Güralp Minimus Lite

Technical Manual

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1 Preliminary Notes

1.1 Proprietary Notice

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1.2 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.

1.3 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.

1.4 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`***

1.5 System Overview

Thank-you for purchasing a Güralp Minimus$_2$ or Minimus Lite digitiser.

This section describes the key components of a Minimus$_2$ system. The Minimus$_2$ 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.

The Minimus$_2$ has four fully-featured analogue input channels.

1.6 Key features

- 24-bit, four-channel digitiser with nominal 2.39 µV/count sensitivity.
- Compact form, measuring just 134 × 99 × 45 mm and weighing just 0.6 kg.
- Compatible with all analogue seismic sensors with a voltage output.
- Simultaneously accommodates one triaxial sensor(s), one infra-sound sensor(s).
- Supports automatic 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.

1.7 Typical applications

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

2 System description

2.1 Güralp Minimus$_2$ digitiser

The Güralp Minimus$_2$ is a combined digitiser and advanced communications unit. The Minimus$_2$ 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 Certis).

When used with newer version of Güralp 3T instruments and the Certis Instrument, the digital serial connection available on the 26-way instrument connector is used to convey additional state of health information as well as calibration and response information.

2.1.1 LED indicator

The Minimus$_2$ has an LED indicator on the upper surface, which provides status and configuration information.

-
  White: This occurs from power-up until software starts
-
-
  Three flashes followed by a pause, then repeat.
- Each flash is either Red or Green
- First Flash – Internal SD card good and recordings (Green)
- Second Flash – External Removable SD card is good and recording (Green)
- Third Flash - GPS Time lock is good (Green)
-
  1 blue flash: a trigger event has been detected.

2.1.2 Bluetooth connectivity

The Minimus$_2$ features Bluetooth connectivity, allowing sensor and state-of-health data to be monitored using the Güralp GüVü app on an Android mobile phone or tablet.

The Bluetooth can be disabled via software to save processor usage 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.

See Section 22 for further details on connecting to the Minimus$_2$ and its attached sensors using a phone or tablet.

2.1.3 Data storage

The Minimus$_2$ uses microSD (non-volatile) memory technology to store seismic data locally. The Minimus$_2$ 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 without any technical knowledge.

The Minimus$_2$ is supplied with two microSD cards that are of equal storage capacity (*e.g.* two 64 GB cards).

Güralp recommends the use of industrial-grade SD cards.

2.1.3.1 External microSD card – new style

The upper surface of the Minimus$_2$ 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 Minimus2 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 Minimus2 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 Minimus2, 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. 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.

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

2.1.3.2 Internal microSD card

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

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

2.1.4 Web interface

The Minimus$_2$ contains on-board firmware that presents monitoring and configuration interfaces. These are accessible through Güralp's Discovery software or, with the built-in web server, via Discovery's browser interface or any standards-conformant web browser.

The Discovery interface allows a number of instrument monitoring, control and configuration options:

- Sensor readings and instrument State-of-Health
- Network configuration and authentication
- Sensor, timing, and station configuration/information
- Remote data-streaming configuration
- Local data-storage configuration

2.2 Accessory package

2.2.1 Ethernet cable

The Ethernet connector allows use of 100BASE-T networks. The cable that connects to the Minimus$_2$ has a metal cover which is IP68-rated and ensures consistent connections in harsh installation environments. At the other end of the blue Ethernet cable, there is a standard 8P8C modular jack (often incorrectly called an RJ45) for

attachment to all common networking devices (*e.g.* PC, laptop, router, switch, modem etc.).

Please see section 21.1 for the pin-out and further details.

2.2.2 Compact GNSS receiver and cable

The Minimus$_2$ is supplied with a new-generation compact GNSS receiver with 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.

Please see section 21.3 for pin-out details.

2.2.3 Power cable

The Minimus$_2$ comes with a dedicated power cable with a standard military-specification bayonet connector on one end and bare ends at the other. Two pins are employed to carry power. The second pair of pins carry a serial port. When used in conjunction with a Güralp Power Pack Module, these carry information about charge status, solar panel operation, battery capacity etc.

Note: The Minimus$_2$ does not use a grey/blue combined power/data cable, as used with many other Güralp products.

Please see section 21.2 for the pin-out details.

2.2.4 Diagnostic GNSS to Serial cable adapter

The Minimus$_2$ 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 using a serial terminal emulator (see section 17).

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. Please see section 21.3 for full pin-out details.

2.3 Güralp Discovery software

Güralp Discovery is a software application for seismometer configuration and control, state-of-health monitoring, and waveform viewing and acquisition.

Discovery can be downloaded from the following link:

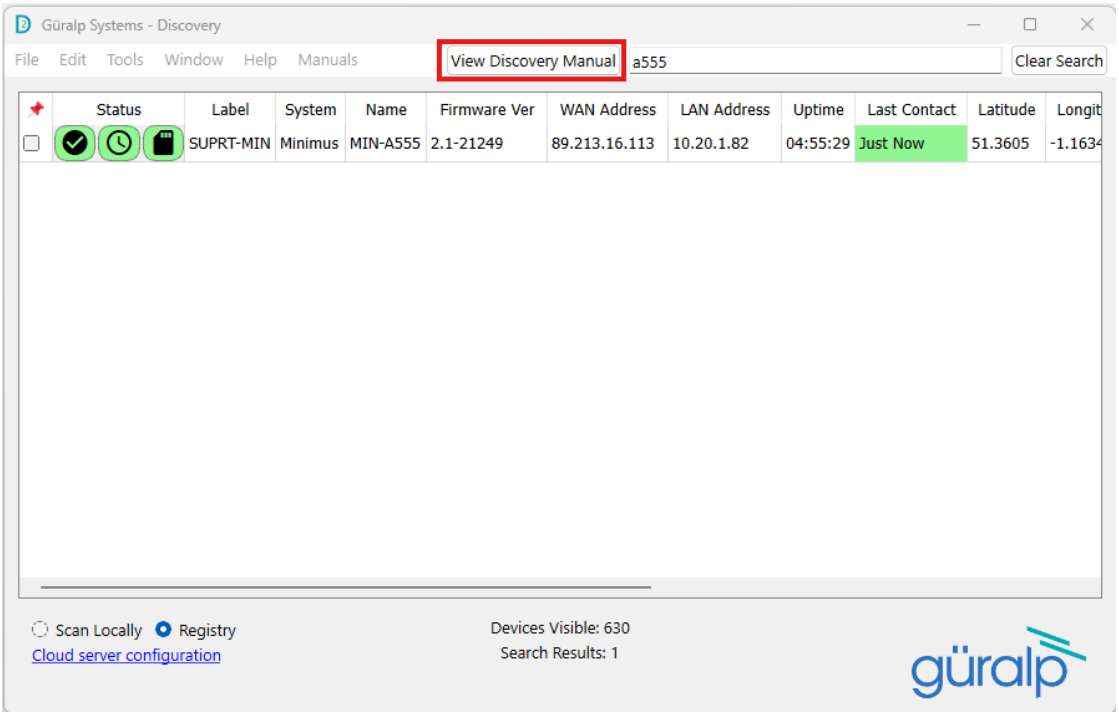
https://www.guralp.com/sw/download-discovery.shtml.

An important benefit of Discovery is that it allows the user to identify the instruments' IP addresses on a LAN or via a cloud-based or organisational registry server without the need for static IP addresses at the stations.

Discovery also provides simple, convenient instrument and data management with access to hardware State-of-Health (SoH), data streaming; GNSS location; response and calibration data.

Discovery can download Minimus2 firmware from the Internet and remotely install it onto any connected digitisers.

Running Discovery on a network connected PC will show any connected Güralp products as below:



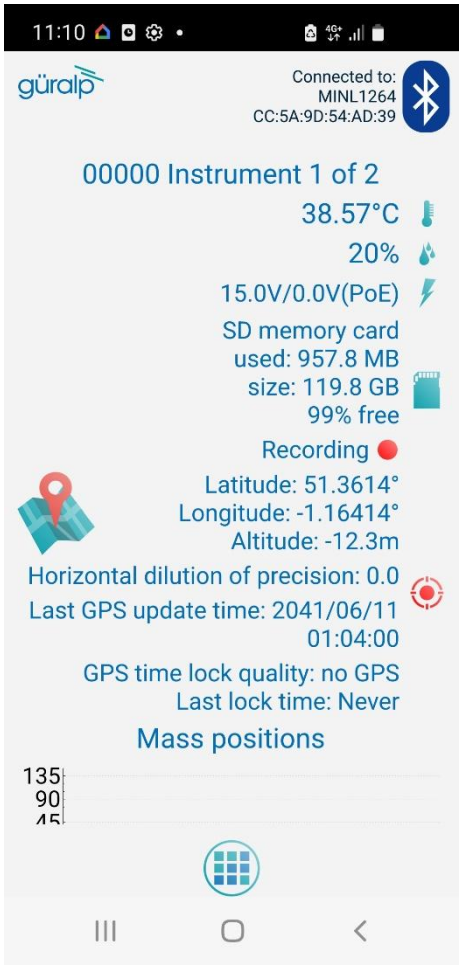
Note: This document provides some information about Discovery, especially when related to the use of Minimus$_2$ and Minimus Lite units, including firmware upgrades and configuration instructions.

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 above).

2.4 Güralp GüVü Android app

For added confidence during deployments in the field, Güralp GüVü, a Bluetooth App, displays waveforms, orientation, temperature and humidity data for instant checking of installation integrity.

Please refer to Chapter 22 for installation and usage instructions. It is available on PlayStore.



3 Configuration Workflow (Quick-Start)

Note: Güralp strongly recommends exploring and familiarising yourself with the Minimus Lite 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 or after the deployment.

	Task	Description	Deployment Stage	Chapter
1	Access Web Interface	Connect and log in to the device. Basic networking configuration	Before	4
2	Check Timing Status	Ensure the GNSS receiver is working properly and obtain a GPS lock	Before During	5
3	Set Up Device	Select connected analogue sensor and insert metadata	Before	6
4	Configure Data Streaming	Enable desired channels to stream and choose their sample rates	Before	7
5	Configure Data Recording	Enable desired channels to record to the SD cards and choose their sample rates	Before	8
6	Locate Metadata	Find and download metadata as Dataless SEED volume, RESP files or Station XML files	Before	9
7	Configure Triggers (Optional)	Choose EEW (Earthquake Early Warning) and triggers configuration	Before	10
8	Enable Remote Connectivity (Optional)	Configure the device to be able to communicate with it remotely	Before	11
9	Automate Processes (Optional)	Enable scripting capabilities and upload scripts to automate repetitive procedures	Before	12
10	Download Data	Download data either from the device's webpage (also remotely) or directly from the external SD card	During After	13

11	Upgrade Firmware	Perform a firmware upgrade via Discovery software	Before During After	14
12	Perform Mass Configuration (Optional)	Export configuration from device and upload it to other devices in the network via Discovery software	Before	15
13	Use Güralp Power Pack Module	Configure the PPM to best suit your power requirements	Before During	16

4 Getting started

4.1 System set-up

Power up the Minimus$_2$ using a power supply with a DC output of between 10 and 36 Volts. The Minimus$_2$ may initially require power higher than 10V at start-up but will reduce during standard operation. 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 will, in turn, provide power to all connected instruments. Alternatively, the system can be powered by POE (Power over ethernet).

Once the Minimus is powered up, the LED will start blinking following the pattern described in Section 2.1.1.

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.

4.1.1 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 **Error! Reference source not found.**. However, configuring your laptop to o btain 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.

4.1.1.1 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
```

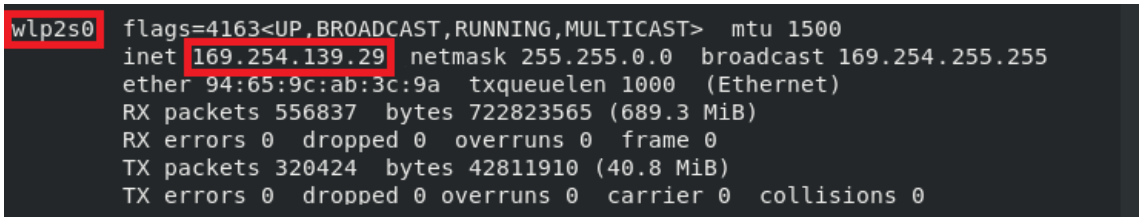
to identify the Ethernet network interface to which the Minimus is connected. Once you have identified the correct interface, connect the Minimus, power it up and enter the commands:

```
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.`...



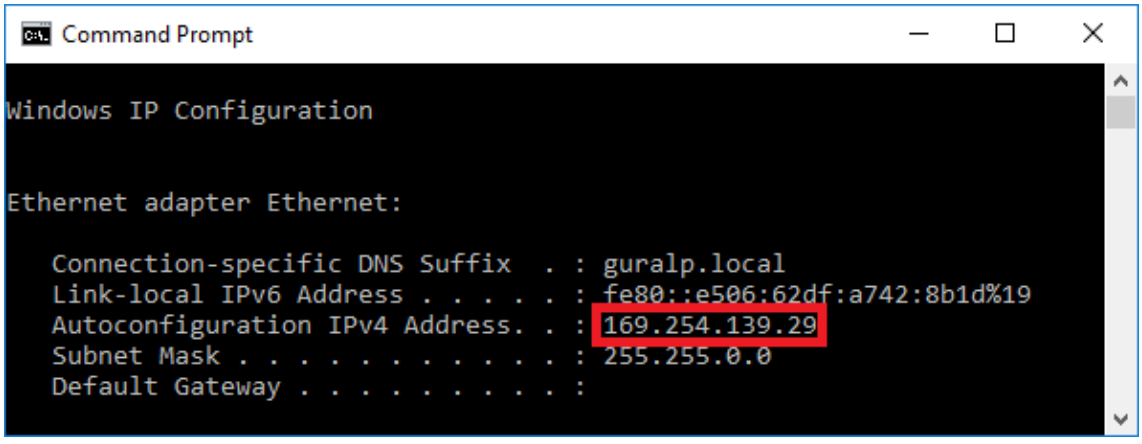
In the example above, the interface has been allocated address `169.254.139.29`, which is in the correct network.

4.1.1.2 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.

4.1.2 Your Device's IP address: Discovery

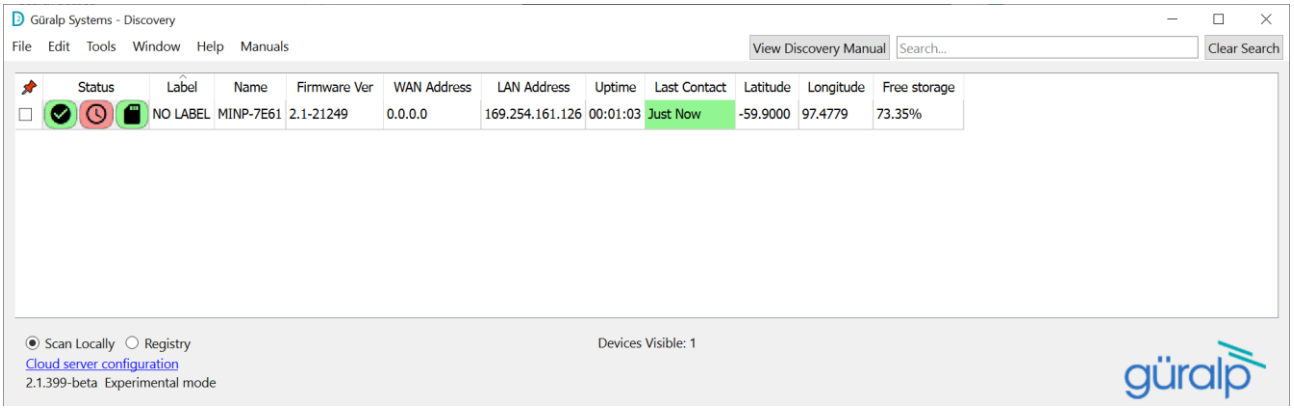
Once your laptop or PC is configured to obtain an IP address automatically, and the Minimus is powered up and connected to it using the blue Ethernet cable, you are ready to start communicating with your device. The first step is to find out the device's IP address.

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 4.1.1 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.

4.2 Web Page Interface Login

Note: Some changes in configuration require a reboot to take effect. The banner at the top of the webpage reflects this if required.

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

If the login is required, the web interface will initially show a status display only.

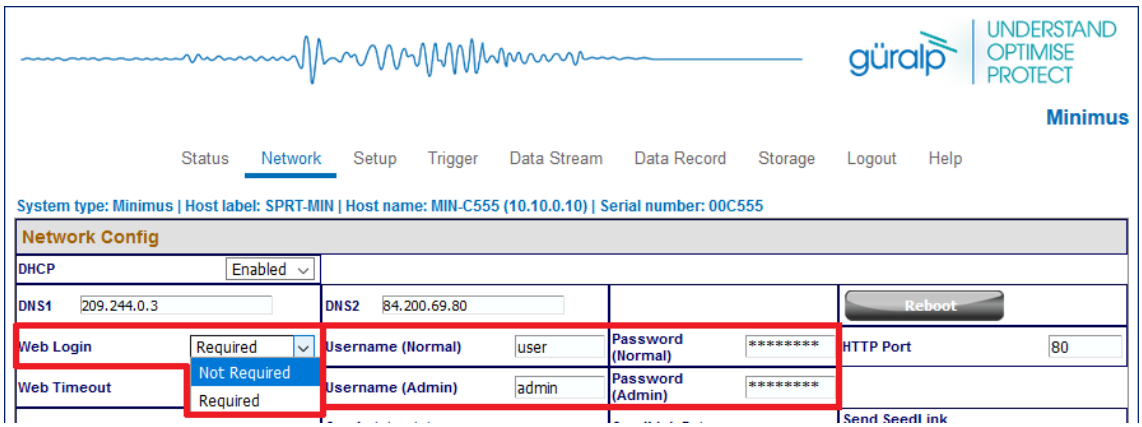
Clicking on "Login" opens allows to type in the user-name and password to access the content of the web page.

Logging in with normal user account unlocks only basics configuration and control features in order to prevent any advanced settings to be modified. The default user-name for normal user login is `user` and password of `user`.

Logging in with the administrator account unlocks all the configuration and control features available in the web page. The default user-name for administrator user login is `admin` and password of `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, the "Web Login" drop-down menu in the Network tab allows to disable the request of login every time the web page is accessed. When the login is not required, you will automatically be logged in as `user`. The user-name and password for both normal user and administrator login are configurable in the Network tab.



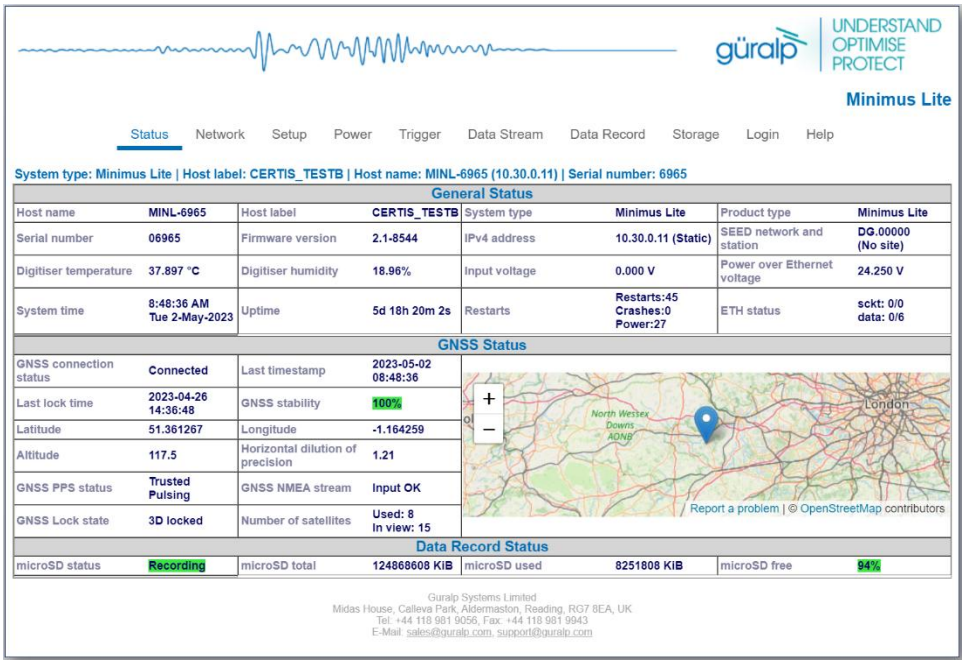
4.3 System status

The Status tab of the web browser interface provides state-of-health information about the Minimus$_2$ and connected instruments.

