güralp

RADIAN

POSTHOLE AND BOREHOLE

MINIMUM SIZE. MAXIMUM RANGE. UNRIVALLED VERSATILITY.

At just 55 mm diameter, the Radian is the ideal subsurface digital seismometer

> Operational at any angle with Bluetooth connectivity for rapid, low cost deployment
> Industry standard formats for data and instrument management
> Integrated broadband seismometer, accelerometer and magnetometer as standard

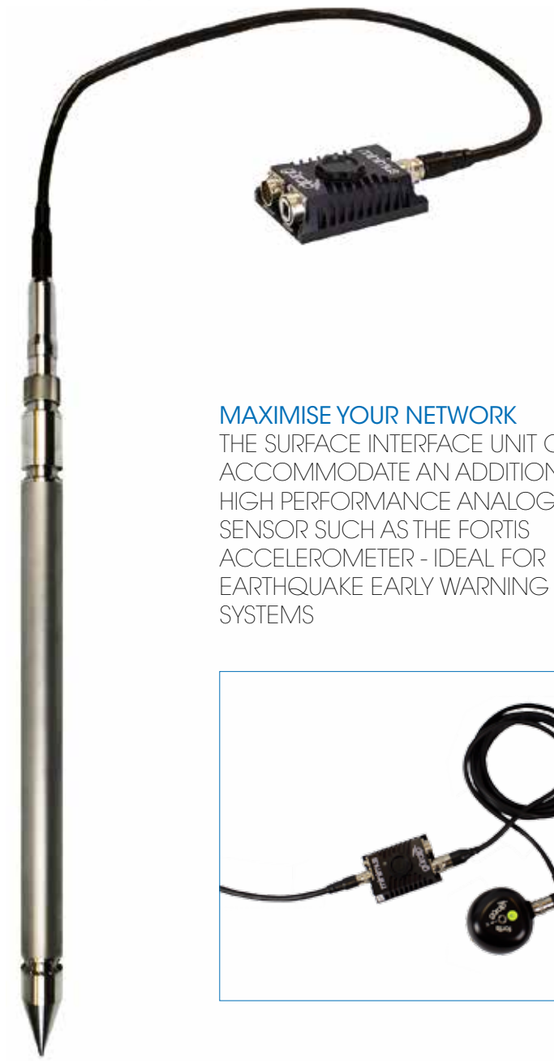
APPLICATIONS

> Seismic monitoring at all scales: local, regional and global
> Microseismic and induced seismicity monitoring
> Volcanic unrest monitoring
> Installation in areas of high cultural noise

Radian

Unlike any other force feedback seismometer, the ultra slim Radian can operate at any angle, making it easier and cheaper to deploy than traditional posthole and borehole systems.

RADIAN POSTHOLE



RADIAN BOREHOLE
(WITH RADIAN SENSOR DIAGRAM)

MAXIMISE YOUR NETWORK
THE SURFACE INTERFACE UNIT CAN ACCOMMODATE AN ADDITIONAL HIGH PERFORMANCE ANALOGUE SENSOR SUCH AS THE FORTIS ACCELEROMETER - IDEAL FOR EARTHQUAKE EARLY WARNING SYSTEMS

Plug-in and go approach for efficient seismic deployments.

A triaxial, broadband, digital seismometer with integrated MEMS accelerometer and magnetometer.

The posthole - designed for deployment in uncased holes in the shallow subsurface, the instrument can be installed using a simple hand auger. Posthole deployments reduce site noise, without the expense of surface vaults.

The borehole - can be installed in deeper, non-vertical cased holes. Borehole installations allow you to get closer to the seismic event, improving the accuracy of subsurface velocities and event depths. To further aid this, multiple Radians can be strung together for vertical seismic profiling (VSP).

The Radian system includes a Surface Interface Unit (SIU) that delivers data communication and storage capability. The SIU records data on dual-redundant microSD cards and shares the data either via Ethernet and Bluetooth connections, or via Android app. This means that the system can be fully checked without disturbance following deployment.

Record the full spectrum of seismic events for accurate event cataloguing.

Compared to short-period geophones, the Radian's active feedback sensor ensures consistent amplitude and phase response across the bandwidth of the instrument.

Low self-noise and wide dynamic range allow accurate detection of small seismic events and recording of strong shaking in one instrument.

