Güralp Minimus$_2$

including Güralp Discovery software and the GüVü app

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
```

2   System Overview

Thank-you for purchasing a Güralp Minimus$_2$ 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.

2.1   Key features

- 24-bit, four-channel digitiser with nominal 2.44 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.

2.2   Typical applications

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

3 System description

3.1 Güralp Minimus₂ 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.

3.1.1 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.

3.1.2 Bluetooth connectivity

The Minimus$_2$ features Bluetooth connectivity, allowing sensor and state-of-health data to be monitored using the Güralp GüVü app (see section 3.4 **Error! Reference source not found.**on page 14) 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 Chapter 6.4 on page 58 for further details on connecting to the Minimus$_2$ and its attached sensors using a phone or tablet.

3.1.3 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

3.1.3.1 Primary (hot-swappable) 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.

3.1.3.2   Internal (back-up) 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.

3.1.4   Web interface

The Minimus$_2$ contains on-board firmware that presents monitoring and configuration interfaces. These are accessible through Güralp's Discovery software (see section 3.3 **Error! Reference source not found.**on page 13) 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

Please refer to Chapter 4.3 on page 17 for full usage instructions.

3.2   Accessory package

3.2.1   Ethernet cable

The Ethernet connector allows use of 10BASE-T, 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 11.1 on page 65 for the pin-out and further details.

3.2.2   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 11.3 on page 67 for pin-out details.

3.2.3   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 does not use a grey/blue combined power/data cable, as used with many other Güralp products.

Please see section 11.2 on page 65 for the pin-out details.

> **Caution:** 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.

3.2.4   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-subminiature 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 7 on page 60).

> **Note:** This facility should rarely be required. It is primarily intended for use by the Güralp Support Team to help diagnose any problems with the Minimus2 that may be experienced by the user.

A serial-to-USB converter (not supplied) may need to be used to connect to PCs or laptops that don't have a nine-pin serial connector. Please see section 11.3 on page for full pin-out details.

3.3   Güralp Discovery software

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

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.

3.4 Güralp GüVü Android and iOS 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 6 on page 57 for installation and usage instructions.

4 Getting started

4.1 System set-up

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

A typical set-up for the connected to an analogue sensor.

Power up the using a power supply with a DC output of between 10 and 36 Volts. We recommend fitting an in-line 3.5 A anti-surge fuse in the positive power lead to protect the external wiring of the installation. The will, in turn, provide power to all connected instruments. Alternatively, the system can be powered by POE (Power over ethernet).

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

If the Minimus$_2$ 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. More details on how to correctly configure the connection using APIPA (Automatic Private IP Addressing) are in section 14 on page 80.

4.2 Güralp Discovery software installation

Discovery is a convenient way to identify a device without having to know its IP address. It allows easy access to the WEB configuration page as well as live waveforms, and to control and configure the Minimus$_2$ and connected sensors.

Visit www.guralp.com/sw/download-discovery.shtml for links for all available platforms (currently Windows 32-bit and 64-bit, macOS 64-bit and Linux 64-bit).

Download the installer appropriate for your architecture and operating system, run the installer and follow the instructions on screen. (Full details of installation and upgrading are in section 4.2 on page 15.)

> **Note:** Windows users may have to reconfigure the Windows FireWall in order to allow Discovery to communicate properly. Please see section **Error! Reference source not found.**on page **Error! Bookmark not defined.** for full

Under Windows, the first time that you start Discovery, Windows may ask you to specify how you wish Discovery to interact with the Windows Firewall. Because Discovery requires network communication in order to function, it is important that allow access.

The Discovery software 'looks' on the local network for any connected Güralp devices. These are displayed as shown below:

Any device on the same subnet will be displayed. The protocol uses a 'broadcast' UDP packet to request a response from connected systems. This will likely not penetrate routers, firewalls etc unless expressly permitted.

However, any device on a local ethernet hub or switch should respond. This allows connection without using or typing specific IP addresses.

In an office environment, a local DHCP server will likely offer an address to any connected device. Güralp digitisers have DHCP enabled by default so making connection to the network trivial. Discovery will display the device as above without any worry about addresses.

You can choose which information is shown for each device in the main window. You can select which columns to display – and hide unwanted ones – by clicking on "Show" from the "View" menu.

The "Status" column is composed of three icons that represent the Minimus$_2$ connectivity status (whether device is reachable/active or not), timing status (GNSS or PTP) and storage status (primary/secondary) respectively.

Hovering the mouse over any of these three icons will display tool-tips giving a brief description of the status including, for the timing indicator, details of which timing subsystems are operating:
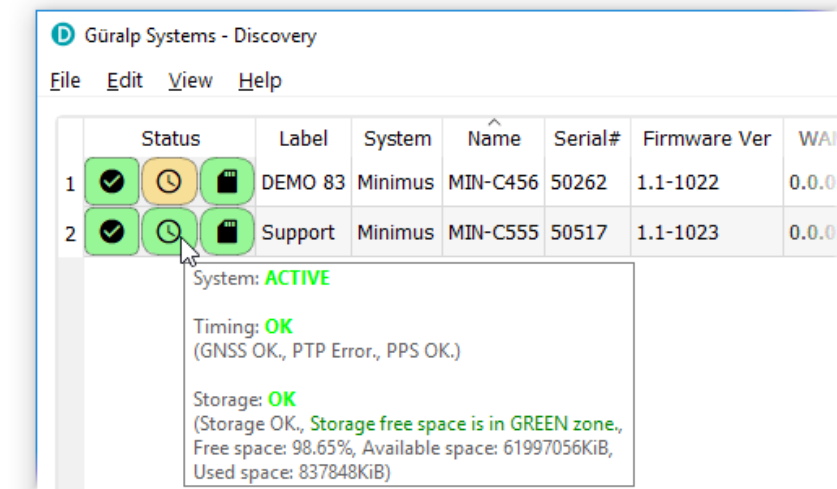
Within Discovery, internal and connected sensors are referred to as follows:

4.3   Viewing waveforms and system state-of-health

Waveform data recorded by the ' internal sensors and other connected sensors can be viewed using several methods, which are described in the following sections.

4.3.1   Using Discovery's "Live View" window

4.3.1.1   Main features

Discovery offers a versatile live waveform/data viewer. To open the Viewer, in Discovery's main window, select an instrument and, from the View tab in the toolbar, select "Live View".

The menu will then present three options for data streaming:

- GDI and GCF channels

- GDI only

- GCF only

The GCF option uses the Scream! Protocol to stream data in GCF packets of, typically, 250, 500 or 1,000 samples. The GDI protocol streams data sample-by-sample and also allows the sending of each instrument's calibration parameters so that data can be expressed in terms of physical units rather than digitiser counts.

Güralp recommends using the "GDI only" option for waveform viewing. Metadata (including Calibration) is automatically sent with a stream. The display is thus shown in real units – not just counts.

The main features of – and the key buttons within – the Live View window are shown in the following screen-shot. Basic amplitude and time zoom functions are given in the Window zoom controls panel and streams can be easily added to or removed from the window by using the check-boxes in the left panel.

The channels are divided in groups with different hierarchical importance. The most important are the velocity/acceleration channels with higher sample rates: these belong to group 1. The least important belong to group 6, which includes humidity, temperature, clock diagnostics *etc*. When the live view is launched, only the channels in group 1 are selected. It is possible to change this setting by selecting a different group number from the "Select group up to" box at the bottom of the channel list.
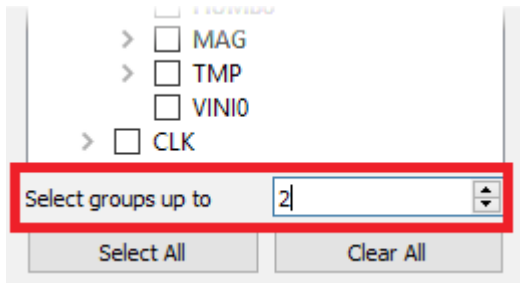
When only few channels are selected for viewing, the channel name labels also show data statistics, including the maximum, minimum and average amplitudes in physical units.

If too many channels are in view for this information to be visible, you can left-click on a label and the label and trace will then expand to half the height of the screen, revealing these statistics. The other channels will be compressed into the remaining space. Another left-click on the same channel will return the window to normal. Alternatively, a left-click on a different channel will shrink the original one and expand the newly-selected one.

By selecting and dragging the mouse over a window of waveform data, the viewer will display similar statistics for the data within the selected window. When a window of data is selected, use the ⇧ key to subtract the ADC offset from the maximum, minimum and average values. Use the Alt key to calculate the integral of the selected data. By right-clicking on the window, you can perform advanced analysis on the data, including plotting power spectral density graphs (PSDs), spectrograms and discrete Fourier transforms (DFTs), as shown below:

4.3.1.2 Window control short-cuts

You can change the display of the waveforms with based on a combination of keystrokes and mouse-wheel scrolling (or track- / touch-pad scrolling on a laptop).

These commands are shown in the table below:

Command	Window control
Amplitude control	
	Increase/decrease amplitude of all traces
+ hover cursor over channel label	Increase/decrease amplitude of individual trace
Ctrl + + hover cursor over channel label	Shift individual trace offset up/down
Time control	
Ctrl +	Pan time-scale right/left
⇧ +	Zoom time-scale in/out
Trace focus	
on trace label	Focus on individual trace
Trace selection	
Del + hover cursor over on individual trace / trace label	Remove / de-select trace from Viewer window
Details control	
⇧ + hover cursor over on individual trace / trace label	Reset the maximum and minimum values to the average value of the selected data

4.3.1.3 GDI connection settings

The GDI protocol allows a receiver, such as Discovery, to select which channels to receive by use of a "channel subscription list". This feature can be useful in cases where the connection between Minimus$_2$ and Discovery has limited bandwidth. To subscribe to specific channels, right-click on a digitiser in Discovery's main window and select "GDI Configuration" from the context menu.

The resulting window has two very similar tabs. The "Subscription configuration" tab refers to channels selected for transmission and the "Storage configuration" tab affects which channels are selected for recording.

Click on the [Connect] button to connect to the GDI server.

By default, Discovery subscribes to all channels. To alter this behaviour, change the radio-button from "Automatically subscribe to all available channels" to "Use subscription list". In subscription list mode, the channels in the list on the left-hand

side are those to which Discovery subscribes. All available channels are listed on the right-hand side.

Channels can be moved between lists – *i.e.* switched between being subscribed and being unsubscribed – by using the arrow buttons on the middle:

<<	Subscribe to all channels shown in the **Available channels** list
<	Subscribe to all selected channels in the **Available channels** list
>	Unsubscribe from all selected channels in the **Subscribed channels** list
>>	Unsubscribe from all channels in the **Subscribed channels** list

4.3.1.4　Backfill from microSD card

Gaps in the waveforms due to network disconnections can be backfilled by requesting missing data to the local storage.

In the Discovery GDI "Live View", highlight the portion of data including the gap, right-click and select "Request backfill".

The gaps are backfilled automatically for all the streams selected, if the requested data is available in the microSD card.

4.3.2　Using Scream!

Data from the Minimus$_2$ and attached sensors can also be viewed and analysed using Güralp's Scream! Software.

For full usage information on Scream!, please refer to the on-line Güralp manual **MAN-SWA-0001**.

In Scream!'s Network Control window, add a UDP or TCP Server using the address reported under "LAN Address" in Discovery's main window (as described in section **Error! Reference source not found.**on page **Error! Bookmark not defined.**).

	Status	Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longitude
1	⊘ ⏱ ▣	Support	Minimus	MIN-C555	50517	1.1-1022	0.0.0.0	10.10.0.13	00:15:10	51.3607	-1.1630

Right-click on the newly-added server and select `GCFSEND:B` (or `Connect`) from the context menu. This sends a command to the Minimus$_2$ to start data transmission. Once the `GCFSEND:B` (or `Connect`) command has been issued, the instruments and their associated streams should begin to appear in Scream!'s main window.