Host Label can be set in the Setup page. This is also visible on the Discovery front page.

The map requires access to the internet to display correctly. The computer used to view the Minimus$_2$ must therefore be internet connected.

The MicroSD Used item acts as a verification that the system is truly recording data. If this item shows periodic changes, the data is being written to the card.



4.4 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.

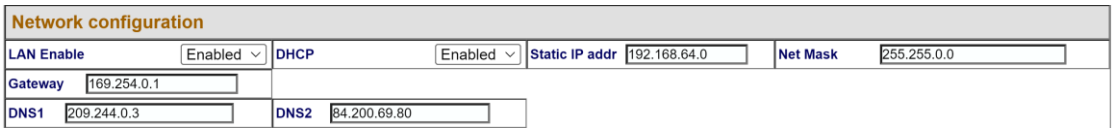
Station Code and **Network Code** are all standard metadata header values used by the miniSEED file format, which will be used as identifiers in locally-stored miniSEED files (see section **Error! Reference source not found.**).

4.5 Network configuration

4.5.1 IP address and gateway

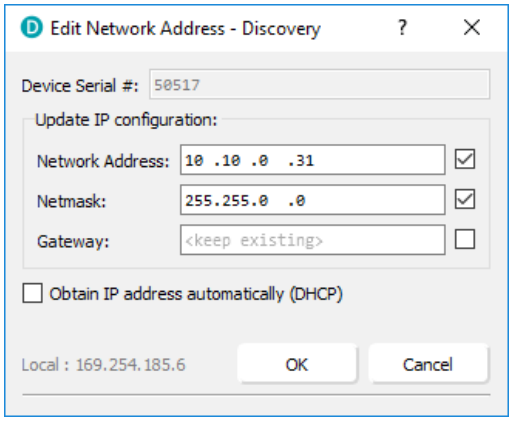
By default, the Minimus$_2$ uses DHCP (Dynamic Host Configuration Protocol) to acquire its network configuration but static addressing can be used if required.

To configure static addressing, visit the Network tab of the instrument's web page and, under "DHCP", change the mode from "Enabled" to "Disabled" in the drop-down menu. 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$_2$ must be re-booted. To do this, click the Reboot button.

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



5 Timing Options

The Minimus$_2$ system synchronises its sample clock using an attached GNSS receiver.

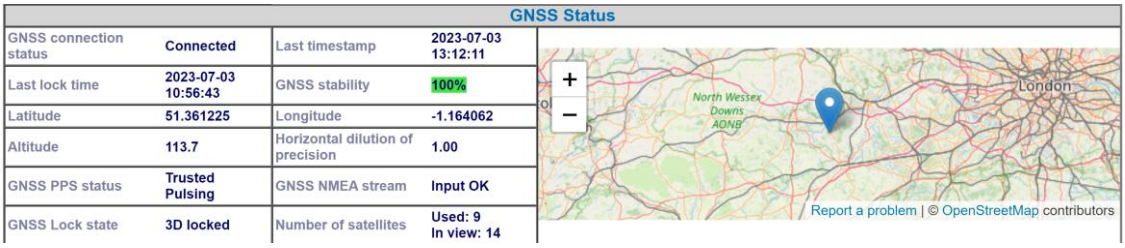
The currently supported GNSS systems are Navstar (GPS), GLONASS, BeiDou and Galileo.

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 Minimus$_2$ accessory pack includes a combined GNSS antenna and receiver for this purpose: see Section 2.2.2 for details.

5.1.1 GNSS lock status

This is available in the Status tab of the instrument's web page.



A number of GNSS reporting parameters are given, including:

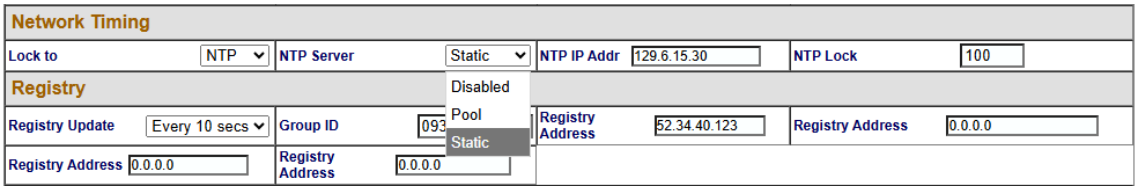
- Connection status
- Last GNSS update (sync) & last GNSS lock date/time
- GNSS Stability:
  - 0% = no receiver connected;
  - 1% = receiver connected, but waking up (this can occur if the GNSS receiver has been moved a long distance since last power-up).
  - 2-99% = view of sky obstructed.
  - 100% = 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)

5.1.2 NTP (Network Timing Protocol) configuration

This gives the system time to within 1 second. It is not generally recommended that this is used as the main time source for deployments. GNSS offers accurate time for this purpose.

By default, the NTP server option (located under the Network tab of the instrument's web page) 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.



5.1.3 PTP (Precision Time Protocol)

The Minimus$_2$ system currently does NOT support PTP.

6 Configuration and Control of Connected Instruments

6.1 Analogue Instruments

6.1.1 Setting instrument type

The analogue sensor type is user-selectable from the Setup tab and the Minimus$_2$ includes a choice of several Güralp sensors and accelerometers. If the sensor is not in the list, select “Generic velocity” or “Generic acceleration”, according to the instrument's response.

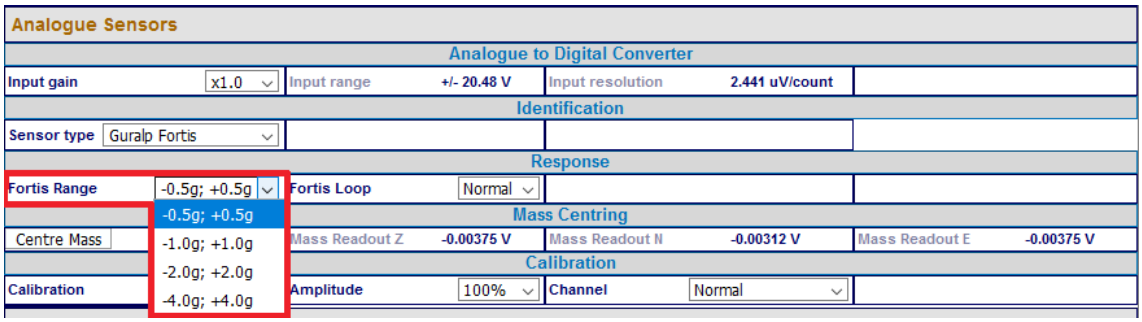
A reboot is required after this change.

6.1.2 Setting instrument (sensor) gain for Güralp Fortis

The Güralp Fortis strong-motion accelerometer features a remotely-switchable gain option that can be controlled from the webpage of the connected Minimus$_2$ or Minimus Lite. . 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.

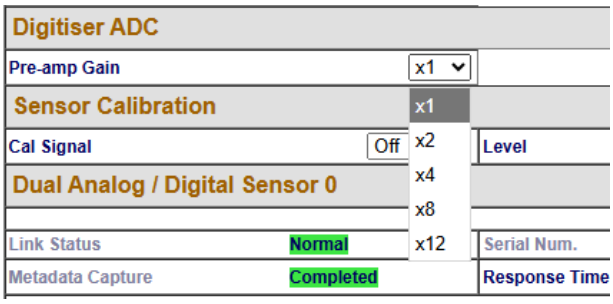
To change the gain electronically, first, set the “Instrument Type” to “Güralp Fortis”. Setting this option will then enable the “Instrument Gain” control. Under the “Instrument Gain”, select a gain setting (options: ±0.5g; ±1g; ±2g; ±4g).

Setting the instrument type to “Fortis” will also change the miniSEED channel names to indicate that data are recorded from an accelerometer, *e.g.* “HNZ”.



6.1.3 Setting digitiser gain

The input gain can be controlled from the Setup tab of the web page using the "Pre-amp Gain" drop-down box. Digitiser gain options available are: ×1, ×2, ×4, ×8 and ×12.



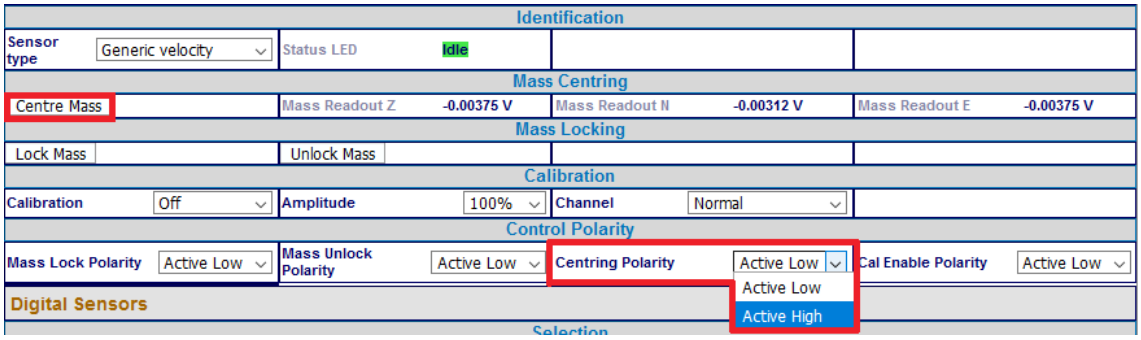
The input range and resolution change automatically when the gain is selected and the gain in the RESP files and Dataless SEED is updated automatically.

6.1.4 Mass control

The Minimus$_2$ can lock, unlock and centre the masses of connected instruments.

6.1.4.1 Mass centring

Many broadband seismometers (*e.g.* Güralp 3T and 3ESPC) support remote/electronic mass centring. Change the polarity of the control signal using the drop-down menu if necessary.



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 in the Centring tab of the instrument Control Centre window.

6.1.4.2 Mass locking

Some seismometers require their masses to be locked for 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, if necessary.

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

6.1.5 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.

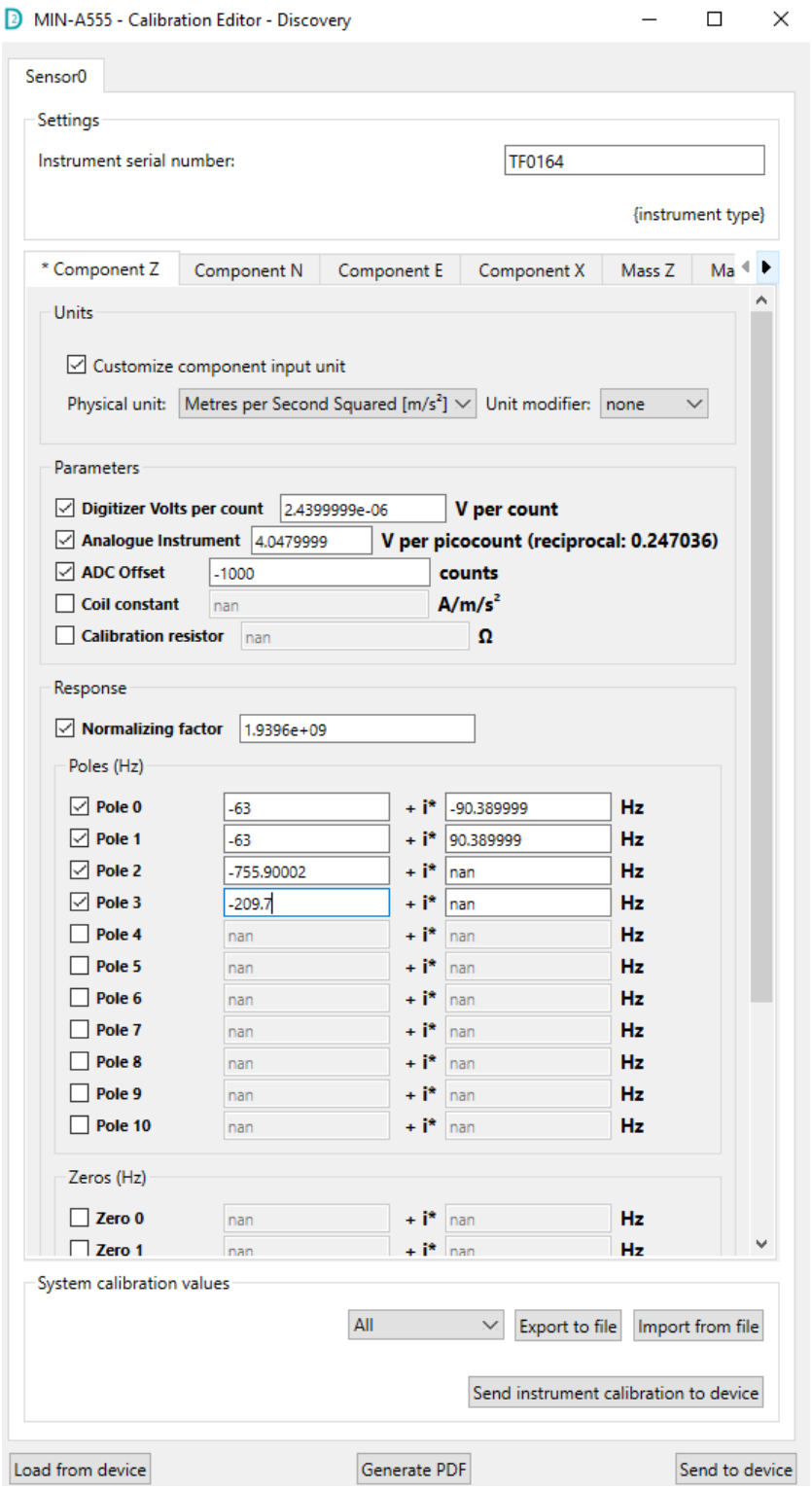
Response parameters typically consist of a sensitivity or "gain", measured at some specified frequency, and a set of poles and zeros for the transfer function that expresses the frequency response of the sensor. A full discussion of poles and zeros is beyond the scope of this manual.

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 $Minimus_2$ is programmed at the factory so that it knows its own calibration values.

Although the $Minimus_2$ automatically receives calibration parameters from connected digital instruments (*e.g.* Güralp Certis), calibration values need to be entered manually for connected analogue sensors (*e.g.* Güralp Fortis). All Güralp sensors are fully calibrated before they leave the factory. The results are given in the calibration pack supplied with each instrument.

To enter the calibration values for your analogue instruments, right-click the $Minimus_2$ in Discovery's main window and select "Calibration" → "Edit Poles & Zeros".



This form has one tab for each seismic component, for the mass positions and calibration channel. The instrument's response values should be entered in the 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

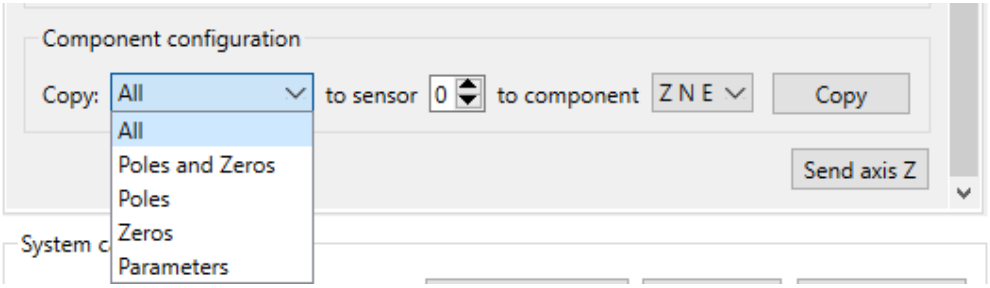
with the instrument. In the calibration document, this parameter is often referred to as “Velocity Output V/m/s” or “Acceleration Response V/m/s²” depending on the analogue instrument. This value can vary slightly across the three components.

- 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.

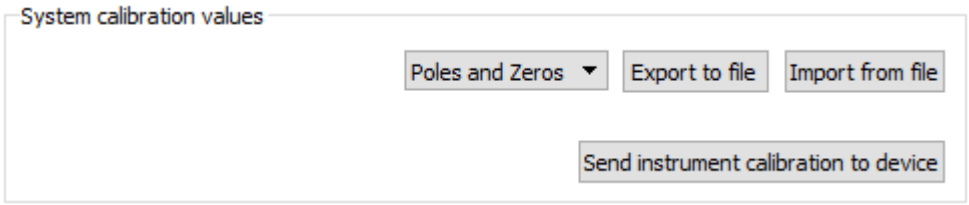
Note: If the calibration document is lost, please visit the website to learn how to request a copy (https://www.guralp.com/customer-support).

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.

6.2 Digital instruments

Minimus$_2$ supports the Güralp Certis instrument. This can be connected either as a Digital instrument or a traditional Analogue device. The same cable is used in either case.

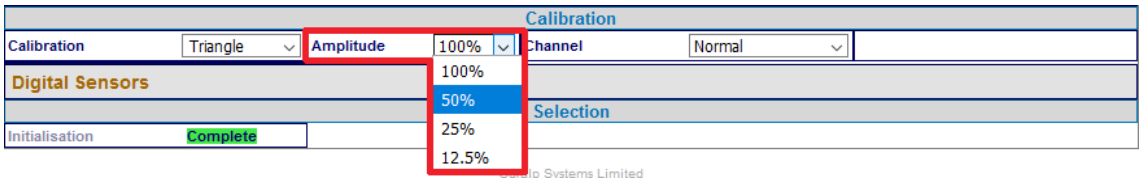
In the case of the digital connectivity, the serial connection conveys metadata in addition to the seismic signals. Information such as temperature, internal humidity, mass positions are all made available.

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

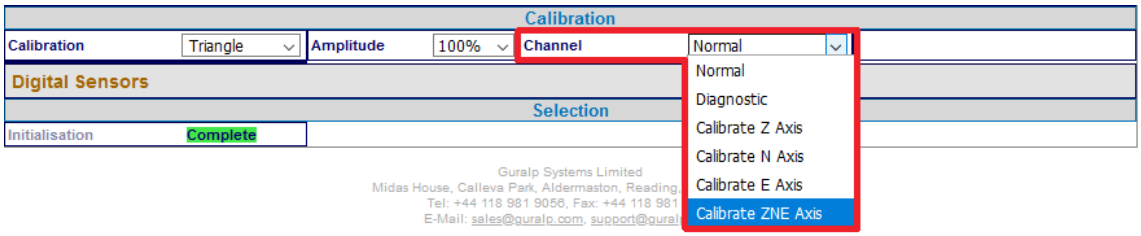
6.3 Inject a calibration signal

To check whether the analogue sensor(s) connected to the Minimus$_2$ is correctly calibrated, go to the Setup tab of the web page and use the drop-down menu to choose between Triangle, Square and White Noise signal to be injected into the sensor's feedback loop.

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

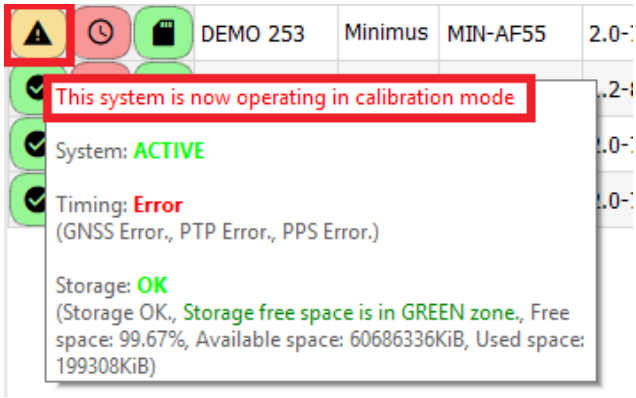


Finally, enable the calibration on all three components of the selected analogue sensor.



