

Güralp Fortimus

Technical Manual

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Table of Contents

1	Preliminary Notes							
	1.1 Proprietary Notice	7						
	1.2 Gaulions and Notes	<i>1</i> 7						
	1.4 Conventions	7						
_								
2	System Overview	8						
	2.1. Kov factures	0						
	2.1 Rey realures	0 8						
		0						
3	System description	9						
Ŭ	2.1. Cürcle Fortimus digital appalaremeter	•						
	3.1.1 Liquid Crystal Display	9						
	3 1 2 FD indicator	10						
	3.1.3 Bluetooth connectivity	.11						
	3.1.4 MEMS accelerometer	.12						
	3.1.5 Data storage	. 12						
	3.1.6 WiFi connectivity	.15						
	3.1.7 Web interface	.16						
	3.2 Accessory package	.17						
	3.2.2.1 Ethernet Cable	. 17						
	3.2.3 Power cable	.18						
	3.2.4 Diagnostic GNSS to Serial cable adapter	.18						
	3.3 Güralp Discovery software	.19						
	3.4 Güralp GüVü Android and iOS app	. 20						
4	Getting started	.21						
	4.1 Unpacking and packing	.21						
	4.2 System set-up	.22						
	4.3 Güralp Discovery software installation	.23						
	4.4 viewing waveforms and system state-of-nealth	.26						

5 LCD Display menu	
5.1 Main menu	
5.2 Status	
5.3 Settings	
5.3.1 Settings \rightarrow display	
5.3.2 Settings \rightarrow network	
5.4 Alignment	
5.5 Waveform	
5.6 Maintenance	
5.6.1 Reboot	
5.6.2 Restore factory settings	
5.6.3 Lock the configuration	
Ũ	

6	Installation	41
	6.1 Permanent installation	41
	6.2 Temporary installations	43
	6.3 Installation in Hazardous environments	43

7	System configuration	.44
	7.1 Web Page login	.44
	7.2 System status	.45
	7.3 Station meta-data	. 47
	7.4 Network configuration	.47
	7.4.1 I.P. address and gateway	.47
	7.4.2 NTP (Network Timing Protocol) configuration	.48
	7.5 WiFi	. 49
	7.5.1 Connecting to a WiFi network	.49
	7.5.2 WiFi connection status	. 50
	7.5.3 Changing WiFi networks	. 50
	7.6 GDI push (auto-connection)	. 51
	7.7 QSCD	. 52
	7.8 Controlling the LCD from the web interface	. 52
	7.9 Data storage	. 54
	7.10 Storage	. 55
	7.10.1 Recording status	. 55
	7.10.2 MicroSD card re-formatting	. 56
	7.10.3 MicroSD card data flushing and unmounting	.57
	7.10.4 Download recorded data	. 58
	7.10.5 Downloading data for specific time-intervals	
	7.10.6 Bulk data extraction	.60
	7.10.7 The contents of the microSD card	.61
	7.10.8 Request data from microSD card	.63

7.11 Data transmission	66
7.11.1 Scream! (GCF format + Scream protocol)	67
7.11.2 GDI-link protocol	68
7.11.3 SEEDlink protocol	68
7.12 Synchronisation of the sample-clock	72
7.12.1 GNSS lock status	73
7.12.2 Precision Time Protocol (PTP)	74
7.13 Deploy mode: Full power-save	76
7.14 Configuration and control of the accelerometer	77
7.14.1 Setting instrument (sensor) gain	77
7.14.2 Sensor centring	79
7.14.3 Output polarity	79
7.14.4 Instrument response parameters	81
7.14.5 Inject a calibration signal	85
7.15 Setting sensor orientation and depth parameters	86
7.15.1 Applied rotation	86
7.15.2 Instrument installation parameters	87
7.16 Transforms	87
7.16.1 Pass-through	89
7.16.2 Differentiation	90
7.16.3 1 st order LPF	90
7.16.4 1 st Order HPF	91
7.16.5 1 st Order Band/Notch filter	91
7.16.6 2 nd Order biquad	92
7.16.7 Integration	93
7.16.8 Double Integration	94
7.16.9 EEW Parameter Observer	95
7.16.10 STA/LTA RATIO	96
7.16.11 Inree-dimensional rotation	98
7.16.12 QSCD Sender (triplet)	99
7.10.13 MIMA Logger	100
7.17 Ealthquake Early Warning	101
7.17.1 Trigger Sources	102
7.17.2 Trigger desurations	.105
7.17.5 LOW Latericy Mode	107
7.17.4 CAF TELEIVEL	. 100
7.17.5 Seisinic Event Table	110
7.18 1. Configuring a Fortimus for use with a registry	
7.10.1 Configuring at orallog of use with a registry	1 1 Z
7.10.2 Configuring Discovery for use with a registry	114
7 10 Undating Fortimus firmware	117
7.10 Opticiting Fortunus innivare	121
7.20 Import / Export an existing comiguration	122

8	GüVü app	125
	8.1 Getting stated	125

8.2 View settings	
8 3 1 Setting the PIN code	
8.4 Emailing a deployment report	130
9 Advanced troubleshooting	
9.1 Reset all settings during boot phase	132
10 Appendix 1 – Instrument/channel names	
10.1 Environmental channels	137
10.2 Broadband accelerometer channels	
11 Appendix 2 – Fortimus network ports	140
12 Appendix 3 – Connector pin-outs	141
12.1 Ethernet	141
12.2 Power	
12.3 GNSS/serial	143
13 Appendix 4 – Güralp Discovery installation	
13.1 Installation in Linux	144
13.2 Installation in Mac.	
13.3 Installation in Windows	
13.4 Configuring Windows Firewall	
13.5 Update	154
14 Appendix 5 – I.P. address configuration on PC or Laptop	
14.1 On Linux	
14.2 On macOS	159

15	Appendix 6 – LCD menu map	161
16	EU Declaration of Conformity	162
17	Revision History	163

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 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: <u>www.guralp.com</u> 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 Fortimus digital accelerometer.

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

2.1 Key features

- Digital, three-axis, strong-motion, force-feedback accelerometer.
- Flat response to ground acceleration from DC to 315 Hz.
- Selectable gains for full-scale readings of ±4 g, ±2 g, ±1 g and ±0.5 g.
- 24-bit digitiser with a nominal sensitivity of 2.44 μ V per count.
- Selectable sample rates from 1 sample per hour to 5000 sps.
- Data streaming in real-time using GCF (Scream!), GDI-link and SEEDlink.
- Compact form, measuring just 165 × 165 × 84 mm.
- Internal ±2 g MEMS accelerometer for orientation.
- Identification of I.P. address via Güralp Discovery software and, optionally, a cloud-based or organisational registry server.
- Remote instrument and data management via Discovery software.
- Android app for installation integrity checking via Bluetooth.
- Low-latency mode for Earthquake Early Warning (< 40 ms).
- Hot-swappable data storage with dual redundant 64 GB microSD cards.
- GNSS time-synchronisation, compatible with Navstar (GPS), GLONASS, BeiDou and Galileo constellations, with PTP available as an alternative timesource.
- Touch-sensitive, 2.4 inch colour LCD for monitoring and control operations.

2.2 Typical applications

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

3 System description

3.1 Güralp Fortimus digital accelerometer

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



The labelled parts are:

- **A** Hole for mounting bolt
- B Status LED
- **C** Touch-screen display
- **D** WiFi antenna

- **E** Power connection
- F Cover for SD card
- **G** Ethernet connection
- H GNSS connection

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

3.1.1 Liquid Crystal Display

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



The LCD features are described in detail in chapter 5 on page 33.

3.1.2 LED indicator

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

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



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

 \bigcirc

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

\bigcirc

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



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



3.1.3 Bluetooth connectivity

The Fortimus features Bluetooth connectivity, allowing sensor and state-of-health data to be monitored using the Güralp GüVü app (see Section 3.4 on page 20) running on an Android mobile phone or tablet.

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 8 on page 125 for further details on connecting to the Fortimus using a phone or tablet.

3.1.4 MEMS accelerometer

The Fortimus digital accelerometer is equipped with a triaxial **M**icro **E**lectro-**M**echanical **S**ystem (MEMS) accelerometer with a measurement range of ±2 g. The three axes of sensitivity, Z, N and E, align with those of the main accelerometer outputs and are orientated as illustrated below:



3.1.5 Data storage

The Fortimus uses microSD (non-volatile) memory technology to store seismic data within the instrument. The Fortimus features two such microSD cards in order to provide redundancy; this helps to protect the recorded data in the unlikely event of any corruption or problem with the memory cards. One card is internal and cannot be removed by the customer; the other is hot-swappable and easily accessible without any technical knowledge.

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

3.1.5.1 Primary (removable / hot-swappable) microSD card slot

To remove a card, follow the sequence below:



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



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

The horizontal edge of the microSD card is now visible

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

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



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

To replace the card, remove any existing card, as shown previously, and then:



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



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

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

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



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



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

Caution: When the external microSD card is removed, the internal card keeps recording data, unless recording is stopped using Unmount Cards. button (see Section 7.10.3 on page 57). However, when the external card is re-connected, any data written to the internal card while the removable card was absent will overwritten.

3.1.5.2 Internal (back-up) microSD card

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



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

3.1.6 WiFi connectivity

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



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

See Section 7.5 on page 49 for further details on how to configure the Fortimus to connect to a wireless network.



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

3.1.7 Web interface

The Fortimus contains on-board firmware that presents monitoring and configuration interfaces. These are accessible through Güralp's Discovery software (see Section 3.3 on page 19) or, with the built-in web server, via Discovery's browser interface or any standards-conformant web browser.

		güral	JNDERSTAND OPTIMISE PROTECT								
							Fortimus				
	Status Network Setup Trigger Data Stream Data Record Storage Logout Help										
			55		5	5					
System type: Fortimu	ıs Host label: S	PRT-FMUS Host name	: FMUS-DE5B (10).10.0.25) Serial num	iber: 00DE5B						
System Status			General	information							
Host name	EMUS-DE5B	Host label	SPRT_FMUS	System type	Fortimus	Product type	Fortimus				
Serial number	00DE5B	Firmware version	2.0-7593	IPv4 address	10.10.0.25 (DHCP)	SEED network and station	DG.TEST (SPRT-FMUS)				
Digitiser temperature	28.633 °C	Digitiser humidity	35.18%	Input voltage	12.725 V	Power over Ethernet voltage	0.010 V				
System time	2:56:02 PM Mon 11- Nov-2019	Uptime	19m 57s	ETH status	sckt: 11/20 data: 0/6						
			GNS	S Status							
GNSS connection statu	s Connected	Last timestamp	2019-11-11 14:56:01	1 the fit	X	Hills AONB	1 March				
Last lock time	2019-11-11 14:53:55	GNSS stability	100%	+	North Wessex	Lasta	London				
Latitude	51.3607	Longitude	-1.1631		Downs	- Arta	ANNA -				
Altitude	92.7	Horizontal dilution of precision	1.32	AT A	A A	SEXT	AAD				
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK		100	Report a problem 1 @ Oper	StreetMan contributors				
GNSS Lock state	3D locked	Number of satellites	Used: 7 In view: 10			// Report a problem (S open	Sirecular contributors				
			Data rec	ord status		-					
microSD status	Recording	microSD total	60686336 KiB	microSD used	1065912 KiB	microSD free	98%				
			Se	nsors		-					
Number of sensors detected	1										
Senso	or0	Serial number (0)		Firmware ver (0)	0.3						
Seismometer Z (0) 4325921 Seismometer N (0) -5084259 Seismometer E (0) -4594544											
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The web 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 7 on page 44 for full usage instructions.

3.2 Accessory package

3.2.1 Ethernet cable

The Ethernet connector allows use of 10BASE-T, 100BASE-T or 1000BASE-T networks. The metal gland shell-type connector that connects to the Fortimus is IP68-rated and ensures consistent connection 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 12.1 on page 141 for the pin-out and further details.

3.2.2 Compact GNSS receiver and cable

The Fortimus 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 overmoulded 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.





Please see Section 12.3 on page 143 for pin-out details.

3.2.3 Power cable

The Fortimus comes with a dedicated power cable with a standard militaryspecification bayonet connector on one end and bare ends at the other.



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

Please see Section 12.2 on page 142 for the pin-out details.

3.2.4 Diagnostic GNSS to Serial cable adapter

The Fortimus 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 Fortimus using a serial terminal emulator. (See Section 9 on page 131).



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 Fortimus 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 12.3 on page 143 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.

O Güralp Systems - Discovery														
<u>F</u> ile	<u>E</u> dit	<u>V</u> iev	/ <u>H</u> e	lp										
		Status	5	Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longitude	^
1		0		NO LABEL	Minimus	MIN-2757	10071	1.2-257	89.213.16.113	10.30.0.132	15:25:49	0.0000	0.0000	
2		0		NO LABEL	Minimus	MIN-C457	50263	1.2-230	89.213.16.113	10.30.0.68	00:29:13	0.0000	0.0000	
3	0	0		NO LABEL	Minimus Plus	FMUS-9655	38485	1.2-194	89.213.16.113	10.30.0.61	1 days 19 Hrs	0.0000	0.0000	
4	0	0		NO LABEL	Minimus	MIN-1456	5206	1.2-181	89.213.16.113	10.30.0.43	2 days 21 Hrs	0.0000	0.0000	
5		0		NO LABEL	Minimus	MIN-D457	54359	1.2-146	89.213.16.113	10.30.0.58	15:17:39	0.0000	0.0000	
6	0	0		NO LABEL	Minimus	MIN-D357	54103	1.2-146	89.213.16.113	10.30.0.31	00:03:11	0.0000	0.0000	
7		0		NO LABEL	Minimus	MIN-C355	50005	1.1-8	89.213.16.113	10.30.0.75	16:56:08	0.0000	0.0000	
8		0		RAD Comp Soak	Minimus	MIN-E256	57942	1.1-1022	89.213.16.113	10.20.0.232	17:53:49	51.3604	-1.1634	
9		0		NO LABEL	Minimus	MIN-E656	58966	1.1-1022	89.213.16.113	10.30.0.21	7 days 18 Hrs	51.3612	-1.1641	
10	0	0		Support	Minimus	MIN-C555	50517	1.1-1022	89.213.16.113	10.10.0.13	00:02:18	0.0000	0.0000	
11		0		DEMO 83	Minimus	MIN-C456	50262	1.1-1022	89.213.16.113	10.10.0.36	6 days 17 Hrs	0.0000	0.0000	
12		0		NO LABEL	Minimus	MIN-CF57	53079	1.1-1022	89.213.16.113	10.20.0.37	00:09:48	51.3607	-1.1635	
13		0		NO LABEL	Minimus	MIN-D157	53591	1.1-1022	89.213.16.113	10.20.0.102	00:09:48	51.3607	-1.1634	
14		0		NO LABEL	Minimus	MIN-2857	11095	1.1-1022	89.213.16.113	10.30.0.87	7 days 18 Hrs	51.3612	-1.1640	
15		0		TR1191-4A7	Minimus	MIN-AA57	43607	1.1-1022	89.213.16.113	10.30.0.152	2 days 17 Hrs	51.3612	-1.1640	
Se	Scan Locally Registry 52.34.40.123													
Regi	istere	d Syste	ms									gù	iralp	
78 of	79 51	/stems	respo	ondina										

An important benefit of Discovery is that it allows the user to identify the instruments' I.P. addresses on a LAN or via a cloud-based or organisational registry server without the need for static I.P. 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 Fortimus firmware from the Internet and remotely install it onto any connected Fortimus.

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 8 on page 125 for installation and usage instructions.



4 Getting started

4.1 Unpacking and packing

The Fortimus is delivered in environmentally-friendly, flat-packable, suspension packaging. The packaging is specifically designed for the Fortimus and should be re-used whenever you need to transport the sensor. Please note any damage to the packaging when you receive the equipment and unpack on a clean surface. The package should contain the digital accelerometer, the pigtail power cable, the GNSS receiver and cable, the Ethernet cable and the fixing bolt.



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

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

4.2 System set-up

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

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



To get started, connect the cables as shown in the figure above and as described in Section 3.2 on page 17.

Power up the Fortimus using a power supply with a DC output of between 10 and 36 Volts.

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

If the Fortimus 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 I.P. address automatically. More details on how to correctly configure the connection using APIPA (Automatic Private I.P. Addressing) are in Section 14 on page 158.

4.3 Güralp Discovery software installation

To view live waveforms, and to control and configure the Fortimus, you will need to use Güralp Discovery software.

Visit <u>www.guralp.com/sw/download-discovery.shtml</u> 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 13 on page 144.)



Note: Windows users may have to reconfigure the Windows FireWall in order to allow Discovery to communicate properly. Please see Section 13.4 on page 151 for full details. Brief instructions are below.

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 you understand the options available.

The following screen is displayed:

Windows Security Alert X									
Windows Firewall has blocked some features of this app									
Windows Firewall has blocked some features of discovery on all public, private and domain									
	Name:	discovery							
	Publisher:	Unknown							
	Path:	C:\program files (x86)\guralp systems\discovery \discovery.exe							
Allow discovery to	communicate or	n these networks:							
🗹 Domain netv	works, such as a	a workplace network							
Private netv	vorks, such as n	ny home or work network							
Public networks, such as those in airports and cafés (not recommended because these networks often have little or no security)									
What are the risks of allowing an app through a firewall?									
Allow access Cancel									

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 WiFi hotspots at coffee shops, airports, and other locations.

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

Once you have specified your firewall preferences, Discovery displays a main window which normally shows a list of both locally and remotely connected instruments. If you close this main window, Discovery will quit.

Discovery will initially "listen" for connected instruments on your local network. This mode can be refreshed by clicking the Scan Locally button or by pressing the



You can add instruments to the list by right-clicking in the blank area and selecting "Add device" or choosing this option from the Edit menu:

📵 Güralp Systems - Discovery - 🗆 X													
File	File Edit View Help												
	Status	Label SPRT-FMUS	System Fortimus	Name FMUS-DE5B	Firmware Ver 2.0-7544	LAN Address 10.10.0.25	Uptime 01:36:27	Last Contact Just Now	Latitude 51.3605	Longitude -1.1632	Altitude 133.70	Timing quality 0	
C		NO LABEL	Minimus	MIN-AF55	1.2-8707	10.10.0.6	6 days 1 Hrs	Just Now	0.0000	0.0000	0.00	0	
C		DEMO 83	Minimus	MIN-C456	2.0-7544	10.10.0.17	01:19:32	Just Now	51.3606	-1.1633	130.70	0	
C		SPRT-MIN	Minimus	MIN-C555	2.0-7545	10.10.0.10	00:55:04	Just Now	51.3606	-1.1633	103.10	100	
						Data V CAP R	/iewer Receiver						
Scan Locally Registry 52.34.40.123 Local Systems								miniSEED Extractor Power board control Sonardyne Debugger			güralþ		
4 of	4 of 4 systems responding												

The following dialogue is displayed:

Add device - Discovery	_		×
Device IP address:			
	Cancel	Ad	ld
			_

Enter the IP address of the Fortimus (or other device, such as Güralp Minimus) to be added and click the Add button. The newly added device will appear in the device list.



Note: The newly added device will be removed from the list and not automatically re-added if a local network scan is performed.

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.

D G	Güralp Systems - Discovery -											×								
File	Edit	Vie	N H	elp																
Live View		Syste	em Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longitude		^								
11	Scan Locally Ctrl+L Registry Ctrl+R		himus	s MIN-C555	50517	1.1-1022	89.213.16.113	10.10.0.13	02:03:18	51.3607	-1.1629									
12	Ø]	Show	Channe A		himus	s MTN-C456	50262	1.1-1022	89.213.16.113	10.10.0.36	6 days 19 Hrs	0.0000	0.0000						
13	Ø	ভ		NO LABEL	M	~	Status Label	1095	1.1-1022	89.213.16.113	10.30.0.87	7 days 20 Hrs	51.3612	-1.1640						
14		0		TR1191-4A7	Μ	~	System	3607	1.1-1022	89.213.16.113	10.30.0.152	2 days 19 Hrs	51.3612	-1.1640						
15	Ø	0		NO LABEL	м	~	Name Serial#	3351	1.1-1022	89.213.16.113	10.30.0.131	7 days 21 Hrs	51.3612	-1.1640						
16	Ø	O		NO LABEL	м	~	Firmware Ver	1287	1.1-1022	89.213.16.113	10.20.0.182	1 days 0 Hrs	51.3607	-1.1635						
17 🕑 🔳 NO LABEL 🛛 M		Cor	Connection Type)775	1.1-1022	89.213.16.113	10.20.0.180	1 days 0 Hrs	51.3606	-1.1635										
18	0	0		GSL Minimus	м	~	LAN Address	LAN Address	LAN Address	LAN Address	LAN Address	7477	1.1-1022	62.49.27.35	192.168.254.246	7 days 22 Hrs	51.3613	-1.1637		
19		0		NO LABEL	м		Netmask	1831	1.1-1022	89.213.16.113	10.20.0.242	01:34:24	51.3607	-1.1635						
20	Ø	0		NO LABEL	м	~	Uptime Last Contact	1575	1.1-1022	89.213.16.113	10.20.0.243	01:34:53	51.3607	-1.1635						
21	0	0		NO LABEL	Μ	< L	Latitude	1031	1.1-1022	89.213.16.113	10.20.0.181	1 days 0 Hrs	51.3606	-1.1635						
22 O NO LABEL M		~	Longitude Altitude	1543	1.1-1022	89.213.16.113	10.20.0.185	1 days 0 Hrs	51.3606	-1.1635		~								
Scan Locally Registry 52 Registered Systems				GNSS Quality Voltage Humidity Temperature							gür	alþ								

The "Status" column is composed of three icons that represent the digitiser connectivity status (whether Fortimus is reachable/active or not), timing status (GNSS/PTP/PPS) 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:



4.4 Viewing waveforms and system state-of-health

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

4.4.1 Using Discovery's "Live View" window

4.4.1.1 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.

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 first 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:



Selected data window

4.4.1.2 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 traces2						
+ 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						
1 + ↓	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						

4.4.1.3 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 Fortimus 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 Fortimus 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.