Ultra-wide frequency response between 120 s and 200 Hz makes the Radian ideal for seismic monitoring at all scales: global or teleseismic, regional, local and microseismic/ reservoir.

An internal magnetometer and MEMS accelerometer work together to automatically compensate for tilt and horizontal orientation delivering high-quality waveforms with no need for post-processing.

A resilient housing constructed from SAE 316 corrosion-resistant stainless steel and a 1500 psi water-proof connector protects the instrument in wet holes.

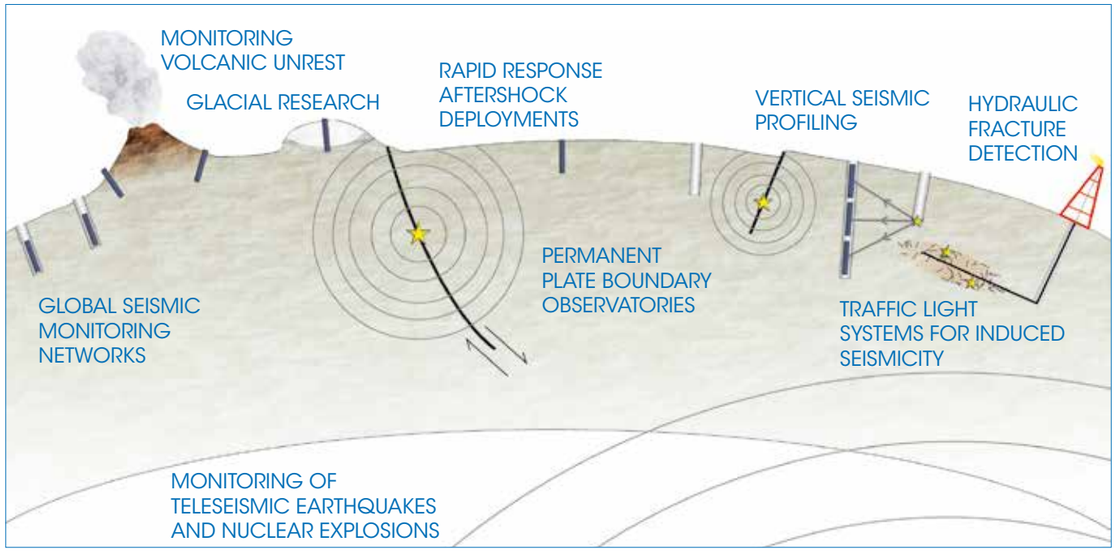
Key features

- State-of-the-art seismic sensor allows full operation over a full tilt range of ±180° by automatically centring the mass
- Instrument orientation and inclination are measured using the internal magnetometer and MEMS accelerometer to store and stream geographically-aligned waveforms
- Internal MEMS accelerometer extends the dynamic range of the instrument up to 2 g to capture high amplitude ground motion from local seismic events
- A slim-line 55 mm diameter silhouette with 770 mm length for rapid posthole deployment
- Radian Borehole fixes to casing with retractable three-jaw motorised hole-locks (industry standard)
- Streaming and storage of instrument response and calibration parameters dramatically simplifies data management (RESP and dataless SEED formats)
- Bluetooth communication via Android App confirms integrity of the installation without physical disturbance of site
- Triaxial orthogonal (ZNE) instrument with high cross-axis rejection (> 65 dB)
- Customer can select either velocity or acceleration variants depending on the preferred output (configurable prior to shipping)
- User can electronically select customised frequency responses available between 120 s to 200 Hz (e.g. short-period option)
- Low latency outputs available (approx. 0.04 s data packets)
- Robust and water-proof, encased in SAE 316 corrosion-resistant stainless steel to protect the instrument in extreme down-hole environments
- No mass locking required
- Automatic mass centring
- Portable design ideal for rapid response deployments in remote field locations
- Dual-redundant microSD card storage
- Low power consumption (2.4 W) suitable for temporary deployments using batteries and solar panels
- Accurate time-base provided by either surface GPS, Network Timing Protocol (NTP), or internal clock (< 1 ms drift per day without GPS)

Applications

Dynamic range

The MEMS accelerometer maximises recording range where traditional broadband seismometers would normally clip allowing the Radian to record micro- and macro-seismic activitiy at all scales.



