for the IP address:

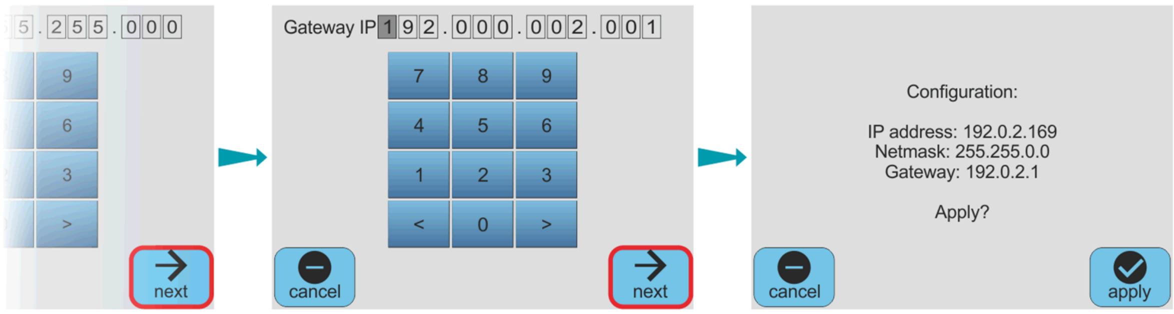


Enter the desired IP address using the on-screen virtual numeric keypad and then press "next", which takes you to the netmask screen.

Enter the desired netmask in the same way. Pressing "next" again takes you to the "Gateway IP" screen:



After entering the IP address of your gateway (default router), press "next" again to reach the confirmation screen:



Pressing "apply" here configures the Certimus with the parameters that you have just entered. Pressing "cancel" discards all of the changes and the Certimus' networking configuration is not affected.

3.3.3 Alignment

The “alignment” page shows a virtual bubble level based on the output of the MEMS accelerometer built-in the Certimus. The red circle moves around the screen as the position of the Certimus is altered, mimicking the bubble in a real bubble level; i.e. the red circle moves towards the highest part of the top of the instrument.

Note: The virtual bubble level works if and only if the MEMS accelerometer channels are enabled for streaming and/or recording.

3.3.4 Waveform

The “waveform” page shows real-time data in graphical format. The horizontal axis represents time and the display constantly scrolls to the left as the latest data are plotted on the right-hand side of the graph. Three modes are available:

In "seismic" mode, the signals from the main acceleration outputs of the Certimus are displayed.

In "accel..." mode, the outputs from the internal MEMS accelerometer are displayed.

In "auxiliary" mode, the display graphs the output from the internal temperature sensor, the internal supply voltage and the power consumption.

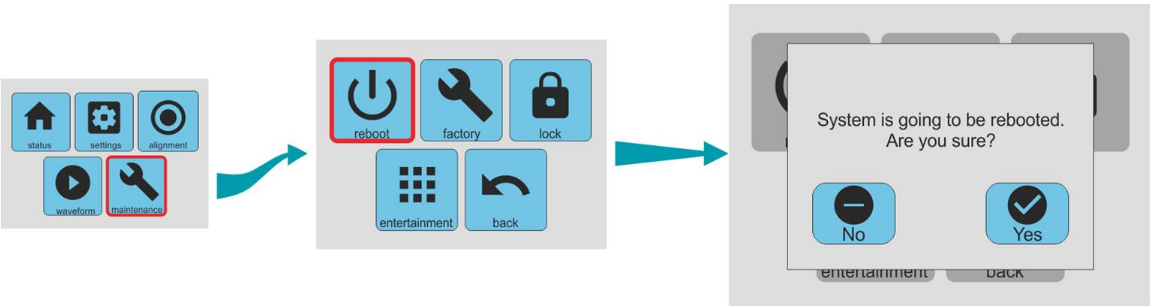
3.3.5 Maintenance

The “maintenance” page allows the user :to

- reboot the system;
- reset the configuration to factory values; and
- lock the “settings” and “maintenance” pages to prevent undesired alteration.

These are discussed in the following sections.

3.3.5.1 Maintenance → Reboot



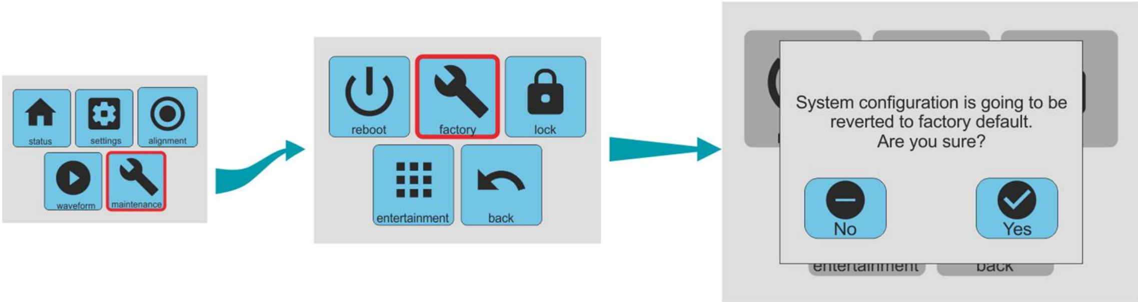
This option reboots the processor in the Minimus digitiser without interrupting power. Because this will interrupt digitisation and potentially affect the configuration (some changes only take effect after a reboot), it is protected by a confirmation screen.

Click 

if you wish to continue and 

if you have arrived at this screen unintentionally and wish to return to the main menu.

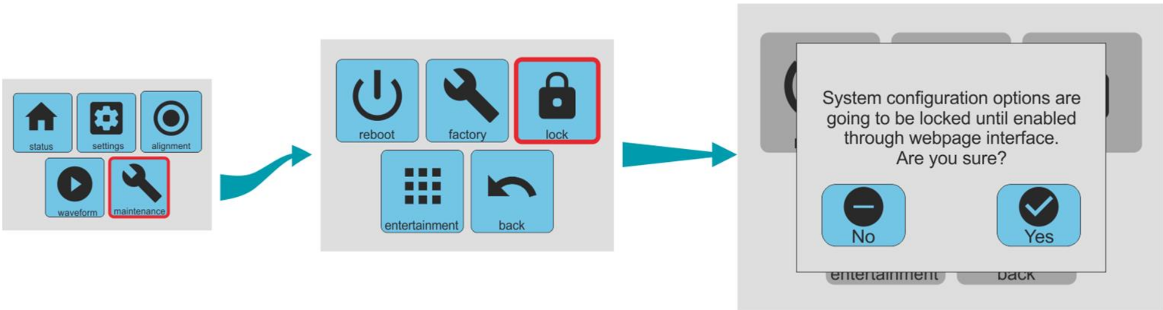
3.3.5.2 Maintenance → Restore Factory Settings



This option restores the configuration to the state in which the instrument was delivered. Because this will interrupt digitisation and affect the configuration, it is protected by a confirmation screen.

Click  if you wish to continue and  if you have arrived at this screen unintentionally and wish to return to the main menu.

3.3.5.3 Maintenance → Lock the Configuration



This option locks the LCD interface so that the instrument can only be reconfigured via its web interface. This can be useful when physical access to the instrument cannot be fully controlled. Because this can be disruptive, this option is protected by a confirmation screen.