General Disconnect Automatically connect when server is available Disconnect Subscription configuration I new data samples for FM8859-0MAGE0 (22020101/855 Subscription configuration Automatically subscribe to all available streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of the streams Image: Control of	D FMUS-8859 - GDI Config	uration - Discovery			_		×
Subscription configuration Automatically subscribe to all available streams Image: Subscription list Subscribed streams FM8859-0ACCE0 FM8859-0ACCE2 FM8859-0ACCC2 FM8859-0ACCC2 FM8859-0ACCC2 FM8859-0ACCC2 FM8859-0ACCC0 FM8859-0ACCC2 FM8859-0ACCC2 FM8859-0ACCC0 FM8859-0ACCC2 FM8859-0ACCC2 FM8859-0ACCC0 FM8859-0ACL0 FM8859-0ACL0 FM8859-0CAL0 FM8859-0CGPS0 FM8859-0CPDMS	General	nen server is available		1 new data samples fo	r FM8859-0MAGE0 (J	Disconne 2 <i>2020101,</i>	ect <i>(850)</i>
Subscribed streams Available stream FM8859-0ACCE0 ^ FM8859-0ACCC0 FM8859-0ACCN0 FM8859-0ACCN0 FM8859-0ACCN2 FM8859-0ACCC2 FM8859-0ACCZ2 FM8859-0ACL2 FM8859-0ACL0 FM8859-0AXLE0 FM8859-0AXL0 FM8859-0AXL0 FM8859-0AXL0 FM8859-0ACL0 FM8859-0CAL0 FM8859-0CGPS0 FM8859-0CGPS0 FM8859-0CPDMS FM8859-0CPDMS	Subscription configuration	Storage configuration to all available streams					
FM8859-0ACCE0 ^ FM8859-0ACCE2 FM8859-0ACCN0 FM8859-0ACCZ0 FM8859-0ACCZ2 FM8859-0AXLE0 FM8859-0AXLE0 FM8859-0AXLE0 FM8859-0AXLE0 FM8859-0AXL0 FM8859-0AXL0 FM8859-0AXL0 FM8859-0AXL0 FM8859-0CAL0 FM8859-0CAL0 FM8859-0CGPS0 FM8859-0CGPSP FM8859-0CPDMS FM8859-0CPDMS	Subscribed streams				Ava	ailable stre	ams
FM8859-0CPD5M FM8859-0CPMPD			<< < >	FM8859-0ACCE0 FM8859-0ACCE2 FM8859-0ACCN0 FM8859-0ACCN2 FM8859-0ACCZ0 FM8859-0ACCZ2 FM8859-0AXLE0 FM8859-0AXLE0 FM8859-0AXL20 FM8859-0CAL0 FM8859-0CAL0 FM8859-0CBS0 FM8859-0CPDS5 FM8859-0CPDM5 FM8859-0CPDM5 FM8859-0CPDM5 FM8859-0CPDM5			~

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

4.4.1.4 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".

Getting started



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



4.4.2 Using Scream!

Data from the Fortimus 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 4.3 on page 23).

		Status	Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longitude
1	0	0	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 Fortimus 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.

🔛 Scream!							_		<
<u>F</u> ile <u>V</u> iew <u>W</u> indows <u>H</u> elp									
MIN-6855		Stream ID	Rec.	Comp.	SPS	End Time	Date	RIC	
🖻 🖉 Sensor0		1AXLE0	No	16 bit	100	13:30:55	14/07/2016	130	
MN6B55-AXL		1AXLN0	No	8 bit	100	13:30:58	14/07/2016	-8237	
- AMN6855-CLKC		1AXLZ0	No	16 bit	100	13:30:56	14/07/2016	14271	
MINER55-HUM		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	
BMN6855-MAG		1MAGE0	No	8 bit	5	13:29:23	14/07/2016	-5322	
MN6B55-MAS		1MAGN0	No	8 bit	5	13:29:51	14/07/2016	-6660	
MN6B55-OVIN	_	1MAGZ0	No	8 bit	5	13:28:55	14/07/2016	-1344	
MN6B55-PLLC		1MASE0	No	16 bit	100	13:30:55	14/07/2016	-4506	
- 🖯 MN6B55-ROT		1MASN0	No	16 bit	100	13:30:56	14/07/2016	3732	
AMN6855-TMP		1MASZ0	No	16 bit	100	13:30:59	14/07/2016	-1655	
- AMN6855.VEL		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	
RA03ED-1AXL		1VELE0	No	32 bit	200	13:31:00	14/07/2016	-590772	
BA03ED-1INT		1VELEC	No	32 bit	200	13:31:00	14/07/2016	-2006039	
BRA03ED-1MAG		1VELN0	No	32 bit	200	13:31:00	14/07/2016	-1617447	
BA03ED-1MAS		1VELNC	No	32 bit	200	13:31:00	14/07/2016	-1512488	
BRA03ED-1BOT		1VELZ0	No	32 bit	200	13:31:00	14/07/2016	-493488	
BBA03ED-1TMP		1VELZC	No	32 bit	200	13:31:00	14/07/2016	-201964	
		AXLEO	No	16 bit	100	13:30:56	14/07/2016	-672	
BRAUSED-IVEL	_	JAXLN0	No	8 bit	100	13:30:58	14/07/2016	-296	_
Server: 10.10.0.5:1567		51 streams		1,372,1	40 Kb :	stream buffer	PC Time (UTC)	: 13:31:06	11

To configure the Fortimus, double-click on its entry to open its web page.

Note: If stream recording is enabled, make sure that the file-name format in Scream! (on the Files tab of the <u>File→Setup</u> dialogue) is set to YYYY\ YYYYMN\YYYMMDD\I_A_YYYYMDD_HHNN in order to prevent file names conflicting. More information can be found in Scream! manual <u>MAN-</u> <u>SWA-0001</u> available on the Güralp website.

5 LCD Display menu

The Fortimus is equipped with a multi-touch, 2.4 inch (61 mm), full colour LCD display that shows the instrument's state of health, inclination and real-time output waveforms. It also allows configuration of the instrument as well as some control operations.

While the Fortimus is booting up, it displays a white screen with the Güralp logo in the middle and a progress-bar at the bottom.



Once the Fortimus has booted up completely, the LCD automatically displays the "status" page.

To move back to the main menu, touch anywhere in the screen and the main menu will be displayed.

Note: When using the touch screen, keep your finger in place on each button for approximately half a second to ensure that your touch is registered. This delay helps prevent accidental triggering of menu functions. The LCD's touch features can be disabled completely if desired: see Section 5.6.3 on page 40 for details.

The LCD behaviour can be configured in the Fortimus web interface, see Section 7.8 on page 52 for more details.

The complete LCD menu map is illustrated in Section 15 on page 161.

5.1 Main menu

The main menu offers the following options:

- status
- settings
- alignment
- waveform
- maintenance



These are discussed in the following sections.

5.2 Status



The "status" page shows information about serial number, Bluetooth status, time and date, GNSS/PTP status, input voltage and power, humidity, temperature, microSD cards recording status, I.P. address.

The top of the status display shows a series of icons:



These, from left to right, correspond to synchronisation (\bigcirc), GNSS location (\bigcirc), WiFi reception ($\widehat{\frown}$) and Bluetooth status (3). The icon does not appear if the relevant service is disabled. If the service is enabled but in a fault condition (i.e. not connected or no GPS fix found), the icon is shown with a line through it.

Warning and errors are shown here when necessary. Warnings are shown with an amber triangle on a grey background ((), as shown on the left below. Errors are show with a red circle on an amber background ((), as shown on the right.



The messages that can be displayed are:

- Normal operation:
 - System OK : GNSS or PTP are locked, microSD cards are recording.
- Warnings:

- **Warning! SD card not fitted** : At least one of the microSD cards is not recording.
- Warning! Waiting for PPS lock : PPS signal is unstable.
- Errors:
 - Error! Clock not locked (0%) : GNSS quality is less than 95% and PTP is not available.
 - **Error! Clock not locked (PTP 0%)** : PTP quality is less than 80% and GNSS is not available.
 - **Error! Clock not locked (NTP only)** : GNSS quality is less than 95% and PTP quality is less than 80%.

5.3 Settings



The "settings" menu offers the following options:

- display; and
- network.

These are discussed in the following sections.

5.3.1 Settings \rightarrow display



The "display" page allow control of brightness, the inactivity time-out and the orientation of the display.

• The brightness can be set to be adjusted automatically, based on the ambient light level, or manually adjusted with the "lower" and "higher" buttons.

The display can be set to stay on permanently (with a consequent increase in power consumption) or to automatically switch off after 5 s, 10 s, 30 s, 60 s or 120 s of inactivity. The currently-selected mode is indicated by the green background.

When the display has been switched off, it can be switched on again by touching and holding for a second.

• The orientation can be set to be normal or flipped. Selecting "auto-flip" will instruct the instrument to flip the display automatically based on attitude as determined by the internal MEMS accelerometer. The currently-selected mode is indicated by the green background.

5.3.2 Settings \rightarrow network



The network page allows you to choose between DHCP mode, where the networking parameters are set by an external DHCP server, or static mode, where the network parameters must be typed in manually.

The current network mode is shown on the main status display:



If you select DHCP mode from the network page, you are asked for confirmation but no other configuration is required:


If you select static mode from the network page, you are prompted first for the IP address:



Enter the desired IP address using the on-screen virtual numeric keypad and then press "next", which takes you to the netmask screen.

Enter the desired netmask in the same way. Pressing "next" again takes you to the "Gateway IP" screen:



After entering the IP address of your gateway (default router), press "next" again to reach the confirmation screen:



Pressing "apply" here configures the Fortimus with the parameters that you have just entered. Pressing "cancel" discards all of the changes and the Fortimus' networking configuration is not affected.

5.4 Alignment



The "alignment" page shows a virtual bubble level based on the output of the MEMS accelerometer built-in the Fortimus. The red circle moves around the screen as the position of the Fortimus is altered, mimicking the bubble in a real bubble level; i.e. the red circle moves towards the highest part of the top of the instrument.



Note: The virtual bubble level works if and only if the MEMS accelerometer channels are enabled for streaming and/or recording.

See Section 6.1 on page 41 for more details about using the alignment tool.

5.5 Waveform



The "waveform" page shows real-time data in graphical format. The horizontal axis represents time and the display constantly scrolls to the left as the latest data are plotted on the right-hand side of the graph. Three modes are available:



In "seismic" mode, the signals from the main acceleration outputs of the Fortimus are displayed.



In "accel..." mode, the outputs from the internal MEMS accelerometer are displayed.



In "auxiliary" mode, the display graphs the output from the internal temperature sensor, the internal supply voltage and the power consumption.

5.6 Maintenance



The "maintenance" page allows the user :to

- reboot the system;
- reset the configuration to factory values; and
- lock the "settings" and "maintenance" pages to prevent undesired alteration.

These are discussed in the following sections.

5.6.1 Reboot



This option reboots the processor in the Minimus digitiser without interrupting power. Because this will interrupt digitisation and potentially affect the configuration (some changes only take effect after a reboot), it is protected by a confirmation screen.

Click if you wish to continue and if you have arrived at this screen unintentionally and wish to return to the main menu.

5.6.2 Restore factory settings



This option restores the configuration to the state in which the instrument was delivered. Because this will interrupt digitisation and affect the configuration, it is protected by a confirmation screen.

Click if you wish to continue and if you have arrived at this screen unintentionally and wish to return to the main menu.

5.6.3 Lock the configuration



This option locks the LCD interface so that the instrument can only be reconfigured via its web interface. This can be useful when physical access to the instrument cannot be fully controlled. Because this can be disruptive, this option is protected by a confirmation screen.

Click if you wish to continue and if you have arrived at this screen unintentionally and wish to return to the main menu.



Note: Once "settings" and "maintenance" are locked, they can only be reenabled from the Fortimus web page. See Section 7.8 on page 52 for more details.

6 Installation

6.1 Permanent installation

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

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

 Prepare the surface by scribing an accurate N/S orientation line and installing a grouted-in fixing bolt on the line, near the middle. An anchor terminating in a 6 mm or 8 mm (1/4 or 5/16 inch) threaded stud is suitable.

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



2. Place the accelerometer over the fixing bolt and rotate to bring the orientation line and pointers accurately into registration with the scribed base-line.

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

- 3. Connect all the cables as described in Section 4.2 on page 22 and power on the Fortimus.
- 4. Touch the alignment button at the top right of the LCD screen: This will display the digital levelling tool

Installation



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

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



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

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



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

The instrument is now installed and transducing ground motion.

6.2 Temporary installations

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

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

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

6.3 Installation in Hazardous environments

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

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

System configuration 7

Advanced 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 address of the instrument from any common web browser.

Note: Some changes in the settings require a system reboot to be applied. This is notified on the top right of the Fortimus web page with the message *Reboot Required*. It is suggested to perform all the modifications and reboot the Fortimus when the configuration is completed clicking on any of the Reboot buttons.

7.1 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.

			güral	JNDERSTANI OPTIMISE PROTECT			
							Fortim
Sustam tunai Fastimuu	Host Joholy (Status	Login Help			
System type: Fortinus System Status	s nost label: 3	SPRI-FMUS Host name	E FMUS-DESD (10	. 10.0.20] Senai nun	IDel: UUDEDD		
-			General	information			
Host name	FMUS-DE5B	Host label	SPRT-FMUS	System type	Fortimus	Product type	Fortimus
Serial number	00DE5B	Firmware version	2.0-7593	IPv4 address	10.10.0.25 (DHCP)	SEED network and station	DG.TEST (SPRT-FMUS)
Digitiser temperature	27.592 °C	Digitiser humidity	35.16%	Input voltage	12.725 V	Power over Ethernet voltage	0.010 V
System time	3:03:20 PM Mon 11- Nov-2019	Uptime	27m 15s	ETH status	sckt: 11/20 data: 0/6		
			GNS	S Status			
GNSS connection status	Connected	Last timestamp	2019-11-11 15:03:19	ALL AL	X	Hills AONB	AND
ast lock time	2019-11-11 14:53:55	GNSS stability	100%	+	North Wessex	lost	London
Latitude	51.3602	Longitude	-1.1628	1-542	AONB	- ALAN	CAR A
ltitude	77.7	Horizontal dilution of precision	1.49		FE /	200	ACA
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK	The	100	Report a problem I @ Oper	
GNSS Lock state	3D locked	Number of satellites	Used: 7 In view: 11			17	
nin na CD status	Description	aniana OD tatal	Data rec	cord status	4000 100 100	mines CD for a	0.000
nicrosD status	Recording	microsp total	00080330 KIB	microsD used	1000420 KIB	microSD free	90%
Number of sensors		1	5e	115015		1	
detected	1						
Senso	r0	Serial number (0)		Firmware ver (0)	0.3		
		Seismometer Z (0)	-4320794	Seismometer N (0)	-5063998	Seismometer E (0)	-4605983

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 username 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 Fortimus 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.

	güralp UNDERSTAND OPTIMISE PROTECT		
			Minimus
Status Network	Setup Trigger Data Stream	Data Record Storage	Logout Help
System type: Minimus Host label: SPRT-M	IN Host name: MIN-C555 (10.10.0.10) 3	Serial number: 00C555	
Network Config			
DHCP Enabled ~		_	
DNS1 209.244.0.3	DN S2 84.200.69.80		Reboot
Web Login Required 🗸	Username (Normal) user	Password ******** (Normal)	HTTP Port 80
Web Timeout Required	Username (Admin) admin	Password ************************************	
		I	Send SeedLink

7.2 System status

The "Status" tab of the web browser interface provides state-of-health information about the Fortimus. These parameters are described as follows:

- Host name: the serial number of the Fortimus;
- Host label: the customisable name of the Fortimus system;
- System type: the name of the connected instrument, e.g. "Fortimus";
- **Product type**: the type of the connected instrument, e.g. "Fortimus";

- Serial number: the serial number of the Fortimus;
- Firmware version: the DIG firmware version running on the Fortimus;
- IPv4 address: the static or Dynamic LAN I.P. address of the Fortimus;
- SEED network and station: Network and Station SEED codes of the Fortimus;
- **Temperature**, **humidity**, **Input voltage** and **PoE voltage**: the internal temperature and humidity of the Fortimus; input voltage supplied and optional PoE voltage supplied to the Fortimus;
- System time: the current internal system date and time;
- Uptime: the time the Fortimus has been running since the last reboot;
- **ETH status**: the number of total active TCP connection in use and connection used for data transmission;
- GNSS status, last GNSS timestamp, last GNSS lock time since significant timing drift or re-boot, GNSS stability of the lock, horizontal dilution of precision (based on satellite coverage), GNSS PPS status, GNSS NMEA stream, GNSS lock state (2-D or 3-D), number of satellites used and in view;
- Latitude, longitude and altitude of the system, as provided by the GNSS receiver;
- PTP state, last PTP timestamp, last PTP lock time since significant timing drift or re-boot, PTP stability in time accuracy, master IPv4 address (I.P. address of the PTP master), master clock class and accuracy, master time source, network path delay, network jitter estimate (quality indicator in ns), network outliers;
- MicroSD card recording status, total storage capacity, used storage space and available storage space;
- Real-time sensor values from the accelerometer.

7.3 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 7.9 on page 54).

7.4 Network configuration

7.4.1 I.P. address and gateway

By default, the Fortimus 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 I.P. address, the Net Mask and the address of the Gateway (default router), as shown:

	güralp UNDERSTAND OPTIMISE PROTECT									
			Minimus							
Status Netwo	k Setup Trigger Data Stream	Data Record Storage	Logout Help							
System type: Minimus Host label: SPRT-	System type: Minimus Host label: SPRT-MIN Host name: MIN-C555 (10.10.0.10) Serial number: 00C555									
Network Config										
DHCP Disabled ~	Static IP addr 10.10.0.10	Net Mask 255.255.255.0	Gateway 10.10.255.1							
DNS1 209.244.0.3 Disabled	DN S2 84.200.69.80		Reboot							
Web Login Required ~	Username (Normal) user	Password ******* (Normal)	HTTP Port 80							

Before any changes made here will take effect, the Fortimus must be re-booted. To do this, click the Reboot button on the "Data Record" tab.

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

The first two bytes of the address, therefore, are always 169.254. The third byte is the equal to the last two characters of the serial number interpreted as a hexadecimal number and then converted into base 10. The forth byte is the equal to the next-to-last two digits of the serial number, also converted from hexadecimal into base 10.

For example, if the serial number of the Fortimus is FMUS-C555, the preassigned Static I.P. address will be 169.254.85.197, where

- FMUS-C555 \Rightarrow "55" \Rightarrow (55)₁₆. = (85)₁₀ \Rightarrow 85 and
- FMUS-C555 \Rightarrow "C5" \Rightarrow (C5)₁₆ = (197)₁₀ \Rightarrow 197

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

D Edit Network Address - Discovery ?										
Device Serial #: 50517 Update IP configuration:										
Network Address:	10 .10	0.0	.31							
Netmask:	255.25	5.0	.0							
Gateway:	<keep< td=""><td>exis</td><td>ting></td><td></td><td></td></keep<>	exis	ting>							
Obtain IP address automatically (DHCP)										
Local : 169.254.185.	6		ок	Can	cel					

7.4.2 NTP (Network Timing Protocol) configuration

Note: Network Timing Protocol (NTP) is only used for setting the system's internal clock at boot-up, it is *not used for sample timing*. See Section 7.12 on page 72 for details about synchronising the sample clock.

However: if neither GNSS nor PTP are available but NTP is locked and the sample clock's time is more than five seconds different from NTP's time, the sample clock will be adjusted (in a step-change) to NTP time.

By default, the NTP server option 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 I.P. 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 I.P. address of your NTP server here.

7.5 WiFi

The Fortimus can act as a WiFi client, connecting to an existing WiFi network. Both open and secure (WEP, WPA and WPA2) networks are supported.

Note: The Fortimus does not function as WiFi access point (AP) so it is not possible to connect a WiFi-enabled laptop, for example, directly to the unit. A separate WiFi AP is required in this case so that both laptop and Fortimus can connect to the same network.

The WiFi connection is configured and monitored from the "Network" tab of the Fortimus web page:

WiFi					
Status	WiFi Standby	🗹 WiFi Enable	Access Points	Select Network	~
Requested AP	gold	Password	Connect		Auto Connect
Connected to		WiFi IP			

7.5.1 Connecting to a WiFi network

Visit the "Network" tab of the Fortimus web page and ensure that:

- the "WiFi Enable" check-box is ticked; and
- the "Auto Connect" check-box is clear as high-lighted above.

Use the "Access Points" drop-down menu to select the desired network and enter the password or passphrase in the "Password" text field, if required.

Click the **Connect** button to connect to the network.

Note: A Fortimus connect to a WiFi network automatically appears in Discovery's "Scan Locally" section only when (a) the computer running Discovery is connected to the same WiFi network *and* (b) the Fortimus' Ethernet is disconnected or disabled.

7.5.2 WiFi connection status

The status of the WiFi connection is displayed at the top left of the WiFi section of the Network tab of the web page:

WiFi		_		
Status	WiFi Off	🗌 WiFi Enable	Access Points Select Network	~
Requested AP	gold	Password	Connect	Auto Connect
Connected to		WiFi IP		

The possible values for the status are:

- WiFi off the WiFi interface is disabled. Tick the "WiFi Enable" check-box to enable the interface, if required.
- WiFi Standby the WiFi interface is enabled but not currently connected to any network. If no connection is required, clear the "WiFi Enable" check-box to disable the interface.
- WiFi Connecting the WiFi interface is in the process of connecting to the selected network.
- WiFi Connected the WiFi interface is connected to the network shown in the box below and the DHCP server has allocated the IP address displayed in the adjacent box. (Static IP addressing is not supported).

Once a successful connection is established, tick the "Auto Connect" check-box so that the Fortimus will attempt to reconnect to the same network whenever possible. The name of the selected network appears in the "Requested AP" box.

7.5.3 Changing WiFi networks

WiFi						
Status	WiFi Connected	🗹 WiFi Enable		Access Points	Select Network	~
Requested AP	gold	Password	MidasTouchLobby	Connect		Auto Connect
Connected to	gold	WiFi IP	192.168.254.120			

A different network can be selected from the "Access Points" drop-down menu – and the new password entered – while the Fortimus is still connected to a network. The instrument will not connect to the new network until the **Connect** button is clicked.

7.6 GDI push (auto-connection)

A Fortimus 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 Fortimus 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 I.P. 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 s	ettings				
Connection		Connection	Connection	Connection	

When auto-connection from a Fortimus to a host is configured, the Fortimus 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 Fortimus will then negotiate a link and start streaming data.

If the connection drops, the Fortimus 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 11 on page 140 for a list of the network ports used by the Fortimus.

7.7 QSCD

The Fortimus can push data in QSCD format (**Q**uick Seismic **C**haracteristic **D**ata) to one or more clients, using outgoing network connections.

To configure a connection, locate the QSCD section of the Network tab of the web page, as shown below. Type either the I.P. address or the host-name of the target client into any of the "Server" fields. This will push data using UDP port 9908, which is the default. If you wish to use a different port number, add a colon (':') and the port number to the end of the specification. For example, 192.0.2.91:9876 or gscd.server.com:9876.

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

The Fortimus does not automatically send all data when using the QSCD protocol. Channels to be transmitted must be selected (in Z/N/E triplets) and each channel passed through a QSCD transform. See Section 7.16.12 on page 99 for details on how to configure this transform.

