

RADIAN

ANY ANGLE TRIAXIAL, BROADBAND, DIGITAL SEISMOMETER
FOR BOREHOLE AND SUB-SURFACE INSTALLATIONS



A versatile sub-surface medium-motion instrument available as either a posthole or borehole system for depths up to 2000 m

KEY FEATURES

- > 120 s to 200 Hz response with user-selectable high-pass frequency corner from 1 to 120 seconds
- > Operational at any angle with ultra slim 55 mm diameter enclosure and 250 bar/25 MPa connector
- > Choose either acceleration or velocity response
- > STA/LTA and threshold triggering
- > The system can incorporate an additional analogue instrument if desired
- > Radian Borehole has hole-lock options for cased holes ranging from 60 mm to 140 mm and can form multi-instrument strings for vertical seismic profiling

APPLICATIONS

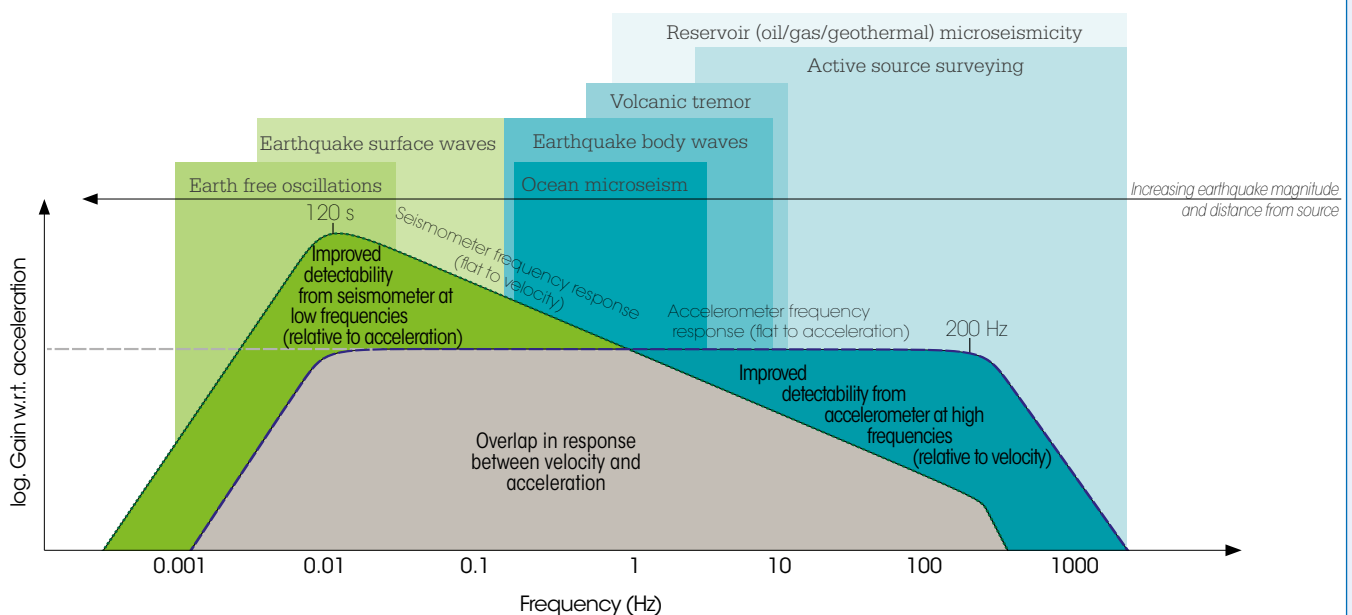
- > Microseismic and induced seismicity monitoring
- > Volcanic unrest monitoring
- > Seismic monitoring in areas of high cultural noise
- > Strong motion monitoring caused by local events
- > Ice-quake monitoring in glaciers
- > Vertical seismic profiling (borehole instrument)
- > Traffic light monitoring for energy extraction or storage

Radian

With an ultra-wide response, an adjustable high-pass frequency corner and, the capability of operating at any angle, Radian offers up opportunities for subsurface deployments that would otherwise prove too challenging or unpredictable.

Response selection

When ordering, select either a velocity or acceleration instrument response depending on the preferred output.



Applications

- > Microseismic and induced seismicity monitoring
- > Volcanic unrest monitoring
- > Ice-quake monitoring in glaciers
- > Seismic monitoring in areas of high cultural noise
- > Strong motion monitoring caused by local events
- > To complement dense surface arrays
- > Vertical seismic profiling (VSP)
- > Traffic light systems for energy extraction or storage

At just 55 mm diameter, the Radian seismometer is designed for simplified deployments in the subsurface.