Stream ID	Rec.	Comp.	SPS	End Time	Date	RIC
1AXLE0	No	16 bit	100	13:30:55	14/07/2016	130
1AXLN0	No	8 bit	100	13:30:58	14/07/2016	-8237
1AXLZ0	No	16 bit	100	13:30:56	14/07/2016	14271
1INTE0	No	8 bit	100	13:30:59	14/07/2016	-12068
1INTN0	No	8 bit	100	13:30:58	14/07/2016	-8782
1INTZ0	No	8 bit	100	13:30:57	14/07/2016	-22655
1MAGE0	No	8 bit	5	13:29:23	14/07/2016	-5322
1MAGN0	No	8 bit	5	13:29:51	14/07/2016	-6660
1MAGZ0	No	8 bit	5	13:28:55	14/07/2016	-1344
1MASE0	No	16 bit	100	13:30:55	14/07/2016	-4506
1MASN0	No	16 bit	100	13:30:56	14/07/2016	3732
1MASZ0	No	16 bit	100	13:30:59	14/07/2016	-1655
1ROTP0	No	8 bit	5	13:28:11	14/07/2016	0
1ROTR0	No	8 bit	5	13:28:11	14/07/2016	0
1ROTY0	No	8 bit	5	13:28:11	14/07/2016	-30336
1TMPA0	No	8 bit	5	13:28:11	14/07/2016	4222
1VELE0	No	32 bit	200	13:31:00	14/07/2016	-590772
1VELEC	No	32 bit	200	13:31:00	14/07/2016	-2006039
1VELN0	No	32 bit	200	13:31:00	14/07/2016	-1617447
1VELNC	No	32 bit	200	13:31:00	14/07/2016	-1512488
1VELZ0	No	32 bit	200	13:31:00	14/07/2016	-493488
1VELZC	No	32 bit	200	13:31:00	14/07/2016	-201964
AXLE0	No	16 bit	100	13:30:56	14/07/2016	-672
AXLN0	No	8 bit	100	13:30:58	14/07/2016	-296

Server: 10.10.0.5:1567 | 51 streams | 1,372,140 Kb stream buffer | PC Time (UTC): 13:31:06

To configure the Minimus$_2$, double-click on its entry to open its web page.

5 System configuration

System configuration, control and configuration tools are available by selecting an instrument in Discovery, right-clicking its entry and selecting "View Web Page". Alternatively, the web interface can be viewed by navigating to the LAN or WAN address of the instrument from any common web browser.

Some changes in config. Require a reboot to take effect. The banner at the top of the WEB page reflects this if required.

5.1 Web Page login

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.

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. The user-name and password for both normal user and administrator login are configurable in the "Network" tab.

5.2 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.

5.3   Data streams

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.

E.g.: 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 timelock ensues.
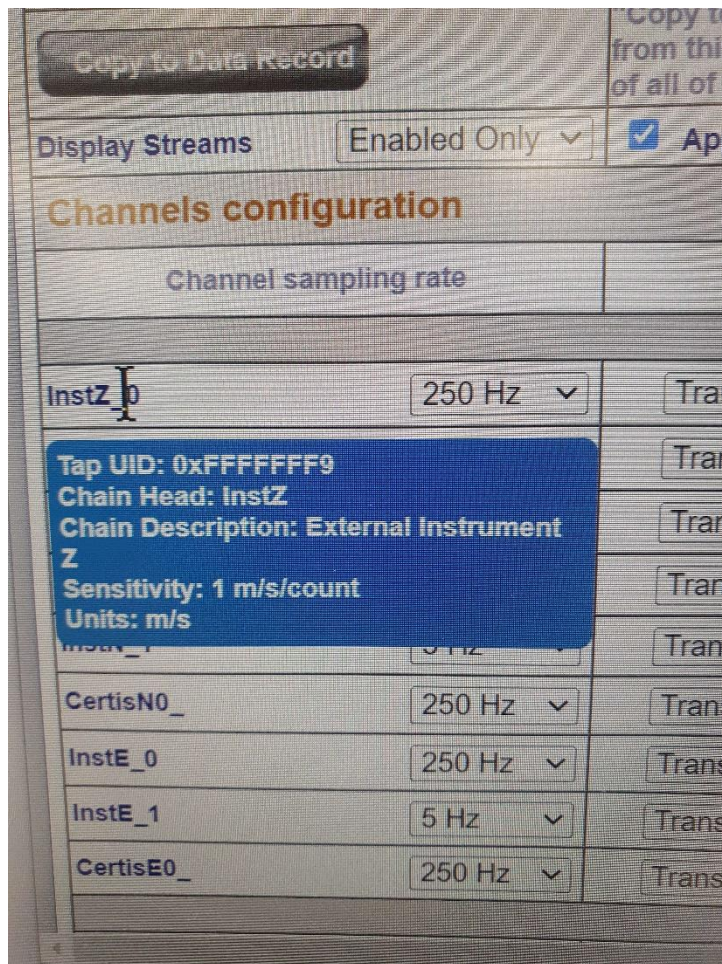
5.4 Station meta-data

Discovery provides a number of flexible station meta-data inputs. These are accessible from the "Setup" tab of the instrument's web page.

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

"**Station Name**", "**Network Code**" are all standard meta-data header values used by the miniSEED file format, which will be included in locally-stored miniSEED files (see section 5.8.6 on page 31).

5.5 Network configuration

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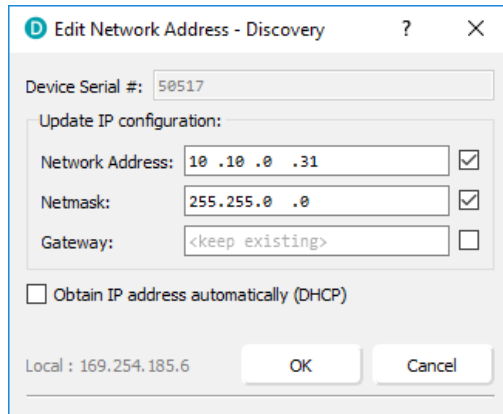
By default, the Minimus$_2$ uses DHCP (Dynamic Host Configuration Protocol) to acquire its network configuration but static addressing can be used if required.

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 button.

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

5.5.2   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 "Setup" 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.

5.6   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.

GDI auto-connection settings							
Connection		Connection		Connection		Connection	

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 10 on page 64 for a list of the network ports used by the Minimus$_2$.

5.7 Data storage

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

Data Record							
Disable All		Restore default		The "Disable All" and "Restore default" button will ALSO affect settings of any other sensors		Reboot	
Copy to Data Stream		"Copy to Data Stream" will apply settings from this page to streaming configuration of all of the sensors.		Recording status — Recording		For more information about microSD cards status please visit "Storage" tab	
Display Streams	Enabled Only ⌄	☑ Apply configuration for tap groups				Display On Page	Sensor 0 ⌄
Channels configuration							
	Channel sampling rate		Data transform		SEED name - please use check-box to modify the default	RESPonse file - if available	
Seismic channels							
InstZ_sd	250 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .CHZ		RESP_file_7	
InstN_sd	250 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .CHN		RESP_file_10	
InstE_sd	250 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .CHE		RESP_file_13	
Mass position channels							
MassZ_sd	1 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .LMZ		RESP_file_17	
MassN_sd	1 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .LMN		RESP_file_19	
MassE_sd	1 Hz ⌄	Transforms not available on Minimus2 ⌄		☐ DG.00000.1 .LME		RESP_file_21	

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 8 on page 62.

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 5.12.5 on page 42).

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 3.1.1 on page 8) and the instrument web page will display the following screen.
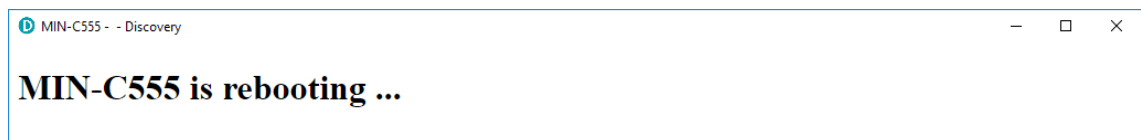
Once the Minimus$_2$ has successfully restarted, the full web browser display and controls will be available for use again.

5.8   Storage

5.8.1   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:
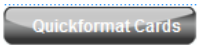
- Whether a card is inserted;

- 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.

5.8.1.1 Quick format

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.

5.8.1.2 Full format

This will fully zero out the files on the device, but will take much longer and is not needed to erase data from the device. 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 15 hours to complete.

5.8.2   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 (see Section **Error! Reference source not found.** on page **Error! Bookmark not defined.**) or event table (see Section **Error! Reference source not found.** on page **Error! Bookmark not defined.**).

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.
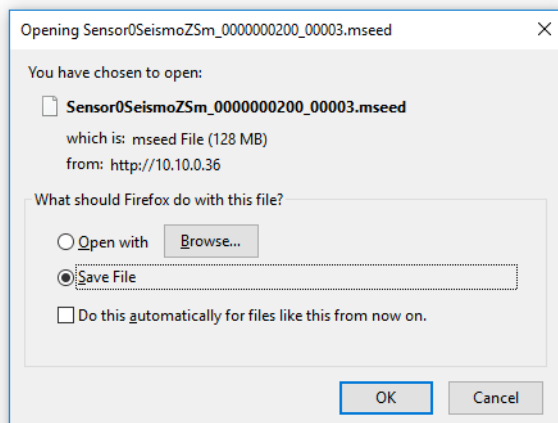
5.8.3   Downloading recorded data

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

SD Card files

	Filename	Size (bytes)	Start data timestamp	Last data timestamp
☐	000_InstZ_sd.mseed	134217728	2023-06-22 16:20:39	--> 2023-06-30 12:43:08
☐	001_InstN_sd.mseed	134217728	2023-06-22 16:20:39	--> 2023-06-30 12:47:02
☐	002_InstE_sd.mseed	134217728	2023-06-22 16:20:39	--> 2023-06-30 12:40:07
☐	003_InstX_sd.mseed	54644736	2023-06-22 16:20:39	--> 2023-07-03 12:40:09
☐	004_Temperatur_sd.mseed	7405568	2023-06-22 16:26:48	--> 2023-07-03 12:30:05
☐	005_Humidity_sd.mseed	8916992	2023-06-22 16:26:48	--> 2023-07-03 12:26:37
☐	006_Voltage_sd.mseed	5984256	2023-06-22 16:26:48	--> 2023-07-03 12:35:44
☐	007_Power_sd.mseed	14512128	2023-06-22 16:26:48	--> 2023-07-03 12:30:16
☐	008_Phase_sd.mseed	466944	2023-06-22 16:26:48	--> 2023-07-03 08:59:50
☐	009_DAC_sd.mseed	471040	2023-06-22 16:26:48	--> 2023-07-03 08:59:50
☐	010_MassZ_sd.mseed	471040	2023-06-22 16:26:48	--> 2023-07-03 08:59:50
☐	011_MassN_sd.mseed	471040	2023-06-22 16:26:48	--> 2023-07-03 08:59:50
☐	012_MassE_sd.mseed	471040	2023-06-22 16:26:48	--> 2023-07-03 08:59:50
☐	013_InstE_sd.mseed	93237248	2023-06-30 12:40:18	--> 2023-07-03 12:41:25
☐	014_InstZ_sd.mseed	93171712	2023-06-30 12:43:19	--> 2023-07-03 12:41:24
☐	015_InstN_sd.mseed	93085696	2023-06-30 12:47:14	--> 2023-07-03 12:41:25

Download selected files

Clicking on the file from the list automatically starts a download using your browser's standard mechanism:

Opening Sensor0SeismoZSm_0000000200_00003.mseed   ✕

You have chosen to open:

📄 **Sensor0SeismoZSm_0000000200_00003.mseed**

which is: mseed File (128 MB)
from: http://10.10.0.36

What should Firefox do with this file?

○ Open with   Browse...

◉ Save File

☐ Do this automatically for files like this from now on.

OK   Cancel

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Multiple files can be downloaded simultaneously by ticking the 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 file-names are also changed when the files are written to. Until they are written to, 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.