7.8 Controlling the LCD from the web interface

In the "Setup" tab of the Fortimus web page, the user can remotely control the LCD display settings.

Locking and unlocking of the "settings" and "maintenance" features can be selected using the drop-down menu named "Display settings":

				Display			
Display settings	Unlocked 🗸	Display brightness	Auto 🗸	Display switch-off	Never ~	Display flip	Auto ~
Touch sense	Unlocked						
	Locked		0	and Questioner Limited			

The display brightness is adjustable using the drop-down menu named "Display brightness":

3611501	Sensor u 🗸	uh l		Azimuui	U	Debri	U
Fortimus			Auto				
			10%	ensor Status			
Initialisation	Complete	Sensor State	20%				
			30%	dentification			
Model	Fortimus	Serial Number 0 (40%	Firmware	0.3	Configuration 1	
			50%	Response		_	
Fortimus Range	-1.0g; +1.0g $ \sim $	Fortimus Loop	60%				
			700/	ass Centring			
Centre Mass			70%				
			80%	Calibration		•	
Calibration	Off ~	Amplitude	90%	Calibration Signal	Disabled ${\scriptstyle \lor}$		
			100%	Display			
Display settings	Unlocked $ \sim $	Display brightness	Auto 🗸	Display switch-off	Never ~	Display flip	Auto ~
Touch sense	Enable 🗸						

The display can be set to switch off after a selectable period of time while it is untouched. When the display is off, it can be switched back on by touching it for a couple of seconds.

				sensor status				
Initialisation	Complete	Sensor State	ldle			Never		
				Identification		5s		
Model	Fortimus	Serial Number	0 (0x0)	Firmware	0.3	10s	Configuration 1	
				Response		205		
Fortimus Range	-1.0g; +1.0g $ \smallsetminus $	Fortimus Loop	Normal \sim			200		
		•	1	Mass Centring		305		
Centre Mass						45s		
				Calibration		60s		
Calibration	Off ~	Amplitude	100% ~	Calibration Signal	D	90s		
				Display		120s		
Display settings	Unlocked $ \sim $	Display brightness	Auto 🗸	Display switch-off		Never ~	Display flip	Auto ~
Touch sense	Enable 🗸							

The LCD is, by default, oriented with the top of the screen pointing North (relative to the instrument). The orientation can be flipped by 180 degrees if required or it can be set to "automatic". When the auto-flip is enabled the orientation changes according to the MEMS output.

				Display				
Display settings	Unlocked $ \smallsetminus $	Display brightness	Auto 🗸	Display switch-off	Never ~	Display flip	Auto	~
Touch sense	Enable \vee			-			Norm	nal
			0	urale Custome Limited			Auto	
		Midas	House, Calleva I Tel: +44 118 9	Park, Aldermaston, Reading, RG7 8 981 9056, Fax: +44 118 981 9943	EA, UK		Flip	

For security reasons, the LCD's touch sensor can be disabled using the option "Touch sense". Once disabled, touching the screen has no effect and no commands can be issued via the LCD.

To restore normal operation, set "Touch sense" to "Enable" from the Fortimus web page.

				Display			
Display settings	Unlocked $ \smallsetminus $	Display brightness	Auto 🗸	Display switch-off	Never ~	Display flip	Auto ~
Touch sense	Enable 🗸						
	Enable		G	uraln Svetame Limited			
	Disable	Mida	s House, Calleva Tel: +44 118 9	Park, Aldermaston, Reading, F 981 9056 Fax: +44 118 981 9	RG7 8EA, UK 943		



Note: "Touch sense" can be re-enabled *only* from the web interface. It is not possible to re-enable it using the LCD screen.

7.9 Data storage

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

	güralp UNDERSTAND OPTIMISE PROTECT				
				Fortimus	
	Status Netw	rork Setup Trigger Data Str	eam Data Record Storage	ogout Help	
	otatus nem	ione octup migger Data oti	cam Data Necord Storage	Logour help	
System type: Fortimu	s Host label: SPF	RT-FMUS Host name: FMUS-DE5B (10.	10.0.25) Serial number: 00DE5B		
Data Record			1		
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	All ~	Apply configuration for tap groups		Display On Page Sensor 0 🗸	
Channels configu	uration				
Channel samp	pling rate	Data transform	SEED name - please use check-box to modify the default	RESPonse file - if available	
		Seismic	channels		
S0CalibA	200 Hz 🗸 🗸	Transforms Disabled for this tap $$	DG.TEST. 00 HCA	<u>RESP_file_6</u>	
S0SeisZA	200 Hz 🗸 🗸	Transforms Disabled for this tap $\!$	DG.TEST.00 .HNZ	<u>RESP_file_9</u>	
S0 SeisNA	200 Hz 🗸 🗸	Transforms Disabled for this tap $$	DG.TEST.00 .HNN	RESP_file_13	
SOSeisEA	200 Hz 🗸	Transforms Disabled for this tap $\!$	DG.TEST.00 .HNE	RESP_file_17	
S0 SeisZB	Disabled $ \smallsetminus $	Tap Disabled 🗸	DG.TEST.00 .ANZ	RESP_file_10	
S0 SeisNB	Disabled $ \sim $	Tap Disabled 🗸	DG.TEST. 00 .ANN	RESP_file_14	
SOSeisEB	Disabled $ \sim $	Tap Disabled 🗸	DG.TEST. 00 .ANE	RESP_file_18	
		MEMS accelero	meter channels		
SOAccZA	100 Hz 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 99 .HNZ	<u>RESP_file_26</u>	
SOAccNA	100 Hz 🗸 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 99 .HNN	<u>RESP_file_30</u>	
SOAccEA	100 Hz 🗸 🗸	Transforms Disabled for this tap $\!$	DG.TEST. 99 .HNE	<u>RESP_file_34</u>	
SOAccZB	Disabled $ \sim $	Tap Disabled $\!$	DG.TEST. 99 ANZ	RESP_file_27	
SOAccNB	Disabled $ \sim $	Tap Disabled $\!$	DG.TEST. 99 .ANN	<u>RESP_file_31</u>	
SOAccEB	Disabled $ \sim $	Tap Disabled $\!$	DG.TEST. 99 ANE	RESP_file_35	
		Magnetome	ter channels		
SOMagZ	5 Hz 🗸 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 99 MFZ	RESP_file_38	
SOMagN	5 Hz 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 99 .MFN	RESP_file_40	
SOMagE	5 Hz 🗸 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 99 .MFE	RESP_file_42	

This page allows to configure the recording channels available in the Fortimus.

The names and contents of each file are described in Section 10 on page 137.



Note: When changing a setting in the Fortimus 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. SOSeisZA, SOSeisNA, SOSeisEA.

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 real-time transmission channels by clicking the Copy to Data Stream button. Default channel configuration can be applied by clicking the Restore default button.
- in second column from the left, drop-down boxes are available for each channel to enable/disable transforms and, once transform is enabled, to select the transform to apply (see Section 7.16 on page 87);
- 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 7.14.4 on page 81).

Upon changing the sample rate, enabling a transform or changing Location and Channels codes, the Fortimus 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 3.1.2 on page 10) and the instrument web page will display the following screen.

FMUS-C456 is rebooting ...

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

7.10 Storage

7.10.1 Recording status

MicroSD cards need to be specifically formatted to operate with the Fortimus. The cards shipped with the Fortimus and with Radian systems 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.

SD Cards status			
External microSD card present	PRESENT	Number of 128-MiB miniSEED files	452
External microSD card usable	USABLE	Internal microSD card usable	USABLE
External microSD card init count	1	Internal microSD card init count	1
External microSD card is primary microSD card	PRIMARY	Internal microSD card is primary microSD card	BACKUP
Primary microSD card is recording samples	RECORDING	Backup microSD card is recording samples	RECORDING

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 <u>QuickformatCards</u> or <u>FulformatCards</u> may solve the issue. Note that the quick format simply moves the write-pointer to the beginning of the recording space, hence overwriting any existing data. The full format, in contrast, erases all the existing data (and can take several hours).

7.10.2 MicroSD card re-formatting

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

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

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

Note: A series of tests separated only by quick formats can leave some files with residual data in them. This is not normally a problem because a deployment will typically create data-sets longer than any test, overwriting any data remaining from the tests. The miniSEED extractor utility described in Section 7.11.3.1 on page 71 can be used to remove the residual data if they cause any problems.

7.10.2.1 Quick format

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

🚺 Java	script Confirm - http://10.10.0.13/tab7.html - Discovery	×
	Are you sure? Quickformat will erase the data from all of the installed cards. Please make sure that no important data will get destroyed before continuing.	
	OK Cancel	

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

7.10.2.2 Full format

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

D Javas	D Javascript Confirm - http://10.10.0.13/tab7.html - Discovery X						
1	Are you sure? Fullformat will erase the data from all of the installed cards. Pleas make sure that no important data will get destroyed before continuing.	;e					
	OK Cancel						

The process takes several hours: check the status countdown indicators on the topright of "Storage" tab.

SD Card control

Flush data	Unmount Cards	Quickformat Cards	Fuliformat Cards
			Formatting progress: 0% ~196 minutes remaining



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

7.10.3 MicroSD card data flushing and unmounting

The **Flush data** button flushes data still in the buffer into the microSD card storage. Perform a flushing before downloading data from the Storage tab (see Section 7.10.4 on page 58) or event table (see Section 7.17.5 on page 110).

The <u>Unmount Cards</u> 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.

7.10.4 Download recorded data

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

~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		V		güralp	UNDERSTAND OPTIMISE PROTECT	
						Minimus	
	Status	Network Setup Trigger Data St	tream Data Record	Storage	Logout Help		
Syste	em type: Minimus   Host labe	el: SPRT-MIN   Host name: MIN-C555 (10.10.0.	10)   Serial number: 00C55	55			
SD	Card control						
	Flush data	Unmount Cards	Quickformat Cards		Fullformat Ca	irds	
					Formatting status	: idle	
SD	Cards status						
Exter	nal microSD card present	PRESENT	Number of 128-MiB minis	SEED files	463		
Exter	rnal microSD card usable	USABLE	Internal microSD card us	able	USABLE		
Exter	rnal microSD card init count	1	Internal microSD card ini	it count	1		
Exter	nal microSD card is primary	microSD card PRIMARY	Internal microSD card is	primary micro	SD card BACKUP		
Prima	ary microSD card is recordin	g samples <b>RECORDING</b>	Backup microSD card is	recording sam	nples RECORDING	G	
Cha	annel data download by	y time selection				1	
	Channel: DG	TEST.00.HDF V From: dd / mm / yyyy	: To: dd / mm / 3	YYYY  :	Download		
SD (	Card files						
÷		Filename 💠	Size (bytes) 💠	1	Last data times	tamp 🔶	
	00C555 SOAccEA	00100 00000.mseed	16726272	2019-11-07	16:38:35.11000	0000	
П	00C555 SOSeisEA	00200 00001.mseed 1	102752256	2019-11-07	16:35:58.27000	0000	
	00C555 SOSeisNA	00200 00002.mseed	L02764544	2019-11-07	16:40:54.14500	0000	
П	00C555 SOSeisZA	 00200 00003.mseed	115785728	2019-11-07	16:40:58.61000	0000	
	00C555 SOSeisXA	00200 00004.mseed 5	95154176	2019-11-07	16:36:31.36000	0000	
	00C555 SOAccNA	 00100 00005.mseed	58460544	2019-11-07	16:37:06.54000	0000	
	00C555 SOAccZA	 00100 00006.mseed	77713408	2019-11-07	16:37:21.24000	0000	
	00C555 SOIntE	 00100 00007.mseed	17247360	2019-11-07	16:36:38.20000	0000	
	00C555 SOIntN	 00100 00008.mseed	17206400	2019-11-07	16:36:38.20000	0000	
	00C555 S0IntZ	 00100 00009.mseed	17185920	2019-11-07	16:36:38.20000	0000	
	status.log		3594107	2019-11-07	16:32:00.00000	0000	
	system.log		233008	2019-11-07	16:28:52.00000	0000	
	init.log	2	232796	2019-11-07	16:28:53.00000	0000	
	table of events.bin		537600	2019-11-07	16:10:56.00000	0000	
Dov	wnload selected files						
Aux	ciliary files						
	Filename		Descripti	on		¢	
fram	1.log	FRAM log file					
calv	als.txt	SCREAM! calibration values	3 Taina				
cali	b.txt	Calibration text file	јатив				
	Calibration text file Guralp Systems Limited Midas House, Calleva Park, Aldermaston, Reading, RG7 8EA, UK Tel: +44 118 981 9056, Fax: +44 118 981 9943 E-Mail: sales@guralp.com, support@guralp.com						

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

#### Güralp Fortimus

Opening Sensor0SeismoZSm_000000200_00003.mseed	×
You have chosen to open:	
Sensor0SeismoZSm_000000200_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	

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.

#### 7.10.5 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:

Cha	Channel data download by time selection									
	Channel:	DG.TEST.00.HDF	√ F o	m: dd / mm / yyyy	:	To: dd / mm / ;	уууу -	:	Download	
SD	Card files	DG.TEST.00.HDF	^							
		DG.TEST.00.HDF								
\$		DG.TEST.00.HHZ		\$	Size (	bytes) 🔷 🖨		Last	data timesta	amp 🜩
	00C555_S0AccEA	DG.TEST.00.HHZ	ed		76812288		2019-11	-07 16:	53:08.4700000	000
	OOC555_SOSeisEA	DG.TEST.00.HHN	ed		102875136		2019-11	-07 16:	52:23.1950000	000
	OOC555_SOSeisNA	DG.TEST.00.HHN	ed		102842368		2019-11	-07 16:	51:18.0750000	000
	00C555_S0SeisZA	DG.TEST.00.HHE	ed		115867648		2019-11	-07 16:	51:30.7350000	000
	OOC555_SOSeisXA	DG TEST 00 HHE	ed		95268864		2019-11	-07 16:	51:50.500000	000
	00C555_S0AccNA	DG TEST 00 HMZ	ed		68534272		2019-11	-07 16:	50:45.090000	000
	00C555_S0AccZA	DG. TEST.00.HMZ	ed		77799424		2019-11	-07 16:	51:14.460000	000
	00C555_S0IntE	DG. TEST.00.HMZ	ed		47296512		2019-11	-07 16:	49:50.320000	000
	00C555_S0IntN	DG.TEST.00.HMN	ed		47255552		2019-11	-07 16:	49:50.320000	000
	00C555_S0IntZ	DG.TEST.00.HMN	ed		47235072		2019-11	-07 16:	49:50.320000	000
	00C555_S0HumidA	DG.TEST.00.HME	ed		4960256		2019-11	-07 16:	45:55.700000	000
	00C555_S0Voltage	DG.TEST.00.HME	ed		8941568		2019-11	-07 16:	47:53.500000	000

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

Cha	Channel data download by time selection									
	Channel: DG.TEST.00.HDF 🗸 From: dd / mm / yyyy 🛛 : To: dd / mm / yyyy 🛛 : Download									
SD	Card files								、 、	
			<		Noven	nber 2	019	~	>	
\$		Filename	Mon	Tue	Wed	Thu	Eri	C =+	Sum	Last data timestamp 🔶
	00C555_S0AccEA	00100_00000.mseed	Mon	Tue	wed	mu	FII	Sqr	Sun	2019-11-07 16:53:08.470000000
	OOC555_SOSeisEA	00200_00001.mseed	28	29	30	31	1	2	3	2019-11-07 16:52:23.195000000
	00C555_S0SeisNA	00200_00002.mseed	4	5	6	7	8	9	10	2019-11-07 16:51:18.075000000
	00C555_S0SeisZA	00200_00003.mseed	11	12	13	14	15	16	17	2019-11-07 16:51:30.735000000
	00C555_S0SeisXA	00200_00004.mseed	18	19	20	21	22	23	24	2019-11-07 16:51:50.50000000
	00C555_S0AccNA	00100_00005.mseed								2019-11-07 16:50:45.090000000
	00C555_S0AccZA	00100_00006.mseed	25	26	27	28	29	30	1	2019-11-07 16:51:14.460000000
	00C555_S0IntE	00100_00007.mseed	2	3	4	5	6	7	8	2019-11-07 16:49:50.320000000
	00C555 S0IntN	00100 00008.mseed				2000	12			2019-11-07 16:49:50.320000000

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



**Note:** The pop-up calendars are not supported by Discovery's built-in browser. The required dates can simply be typed in or the entire operation can be performed in an external web browser.

### 7.10.6 Bulk data extraction

To view files saved on the external microSD card, remove the card, as described in Section 3.1.5 on page 12. Insert the card into a microSD card reader (external or inbuilt) on your PC/laptop. Within a few seconds, the card should appear as a removable disk/drive.

A microSD card formatted for the Fortimus 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.

<b>_</b>   🛃	<b>-</b> - 1			Drive Tools	Removable Disk (D:)					-	⊐ ×
File	Home	Share	View	Manage							^ 🕐
Navigation pane 👻	🔲 Previe	ew pane Is pane	Extra I	arge icons icons	Large icons	Medium-sized icons     ∧       Image: Details     ▼       Image: Details     ▼	Sort by •	<ul> <li>Group by ▼</li> <li>Add columns ▼</li> <li>Size all columns to fit</li> </ul>	<ul> <li>Item check boxes</li> <li>File name extensions</li> <li>Hidden items</li> </ul>	Hide selected items	Options
	Panes				Layout			Current view	Show/hide		
$\leftarrow \  \  \rightarrow$	· 1	→ This	PC → Rer	novable Disk	(D:)				✓ Ö Search Re	movable Disk (	D:) ,0
						÷					

#### 7.10.7 The contents of the microSD 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.

Eemovable Disk (D:) - C									
$\leftarrow$ $\rightarrow$ $\checkmark$ $\uparrow$ $\blacksquare$ $\Rightarrow$ This $\Rightarrow$ Removable D	Search Remova	ble Disk (D:) 🔎							
Name	Date modified	Туре	Size						
all_miniSEED_files_are_in_here	20/07/2016 03:00	File folder							
GU.dataless	20/07/2016 03:00	DATALESS File	4,608 KB						
use_this_file_with_Win32DiskImager.exe_t	20/07/2016 03:00	Disc Image File	1,184 KB						
init.log	20/07/2016 03:00	Text Document	65,536 KB						
system.log	28/07/2016 03:00	Text Document	65,536 KB						
5 items									

The typical contents of the all_miniSEED_files_are_in_here directory looks like this:

🔜   💆 🔜 🗧   all_miniSEED_files_are_in_here			- 🗆 X
File Home Share View			~ (
$\leftarrow \rightarrow \checkmark \uparrow$ Removable Dis > all_miniSEED_files_	are_in_here v Ö	Search all_mini	SEED_files_are 🔎
Name	Date modified	Туре	Size
Sensor0AccelERou_0000000100_00013.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0AccelNRou_0000000100_00015.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0AccelZRou_0000000100_00017.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0HumidBRou_000000010_00023.mseed	22/07/2016 09:14	MSEED File	131,072 KB
Sensor0IntERough_0000000100_00007.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0IntNRough_000000100_00009.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0IntZRough_0000000100_00011.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0MassPosER_000000100_00018.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0MassPosNR_000000100_00002.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0MassPosZR_000000100_00004.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor0TemprCRou_0000000010_00021.mseed	22/07/2016 09:14	MSEED File	131,072 KB
Sensor0VoltageRo_000000010_00022.mseed	22/07/2016 09:12	MSEED File	131,072 KB
Sensor1AccelERou_0000000100_00006.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1AccelNRou_000000100_00008.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1AccelZRou_000000100_00010.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1IntERough_0000000100_00001.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1IntNRough_000000100_00003.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1IntZRough_0000000100_00005.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1MassPosER_000000100_00012.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1MassPosNR_000000100_00014.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1MassPosZR_000000100_00016.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1VelocESmo_000000200_00019.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1VelocNSmo_000000200_00020.mseed	22/07/2016 09:21	MSEED File	131,072 KB
Sensor1VelocZSmo_000000200_00000.mseed	22/07/2016 09:21	MSEED File	131,072 KB
24 items			

The file-name consists of four components:

- The stream name, truncated to 16 characters see Section 10 on page 137 for a full list of these;
- The sample rate, (in samples per second), as a ten-digit decimal number, leftpadded with zeroes;
- A number which functions as a counter to ensure unique name 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 Fortimus' flash RAM or are dynamically generated:

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

- *network*.DATALESS: where *network* is the two-character Network code defined in the "Setup" tab (e.g. GU.DATALESS). This file is a Dataless SEED volume that contains meta-data including instrument responses, coordinates, compression type etc. The Dataless SEED volume is generated from the .RESP files for each channel;
- fram.log: FRAM log file (stored in FRAM);
- calvals.txt: calibration values in the format compatible with the Scream! Software package (dynamically generated);
- polezero.txt: poles, zeros and normalising factors in the format compatible with the Scream! software (dynamically generated);
- calib.txt: calibration text file with poles, zeros and gains expressed in hexadecimal (stored in FRAM);

### 7.10.8 Request data from microSD card

Discovery can be used as viewer of seismic data locally recorded in the microSD card of a Fortimus.

Select the Fortimus of interested, right-click and choose "Data calendar view" to open the complete list of streams.

D Güralp S	ystems	Discovery													-		×
File Edit	View	Help															
Stat	us	Label	System	Name	Firmware Ver	LAI	N Addre	ess U	Uptime	Last Contact	Latitude	Longitude	Altitude	Timing quality			
00		SPRT-MIN	Minimus	MIN-C555	2.0-7548	10.	Co	ontrol Ce	ntre		51.3608	-1.1632	123.90	100			
0		SPRT-FMUS	Fortimus	FMUS-DE5B	2.0-7548	10.	Liv	ve View		•	1.3605	-1.1632	-12.34	0			
0		NO LABEL	Minimus	MIN-AF55	1.2-8707	10.	Fir	rmware U	Jpdate		).0000	0.0000	0.00	0			
0		DEMO 83	Minimus	MIN-C456	2.0-7548	10.	0. System Configuration		1.3606	-1.1633	-12.34	0					
							Da	Data calendar view									
							Edit Network Address										
							File Exchange										
Scan Locally Registry 52.34.40.123					Show On Map							~''		-			
Local Systems				Vie	view Web Page View Web Page (in system browser)							gu	aip	)			
4 of 4 systems responding				Ca	Calibration +												

The calendar shows two weeks of data preceding the time when the request is sent and it includes all the available channels recorded in the microSD card, distinct by stream name and predefined colour.





**Note:** Any gap in the calendar view is symptom of a gap in the recorded data.

Use the mouse-wheel scrolling (or track- / touch-pad scrolling on a laptop) or highlight a portion of data, right-click and select "Zoom in" to zoom into the data. Multiple channel are selectable using key Ctrl.