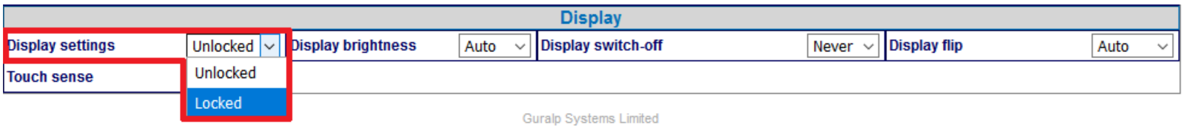
Click  if you wish to continue and  if you have arrived at this screen unintentionally and wish to return to the main menu.

Note: Once “settings” and “maintenance” are locked, they can only be re-enabled from the Minimus web page. See Section 3.3.6 for more details.

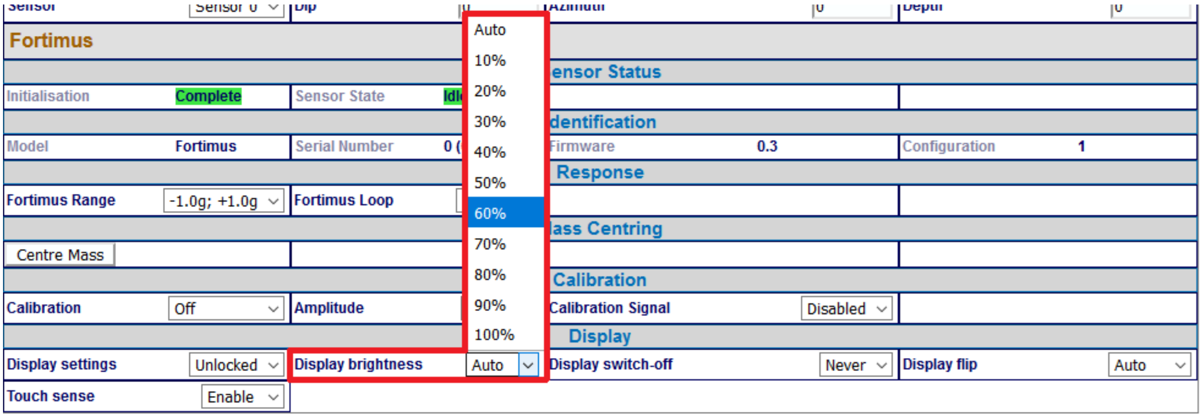
3.3.6 Controlling the LCD from the Web Interface

In the “Setup” tab of the Certimus web page, the user can remotely control the LCD display settings.

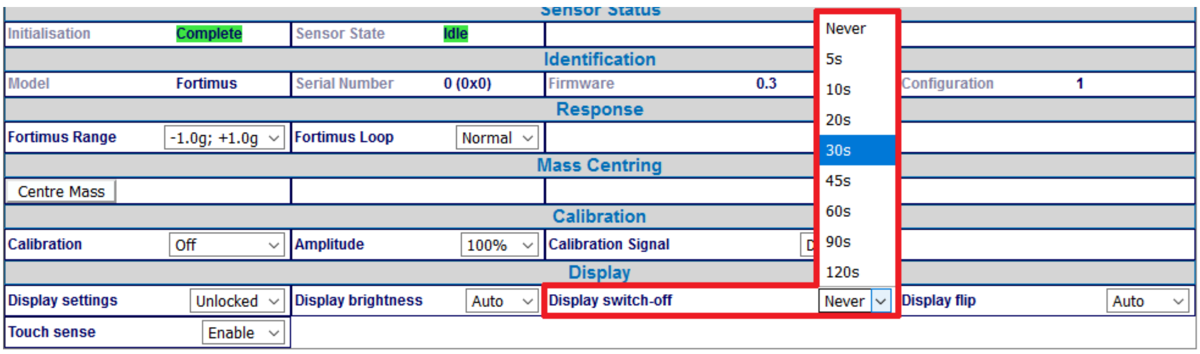
Locking and unlocking of the “settings” and “maintenance” features can be selected using the drop-down menu named “Display settings”:



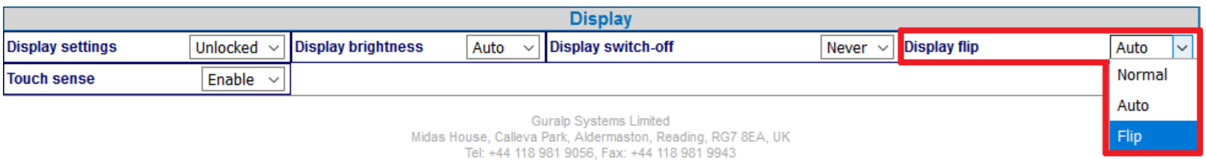
The display brightness is adjustable using the drop-down menu named "Display brightness":



The display can be set to switch off after a selectable period of time while it is untouched. When the display is off, it can be switched back on by touching it for a couple of seconds.



The LCD is, by default, oriented with the top of the screen pointing North (relative to the instrument). The orientation can be flipped by 180 degrees if required or it can be set to "automatic". When the auto-flip is enabled the orientation changes according to the MEMS output.