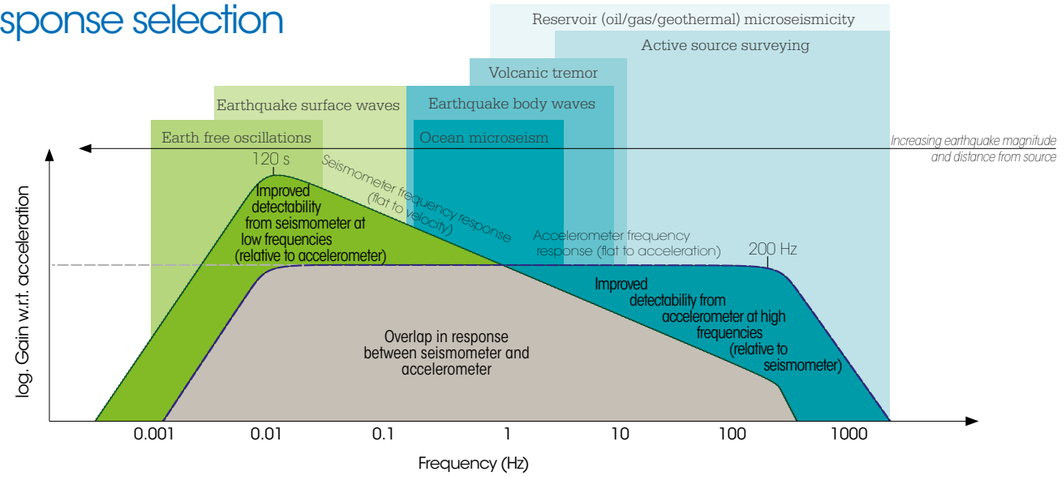
Posthole

- Rapid deployment for volcanic unrest or aftershock monitoring
- Record long-period tremor events and volcanic-tectonic earthquakes using a single instrument
- Ultra-dense recording arrays for microseismic monitoring in noisy environments
- Traffic light systems for energy extraction or storage
- Accurately record strong ground shaking caused by local events
- Permanent regional and global seismic networks
- Suitable for recording ice quakes in glaciers
- Minimise cultural noise for measurement of seismic events down to sensor's noise floor
- Dramatically improved noise performance of 20dB compared to vault installations (horizontal components; IRIS figures)
- Reduced material costs and footprint compared with traditional seismic vault designs
- Reduced total fieldwork and transportation costs
- Can also be drilled/cored into bed-rock for exceptional coupling and noise performance
- High performance in areas of high cultural noise