In Discovery, right-click on the Fortimus of interest and select "Live View"  $\rightarrow$  "GDI" to open a data viewer window. Select the streams that are going to be backfilled with recorded data.

In the calendar window select the portion of data to backfill into the viewer. Rightclick and select "Request backfill".



The requested data is automatically imported in the GDI data viewer in Discovery.





**Note:** The time required to upload the data depends on the window duration and the sample rate. Subsequent requests are queued and a new one is served once the previous one is completed.

## 7.11 Data transmission

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

güralp UNDERSTAND									
Fortimus									
s	Status Network Setup Trigger Data Stream Data Record Storage Logout Help								
olardo howork oclap migger bald orean bala needed orolage Edgout help									
System type: Fortimus   Host label: SPRT-FMUS   Host name: FMUS-DE5B (10.10.0.25)   Serial number: 00DE5B									
Data Stream									
Disable All Streams		Restore default	The "Disable All" and "Restore default" button will ALSO affect settings of any other sensors	Reboot					
Copy to Data Record		"Copy to Data Record" will apply settings from this page to recording configuration of all of the sensors.							
Display Streams All	~	Apply configuration for tap groups		Display On Page Sensor 0 🗸					
Channels configurat	tion								
Channel sampling	rate	Data transform	SEED name - please use check-box to modify the default	RESPonse file - if available					
		Seismic	channels						
0CAL0	200 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 00 .HCA	<u>RESP_file_5</u>					
0ACCZ0	200 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 00 .HNZ	<u>RESP_file_7</u>					
0ACCN0	200 Hz 🗸 🗸	Transforms Disabled for this tap $ \lor $	DG.TEST. 00 .HNN	RESP_file_11					
0ACCE0	200 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 00 .HNE	RESP_file_15					
0ACCZ2	5 Hz 🗸 🗸	Transforms Disabled for this tap $ \smallsetminus $	DG.TEST. 00 .MNZ	<u>RESP_file_8</u>					
0ACCN2	5 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 00 .MNN	RESP_file_12					
0ACCE2	5 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 00 .MNE	<u>RESP_file_16</u>					
		MEMS accelero	meter channels						
0AXLZ0	100 Hz 🗸	Transforms Disabled for this tap $$	DG.TEST. 99 .HNZ	<u>RESP_file_25</u>					
OAXLNO	100 Hz $$	Transforms Disabled for this tap $$	DG.TEST. 99 . HNN	<u>RESP_file_29</u>					
0AXLE0	100 Hz $\sim$	Transforms Disabled for this tap $$	DG.TEST. 99 .HNE	RESP_file_33					
		Magnetome	ter channels						
OMAGZO	5 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 99 MFZ	<u>RESP_file_37</u>					
OMAGNO	5 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TEST. 99 MFN	RESP_file_39					
0MAGE0	5 Hz 🗸 🗸	Transforms Disabled for this tap $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	DG.TE ST. 99 .MFE	RESP_file_41					

This page allows to configure the transmitted channels available in the Fortimus.

The names and contents of each channel are described in Section 10 on page 137.



**Note:** When changing a setting in the Fortimus 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 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. 0ACCZ0, 0ACCN0, 0ACCE0.

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 second column from the left, drop-down boxes are available for each channel to enable/disable transforms and, once transform is enabled, to select the transform to apply (see Section 7.16 on page 87);
- 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 7.14.4 on page 81).

Upon changing the sample rate, enabling a transform or changing Location and Channels codes, the Fortimus 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 3.1.2 on page 10) and the instrument web page will display the following screen.

### FMUS-C456 is rebooting ...

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

### 7.11.1 Scream! (GCF format + Scream protocol)

The Fortimus can act as a Scream! Server and streams 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 4.4.2 on page 31) or any software that can communicate using the Scream! Protocol, including SeisComP3.

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])

- Affinity digitiser
- Network Acquisition Module (Güralp NAM)

Data can also be received by software that can communicate using the Scream! Protocol, including SeisComp3 and Earthworm.



**Note:** Güralp devices running the Platinum software *can* receive GCF data over the Scream protocol, but the GDI-link protocol is preferred in these cases.

### 7.11.2 GDI-link protocol

The Fortimus can also 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 (<u>www.isti.com/products/earthworm/</u>)

GDI-link supports both data push and pull from/to the Fortimus. See Section 7.6 on page 51 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. 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 preconverted into real physical units instead of just as raw digitiser counts, obviating a requirement for receivers to be aware of calibration values.

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

#### 7.11.3 SEEDlink protocol

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



Note: The Fortimus SEEDlink back-fill implementation is packet-based.

FortimusIn the "Network" tab of the Fortimus web page, select the desired SEEDlink mode.

Network (	Config						
DHCP	Enabled $\sim$						
DNS1 209	9.244.0.3	DNS2 84.200.69.80				Reboot	
Web Login	Required ~	Username (Normal)	user	Password (Normal)	******	HTTP Port	80
Web Timeout	t Never ~	Username (Admin)	admin	Password (Admin)	******		
SeedLink	Enabled, 65536 records 🗸	Send status.txt Every 300	seconds	SeedLink Data Packet Format	Optimal ~	Send SeedLink EEW Packet Every	0 deciseconds
TFTP Server	Disabled	TFTP File					
Network	Debug, 512 records						
РТР	Debug, 2048 records	PTP Offset		PTP Transmission		1	
Mode Disa	Debug, 65536 records	Correction 0	nanoseconds	Mode	Multicast ~		
NTP Server	Debug, 139264 records						
Registry	Debug, 622592 records						
Degistry Und	Enabled, 2048 records	Crown ID		Registry	24 40 122		
Registry Opd	Enabled, 65536 records			Address 52.	34.40.123		
Tunnel (p	Enabled, 139264 records						
LNS url	Enabled, 622592 records	LNS Username		LNS Password		Start Test	

The choices are:

- "Enabled" This is the normal operating mode. Choose between backfill buffer sizes of 2,048 records, 65,536 records, 139,264 records or 622,592 records;
- "Disabled" turns off the SEEDlink server; and
- "Debug" this mode produces additional messages in the *seedlink.log*. which may be helpful if trying to diagnose a problem. It is available with backfill buffer sizes as before and, additionally, 512 records.



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

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



**Note:** The modified SEEDlink is only available for EEW channels - i.e. the main seismic channels (generated with causal low latency filters) and the STA, LTA, STA/LTA ratio channels.

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 Fortimus web page select the interval in deciseconds (1 decisecond = 100 ms or 0.1 seconds) between miniSEED packets.

Network Config			
DHCP Enabled ~			
DNS1 209.244.0.3	DNS2 84.200.69.80		Reboot
Web Login Required ~	Username (Normal) user	Password ******** (Normal)	HTTP Port 80
Web Timeout Never 🗸	Username (Admin) admin	Password ******** (Admin)	
SeedLink Enabled, 65536 records ~	Send status.txt Every 300 seconds	SeedLink Data Packet Format Optimal 🗸	Send SeedLink EEW Packet 10 deciseconds Every
Data Record Size 512 Bytes ~	TFTP Server 10.30.255.197	TFTP File	

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 Fortimus web page controls this behaviour.



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

Network Config							
DHCP	Enabled $\sim$						
DNS1 209.244.0.3		DNS2 84.200.69.80				Reboot	
Web Login	Required 🗸	Username (Normal) User		Password (Normal)	******	HTTP Port	80
Web Timeout	Never ~	Username (Admin) admi	in	Password (Admin)	******		
SeedLink Enabled, 65	536 records 🗸	Send status.txt Every 300 s	seconds	SeedLink Data Packet Format	Optimal 🗸	Send SeedLink EEW Packet Every	10 deciseconds
Data Record Size	512 Bytes 🗸	FFTP Server 10.30.255.197		TFTP File			
Network Timing	512 Bytes						
PTP	256 Bytes	PTP Offset		РТР			·- · ·

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 <u>http://ds.iris.edu/ds/nodes/dmc/software/downloads/slinktool/</u>.

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

#### slinktool -Q IP-Address

which produces output like the following:

```
00 CHZ D 2016-09-13 10:42:18 -
                                         2016-09-13 10:46:56
DG TEST
DG TEST
        01 HHZ D 2016-09-13 10:42:18 -
                                         2016-09-13 10:46:56
                                         2016-09-13 10:46:56
DG TEST 00 CHN D 2016-09-13 10:42:18 -
        01 HHN D 2016-09-13 10:42:18
DG TEST
                                         2016-09-13 10:46:56
        00 CHE D 2016-09-13 10:42:18
                                         2016-09-13 10:46:56
DG TEST
                                      _
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, 2016,257,10:44:02.750000
(latency ~3.0 sec)
```

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



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

#### 7.11.3.1 MiniSEED extractor

D	D Güralp Systems - Discovery — 🗆 🗙										
File	le Edit View Help										
•	Data Viewer CAP Receiver Add Device	stem :imus	Name FMUS-DE5B	Firmware Ver 2.0-7548	LAN Address 10.10.0.25	Uptime 00:10:05	Last Contact Just Now	Latitude 51.3605	Longitude -1.1632	Altitude -12.34	Timing quality 0
	Power board control Sonardyne Debugger	mus mus	MIN-AF55 MIN-C456	1.2-8707 2.0-7548	10.10.0.6 10.10.0.17	6 days 6 Hrs 00:16:36	Just Now Just Now	0.0000 51.3606	0.0000	0.00 -12.34	0
C	SPRT-MIN Min	imus	MIN-C555	2.0-7548	10.10.0.10	01:00:01	Just Now	51.3606	-1.1632	120.80	100
S Loc	Scan Locally Registry 52.34.40.123										

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.

D miniSEED Extractor - Dis	– 🗆 ×						
Choose Files to Process	Browse						
Select Destination Folder	Browse						
Gap Search Trim Files	Close						

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.

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.

# 7.12 Synchronisation of the sample-clock

The Fortimus 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 Fortimus accessory pack includes a combined GNSS antenna and receiver for this purpose: see Section 3.2.2 on page 17 for details.
### 7.12.1 GNSS lock status

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

		-M-www	Mhm	V		güralp	INDERSTAND OPTIMISE PROTECT			
							Fortimus			
System type: Fortimu	Status Ne	etwork Setup Ti SPRT-FMUS   Host name	rigger Data Sti e: FMUS-DE5B (10.	ream Data Reco 10.0.25)   Serial num	rd Storage	Logout Help				
System Status										
			General i	nformation						
Host name	FMUS-DE5B	Host label	SPRT-FMUS	System type	Fortimus	Product type	Fortimus			
Serial number	00DE5B	Firmware version	2.0-7593	IPv4 address	10.10.0.25 (DHCP)	SEED network and station	DG.TEST (SPRT-FMUS)			
Digitiser temperature	28.633 °C	Digitiser humidity	35.18%	Input voltage	12.725 V	Power over Ethernet voltage	0.010 V			
System time	2:56:02 PM Mon 11- Nov-2019	Uptime	19m 57s	ETH status	sckt: 11/20 data: 0/6					
GNSS Status										
GNSS connection statu	s Connected	Last timestamp	2019-11-11 14:56:01	ALA -	X	Hills AONB	A MARC			
Last lock time	2019-11-11 14:53:55	GNSS stability	100%	+	North Wessex	Link	London			
Latitude	51.3607	Longitude	-1.1631	N - 9272	Downs	- And	ANA			
Altitude	92.7	Horizontal dilution of precision	1.32		A A	SER	AA			
GNSS PPS status	Trusted Pulsing	GNSS NMEA stream	Input OK		100	A At	THA			
GNSS Lock state	3D locked	Number of satellites	Used: 7 In view: 10			// Report a problem ( @ Oper	Streetmap contributors			
		_	Data rec	ord status						
microSD status	Recording	microSD total	60686336 KiB	microSD used	1065912 KiB	microSD free	98%			
		1	Ser	ISOTS		1				
Number of sensors detected	1									
Senso	or0	Serial number (0)		Firmware ver (0)	0.3					
		Seismometer Z (0)	-4325921	Seismometer N (0)	-5084259	Seismometer E (0)	-4594544			
		Midas H	Guralp Sys ouse, Calleva Park, Ald Tel: +44 118 981 9056, E-Mail: <u>sales@guralp.c</u>	ttems Limited ermaston, Reading, RG7 8 , Fax: +44 118 981 9943 om, <u>support@guralp.com</u>	EA, UK					

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)

### 7.12.2 Precision Time Protocol (PTP)

The Fortimus system supports timing provided through PTP.

		M	Mmm	·	ç		DERSTAND FIMISE DTECT
							Minimus
	Status Netw	ork Setup Trigg	ger Data Strea	am Data Reco	rd Storage Lo	gout Help	
System type: Minimus	s I Host label: SPR	T-MIN I Host name: MIN	-C555 (10.10.0.10	)   Serial number: (	0C555		
System Status				,,			
-,			General inf	ormation			
Host name	MIN-C555	Host label	SPRT-MIN	System type	Minimus	Product type	Minimus
Serial number	00C555	Firmware version	2.0-7548	IPv4 address	10.10.0.10 (DHCP)	SEED network and station	DG.TEST (No site)
Digitiser temperature	29.019 °C	Digitiser humidity	26.12%	Input voltage	12.966 V	Power over Ethernet voltage	0.000 V
System time	9:05:15 AM Fri 8-Nov-2019	Uptime	16h 53m 3s	ETH status	sckt: 12/20 data: 2/6		
			GNSS S	itatus		•	
GNSS connection state	us Disconnected	Last timestamp	0000-00-00 00:00:00	( the factor	A PR	HIIIS AONB	J. J.R.C.
Last lock time	Never	GNSS stability	Disconnected	+	× 11	L. Chan	London
Latitude	51.3606	Longitude	-1.1633	(	CASA		
Altitude	-12.34	Horizontal dilution of precision	Undefined	A A A A	AONB	1 Store	24
GNSS PPS status	Not Trusted No Pulse	GNSS NMEA stream	Bad input	X	1000		ATT
GNSS Lock state	No lock	Number of satellites	Used: 0 In view: 0	18 200	Repor	t a problem   © OpenStreet	Map contributors
			PTP St	atus			
PTP state	Phase Locked	Last PTP timestamp	2019-11-08 09:14:40Z	Last PTP lock time	e 2019-11-08 08:59:22Z	PTP stability	100%
Master IPv4 address	10.30.255.35	Master clock class	PRI_REF_PTP	Master clock accu	iracy < 100ns (0x21)	Master time source	GPS
Network path delay	38.1 us	Network jitter estimat	e ±983 ns	Network outliers	4%		
aniana 0D atatua	Descrition	unio de OD de de l	Data recor	d status	4000000 1/17		0707
microSD status	Recording	microSD total	60686336 KiB	microSD used	1299032 KIB	microSD free	97%
Number of sensors			36115				
detected	1						
Senso	or0	Serial number (0)	TF064	Firmware ver (0)	6.0		
		Integrator Z (0)	-6	Integrator N (0)	-5	Integrator E (0)	-6
		Seismometer Z (0)	64	Seismometer N (0	)) 287	Seismometer E (0)	483
		Midas House, Tel: E-Ma	Guralp Syster Calleva Park, Aldern +44 118 981 9058, F il: <u>sales@guralp.com</u>	ns Limited naston, Reading, RG7 ax: +44 118 981 9943 <u>), support@guralp.com</u>	8EA, UK		

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

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

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

Under the heading "Network config" are four options:

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

Netw	letwork Timing										
PTP Mode	Run always - Override GPS	PTP Offset Correction	0 nanoseconds	PTP Transmission Mode	Unicast 🗸	PTP Master IP	0.0.0.0				
NTP Se	Run if needed - Offline backup										
Regi	Run always - Online backup										
Regist	Run always - Override GPS	Group ID	SOF	Registry Address	52.34.40.123						

PTP can be configured for multicast or unicast mode. In unicast mode, the server I.P. address must be specified. This is available in the "Network" tab of the digitiser's web page.

PTP PTP			
Mode Run always - Override GPS V Correction 0 nanoseconds Transmission U Mode	Unicast 🗸	PTP Master IP	0.0.0.0
NTP Server Pool V	Unicast		

## 7.13 Deploy mode: Full power-save

The Fortimus 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 Fortimus web page. Changes are not applied immediately.

	güralp UNDERSTAND OPTIMISE PROTECT									
							Fortimus			
Status	Network Setup	Trigger D	ata Stream Data	Record Storag	je l	Logout Help				
System type: Fortimus   Host labe	System type: Fortimus   Host label: SPRT-FMUS   Host name: FMUS-DE5B (10.10.0.25)   Serial number: 00DE5B									
Digitizer Controls										
Reboot			Reset All Setting	IS		The "Reset All Set affect settings on	tings" button will ALSO other pages			
Digitizer Config										
Auto Refresh 1	Auto Reboot	On Error $ \smallsetminus $	Low Latency Mode	Balanced	~					
Host Label SPRT-FMUS	5 Station Code	TEST	Network Code	DG		Site Name	SPRT-FMUS			
Bluetooth PIN 0000	Bluetooth	Enabled ${\scriptstyle \lor}$	Filter quality	High	~					
Deploy Mode Normal	✓ Deploy									
Applied Rotation Normal										
Analogue 0										

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

Digitizer Control	S									
Reboot			Reset All Settings			T	The "Reset All Settings" button will ALSO affect settings on other pages			
Digitizer Config	Digitizer Config									
Auto Refresh	1	Auto Reboot				~				
Host Label	SPRT-MIN	Station Code	System is about to	be deployed. Are you sure?	DG	S	Site Name	No site		
Bluetooth PIN	0000	Bluetooth		ligh 🕔	~					
Deploy Mode	Power Save $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	Auto Center								
Applied Rotation				OK Cancel						
Analogue 0	0 °									
Digital 1	0 °	Digital 2	0 °	Digital 3	0	) [	Digital 4	0	•	
Digital 5	0 •	Digital 6	0 °	Digital 7	0		Digital 8	0	•	

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	Digitizer Config									
Auto Refresh		1	Auto Reboot	On Error $\checkmark$	Low Latency Mode	Balanced	~			
Host Label	SP	RT-MIN	Station Code	TEST	Network Code	DG		Site Name	No site	
Bluetooth PIN	00	000	Bluetooth	Enabled $\lor$	Filter quality	High	$\sim$			
Deploy Mode	Powe	r Save $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$	Auto Center Disable(h	r) 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 Fortimus via a serial connection (see Section 9 on page 131) or to use the GüVü Bluetooth app (see Section 8.3 on page 128).

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.

## 7.14 Configuration and control of the accelerometer

#### 7.14.1 Setting instrument (sensor) gain

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

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

			VMM~~	·····		güralþ	UNDERSTAND OPTIMISE PROTECT
							Fortimus
	Ofetus	turale Oatur	Trianan	Data Otra ann - Data Da	oteres 1	anavé Ulala	
	Status Ne	etwork Setup	ringger L	Jala Stream Dala Re	cord Storage I	Logoul Heip	
System type: Fortin	nus   Host label: S	PRT-FMUS   Host na	me: FMUS-DE	5B (10.10.0.25)   Serial n	umber: 00DE5B		
Digitizer Contro	ols						
Reboot				Reset All Settings		The "Reset All Sett affect settings on c	ings" button will ALSO other pages
Digitizer Config	l						
Auto Refresh	1	Auto Reboot	On Error $ \smallsetminus $	Low Latency Mode	Balanced ~		
Host Label	SPRT-FMUS	Station Code	TEST	Network Code	DG	Site Name	SPRT-FMUS
Bluetooth PIN	0000	Bluetooth	Enabled ${\scriptstyle \lor}$	Filter quality	High ~		
Deploy Mode	Normal ~	Deploy					
Applied Rotatio	n						
Analogue 0	0 °						
Sensor Installat	tion Parameter	S					
Sensor	Sensor 0 v	Dip	0	Azimuth	0	Depth	0
Fortimus							
		-		Sensor Status		-	
Initialisation	Complete	Sensor State	ldle				
Model	Fortimus	Serial Number	0 (0x0)	Identification Firmware	0.3	Configuration	1
inouti	Torunao	oona nambor	0 (0,0)	Response	0.0	comguration	
Fortimus Range	-1.0g; +1.0g ~	Fortimus Loop	Normal ~				
	-0.5g; +0.5g		1	Mass Centring		•	
Centre Mass	-1.0g; +1.0g						
	-2.0g; +2.0g			Calibration		1	
Calibration	-4.0g; +4.0g	Amplitude	100% ~	Calibration Signal	Disabled $\vee$		
				Display			
Display settings	Unlocked ~	Display brightness	Auto ~	Display switch-off	Never ~	Display flip	Auto 🗸
Touch sense	Enable 🗸						
		Midas	Gi s House, Calleva Tel: +44 118 9	uralp Systems Limited Park, Aldermaston, Reading, RG 381 9056, Fax: +44 118 981 994	7 8EA, UK 3		

il: sales@guralp.com, support@guralp.com

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

### 7.14.2 Sensor centring

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

Fortimus	Fortimus									
			1	Sensor Status						
Initialisation	Complete	Sensor State	Idle							
	Identification									
Model	Fortimus	Serial Number	0 (0x0)	Firmware	0.3	Configuration	1			
Response										
Fortimus Range	-1.0g; +1.0g $ \smallsetminus $	Fortimus Loop	Normal $\sim$							
Mass Centring										
Centre Mass										
				Calibration						
Calibration	Off ~	Amplitude	100% ~	Calibration Signal	Disabled $ \smallsetminus $					
				Display						
Display settings	Unlocked $ \smallsetminus $	Display brightness	Auto 🗸	Display switch-off	Never $\sim$	Display flip	Auto 🗸			
Touch sense	Enable $\vee$									

### 7.14.3 Output polarity

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

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

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

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

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



#### 7.14.4 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 zeroes for the transfer function that expresses the frequency response of the sensor. A full discussion of poles and zeroes 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 Fortimus is programmed at the factory so that it knows its own calibration values.

To explore the calibration values of the Fortimus' sensor and digitiser, right-click the Fortimus in Discovery's main window and select "Calibration"  $\rightarrow$  "Calibration Editor". The resulting screen is shown here shortened:

ensor0	5		
Settings			
Instrument serial num	ber:		Accelerometer
Component Z Co	mponent N Component I	E Calibration cha	annel
Parameters			
Digitizer Volt	s per count 5.781651e-7	7 V p	er count
🗹 Analogue Ins	trument Gain 1	v	/ per m/s²
ADC Offset	0	counts	
Coil constant	nan	A/m/s²	
Calibration re	sistor nan	Ω	
Response			
	actor 20152000	Unit	
✓ Normalizing t	30153000	Unit	
Poles (Hz)			
Pole 0	-159	+ i* 286	Hz
Pole 1	-159	+ i* -286	Hz
Pole 2	-281.60001	+ i* 0	Hz
Zero 3	nan	+ I* nan	Hz
Zero 4	nan	+.	
Zero 5	nan	+ <b>i</b> * nan	Hz
Component configu	ation		
Copy: Poles and Z	eros 🔻 to sensor 0 🚖	to component ZN	Е 🔻 Сору
			Send axis Z
System calibration val	Jes		
	Poles and Z	leros 🔻 Export t	o file Import from file
		Send instrume	ent calibration to device

This form has one tab for each seismic component. The instrument's response values 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 Fortimus.
- Analogue instrument gain this specifies the output voltage of the accelerometer per unit of ground motion in ms⁻², as measured at 1 Hertz.
- 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 Fortimus.
- The **Coil constant** is the coil constant for the component being calibrated, in  $A/m/s^2$ , as given on the analogue sensor calibration sheet.
- The **Calibration resistor is the value of the calibration resistor**, in  $\Omega$ , 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 zeroes) 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.