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

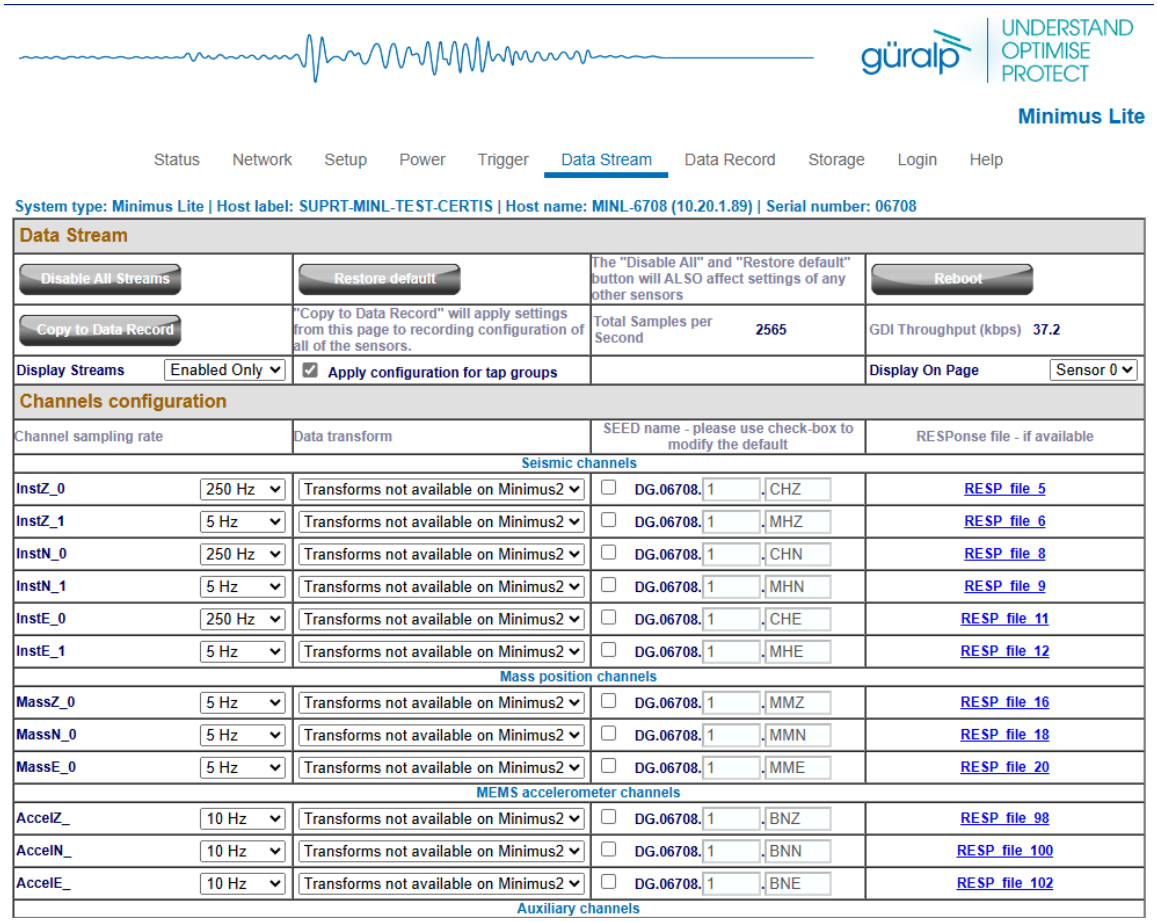
While the calibration is in progress, the webpage shows the warning message Calibration in progress and Discovery flags the status icon in yellow.



7 Data Transmission

7.1 Data Stream Tab

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



Three streaming protocols are supported:

GDI – Güralp Data Interchange. This is used with Discovery and offers live, low latency data combined with channel metadata. All calibration and response information is contained within the stream

GCF – Guralp Compressed Format. A legacy protocol for use with Güralp Scream.

SeedLink – An industry standard, packet-based protocol. The packetising causes potentially significant delays. Güralp has implemented various extensions to the protocol to reduce packet size and payload to speed up for early warning applications. The metadata is not conveyed within the stream. The dataless file is required to be transferred separately to give calibration and response information. This can be error prone!

All 3 servers are active. Making the connection starts the stream.

The Data Stream page allows to configure the transmitted channels for each of the connected instruments and sensors internal to the Minimus$_2$. The drop-down box at

the top-left of the page named Display Streams filters out visible channels among Enabled and Disabled.

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

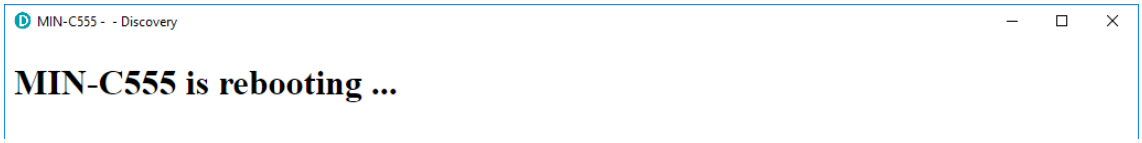
The drop-down box at the top-right of the page named Display On Page allows to move from different instruments, *e.g.* Sensor 1.

The page is divided in four columns:

- In most-left column, 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). All streaming can be stopped by clicking the Disable All button. 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.
- Contrary to the Minimus digitiser, transforms are not supported by Minimus$_2$ and this is reflected in the second column "Data transform".
- In third column from left, Location and Channel SEED codes can be configured. Cells are greyed out by default (default values applied) and they can be edited by clicking on the check-box;
- In most-right column contains links to the RESP files associated to each of the seismic channels (see Section 6.1.5).

Upon changing the sample rate, or changing Location and Channels codes, the Minimus$_2$ 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 2.1.1) and the instrument web page will display the following screen.



Once the Minimus$_2$ has successfully restarted, the full web browser display and controls will be available for use again.

In addition to the main seismic streams, there are a number of other data streams. These can be seen from the Data Stream or Records tabs. Use hover help on the stream name to gain more insight as to what the stream represents.

Many of the additional streams should be recorded at low sample rates during deployment. They are a vital tool to understanding the deployment and environment.

For example, the temperature and GPS time phase measurement (PLL) together can be used to diagnose possible reasons for time lock degrading in a deployment. In the event of snow covering the GPS antenna, the temperature and phase measurements will show significant changes. A stable phase of a few counts from zero is expected as the GPS time is compared to internal time. Flatlining of the phase implies a loss of GPS time signal. When signal is regained, the phase will start with a larger value and gradually reduce as time lock ensues.

7.2 GDI-link protocol

The Minimus$_2$ can transmit data using the GDI-link protocol. GDI-link can currently be used with:

- Güralp instruments with embedded acquisition modules (*e.g.* 40TDE)
- Güralp DM24 and CD24 digitisers with embedded acquisition modules (e.g. Güralp DM24S*x*EAM[U])
- Güralp Affinity digitisers
- Güralp NAM (Network Acquisition Module)
- Earthworm software (www.isti.com/products/earthworm/)

GDI-link supports both data push and pull from/to the Minimus$_2$. See Section 7.5 to configure 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 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.

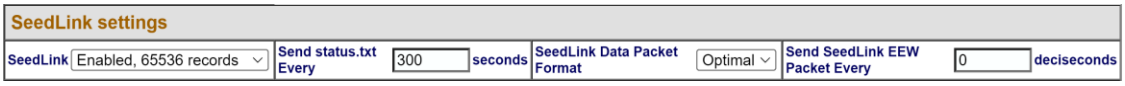
A significant advantage of GDI-link is that it has the ability to stream data pre-converted into real physical units instead of just as raw digitiser counts, obviating a requirement for receivers to be aware of calibration values.

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

7.3 SeedLink Protocol

The Minimus$_2$ can act as a SeedLink server to send SeedLink 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.

In the “Network” tab of the ' web page, select the desired SeedLink mode:



The choices are:

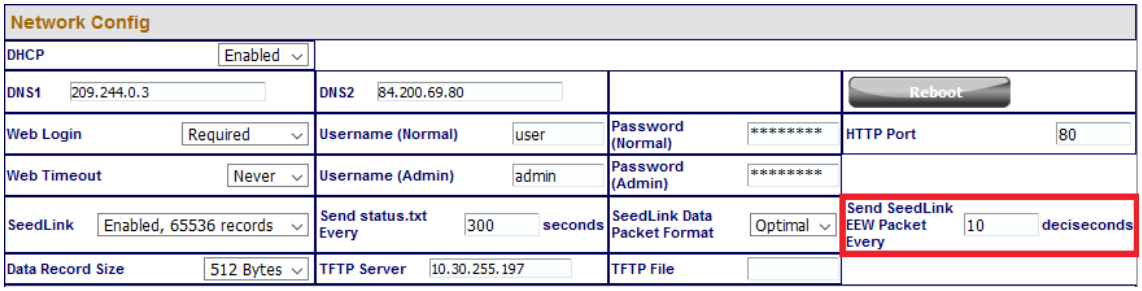
- “Enabled” - This is the normal operating mode. Choose between backfill buffer sizes of 2,048 records, 65,536 records or 139,264 records.
- “Disabled” - turns off the SeedLink server.
- “Debug” - this mode produces additional messages in the file `seedlink.log` which may be helpful if trying to diagnose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

backfill buffer sizes as before and, additionally, a 512-record buffer. (622,592 is listed but not implemented).

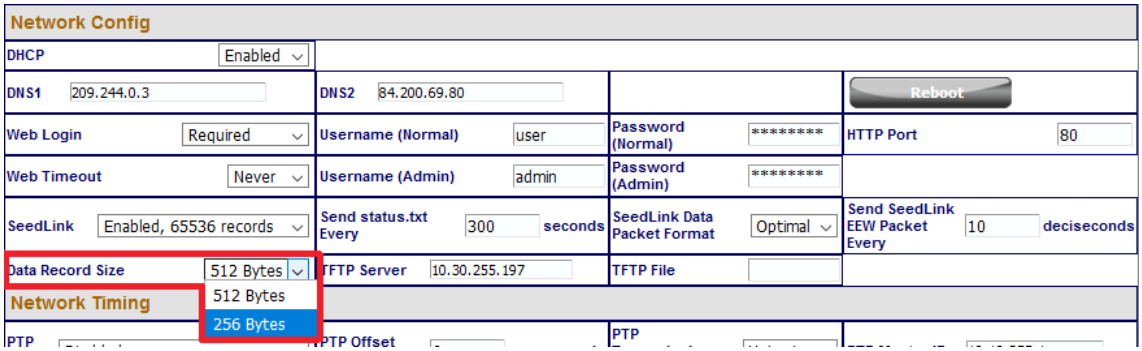
Standard SeedLink has a fixed packet size of 512 Bytes and each miniSEED packet is completely populated with data before it is transmitted. The Minimus$_2$ supports a modified version of SeedLink that allows the transmission of incomplete packets. This improves latency.

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.

In the "Network" tab of the web page, select the interval in deciseconds (1 deciseconds = 100 ms or 0.1 seconds) between miniSEED packets ("Send SeedLink EEW Packets Every").



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 web page controls this behaviour.



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

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 http://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, you will need 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$_2$ 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.

7.4 Scream! (GCF format + Scream protocol)

The Minimus$_2$ 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 (see Section **Error! R eference source not found.**) or any software that can communicate using the Scream! Protocol, including Earthworm.

These include:

- Güralp instruments with embedded acquisition modules (*e.g.* 40TDE)
- Güralp DM24 and CD24 digitisers with embedded acquisition modules (*e.g.* Güralp DM24S*x*EAM[U])
- Güralp Affinity digitiser
- Network Acquisition Module (Güralp NAM)

7.4.1 Low Bandwidth Considerations

If streaming data with a low bandwidth connection, it is advised to minimise channel sampling rates where possible to prevent issues with data streaming. The default calibration sampling rate is 4000 Hz, it would be recommended to reduce this in the case of a low bandwidth connection. This channel is not always enabled so if it doesn't appear within the 'Data Stream' tab, select 'All' under 'Display Streams' and it will appear.

If connecting to the Minimus$_2$ via a modem, such as in our Rapid Deployment Kit, a low bandwidth would be expected and the above should apply.

7.5 GDI push (auto-connection)

A Minimus$_2$ normally acts as a GDI server, where a client initiates a connection in order to pull data from it. This is the mechanism used when the GDI viewer in Discovery is launched.

The "GDI auto-connection" feature enables the Minimus$_2$ to establish *outgoing* network connections in order to *push* data to one or more remote clients, such as Platinum systems or an Earthworm system running the `gdi2ew` plug-in.

To configure an auto-connection, type either the IP address or the host-name 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$_2$ to a host is configured, the Minimus$_2$ 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$_2$ will then negotiate a link and start streaming data.

If the connection drops, the Minimus$_2$ will attempt every 60 seconds to reconnect.

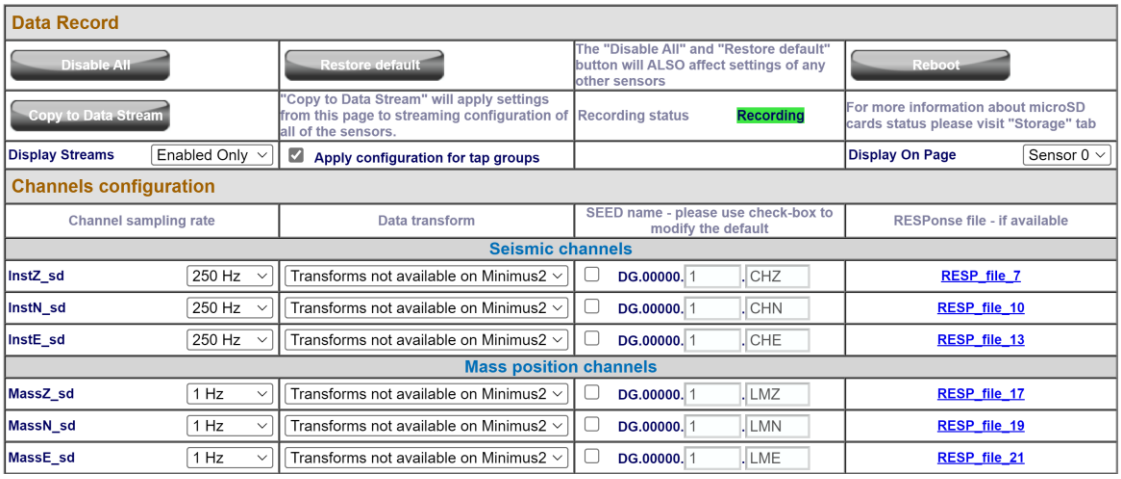
Note: The default port number for a GDI-link receiver is 1566. Push servers will normally connect to this port. The default port number for a GDI-link

transmitter is 1565. Receivers wishing to pull data will normally connect to this port. See Chapter 20 for a list of the network ports used by the Minimus$_2$.

8 Data Recording

8.1 Data Record Tab

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



This page allows to configure the recording channels for each of the connected instruments and sensors internal to the Minimus$_2$.

The names and contents of each channel are described in Section 18 .

Note: When changing a setting in the Minimus$_2$ web page, ensure that you wait until the page refreshes before changing another setting. This allows time for the previous change to take effect.

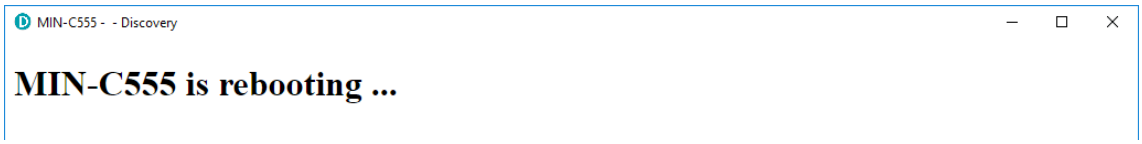
The drop-down box at the top-left of the page named “Display Streams” filters out visible channels among All, Enabled and Disabled. The option “Apply configuration for tap groups” automatically apply the same configuration to three streams that belong to the same tap, *e.g.* InstZ, InstN, InstE. The drop-down box at the top-right of the page named “Display On Page” is used to select the Sensor configuration to display on the page.

The page is divided in four columns:

- In the left-most column, 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). All streaming can be stopped 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 third column from left, Location and Channel SEED codes can be configured. Cells are greyed out by default (default values applied) and they can be edited by clicking on the check-box;
- In most-right column contains links to the RESP files associated to each of the seismic channels (see Section 6.1.5).

Upon changing the sample rate, or changing Location and Channels codes, the Minimus$_2$ needs 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 2.1.1) and the instrument web page will display the following screen.



Once the Minimus$_2$ has successfully restarted, the full web browser display and controls will be available for use again.

8.2 Storage Tab

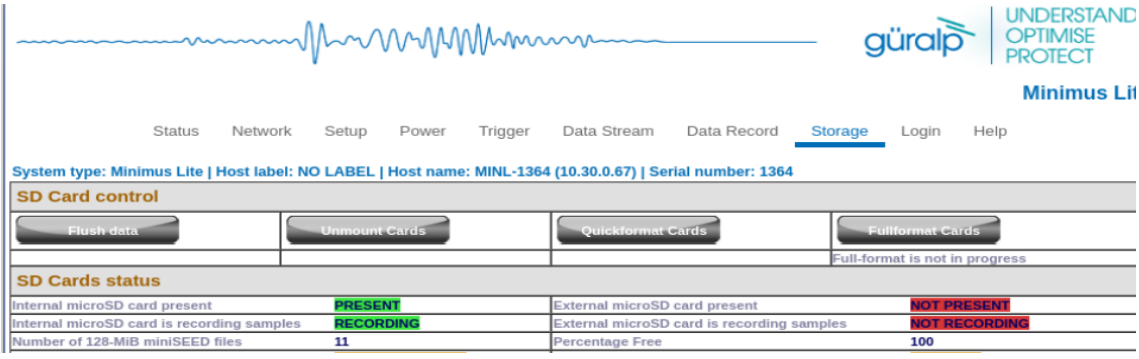
8.2.1 Recording status

MicroSD cards need to be specifically formatted to operate with the Minimus$_2$. The cards shipped with the Minimus$_2$ are supplied pre-formatted.

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

The MicroSD card and data recording status can be monitored in the upper panel of the Storage tab.

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.



Sections of this panel indicate the status of the following:

- Whether a card is inserted;
- Whether an inserted card is usable (*i.e.* correctly formatted); and
- Whether the card is recording data.

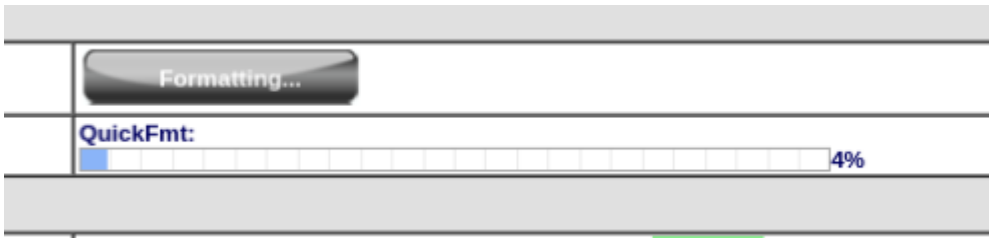
Note: If the recording status of the cards is marked **NOT RECORDING**, clicking on the Quick Format button may solve the issue. Note that the quick format simply moves the write-pointer to the beginning of the recording space, hence overwriting any existing data.