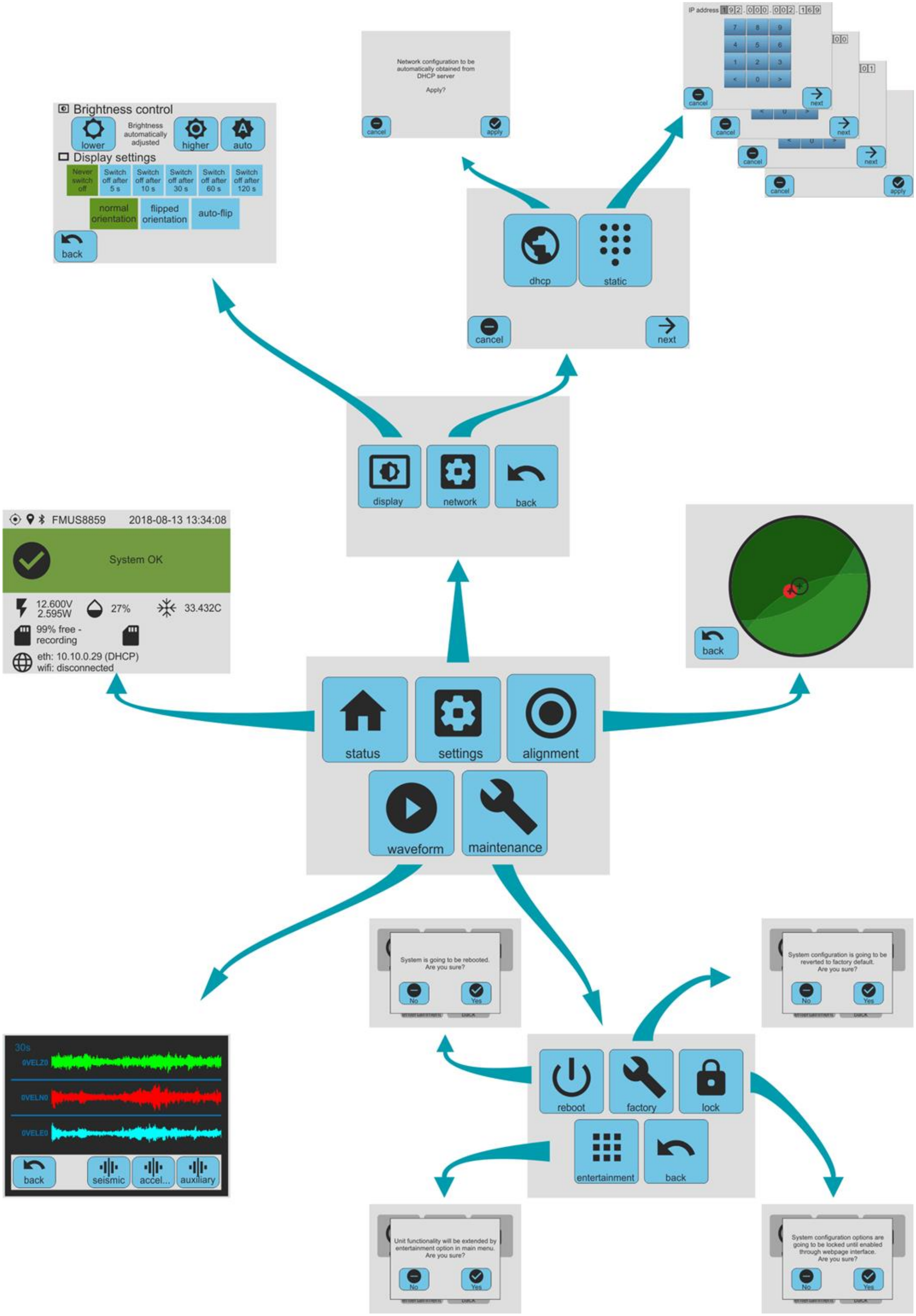


For security reasons, the LCD's touch sensor can be disabled using the option "Touch sense". Once disabled, touching the screen has no effect and no commands can be issued via the LCD.

To restore normal operation, set "Touch sense" to "Enable" from the Certimus web page.

Note: "Touch sense" can be re-enabled only from the web interface. It is not possible to re-enable it using the LCD screen.

3.3.7 LCD Menu Map



3.4 Bluetooth Connectivity: the GüVü App

The GüVü app provides monitoring and control of nearby Minimus units using the Bluetooth protocol. It is available for Android devices.

GüVü can be downloaded from the Google Play store at:

https://play.google.com/store/apps/details?id=com.guralp.whisper

3.4.1 Getting Stated

To launch GüVü, follow the steps shown in the figure below:

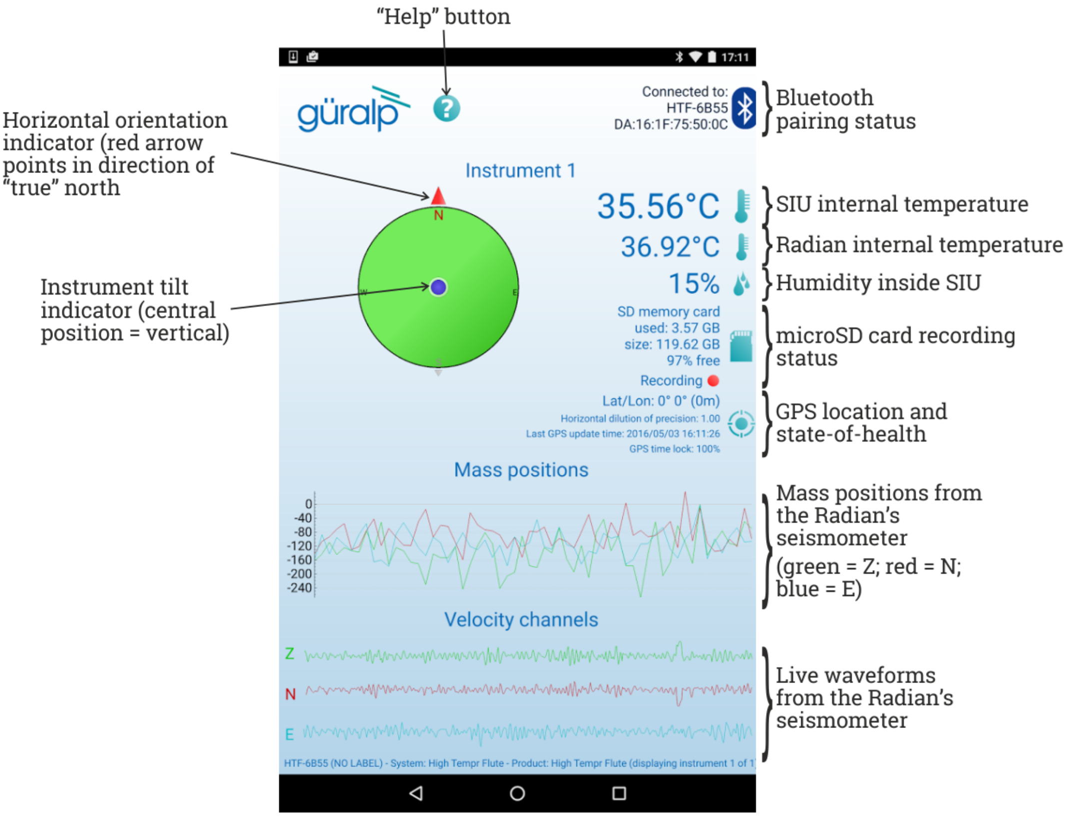
Steps for launching the GüVü App:

1. Launch by clicking on the GüVü icon from either the Apps Menu or from the Home Screen.
2. Wait a few seconds for the app splash screen.
3. Press the Bluetooth icon to enable Bluetooth connectivity (if not already enabled) and to search for available devices to with which to pair.
4. Select the appropriate device from the list to pair. Wait a few seconds for the main viewer screen to show.

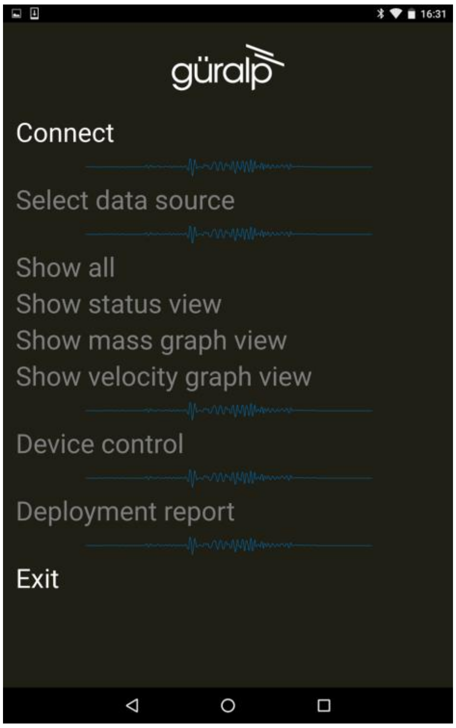
The instrument connection screen can also be accessed by pressing the menu icon on the main instrument status window, and selecting the “Connect” option.

If you experience problems connecting, try forcing GüVü to quit and then re-launching the app.