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 <u>Copy</u> button to copy and paste the selected values. Finally click on <u>Send axis Z</u> button to send the calibration values to the digitiser and save them permanently. Repeat this last step for the other axis. Note that <u>Send axis Z</u> only sends the calibration of the selected axis.

Compo	nent configuration						
Copy:	Poles and Zeros	▼ to sense	vr 0 韋	to component	ZNE	•	Сору
							Send axis Z

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".

System calibration values				
	Poles and Zeros	•	Export to file	Import from file
		Ser	nd instrument cal	ibration to device

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 **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 flow" and "Data record" tab of the Fortimus web page.

	güralp UNDERSTAND OPTIMISE PROTECT				
			Fortimus		
Status N	etwork Setup Trigger Data St	ream Data Record Storage I	Logout Help		
System type: Fortimus   Host label:	SPRT-FMUS   Host name: FMUS-DE5B (10	.10.0.25)   Serial number: 00DE5B			
Data Stream					
Disable All Streams	Restore default	The "Disable All" and "Restore default" button will ALSO affect settings of any other sensors	Reboot		
Copy to Data Record	"Copy to Data Record" will apply settings from this page to recording configuration of all of the sensors.				
Display Streams All	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			
0CAL0 200 Hz	$\sim$ Transforms Disabled for this tap $  imes $	DG.TEST.00 .HCA	RESP_file_5		
0ACCZ0 200 Hz	$\checkmark$ Transforms Disabled for this tap $\checkmark$	DG.TEST. 00 .HNZ	<u>RESP_file_7</u>		
0ACCN0 200 Hz	$\checkmark$ Transforms Disabled for this tap $\checkmark$	DG.TEST. 00 . HNN	RESP_file_11		
0ACCE0 200 Hz	$\checkmark$ Transforms Disabled for this tap $\checkmark$	DG.TEST. 00 .HNE	RESP_file_15		

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

# #	<< Gural	p SEED resp	ponse file b	uilder v1.2-80	515 >>		
÷		CHANNEL RE	ESPONSE DATA				
B050F03	Station:	TEST					
B050F16	Network:	DG					
B052F03	Location:	OK					
B052F04	Channel:	HNZ					
B052F22	Start date:	2018.214.1	11:26:48				
B052F23	End date:	No Ending	Time				
#	========						
÷	+		+			-+	+
÷	+		Channel	Sensitivity.	TEST ch HNZ	i.	+
÷	+		+			-+	+
#							
B058F03	Stage sequence	ce number:		0			
B058F04	Sensitivity:			2.131148	2+05		
B058F05	Frequency of	sensitivit	ty:	1.000000	2+00 HZ		
B058F06	Number of cal	librations		0			
#							
#	+	+				+	+
#	+	1	Response (1	Poles & Zeros)	, TEST ch HNZ	1	+
#	+	+				+	+
#							
B053F03	Transfer fund	ction type:	:	A [Laplac	ce Transform (R	ad/sec)]	
B053F04	Stage sequend	ce number:		1			
B053F05	Response in u	units looku	up:	M/S**2 -	Acceleration i	n Metres Per	Second Squared
B053F06	Response out	units lool	kup:	V - Volts	3		
B053F07	A0 normalizat	tion factor	r:	3.0229558	5+12		
B053F08	Normalization	n frequency	Y:	1.000000	2+00		

Right-click anywhere and select "Back" to return to the Fortimus web page.

D MIN-C45	6 - Discovery
+ +	<< Güralp SEED response file buil
ŧ	CUANNEL RESPONSE DATA
B050F03	Back T
B050F16	Forward
B052F03 B052F04	Reload
B052F22	View Page Source 8,045,14:56:59
B052F23	Ing gate: 2018,046,12:03:06
#	
+	+ +
4	I (Thornol G

To save a RESP file, right click on it in the main list and select "Save Link":

ED Location	Display on page	Sensor0 *
	The "Reset All Settings" bu affect settings on other pag	tton will ALSO es
0K	<u>RESP fil</u>	Follow Link
0K	<u>RESP_fik</u>	Save Link
0L	RESP file	Back 63
0K	RESP file	Forward
0L	RESP file	Keload View Page Source
0K	RESP file	Copy Link URL
0L	RESP file 10	<u>5</u>



**Note:** RESP files are not available for channels that have a transform enabled. For details about transforms, see Section 7.16 on page 87.

## 7.14.5 Inject a calibration signal

To check whether the Fortimus 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.

Fortimus	Fortimus												
	Sensor Status												
Initialisation	Complete	Sensor State	Idle										
				Identification									
Model	Fortimus	Serial Number	0 (0x0)	Firmware	0.3		Configuration	1					
				Response									
Fortimus Range	-0.5g; +0.5g 🗸	Fortimus Loop	Normal $\sim$										
			Ν	lass Centring									
Centre Mass													
				Calibration									
Calibration	Off 🗸	Amplitude	100% ~										
	Off			Display									
Display settings	Triangle	Display brightness	Auto 🗸	Display switch-off		Never $ \smallsetminus $	Display flip	Normal ~					
Touch sense	Square												
	White Noise		Gu	uralp Systems Limited									

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

	Calibration								
Calibration	Off ~	Amplitude	100% ~						
			100%	Display					
Display settings	Unlocked $ \sim $	Display brightness	50%	Display switch-off	Never $\sim$	Display flip	Normal 🗸		
Touch sense	Enable 🗸		25%						
			12.5%	alp Systems Limited					



**Note:** The calibration channel, named *OACCCO*, produces an output if and only if the calibration is in progress.

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



# 7.15 Setting sensor orientation and depth parameters

## 7.15.1 Applied rotation

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

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

			www	·····		güralp	UNDERSTAND OPTIMISE PROTECT
							Fortimus
	01-1	turada Oatura	Trianan D	Data Data D		Lange to the land	
	Status Ne	etwork Setup	i rigger u	Data Stream Data R	ecord Storage	Logout Help	
System type: Fortim	us   Host label: S	PRT-FMUS   Host na	ame: FMUS-DE	5B (10.10.0.25)   Serial	number: 00DE5B		
Digitizer Control	Is						
Pahoat				Posot All Sottings	)	The "Reset All Set	tings" button will ALSO
Keboot	-			-Reset Air Settings		affect settings on	other pages
Digitizer Config		-					
Auto Refresh	1	Auto Reboot	On Error $ \smallsetminus $	Low Latency Mode	Balanced	~	
Host Label	SPRT-FMUS	Station Code	TEST	Network Code	DG	Site Name	SPRT-FMUS
Bluetooth PIN	0000	Bluetooth	Enabled ${\scriptstyle \lor}$	Filter quality	High	~	
Deploy Mode	Normal ~	Deploy					
Applied Rotation	n			-			
Analogue 0	0 °						
Sensor Installati	ion Parameter	S				•	
Sensor	Sensor 0 v	Dip	0	Azimuth	0	Depth	0
Fortimus		1		1			
				Sensor Status			
Initialisation	Complete	Sensor State	ldle				
		Ta		Identification			
Model	Fortimus	Serial Number	0 (0x0)	Firmware	0.3	Configuration	1
Fortimus Pango	1.001.11.00.11	Fortimus Loop	Normal	Response			
Torumus Runge	-1.0g, +1.0g *	rorumus coop		Mass Centring			
Centre Mass		[		lass centing			
				Calibration			
Calibration	Off ~	Amplitude	100% ~	Calibration Signal	Disabled	/	
		-		Display		_	
Display settings	Unlocked $ \sim $	Display brightness	Auto 🗸	Display switch-off	Never	<ul> <li>Display flip</li> </ul>	Auto 🗸
Touch sense	Enable 🗸						
		Mida	Gi as House, Calleva I Tel: +44 118 S E-Mail: <u>sales@</u>	uralp Systems Limited Park, Aldermaston, Reading, R 981 9056, Fax: +44 118 981 99 9 <u>guralp.com, support@guralp.</u>	IG7 8EA, UK 143 com		

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

#### 7.15.2 Instrument installation parameters

The Dip (tilt angle from vertical), Azimuth (tilt direction from North) and Depth of Fortimus can be set in the "Setup" tab of the web interface in the section "Instrument Installation Parameters". The instrument to which the displayed parameters apply is selected using the drop-down menu.

	güralp UNDERSTAND OPTIMISE PROTECT									
							Fortimus			
	Ctatus No	stwork Cotup	Triggor	ata Straam - Data Da	cord Ctorago	Logout Holp				
	Status	etwork Setup	Lingger L	Jala Sireani Dala Re	cord Storage	Logout Heip				
System type: Fortim	nus   Host label: S	PRT-FMUS   Host na	me: FMUS-DE	5B (10.10.0.25)   Serial n	umber: 00DE5B					
Digitizer Contro	ls									
Reboot				Reset All Settings		The "Reset All Settings on of	ngs" button will ALSO			
Digitizer Config	_	I				and of settings on of	and pages			
Auto Refresh	1	Auto Reboot		Low Latency Mode	Ralanced ~	1				
Host Label		Station Code		Network Code	balanced •	Site Name				
Pluotooth DIN		Blueteeth	Enabled	Filtor quality	Uish	Site Marine	JSFRI FM05			
Deploy Mode	Nermel	Dealer	Elidbieu V	riter quality	High V					
Applied Potetie		Deploy								
Applied Rotatio		1		1		1				
Analogue U	0									
Sensor Installat	ion Parameter	s								
Sensor	Sensor 0 ~	Dip	0	Azimuth	0	Depth	0			
Fortimus										
Initialisation	Complete	Sensor State	Idle	Sensor Status		1				
Initialisation	complete	Selisor State	luic	Identification						
Model	Fortimus	Serial Number	0 (0x0)	Firmware	0.3	Configuration	1			
		I		Response		I				
Fortimus Range	-1.0g; +1.0g ~	Fortimus Loop	Normal 🗸							
Contro Mago		1		Mass Centring		1				
Centre Mass				Calibration						
Calibration	Off ~	Amplitude	100% ~	Calibration Signal	Disabled ~					
				Display		1				
Display settings	Unlocked ~	Display brightness	Auto 🗸	Display switch-off	Never ~	Display flip	Auto ~			
Touch sense	Enable 🗸									
		Mida	G s House, Calleva Tel: +44 118 9 E-Mail: <u>sales@</u>	uralp Systems Limited Park, Aldermaston, Reading, RG 881 9056, Fax: +44 118 981 994 <u>8guralp.com, support@guralp.cc</u>	37 8EA, UK 3 2011					

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

# 7.16 Transforms

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

When a specific transform is activated on a particular channel, the resulting streamed (or recorded, accordingly to the chosen configuration) data output is automatically transmitted and/or recorded with the transform applied. The units-of-measure are re-calculated accordingly.

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

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		STAND Se St									
Reboot Required - Fortimu											
Status Network Setup Trigger Data Stream Data Record Storage Logout Help											
System type: Fortimus Host label:	PRT-	FMUS Host name: FMUS-DE5B (10.1	10.0.25) Serial number: 00DE5B								
Data Stream											
Disable All Streams		Restore default	The "Disable All" and "Restore default" button will ALSO affect settings of any other sensors	Reboot							
Copy to Data Record	"Co froi of a	opy to Data Record" will apply settings m this page to recording configuration all of the sensors.									
Display Streams All	∕ ⊻	Apply configuration for tap groups		Display On Page Sei	nsor 0 🗸						
Channels configuration											
Channel sampling rate		Data transform	SEED name - please use check-box to modify the default	RESPonse file - if availat	ole						
	_	Seismic	channels								
0CAL0 200 Hz	/	Transforms Disabled for this tap $ \lor$	DG.TEST. 00 HCA	<u>RESP_file_5</u>							
0ACCZ0 200 Hz	/	Enable Transform (reboot) 🗸 🗸	DG.TE ST. 00 .HNZ	RESP_file_7							
0ACCN0 200 Hz	/	Transforms Disabled for this tap	DG.TE ST. 00 .HNN	RESP_file_11							
0ACCE0 200 Hz	~	Enable Transform (reboot)	DG.TEST.00 .HNE	<u>RESP_file_15</u>							

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

The available transforms are:

- Pass-through see Section 7.16.1 on page 89.
- 2nd order bi-quadratic filter see Section 7.16.6 on page 92.
- 1st order low-pass filter see Section 7.16.3 on page 90.
- 1st order high-pass filter see Section 7.16.4 on page 91.
- 1st order band/Notch filter see Section 7.16.5 on page 91.
- STA/LTA ratio see Section 7.16.10 on page 96.
- Integration see Section 7.16.7 on page 93.
- Double integration see Section 7.16.8 on page 94.
- Three-dimensional rotation see Section 7.16.11 on page 98.
- EEW parameters Observer see Section 7.16.9 on page 95.
- Differentiation see Section 7.16.2 on page 90.
- QSCDx sender see Section 7.16.12 on page 99.
- MMA logger see Section 7.16.13 on page 100.

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

To use customised parameters, visit the "Transform" tab and select the "Saved User Parameters" option in the "Parameter Source" drop-down menu. Type in the required parameters and then click Save Parameters to store them. It is possible to switch between Default and Saved User Parameters without altering the stored custom parameters but clicking Save Parameters while "Default parameters" is selected will overwrite the customised parameters with the default values.

Parameter Source	Default Parameters 🔹	Save Parameters
Select which transform parameters to use: Defaults	Default Parameters Saved User Parameters	
or Recall saved user settings from memory		

The various transforms are each described in the following sections.



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

7.16.1 Pass-through

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

Status	Network Se	tup Power	Trigger	Data Strean	n	Data Record	Transforms	Storage	Logout	Help	
System type: Mini	mus Host label: S	upport Host n	ame: MIN-C55	5 (10.10.0.13)	Se	erial number: 505	17				
Data Stream											
Display Streams	All	Transform		1	Try t	o NOT change any	SEED Location	Display On	Page	Sensor0 •	
Reboot		Disable A	l Streams		Reset All Settings			The "Reset affect setti	The "Reset All Settings" button will ALSO affect settings on other pages		
0XCHN0	200 Hz	• Tr	ansforms Disa	abled 🔻	DG.TEST. 00 HDF			RESP file 5			
0ACCZ0	200 Hz	• Pas	s-through	•	DG.TEST. 00 .HHZ				<u>RESP fil</u>	<u>e 7</u>	
Status	Network Se	tup Power	Trigger	Data Strean	n	Data Record	Transforms	Storage	Logout	Help	
System type: Mini	mus Host label: S	upport Host n	ame: MIN-C55	5 (10.10.0.13)	Se	erial number: 505	17				
Configure Tran	Configure Transforms										
	0ACCZ0										
Selected Transform						Pass-	through				

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

7.16.2 Differentiation

This transform differentiates the input data, e.g. if the input is a velocity (ms⁻¹) channel, the output will be acceleration (ms⁻²). It has no configuration parameters.



7.16.3 1st order LPF

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



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

Status	Network	Setu	Power	Trigger	Data Strea	m	Data Record	Transforms	Storage	Logout	Help		
ystem type: Minimus Host label: Support Host name: MIN-C555 (10.10.0.13) Serial number: 50517													
Data Stream													
Display Streams	All	۲	Transform			Try	to NOT change an	y SEED Location	Display O	n Page	Sensor0 •		
Reboot			Disable /	II Streams			Reset All Setting	JS	The "Rese affect sett	t All Settings" ings on other	button will ALSO pages		
0XCHN0	200 H	z ▼	1	ransforms Di	sabled 🔻		DG.TEST.00	HDF		<u>RESP_fil</u>	<u>e 5</u>		
0ACCZ0	ACCZ0 200 Hz												
Status	Network	Setup	o Power	Trigger	Data Strea	m	Data Record	Transforms	Storage	Logout	Help		
System type: Minim	us Host lat	el: Sup	port Host I	name: MIN-C	555 (10.10.0.13	Se	erial number: 50	517					
Configure Trans	sforms												
	0VELZ0												
selected Transform 1st Order LPF Parameter Source Default Parameters Save Parameters													
Corner Frequency (H	z)		10										

7.16.4 1st Order HPF

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



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

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

	Note: The hill low-pass filt	igh-pas er from	ss filter is im 1 the unfilter	plemented ed data:	by subtract	ting the out	put of a
	→ ⊗		= ,		}→		
Stat System type: I	us Network Setu Minimus Host label: Suj	o Power oport Host n	Trigger Data Str ame: MIN-C555 (10.10.0	Data Record	I Transforms	Storage Logout	Help
Data Stream	m						
Display Stream	ns All 🔻	Transform		Try to NOT change a	iny SEED Location	Display On Page	Sensor0 •
Rebo	pot	Disable A	ll Streams	Reset All Settin	igs	The "Reset All Setting affect settings on othe	s" button will ALSO r pages
0XCHN0	200 Hz 🔻	Т	ansforms Disabled	SEED Location 5	0K	RESP	file 5
0ACCZ0	200 Hz 🔻	1st	Order HPF	SEED Location 7	0K	RESP	file 7
Stat	us Network Setu	p Power	Trigger Data Str	ream Data Record	Transforms	Storage Logout	Help
Configure	Transforms	port most n	ane. mn-c555 (10.10.0	.15/ Senai number. 5	0.511		
configure	Inditationina		0	ACC70			
Selected Trans	form 1st Orde	er HPF	Parameter Source	AUG20	Default Parameters	s V Save	Parameters
Corner Freque	ncy	10			L		
		,					/

7.16.5 1st Order Band/Notch filter

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



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

•

- A 1st order high pass filter (implemented using an LPF and a subtractor, as described in Section 7.16.4 on page 91), to gradually attenuate low-frequency integrator drift.
- A 1st order low pass filter (implemented as described in Section 7.16.3 on page 90).

The configurable parameters are the "High Pass Frequency" (HPF corner frequency as defined in Section 7.16.4 on page 91) and the "Low Pass Frequency" (LPF corner frequency as defined in Section 7.16.3 on page 90).

Statu	us Netw	vork Setu	p Power	Trigger	Data Strea	m	Data Record	Tra	nsforms	Storage	Logout	Help			
System type: N	Ainimus H	ost label: Su	pport Host na	me: MIN-C5	555 (10.10.0.13)) S	erial number: 5	0517							
Data Strean	Data Stream														
Display Stream	s All	۲	Transform			Try	to NOT change a	ny SEED	Location	Display On	Page	Sensor0 V			
Rebo	ot		Disable Al	Streams			Reset All Settin	gs		The "Reset affect setti	All Settings" ngs on other	' button will ALSO pages			
0XCHN0		200 Hz 🔻	Tra	ansforms Dis	sabled 🔻		DG.TEST.00	HDF]		<u>RESP fil</u>	<u>e 5</u>			
0ACCZ0	ACCZ0 200 Hz V Band/Notch Filter (1st Order) DG.TEST.00 HHZ RESP file 7														
Statu	us Netw	vork Setu	p Power	Trigger	Data Strea	m	Data Record	Tra	nsforms	Storage	Logout	Help			
System type: N	Ainimus H	ost label: Su	pport Host na	me: MIN-C5	555 (10.10.0.13)) S	erial number: 5	0517							
Configure 1	ransform	IS													
					OVE	LZO									
Selected Transf	Selected Transform Band/Notch Filter (1st Order) Parameter Source Default Parameters														
High Pass Frequ	iency (Hz)	0.1	Low Pass Fre	quency (Hz)	50]									

7.16.6 2nd Order biquad

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



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

The two configurable parameters are:

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

System type: Mini	mus H	ost label:	Sup	oport Host name: MIN-C555 (10.1	10.0.13		Serial number: 505	517				
Data Stream												
Display Streams	All		•	Transform		Try	y to NOT change any	y SEED	Location	Display Or	n Page	Sensor0 •
Reboot Disable All Streams						Reset All Settings The "Rese affect settings					t All Settings" ings on other p	button will ALSO pages
OXCHNO 200 Hz Transforms Disabled DG.TEST,00 HDF RESP file 5										<u>e 5</u>		
0ACCZ0		200 Hz	•	2nd Order Biquad	•		DG.TEST.00	.HHZ			RESP file	e <u>7</u>
Status System type: Mini	Status Network Setup Power Trigger Data Stream Data Record <u>Transforms</u> Storage Logout Help											
Configure Tra	nsform	IS										
					0A0	CZ	Z0					
Selected Transform	ı			2nd Order Biquad	Param	ete	er Source	Defau	ılt Paramete	rs ~	Save Par	ameters
Type (HPF/LPF)	0	Co	rner	Frequency (Hz) 10								
0 = Low Pass Filte	r, 1 = Hig	h Pass Fil	ter									

7.16.7 Integration

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



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

- A DC filter (2nd order high-pass bi-quadratic) removes any DC component, which would cause the output to grow without limit;
- The integrator itself; and
- A 1st order high pass filter (implemented using an LPF and a subtractor, as described in Section 7.16.4 on page 91), to gradually attenuate low-frequency integrator drift.

The configurable parameters are:

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

Statu	s Netv	vork S	etu	Power	Trigger	Data Strea	m	Data Record	Trans	sforms	Storage	Logo	it Help	
System type: M	inimus H	lost label:	Sup	port Host na	me: MIN-C	555 (10.10.0.13)	Se	rial number: 50)517					
Data Stream	Data Stream													
Display Streams	All		۲	Transform			Try t	o NOT change an	ny SEED L	ocation	Display On	Page	Sensor	0 🔻
Reboo	t			Disable All	Streams			Reset All Setting	JS		The "Reset affect settir	All Settings on ot	ngs" button will Al her pages	LSO
0XCHN0		200 Hz	۲	Tra	nsforms Di	sabled 🔻		DG.TEST.00	HDF			RES	<mark>P file 5</mark>	
0ACCZ0	ACCZ0 200 Hz V Integration V DG.TEST.00 .HHZ RESP file 7													
Statu:	s Netv	vork S	etu;) Power	Trigger	Data Stream	m	Data Record	Trans	sforms	Storage	Logou	it Help	
Configure T	ransform	1S	Տպ	port i nost nu		355 (10.10.0.15)	1 30	inai mamber: 50	511					
						0A0	:czo)						_
Selected Transfo	vrm			Integr	ation		Pa	rameter Source		Default P	arameters	•	Save Parameter	rs
DC Cut-off Frequ	iency	0.5		Dutput Cut-off F	requency	0.003	Co	onfiguration Mode	9		2			
							0 1 2	= DC filter output = DC HPF + Integ = DC HPF + Integ	t Iration Iration + H	PF				

7.16.8 Double Integration

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



Analogously to the single integrator, the double integrator applies an initial DC highpass filter and then two further high-pass filters, one at the output of each integrator. The high-pass filters are implemented using an LPF and a subtractor, as described in Section 7.16.4 on page 91.