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

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

8.2.2 MicroSD Card Re-Formatting

Ensure that the external microSD card is correctly inserted. Click the Quickformat Cards button in the Storage tab: The button legend will change to ask for confirmation. Press a second time to start the format: The progress bar should immediately start at 1% and take about 5 minutes to complete.



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

8.2.3 MicroSD card data flushing and unmounting

The Flush Data button flushes data still in the buffer into the microSD card storage. Perform a flushing before downloading data from the Storage tab if the very latest data is required. Data is written roughly every 2 minutes.

The Unmount Cards button flushes the data from the buffers into the microSD cards and interrupts the recording. The recording restarts if a new card is inserted in the slot or if a quick-format (or full-format) is performed.

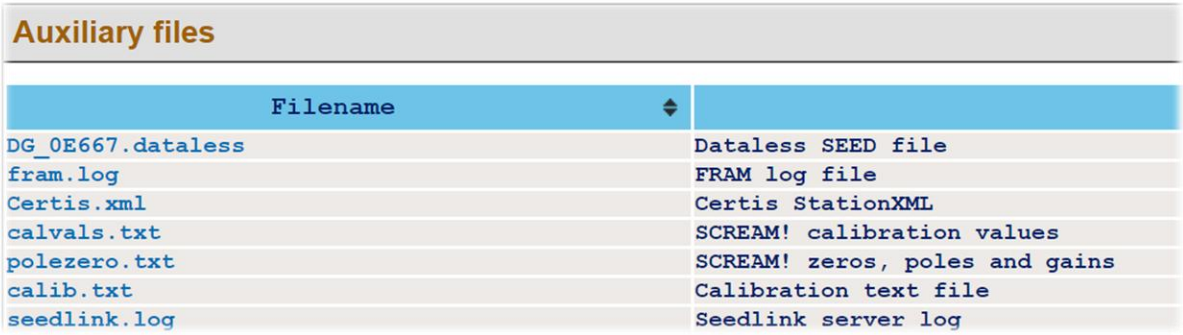
9 Metadata

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.

9.1 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.



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

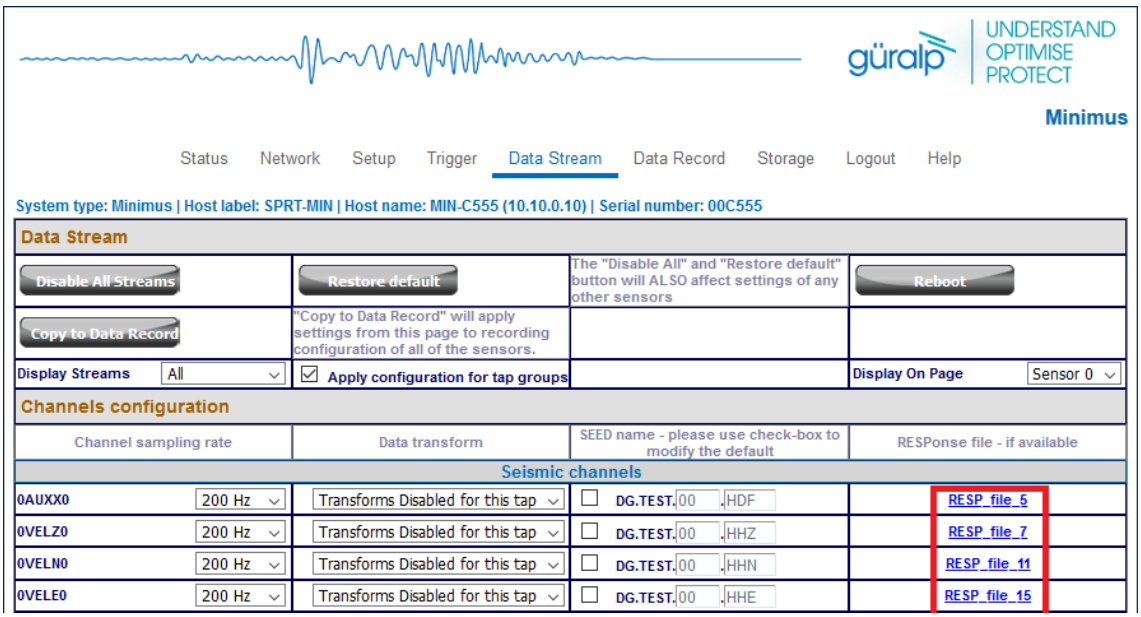
You can also use the `wget` command from the command line to download the Dataless SEED volume from the URL above. The command would look something like this:

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

The Dataless SEED file is generated from the RESP files for each channel (see Section 9.2 below).

9.2 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.

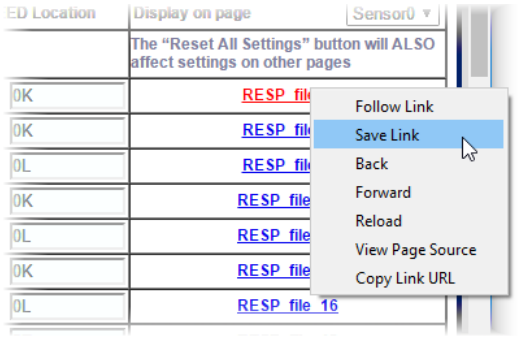


Clicking on a RESP file link produces a page like this:

```
#               << 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:

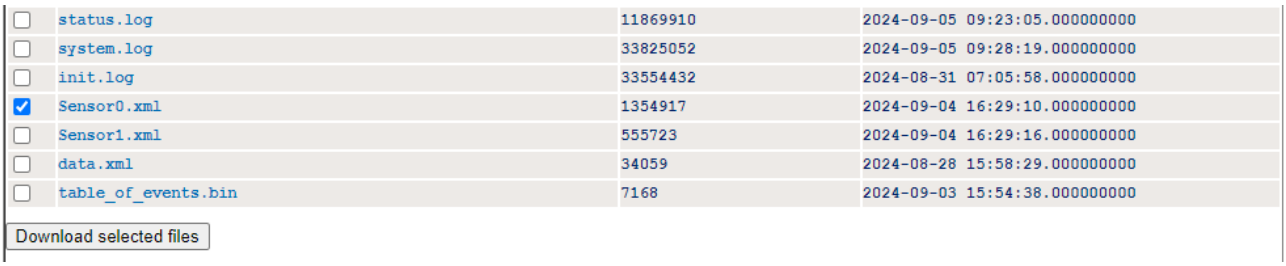
http://10.20.1.92/RESP_file_7.txt

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
```

9.3 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" under the 'Auxiliary Files' section.



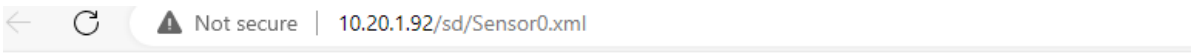
Also the XML files are available by direct URL. Simply type in a web browser the IP address of the Minimus followed by /sd and the XML filename, for example:

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.



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

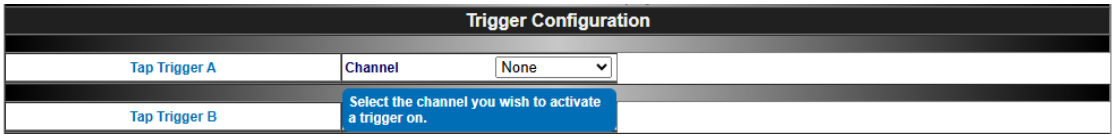

```
<FDSNStationXML xmlns="http://www.fdsn.org/xml/station/1" schemaVersion="1.1">
  <Source>Guralp Certimus</Source>
  <Created>2024-06-10T13:19:59Z</Created>
  <Network code="DG">
    <Station code="0E667">
      <Latitude>51.360699</Latitude>
      <Longitude>-1.163408</Longitude>
      <Elevation>111.900002</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>
```

10 Earthquake Early Warning

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.

10.1 Trigger Configuration

The Trigger Configuration section of the web page under the Triggers tab enables the user to configure the triggering system. The trigger taps should first be selected from the drop-down list of all possible channels.



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

10.1.1 Common options

Channel - Once this is selected, options will appear to enable the sending of a CAP message, configure the sample rate the trigger will use, select the trigger type, and all the necessary triggering options required.

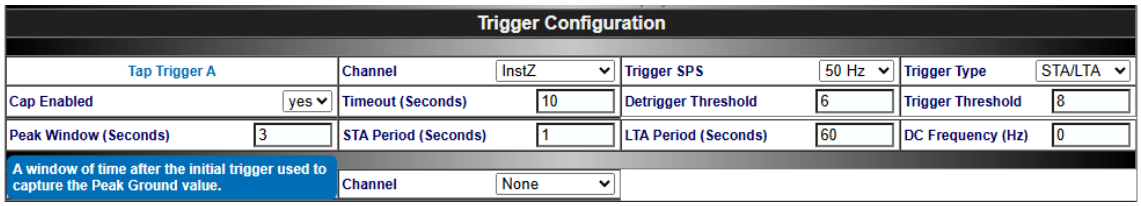
Trigger SPS - It is recommended that Trigger SPS is kept the same as the channel it is on. I.e., if InstZ is streaming at 250 sps, then Trigger SPS should be set to 250 sps to perform the best STA/LTA calculations.

Trigger Type – STA/LTA or Threshold

CAP Enabled – This option will allow the sending of a CAP message on the initial trigger, when enabled it will also show the option for Peak Window which is a time after the initial trigger in which Peak Ground data will be measured. If the Peak Window is set to a number other than 0, a second CAP message will be sent after the window expires containing the peak value measured.

Timeout – After an event has occurred, subsequent triggers within this window will be treated as part of the same event (while also restarting the timeout period).

10.1.2 STA/LTA



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.

Trigger Threshold – When the ratio of STA to LTA exceeds the set threshold value an event is "declared". To trigger below a ratio value instead of above, simply set the detrigger threshold to be higher than the trigger threshold.

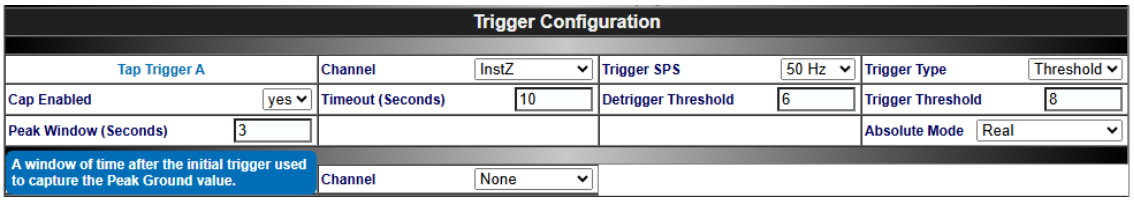
Detrigger Threshold – This is the ratio value to stop triggering. This will likely happen within the Timeout. The trigger event itself will only end when the Timeout and Detrigger conditions have been met.

STA Period – Number of seconds to measure the short period

LTA Period – Number of seconds to measure the long period

DC Frequency – The cut-off frequency of the high pass filter in Hz

10.1.3 Threshold



Trigger Threshold - The threshold algorithm, instead, declares the presence of an event when the signal exceeds a particular value. To trigger below a value instead of above, simply set the detrigger threshold to be higher than the trigger threshold.

Detrigger Threshold - This is the signal value to stop triggering. This will likely happen within the Timeout. The trigger event itself will only end when the Timeout and Detrigger conditions have been met.

Absolute Mode – The signal value used to trigger can be Real, Absolute, or Absolute (No DC). The latter is an option for seismic channels to remove the DC offset.

Although the above is available, it is recommended to use STA/LTA for seismic triggers as it was developed specifically to address the pitfalls of threshold triggering.

10.2 CAP receiver

The EEW Configuration section of the web page under the Triggers tab controls the CAP message configuration parameters, which include the IP address and Port No. of the CAP message receiver as well as other configuration parameters for the contents of the CAP message.

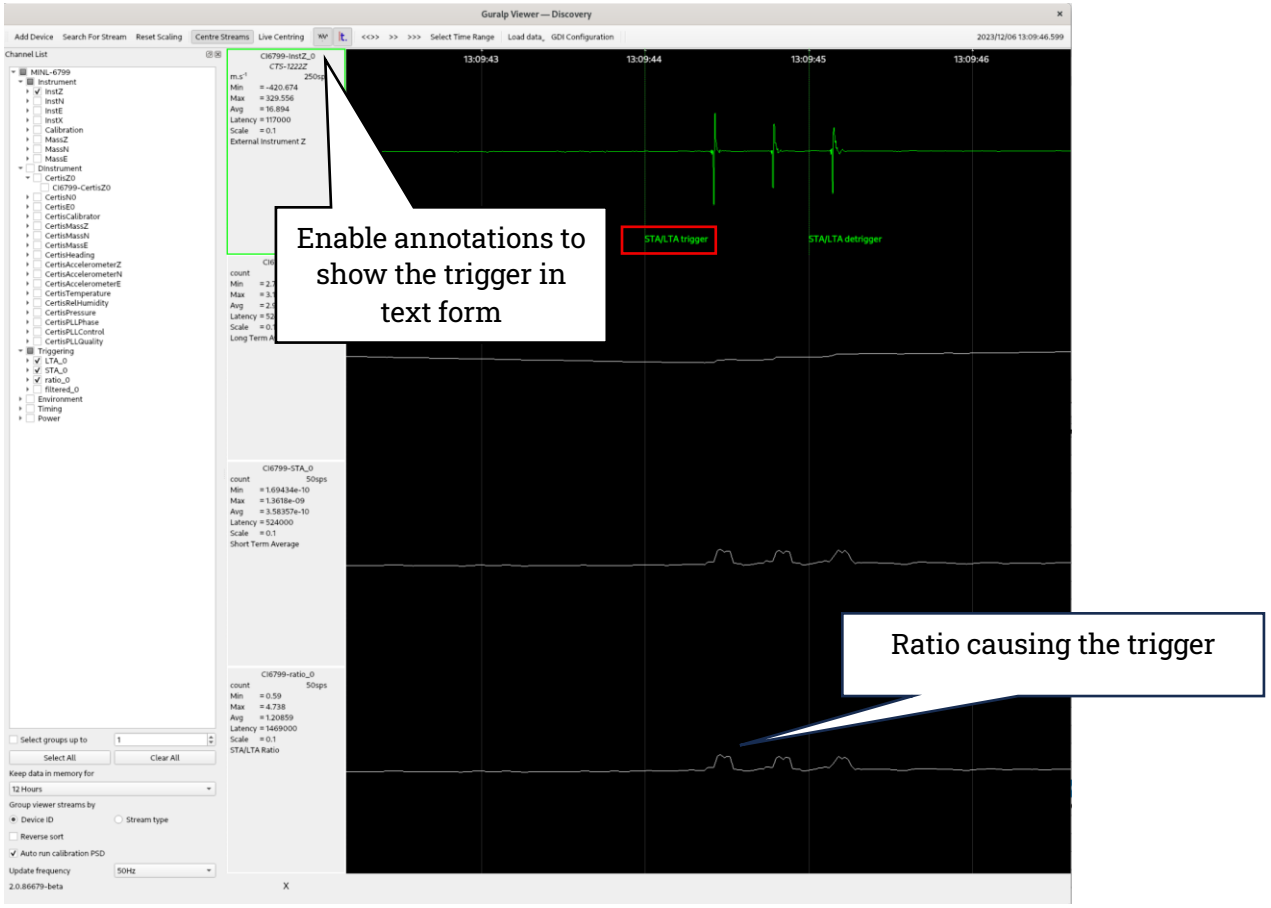
Güralp Discovery includes a CAP (Common Alerting Protocol) receiver. It listens on a specified UDP port for incoming CAP messages. When one arrives, it is displayed and plotted on a map. In addition, the receiver can open a TCP connection to the cloud-based registry server and display CAP messages that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

10.3 STA/LTA Streams

After enabling a trigger, a system reboot is required for the changes to take effect. Once the device restarts, additional data streams become available, displaying the calculated STA, LTA and their ratio (STA/LTA)

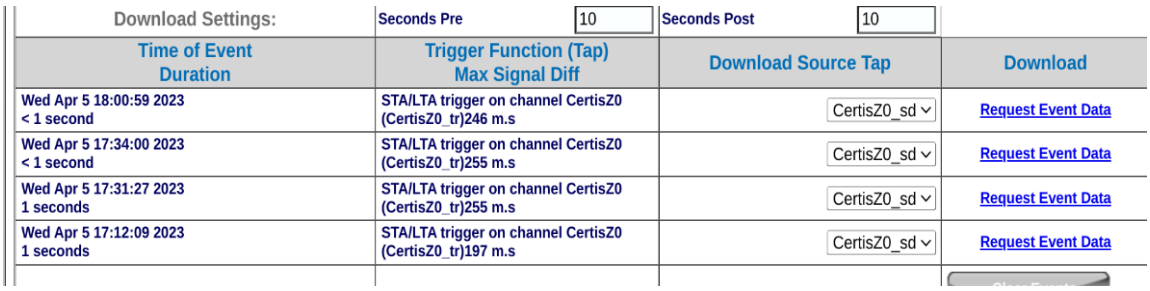
The STA/LTA ratio is evaluated against a threshold configured as described above. Viewing these streams is recommended to better understand the behaviour of the ratio values and to assess the impact of the selected time windows.



10.4 Seismic Event Table

The Minimus$_2$ can generate a “Seismic Event Table”. This is list of events detected by the STA/LTA or threshold trigger enabled on taps. It contains information about the time when the event occurred, its 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 in the table.

The table is located at the top of the Trigger tab in the web page. It might be necessary to refresh the webpage after a trigger is detected to see the even in the Seismic Event Table.



Download Settings:	Seconds Pre 10	Seconds Post 10	
Time of Event Duration	**Trigger Function (Tap) Max Signal Diff**	**Download Source Tap**	**Download**
Wed Apr 5 18:00:59 2023 < 1 second	STA/LTA trigger on channel CertisZ0 (CertisZ0_tr)246 m.s	CertisZ0_sd	Request Event Data
Wed Apr 5 17:34:00 2023 < 1 second	STA/LTA trigger on channel CertisZ0 (CertisZ0_tr)255 m.s	CertisZ0_sd	Request Event Data
Wed Apr 5 17:31:27 2023 1 seconds	STA/LTA trigger on channel CertisZ0 (CertisZ0_tr)255 m.s	CertisZ0_sd	Request Event Data
Wed Apr 5 17:12:09 2023 1 seconds	STA/LTA trigger on channel CertisZ0 (CertisZ0_tr)197 m.s	CertisZ0_sd	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.

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.

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).

11 Remote Connectivity

11.1 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*

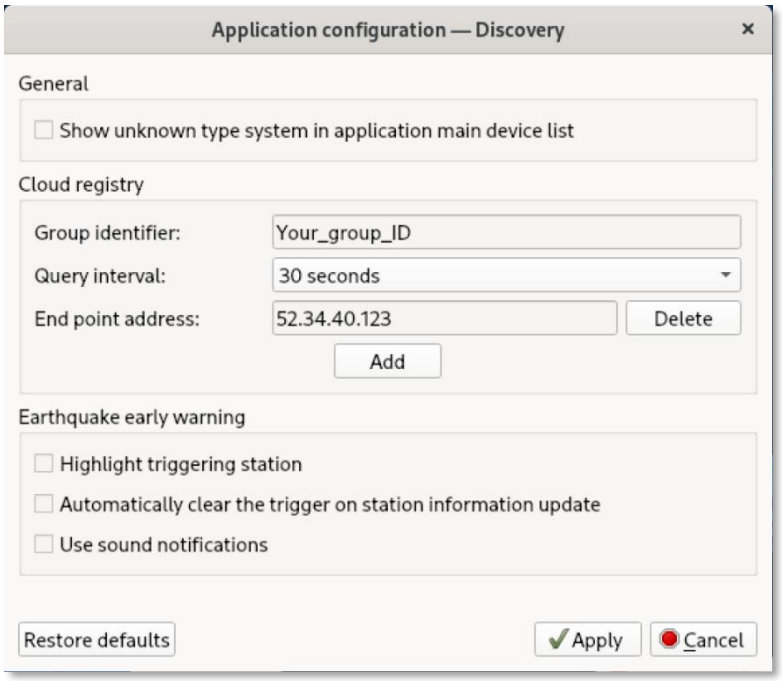
Registered digitisers must be assigned to groups, each of which has a Group Identifier. Instances of Discovery must also be configured with a Group ID and can only display registered digitisers from the matching group. This allows partitioning of large networks into smaller administrative domains. It 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 **Error! Reference source not found.**. 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.



