
Fortis | Strong Motion Accelerometer
Affinity | Digitiser
Radian | Downhole Digital Seismometer
Minimus | Digitiser
Where is Güralp going and where do our new products align?
1. What GSL do well?

2. What do you think GSL need to improve on?

3. What would you like to see from GSL in the future...
Diverse Product Range

- Broadband seismometers
- Ocean-bottom seismometers
- Borehole sensors
- Strong motion accelerometers
- Integrated digital sensors
- Digital data processing
- Software
- Accessories
Diverse Product Range

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Güralp Affinity

CAPTURE. PROCESS. DISTRIBUTE.
Our most sophisticated and adaptable digital acquisition system yet
Sophisticated Digitization

- High-fidelity integrated digitiser and network communications unit for connecting instruments to your network
- Low power (1.2 W without GPS or Ethernet)
- High dynamic range of > 139 dB at 100 sps – capture a wide spectrum of ground motion
- Advanced timing protocols (NTP and PTP)
Easy to use web browser interface

- Simple station metadata configuration for SEEDlink protocol
- Set channel gain separately for different channels
- Flexibility to choose from the full range of sample rates for individual channels
- Full configuration of multiplexed (environmental channels)
Simple and low-latency digital filter

- Simple decimation model
- Only one FIR filter chain for each output sample rate
- Ensures lowest possible latency without sacrificing data quality
Key Features
Güralp Affinity
Key Features

Güralp Affinity

- **Güralp Affinity**
- Robust Stainless Steel casing
- Sensor inputs: 4 channel (3 primary + 1 aux) or 8 channel (2x3 primary + 2x1 aux)
- Up to 64 GB field-swappable USB storage
- 16 GB internal flash storage
- Timing protocols: GPS, Network Time Protocol (NTP), Precision time protocol (PTP)
- Up to 16 environmental multiplexed channels
Applications

- Permanent seismic vault installations
- Seismic monitoring across all scales: local, regional, teleseismic (global)
- Earthquake early warning systems
- Multidisciplinary geophysical observatories
- Borehole and posthole installations
- Dense array networks
STRONG MOTION ACCELEROMETER
Designed to be ‘best in class’, our most versatile accelerometer yet.
Strong Motion Sensor for a New Era

Force feedback triaxial strong motion accelerometer

- Switchable gain/sensitivity
- Ultra low-noise components for high precision and enhanced dynamic range
- Low power consumption (1.3 W)
External features

Güralp Fortis
Fixing bolt for rapid installation for structural health monitoring

Sunken bubble level

Fresh, slimline design

North arrow for alignment during installation

Hard anodised aluminum casing offers robust protection

Adjustable feet for levelling

External features
Güralp Fortis
Switchable gain allows Fortis to be configured for a range of strong motion scenarios

- Gain options: 0.5g, 1g, 2g, 4g
- Locally-switchable (via rotary screw on base)
- Or remotely switchable via digitiser (control lines)
Switchable gain up to 4g allows Fortis to adapt to very high ground shaking scenarios

- **2.2g** measured during 2011 9.0 Tohoku earthquake, Japan
- **2.1g** measured during 2011 M6.4 Christchurch earthquake, New Zealand

Octave-wide bandpassed acceleration signal strengths from Clinton and Heaton (2002), Seismological Research Letters.

New low noise model (NLNM) and new high noise model (NHNM) after Peterson (1993).

ALNM (accelerometer low noise mode) & AHNM (accelerometer high noise model) after Cauzi and Clinton (2013), Earthquake Spectra
Below *New High Noise Model* (NHNM) above 0.07 Hz (14 s)

Below *Accelerometer High Noise Model* (AHNM) from 1-45 Hz

New low noise model (NLNM) and new high noise model (NHNM) after Peterson (1993).

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Applications

- Local earthquake monitoring in active tectonic regions
- Strong ground motion studies (attenuation / amplification)
- Earthquake early warning
- Structural health monitoring (e.g. dams, industry, buildings)
MINIMUM SIZE. MAXIMUM RANGE. UNRIVALLED VERSATILITY.
At just 55 mm diameter, the Radian is the ideal subsurface seismometer
Top data quality with less fieldwork: Dramatic noise reduction using subsurface installation in a ‘plug in and go’ package

Rapid, low-cost deployment: Can operate at any angle (hence, “Radian”), ability to perform fast system checks using widely available communications technology

Simplify instrument and data management: Industry standard data formats and streaming of instrument response and calibration parameters

Maximise your recording range: Capture weak, medium & strong motion data in a single system
Applications