The configurable parameters are:

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

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

Status	Network	Setup	p Power Trigg	ger Data Stre	am Data Re	cord	Transforms	Storage	e Logout	Help					
System type: Minimu	rstem type: Minimus Host label: Support Host name: MIN-C555 (10.10.0.13) Serial number: 50517														
Data Stream	ata Stream														
Display Streams	All	۲	Transform		Try to NOT char	nge any	SEED Location	Display	On Page	Sensor0 •					
Reboot			Disable All Stream	IS	Reset All S	iettings		The "Re affect se	set All Settings" ettings on other p	button will ALSO bages					
0XCHN0	200 Hz	۲	Transform	s Disabled	DG.TEST.	1, OC	HDF		RESP file	<u>) 5</u>					
0ACCZ0	200 Hz	۲	Double Inte	gration	DG.TEST.	۱. OC	HHZ		<u>RESP</u> file	<u>) 7</u>					
Status System type: Minimu: Configure Transf	Status Network Setup Power Trigger Data Stream Data Record <u>Transforms</u> Storage Logout Help ystem type: Minimus Host label: Support Host name: MIN-C555 (10.10.0.13) Serial number: 50517 Configure Transforms														
Selected Transform			Double Integrati	ion	Parameter Source	D	efault Parameters	•	Save Pa	arameters					
DC Cut-off Frequency	0.5	Inter	stage Cut-off Frequenc	y 0.003	Output Cut-off Fre	quency	0.00	15	Configuration Mo	ode 4					
									0 = DC filter out; 1 = DC HPF + 1s 2 = DC HPF + 1s 3 = + 2nd integ 4 = + 2nd integ	but t integration t integration + HPF gration gration + HPF					

7.16.9 EEW Parameter Observer

When an EEW trigger occurs (or is simulated – see below), the peak ground motion values (Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV) and Peak Ground Displacement (PGD)) are calculated and automatically recorded over the selected time-window and subsequently transmitted as a CAP message (see Section 7.17 on page 101 for more details). This transform allows the operator to directly observe the acceleration, velocity and displacement output on the real-time streams. It is available for use with both velocity and acceleration input signals.



The high-pass filters are implemented using an LPF and a subtracter, as described in Section 7.16.4 on page 91.

•

The configurable parameters are:

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

Note: Güralp recommend using the integration (Section 7.16.7 on page 93) and double integration (Section 7.16.8 on page 94) transforms to test the filter parameters, because the effect of the parameters will then be clearly visible in the transformed streams. Once suitable parameters have been determined, they can be copied to the EEW Parameter Observer transform.

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

iystem type: Minimus Host label: Support Host name: MIN-C555 (10.10.0.13) Serial number: 50517												
Data Stream												
Display Streams All	•	Transfor	m	Try t	to NOT change any SEED Location	Display On Page	Sensor0 •					
Reboot		Disa	ible All Streams		Reset All Settings	The "Reset All Settings" butto affect settings on other pages	on will ALSO					
0XCHN0	200 Hz 🔻)	Transforms Disabled •		DG.TEST.00 HDF	RESP file 5						
0ACCZ0	200 Hz 🔹		EEW Parameters Observer 🔻		DG.TEST.00 .HHZ	RESP file 7						

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

System type: Minimus | Host label: NO LABEL | Host name: MIN-C555 (10.10.0.10) | Serial number: 00C555

Configure Transforms	
	0ACCZ0
Selected Transform	EEW Parameters - Observer Parameter Source Default Parameters
DC Cut-off Frequency 0.5	Interstage Cut-off Frequency 0.003 Output Cut-off Frequency 0.0015 Window Time (seconds) 3
Preview Mode 0	
0 = No preview 1 = View acceleration in strear 2 = View velocity in stream 3 = View displacement in strea	n m.

7.16.10 STA/LTA Ratio

The Earthquake Early Warning system (EEW) compares the ratio of a short-term average (STA) to a long-term average (LTA) in order to detect "trigger" conditions. For more information see Section 7.17 on page 101.

Help

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



The configurable parameters are:

- "DC Frequency (Hz)": this specifies the corner frequency (-3 dB point) in Hertz for the initial high-pass filter;
- "LTA Period (seconds)": this is the Short Term Average filter time period (the reciprocal of the corner frequency);
- "STA Period (seconds)": this is the Long Term Average filter time period (the reciprocal of the corner frequency);
- "Trigger Threshold": this is the STA/LTA ratio threshold value above which a trigger will occur;
- "Event Window (Seconds)": this is the duration of the event after the STA/LTA trigger occurs; any subsequent threshold crossing within this period is treated as belonging to the same event. This can be used to avoid spurious false triggers.
- "Initial Timeout (Seconds)": this specifies an initial period of insensitivity after the trigger function is initialised or changed. This can be used to avoid spurious false triggers.

The high-pass filter is implemented using an LPF and a subtracter, as described in Section 7.16.4 on page 91.

	Status	Network	Setup	Power	Trigger	Data Stream	n	Data Record	Tra	nsforms	Storage	Logout	Help
System ty	ype: Minim	ius Host la	bel: SUF	RT-MIN Host	name: MIN	C555 (10.10.0.	13)	Serial number	r: 50517				
Data St	tream												
Display St	treams	All	~	Transform			Try to	o NOT change an	y SEED I	Location	Display On	Page	Sensor0 ~
	Reboot			Disable All	Streams			Reset All Settin	gs		The "Reset affect setti	t All Settings" ngs on other	button will ALSO pages
0AUXX0		200	Hz 🗸	Tra	nsforms Disa	oled ~		DG.TEST.00	.HDF	HDF		<u>RESP</u> file	<u>e 5</u>
0ACCZ0		200	Hz 🗸	STĄ	/LTA Ratio	~		DG.TEST.00	.HHZ	HNZ		<u>RESP</u> file	<u>e 7</u>
	Status	Network	Setup	Power	Trigger	Data Strear	n	Data Record	Tra	insforms	Storage	Logout	Help
System ty	ype: Minim	us Host la	bel: SUP	RT-MIN Host	name: MIN	C555 (10.10.0.	13)	Serial number	r: 50517				
Config	ure Trans	sforms											
						0AC	CZO						
Selected	Transform			STA/LTA Ratio		Parameter S	ourc	e	Defaul	t Parameter		Save Para	meters

STA coefficient

DC coefficient

0.001

LTA coefficient

0.1

0.005

7.16.11 Three-dimensional rotation

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



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

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

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

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

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

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

A rotation of

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

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



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

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

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

As a final check, note that

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

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

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

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

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

Data Stream				
Display Streams	All 🔻	Transform	Try to NOT change any SEED Location	Display On Page Sensor0 ▼
Reboot		Disable All Streams	Reset All Settings	The "Reset All Settings" button will ALSO affect settings on other pages
0AUXX0	200 Hz 🔻	Transforms Disabled •	DG.TEST. 00 .HDF	RESP file 5
0ACCZ0	200 Hz 🔻	Rotation (Triplet)	DG.TEST. 00 .HDF	RESP file 7
0ACCN0	200 Hz 🔻	Rotation (Triplet)	DG.TEST.00 .HDF	RESP file 8
0ACCE0	200 Hz 🔻	Rotation (Triplet)	DG.TEST.00 .HDF	RESP file 11

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

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

Configur	e Transforms						
				0ACCZ0 / 0ACCN0	/ 0ACCE0		
Selected Tra	nsform	Rotatio	n (Triplet)	Parameter Source	Default Parameters •		Save Parameters
Scalar	1	×	0	Y	0	z	0