Once the device is connected, the main view of the app will be displayed. This screen displays a number of status indicators associated with both the Minimus and connected sensors. These features are summarised in the figure below:



Access the menu by pressing the menu icon on the main instrument status window:

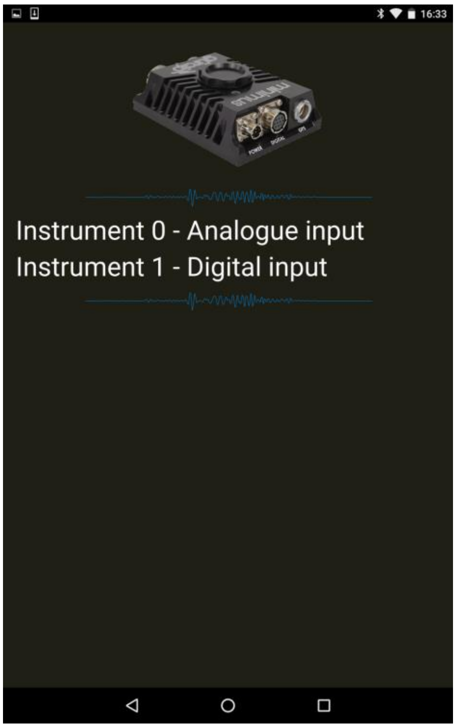


3.4.2 Selecting Data Sources

Güralp view can provide status information about all connected sensors, including digital instruments (*e.g.* Güralp Radian) and analogue instruments.

To select the instrument source that provides information to the main status screen of GüVü, tap the menu icon on the main instrument status window, and then tap the "Select data source" option.

The data source selection screen shows a list of connected instruments. Select an instrument name: this is now the instrument that will be displayed on the main instrument status window.



3.4.3 View Settings

The user can customise the view of the main instrument status window. Four different view options can be cycled through by tapping the menu icon on the main instrument status window:

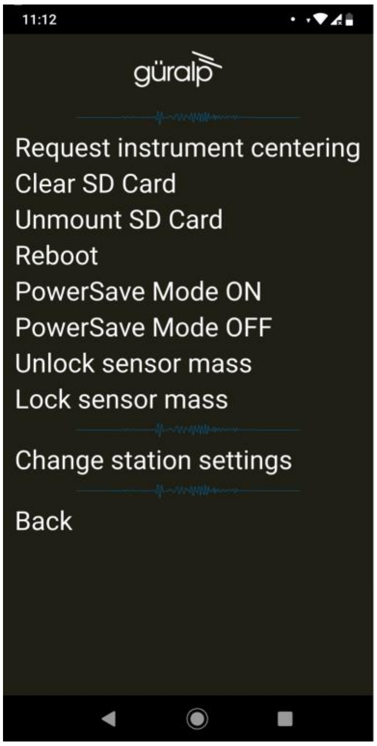
- **Show overview** – the default view setting; show state-of-health status, mass positions, and sensor traces on a single screen;
- **Show status view** – show state-of-health on the main screen only;
- **Show mass graph view** – show mass position traces on the main screen only; and
- **Show velocity graph view** - show sensor traces on the main screen only.

3.4.4 Instrument Control

Several features of the Minimus and connected instruments can be controlled and configured remotely over Bluetooth using GüVü:

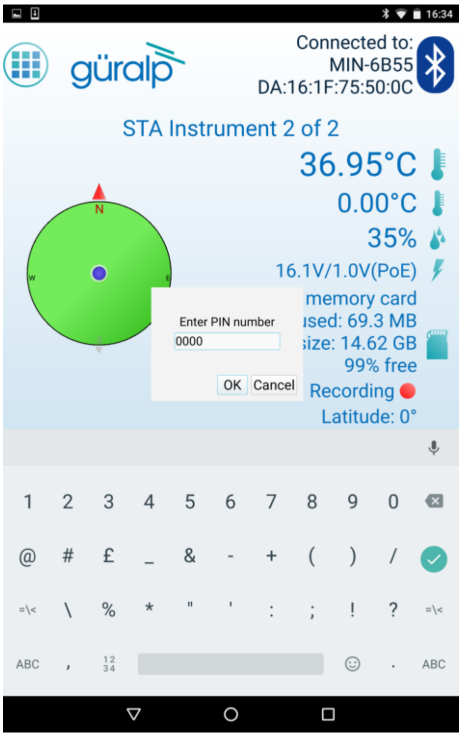
- Analogue instrument centring
- Clearing and un-mounting SD card
- Rebooting the Minimus
- Enable/disable power-saving mode
- Lock/unlock sensor masses
- Station metadata (User Label, Station Name, Network Code, Site Name)
- Network setting (IP, Netmask, Gateway)
- Changing channels' sampling rates

In each case, GüVü will report whether the selected command has been successfully sent to the device.



Note: After any modification to channels' sampling rates or network settings (available through "Change station settings"), the Minimus must be rebooted before the changes will take effect.

These options can be accessed by tapping the menu icon and choosing the Device control option. To access the instrument control and configuration sub-menu, a PIN code has to be entered by selecting the text entry box and tapping OK.

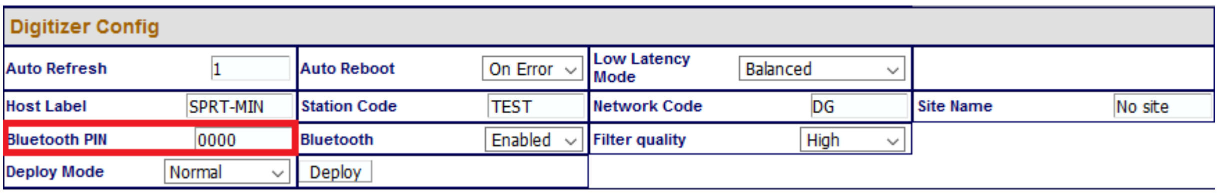


The default PIN code used to access the Instrument Control menu is "0000".

> **Caution:** Güralp recommends changing the PIN code from the default, as described in the following section, in order to maintain station security.

3.4.4.1 Setting the PIN Code

The PIN code for accessing the instrument control menu of GüVü can be changed from the "Setup" tab of the web page. The new four-digit PIN code should be entered into the "Bluetooth PIN" field. The new value is applied by keying ; or clicking the left mouse button in any other setting box.



Digitizer Config							
Auto Refresh	1	Auto Reboot	On Error	Low Latency Mode	Balanced		
Host Label	SPRT-MIN	Station Code	TEST	Network Code	DG	Site Name	No site
Bluetooth PIN	0000	Bluetooth	Enabled	Filter quality	High		
Deploy Mode	Normal	Deploy					