**Seismology:** local, regional & global earthquake monitoring

**Energy:** oil & gas exploration, reservoir monitoring, microseismic & induced seismicity (e.g. fracking, geothermal)

**Volcanology:** rapid deployment for monitoring of unrest
Key Features
Radian Posthole
Key Features

Radian Posthole

- Fully waterproof: 1500 psi connector
- AC-coupled differential electronics: offers surge protection & minimises noise
- In-built MEMS accelerometer and magnetometer (<1° accuracy)
- Pilot cone for rapid burial
- Triaxial broadband seismometer sensors
- Kevlar-reinforced digital cable
Key Features

Radian Posthole

- Automatically corrects for instrument misorientation & tilt
- Additional 3-channel input
- Removable microSD card (dual-redundant)
- Ethernet output
- Ultra-low-latency Streaming available (down to 10 ms)
- Connection for highly accurate external GPS
- Wireless Bluetooth-4 communications via Android phone/tablet to check installation (max 10 m range)
Below New Low Noise Model (NLNM): 1.1-10 s (0.1-0.9 Hz)

Below Medium Low Noise Model Model (MLNM): <30 s (>0.03 Hz)

Octave-wide bandpassed acceleration signal strengths from Clinton and Heaton (2002), Seismological Research Letters.

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MLNM (medium low noise mode) after McNamara & Buland (2004), BSSA
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Integrated MEMS accelerometer captures waveforms from large, nearby earthquakes
Versatile Response

- Radian can be built with acceleration or velocity response
Radian can be built with **acceleration or velocity** response

Velocity response increases gain for long-period, weak ground motion
Versatile Response

- Radian can be built with **acceleration or velocity** response
- **Velocity** response increases gain for long-period, weak ground motion
- **Acceleration** response increases gain for high frequency applications (e.g. microseismic monitoring)
**Aim:** Enhance a station’s noise performance without large footprint (equipment, materials, expense, time)

**How** does posthole burial work?

- Simple deployment using a hand auger tool
- Or core directly into bedrock using drill
- No need for perfect levelling / orientation
- Back-fill using sand / glass beads
- Double O-ring sealed

Faster deployment minimises installation time and fieldwork costs whilst providing excellent performance in noisy environments. Outperforms vault installations.
Growing Need for Posthole

Results from IRIS posthole tests in Alaska

Posthole installations are >20 dB quieter at periods over 40 seconds than vault installations.

“Direct burial sensors [posthole] perform as well and at times better than sensor in vaults on both horizontal and vertical channels across a range of periods (<1 s to 100 s). Moving towards an instrument pool composed entirely of direct burial sensors (some with integrated digitizers) could yield higher-quality data at lower cost.”

Key Features

Radian Borehole

Casing and water-proof connector IP68 to 2000 m depth

3-jaw motorised hole-locks for coupling with borehole casing

Optional connector for stringing multiple Radians together for down-hole arrays / VSP

1250 mm

55 mm
A True Downhole Broadband Seismometer

- Installation in off-vertical holes reduces total installation costs
- Robust casing and connectors withstand the harshest conditions
- Dual three-jaw hole-lock system for maximum coupling
- Easily strung together for downhole arrays
- Surface Interface Unit can gather data from multiple instruments
- Fully compatible with fiber optic communications

Fits boreholes with diameter 61 mm – 115 mm

Maximum borehole depth: 2000 m
**Seismology:** local, regional & global earthquake monitoring

**Energy:** oil & gas exploration, reservoir monitoring, microseismic & induced seismicity (e.g. fracking, geothermal)

**Volcanology:** rapid deployment for monitoring of unrest
### Specifications

#### Broadband Seismometer System

| Configuration / Topology | Triaxial orthogonal (ZNE) |

#### Performance: Broadband Seismometer

| Maximum frequency response bandwidth | 0.0033 to 200 kHz (120 to 0.0025 Hz) Other user-selectable options available within this range |
| Output sensitivity | Velocity or acceleration response (configurable prior to shipping) Velocity response standard sensitivity: 2000 V/m/s peak-to-peak, 0.2 to 1000 Hz/8-bit differential output Acceleration response standard sensitivity: 200 mV/g peak-to-peak, 1000 Hz/8-bit full-scale output Other options available |
| Sensor dynamic range | > 160 dB at 1 Hz |
| Saturation | Below MNLNM (New Low Noise Model) for 0.1 Hz to 0.5 Hz, 10 to 1.3 Hz Below MNLNM (Medium Low Noise Model) above 0.3 Hz to 30 Hz |
| Operational life | 15 years |
| Cross-axis rejection | > 55 dB |
| Linearity | > 0.05 % |
| Lowest output noise level | > 400 Hz |
| Offset setting | Automatic / configurable |
| Transfer function | Measured sensitivity, frequency response and instrument noise are stored within the instrument and accessible via web interface |
| Calibration control | Independent input and enable lines exposed on sensor connector |