7.16.12 QSCD Sender (triplet)

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

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

System configuration

	~~~~~~	M	hhm	۸		güral	UNDE OPTIN PROT	ERSTAND MISE ECT
								Minimus
Status Ne	etwork Setu	p Power Trigger	Data Stream	Data Record	Transforms	Storage	Logout He	lp
System type: Minimus	Host label: SU	PRT-MIN   Host name: MIN	-C555 (10.10.0.	13)   Serial number	: 50517			
Data Stream								
Display Streams	ll ~	Transform		Try to NOT change any	SEED Location	Display On P	age	Sensor0 ~
Reboot		Disable All Streams		Reset All Setting	JS	The "Reset A affect setting	All Settings" butto gs on other page	on will ALSO s
0AUXX0	200 Hz 🗸 🗸	Transforms Disa	bled ~	DG.TEST. 00	.HDF		RESP file 5	
0VELZ0	20 Hz 🗸 🗸	QSCDx Sender (	Triplet) 🗸	DG.TEST. 00	.BHZ		RESP file 7	
OVELNO	20 Hz 🗸 🗸	QSCDx Sender (	Friplet) ∨	DG.TEST. 00	.BHN		RESP file 8	
0VELE0	20 Hz 🗸 🗸	QSCDx Sender (	Friplet) ∨	DG.TEST. 00	BHE		RESP file 11	

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

	gürd	OPTIMISE PROTECT							
				Minimus					
Status Network	Setup Power Trigger	Data Stream Data Recor	d Transforms Storage	e Logout Help					
System type: Minimus   Host lab	System type: Minimus   Host label: SUPRT-MIN   Host name: MIN-C555 (10.10.0.13)   Serial number: 50517								
	0	ACCZ0 / 0ACCN0 / 0ACCE0							
Selected Transform	QSCDx Sender (Triplet)	Parameter Source	Default Parameters ~	Save Parameters					
Period length 20									
Manual Reset	Manual Reset								

#### 7.16.13 MMA Logger

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

$\left( \right)$	

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

The two configurable parameters are:

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

Status	Network	Setup	Power	Trigger	Data Stre	am C	ata Record	Transforms	Storage	Logout	Help
System type: Minim	us   Host lab	el: SUPF	RT-MIN   Host	name: MIN	-C555 (10.10	.0.13)   S	erial numbe	er: 50517			
Data Stream											
Display Streams	All	~ T	ransform			Try to N	OT change a	ny SEED Location	Display On	Page	Sensor0 ~
Reboot		1	Disable All	Streams		Re	set A <mark>ll Sett</mark> ir	ngs	The "Reset affect setti	t All Settings" ngs on other p	button will ALSO bages
0AUXX0	200 H	lz ∨	Trar	nsforms Disa	bled ~		G.TEST.00	.HDF HDF		RESP file	<u>5</u>
0ACCZ0	200 H	lz ∨	MMA	Logger	~		G.TEST.00	.HHZ HNZ		RESP file	<u>7</u>
Status	Network	Setup	Power	Trigger	Data Stre	am (	)ata Record	Transforms	Storage	Logout	Help
System type: Minim	us   Host lab	el: SUPF	RT-MIN   Host	name: MIN	-C555 (10.10	.0.13)   S	erial numbe	er: 50517			
Configure Trans	forms										
					0A	CCZ0					
Selected Transform	Selected Transform MMA Logger Parameter Source Default Parameters V Save Parameters										
Short Period Length	1000	Window	Length in Sho	rt Periods	5						

# 7.17 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.

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

The heart of the Earthquake Early Warning subsystem are the triggering algorithms: an STA/LTA (Short-Time-Average divided by Long-Time-Average) and 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 a pre-set threshold value an event is "declared".

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.

#### 7.17.1 Trigger sources

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

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

The configurable fields in these cases are:

- Score: this assigns a number of points to this trigger. The points value is used when assessing multiple-source triggers. This value is ignored when a trigger is not configured to use multiple sources.
- Destination: this drop-down menu specifies the destination for the trigger. See Section 7.17.2 on page 105 for more information.

Triggers	s configuration				
Source	1st Remote Source ~	Score	100	Destination	Disabled ~

- nth Address: is the I.P. address of the remote source, e.g. another Minimus.
   Sources
   Remote Inputs
- 1st/2nd/3rd/4th I/O Expander Input: Select this value to use inputs from a connected Fortimus 8 channel I/O Expander Module.

The configurable fields in these cases are:

- Score: this assigns a number of points to this trigger. The points value is used when assessing multiple-source triggers. This value is ignored when a trigger is not configured to use multiple sources.
- Destination: this drop-down menu specifies the destination for the trigger. See Section 7.17.2 on page 105 for more information.
   Triggers configuration
   Source 1st I/O Expander Input 
   Score 100 Destination Disabled
- **Tap Trigger M**: seismic or environmental Fortimus channels selectable among any of the active taps in the "Data Stream" and "Data Record" tabs.

The configurable fields in these cases are:

 Score: this assigns a number of points to this trigger. The points value is used when assessing multiple-source triggers. This value is ignored when a trigger is not configured to use multiple sources. Destination: this drop-down menu specifies the destination for the trigger.
 See Section 7.17.2 on page 105 for more information.

iriggers	Inggers computation								
Source	Tap Trigger A [0ACCZ0] 🗸	Score	100	Destination	Disabled	~			

- Sensor number: this drop-down menu is required to enables the trigger on one of Sensor0, the Fortimus.
- Tap: this drop-down menu select the stream to use as input of the trigger algorithm. The choice is between single taps, e.g. *OACCZO*, or triplets, e.g. *First Seismo Triplet*.
- Trigger type: this drop-down menu chooses to use either STA/LTA or threshold algorithm.

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

- "DC Frequency": initial AC coupling HPF corner frequency;
- "LTA Period": Long Term Average filter time period (1/corner frequency);
- "STA Period": Short Term Average filter time period (1/corner frequency);
- "Trigger Threshold": STA/LTA ratio level at which trigger occurs;
- "Event Window": After and even has been detected, subsequent crossing of the STA/LTA ratio threshold within the defined event window are treated as part of the same event and, therefore, not considered as new trigger event;
- "Initial Timeout": period of inactivity after the trigger function is initialised in order to avoid false triggers.

Sources										
	Remote Inputs									
Tap Triggers										
Tap Trigger A Sensor 0 ~				0ACCZ0	~	STA/LTA	Trigger 🗸			
DC Frequency (Hz)	0.04	LTA Period (Seconds)	12	STA Period (Second	5)	0.5	Trigger Threshold	12		
Event Window (Seconds)	5	Initial Timeout (Seconds)	10	Preview in Stre	am					

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

- "Absolute Mode": specifies if the threshold has to act on magnitude with sign (0) or absolute value of the signal (1).
- "Low/High Mode": defines whether the threshold is exceeded when the signal passes below it (0) or above it (1);
- "Threshold": value of the threshold expressed in native signal unit, e.g. m/s²;

- "Timeout": specifies the time to wait (in seconds), after the threshold crossing, before accepting a new event;
- "Hysteresis Percentage": defines the hysteresis point in terms of percentage of threshold value below or above threshold. The hysteresis point is below the threshold for High Mode, above the threshold for Low Mode.

Sources									
Remote Inputs									
Tap Triggers									
Tap Trigger	A		Sensor 0 ~	-		0ACCZ0	~		Threshold Trigger $\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!$
Absolute Mode	0	Low/High Mode	1		Threshold		10	Timeout	10
Hysteresis Percentage	10	Preview in Str	eam						

The "Preview in Stream" box temporally shows the in the live streams the output calculated by the trigger algorithm, e.g. the STA/LTA ratio. In the STA/LTA ratio trigger, when a single stream is selected as source, the calculated STA/LTA ratio is shown in place of the original data.



**Note:** Only STA/LTA ratio has preview on single streams, both Threshold and STA/LTA ratio have preview of triplets.

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

For STA/LTA ratio trigger algorithm:

- 0: shows STA/LTA ratio calculated on 2D resultant vector of N and E components. The 2D STA/LTA ratio is shown in place of original E/W component. Also, shows the STA/LTA ratio calculated on Z component and it is shown in place of original Z component. N/S component shows normal seismic output.
- 1: shows STA/LTA ratio calculated on 3D resultant vector of Z, N and E components. The STA/LTA ratio is shown on E/W component. Z and N/S components show normal seismic output.

Sources								
Local Tap Triggers								
Tap Trigger A		Sensor 0	<		First Seismo Triplet	$\sim$	STA/LTA Trigger 🗸	
DC Frequency (Hz)	0.04	LTA Period (Seconds)	12	12		STA Period (Seconds)		Trigger Threshold
Event Window (Seconds)	5	Initial Timeout (Seconds)	10	10		NE .	1	Preview in Stream
					1 = Trigger off of the 3D resultant of Z, N & E together. 0 = Trigger off of the Z component and the 2D resultant of the horizontal N & E components separately.			

For Threshold trigger algorithm:

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

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

Sources										
Local Tap Triggers										
Tap Trigger A		Sensor 0 🗸		First Seismo Triplet	~	Threshold	Trigger 🗸			
Absolute Mode	0	Low/High Mode	1	Threshold 10		10	Timeout	10		
Hysteresis Percentage	10	3D or Z & NE	1	🗹 Pre	view in Stream					
		1 = Trigger off of the 3D resultant of Z, N & E together. 0 = Trigger off of the Z component and the 2D resultant of the horizontal N & E components separately.					_			

### 7.17.2 Trigger destinations

The options available form the various Destination fields are:

 1st/2nd/3rd/4th CAP receiver: When a trigger is declared, the system will issue messages using the Common Alerting Protocol (for the full specification of this protocol, please refer to

<u>http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html</u>). This field selects to which of the four available CAP receivers the trigger information should be sent to.

Trigger	Triggers configuration										
Source 1st Remote Source ~ Score			100	Destination	[	1st CAP receiver	~				
Destinatio	Destinations										
			<b>Common Alerting Protoco</b>	I Messaging							
1st CAP Add	ress 52.34.40.123	1st CAP Port	11789	Total Score	300	1st CAP Threshold	200				
1st CAP Msg	scope Restricted v	1st CAP Recipient	eew@guralp.com	1st CAP Inhibit Timeout	10	1st CAP Acceptance Window	1				

Various parameters control how the CAP message is created:

- *n*th CAP Address: the I.P. address or DNS name of the CAP receiver;
- $\circ$   $n^{\rm th}$  CAP Port: the UDP port on which the CAP receiver is listening;
- Total Score: this is an information field, it displays an automaticallycalculated total of the scores from all of the input sources that specify this destination;
- *n*th CAP Threshold: this threshold is used when multiple input sources contribute to this trigger. Otherwise trigger threshold from source configuration is used.
- nth CAP Msg scope: this value is copied to the "scope" field of the CAP message;
- nth CAP Recipient: this value is copied to the "addresses" field of the CAP message;

- nth CAP Inhibit Timeout: is the time the Fortimus waits before sending new CAP message if a new event is detected after a previous CAP message was sent;
- nth CAP Acceptance Window: subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window;

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

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

EEW parameters (PGA, PGV and PGD values) are sent in the CAP messages body if and only if the "EEW parameter – Observer" transform is enabled on the source taps (see Section 7.16.9 on page 95).

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

Triggers cont	Triggers configuration										
Source Tap Trig	ger A [0VELZ	)] v Score		100	Destination	1st I/O Expander	Output 🗸				
Destinations											
			Relay Outputs								
1st Hold Time	1			1st Total Score	300	1st Score Threshold	200				
1st Inhibit Timeout	10	1st Acceptance Window	1								

Various parameters control how the I/O Expander behaves:

• *n*th Hold Time: is the relay switch timeout in seconds. If configured to *O* no timeout is used, otherwise relay will be released after specified number of seconds;

•

- nth Total Score: this is an information field, it displays an automaticallycalculated total of the scores from all of the input sources that specify this destination;
- nth Score Threshold: this threshold is used when multiple input sources contribute to this trigger. Otherwise trigger threshold from source configuration is used;
- nth Inhibit Timeout: is the time the Fortimus waits before sending new command to the I/O Expander if a new event is detected after a previous command was sent;
- nth Acceptance Window: subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window.
- 1st/2nd/3rd/4th **Remote Source**: This setting is used for multiple-destination triggering networks. The destinations specified here are other Fortimus or Minimus based instruments, specified by the I.P. addresses configured in the "Remote Outputs" section:

Triggers configuration											
Source Tap Trig	ger A [0VELZ	0] V Score	100	Destination	1st Remote rec	eiver ~					
Destinations											
Remote Outputs											
1st Address		1st Total Score	300	1st Score Thresh	nold	0 1st Inhib Timeout	it 10				
1st Acceptance Wind	low 1										

- *n*th Address: the I.P. address of the remote Fortimus;
- *n*th Total Score: this is an information field, it displays an automaticallycalculated total of the scores from all of the input sources that specify this destination;
- *n*th Score Threshold: this threshold is used when multiple input sources contribute to this trigger. Otherwise trigger threshold from source configuration is used.
- *n*th CAP Inhibit Timeout: is the time the Fortimus waits before sending new message if a new event is detected after a previous message was sent;
- nth Acceptance Window: subsequent source triggers for a given destination are counted towards the cumulative score if they arrive within this window.

#### 7.17.3 Low Latency Mode

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

- Minimum Power ⇒ slow processing / higher latency;
- Balanced ⇒ optimal;
- Minimum latency  $\Rightarrow$  fast processing / lower latency.

								güralp UNDERSTAND OPTIMISE PROTECT		
									Minimus	
St	atus Networ	k Setu	p Trigger	Data Stream	Data Record	Transform Parameters	Storage	Logout	Help	
System typ	System type: Minimus   Host label: SPRT-MIN   Host name: MIN-C555 (10.10.0.10)   Serial number: 00C555									
Digitizer Controls										
Reboot				The "Reset All Settings" button will ALSO affect settings on other pages						
Digitizer Config										
Auto Refres	sh 1		Auto Reboot	On Error	✓ Low Latency Mode	Balanced 🗸	1			
Host Label	SPR	T-MIN	Station Code	TEST	Network Code	e Minimum Power	Site Name		No site	
Bluetooth P	IN 00	00	Bluetooth	Enabled	✓ Filter quality	Balanced Minimum Laton ov				
Deploy Mod	e Norma	~	Deploy			Minimum Latency				

#### 7.17.4 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 7.18 on page 112 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:

🕖 Güralp Systems - Discovery										-		×	
File Edit View	le Edit View Help												
CAP R Add C miniSI Active	eceiver Device EED Extractor FishAffinity SUPRT-MIN fishyNAM	Affinity Minimus NAM2	Name MIN-C456 SUPRT-AFFT MIN-C555 SUPRT-NAM2	Firmware Ver 1.2-8580 1.0-15757 1.2-8572 1.0-15757	WAN Address 0.0.0.0 0.0.0.0 0.0.0.0 0.0.0.0	LAN Address 10.10.0.36 10.10.0.22 10.10.0.13 10.10.0.1	Netmask 255.255.0.0 255.255.0.0 255.255.0.0 255.255.0.0	Uptime 3 days 20 Hrs 56 days 1 Hrs 00:09:05 34 days 19 Hrs	Last Contact Just Now Just Now Just Now Just Now	Latitude 0.0000 0.0000 51.3606 0.0000	Longitude 0.0000 0.0000 -1.1630 0.0000	Altitude 0.00 0.00 106.80 0.00	Tir 0 0 0 0
۲.													>
Scan Locally Registry 52.34.40.123 Local Systems													
The CAP receiver window allows specification of the listening port. Each Fortimus from which messages should be received must have this value specified as the "CAP Port" in its triggering settings (see Section 7.17.2 on page 105). The value should be between 1025 and 65535. You should avoid numbers in the list at <a href="https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers">https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers</a>.

CAP Receiver - Discovery	– 🗆 X
Port 11789	Start
Log events Browse	Load from logfile
Use forwarding server	
España Suomi Sverige United Kingdom France Benapyce România Italia España © OpenStreetMap ropatjábutors	
Clear events	Close

The reception of CAP messages can be enabled or disabled clicking on the button at the top, right-hand side of the window.

Start

Browse

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.

O CAP Receiver - Discovery		– 🗆 X						
Port 11789 Start								
Log events	Browse	Load from logfile						
52.34.40.123 Use forwarding server								

To log CAP messages to a file, tick the "Log events" check-box and use the button to select an appropriate location for the database file.

O CAP Receiver - Discovery		_		×
Port 11789			Star	t
☑ Log events	Browse	I	load from	logfile
Use forwarding server				

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 Fortimus 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 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.

#### 7.17.5 Seismic Event Table

The Fortimus 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.

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

The table is located at the bottom of the "Trigger" tab in the Fortimus web page.

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

Do	wnload Settings:	Seconds Pre	10	Seconds Post	10	Download Z,N,E Triplet
	Note: Use the	Flush data b	utton i	n the Storag	e tab to	o copy most

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

Download Settings:	Seconds Pre	10	Seconds Post	10	Download Z.N.E Triplet
a contract o contragor		**		**	en commond singe rights

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

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



**Note**: The links produce downloadable miniSEED files if and only if the requested data is available in the microSD card. This depends on last flushing time and selected post event time.

## 7.18 Using a registry

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

Administrators can create their own registry servers by installing a simple program on a server. The server itself must have a static IP address and be accessible to all connected Minimus/Fortimus units, as well as the PCs running discovery. Registry servers 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/Fortimus
- 4. Set the Registry server address and Group ID in each instance of Discovery.

#### 7.18.1 Configuring a Fortimus for use with a registry

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

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

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

	Status	Label	System	Name	Serial#	Firmw	vare Ver	WAN Address	LAN Address	Uptime	Latitude	Longitud
1		NO LABEL	Minimus	MTN-1156	4438	1.1-10	122	0.0.0.0	10.10.0.45	00:04:49	51.3607	-1.1630
2		DEMO	Control Ce Live View	entre		•	22	0.0.0.0	10.10.0.36	19:49:55	0.0000	0.0000
3	0	Suppc	Firmware l	Jodate			31	0.0.0.0	10.10.0.13	19:24:21	51.3608	-1.1628
4 Ac	tive	FishAf	System Co	nfiguration			628	0.0.00	10.10.0.22	22 days 20	0.0000	0.0000
5 Ac	tive	fishyN	GDI Config	juration			667	0.0.0	10.10.0.1	8 days 23 Hrs	0.0000	0.0000
			Edit Netwo	ige ork Address								
			Show On M	Лар			<u> </u>					
Sca	n Locally	Registr	View Web	Page								
ocal	Systems		View Web	Page (in sys	tem brows	ser)						
	0,000		Calibration	n		+						
of 5	systems respor	nding	CAP Recei	ver								
			Add device									

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

Registry					
Registry Update	Every 10Secs $ \smallsetminus $	Group ID	NothernArray	Registry Address	52.34.40.123

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 I.P. 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 **Reboot** button.

#### 7.18.2 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:

Status	Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longitude		
	NO LABEL	Minimus	MIN-1156	4438	1.1-1022	0.0.0.0	10.10.0.45	00:04:49	51.3607	-1.1630		
	DEMO 83	Minimus	MIN-C456	50262	1.1-1022	0.0.0.0	10.10.0.36	21:18:15	0.0000	0.0000		
2 O)	Support	Minimus	MIN-C555	50517	1.1-1031	0.0.0	10.10.0.13	20:52:41	51.3607	-1.1629		
n Locally	Registry	52.	34.40.123								gür	à

To set the Group ID in Discovery:

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

C	Güralp Systems - Discovery									
<u>F</u> i	<u>Eile Edit View H</u> elp									
		Settings		Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Add
_	_	Exit		NO LABEL	Minimus	MIN-1156	4438	1.1-1022	0.0.0.0	10.10.0.4
	2	0		DEMO 83	Minimus	MIN-C456	50262	1.1-1022	0.0.0.0	<b>10.10.0.</b> 3
:	3	00		Support	Minimus	MIN-C555	50517	1.1-1031	0.0.0.0	10.10.0.1

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

Application configuration - Discovery									
General									
Cloud registry group identifier	NorthernArray								
Default HTTP connection port	80								
Restore defaults		Cancel	App	ly					

Return to the main windows and test the configuration by clicking the

Registry button. All Fortimus using the same Registry server and Group ID should appear in the main list.

#### 7.18.3 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:

		Statu	5	Label	System	Name	Serial#	Firmware Ver	WAN Address	LAN Address	Uptime	Latitude	Longi
5	0	0		NO LABEL	Minimus	MIN-FD57	64855	1.2-8572	192.0.2.157	10.0.1.64	30 days 4 Hrs	35.4279	-98.02
58	0	0		NO LABEL	Minimus Plus	MINP-6158	24920	1.3-2713	192.0.2.35	10.0.1.67	21 days 22 Hrs	51.3612	-1.164
67	0	0		bktest65	Minimus Plus	MINP-DC58	56408	1.2-8572	192.0.2.201	10.0.1.68	30 days 16 Hrs	37.8761	-122.2
65	0	0		bktest66	Minimus Plus	MINP-DD58	56664	1.2-8572	192.0.2.201	10.0.1.66	9 days 18 Hrs	37.8761	-122.2
53	0	0		bktest68	Minimus Plus	MINP-DE58	56920	1.2-8572	192.0.2.201	10.0.1.65	9 days 18 Hrs	37.8761	-122.2
66	0	0		bktest67	Minimus Plus	MINP-DF58	57176	1.2-8572	192.0.2.201	10.0.1.14	30 days 16 Hrs	37.8761	-122.2
54 🚺	0	0		bktest64	Minimus Plus	MINP-E058	57432	1.2-8572	192.0.2.201	10.0.1.186	30 days 16 Hrs	37.8761	-122.2
C	n Lo	cally		Penistry 5'	2 24 40 122	7							

Sy	stem	Name	Serial#	Firmware Ver	WAN Address	LAN A	ddress	Uptime	Latitude	Longi ^
Minin	nus	MIN-FD57	64855	1.2-8572	192.0.2.157	10.0.1.6	i4	30 days 4 Hrs	35.4279	-98.02
Minin	nus Plus	MINP-6158	24920	1.3-2713	192.0.2.35	10.	Control (	Centre	E1 0640	
Minin	nus Plus	MINP-DC58	56408	1.2-8572	192.0.2.201	10.	Live View	1		
Minin	nus Plus	MINP-DD58	56664	1.2-8572	192.0.2.201	10.	Firmware	Update (using LA	N address)	
Minin	nus Plus	MINP-DE58	56920	1.2-8572	192.0.2.201	10.	System C	onfiguration (usin	g LAN addre	ss)
Minin	nus Plus	MINP-DF58	57176	1.2-8572	192.0.2.201	10.	GDI Conf Edit Netv	iguration (using Li vork Address	AN address)	
Minin	nus Plus	MINP-E058	57432	1.2-8572	192.0.2.201	10.	Show On	Мар		
.34.40.1	123	1					View Wel View Wel	b Page (using LAN b Page (in system	address) browser) (usi	ng LAN add
							Calibratio	20		

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.

 $\times$ Serial# Firmware Ver WAN Address LAN Address Uptime Latitude Longi ^ 4855 1.2-8572 192.0.2.157 10.0.1.64 30 days 4 Hrs 35.4279 -98.02 1.3-2713 192.0.2.35 10, Control Centre 6**408** 1.2-8572 192.0.2.201 10. Live View GDI (using LAN address) GCF (using LAN address) 192.0.2.201 6664 1.2-8572 10. Firmware Update (using LAN address) GDI and GCF (using LAN address) System Configuration (using LAN address) 1.2-8572 192.0.2.201 10. 6**920** GDI Configuration (using LAN address) 7176 1.2-8572 192.0.2.201 10. Edit Network Address 7432 1.2-8572 192.0.2.201 10. Show On Map View Web Page (using LAN address) View Web Page (in system browser) (using LAN address) Calibration ۲

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:

				-		×
WAN Address	LAN	Address	Uptime	Latitud	e Long	i ^
192.0.2.157	10.0.1	.64	30 days 4 Hrs	35.4279	-98.0	2
192.0.2.35 192.0.2.201	10.00 10.	Control ( Live View	Centre	C4 0640		
192.0.2.201 192.0.2.201 192.0.2.201	10. 10. 10.	Firmware System C GDI Conf Edit Netv	e Update (using LA Configuration (usin figuration (using L vork Address	N address) ig LAN add AN address	ress) ;)	
192.0.2.201	10.	Show On View We View We	n Map b Page (using LAN b Page (in system l	address) browser) (u	ising LAI	N add
		Calibratio	on			

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

## 7.19 Updating Fortimus firmware

The firmware of the Fortimus is upgradeable. New releases appear regularly – mostly to add new features but, occasionally, to fix problems. Güralp recommends that the Fortimus 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 Fortimus digitiser. See Section 13.5 on page 154 for more details.

If you have any recorded data that you value, backup all files from the Fortimus microSD card:

- 1. Unplug the external microSD card from your Fortimus.
- 2. Plug the external microSD card into your PC.
- 3. Copy all files from the external microSD card into your PC.
- 4. Unplug the external microSD card from your PC.
- 5. Plug the external microSD card back into your Fortimus.

Once this is complete, to upgrade the Fortimus:

- 1. Run Discovery.
- 2. Right-click on the Fortimus in Discovery main window and select "Firmware Update".

In the "Firmware Update" tab, select "Güralp server – stable (online version: 2.0-****)" to obtain the new firmware from the Internet via a local Ethernet connection. Click Get from server and update

FMUS-DA5B - Firmwar	e Update - Discovery			-		×
Host name: FMUS-DA5B IP address: 10.10.0.11 MAC address: 00:50:C2:40:	5B:DA					
Configuration						
Automatically download	d/upload configuration					
O Reset configuration						
O Apply configuration fro	m file				Browse	
Firmware						
Current firmware date: 14-	Nov-2019					
Current firmware version: 2	2.0-7886					
Güralp server - stable (	(online version: 2.0-7856) <u>Release</u>	<u>e notes</u>	Get from server	and u	pdate	
O Güralp server - experim	nental (online version: 2.0-7856)		Get from server	and u	pdate	
🔿 Local file	[		Browse		Update	
						0%
					Close	e



**Caution:** If updating from any release of v1.2 to v2.0, select the option "Güralp server – version 2.0-**** (online)" only. Do not use "Local file" option unless agreed case-by-case with <u>support@guralp.com</u>.

P address: 10.10.0.11		
MAC address: 00:50:C2:40:5B:DA Configuration		
Automatically download/upload configuration		
Reset configuration		
O Apply configuration from file		Browse
Firmware		
Current firmware date: 29-Apr-2019 Current firmware version: 1.2-8707		
○ Güralp server - stable (online version: 1.2-8713) <u>Release notes</u>	Get from server and	d update
○ Güralp server - experimental (online version: 1.2-8713)	Get from server and	d update
🔿 Local file	Browse	Update
Güralp server - version 2.0-7856 (online)	Get from server and	d update
		Clos

Discovery will ask you if you want to save the Firmware binary file for future use – click <u>Yes</u> for future use, e.g. update other systems offline using same firmware file. Otherwise, proceed with <u>No</u>.



Discovery may ask to overwrite a temporary file on your PC – click
 Yes to allow it to do so.

File download - Guralp Discovery	-	×
File already exists Guralp Discovery ×		
File already exists - overwrite? C:/Users/shicks/AppData/Local/Temp/dig_stable.bin		
Yes No		
Cancel Ok		

 Discovery will confirm through another dialogue box that the file download is complete. Click Yes to begin the firmware upload to the Fortimus.



 At the end of the uploading process, the dialogue box will ask to restart the Fortimus. Click Yes to finalise the process.



 A dialogue box will ask you if you want to upload the previous configuration. Click Yes to finalise the process.



 When the configuration is uploaded, the Fortimus needs to be restarted again. Confirm with Yes to the dialogue box.



- 10. The Fortimus will re-boot and, during this process, the displays will show a white screen with the Güralp logo in the middle and a progress-bar at the bottom.
- 11. Go to the "Storage" of the Fortimus web page and Quick-format the microSD cards of your Fortimus (for details, see Section 7.10.2.1 on page 57).
- 12. Check that all indicators are green (i.e. nothing in red nor in yellow) in Discovery.
- 13. Go to the "Status" tab of the Fortimus web page.
- 14. Check that your Fortimus firmware version is as expected.
- 15. Check that nothing red or yellow shows up in the "Status" tab of the Fortimus web page.

## 7.20 Import / Export an existing configuration

Updating the Fortimus' 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:

D G	üralp Systems - Di	iscovery												-		
<u>F</u> ile	Status	Label	System	Name	Serial#	Firmware	Ver	WAN Address	LAN Address	ι	Jptime	Latitude	Longitude			
1		NO LABEL	Minimus	MIN-1156	4438	1.1-1022		0.0.0.0	10.10.0.45	00:	04:49	51.3607	-1.1630			
2		DEMO 83	Minimus	MIN-C456	50262	1.1-1022		Control Centre			7:55	0.0000	0.0000			
3	00	Support	Minimus	MIN-C555	50517	1.1-1031		Live View		۲	2:21	51.3607	-1.1630			
							_	Firmware Update								
Sci Local	an Locally	Registry	52.	34.40.123				GDI Configuration File Exchange Edit Network Add	n Iress					güı	al	ķ
4 of 5	systems respor	nding						Show On Map View Web Page View Web Page (i	n system browser	)						
								Calibration		۲						
								CAP Receiver Add device								

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.

System Configuration Import/Export Too	- Discovery	– 🗆 X
Configuration source		
Our Seconfiguration from one of the devices:	MIN-9555 (10.10.0.18)	<ul> <li>Download configuration</li> </ul>
O Use configuration from file:		Browse
Devices Select devices for configuration upload MIN-9555 (10.10.0.18)		
Upload		Upload configuration Reboot selected

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.

System Configuration Import/Export Tool ·	Discovery	-		×
Configuration source				
$\bigcirc$ Use configuration from one of the devices:	MIN-9555 (10.10.0.18)	Downlo	ad configur	ation
Use configuration from file:			Browse	
Devices				
Select devices for configuration upload				
MIN-9555 (10.10.0.18)				
Select All				
Upload				
		Uplo	ad configur	ation
		[	Reboot sele	ected
			0	к

Select the configuration file from where it was saved in the File Explorer and confirm. Use the check-boxes to select the devices to which the configuration should be uploaded and click on the Upload configuration button.

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



**Note:** The configuration export and upload doesn't preserve the settings related to the applied transforms.

# 7.21 Control Centre

Several actions can be taken from within Discovery to control your Fortimus digital accelerometer.

These operations can be performed 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 instrument, its serial number and I.P. address, its up-time (time since last boot) and GNSS status.
Console	This button launches a console that allows interactions with the command line of the Fortimus. 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 Fortimus in the Discovery main window.
Map	This button is equivalent to the "Show on Map" entry in the context (right-click) menu of the Fortimus 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 Fortimus in the Discovery main window.
	This tab allows manual centring of the Fortimus accelerometer.



# 8 GüVü app

The GüVü app provides monitoring and control of near-by Fortimus digital accelerometer 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

### 8.1 Getting stated

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



Steps for launching the GüVü App:

- 1. Launch by clicking on the GüVü icon from either the Apps menu or from the Home Screen.
- 2. Wait a few seconds for the app splash screen.
- 4. Select the appropriate Fortimus device from the list of available devices. Wait a few seconds for the main viewer screen to show.

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

If you experience problems connecting, try forcing GüVü to quit and then relaunching 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 digitiser and accelerometer. These features are summarised in the figure below:



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

güralp
Connect
Select data source
Show all Show status view
Show mass graph view Show velocity graph view
Exit
4 O D

## 8.2 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.

#### 8.3 Instrument control

Several features of the Fortimus can be controlled and configured remotely over Bluetooth using GüVü:

- Accelerometer centring
- Clearing and un-mounting SD card
- Rebooting the Fortimus
- Enable/disable power-saving mode
- Station meta-data (User Label, Station Name, Network Code, Site Name)
- Network setting (I.P., Netmask, Gateway)
- Changing channels' sampling rates

In each case, GüVü will report whether the selected command has been successfully sent to the device.

11:12	
güralþ	
Request instrument centerin Clear SD Card	ng
Unmount SD Card Reboot	
PowerSave Mode ON	
PowerSave Mode OFF	
Unlock sensor mass	
Lock sensor mass	
Change station settings	
Back	
< (i)	

**Note:** After any modification to channels' sampling rates, the Fortimus must be rebooted before the changes will take effect.

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



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

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

#### 8.3.1 Setting the PIN code

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

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

#### 8.4 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 (IIII) 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.



# 9 Advanced troubleshooting

In the unlikely event of the user experiencing problems with the operation of the Fortimus, a diagnostics tool is available via the GNSS connector, which also acts as a terminal communications device via a Serial connection.

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 in the "Serial line" box and the Speed should be set to 115,200.

RuTTY Configuration		?	×
Category: Session Logging Terminal Keyboard Bell Features Window Appearance Behaviour Translation Selection Colours Connection Data Proxy Telnet Rlogin SSH Serial	Basic options for your PuTTY set         Specify the destination you want to conner         Serial line         COM1         Connection type:         Raw       Telnet         Rlogin       SSH         Load, save or delete a stored session         Saved Sessions         Default Settings         Web Mirror         Close window on exit:         Always       Never         Only on comparison	ssion sct to Speed 115200 H  Set Save Delete	jal
<u>A</u> bout <u>H</u> elp	<u>O</u> pen	<u>C</u> ance	el 🛛

Finally click the **Open** button and a terminal window will open, connected to the console of the Fortimus.

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.

#### 9.1 Reset all settings during boot phase

The Fortimus 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 Fortimus via the LCD;
- the user is not able to communicate with the Fortimus via a network connection;
- the unit is not responsive; or
- the unit 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 9 on page 131). 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 Fortimus will re-boot. It may be necessary to enter this key combination several times.

A typical boot log is shown below, identifying the stages where Ctrl + R will cause the Fortimus to reset and re-boot.

Do not press any buttons during the first phase of boot-up:

RomBOOT

```
SCKC_CR = 0xA, CKGR_MOR = 0x100FF0A, CKGR_PLLAR = 0x20FDD101,
PMC_MCKR = 0x1122, PIO_PDSR = 0xF2357EB5
SCKC_CR = 0xA, CKGR_MOR = 0x100FF0A, CKGR_PLLAR = 0x20AC3F01,
PMC_MCKR = 0x0202, PIO_PDSR = 0xF2357C25
AT91Bootstrap v3.8.10-1.guralp
```

NAND: ONFI flash detected NAND: Manufacturer ID: 0x2C Chip ID: 0xDA NAND: Page Bytes: 2048, Spare Bytes: 64 NAND: ECC Correctability Bits: 4, ECC Sector Bytes: 512 NAND: Disable On-Die ECC NAND: Initialize PMECC params, cap: 4, sector: 512 NAND: Image: Copy 0x92000 bytes from 0xE000 to 0x2FA0E000 NAND: Done to load image SCKC_CR = 0xA, CKGR_MOR = 0x100FF02, CKGR_PLLAR = 0x20AC3F01, PMC MCKR = 0x0202, PIO PDSR = 0xF2357C25

U-Boot v2019.10-1.guralp

CPU: SAMA5D36 External clock: 12.000 MHz CPU clock: 528.000 MHz Master clock: 132.000 MHz

```
DRAM: 512 MiB
NAND: 256 MiB
MMC: Atmel mci: 0, Atmel mci: 1
Loading Environment from NAND... OK
In: serial
     serial
Out:
Err: serial
Net: eth0: ethernet@f0028000
Total of 1 word(s) were the same
PHY 0x07: OUI = 0x0885, Model = 0x22, Rev = 0x02, 10baseT, HDX
Hit any key to stop autoboot: 0
NAND read: device 0 offset 0x5C0000, size 0x360000
3538944 bytes read: OK
Uncompressed size: 5009436 = 0x4C701C
crc32 for 21000000 ... 214c701b ==> b6ae61d4
Total of 2 word(s) were the same
Total of 1 word(s) were the same
## Starting application at 0x00300000 ...
(boot)Crash Info###
Number of crash left=0
(boot)Last crash time:1970-01-01T00:00:00.000
Board type set to: Fortimus
Recognised external clock: 12000000 Hz
SCKC CR = 0xA, CKGR MOR = 0x100FF02, CKGR PLLAR = 0x20AC3F01,
PMC MCKR = 0 \times 0202, MCK = 132000000 Hz
```

@GURALP SYSTEMS

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

```
v2.0-7642 by teamcity on 10:41:19 12-Nov-2019
Vecbase: 300000 CPUid: 410fc051 Cache: c5187d
PMT init
Unsafe to change DBGU clock while running
mux start SP 300fb4
FPU start
VFP Id=41023051
    0.00 | -> init dbgprint
   0.00 | -> init_cmdutils
    0.00 | -> init_pmt_dlg
    0.00 | -> init memdlg
    0.00 | -> malloc debug
   0.00 | -> start_timer_interrupts
    0.01 | -> rtc init
RTC Time: 2019-11-13T10:05:37 UTC
    0.01 | -> uart start ints
    0.01 | -> init_arm_parse
    0.01 | -> t init task utils
    0.01 | -> gpio init
##### NORMAL INITIALISATION MODE #####
    0.01 | -> unit test init
    0.01 | -> init devio
    0.01 | -> init usart
```