11.2 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 **Error! Reference source not found.**for a list of the network port used by M inimus.

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.

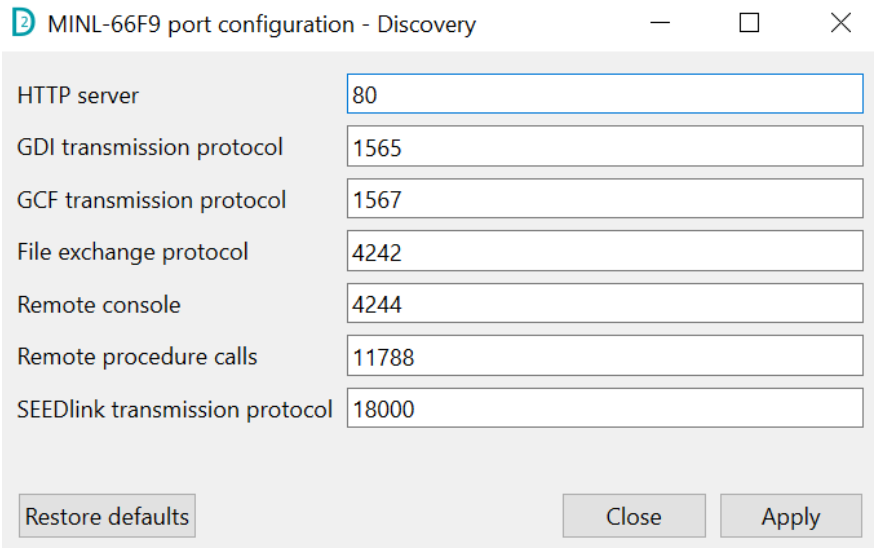
11.2.1 Port Forwarding

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.



11.2.2 Router/Gateway VPN

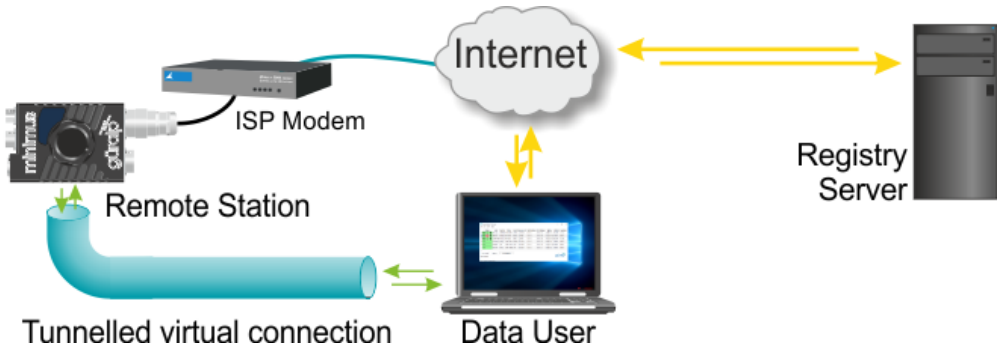
Some WAN routers include a VPN client feature which may allow remotely located instruments to appear as if they are on the same local network as the Discovery instance. Setting up a VPN is beyond the scope of this manual.

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

11.2.3 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).

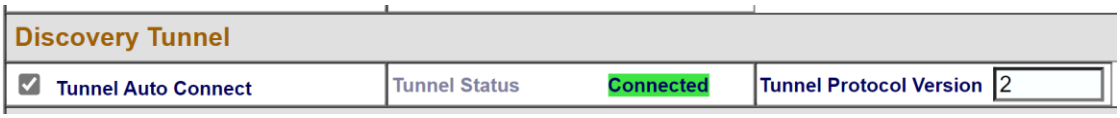
This feature allows all network traffic between a Discovery instance and instrument to be routed via a Registry Server, using only outgoing TCP connections from each end point (device and Discovery instance). In this way, full communication is possible through firewalls and NAT routers without special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



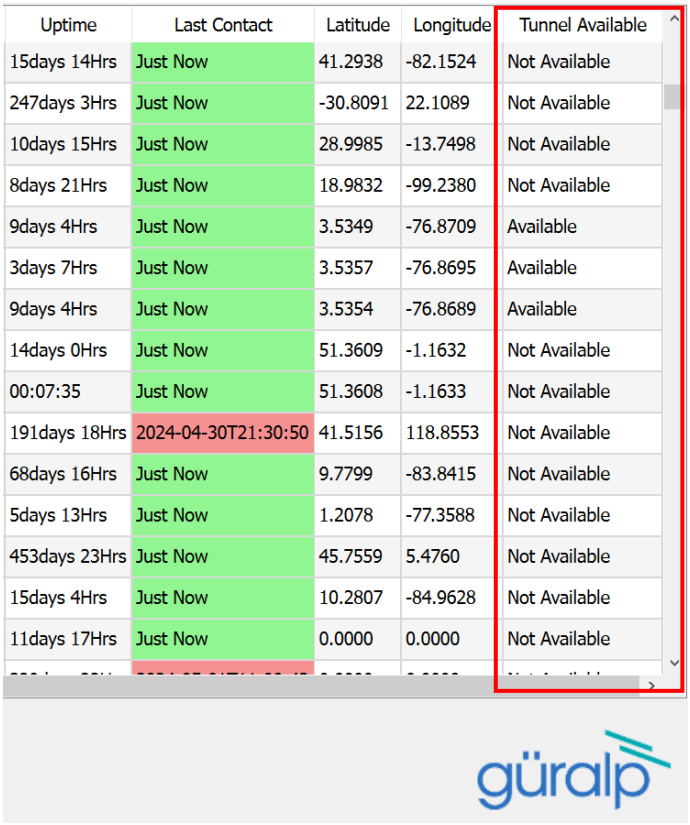
To enable this feature, relevant Güralp devices should be assigned to a Registry server (as explained in Chapter 11.1) and the Tunnel Auto Connect setting should be enabled (see below). Where multiple Registry servers can be configured, the first Registry server slot should contain the tunnel enabled 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.



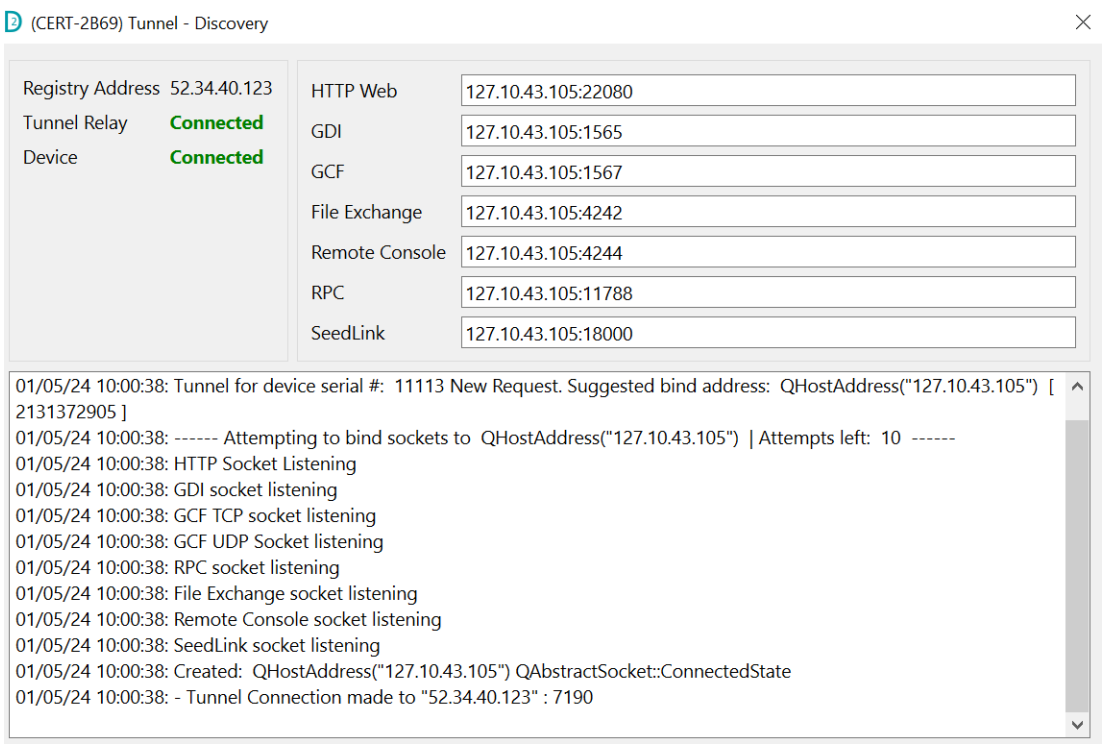
In Registry mode, the Discovery Main Window will display the tunnel availability of listed devices. If this column is not displayed, it can be enabled by selecting Window Show → Tunnel Available. Devices connected to a tunnel-enabled Registry server will be indicated with “Available” in the Tunnel Available 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

12 Scripting

The digitiser 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.

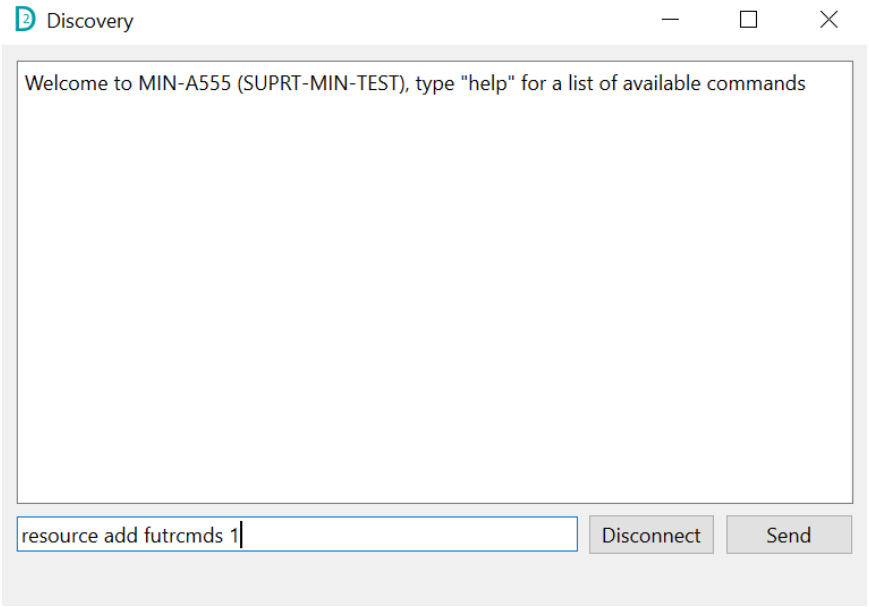
The script file is written on a computer as a .txt file. It is then sent to the digitiser as a file transfer from Discovery.

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



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.

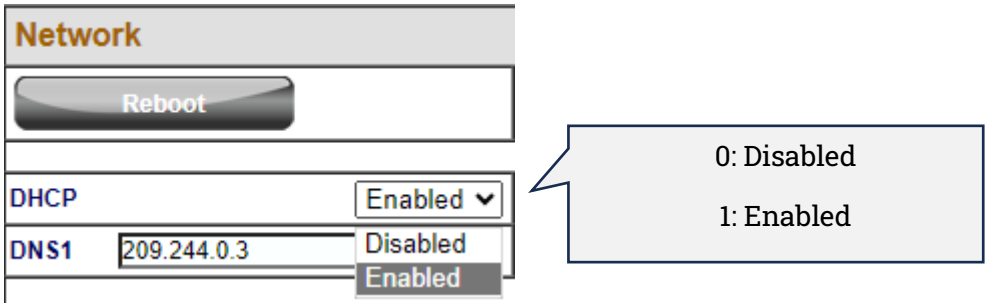
To edit the parameters present in the webpage, use the command "`var set`". For example,

```
var set DHCP 1
```

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

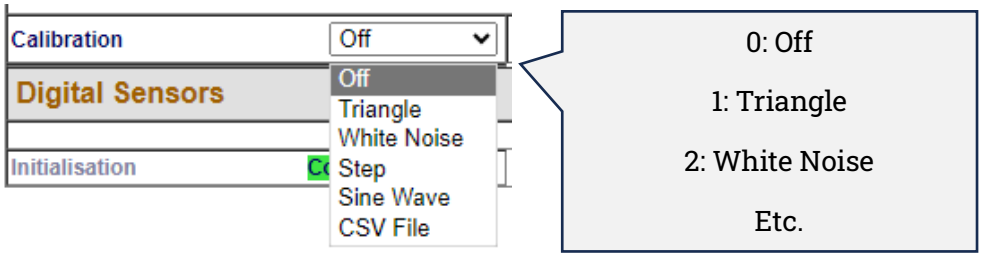
```
var set DHCP 0
```

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`

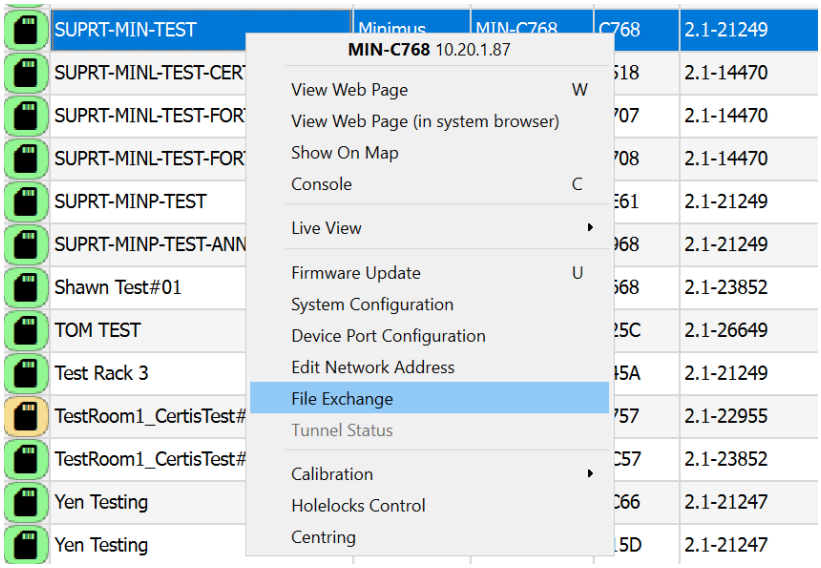
This switches off the logic lines of the 'calibration enable'.

`"0:Calibration" 0`

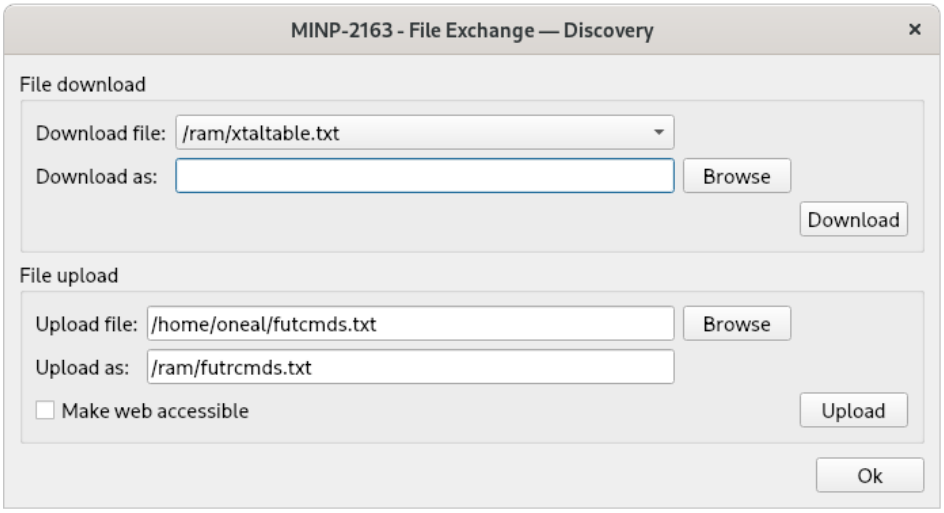
This command will switch off the DAC creating the calibration signal and stop the recording of the special calibration channel.

12.3 Sending a Script File

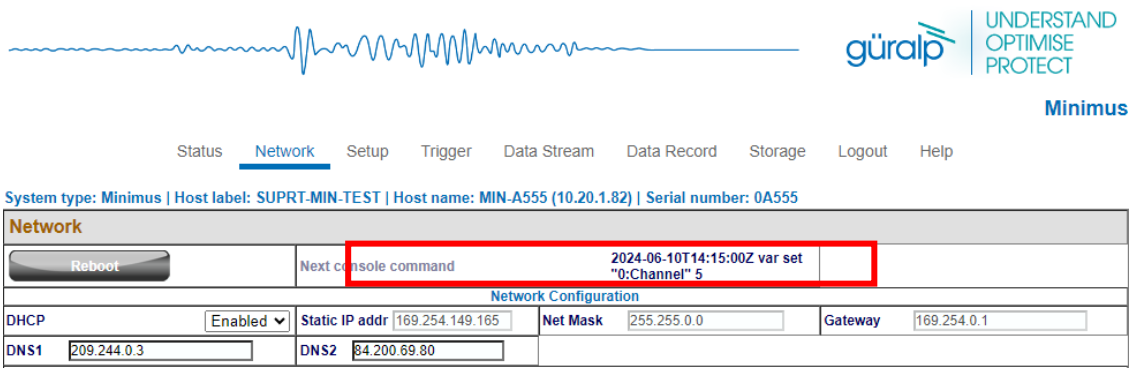
Once the text file with the list of commands is ready, it has to be uploaded in Discovery as a file transfer. To do this, right-click on the Minimus entry and select “File Exchange”.



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.