3.4.5 Emailing a Deployment Report

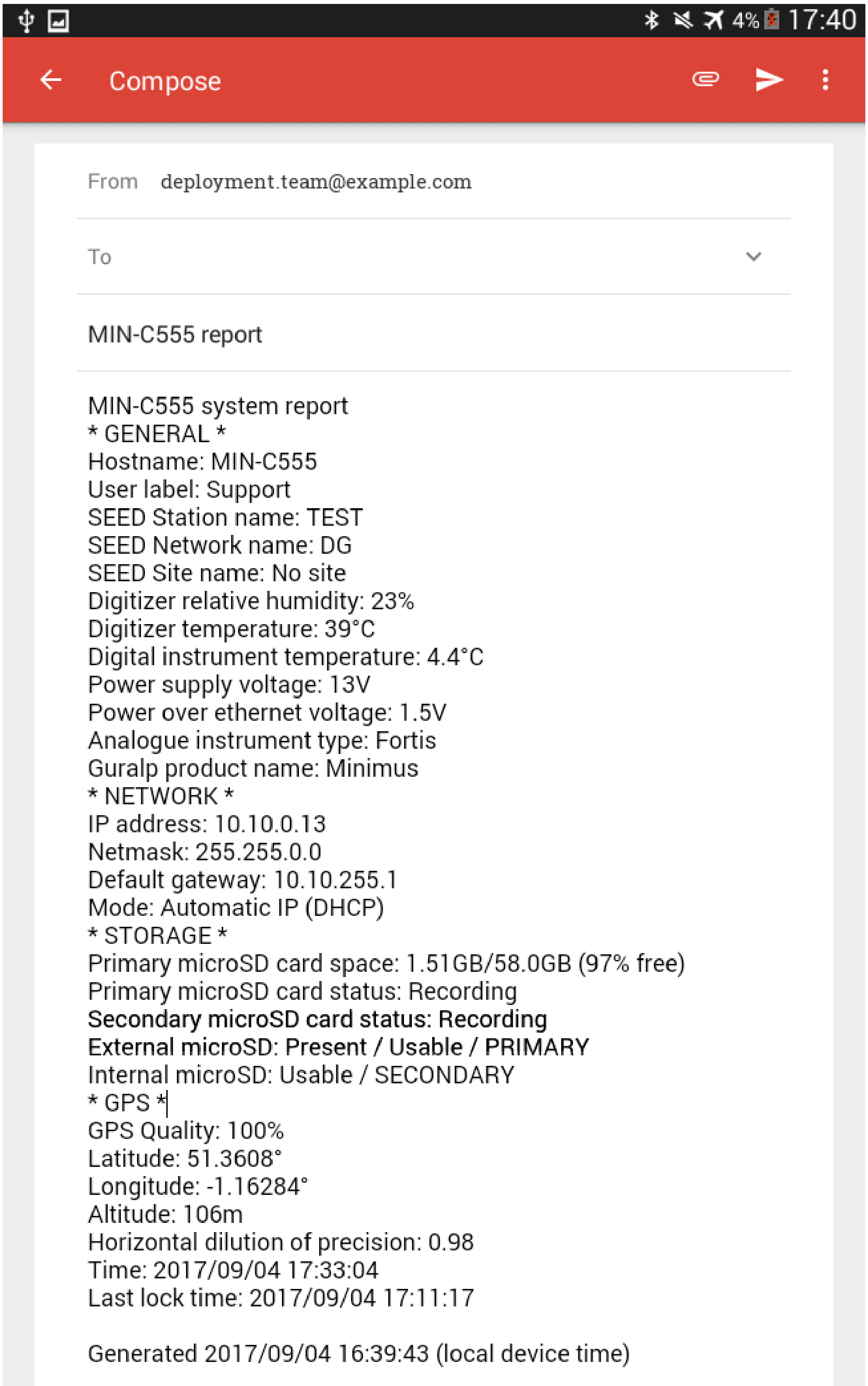
The GüVü app has a feature that allows the user to generate an automatic deployment report that can then be filed via email.

The deployment report includes the following details:

- System name;
- Station name;

- Network code;
- Instrument user label;
- Memory card storage size and recording status;
- Location of site (GNSS latitude, longitude, elevation);
- Time of deployment;
- GNSS lock quality;
- Power supply status;
- Instrument temperature and humidity recordings.

To send a deployment report, tap the menu icon and choose the "Deployment report" option. GüVü will then open the default email application on the device, showing a draft email which will include the parameters described above.


4% 17:40
Compose
From deployment.team@example.com
To
MIN-C555 report
MIN-C555 system report
* GENERAL *
Hostname: MIN-C555
User label: Support
SEED Station name: TEST
SEED Network name: DG
SEED Site name: No site
Digitizer relative humidity: 23%
Digitizer temperature: 39°C
Digital instrument temperature: 4.4°C
Power supply voltage: 13V
Power over ethernet voltage: 1.5V
Analogue instrument type: Fortis
Guralp product name: Minimus
* NETWORK *
IP address: 10.10.0.13
Netmask: 255.255.0.0
Default gateway: 10.10.255.1
Mode: Automatic IP (DHCP)
* STORAGE *
Primary microSD card space: 1.51GB/58.0GB (97% free)
Primary microSD card status: Recording
Secondary microSD card status: Recording
External microSD: Present / Usable / PRIMARY
Internal microSD: Usable / SECONDARY
* GPS *
GPS Quality: 100%
Latitude: 51.3608°
Longitude: -1.16284°
Altitude: 106m
Horizontal dilution of precision: 0.98
Time: 2017/09/04 17:33:04
Last lock time: 2017/09/04 17:11:17
Generated 2017/09/04 16:39:43 (local device time)

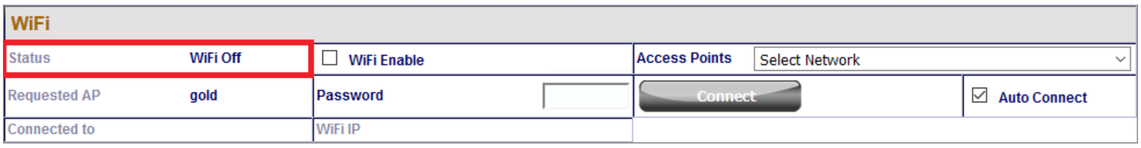
3.5 WiFi Connectivity

This chapter only applies to the Fortimus and Certimus that have built in WiFi capabilities.

WiFi can be used as the main networking method or configured so that it runs parallel to the ethernet configuration. Enabling the WiFi will consume more power, which should be considered for sites that have a limited power supply.

1. To enable WiFi on a Fortimus or Certimus, first check that the external antenna has been attached and screwed into place.
2. Next load up the web page interface, log in as admin and navigate to the Network tab.
3. Scroll to the bottom of the page and locate the WiFi heading, tick the check box next to WiFi enabled to activate the WiFi component.
4. Click on the Disconnect & Scan button, then wait for 10 seconds before checking the drop-down box next to "Access Points" to find the network that you want to connect to.
5. After selecting your network, the "Requested AP" field should now be showing your chosen network, the next option to the right is the "Password" field, enter the password for your WiFi network here,
6. Finally click on Connect to confirm the details and test the connection, the "State" will show as "WiFi Connected" once the connection has been established.

The status of the WiFi connection is displayed at the top left of the WiFi section of the Network tab of the web page:



The possible values for the status are:

- WiFi off - the WiFi interface is disabled. Tick the "WiFi Enable" check-box to enable the interface, if required.
- WiFi Standby - the WiFi interface is enabled but not currently connected to any network. If no connection is required, clear the "WiFi Enable" check-box to disable the interface.
- WiFi Connecting - the WiFi interface is in the process of connecting to the selected network.
- WiFi Connected - the WiFi interface is connected to the network shown in the box below and the DHCP server has allocated the IP address displayed in the adjacent box. (Static IP addressing is not supported).