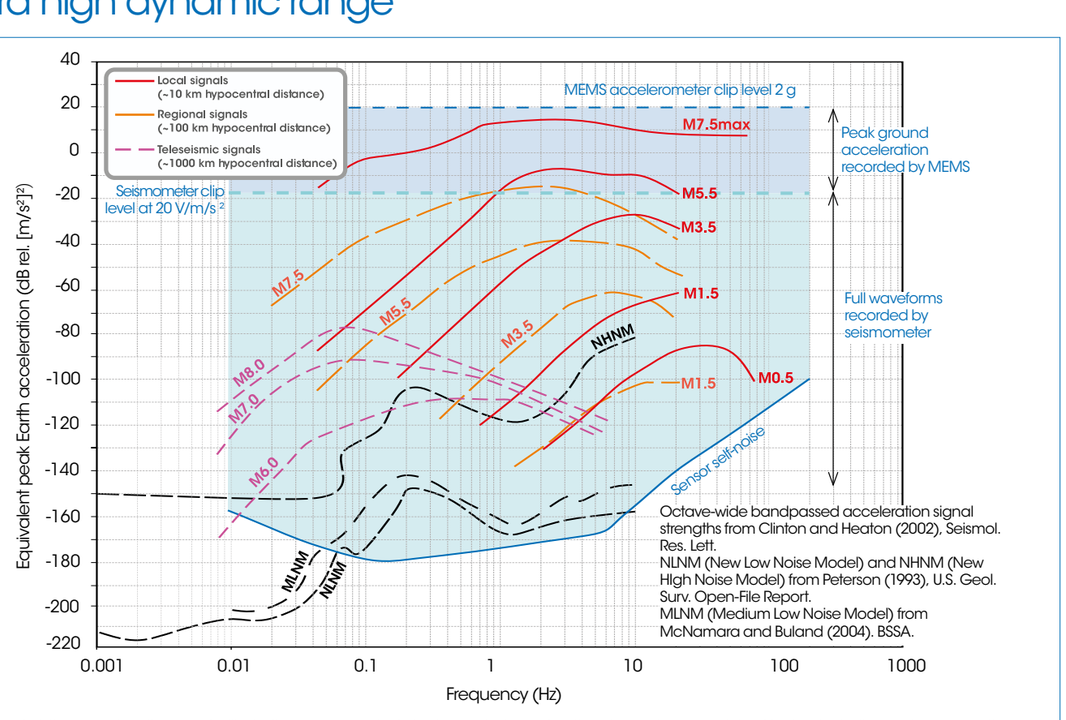
Borehole

- Passive microseismic monitoring
- Vertical seismic profiling (VSP)
- Monitoring of moderate-strong teleseismic earthquakes
- Complement dense surface arrays
- Deep installations allow you to get closer to the source, for better subsurface characterisation
- Ultra-low noise performance at depth
- Excellent coupling with borehole casing provided by three-jaw hole-locks

Response selection



Ultra high dynamic range

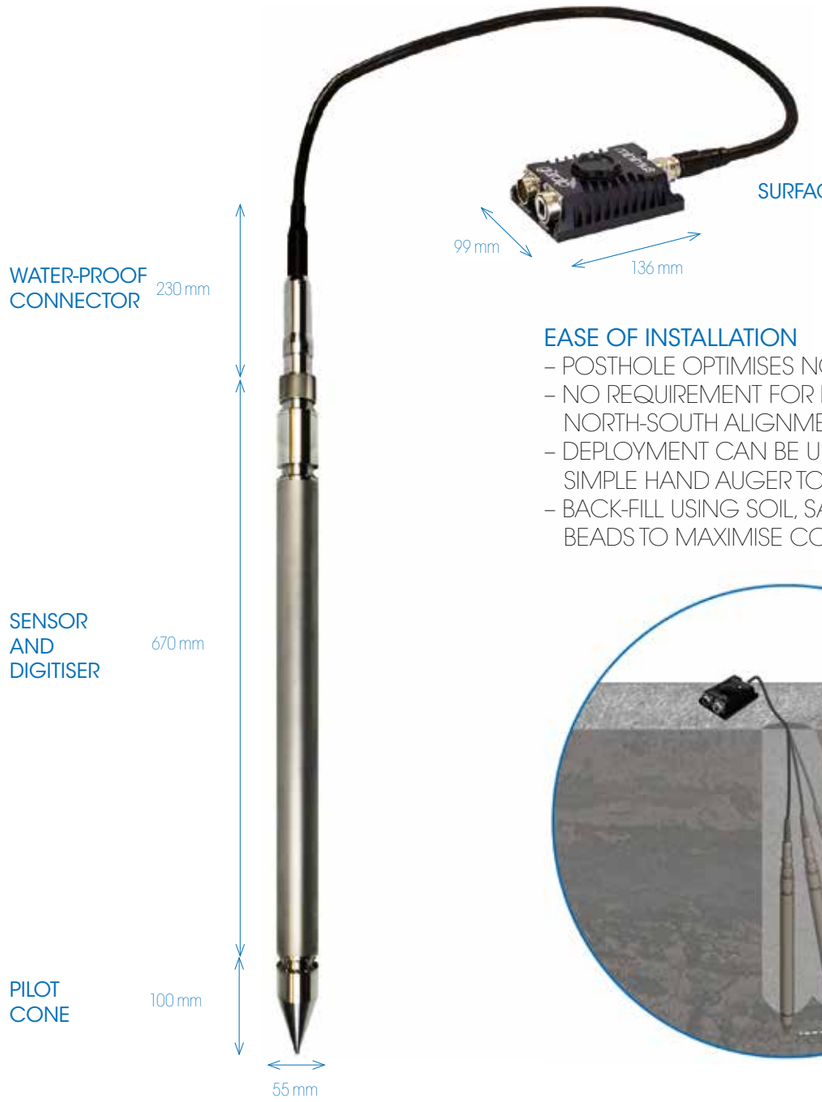


Characteristic ground motions are for illustrative purpose only. Actual recorded acceleration depends on a variety of factors including rupture properties, hypocentral distance, local site attenuation / amplification, station noise level, and digitiser performance.

Self-noise level based on equivalent sensor from a Güralp Breve ocean bottom seismometer.

Radian Posthole

The Güralp Radian Posthole is designed for rapid installation and exceptional noise performance. Its slim-line design - its outer diameter is just 55 mm - and flexibility to work at any angle makes it very simple and cost-effective to deploy.