12.3.1 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`

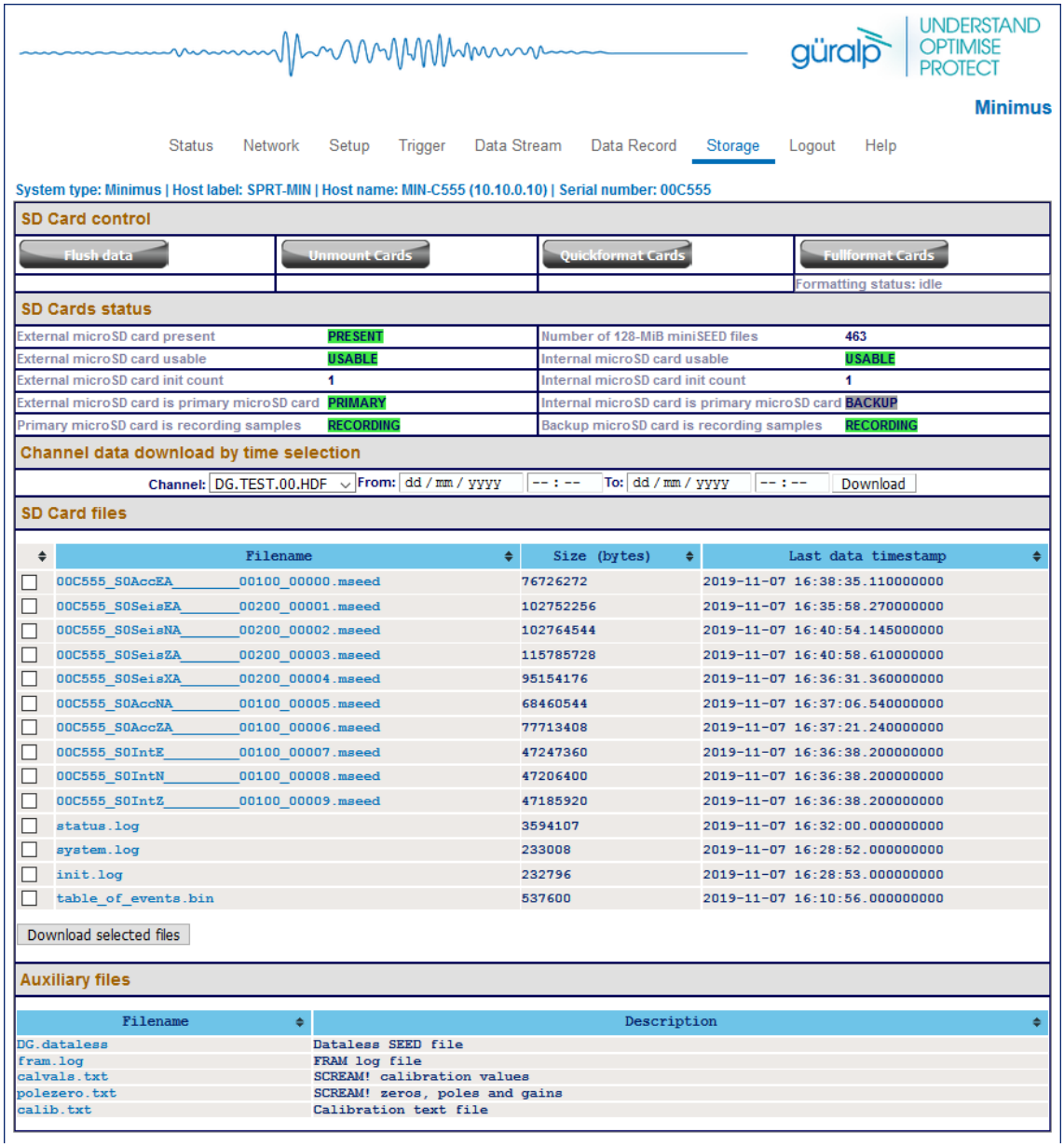
To remove the script and cancel queued up commands, type in the console:
`futrcmds clear`

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

13 Data Download

13.1 Bulk Data Download via Webpage

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

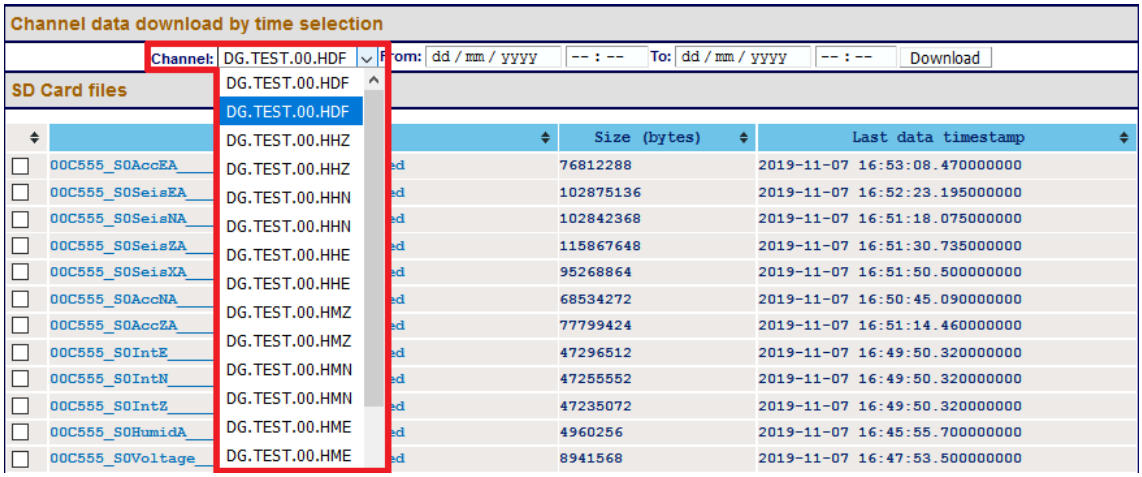


Single or multiple files can be downloaded simultaneously by ticking the check-boxes on the left of each link and clicking on Download Selected Files button.

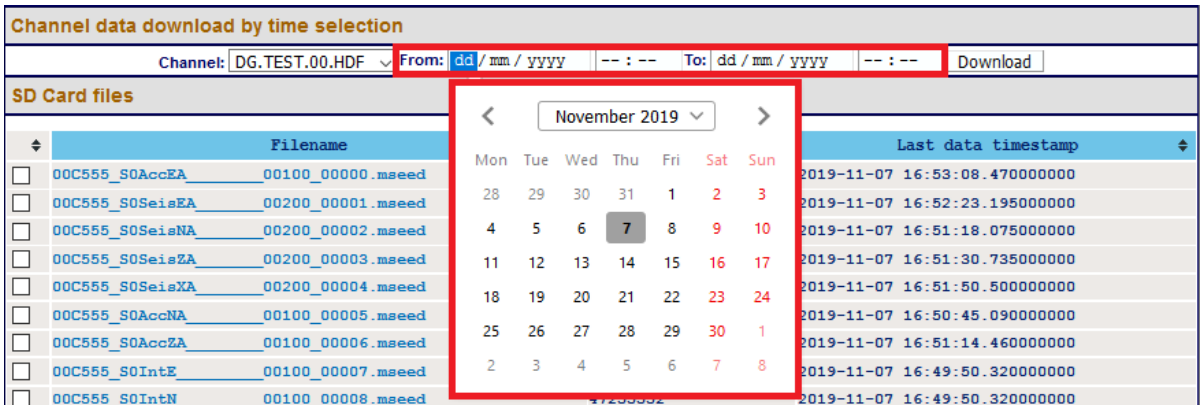
The microSD cards are formatted with empty files, which are filled with data as they become available. The filenames are also changed when the files are written on. Before they are written on, they are marked as “hidden” files, so that it is easier to see how many files contain data when looking at the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

13.2 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.

13.3 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
```

13.4 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'`
```

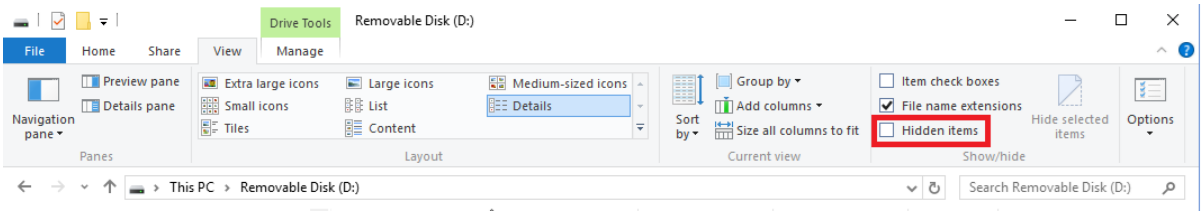
```
# In this example, the 3-components miniSEED file will be named
"DG.04D67-2024.04.28-16.00.00.mseed"
cat z_component.mseed n_component.mseed e_component.mseed >
${net_code}.${station_code}-${date_string}.mseed
```

13.5 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.

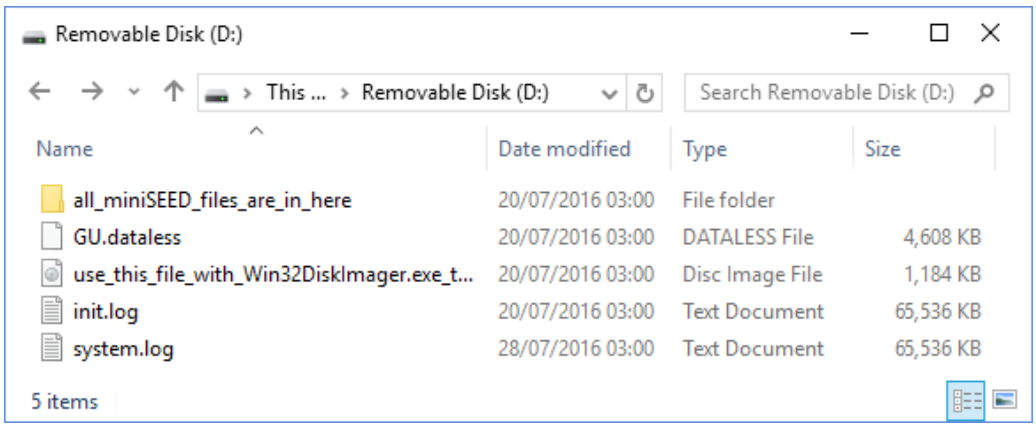
When viewing files in Windows Explorer, it may be helpful to configure your system so that "hidden" files are not shown. In Windows 10, this can be done by checking the “Hidden items” checkbox within the “View” ribbon of Windows Explorer.



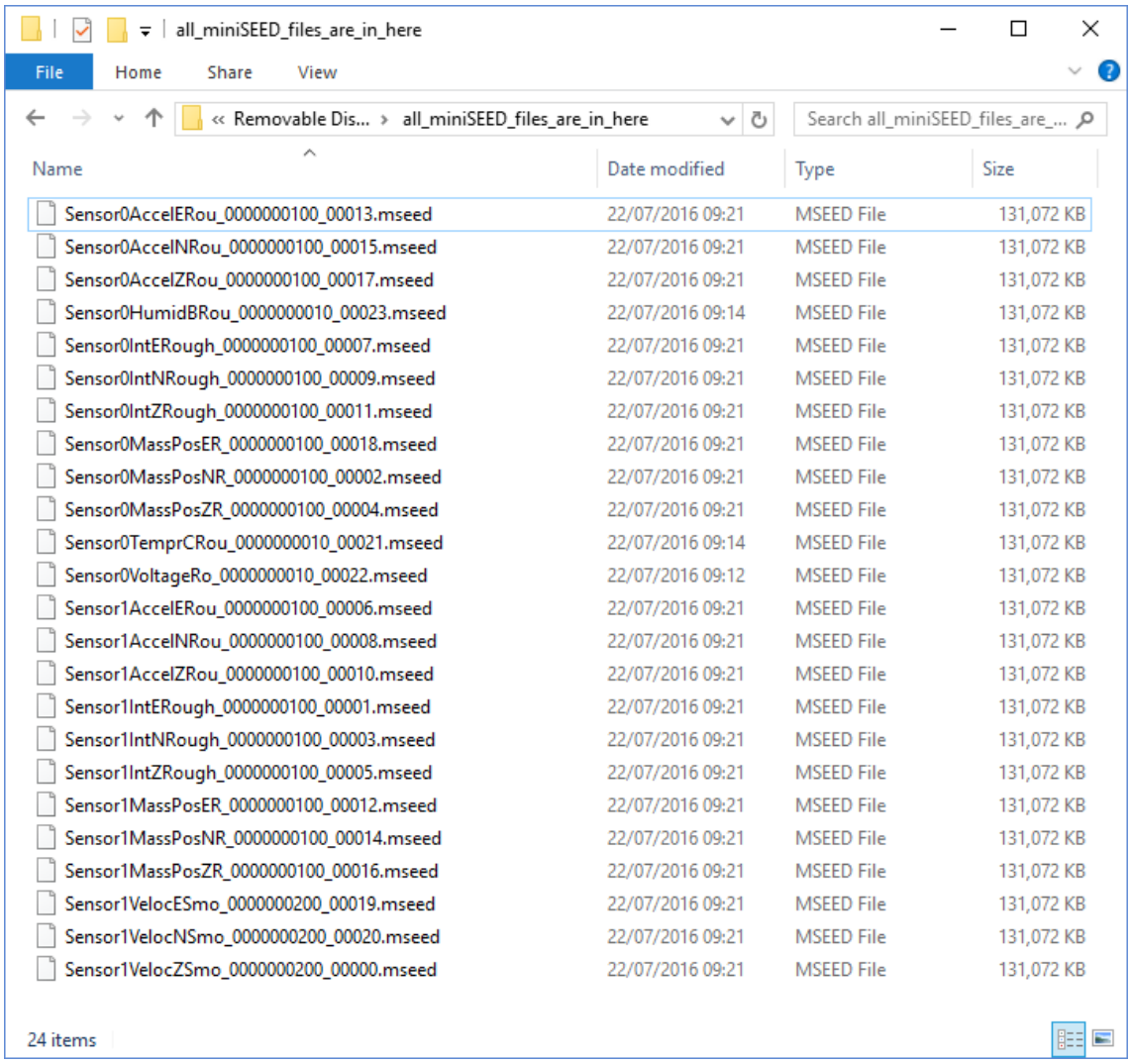
13.5.1 The Contents of the MicroSD Card

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:



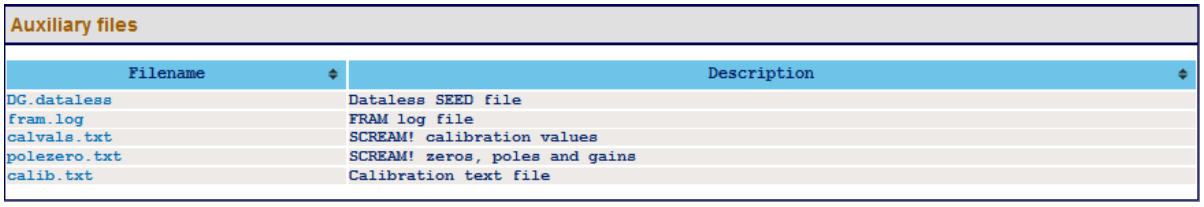
The filename consists of four components:

- 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:

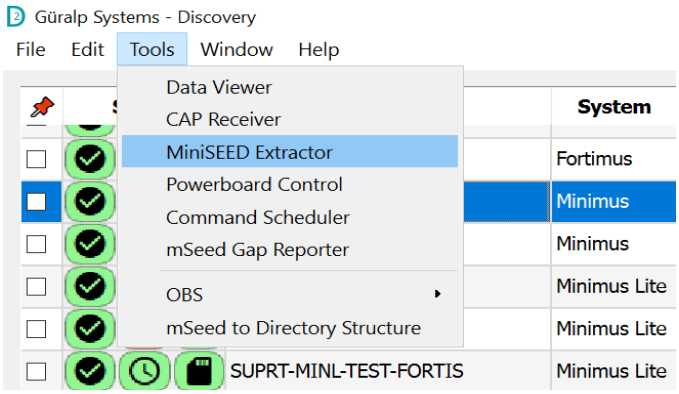
- *<<SEEDnetwork>>*`.DATALESS` : This is a dataless SEED volume that contains metadata including instrument responses, coordinates, compression type and more. It is generated from the RESP files for each channel. The first component of the file name depends on the two-character Network code defined in 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.



13.6 Discovery Tool: MiniSEED Extractor

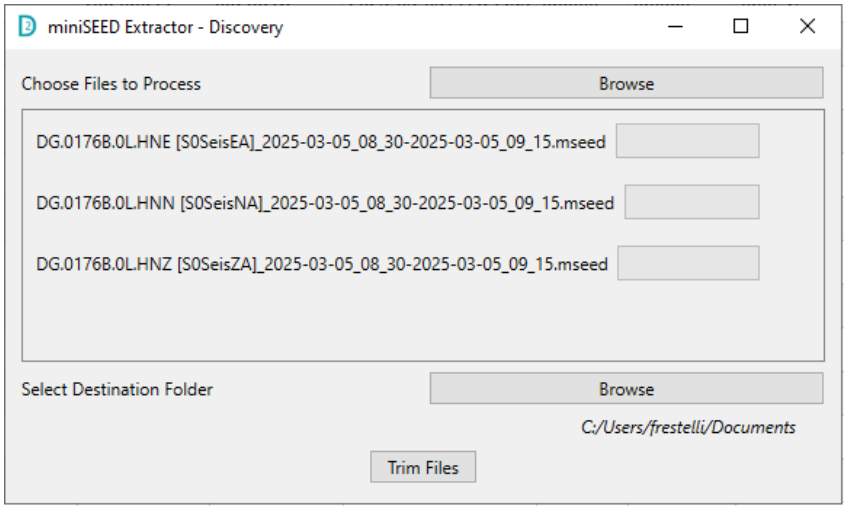
The miniSEED extractor is a tool available from Discovery and solves two problems:

1. 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.
2. 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.



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.

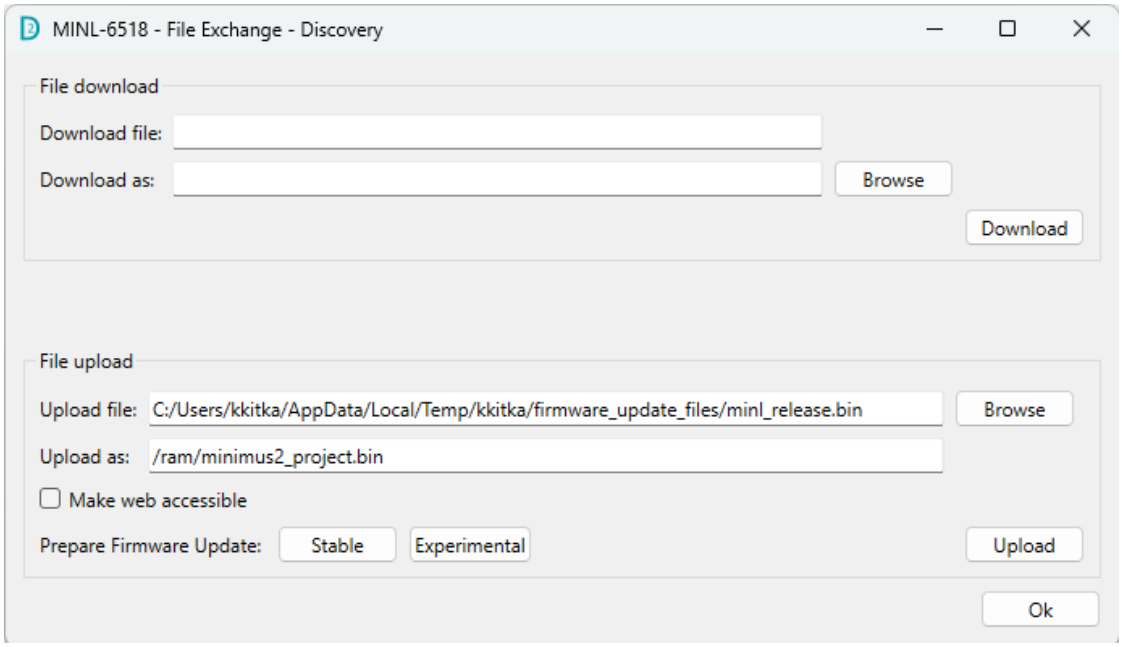


14 Updating Minimus2 Firmware

The firmware of the Minimus$_2$ is upgradeable. New releases appear regularly – mostly to add new features but, occasionally, to fix problems. Güralp recommends that the Minimus$_2$ is regularly checked for availability of firmware updates and, when convenient, these updates should be installed. If in doubt whether to upgrade the firmware or not, please check the release notes (london.guralp.com/download/sw/release_MINL.shtml) or contact support@guralp.com.

To upgrade :

1. Run Discovery.
2. Right-click on the Minimus$_2$ in Discovery main window and select "File Exchange".
3. In the "File Exchange" tab, click on the Stable or Experimental button depending on which firmware you want to install



4. Do not change the upload file name but leave it exactly as it automatically appears.
5. Press upload.
6. The upload takes approx. 40 seconds. The LED on the Minimus$_2$ should change colour after the upload completes: persistent red erasing internal FLASH memory, then persistent blue during programming, then finally persistent white when complete.
7. DO NOT remove power for the whole duration of the firmware update

Note: IP address, system name, netmask are all preserved. To preserve general settings, offload the config first. Use Discovery, right click and select "System Configuration". Download first and upload after the update (see Section 15 below).