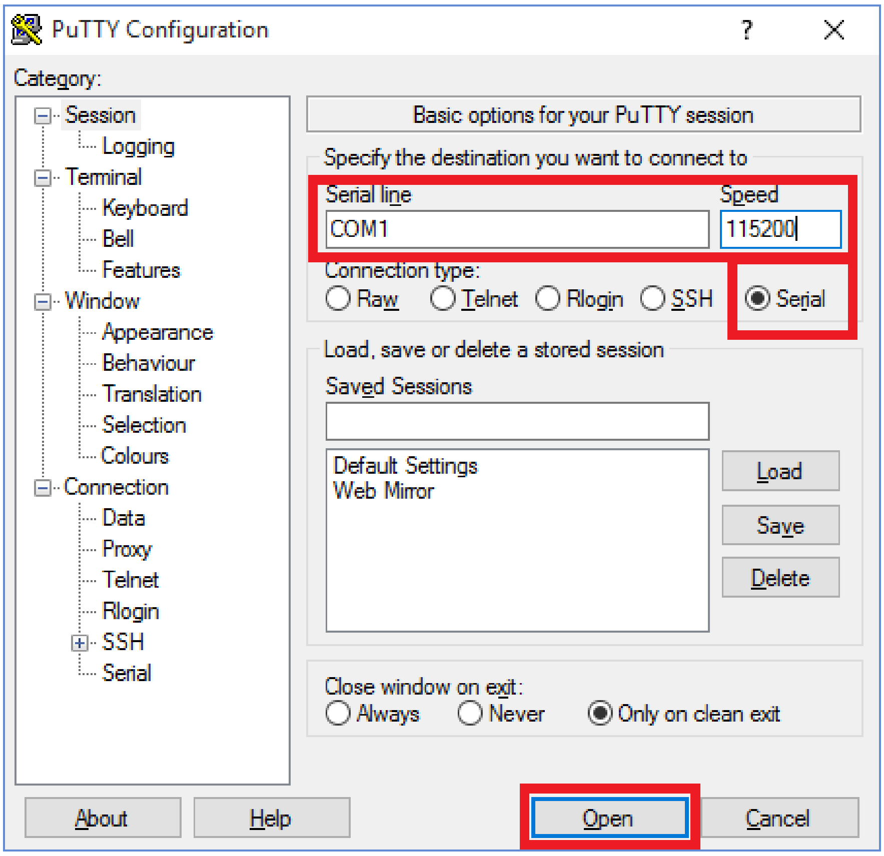
Once a successful connection is established, tick the “Auto Connect” check-box so that the Fortimus or Certimus will attempt to reconnect to the same network whenever possible. The name of the selected network appears in the “Requested AP” box.

3.6 Advanced Troubleshooting

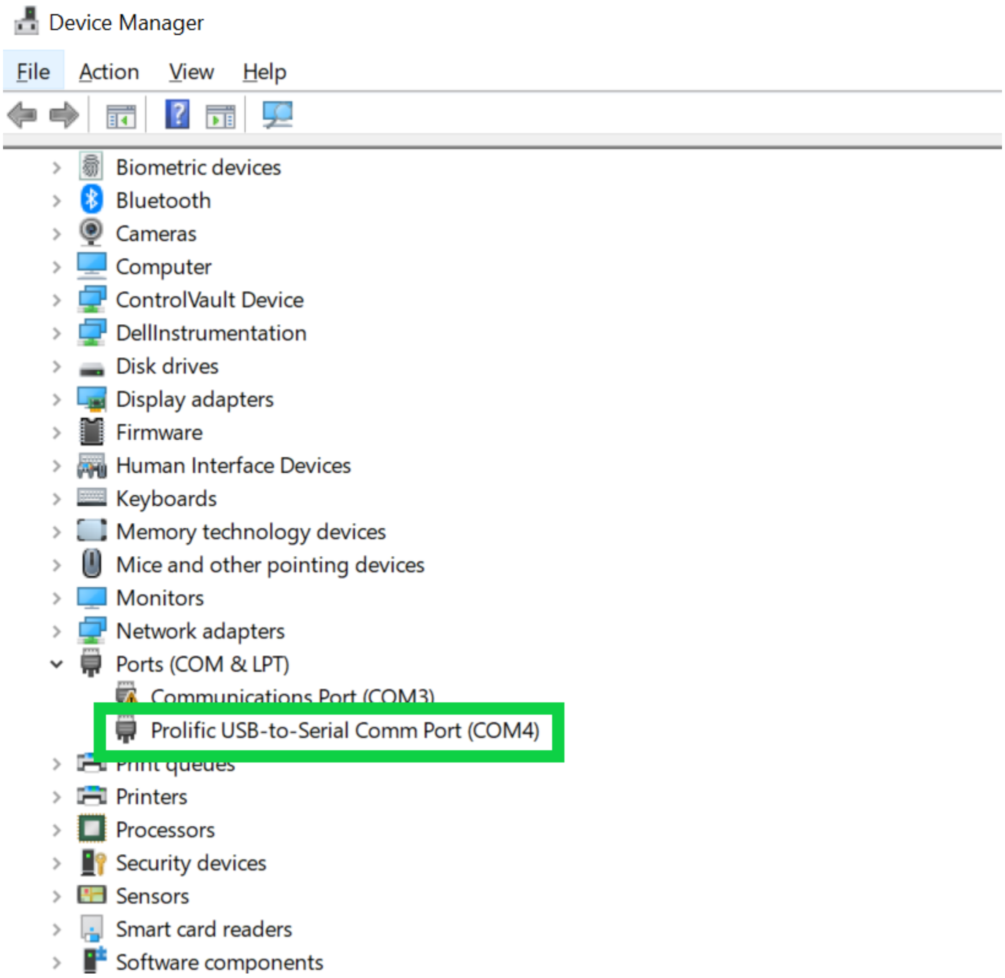
In the unlikely event of the user experiencing problems with the operation of the Minimus, a diagnostics tool is available via the GNSS connector. This connector provides a serial console which can be accessed using a terminal emulator.

The user should first plug in the serial adapter to the GNSS connector, which is then attached to a 9-pin COM port on your PC/laptop (if a 9-pin COM port is not available, a serial-to-USB converter should be used instead and connected to an available USB port. Güralp recommend converters based on the FTDI chip-set.)

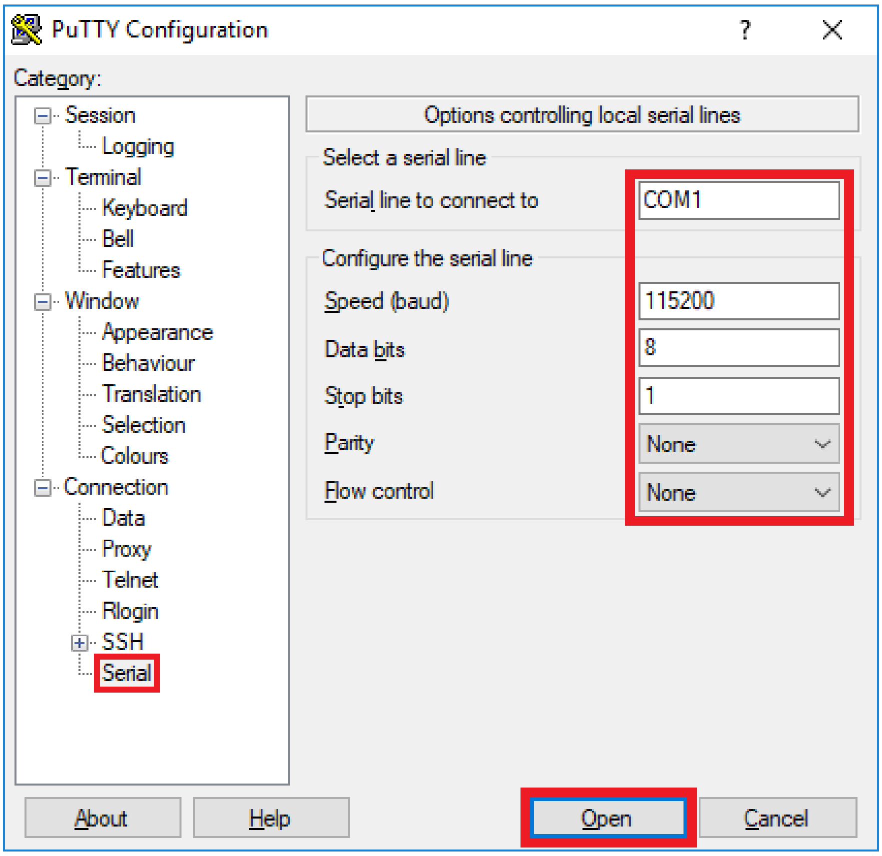
A connection is then made using a terminal emulator, such as minicom under Linux or PuTTY under Windows. The appropriate COM port should be entered as the "Serial line", and the "Speed" should be set to 115200.