5.8.4 Downloading data for specific time-intervals

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

... then select the start and end dates and times using the pop-up calendars:

Lastly, click the Download download button to initiate a file transfer using your browser's standard mechanism.

5.8.5 Bulk data extraction

To view files saved on the external microSD card, remove the card, as described in Section 3.1.3.1 on page 9. 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 disk/drive.

A microSD card formatted for the Minimus$_2$ 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 clearing the "Hidden items" check-box within the ribbon of Windows Explorer.

5.8.6   The contents of the microSD card

The Storage tab on the web interface shows a list of files present on the SD card:
.

The root directory of the disk contains seven items:

- a file named `init.log`. This "write-once" file contains the first 32 MiB of system log information since the card was last formatted.

- a file named `system.log`. This "re-use" file contains the last 64 MiB of the system log;

- a file named `status.log`. This "re-use" file contains the last 32 MiB of damps of system state of health information. A new dump is generated every 20 minutes.

- a disk 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 not human readable: it is used by the Seismic Events Table in the "Trigger" tab

- 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:
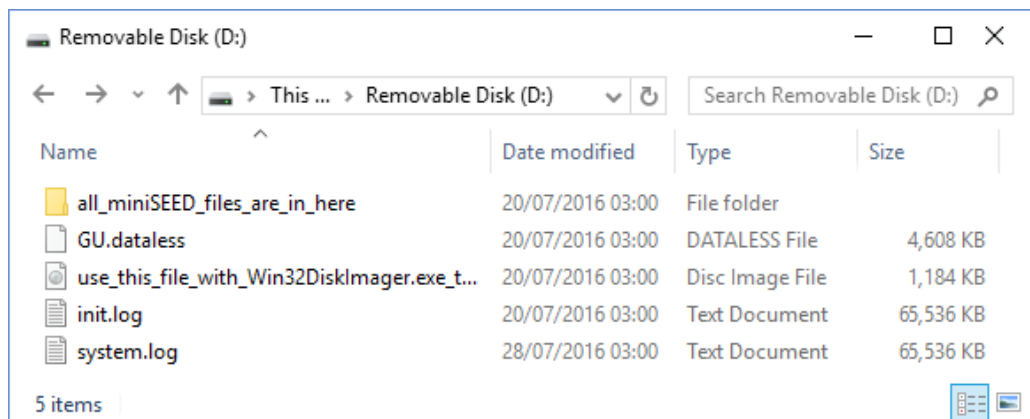
The file-name consists of four components:

- The stream name, truncated to 16 characters - see Section **Error! Reference source not found.**on page **Error! Bookmark not defined.** for a full list of these;

- 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 file-names 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 flash RAM or are dynamically generated:

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

- `network.DATALESS` : This is a Dataless SEED volume that contains meta-data 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.

5.8.7 Time based download via Network

wget -v -t 50 --retry-connrefused --waitretry=10 -OinstZ.mseed
http://$hx/data?channel=InstZ_sd\&from=UTCSECSSINCE1970\&to=UTCSECSSINCE1970+3600 || rm -f instZ.mseed

The above wget run from a computer will fetch a one-hour (3600 second) miniSEED file from the main seismic Z channel. The channel names "InstZ_sd" come from the Data Record Tab.

Time is specified as seconds since 1970 in standard Linux form.

$hx represents the IP address or hostname of the Minimus$_2$.

5.8.8 Request data from microSD card via Network

Files stored on the SD card can be downloaded using HTTP. The example bash script below can be used from a Linus PC or from the WSL shell on a Windows PC: It extracts all files from the SD Card into a directory named after the date and the network address of the Minimus$_2$.

#!/bin/bash # Invoke with one argument: the network # address of the Minimus$_2$

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

5.9   Data transmission

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 – 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 meta data 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.

This page allows to configure the transmitted 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 **Error! Reference source not found.**on page **Error! Bookmark not defined.**.

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.

- 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 5.12.5 on page 42).

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 3.1.1 on page 8) and the instrument web page will display the following screen.
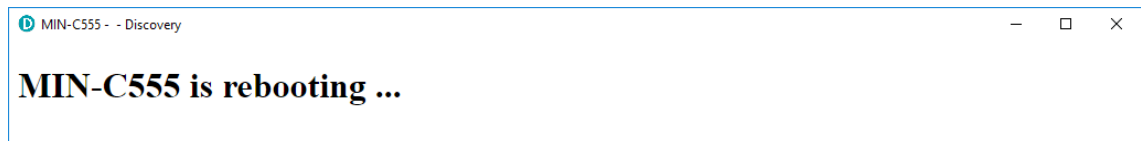
Once the Minimus$_2$ has successfully restarted, the full web browser display and controls will be available for use again.

5.9.1   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 4.3.2 on page 20) 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)

5.9.2   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 5.6 on page 25 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**.

5.9.3   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:

SeedLink settings					
SeedLink Enabled, 65536 records ∨	Send status.txt Every	300 seconds	SeedLink Data Packet Format	Optimal ∨	Send SeedLink EEW Packet Every 0 deciseconds

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 decisecond = 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.
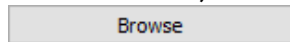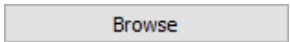
5.9.3.1 MiniSEED extractor

The miniSEED extractor serves two purposes:

- When an SD card is quick-formatted, each file is marked as unused but previously recorded data can still remain in them. Subsequent recordings overwrite these files from the beginning but, if the previous recording had a longer duration, old data will remain in the files. When the files are copied from the SD card to a PC, these older data can cause problems.

- The format used on the SD cards consists of fixed-length, 128 MiB files. Some recordings might not use all of this space. When the files are copied from the SD card to a PC, this can cause wasted disk space.

The miniSEED extractor reads miniSEED files on the PC and copies them to a selected Destination folder, keeping track of the latest block time-stamp as it goes. If it encounters either an unused block or a time-stamp 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.
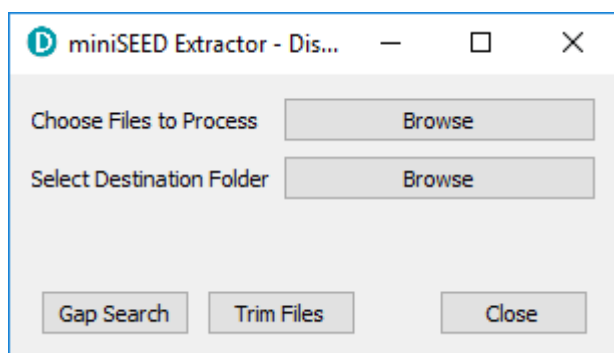
To use the tool, select "miniSEED Extractor" from the Edit menu. Click the first Browse button to select which files you wish to process and then the second Browse button to select the folder into which you wish the output files to be written. Finally, click the Trim Files button to extract the valid data from the selected files into new files in the selected destination folder.

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The same tool can also generate a report of any gaps in the data from the input files. To use, select the input files as before and then click Gap Search to view the report.

5.10 Synchronisation of the sample-clock

The Minimus$_2$ system synchronises its sample clock using an attached GNSS receiver or, if that is not available, Precision Time Protocol (PTP).

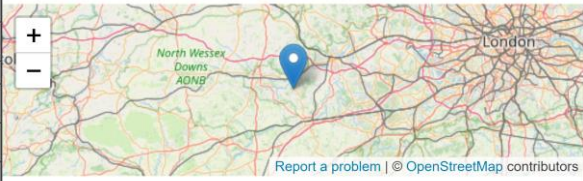The currently supported GNSS systems are Navstar (GPS), GLONASS, BeiDou and Galileo.

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

If visibility of the satellite constellation is available, this is the most accurate way to synchronise your digitiser. The Minimus$_2$ accessory pack includes a combined GNSS antenna and receiver for this purpose: see Section 3.2.2 on page 11 for details.

5.10.1 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)

5.10.2 PTP (Precision Time Protocol)

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

5.11   Deploy mode: Full power-save

The Minimus$_2$ does not yet have power-save functionality, the following will be added in a future firmware update.

The Minimus$_2$ digitiser offers two deployment modes: "Normal" and "Power Save". "Full power-save" mode makes a number of configuration changes in order to reduce the unit's power consumption. This mode is particularly useful when using Maris digital ocean-bottom sensors.

The desired mode can be specified using the "Deploy mode" drop-down menu in the "Setup" tab of web page. Changes are not applied immediately.

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

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

The final step is to click on the Deploy button and confirm or cancel the operation from the pop-up window that appears.

A thirty-second count-down will start before the system enters power-save mode. The screen changes and a new button is added:

Digitizer Controls					
Reboot			Reset All Settings		The "Reset All Settings" button will ALSO affect settings on other pages

Digitizer Config							
Auto Refresh	1	Auto Reboot	On Error	Low Latency Mode	Balanced		
Host Label	SPRT-MIN	Station Code	TEST	Network Code	DG	Site Name	No site
Bluetooth PIN	0000	Bluetooth	Enabled	Filter quality	High		
Deploy Mode	Power Save	Auto Center Disable(hr)	12	Deploy		Abort deployment	
You can abort deployment within	28s						

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

> **Caution:** The power-save mode will disable the Ethernet and GNSS modules. You will not be able to continue to use the web interface.

Once in deploy mode, the only way to re-enable the Ethernet module is to connect to the Minimus$_2$ via a serial connection (see Section 7 on page 60) or to use the GüVü Bluetooth app (see Section 6.4 on page 58).

When a serial or Bluetooth connection is established, type the command **`powersave off`** in the console to disable the "Full power-save" mode and re-enable Ethernet communication.

5.12 Configuration and control of connected analogue instruments

5.12.1 Setting instrument type

The analogue sensor type is user-selectable 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.

5.12.2 Setting instrument (sensor) gain for Güralp Fortis

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

To change the gain electronically, first, 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".

5.12.3 Setting digitiser gain

The input gain can be controlled from the "Setup" tab of the web page using the "Input Gain" drop-down box. Digitiser gain options available are: Unity, ×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.

5.12.4 Mass control

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

5.12.4.1 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.

5.12.4.2 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.

5.12.5 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).

To enter the calibration values for your analogue instruments, right-click the Minimus$_2$ in Discovery's main window and select "Calibration" → "Calibration Editor".

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 .

- **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 a calibration document that is shipped with the instrument.

- 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 .

- The **Coil constant** is the coil constant for the component being calibrated, in A/ms^{-2}, as given on the analogue sensor calibration sheet.

- The **Calibration resistor is t**he value of the calibration resistor, in Ω, as given on the sensor calibration sheet. This is common to all sensor components.

- 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.

- 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.

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.

The drop-down menu in the "Component configuration" section allows selection of what to copy: poles and zeros, gains or everything. The destination sensor and component(s) can be selected in the subsequent drop-down menus. Click on the Copy button to copy and paste the selected values. Finally click on Send axis Z button to send the calibration val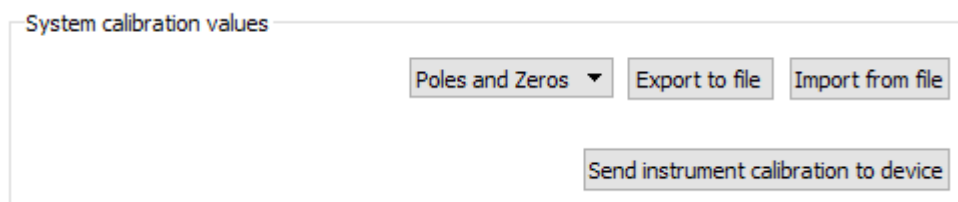ues to the digitiser and save them permanently. Repeat this last step for the other axis. Note that Send axis Z only sends the calibration of the selected axis.