15 Import / Export an existing configuration

Updating the 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.

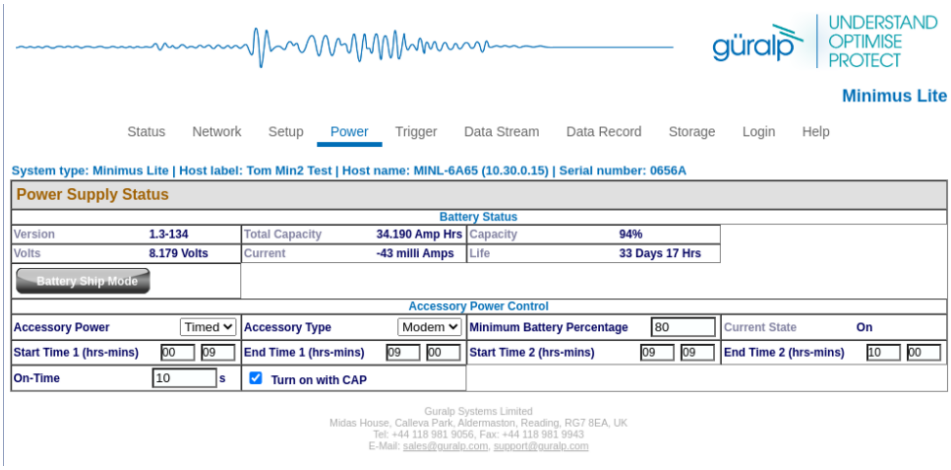
Wait until the process finishes. To apply the new configuration, the unit has to be rebooted: the Reboot Selected button can be used to perform the required system restarts.

16 Using Güralp's Power Pack Module

The PPM offers a battery charge controller that communicated with the digitiser via a serial port. This allows the digitiser to record battery capacity, voltage, current, temperature etc. This information can be viewed as a data stream much like a seismic channel. It can also be written to miniSEED files on the internal SD cards for later analysis.

The behaviour of the power system in relation to the solar panels can be better understood by viewing this data.

There is a 12V accessory output from the battery pack that can be turned on/off remotely or on a timer to power items such as a cellular modem.

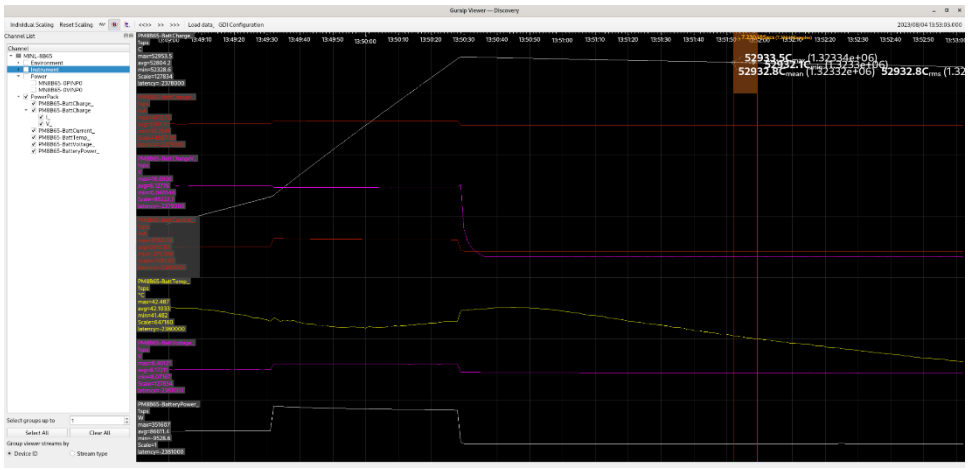


The Accessory Power mode (currently set to 'Timed') defines the operation of the accessory power output from the power pack module. This can be 'on' or 'off' permanently or based on some combination of time and battery capacity.

In the 'timed' mode, the output is 'on' if the system time falls between either start/end time AND the battery capacity is above the stated percentage.

If the trigger option is set, the modem comes on for the 'On-Time' when a CAP message is sent as a result of a trigger event.

When 'Modem' mode is set, the power remains on whilst a download is in progress.

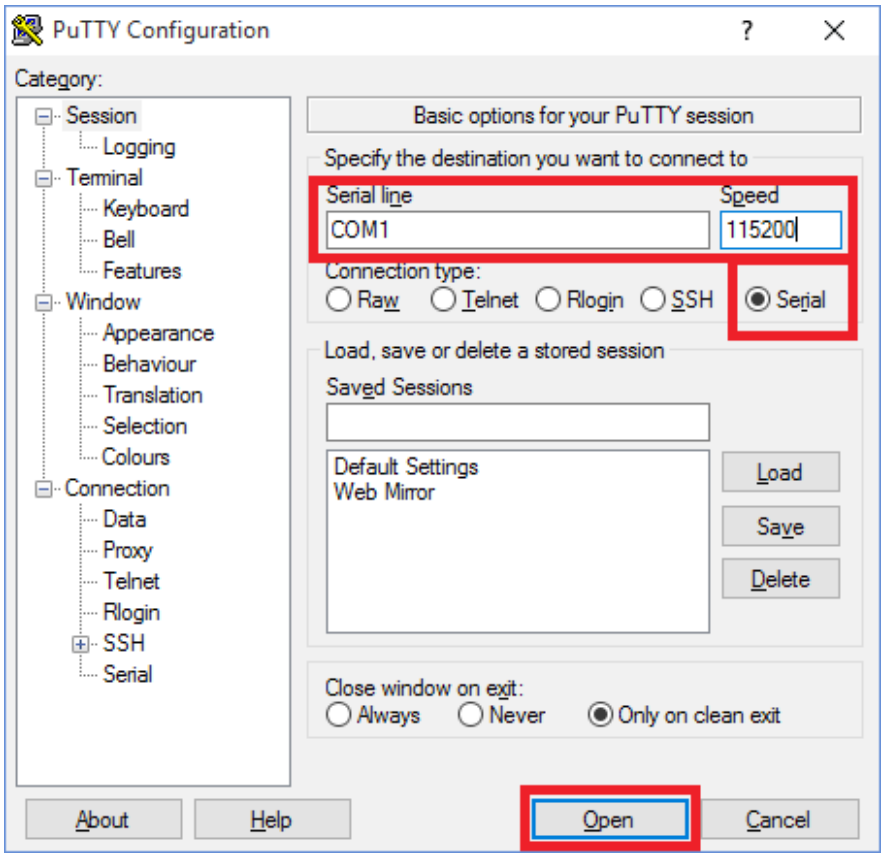


17 Advanced troubleshooting

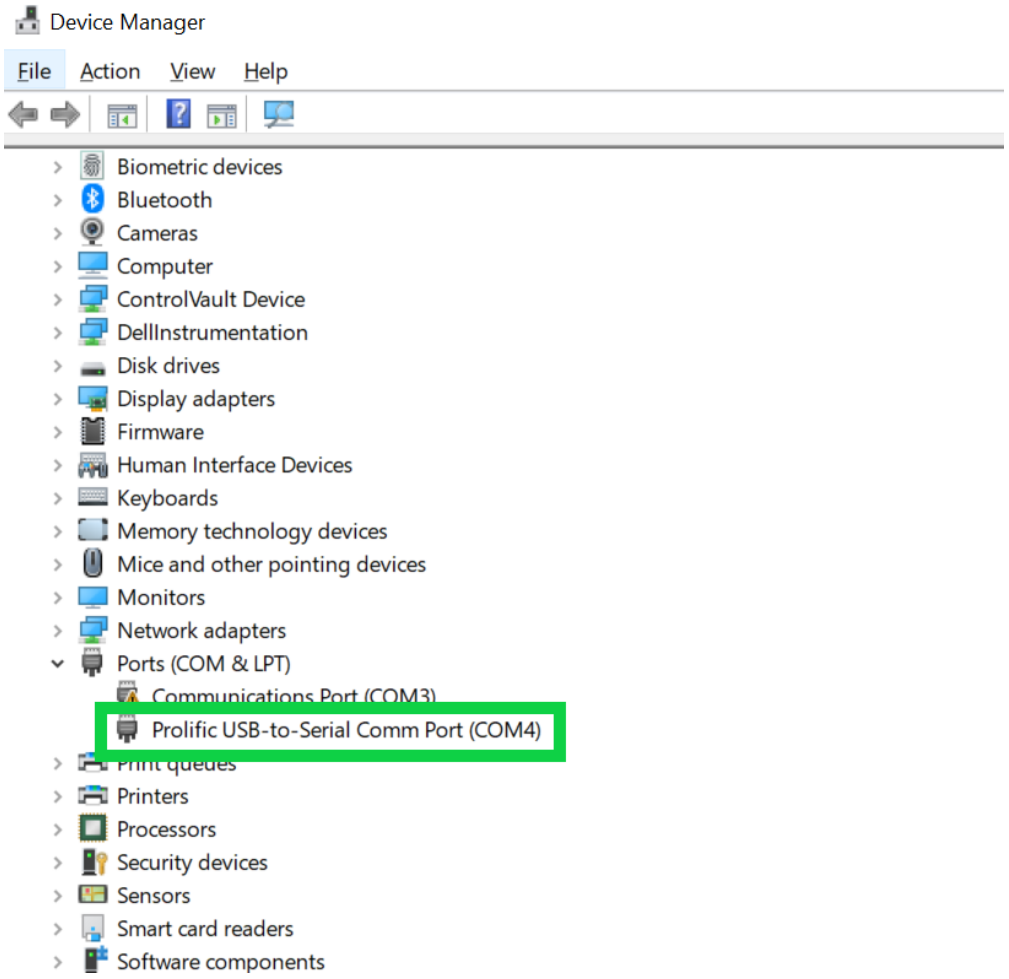
In the unlikely event of the user experiencing problems with the operation of the Minimus$_2$, a diagnostics tool is available via the GNSS connector. This connector provides a serial console which can be accessed using a terminal emulator.

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.)

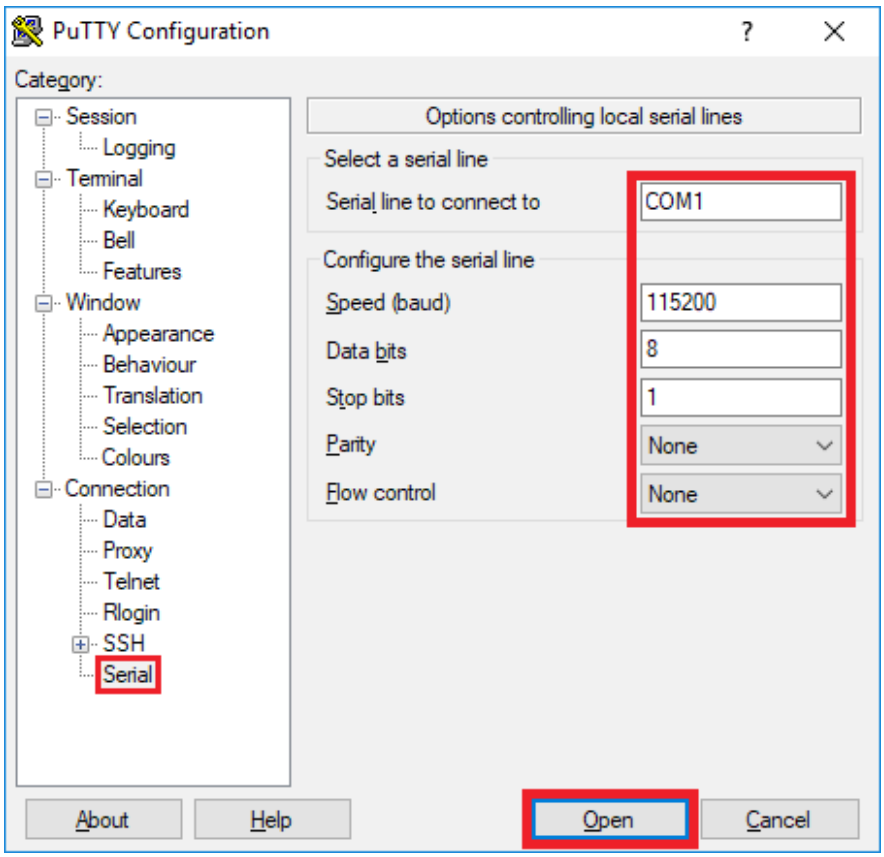
A connection is then made using a terminal emulator, such as minicom under Linux or PuTTY under Windows. Choose Serial as “Connection type”. The appropriate COM port should be entered as the "Serial line", and the "Speed" should be set to 115200.



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 screen-shot below.



Finally click the Open button and a terminal window will open, connected to the console of the Minimus$_2$.

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.

17.1 Reset all settings during boot phase

The Minimus$_2$ 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$_2$ 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 17). 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$_2$ will re-boot. It may be necessary to enter this key combination several times.

18 Appendix 1 – Instrument/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 Minimus Lite. 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

The “Live Stream Codes” of the seismic channels are postfixed with “0” or “1”. This notation distinguishes between the two different sample rates that is possible to select for each streamed channel. For example, the streams `InstZ_0` and `InstZ_1` carry digitisations of the same signal, differing only in the sample rate.

Only one sample rate is available for the recorded seismic channels.

Sensor	Comp.	Data streaming			Data recording	
		Digital filter mode	Live stream name	Live stream code	Data record name	Mini SEED channel code
Seismic channels	Vertical	Acausal	InstZ	InstZ_0	InstZ_sd	xHZ
			InstZ	InstZ_1		
		Causal	InstZ_eew	InstZ_eew_0	InstZ_eew_sd	xHZ
	North	Acausal	InstN	InstN_0	InstN_sd	xHN
			InstN	InstN_1		
		Causal	InstN_eww	InstN_eew_0	InstN_eww_sd	xHN
	East	Acausal	InstE	InstE_0	InstE_sd	xHE
			InstE	InstE_1		
		Causal	InstE_eew	InstE_eew_0	InstE_eew_sd	xHE
Mass position channels	Vertical	Acausal	MassZ	MassZ_0	MassZ_sd	xMZ
	North	Acausal	MassN	MassN_0	MassN_sd	xMN
	East	Acausal	MassE	MassE_0	MassE_sd	xME
MEMS accelerometer	Vertical	Acausal	AccelZ	AccelZ_	AccelZ_sd	xNZ
	North	Acausal	AccelN	AccelN_	AccelN_sd	xNN
	East	Acausal	AccelE	AccelE_	AccelE_sd	xNE
Calibration channel		Acausal	Calibration	Calibration_0	Calibration_sd	xC0
Temperature		Acausal	Temperatur	Temperatur_0	Temperatur_sd	xKT

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
Power usage		Acausal	S0Power	0PINP0	Power_sd	xYP
Relative humidity		Acausal	Humidity	Humidity_0	Humidity_sd	xIH
NTP channels	Phase	Acausal	NTP_DAC_	NTP_DAC_	NTP_DAC_sd	LYT
	DAC	Acausal	NTP_Phase_	NTP_Phase_	NTP_Phase_sd	LYD
	Lpf	Acausal	NTP_lpf_	NTP_lpf_	NTP_lpf_sd	LYU
	Hpf	Acausal	NTP_hpf_	NTP_hpf_	NTP_hpf_sd	LYV
Internal Clock	PLL lock phase	Acausal	Phase_	Phase_	Phase_sd	LYP
	DAC	Acausal	DAC_	DAC_	DAC_sd	LQD
Battery pack	Voltage	Acausal	BattVoltage_	BattVoltage_	BattVoltage_sd	LQV
	Current	Acausal	BattCurrent_	BattCurrent_	BattCurrent_sd	LYI
	Charge Volts	Acausal	BattChargeV_	BattChargeV_	BattChargeV_sd	LQQ
	Charge current	Acausal	BattChargeI_	BattChargeI_	BattChargeI_sd	LYQ
	Temperature	Acausal	BattTemp_	BattTemp_	BattTemp_sd	LYT
	Charge	Acausal	BattCharge_	BattCharge_	BattCharge_sd	LYC
	Power	Acausal	BatteryPower_	BatteryPower	BatteryPower_sd	LYW

19 Appendix 2 - Digital interconnectivity and devices

The Minimus$_2$ has a serial port on the Analogue connector. This can be used for several different protocols depending on what device is in use.

The protocols can be selected permanently by adding a resource variable to the system. The value of this variable dictates the protocol.

Setting the resource variable can be done from the diagnostics serial port either by direct connection to the system or via the console connection from Discovery (double click the digitiser in the list of devices)

From the Minimus$_2$ prompt:

```
MINL-1234 -> resource add uartp6 96
```

The value 96 comes from the table below:

16	$10	Serial Isolated Input/Output Module- Used for adding connection to the Serial Relay box for triggering and EEW. Name- “QUASAR”
96	$60	Allow communication to Güralp digital instrument such as Certis. Name- “INSTRUMENT”

To add the relevant resource using the command you can use either the integer value or the equivalent hexadecimal value with a preceding $ symbol.

Only add the resources when using the appropriate hardware. Doing so without the corresponding equipment may create conflicts within the system with undesirable effects. If you’re not sure whether you need to add a resource or which one to use, please contact support@guralp.com

Note: Use `resource del uartp6` to disable this port.

20 Appendix 3 – Network Ports

The following network ports are used by the Minimus$_2$:

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
123	UDP	NTP Protocol

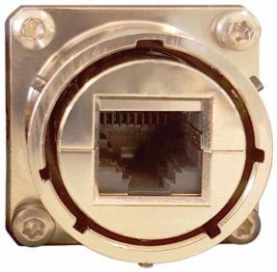
21 Appendix 4 – Connector pin-outs

21.1 Ethernet

The Ethernet connector allows the use of 10BASE-T, 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).

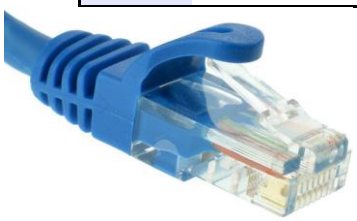
21.1.1 Pin-Outs

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).

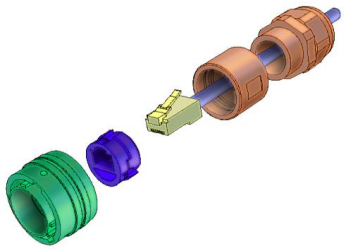


The wiring of a standard ethernet cable is shown below for configuration of different transmission types:

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).



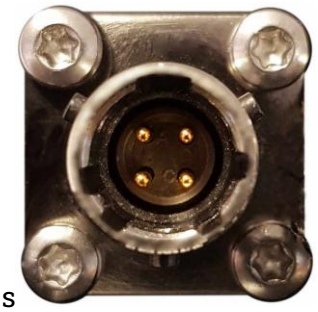
When used in hostile environments, a standard Ethernet cable can have a mating environmental shield (Amphenol part number RJF6MN) fitted.

21.2 Power

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

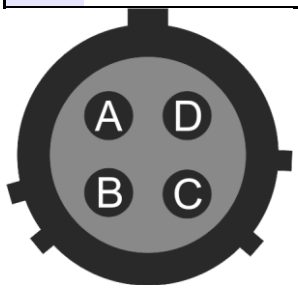
21.2.1 Pin-Outs

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*



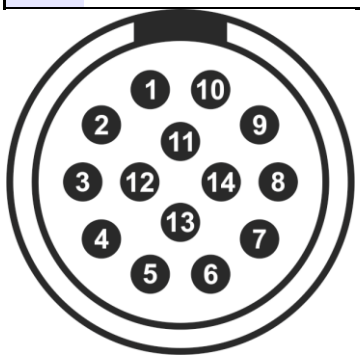
Wiring details for the compatible socket as seen from the cable end (i.e. when assembling).