Note that the COM port can be different that COM1, especially when a USB to serial adapter is used. To find out the appropriate port, open the Device Manager of your machine.



Next, select "Serial" from the bottom of the Category menu in the left-hand pane and check that the settings match those shown in the screenshot below.



Finally click the Open button and a terminal window will open, connected to the console of the Minimus.

In the event of any operational issues, the Güralp Support Team may request you to interact with the console in order to diagnose and fix problems.

3.6.1 Reset All Settings During Boot Phase

The Minimus can be reset to its factory settings during its boot-up stage. This is useful in cases where the user is not able to communicate with the Minimus via a network connection, where the unit is not responsive, or where it does not appear in the Discovery software's scan results.

To carry out a full system reset, connect to the terminal port via a serial connection (as described in Section 3.5). During the middle part of the boot phase, when the text `@GURALP SYSTEMS` and the firmware version number is displayed, key Ctrl + R. This causes all settings (except Username, Password and Bluetooth PIN) to revert to their factory default values, and the Minimus will re-boot. It may be necessary to enter this key combination several times.

A typical boot log is shown below, identifying the stages where Ctrl + R will cause the Minimus to reset and reboot.

Do not press any buttons during the first phase of boot-up:

```
Rebooting system, please wait...

00000101

0000c1c1▒RomBOOT


SCKC_CR = 0xA, CKGR_MOR = 0x100FF0A, CKGR_PLLAR = 0x20FDD101, PMC_MCKR =
0x1122, PIO_PDSR = 0xF13F7C65

SCKC_CR = 0xA, CKGR_MOR = 0x100FF0A, CKGR_PLLAR = 0x21403F01, PMC_MCKR =
0x1302, PIO_PDSR = 0xF13F7C65

AT91Bootstrap v3.8.10-1.guralp


NAND: ONFI flash detected

NAND: Manufacturer ID: 0x2C Chip ID: 0xDA

NAND: Page Bytes: 2048, Spare Bytes: 64

NAND: ECC Correctability Bits: 4, ECC Sector Bytes: 512

NAND: Disable On-Die ECC

NAND: Initialize PMECC params, cap: 4, sector: 512

NAND: Image: Copy 0x92000 bytes from 0xE000 to 0x2FA0E000

NAND: Done to load image

SCKC_CR = 0xA, CKGR_MOR = 0x100FF02, CKGR_PLLAR = 0x21403F01, PMC_MCKR =
0x1302, PIO_PDSR = 0xF23F7C65


U-Boot v2019.10-1.guralp


CPU:  SAMA5D36

External clock: 12.288 MHz

CPU clock:   497.664 MHz

Master clock:  165.888 MHz

DRAM: 256 MiB

NAND: 256 MiB

MMC:  Atmel mci: 0, Atmel mci: 1

Loading Environment from NAND... OK

In:  serial

Out:  serial

Err:  serial
```

```
Net:  eth0: ethernet@f0028000
word at 0xffffea20 (0x06) != word at 0x23000008 (0x07)
Total of 0 word(s) were the same
PHY 0x07: OUI = 0x0885, Model = 0x22, Rev = 0x02, 10baseT, HDX
Hit any key to stop autoboot: 0

NAND read: device 0 offset 0x5C0000, size 0x360000
 3538944 bytes read: OK
Uncompressed size: 5008508 = 0x4C6C7C
crc32 for 21000000 ... 214c6c7b ==> 6f7d4b5e
Total of 2 word(s) were the same
word at 0xffffea20 (0x06) != word at 0x23000008 (0x07)
Total of 0 word(s) were the same
## Starting application at 0x00300000 ...

(boot)Crash Info###
 Number of crash left=0
(boot)Last crash time:1970-01-01T00:00:00.000
Board type set to: Minimus
Recognised external clock: 12288000 Hz
SCKC_CR = 0xA, CKGR_MOR = 0x100FF02, CKGR_PLLAR = 0x21403F01, PMC_MCKR =
0x1302, MCK = 165888000 Hz

@GURALP SYSTEMS
```

Once the "`@GURALP SYSTEMS`" banner has been printed, keying Ctrl + R (at least once) will cause all settings (except Username, Password and Bluetooth PIN) to revert to their default values and cause the Minimus to reboot.

```
v2.0-7548 by teamcity on 14:28:48 07-Nov-2019
Vecbase: 300000 CPUid: 410fc051 Cache: c5187d
PMT init
Unsafe to change DBGU clock while running
mux start SP 300fb4
FPU start
VFP Id=41023051
```

```
  0.00 | -> init_dbgprint
  0.00 | -> init_cmdutils
  0.00 | -> init_pmt_dlg
  0.00 | -> init_memdlg
  0.00 | -> malloc_debug
  0.00 | -> start_timer_interrupts
  0.01 | -> rtc_init
RTC Time: 2019-11-08T14:23:11 UTC
  0.01 | -> uart_start_ints
  0.01 | -> init_arm_parse
  0.01 | -> t_init_task_utils
  0.01 | -> gpio_init
##### NORMAL INITIALISATION MODE #####
  0.01 | -> unit_test_init
  0.01 | -> init_devio
  0.01 | -> init_usart
  0.01 | -> init_devio_cmds
  0.01 | -> rpc_init
  0.01 | -> ram_init
  0.01 | -> ram_exchange_init
  0.01 | -> system_update_init
```