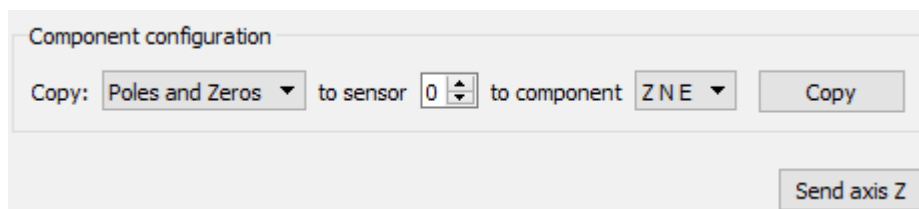
The overall system calibration parameters can be exported and saved in a file for future use by clicking on the Export to file button under "System calibration values".

The resulting file-name 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 to send the calibration values to the digitiser and save them permanently. Note that this action will only send the

calibration of the selected sensor. Click on the **Send to device** button to send the complete calibration to the digitiser.

When transmitting MiniSEED data, the responses of the instruments and digitisers are encoded in a message called a "Dataless SEED" volume. The contents of these volumes can be displayed in human-readable form, known as RESP, by clicking on the "RESP file" link of each channel in the "Data Stream" and "Data Record" tab of the web page.

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

```
#                    << Guralp SEED response file builder v2.1-10402 >>
#
#                    ======= CHANNEL RESPONSE DATA =======
B050F03    Station:      00000
B050F16    Network:      DG
B052F03    Location:     1
B052F04    Channel:      CHZ
B052F22    Start date:   2023,184,10:44:18
B052F23    End date:     No Ending Time
#          ========================================
#          +              +--------------------------------------+              +
#          +              |    Channel Sensitivity, 00000 ch CHZ  |              +
#          +              +--------------------------------------+              +
#
B058F03    Stage sequence number:              0
B058F04    Sensitivity:                        4.184100E+05
B058F05    Frequency of sensitivity:           1.000000E+00 HZ
B058F06    Number of calibrations:             0
#
#          +              +--------------------------------------+              +
#          +              |    Response (Poles & Zeros), 00000 ch CHZ  |        +
#          +              +--------------------------------------+              +
#
B053F03    Transfer function type:             A [Laplace Transform (Rad/sec)]
B053F04    Stage sequence number:              1
B053F05    Response in units lookup:           M/S - Velocity in Metres Per Second
B053F06    Response out units lookup:          V - Volts
B053F07    A0 normalization factor:            1.000000E+00
B053F08    Normalization frequency:            1.000000E+00
B053F09    Number of zeroes:                   0
B053F14    Number of poles:                    0
#
#          +              +--------------------------------------+              +
#          +              |       Channel Gain, 00000 ch CHZ      |              +
#          +              +--------------------------------------+              +
#
B058F03    Stage sequence number:              1
B058F04    Gain:                               1.000000E+00
B058F05    Frequency of gain:                  1.000000E+00 HZ
B058F06    Number of calibrations:             0
#
```

Right-click anywhere and select "Back" to return to the web page.
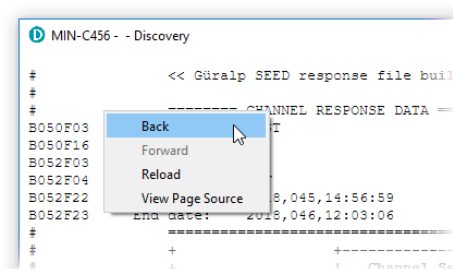
To save a RESP file, right click on it in the main list and select "Save Link":
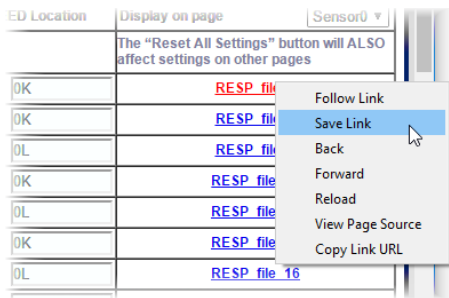
5.13 Configuration and control of connected digital instruments

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 meta data in addition to the seismic signals. Information such as temperature, internal humidity, mass positions are all made available.

5.13.1 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.
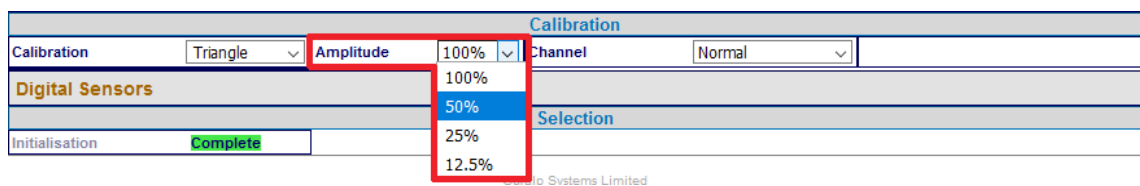
Finally, enable the calibration on all three components of the selected analogue sensor.
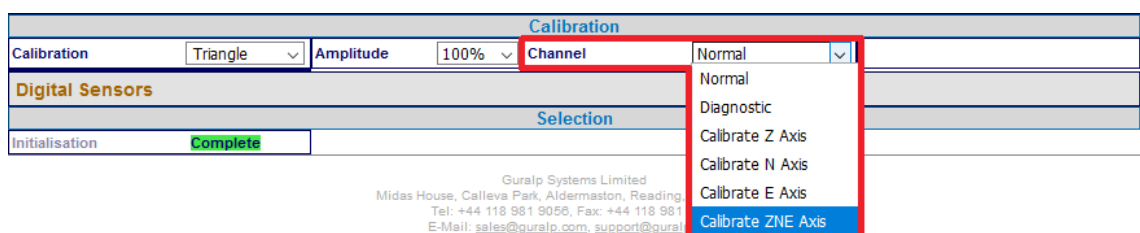
> **Note:** The calibration channel, named *nVELC0* (or *nACCC0*), produces an output if and only if the calibration is in progress.

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

5.14 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.
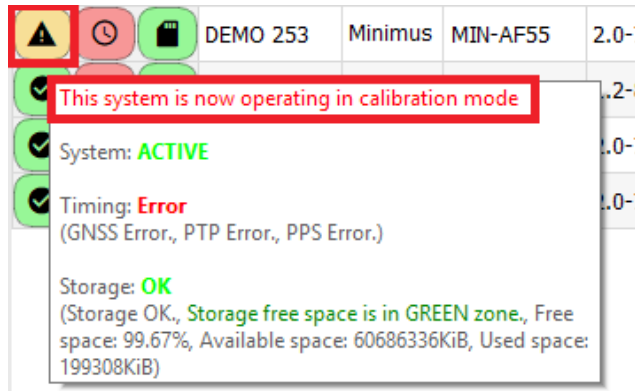
5.14.1 Trigger Configuration

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 triggering sources.

Once this is selected, options will appear to enable the sending of a CAP message, registering the event under the event table, and the sample rate the trigger will use. This sample rate is recommended to keep at 50 Hz or lower to save on computation time and therefore power.

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

The STA/LTA algorithm continuously calculates the average values of the absolute amplitude of a seismic signal in two simultaneous moving-time windows. The short-time-average (STA) is sensitive to seismic events while the long-time-average (LTA) provides information about the current amplitude of seismic background noise at the site.

When the ratio of STA to LTA exceeds the set threshold value an event is "declared", and this event ends when the ratio falls below the de-trigger threshold. The STA/LTA periods and the cut-off frequency of the high pass filter can be modified when trigger type is set to STA/LTA.

The threshold algorithm, instead, declares the presence of an event when the raw data in input passes above or below a pre-set threshold value, and ends when the event raises above this value. To trigger below a value instead of above, simply set the de-trigger threshold to be higher than the trigger threshold.

Trigger 0 Configuration								
Trigger Tap 0	CertisZ0	Cap Enabled 0	yes	Event Table Enabled 0	yes	Trigger SPS 0	50 Hz	
Trigger Threshold 0	8	Detrigger Threshold 0	6	Trigger Type 0	STA/LTA			
STA Period 0	1 s	LTA Period 0	60 s	HPF Cutoff 0	100 Hz			
Trigger 1 Configuration								
Trigger Tap 1	Temperature	Cap Enabled 1	no	Event Table Enabled 1	yes	Trigger SPS 1	1 Hz	
Trigger Threshold 1	45.5	Detrigger Threshold 1	44.5	Trigger Type 1	Threshold			
Trigger 2 Configuration								
Trigger Tap 2	None							
Trigger 3 Configuration								
Trigger Tap 3	None							
Trigger 4 Configuration								

5.14.2 EEW Configuration

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.

AP Msg Scope   Public

5.14.3 CAP receiver

Güralp Discovery includes a CAP (Common Alerting Protocol) receiver. It listens on a specified UDP port for incoming CAP messages. When one arrives, it is displayed and plotted on a map. In addition, the receiver can open a TCP connection to the cloud-based registry server and display CAP messages that have been sent to the registry server. See Section **Error! Reference source not found.**on page **Error! Bookmark not defined.** for information about configuring a registry server.

All CAP messages can be stored in a log-file. The full message is recorded so that it can be re-loaded later, if required.

The CAP receiver functionality is accessed using the context (right-click) menu in Discovery or clicking on "Edit" in the menu bar:
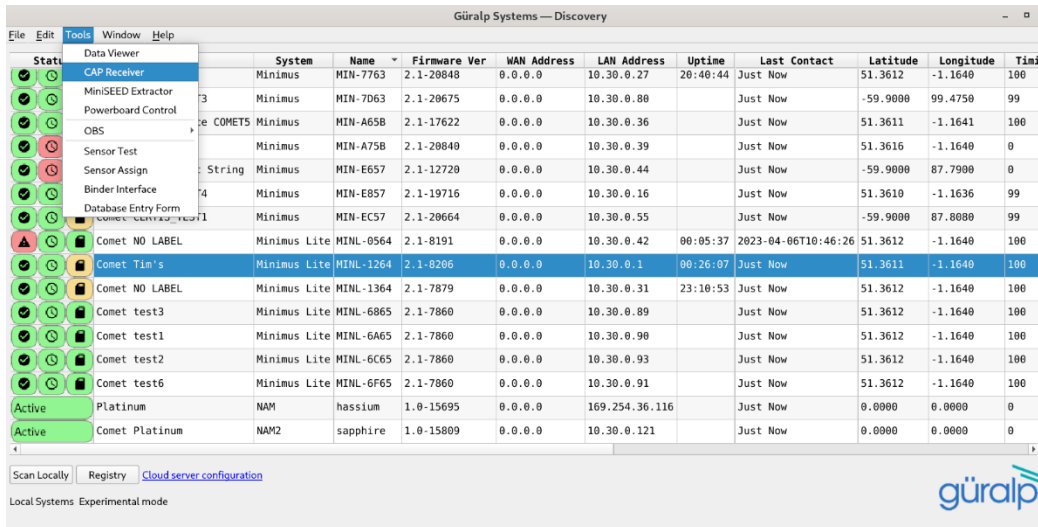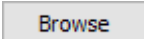
The CAP receiver window allows specification of the listening port. Each digitiser from which messages should be received must have this value specified as the "CAP Port" in its triggering settings. The value should be between 1025 and 65535. You should avoid numbers in the list at https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers.
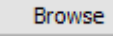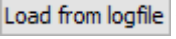
The reception of CAP messages can be enabled or disabled clicking on the [Start] button at the top, right-hand side of the window.

If you wish to forward the CAP messages to a server, type its IP address into the field and tick the check-box named "Use forwarding server". An error message is displayed if the entered IP address is not valid.
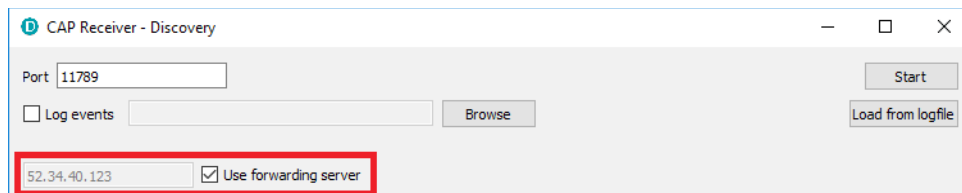
To log CAP messages to a file, tick the "Log events" check-box and use the [Browse] button to select an appropriate location for the database file.