```
0.01 | -> init_devio_cmds

0.02 | -> rpc_init

0.02 | -> ram_init

0.02 | -> ram_exchange_init

0.03 | -> system update init
```

If your key-strokes have been recognised, Ctrl+R will be printed in the boot log, as shown below – once for each time your keystrokes were logged:

```
0.03 | -> i2c init
i2c configure( 0, 100000Hz )
Using pclk 33000000, cdiv 161, shift 0 => 100000
i2c configure( 1, 100000Hz )
Using pclk 33000000, cdiv 161, shift 0 => 100000
i2c configure( 2, 100000Hz )
Using pclk 33000000, cdiv 161, shift 0 => 100000
    0.06 | -> i2c dac init
Ctrl+R
Ctrl+R
Ctrl+R
Ctrl+R
Ctrl+R
Ctrl+R
Ctrl+R
    0.06 \mid -> i2c humid init
Humidity sensor test SUCCESS
   0.07 | -> fram init
Installing NVR device. size 12640
    0.10 | -> net sockets init
   0.14 | -> newtask init
USE ADC FORTIMUS
   0.14 | -> display init
i2c rd S FAILED [bus: 2 | slave: 0x38]
i2c rd S FAILED [bus: 2 | slave: 0x38]
i2c rd S FAILED [bus: 2 | slave: 0x38]
###FAIL OF i2c write( 2, 38, 1[000000], 1, 0x22a4ff7b )
after 3 attemptsi2c configure( 2, 100000Hz )
Using pclk 33000000, cdiv 161, shift 0 => 100000
If you saw the previous i2c operations failing, do not panic, it
was an attempt to detect FT6x36 touchscreen...
GT911 PIN CONFIGURATION...
GT911 SETTING PINS TO 0...
GT911 SETTING PINS TO 0...
GT911 SETTING RESET TO 1...
GT911 SETTING GT911 PIN IRQ TO INPUT...
GT911 Config checksum: 9a
GT911 Product ID: 00 31 31 39
GT911 Firmware Version: 1060
GT911 Vendor Id: 00
GT911 Config Version: 00
GT911 Written Resolution of X/Y Axis: 0000-0000
GT911 resolution X (0x8146) / resolution Y (0x8146) / Touch
number: 0000 / 0000 / ff
gt911 has been detected
                           2.69 | -> aux ioexp init
    2.70 | -> init whalesong
```

```
2.70 | -> analog232 init
    2.73 | -> start timers
    2.76 | -> spi datalink init semaphores
    2.79 | -> chain init
Using 251 coefficients.
    2.87 | -> var user init
    3.20 | -> calibration init
    4.86 | -> gcftx init
    4.89 | -> spi datalink chains init
Sensor0 is accelerometer
    5.15 | -> init nand
    6.18 | -> adc12 init
    6.20 | -> init random
    6.24 | -> ltc4151 vc monitor init
    6.27 | -> voltage sniffer init
    6.31 | -> init lut
    6.42 | -> i2c humid init ui
    6.45 | -> sd init
    6.48 | -> sd file init
    6.51 | -> sd log init
    6.54 | -> streaming client init
2019-11-13T10:05:43.000Z Retime Request Waiting (35s/3600s/Boot
delay)
    6.59 | -> xtaltable init
No XTAL table found.
    6.71 | -> qps pps init
Chain 54 already set.
FMUS-DA5B-> 6.82 | -> init var debug
    6.85 | -> tcpdump init
    6.88 | -> var html init
    6.91 | -> init http_server
    6.94 | -> sd_init_var
    6.96 | -> gps_pps_ui_init
    6.99 | -> xtaltable_ui_init
checking for xtaltable.txt
    7.03 | -> init_fpga_datalink
    7.06 | -> init auto center
    7.09 | -> init embedded fs
    7.12 | -> status txt init
    7.18 | -> lan init web
#####tx lock:
majic:f710f7f7
Call lock value:-1
                      7.19 | -> init responder ui
1969-12-31T23:59:59.459Z User variable "Group ID" modified (called
from init responder ui)
    7.20 | -> init tunnel ui
    7.24 | \rightarrow quasar init
Quasar Serial Isolated Input/Output Module support is disabled.
    7.31 | -> quasar init ui
    7.31 | -> applied rot init web
```

7.31 | -> installation_parameters_init_web
7.35 | -> init_fortimus_web
7.39 | -> analog232_init_web
7.46 | -> init_transforms
7.49 | -> triggers_init_ui
7.66 | -> chain_init_web
7.95 | -> transform_init_web
9.11 | -> storage_init_web
9.16 | -> spi_datalink_ui_init
9.20 | -> gps_init_ui
9.23 | -> gps_init

Once the boot-up reaches this stage, pressing Ctrl + R will no longer have any effect.

If Ctrl + R was recognised during the second stage of boot-up, then the Fortimus will reset and re-boot:

```
Ctrl+R NVR load, resetting all vars to their default values and
then rebooting
Forcing all vars to default values (including non-default-able)
PPS clock sources ACTIVE: 0x00000001 [GPS:0 PTP:0 RTC:0 TABLE:1]
PPS clock sources ACTIVE: 0x01000001 [GPS:1 PTP:0 RTC:0 TABLE:1]
PPS clock sources ACTIVE: 0x01010001 [GPS:1 PTP:1 RTC:0 TABLE:1]
PPS clock sources ACTIVE: 0x01010101 [GPS:1 PTP:1 RTC:1 TABLE:1]
Ctrl+R
Ctrl+R
Ctrl+R
sd manager: probed both microSD card slots
11.58 {calibration.c;1142} calibration write to fram:
successfully wrote calib to FRAM
11.60 {var_nvr.c;773} 'sd_format_time' $20301021 --> $00000000
11.61 {var_nvr.c;773} 'sd_unmount_time' $22647008 --> $0000000
11.62 {var_nvr.c;773} 'pps_src_table' 168 --> 1
11.63 {var nvr.c;773} 'pps src gps' 0 --> 1
11.63 {var_nvr.c;773} 'pps_src_ptp' 69 --> 1
11.64 {var nvr.c;773}
                       'pps src rtc' 132 --> 1
11.64 {var nvr.c;773}
                       'rtcSavedOffsetSecs nv' -1737983855 --> 0
11.65 {var nvr.c;773} 'rtcSavedOffsetNano nv' 402788896 --> 0
11.66 {var nvr.c;773} 'rtcSavedFreqErrorPPB nv' -2129883872 -->
1000000
11.67 {var nvr.c;773} 'rtcSavedOffsetTime nv' $52080158 -->
$0000000
11.68 {var nvr.c;773} 'xtaltable offset' 610275339 --> 0
÷
```

# 10 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
С	≥ 250 Hz to < 1000 Hz
н	≥ 80 Hz to < 250 Hz
В	≥ 10 Hz to < 80 Hz
М	> 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 SOAccZA and SOAccZB carry digitisations of the same signal, differing only in the sample rate.

## 10.1 Environmental channels

			Data streaming	Data recording		
Sensor	Comp.	Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
		Acqueal	S0AccZ	0AXL10	S0AccZA	xN1
	1	Acausai			S0AccZB	xN1
		Causal	S0AccelZLowLat	0AXL1C		xN1
	2	Acausal	SOAccN	0AXL20	SOAccNA	xN2
MEMS accelerometer					SOAccNB	xN2
		Causal	S0AccelNLowLat	0AXL2C		xN2
	3	Acausal	S0AccE	0AXL30	SOAccEA	xN3
					SOAccEB	xN3
		Causal	S0AccelELowLat	0AXL3C		xN3
Magnetometer	1	Acausal	S0MagZ	0MAG10	S0MagZ	xF1

#### Güralp Fortimus

#### Appendix 1 – Instrument/channel names

			Data streaming	Data recording		
Sensor	Comp.	Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
	2	Acausal	S0MagN	0MAG20	S0MagN	xF2
	3	Acausal	S0MagE	0MAG30	S0MagE	xF3
Input voltage		Acausal	S0Voltage	0VINP0	S0Voltage	xYV
Digitiser power usage		Acausal	S0Power	0PINP0	S0Power	хҮР
Humidity	Relative within Minimus	Acausal	S0HumidA	0HUMA0	S0HumidA	xIO
	Within sensor enclosure	Acausal	S0HumidB	0HUMB0	S0HumidB	xIO
Pressure	Within sensor enclosure	Acausal	S <i>n</i> Pressure	<i>n</i> PRSR0	S <b>n</b> Pressure	xDI
	External	Acausal	S <i>n</i> ExtPressure	<b>n</b> PRSR1	S <i>n</i> ExtPressure	xDO
<b>T</b>	Precision temperature	Acausal	S0TemprA	0TMPA0	S0TemprA	хKO
Temperature	First derivative of temperature	Acausal	S0TemprD	0TMPD0		xKD
	Internal clock offset from GNSS	Acausal	ClkGpsOffset	0CGPSO	ClkGpsOffset	BEO
	Internal clock period difference from GNSS	Acausal	ClkGpsPeriod	0CGPSP	ClkGpsPeriod	BEF
Internal Cleak	Internal clock DAC frequency pulling	Acausal	ClkDacFreqPull	0CVDAC	ClkDacFreqPull	BED
	Test internal clock drift	Acausal	ClkTestPbpS	0CTSTB	ClkTestPpbS	BEB
	Internal clock offset from PTP	Acausal	ClkPtpOffset	0CPTPO	ClkPtpOffset	BEP
	Delay MS	Acausal	ClkPtpDelayMS	0CPDMS	ClkPtpDelayMS	BEA
	Delay SM	Acausal	ClkPtpDelaySM	0CPDSM	ClkPtpDelaySM	BEB
	Mean path delay	Acausal	ClkPtpMeanPathDelay	0CPMPD	ClkPtpMeanPathDelay	BEC
PLL clock offset		Acausal	S <b>n</b> PLLOffset	0PLLO0	S <b>n</b> PLLOffset	хYО

## 10.2 Broadband accelerometer channels

			Data streaming	Data recording		
Sensor	Comp.	Digital filter mode	Live stream name	Live Stream code	Data record name	Mini SEED channel code
		Acausal	S0SeisZ	0ACCZ0	S0SeisZA	xNZ
	Vertical		S0SeisZ	0ACCZ2	S0SeisZB	xNZ
		Causal	Se0SeisZLowLat	0ACCZC	Se0SeisZLowLat	xNZ
	North	Acausal	S0SeisN	0ACCN0	S0SeisNA	xNN
Analogue accelerometer			S0SeisN	0ACCN2	S0SeisNB	xNN
		Causal	Se0SeisNLowLat	0ACCNC	Se0SeisNLowLat	xNN
	East	Acausal	S0SeisE	0ACCE0	S0SeisEA	xNE
			S0SeisE	0ACCE2	S0SeisEB	xNE
		Causal	Se0SeisELowLat	0ACCEC	Se0SeisELowLat	xNE
Calibration channel		Acausal	S0Calib	0ACCC0		xCA

# 11 Appendix 2 – Fortimus network ports

The following network ports are used by the Fortimus:

Port	Layer 4 Protocol	Description
80	TCP	HTTP server
1565	TCP	GDI transmission protocol
1567	TCP/UDP	GCF transmission protocol
4242	TCP	File exchange protocol
4244	TCP	Remote console
11788	UDP	Remote procedure calls
18000	TCP	SEED-link transmission protocol

# 12 Appendix 3 – Connector pin-outs

## 12.1 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.

#### 12.2 Power

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



Pin	Function
Α	Ground
В	10-36 V DC input
С	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.

## 12.3 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).

# 13 Appendix 4 – 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 <u>www.guralp.com/sw/download-discovery.shtml</u> to download the appropriate installation script or use the command

```
wget http://www.guralp.com/download/discovery/Discovery.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  $-\circ$  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. A 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 <u>www.guralp.com/sw/download-discovery.shtml</u> and download the appropriate disk-image file.

🔍 🔍 🖉 Guralp Systems Ltd: Seismic 🗆 💥 +									
www.guralp.com/download/discovery/Discovery.d	mg	▼	→ Q, Search		☆自	□ +	â -	A 💁-	≡
al'iralà									
gaiaip									
HOME ABOUT US	APPLICATIONS PRODUCTS	SYSTEMS	SERVICES	SUPPORT	CONTACT US				
Discovery Dov	wnload Page								
To download a copy of Güralp's Disc	covery software, please select a link from the	ist below:							
Microsoft Windows - 32-bit vi http://www.guralp.com/down	ersions: load/discovery/DiscoveryInstall_x86.exe								
<ul> <li>Microsoft Windows - 64-bit w http://www.guralp.com/down</li> </ul>	ersions: load/discovery/DiscoveryInstall.exe								
MacOS X - 64-bit:     http://www.guralp.com/down	load/discovery/Discovery.dmg								
Linux - 64-bit versions:     http://www.auralo.com/down	load/discovery/discovery linux x64.tar.gz								
	Email Us Submit Enquiry	contact Us	Contact Local Dist	ributor					
Find	out more about our track record & experience	and read about sel	ected projects in our o	case studies.					
									_

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

Www.gurab.com/download/discovery/Discovery.dmg     Image: Comparing Discovery.dmg       HOME     ABOUT US       ABOUT US     AProgram Contract US       You have chosen to com:	🗣 🌻 🔍 🗮 Guralp Systems Ltd: Seismic 🗙 🕂								
	• www.guralp.com/download/discovery/Discovery.dmg	V 🔿 Q. Search		• •	÷	â	4 4	•	=
<complex-block><complex-block></complex-block></complex-block>		Opening Discovery.dmg UPPORT Vou have chosen to open: Discovery.dmg UPPORT Discovery.dmg Upp	сонтист	rus		<b>n</b>			

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 the display of the Discovery drag and drop installation window:

 _ Dis	covery	
		güralp
D	A	
 discovery.app	Applications	
 	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~

- 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.

Setup - Discover			×
Select Start Menu Folder Where should Setup place the program's s	shortcuts?	1 1 1	B
Setup will create the program's s	shortcuts in the following Sta	rt Menu folder.	
Guralp Systems\Discover	to select a different folder, c	Browse	
	< <u>B</u> ack <u>N</u> ext	> Cancel	
Click Next>, key ↔	or key Alt	N to co	ntinue.

4. The next screen asks whether you would like to place an icon for Discovery on the desktop:

Cature Discourse			~	
Setup - Discover			~	
Select Additional Tasks				
Which additional tasks should be performe	ed?			
Select the additional tasks you would like	Setup to perform while inst	alling Discover,		
then click Next.				
Additional icons:				
Create a desktop icon				
	< Back Next	t> Ca	ancel	
				_
ck the check-box if you	wish and the	n click	Next >	kev
on the oncon box if you	wish and the		<u>deve</u> >	



5. The installer then offers a last chance to change any of your decisions:

Setup - Discover —	
Ready to Install Sature is now ready to begin installing Discover on your computer	
Setup is now ready to begin installing discover on your computer.	
Click Install to continue with the installation, or click Back if you want to review change any settings.	or
Destination location: C:\Program Files (x86)\Guralp Systems\Discover	^ ·
Start Menu folder: Guraln Systems/Discover	
<	>
	Creat
< Back Tuztan	Cancel
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 **Instal**, the installation begins and a progress screen is displayed:

🛈 Setup - Discover	_		×
Installing Please wait while Setup installs Discover on your computer.		(
Extracting files C: \Program Files (x86) \Guralp Systems\Discover \Qt5Webkit.dll			
		Can	cel

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:



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"

≡		More \checkmark				
ŵ	Best match					
0	Allow an app through Window Control panel	ws Firewall 🗟				
	2 allow an app Help from Microsoft					
	Web	>				
	𝒫 allow an app - Search the web					
	${\cal P}$ allow an app through windows ${\cal P}$	10 firewall				
ŝ	\mathcal{P} allow an app through windows t	firewall				
2						
	allow an app		[]]	Q	٨	

- 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".)

Allow apps to communicate through Wind	lows Firowall						
To add, change or remove allowed apps and ports, slid	Change settings						
to add, change of remove allowed apps and ports, click	c change settings.						
What are the risks of allowing an app to communicate?							
Allowed apps and features:							
Name	Domain	Private	Public	^			
Core Networking			~				
✓ Cortana	\checkmark		~				
Delivery Optimization	\checkmark		\checkmark				
✓ DiagTrack			\checkmark				
✓ DIAL protocol server		V					
discovery	\checkmark			>			
Distributed transaction Co-ordinator							
☑ Dropbox			✓				
Email and accounts	\checkmark		V				
Feedback Hub	\checkmark		\checkmark				
File and Printer Sharing	\checkmark						
✓ Films & TV	~	✓	✓	\checkmark			
	Deta	ails	Remove	e e			
		Allow anot	ther app				

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 WiFi hotspots at coffee shops, airports, and other locations.

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

5. First click the OChange settings buttons to activate the interface.

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



7. Click the <u>Network types...</u> button. The "Choose network types" window is shown:

Allow apps to con To add, change or remo What are the risks of all	municate through Windows Firewall ve allowed apps and ports, click Change settings. wing an app to communicate?	Change settings
Allowed apps and Fas Name Ed Core Network Yo Cortana Delivery Optin DiagTrack DIAL protoco discovery W Distributed Tr Yo Distributed Tr Yo Distributed Tr Yo Email and acc Feedback Hub File and Printer SI Films & TV	Choose Network Types Allow this app or port to communicate through Windows Firewall for the selected network type: Domain: Networks at a workplace that are attached to a domain Private: Networks at home or work where you know and trust the people and devices on the network Public: Networks in public places such as airports or cafés OK Canc	x ate Public ^ g ? Ø ? Ø ? Ø ? Ø ? Ø ? Ø ? Ø ? Ø

After making appropriate changes, click OK 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 Alt + H followed by A:

D G	üralp S	ystems -	Disco	overy				
File	Edit	View	Help	>				
		Status	D	About	System	Name	Firmware Ver	WAN Address
1		0	?	Help	Minimus	MIN-B056	1.0-1271	95.6.57.152
2	Ø	0		SalesDEMO	Minimus	MIN-8256	1.1-1022	89.213.16.117
3	Activ	e		fishyNAM	NAM2	SUPRT-NAM2	1.0-15757	89.213.16.113
4		0		Murray	Minimus Plus	MINP-6158	1.2-8599	89.213.16.113
5	Ø	0		NO LABEL	Minimus Plus	MINP-E658	1.2-8563	89.213.16.113
6	Ø	0		NO LABEL	Minimus Plus	MINP-DD58	1.2-8555	89.213.16.113
7		0		NO LABEL	Minimus Plus	MINP-E558	1.2-8563	89.213.16.113
8	Ø	0		NO LABEL	Minimus Plus	MINP-E058	1.2-8555	89.213.16.113
9	0	0		NO LABEL	Minimus Plus	MINP-6458	1.2-8563	89.213.16.113
10	0	0		NO LABEL	Minimus Plus	MINP-E958	1.2-8563	89.213.16.113

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 Update button will be disabled, as shown above.

If a newer version is available, the screen will look like this:

Discovery About - Guralp Disco	very	-		×
	Discovery application is provided by Guralp Systems Limited.			
güralþ	Head office: Gurajp Systems Limited, Midas House, Calleva Park, Aldermaston, Reading. RG7 8EA, United Kingdom Tel: +44 113 981 9056 E-Mail: sales@guraip.com			
	Discovery version: Experimental 0.1.351 Update to version 0.1.669 is available online. Please use "Update" button	to downl	oad the in Upda	staller.
	Ok			

If you with 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 <u>Update</u>, you may see the following warning if the previous installer is still in your download folder:

File download - Guralp Discovery	— [
	_	
File already exists Guralp Discovery	×	taller.
File already exists - overwrite?		te
C:/Users/fish.GURALP/AppData/Local/Temp/Discovery	Install.exe	s Netmask
		255.255.0.
Yes	No	255.2 55.0
Close this window automatically when finished.		255.255.0
Cancel Ok		255.255.0
		255.2 55.0.
ürc		255.255.0
uic		255.255.0.

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

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

File download - Guralp Discovery	-		×	
Downloading discovery installer.				
Completed in 41%				
(12335614B of 29530541B)				
Close this window automatically when finished.				
Cancel Ok				



When the download is complete, the following screen is displayed:

If you wish to complete the installation immediately, click <u>Yes</u>. If you would rather defer the installation, click <u>No</u> 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:

Windows Security Alert X			×
Windows Firewall has blocked some features of this app			
Windows Firewall has blocked some features of discovery on all public, private and domain networks.			
	Name:	discovery	
	Publisher:	Unknown	
	Path:	C:\program files (x86)\guralp systems\discovery \discovery.exe	
Allow discovery to communicate on these networks:			
Domain networks, such as a workplace network			
Private networks, such as my home or work network			
Public networks, such as those in airports and cafés (not recommended because these networks often have little or no security)			
What are the risks of allowing an app through a firewall?			
		Allow access	el

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 WiFi hotspots at coffee shops, airports, and other locations.

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

14 Appendix 5 – I.P. address configuration on PC or Laptop

With APIPA (Automatic Private I.P. 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 Fortimus 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



and provide the appropriate password. Then, enter the command

ifconfig

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

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

replacing *w1p2s0* 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....



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.

0 0	O O Network	
Show All		٩
	Location: Automatic	:
 Ethernet Connected Bluetooth Not Connected FireWire Not Connected AirPort On 	Status: Status: Configure: IP Address: Subnet Mask: Router: DNS Server: Search Domains:	Connected Ethernet is currently active and has the IP address 192.0.2.143 Using DHCP \Rightarrow 192.0.2.143 255.255.255.0 192.0.2.254
+ – 🌣 -	prevent further changes.	Advanced ? Assist me Revert Apply

- 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 Fortimus connected and powered up, click the 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:

Ethernet Connected	$\langle \cdots \rangle$	Status: Connected
Bluetooth Not Connected	8	Ethernet is currently active and has the IP address 169.254.56.230
● FireWire Not Connected	**	Configure: Using DHCP
e AirPort	1	IP Address: 169.254.56.230
On	*	Subnet Mask: 255.255.0.0

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 + R.

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

Key **I** + **R** and type **cmd**., then **^I**. 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.



We

16 EU Declaration of Conformity

CE

Guralp Systems Ltd Midas House, Calleva Park, Aldermaston READING, RG7 8EA.

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

Declare under our sole responsibility that the following product

Equipment name: Fortimus with GPS Model Number: FMUS-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 61000-4-2:2006 +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 February 2020

Systems Director

17 Revision History

D	2021-09-09	Added EU Declaration of Conformity
-		

- C 2020-01-06 Corrected labels for main illustration in system description.
- B 2019-12-02 Updated web page screenshots. Updated Data Stream and Data Storage. Updated stream and file names. Updated and added Transforms. Updated EEW and Triggering. Added back-fill from miscoSD card.
- A 2018-08-19 Initial release