If your key-strokes have been recognised, `Ctrl+R` will be printed in the boot log, as shown below – once for each time your keystrokes were logged:

```
C0.01 | -> i2c_init
i2c_configure( 0, 100000Hz )
Using pclk 41472000, cdiv 203, shift 0 => 100173
i2c_configure( 1, 100000Hz )
Using pclk 41472000, cdiv 203, shift 0 => 100173
i2c_configure( 2, 100000Hz )
Using pclk 41472000, cdiv 203, shift 0 => 100173
  0.01 | -> i2c_dac_init
Ctrl+R
Ctrl+R
```

```
Ctrl+R

Ctrl+R

Ctrl+R

Ctrl+R

Ctrl+R

  0.01 | -> i2c_dac_init

  0.01 | -> i2c_humid_init

Humidity sensor test SUCCESS

  0.01 | -> fram_init

Installing NVR device. size 12640

  0.04 | -> net_sockets_init

  0.06 | -> newtask_init

USE ADC MINIMUS

  0.07 | -> init_whalesong

  0.07 | -> analog232_init

  0.07 | -> start_timers

Warning non-integer microsecond divisor from 82944000

  0.08 | -> spi_datalink_init_semaphores

  0.09 | -> chain_init

Using 251 coefficients.

  0.15 | -> var_user_init

[SD log not available!] User variable "last_loc_lat" modified (called from
load_from_fram)

[SD log not available!] User variable "last_loc_lon" modified (called from
load_from_fram)

[SD log not available!] User variable "station_start_t" modified (called
from load_from_fram)

[SD log not available!] User variable "DHCP" modified (called from
load_from_fram)

[SD log not available!] User variable "Static IP addr" modified (called
from load_from_fram)

[SD log not available!] User variable "Net Mask" modified (called from
load_from_fram)

[SD log not available!] User variable "Gateway" modified (called from
load_from_fram)

[SD log not available!] User variable "DNS1" modified (called from
load_from_fram)
```

```
[SD log not available!] User variable "DNS2" modified (called from
load_from_fram)

[SD log not available!] User variable "Username" modified (called from
load_from_fram)

[SD log not available!] User variable "Password" modified (called from
load_from_fram)

[SD log not available!] User variable "tunnel_password" modified (called
from load_from_fram)

[SD log not available!] User variable "tunnel_username" modified (called
from load_from_fram)

[SD log not available!] User variable "tunnel_connection" modified (called
from load_from_fram)

[SD log not available!] User variable "Host Label" modified (called from
load_from_fram)

[SD log not available!] User variable "Station Code" modified (called from
load_from_fram)

[SD log not available!] User variable "Network Code" modified (called from
load_from_fram)

[SD log not available!] User variable "Site Name" modified (called from
load_from_fram)

[SD log not available!] User variable "Bluetooth PIN" modified (called
from load_from_fram)

[SD log not available!] User variable "Filter quality" modified (called
from load_from_fram)

[SD log not available!] User variable "CAP Msg HMAC Key" modified (called
from load_from_fram)

[SD log not available!] User variable "Registry Address" modified (called
from load_from_fram)

[SD log not available!] User variable "tunnel_url" modified (called from
load_from_fram)

[SD log not available!] User variable "Password (Normal)" modified (called
from load_from_fram)

[SD log not available!] User variable "Username (Admin)" modified (called
from load_from_fram)

[SD log not available!] User variable "Password (Admin)" modified (called
from load_from_fram)

[SD log not available!] User variable "Username (Normal)" modified (called
from load_from_fram)

[SD log not available!] User variable "Group ID" modified (called from
load_from_fram)

  0.45 | -> calibration_init

  1.91 | -> gcftx_init
```

```
  1.92 | -> spi_datalink_chains_init
Sensor0 is velocimeter
Sensor1 is accelerometer
Sensor2 is velocimeter
Sensor3 is velocimeter
Sensor4 is velocimeter
Sensor5 is velocimeter
Sensor6 is velocimeter
Sensor7 is velocimeter
Sensor8 is velocimeter
  3.33 | -> init_nand
  4.17 | -> adc12_init
  4.18 | -> init_random
  4.18 | -> ltc4151_vc_monitor_init
Voltage/Current readings are not provided by LTC4151 chip.
  4.19 | -> voltage_sniffer_init
  4.20 | -> init_lut
  4.28 | -> i2c_humid_init_ui
  4.30 | -> sd_init
  4.31 | -> sd_file_init
  4.31 | -> sd_log_init
  4.31 | -> streaming_client_init
2019-11-08T14:23:15.000Z Retime Request Waiting (35s/3600s/Boot delay)
  4.33 | -> xtaltable_init
No XTAL table found.
  4.40 | -> gps_pps_init
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
Chain 54 already set.
```

```
MIN-C555->   4.44 | -> init_var_debug
  4.44 | -> tcpdump_init
  4.45 | -> var_html_init
  4.45 | -> init_http_server
  4.46 | -> sd_init_var
  4.46 | -> gps_pps_ui_init
  4.46 | -> xtaltable_ui_init
checking for xtaltable.txt
  4.47 | -> init_fpga_datalink
  4.47 | -> init_auto_center
  4.48 | -> init_embedded_fs
  4.48 | -> status_txt_init
  4.49 | -> lan_init_web

#####tx_lock:
majic:f710f7f7
 Call_lock value:-1  4.50 | -> init_responder_ui
  4.51 | -> init_tunnel_ui
  4.52 | -> quasar_init
Quasar Serial Isolated Input/Output Module support is disabled.
  4.53 | -> quasar_init_ui
  4.53 | -> applied_rot_init_web
  4.54 | -> installation_parameters_init_web
  4.55 | -> init_fpga_web
  4.62 | -> analog232_init_web
  4.73 | -> init_transforms
  4.74 | -> triggers_init_ui
  5.02 | -> chain_init_web
  10.52 | -> transform_init_web
  13.14 | -> storage_init_web
  13.19 | -> spi_datalink_ui_init
  13.32 | -> gps_init_ui
  13.33 | -> gps_init
```

Once the boot-up reaches this stage, pressing Ctrl + R will have no effect.

If Ctrl + R was recognised during the second stage of boot-up, then the Minimus will reset and reboot:

```
Ctrl+R NVR load, resetting all vars to their default values and then
rebooting

Forcing all vars to default values (including non-default-able)

PPS clock sources ACTIVE: 0x00000001 [GPS:0 PTP:0 RTC:0 TABLE:1]

PPS clock sources ACTIVE: 0x01000001 [GPS:1 PTP:0 RTC:0 TABLE:1]

PPS clock sources ACTIVE: 0x01010001 [GPS:1 PTP:1 RTC:0 TABLE:1]

PPS clock sources ACTIVE: 0x01010101 [GPS:1 PTP:1 RTC:1 TABLE:1]

Ctrl+R

Ctrl+R

Ctrl+R

sd_manager: probed both microSD card slots

11.58 {calibration.c;1142} calibration_write_to_fram: successfully wrote
calib to FRAM

11.60 {var_nvr.c;773} 'sd_format_time' $20301021 --> $00000000

11.61 {var_nvr.c;773} 'sd_unmount_time' $22647008 --> $00000000

11.62 {var_nvr.c;773} 'pps_src_table' 168 --> 1

11.63 {var_nvr.c;773} 'pps_src_gps' 0 --> 1

11.63 {var_nvr.c;773} 'pps_src_ptp' 69 --> 1

11.64 {var_nvr.c;773} 'pps_src_rtc' 132 --> 1

11.64 {var_nvr.c;773} 'rtcSavedOffsetSecs_nv' -1737983855 --> 0

11.65 {var_nvr.c;773} 'rtcSavedOffsetNano_nv' 402788896 --> 0

11.66 {var_nvr.c;773} 'rtcSavedFreqErrorPPB_nv' -2129883872 --> 1000000

11.67 {var_nvr.c;773} 'rtcSavedOffsetTime_nv' $52080158 --> $00000000

11.68 {var_nvr.c;773} 'xtaltable_offset' 610275339 --> 0
```