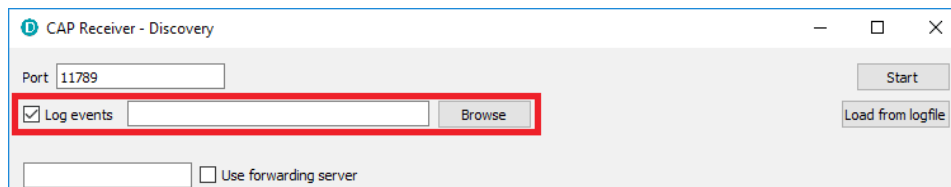
To import an existing database of events, first enable logging, then browse to the file using the [Browse] button and, finally, click the [Load from logfile] button to load the file. If no file is specified, the logging is automatically switched off and a pop-up message is displayed.

When an event is detected and a CAP message is received, the location of the digitiser that generated the trigger is identified by a pointer displayed on the map. The events and the information contained in the CAP message are displayed at the right-hand side of the window. This includes the SEED identifiers, network, station, channel and

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location, along with the time, the recipients and the threshold value which was exceeded.
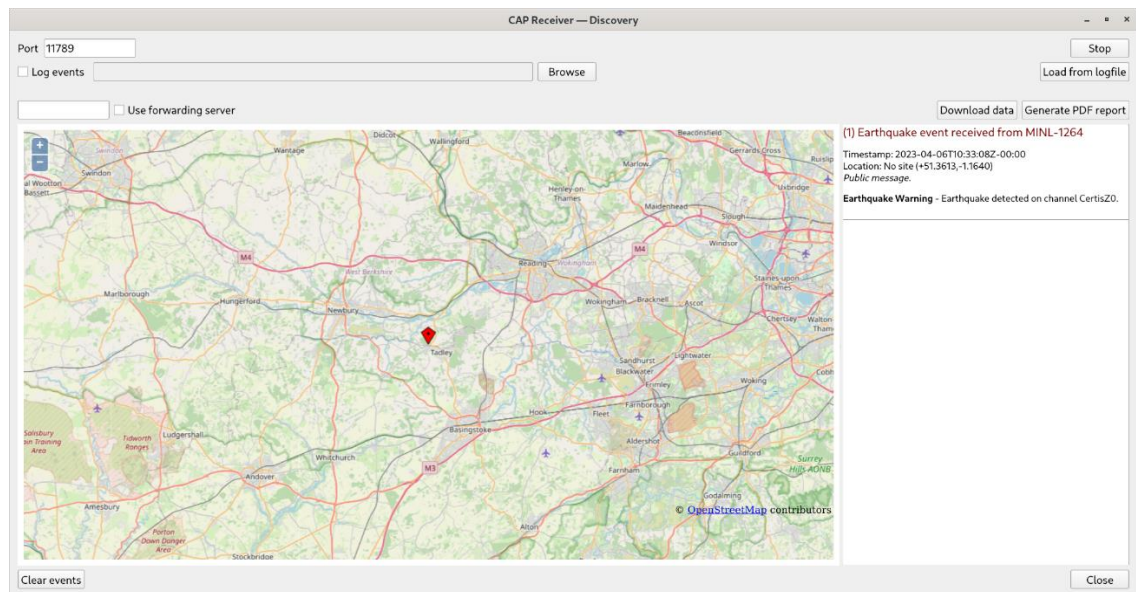
If the EEW parameters are enabled in a particular source, after the first CAP message containing the event information, three other messages with the PGA/PGV/PGD details are sent, one for each component.

Click on the Clear events button to clear markers from the map and descriptions from the right-hand-side list. This action does not affect the contents of the log-file.

5.14.4 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.

> **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.

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

5.15   Using a Registry

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 (contact support@guralp.com for more details). The server itself must have a static IP address and be accessible to all connected Minimus$_2$ units, as well as the PCs running discovery. Registry server's programs are currently available for Linux and Windows. Please contact Güralp technical support 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.
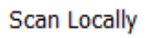
Registered digitisers must be assigned to groups, each of which has a **Group Identifier**. Instances of Discovery must also be configured with a Group ID and can only display registered digitisers from the matching group. This allows partitioning of large networks into smaller administrative domains. It also makes possible the simultaneous use of the Güralp shared registry server by multiple organisations.

To use a registry:

1. Choose whether to use the Güralp shared registry or to deploy your own. If deploying your own, install the software on your chosen server and note its public IP address.

2. Choose one or more Group IDs for your digitisers.

3. Set the Registry server address and Group ID in each Minimus$_2$.

4. Set the Registry server address and Group ID in each instance of Discovery.

5.15.1   Configuring a Minimus$_2$ for use with a registry

The address of the registry server and the chosen Group ID must be set individually for each participating digitiser.

To do this, first connect the Minimus$_2$ to the same network as a PC running Discovery and click the Scan Locally button, so that the Minimus$_2$ appears in the main

Discovery list. Right-click () on the digitiser's entry and select "View Web Page" from the context menu:

In the resulting web page, select the "Network" tab. The Registry parameters can be found near the bottom of the resulting screen:
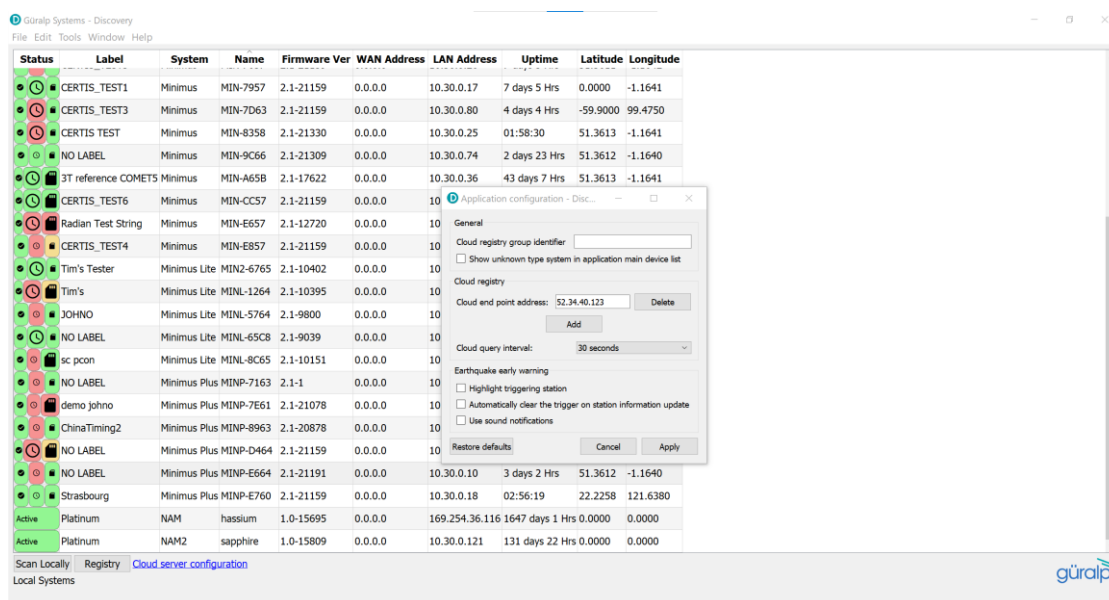

These are:

- **Registry Update**: the frequency at which the registry is updated with details of this digitiser can be specified here, using the drop-down menu;

- **Group ID**: the chosen Group Identifier should be entered here;

- **Registry Address**: the IP address of the registry should be entered here. To use the Güralp shared cloud server, enter `52.34.40.123`.

Once you have set the correct values, the digitiser must be rebooted before they will take effect. To do this, click the button.
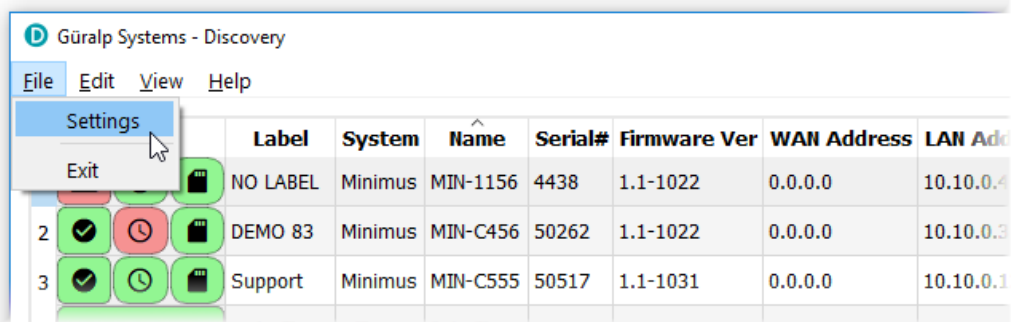
5.15.2   Configuring Discovery for use with a registry

To specify a registry server for an instance of discovery, type its address into the field at the bottom left of the main screen:
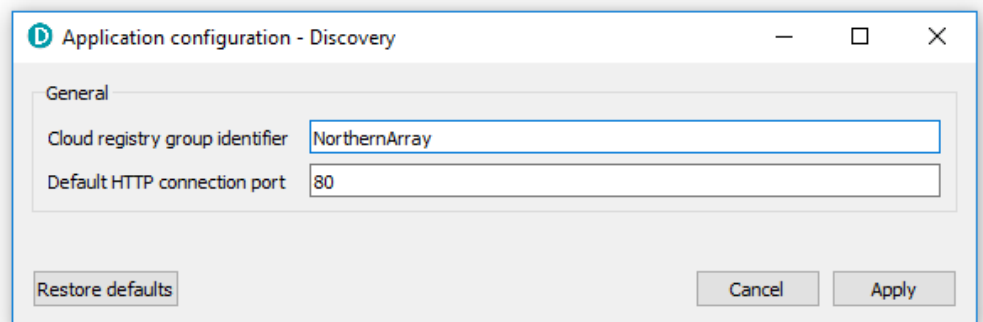

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To set the Group ID in Discovery:

1. Select "Settings " from the "File" menu:

2. Type the chosen Group ID in the "Cloud registry group identifier" field and click ⬚ Apply .

Return to the main windows and test the configuration by clicking the ⬚ Registry button. All digitisers using the same Registry server and Group ID should appear in the main list.

5.15.3 Registry mode: using WAN or LAN addresses

When Discovery displays a list of devices found from a local scan, all access to those systems is initiated via the LAN address. When displaying a list of registered devices, you have the option of using either the LAN address or the WAN address. This can be useful when the WAN address has been configured but is not yet available or when a registered device is installed remotely and not available on the LAN. The feature is controlled by exactly where you right-click in the list of devices.

If you right-click anywhere other than in the LAN address column, the WAN address is used and the behaviour is otherwise exactly as previously documented. To access the digitiser via its LAN address, right-click in the LAN address column, as shown below:

When you click on the LAN address of an entry, the context menu changes:

Entries for firmware updates, system and GDI configuration and web page access all now use the LAN address rather than the WAN address.

In addition, all options on the Live View sub-menu use the LAN address:

and the calibration page editor is also invoked using the LAN address:

For these techniques to work, the digitiser and PC must be connected to the same LAN.

5.16 Updating Minimus$_2$ 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.

The procedure below guarantees a straightforward upgrade and prevents any data loss or misconfiguration.

> **Note:** The latest version of Discovery software must be used to perform the firmware update of any digitiser. See section **Error! Reference source not found.**on page **Error! Bookmark not defined.** for more details.

Once this is complete, to upgrade the :

1. Run Discovery.

2. Right-click on the Minimus$_2$ in Discovery main window and select "File Exchange".

3. In the "File Exchange" tab, select the new software binary file with the Browse button as below:

4. Set the upload file name exactly as shown below. Note: the *ram* is prepended automatically.

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 before the white LED!!!

5.17 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.

5.18   Control Centre

Several actions can be taken from within Discovery to control any of the instruments connected to the Minimus$_2$ as well as the digitiser itself.

This operation can be done by right-clicking on the digitiser's entry in the list and select "Control Centre" from the context menu. The meanings of the icons are given in the table below.