21.3 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

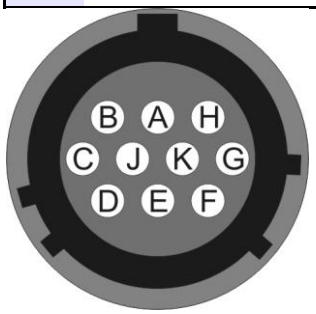


Wiring details for the compatible plug, FGG.1K.314.*, as seen from the cable end (*i.e.* when assembling).

21.4 Digital Port

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).

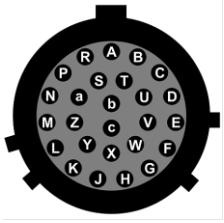
21.5 Analogue Port

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).

22 Appendix 5: The GüVü App

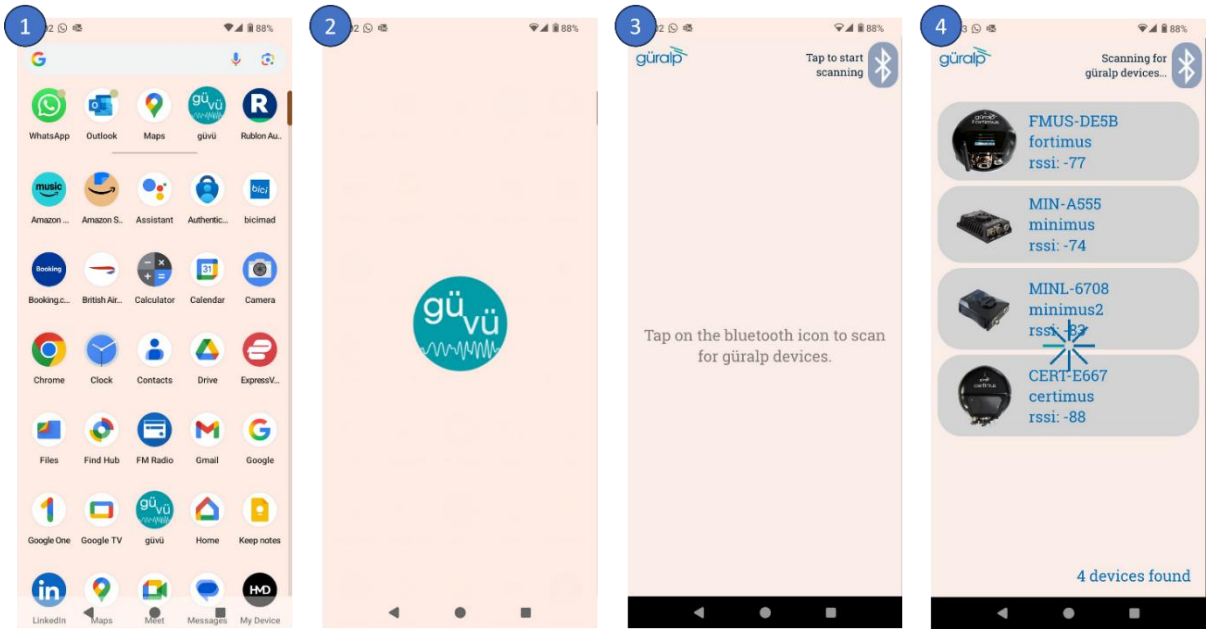
The GüVü app provides monitoring and control of nearby Minimus units using the Bluetooth protocol. It is available for Android devices.

GüVü can be downloaded from the Google Play store at:

https://play.google.com/store/apps/details?id=com.guralp.whisper

22.1 Getting Stated

To launch GüVü, follow the steps shown in the figure below:

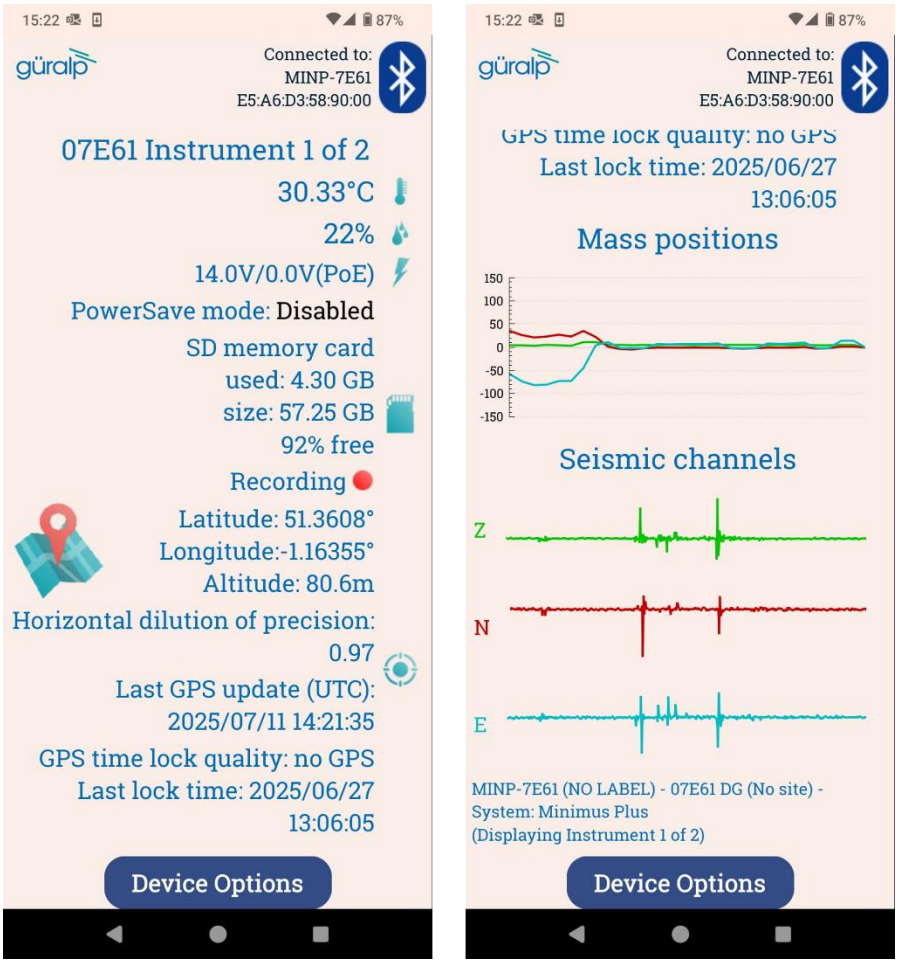


Steps for launching the GüVü App:

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.

If you experience problems connecting, try forcing GüVü to quit and then re-launching the app, or going closer to your instrument.

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.

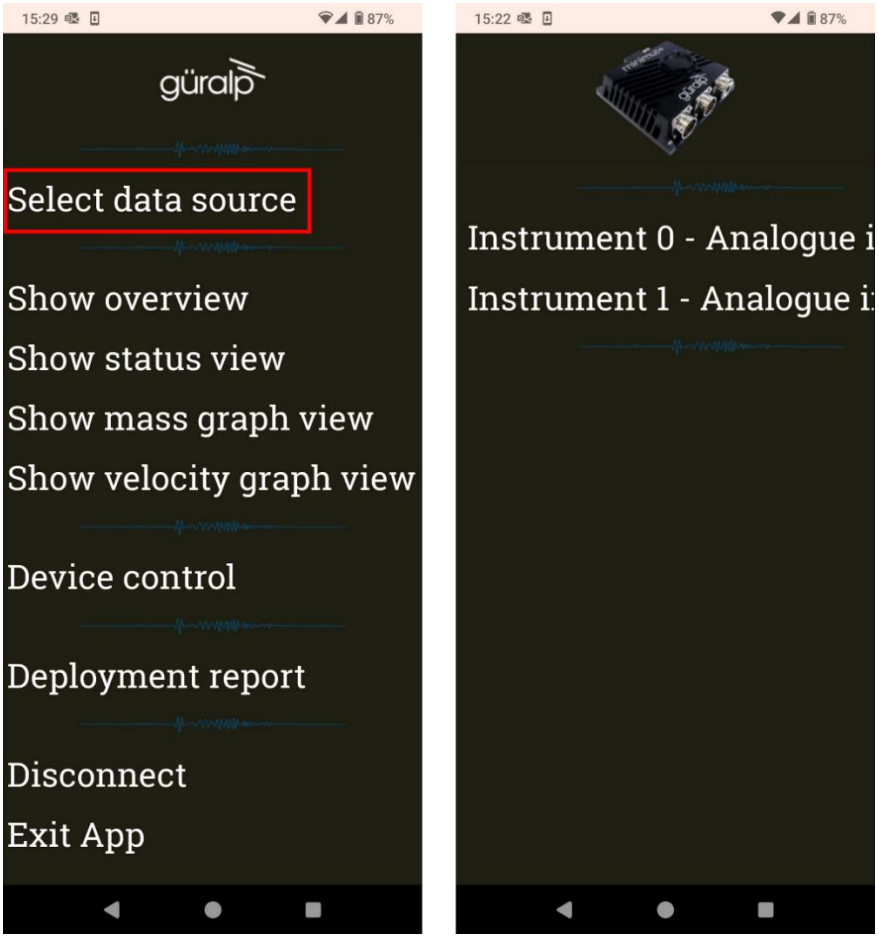


22.2 Selecting Data Sources

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, select **Device Options** from 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.



22.3 View Settings

The user can customise the view of the main instrument status window. Four different view options can be cycled through by tapping Device Options menu 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.

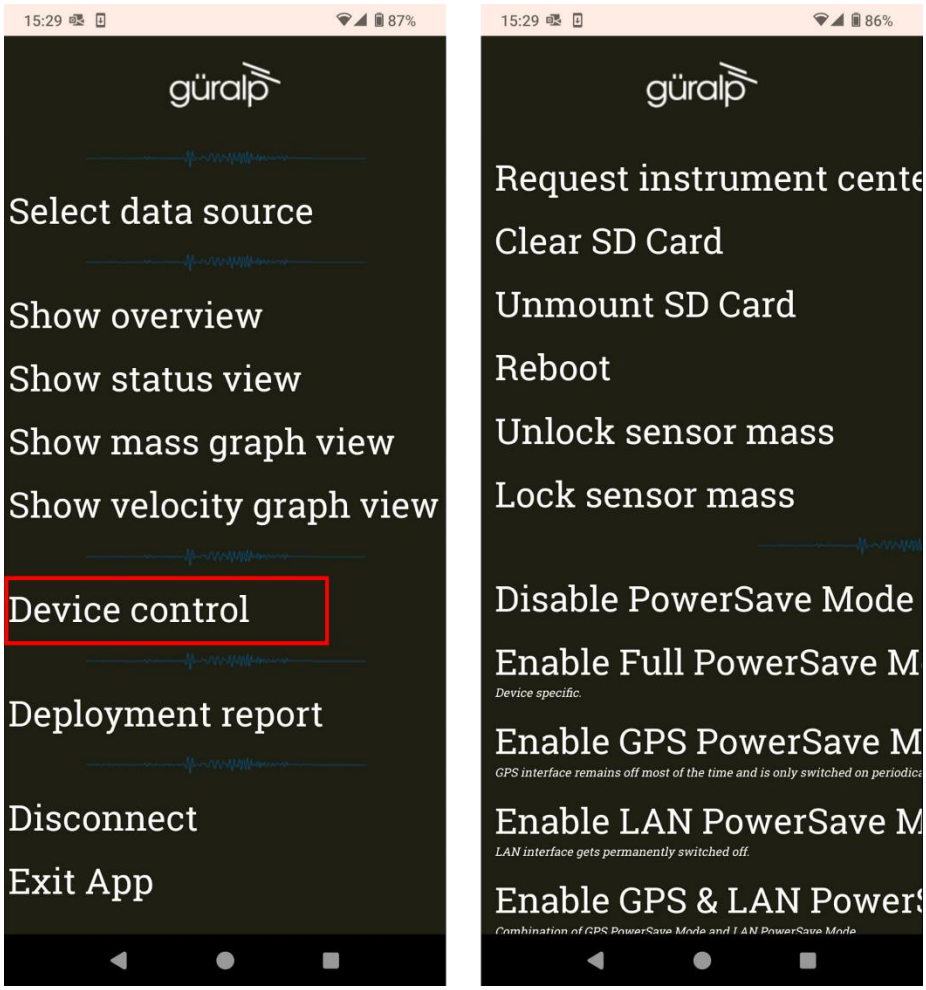
22.4 Instrument Control

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 various power-saving modes
- Lock/unlock sensor masses

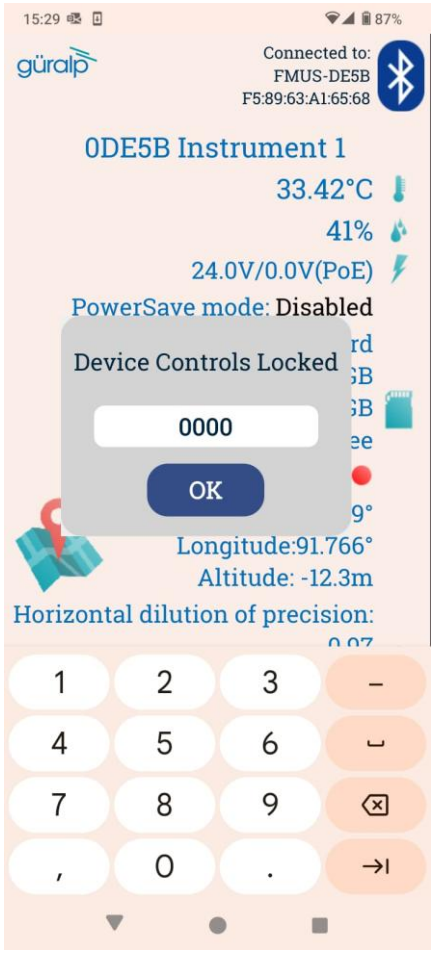
- Station metadata (User Label, Station Name, Network Code, Site Name)
- Network setting (IP, Netmask, Gateway)
- Changing channels' sampling rates

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 **Device Options** menu 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.

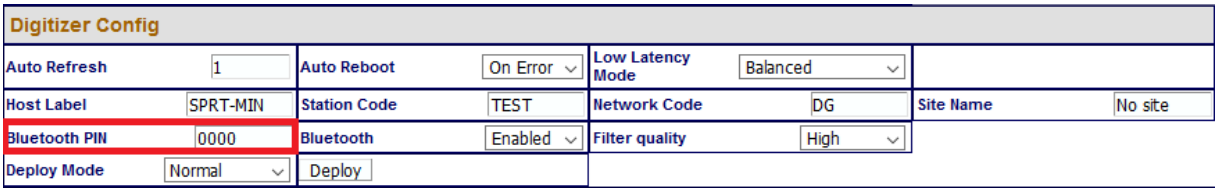


The default PIN code used to access the Instrument Control menu is "0000".

Caution: Güralp recommends changing the PIN code from the default, as described in the following section, in order to maintain station security.

22.4.1 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.



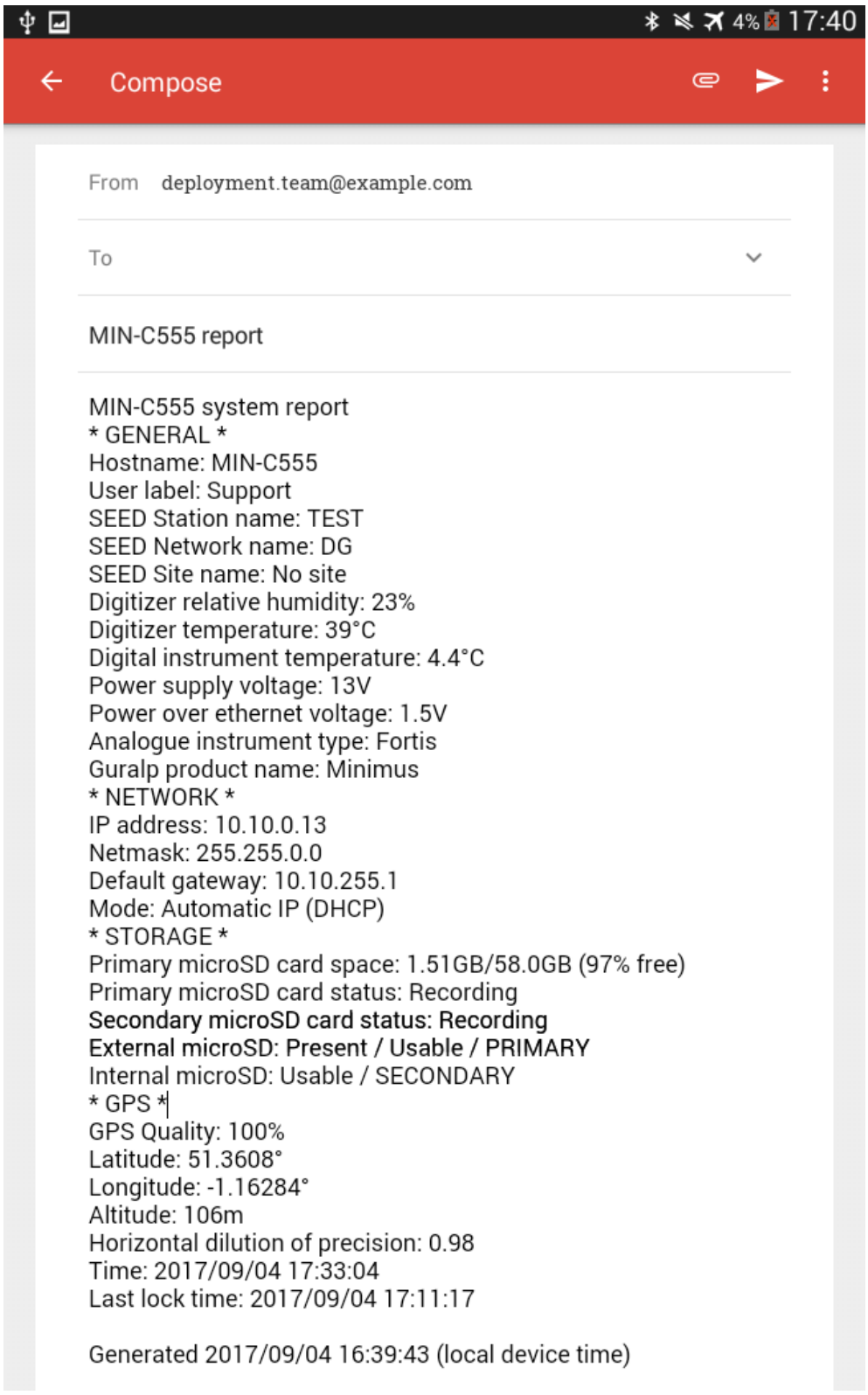
22.5 Emailing a Deployment Report

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 Device Options menu 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.


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)

23 EU Declaration of Conformity

CE

We

Guralp Systems Ltd
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READING, RG7 8EA.

Tel: +44 118 981 9056
E-mail: technical@guralp.com

Declare under our sole responsibility that the following product

Equipment name: Minimus$_2$ with GPS
Model Number: MIN2-0001 and appropriate variants

Is in conformity with the

Radio Equipment Directive 2014/53/EU
Electromagnetic Compatibility Directive 2014/30/EU
Low Voltage Directive 2014/35/EU
Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU

by applying the following harmonised standards and technical specifications:

EN 55011, EN 55016:2009 +A1:2010 – Conducted Emissions
EN 55011, EN 55032 :2009 +A1:2010 – Radiated Emissions
EN 61000-4-2:2009 – Electrostatic Discharge Immunity
EN 61000-4-3:2006 +A1:2008 +A2:2010 – Radiated RF Immunity
EN 61000-4-4:2012 – Electrical Fast Transients Immunity
EN 61000-4-5:2014 – Voltage Surge Immunity
EN 61000-4-6:2014 – Conducted RF Immunity
EN 61000-4-8:2010 – Power Frequency Magnetic Field Immunity
IEC 61010-1 3rd Edition - Low voltage Safety
2011/65/EU – RoHS

Signed for and on behalf of
Guralp Systems Ltd
on 25 November 2022

Systems Director