EASE OF INSTALLATION

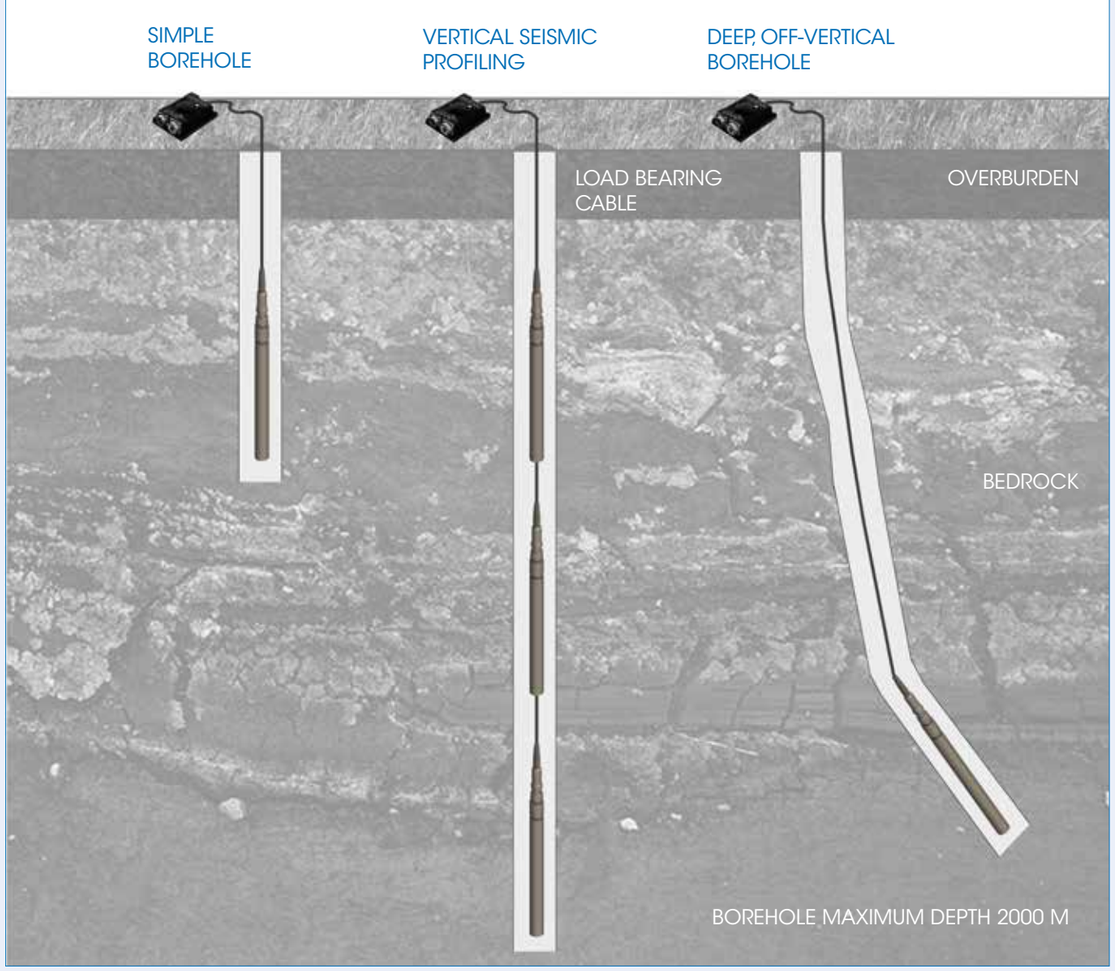
- POSTHOLE OPTIMISES NOISE PERFORMANCE
- NO REQUIREMENT FOR PRECISE VERTICAL OR NORTH-SOUTH ALIGNMENT
- DEPLOYMENT CAN BE UNDERTAKEN WITH A SIMPLE HAND AUGER TOOL
- BACK-FILL USING SOIL, SAND OR GLASS BEADS TO MAXIMISE COUPLING

Radian Borehole

The Güralp Radian Borehole is a true broadband downhole seismometer. Its robust casing withstands the harshest conditions. Easily strung together for down-hole arrays. The surface box gathers data from multiple instruments.