Icon	Function
State of health	This tab provides information about the general state of the digitiser, its serial number and IP address, it's up-time (time since last boot) and GNSS status.
Console	This button launches a console that allows interactions with the command line of the Minimus$_2$. The list of available commands and their respective descriptions can be displayed by entering the command "help". This should generally only be done on the advice of the Güralp technical support team.
Webpage	This button is equivalent to the "View Web Page" entry in the context (right-click) menu of the Minimus$_2$ in the Discovery main window.

Icon	Function
Map	This button is equivalent to the "Show on Map" entry in the context (right-click) menu of the Minimus$_2$ in the Discovery main window.
Live data view	This button is equivalent to the "Live View" entry in the context (right-click) menu of the Minimus$_2$ in the Discovery main window.
Centring	This tab allows manual centring of connected analogue and digital (*e.g. Certis*) instruments.

6   GüVü app

The GüVü app provides monitoring and control of near-by digitisers using the Bluetooth protocol. It is available for both Android and Apple devices.

GüVü can be downloaded from the Google Play store at:

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

or from the Apple store at:

https://itunes.apple.com/us/app/id1208418113

6.1   Getting started

Steps for launching the GüVü App:

1. Launch by clicking on the GüVü icon from either the Apps Menu or from the Home Screen.

2. Wait a few seconds for the app splash screen.

3. Press the Bluetooth icon ( ) to enable Bluetooth connectivity (if not already enabled) and to search for available devices to with which to pair.

4. Select the appropriate device from the list to pair. Wait a few seconds for the main viewer screen to show.

The instrument connection screen can also be accessed by pressing the menu icon ( ) on the main instrument status window, and selecting the "Connect" option.

If you experience problems connecting, try forcing GüVü to quit and then re-launching the app.

Once the device is connected, the main view of the app will be displayed. This screen displays a number of status indicators associated with both the Minimus$_2$ and connected sensors. These features are summarised in the figure below:

Access the menu by pressing the menu icon ( ) on the main instrument status window:

6.2   Selecting data sources

Güralp view can provide status information about all connected sensors, including digital instruments (*e.g.* Güralp Certis) and analogue instruments.

To select the instrument source that provides information to the main status screen of GüVü, tap the menu icon ( ) on the main instrument status window, and then tap the "Select data source" option.

The data source selection screen shows a list of connected instruments. Select an instrument name: this is now the instrument that will be displayed on the main instrument status window.

6.3　View settings

The user can customise the view of the main instrument status window. Four different view options can be cycled through by tapping the menu icon ( ) on the main instrument status window:

- **Show all** – 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.

6.4　Instrument control

Several features of the Minimus$_2$ 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$_2$
- Enable/disable power-saving mode
- Lock/unlock sensor masses
- Station meta-data (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.

These options can be accessed by tapping the menu icon ( ) and choosing the "Device control" option. To access the instrument control and configuration sub-menu, a PIN code has to be entered by selecting the text entry box and tapping

OK .Note: Any change to the sample rates requires a system reboot to take effect.

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

6.4.1   Setting the PIN code

The PIN code for accessing the instrument control menu of GüVü can be changed from the "Setup" tab of the web page. The new four-digit PIN code should be entered into the "Bluetooth PIN" field. The new value is applied by keying ⏎; or clicking the left mouse button in any other setting box.

Digitizer Config								
Auto Refresh	1	Auto Reboot	On Error ⌄	Low Latency Mode	Balanced ⌄			
Host Label	SPRT-MIN	Station Code	TEST	Network Code	DG	Site Name		No site
Bluetooth PIN	0000	Bluetooth	Enabled ⌄	Filter quality	High ⌄			
Deploy Mode	Normal ⌄	Deploy						

6.5   Emailing a deployment report

The GüVü app has a feature that allows the user to generate an automatic deployment report that can then be filed via email.

The deployment report includes the following details:

- System name;

- Station name;

- Network code;

- Instrument user label;

- Memory card storage size and recording status;

- Location of site (GNSS latitude, longitude, elevation);

- Time of deployment;

- GNSS lock quality;

- Power supply status;

- Instrument temperature and humidity recordings.

To send a deployment report, tap the menu icon (⊞) and choose the "Deployment report" option. GüVü will then open the default email application on the device, showing a draft email which will include the parameters described above.

Lastly, click the Download download button to initiate a file transfer using your browser's standard mechanism.

7   Advanced troubleshooting

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

The user should first plug in the serial adapter to the GNSS connector, which is then attached to a 9-pin COM port on your PC/laptop (if a 9-pin COM port is not available, a serial-to-USB converter should be used instead and connected to an available USB port. Güralp recommend converters based on the FTDI chip-set.)

A connection is then made using a terminal emulator, such as minicom under Linux or PuTTY under Windows. The appropriate COM port should be entered as the "Serial line", and the "Speed" should be set to 115200.
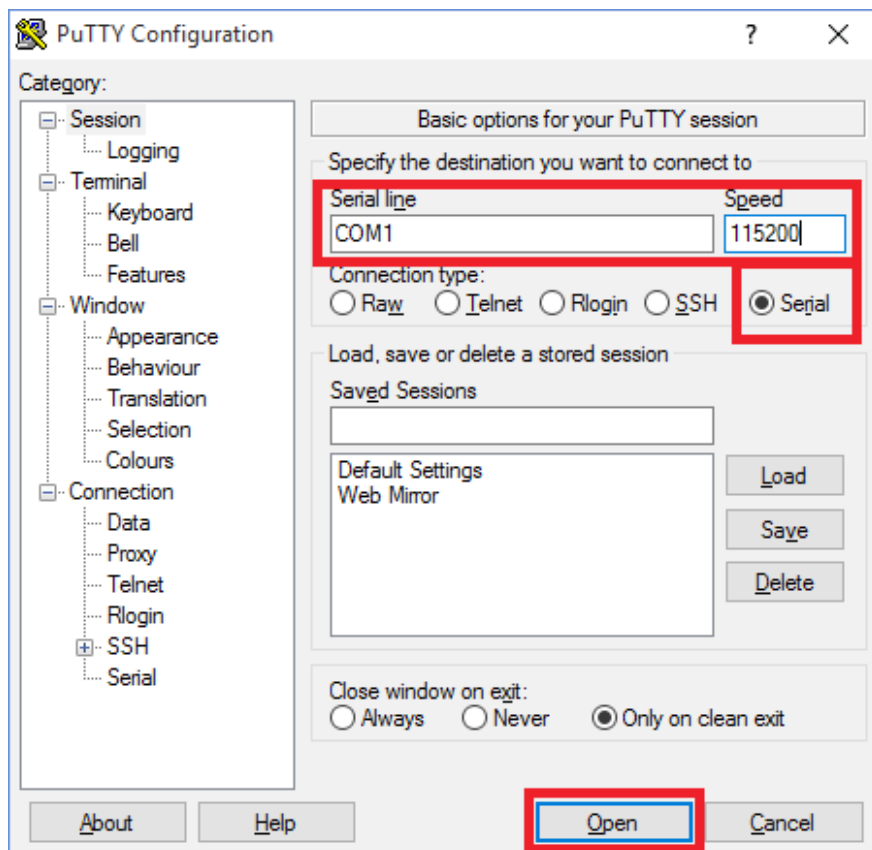
Next, select "Serial" from the bottom of the Category menu in the left-hand pane and check that the settings match those shown in the screen-shot below.
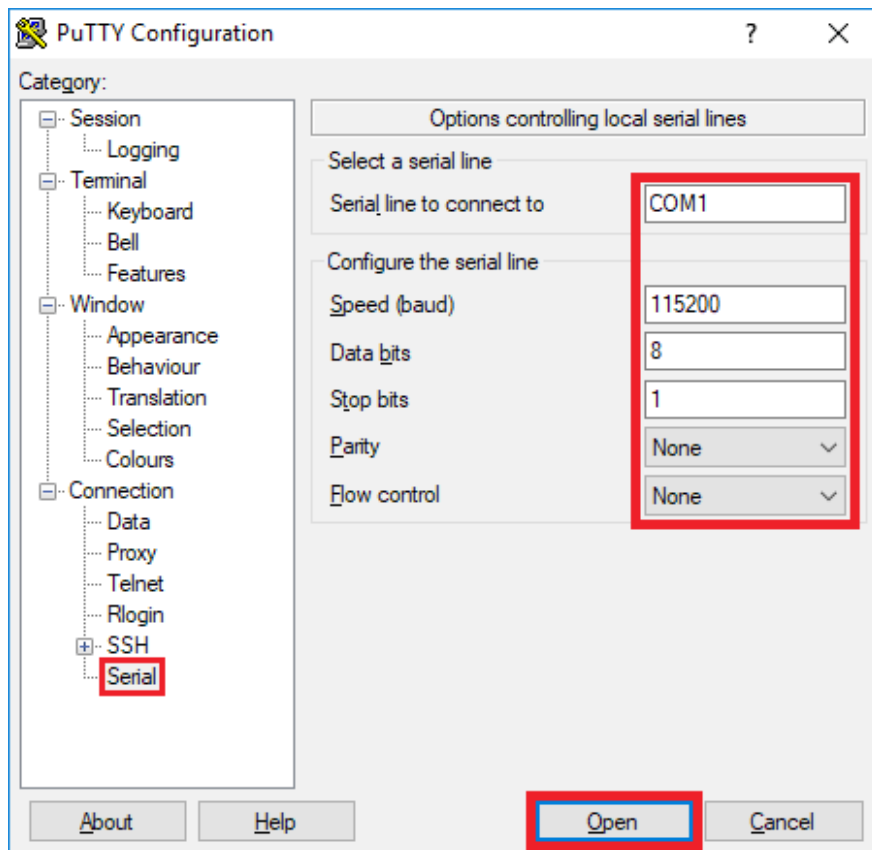
Finally click the [Open] button and a terminal window will open, connected to the console of the .

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.

7.1 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 7 on page 60). 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.

Once the "`@GURALP SYSTEMS`" banner has been printed, keying [Ctrl] + [R] (at least once) will cause all settings (except Username, Password and Bluetooth PIN) to revert to their default values and cause the Minimus$_2$ to reboot.

8 Appendix 1 – Instrument/channel names

The tables in this section show the names and codes of the streamed channels along with the record names and channel codes for recorded data. The first character "x" in miniSEED channel code represents the sample rate. The possible values are shown in the table below:

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

The "Data record names" of the seismic channels and MEMS accelerometer channels are postfixed with "A" or "B". This notation distinguishes between the two different sample rates that is possible to select for each recorded channel. For example, the recorded streams S0AccZA and S0AccZB carry digitisations of the same signal, differing only in the sample rate.

9 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 instrument is in use.

The protocols can be selected permanently by added 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 $20

The value $20 comes from the table below:

$20	Port forwarding or serial port to TCP socket
$60	Güralp digital instrument such as Certis
$70	Güralp 3T to gain access to Calibration and Poles/Zeros etc

Note: Use resource del uartp6 to disable this port.

10   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	SEEDlink transmission protocol

11 Appendix 4 – Connector pin-outs

11.1 Ethernet

This is an Amphenol RJField-series 8P8C connector. It consists of a standard ISO 8877 8P8C modular socket (often called RJ45) in a bayonet mounting compatible with MIL-DTL-26482 (formerly MIL-C-26482).

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-

This connector accepts unmodified ISO 8877 8P8C modular connectors (often called RJ45 connectors or Ethernet "Cat 5/6" connectors).
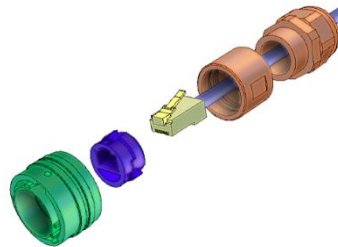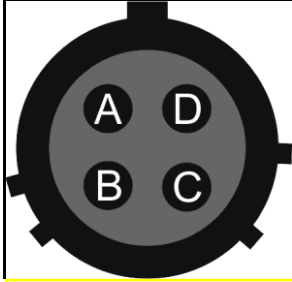

When used in hostile environments, a standard Ethernet cable can have a mating environmental shield (Amphenol part number RJF6MN) fitted.