#### Performance: MEMS Accelerometer

| Frequency bandwidth | DC to 0.05 Hz (0.1 Hz) |
| Linear acceleration noise density | 150 µg/Hz^1/2 at 100 Hz |
| Clip level | 2 g, 4 g, 6 g, 8 g, 16 g (user-selectable) |

#### Environmental Channels

| Sensor Mass positions | Three independent sensor mass position outputs (single-ended) |
| Orientation sensors | 3 channels for MEMS accelerometer 3 channels for electronic compass |
| Other sensors | Temperature |

#### Internal I/O

| Digital resolution/Output format | 24 bit |
| Dynamic range | > 160 dB |
| Selectable gain options | 1x, 2x, 4x, 8x, 12x |
| Anti-aliasing filter at Nyquist | > 127 dB |
| Sampling rates | 1 to 5000 samples per second, user selectable |

#### Timing

| Timing protocols | GPS, NTP (Network Timing Protocol) |
| GPS connector | Lemo differential serial + FPG connector via Surface Interface Unit |
| Timing drift without GPS | < 1 ms per day |

#### Digital Sensor Power

| Power consumption (at 12 V DC) | 11 W |
| Protection | AC-coupled differential electronics |

#### Environmental

| Operating temperature | -50 to +80 °C (high temp option to +100 °C) |
| Maximum deployment depth | 2000 m |
| Humidity | 0-100 % relative humidity |
| Robustness | IP68 to 2000 m depth |

#### Physical

| Diameter | 65 mm |
| Case height including connector | 700 mm (including hole-lock) |
| Weight | 7.1 kg (sensor and cable included) |
| Sensor and load-bearing cable | Kevlar/English AC-coupled |
| Orientation connector | North vertical axis, male connector on sensor, female connector on cable |

#### Surface Interface Unit (SIU)

| Dimensions | 99 mm x 39 mm x 128 mm |
| Weight | 0.61 kg (without connectors) |
| Operating temperature | -20 to +60 °C |
| Additional sensor input | Four 90 V peak-to-peak (±45 V) differential channels and three 250 V peak-to-peak (±125 V) single-ended inputs via 28-pin multisens connector |
| Storage capacity | 2GB field-replaceable microSD card flash storage (dual redundant); other options upon request available |
| Data storage format | min/SEED (minidate stored in datasets SEED format) |
| Communication interfaces | Ethernet (Gigabit Discovery software - free download), Bluetooth (Android phone/tablet app - Octafly VS) |
| Data streaming protocols | Wi-Fi, Ethernet (SEED format) and G9-Link (metadata sent in RHP, data stored SEED format) |
| Power consumption | 0.9 W without Ethernet and GPS 1.68 W with Ethernet and GPS |

Additional environmental sensors: Humidity

*Surface Interface Unit specifications are suitable for posthole and single borehole applications.* Please contact us about the VAB unit.
Güralp MINIMUS

Ultra compact digitizer filled with technology
Key Features

• 24-bit four channel digitizer
• Weight = 550 grams
• Internal 2 g – 16 g MEMs accelerometer
• Simultaneously accommodate infrasound sensor and digital feed from Radian
• Identification of IP address via Discovery and Cloud registry server
• Hot-swappable data storage and dual redundant microSD cards
• Designed for Earthquake Early Warning
• Low-latency mode – 6 µs for ADC conversion and causal filtering
• Low-latency mode – < 40 ms transmission using GDI protocol (network dependent)
Additional Features

- Automatically corrects for instrument misorientation & tilt
- Additional 3-channel input
- Removable microSD card (dual-redundant)
- Ethernet output
- Ultra-low-latency Streaming available (down to 10 ms)
- Connection for highly accurate external GPS
- Wireless Bluetooth-4 communications via Android phone/tablet to check installation (max 10 m range)
Key Features

- 24-bit four channel digitizer
- Weight = 550 grams
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- Hot-swappable data storage and dual redundant microSD cards
So, where are we going?

Affinity = High quality vault/permanent installation digitizer and data logger.

Radian = Worlds first digital posthole/borehole seismometer that can operate at any angle. Competitor? None.
So, where are we going?

Fortis = Compact and versatile strong motion accelerometer with large dynamic range. Back to market leader

Minimus = Ultra compact, cutting edge digitizer. Untouchable.
Gracias!!

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