ROBUST VERSATILITY

- INSTALLATION IN OFF-VERTICAL HOLES
- CAN BE EASILY STRUNG TOGETHER FOR VERTICAL SEISMIC PROFILING (VSP)
- RECOVERY PERFORMED USING SECURE HOLE-LOCK RELEASE MECHANISM
- ROBUST LOAD-BEARING SENSOR CABLE



Radian

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SPECIFICATIONS

BROADBAND SEISMOMETER SYSTEM	
Configuration / Topology	Triaxial orthogonal (ZNE)
PERFORMANCE: BROADBAND SEISMOMETER	
Maximum frequency response bandwidth	0.0083 to 200 Hz (120 to 0.005 s) Other user selectable options available within this range Velocity or acceleration response (configurable prior to shipping)
Full-scale clip level	Velocity response nominal: ±25 mm/s (equivalent to differential output sensitivity of 2000 V/m/s) Acceleration response nominal: ±12.5 mm/s^2 (equivalent to differential output sensitivity of 200 V/m/s^2) Other sensitivities and options available
Sensor dynamic range	> 149 dB at 1 Hz
Self-noise	Below NLNM (New Low Noise Model) from 17 s (0.06 Hz) to 9 Hz < -155 dB from 120 s to 10 Hz
Operational tilt range	±180°
Cross axis rejection	> 65 dB
Linearity	> 95 dB
Lowest spurious resonance	> 450 Hz
Offset zeroing	Automatic / configurable
Transfer function	Measured sensitivity, frequency response and instrument poles and zeros are stored within the instrument and accessible via web interface
Calibration controls	Independent signal and enable lines exposed on sensor connector
PERFORMANCE: MEMS ACCELEROMETER	
Frequency bandwidth	DC to 100 Hz (0.01 s)
Linear acceleration noise density	150 µg /Hz $^{-0.5}$ at 100 Hz
Clip level	2 g
ENVIRONMENTAL CHANNELS	
Sensor mass positions	Three independent sensor mass position outputs (single-ended)
Orientation sensors	MEMS accelerometer (three component) Magnetometer (three component)
Other sensors	Temperature
INTERNAL DIGITISER	
Digital resolution/output format	24-bit
Dynamic range	> 120 dB
Selectable gain options	1×, 2×, 4×, 8×, 12×
Anti-aliasing filter at Nyquist	> 172 dB
Sampling rates	1 to 5000 samples per second, user selectable
TIMING	
Timing protocols	GPS, NTP (Network Timing Protocol)
GPS connector	Lemo differential serial + PPS connector via Surface Interface Unit
Timing drift without GPS	< 1ms per day

DIGITAL SENSOR POWER	
Power consumption (at 12 V DC)	1.1 W
Protection	AC-coupled differential electronics
Power input voltage range	10– 36 V DC
ENVIRONMENTAL	
Operating temperatures:	-30 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	55 mm
Case height excluding connector	770 mm (posthole) 1240 mm (borehole)
Weight	7.1 kg (excl. connector and hole-lock option)
Sensor enclosure/materials	SAE 316 corrosion resistant stainless steel Gold plated contacts O-ring seals throughout
Connector	Mil-spec 1500 psi water-proof connector
Sensor and load-bearing cable	Kevlar-refinforced, AC-coupled
Orientation indicator	North vertical scribe mark on side on outer casing and inside connector
SURFACE INTERFACE UNIT*	
Dimensions	136 mm × 99 mm × 39 mm
Weight	674 g (without connectors)
Operating temperature	-20 to +80 °C
Additional sensor inputs	Primary channels: Four at 24 bits. Differential input: 40 V peak-to-peak (± 20 V). Also compatible with single-ended inputs: 20 V peak-to-peak (± 10 V)
Secondary channels:	Three analogue channels for sensor mass positions. One internal callibration channel
Internal environmental channels:	Humidity Temperature Supply voltage MEMS accelerometer (three component) Magnetometer (three component)
Flash memory and storage	64 GB field-swappable microSD card flash storage (dual redundant); other options upto 256 GB available.
Data recording formats	miniSEED (metadata stored in dataless SEED format)
Configuration and control	(Ethernet) Güralp Discovery - free download, web browser interface. (Bluetooth) Güralp Vu free Android phone/tablet app
Data streaming protocols (via Ethernet)	GCF (Scream!) and GDI-link (metadata sent in RESP / dataless SEED file formats), SEEDlink
Power consumption	1.3 W without Ethernet and GPS 1.9 W with Ethernet and GPS

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

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