11.2 Power

This is a standard 4-pin military-specification bayonet plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482).

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).

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

11.3   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 home.

- To disengage, hold the mating connector by the gnurled 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
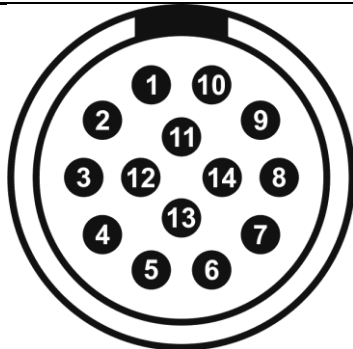
Wiring details for the compatible plug, FGG.1K.314.*, as seen from the cable end (*i.e.* when assembling).

11.4   Digital

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
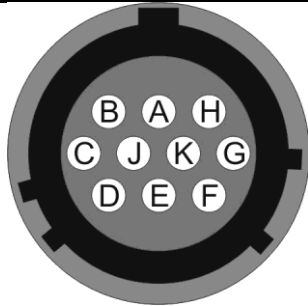
Wiring details for the compatible plug, ***-12-10P, as seen from the cable end (*i.e.* when assembling).

11.5   Analogue 1 and Analogue 2

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.
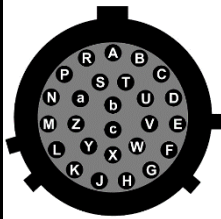
Wiring details for the compatible socket, ***-16-26S, as seen from the cable end (*i.e.* when assembling).

12 Appendix 5 – Dimensions and drawings

12.1 Minimus$_2$

13 Appendix 6 – Güralp Discovery installation

Güralp Discovery is a software package for Microsoft Windows, MAC and Linux, which facilitates the identification, configuration and management of Güralp digitisers and instruments.

Güralp Discovery has a conventional `.msi` -based installer. Once installed, the software can check whether it is the current version and can update itself using a button on the Help→About menu.

13.1 Installation in Linux

The Linux version of Discovery 64-bit is delivered in a self-contained package.

To install Güralp Discovery:

1. Open the terminal

2. Visit www.guralp.com/sw/download-discovery.shtml to download the appropriate installation script or use the command

   ```
   wget
   http://www.guralp.com/download/discovery/Discove
   ry.run
   ```

3. Make the downloaded file executable using the command

   ```
   chmod +x Discovery.run
   ```

4. Run the script with the `-h` option to see the installer's help message:

   ```
   ./Discovery.run -h
   Online installer for Guralp Systems Discovery
   application
   Usage: ./Discovery.run [parameters]
   Parameters:
   -h : this message
   -i : perform installation
   -o <directory> : output directory (default
   /opt/guralp/discovery)
   ```

5. Execute the script, either accepting the default installation directory

   ```
   ./Discovery.run -i
   ```

   or providing your own, alternative location

   ```
   ./Discovery.run -i -o /usr/lib/discovery
   ```

The script proceeds through the following installation stages:

1. A confirmation prompt:

    ```
    Guralp Discovery will be installed in:
    /opt/guralp/discovery. [C]ontinue/[A]bort
    ```

    Type C to continue installation in listed directory, or A to abort and change directory using the -o execution parameter

2. Downloading. The following message is printed:

    ```
    Downloading Discovery from Guralp Systems
    server [Downloading]
    ```

    This step downloads the discovery package from the Güralp server. It is around 50 MiB in size so downloading may take a long time if you have a slow Internet connection.

3. Next, the following message is printed:

    ```
    Creating installation directory:
    /opt/guralp/discovery [OK]
    ```

    This step creates the installation directory. If an error occurs at this stage, please make sure that the user running the installation script has permission to create the specified directory.

4. The downloaded archive is now unpacked into the specified installation directory. The following message is printed:

    ```
    Unpacking Discovery to /opt/guralp/discovery
    [OK]
    ```

5. The next step removes the downloaded file from the disk.

    ```
    Removing downloaded Discovery archive [OK]
    ```

6. At this point, the installation is complete. The message

    ```
    Discovery is now installed in:
    /opt/guralp/discovery/discovery
    ```

    is displayed and the application is available in the specified directory.

13.2   Installation in Mac

To install Güralp Discovery in a macOS machine:

1. Open Safari, visit www.guralp.com/sw/download-discovery.shtml and download the appropriate disk-image file.

2. Either save the downloaded file on a local drive, or automatically open it with DiskImageMounter.

3. If you saved the file to disk, navigate to the download location and open Discovery.dmg with DiskImageMounter.

4. Successful mounting should result in Discovery drag and drop installation window

5. Drag and drop discovery.app to the Applications folder.

6. When finished, the installation is complete and the Discovery app can be found in Launcher or Applications folder in Finder.

13.3   Installation in Windows

To install Güralp Discovery on a Windows machine:

1. Download the appropriate installer – 32-bit or 64-bit – from

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

2. Double-click the downloaded file. You may be asked whether you wish to continue: answer yes.

3. The following screen asks where, in the Start Menu, you would like to place the Discovery short-cut. The default location is normally satisfactory but you can change it from here if you wish.
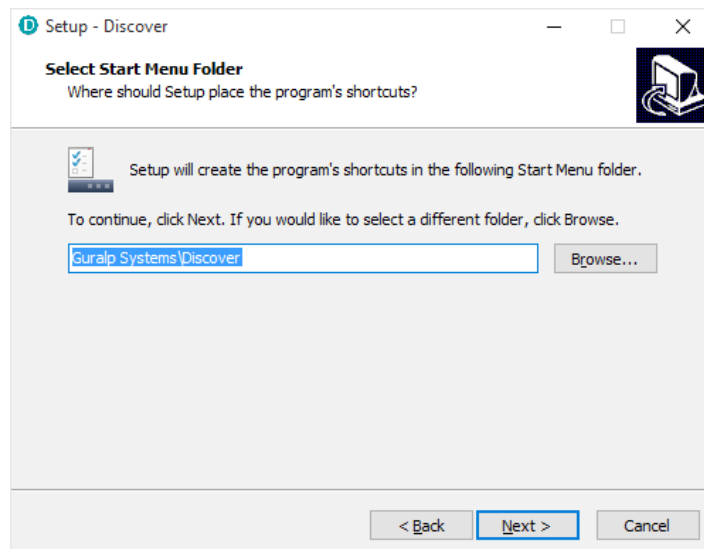
Click [Next >], key ↵ or key Alt + N to continue.

4. The next screen asks whether you would like to place an icon for Discovery on the desktop:
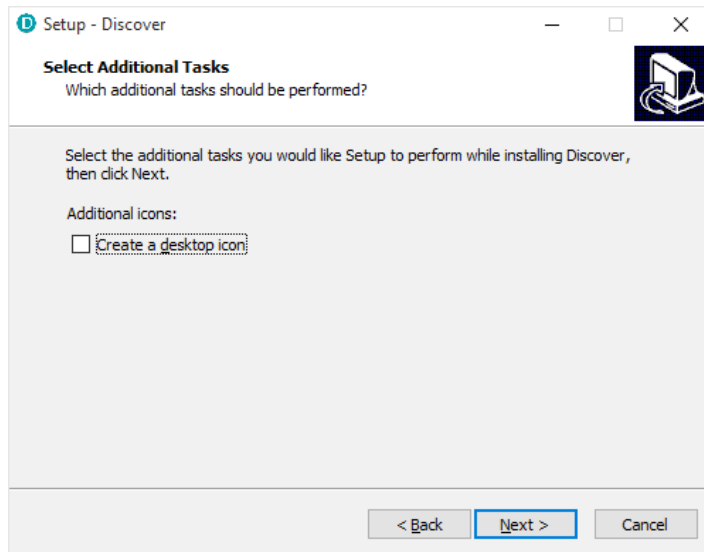
Tick the check-box if you wish and then click **Next >**, key ⏎ or key **Alt** + **N** to continue.

5. The installer then offers a last chance to change any of your decisions:
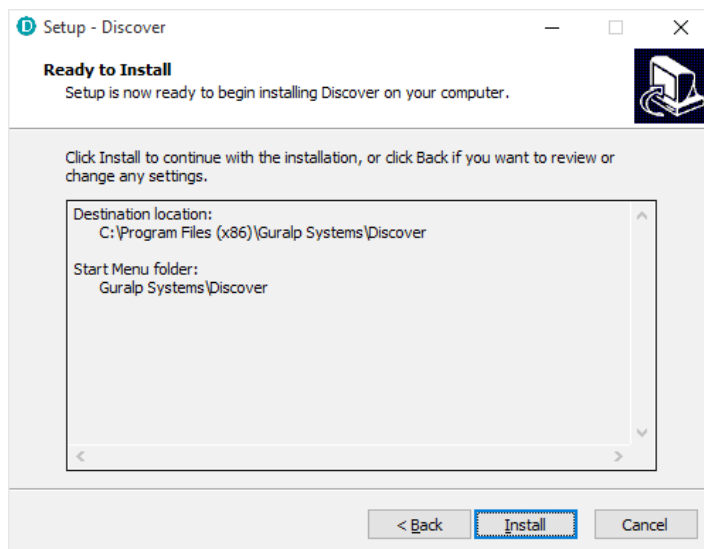
Click **Install**, key ⏎ or key **Alt** + **I** if you are happy with your choices or click **< Back** (or key **Alt** + **B**) if you wish to revisit any of them.

6. Once you have clicked ⟨Install⟩, the installation begins and a progress screen is displayed:
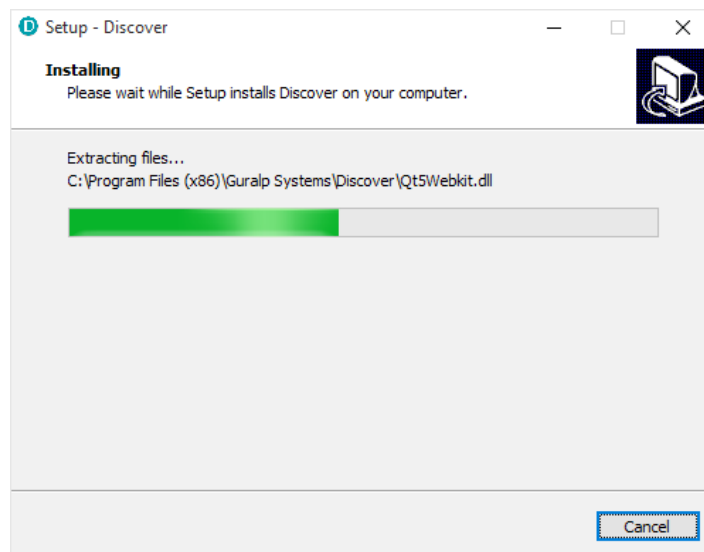
Pressing ⟨Cancel⟩ or keying ⟨Esc⟩ now will remove all of the installed files (except the installer itself) and reverse any changes made so far.

7. Once installation is complete, the following screen is displayed:
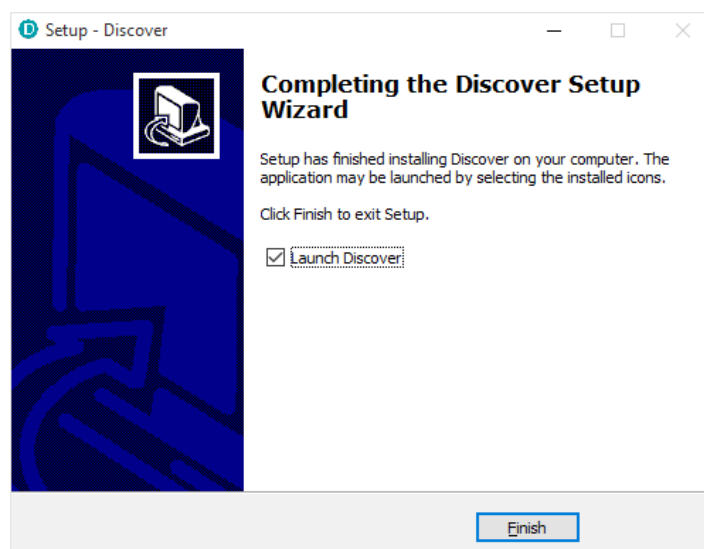
Press ⟨Finish⟩, key ⟨↵⟩ or key ⟨Alt⟩+⟨F⟩ to close the installer and launch Discovery.

> **Note:** Discovery for Windows 64-bit requires Microsoft Visual C++ 2015. Discovery may ask to install it if it is not installed yet.

13.4   Configuring Windows Firewall

Windows Firewall can interfere with Discovery's ability to send information to instruments and/or receive information from instruments over the network. If you

use Windows Firewall, you should make special provision for allowing Discovery to communicate, as described in this section.

1. Click in the "Ask me anything" search box at the bottom left of your Windows screen:


2. Type "allow an app"
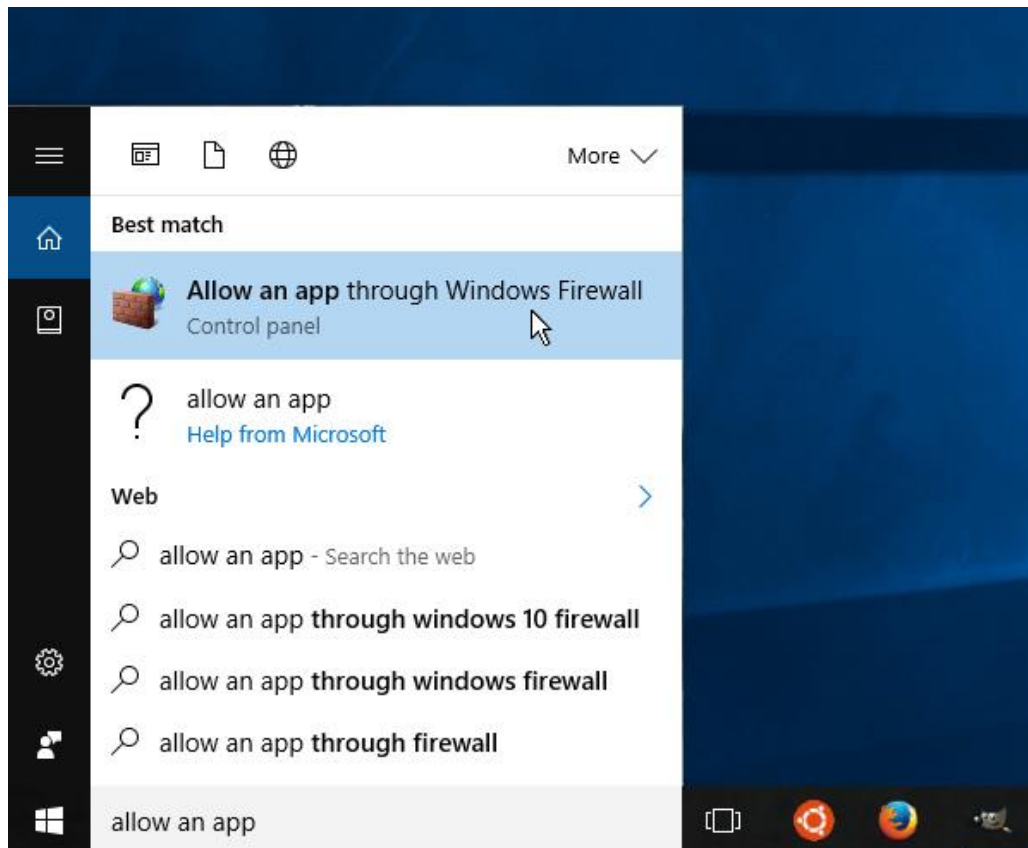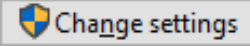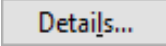
3. Select "Allow an app through Windows Firewall" from the search results.

4. Windows will display the "Windows Firewall Allowed Applications" screen.
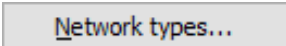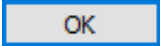
   This displays a list of applications in alphabetical order. Each application is provided with three check-boxes which indicate whether the application can communicate with networked devices in the "Domain" profile, the "Private" profile or the "Public" profile. (Profiles are also known as "network locations".)

   The "Domain" profile applies to networks where the host system can authenticate to a domain controller. The "Private" profile is a user-assigned profile and is used to designate private or home networks. The default profile is the "Public" profile, which is used to designate public networks such as Wi-Fi hotspots at coffee shops, airports, and other locations.

For a more complete discussion of this topic, please see http://www.tenforums.com/tutorials/6815-network-location-set-private-public-windows-10-a.html or your Windows documentation.

5. First click the buttons to activate the interface.

6. Highlight the "discovery" line and then click the button. The "Edit an app" window is shown:
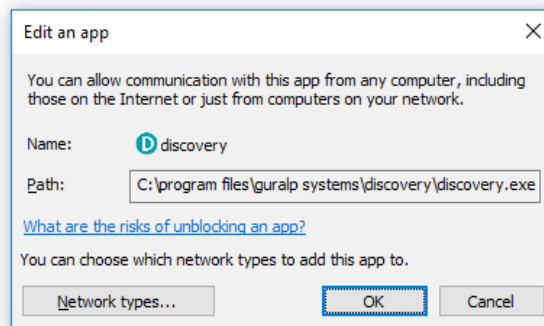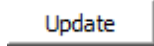

7. Click the button. The "Choose network types" window is shown:

8. After making appropriate changes, click first in the "Choose network types" window, then in the "Edit an app" window, then in the "Windows Firewall Allowed Applications". This closes the Windows Firewall "Allowed Applications" tool and saves the changes that you have made.

13.5 Update

If a PC running Güralp Discovery has an Internet connection, Discovery can check whether an update is available. To initiate this, click About from the Help menu or type + followed by :

A screen like the following is displayed:

The currently installed version is shown. If this is the most recent version available, the screen will say `Up to date` and the button will be disabled, as shown above. If a newer version is available, the screen will look like this:
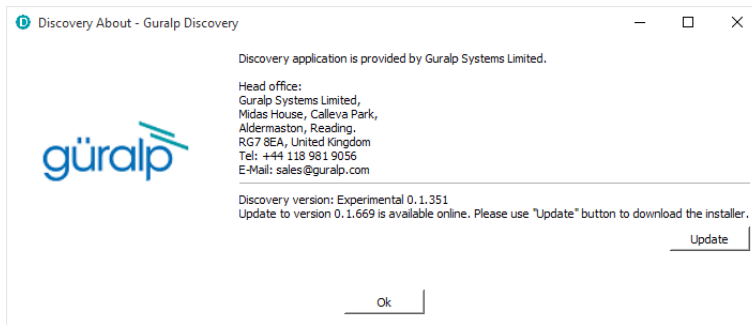
If you want to proceed with downloading the newer version, click the [Update] button. This does not commit to an immediate upgrade: it just downloads the installer. If you do not wish to download the installer, click [Ok] to close the "Discovery About" dialogue.

If you clicked [Update], you may see the following warning if the previous installer is still in your download folder:

Simply click [Yes] or key [↵] to continue: the download will start immediately.

While the download is in progress, the following indicator will be displayed:
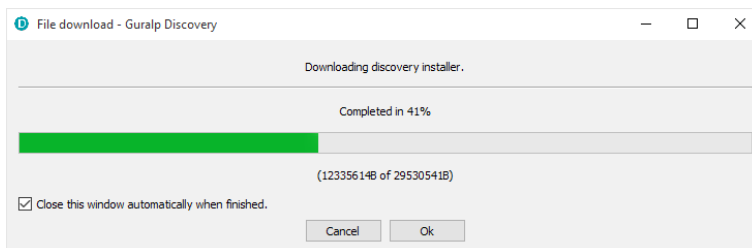
When the download is complete, the following screen is displayed:

If you wish to complete the installation immediately, click [Yes]. If you would rather defer the installation, click [No] and run the installer at a more convenient time.

Once the upgrade is complete, start Discovery in the usual way. Windows, recognising that the program has changed, may ask you to specify how you wish Discovery to interact with the Windows Firewall. Because Discovery requires network communication in order to function, it is important that you understand the options available.

The following screen is displayed:

The screen provides three check-boxes which indicate whether Discovery can communicate with networked devices in the "Domain" profile, the "Private" profile or the "Public" profile. (Profiles are also known as "network locations".)

The "Domain" profile applies to networks where the host system can authenticate to a domain controller. The "Private" profile is a user-assigned profile and is used to designate private or home networks. The default profile is the "Public" profile, which is used to designate public networks such as Wi-Fi hotspots at coffee shops, airports, and other locations.

For a more complete discussion of this topic, please see www.tenforums.com/tutorials/6815-network-location-set-private-public-windows-10-a.html or your Windows documentation.

14 Appendix 6 – IP address configuration on PC or Laptop

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`.

Connect the Minimus$_2$ to the laptop or PC using the blue Ethernet cable and power it up.

14.1 On Linux

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

```
sudo bash
```

Key [⏎] and provide the appropriate password. Then, enter the command

```
ifconfig
```

to identify the Ethernet network interface to which the Minimus$_2$ is connected. Once you have identified the correct interface, connect the , 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 169.154....

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

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

14.2 On macOS

Click the Apple icon in the upper-left corner of the screen, and select "System Preferences."

1. Click the "Network" icon to open the Network Preferences pane and select "Ethernet" from the list on the left side of the window.

2. Click the gear button, ⚙▾, in the lower-left corner of the window, then click "Make Service Inactive." Click the "Apply" button to disable the NIC (Network Interface Card).

3. With the Minimus$_2$ connected and powered up, click the ⚙▾ button again, click "Make Service Active" and click "Apply" to re-enable the NIC.

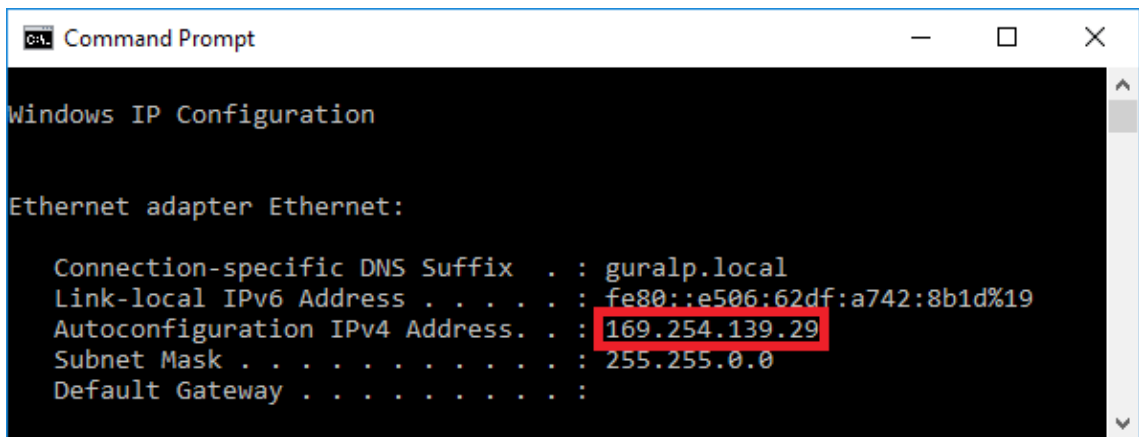4. Check that the interface has been assigned an address in the correct network:

In the example above, the interface has been allocated address `169.254.56.230`, which is in the correct network.

14.3 On Windows

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

Right-click on the network adapter which is connected to the Minimus$_2$ and select "Disable" from the context menu. Right-click on the same adapter again and select "Enable". Close the network settings window.

Key ⊞ + R and type `cmd`., then ↵. This opens a command window. 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 `169.254.56.230`, which is in the correct network.

15   EU Declaration of Conformity

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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

16 Revision History