Radian is available as either a posthole instrument for deployment in uncased holes, or as a borehole instrument for installation in narrow, (60 mm - 100 mm) or wide (100 mm - 140 mm), cased holes.

Unlike other subsurface seismometers, the Radian can operate at any angle. This opens up opportunities for deployment in unpredictable or challenging environments such as shifting ice shelves or non-vertical boreholes. Additionally, the Radian borehole can be deployed as a single instrument or multiple instruments can be strung together for vertical seismic profiling (VSP).

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

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

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

The ultra-wide frequency response between 120 s and 200 Hz makes the Radian ideal for seismic monitoring at all scales, particularly in areas of high cultural noise. For increased flexibility, the high-pass frequency corner can be remotely configured to suit the deployment environment.

An internal magnetometer and MEMS based accelerometer work together to provide tilt and horizontal orientation. The appropriate correction can be applied to deliver high-quality waveforms with no need for post-processing.

A resilient enclosure constructed from SAE 316 corrosion-resistant stainless steel and a 250 Bar/25 MPa water-proof connector protects the instrument in wet holes.

For installations where back-filling to maximise coupling is not practical, the Radian Borehole with hole-lock mechanisms is recommended.

Minimus surface interface unit

The Radian system includes the Minimus digitiser as a surface interface unit to deliver sensor configuration as well as data communication, timing and storage capability. Minimus records data on dual-redundant microSD cards and shares the data via Ethernet and Bluetooth connections.

We have two versions of the Minimus surface interface unit, one for deployments up to 100 metres that uses copper cable, and one for deployments over 100 metres that require a fibre optic system. The power requirement is higher with the fibre optic system.

Confident deployments

For added confidence during deployments the free GüVü, Bluetooth App, displays waveforms, orientation, temperature and humidity data.

Key features

State-of-the-art seismic sensor allows full operation over a full tilt range of $\pm 180^\circ$ by automatically centring the mass

Triaxial orthogonal (ZNE) instrument with high cross-axis rejection (> 65 dB)

120 s to 200 Hz with user-selectable high-pass frequency corner from 1 s to 120 s

You can select either velocity or acceleration variants depending on the preferred output (configurable prior to shipping)

Streaming and storage of instrument response and calibration parameters dramatically simplifies data management (RESP and Dataless SEED formats)

Slim-line 55 mm diameter enclosure constructed from robust and water-proof, SAE 316 corrosion-resistant stainless steel with a 250 Bar/25 MPa water-proof connector to protect the instrument in wet holes

Low latency outputs available (approx. 0.04 s data packets)

Accurate time-base from surface GNSS, Precision Time Protocol (PTP), or internal clock (< 1 ms drift per day unfixed)

Free GüVü Bluetooth App for checking installation integrity (Android)

Dual-redundant 16 GB microSD cards (1 fixed, 1 hot-swappable)

Radian Posthole system for deployment in uncased holes.

RADIAN POSTHOLE SYSTEM

MINIMUS SURFACE INTERFACE UNIT

45 mm
99 mm
134 mm

230 mm

> WATER-PROOF CONNECTOR

> MAGNETOMETER

> MEMS BASED ACCELEROMETER

> VERTICAL MASS

> NORTH/SOUTH MASS

> EAST/WEST MASS

> PILOT CONE

770 mm

55 mm

EASE OF INSTALLATION

- POSTHOLE OPTIMISES NOISE PERFORMANCE
- NO REQUIREMENT FOR PRECISE VERTICAL OR NORTH-SOUTH ALIGNMENT
- BACK-FILL USING SOIL, SAND OR GLASS BEADS TO MAXIMISE COUPLING

MAXIMISE YOUR NETWORK

THE MINIMUS CAN ACCOMMODATE AN ADDITIONAL HIGH PERFORMANCE ANALOGUE SENSOR SUCH AS THE FORTIS ACCELEROMETER - IDEAL FOR EARTHQUAKE EARLY WARNING SYSTEMS

Key features

State-of-the-art seismic sensor allows operation over a full tilt range of $\pm 180^\circ$ by automatically centring the mass

Triaxial orthogonal (ZNE) instrument with high cross-axis rejection (> 65 dB)

120 s to 200 Hz with user-selectable high-pass frequency corner from 1 s to 120 s

Low latency outputs available (approx. 0.04 s data packets)

Streaming and storage of instrument response and calibration parameters dramatically simplifies data management (RESP and Dataless SEED formats)

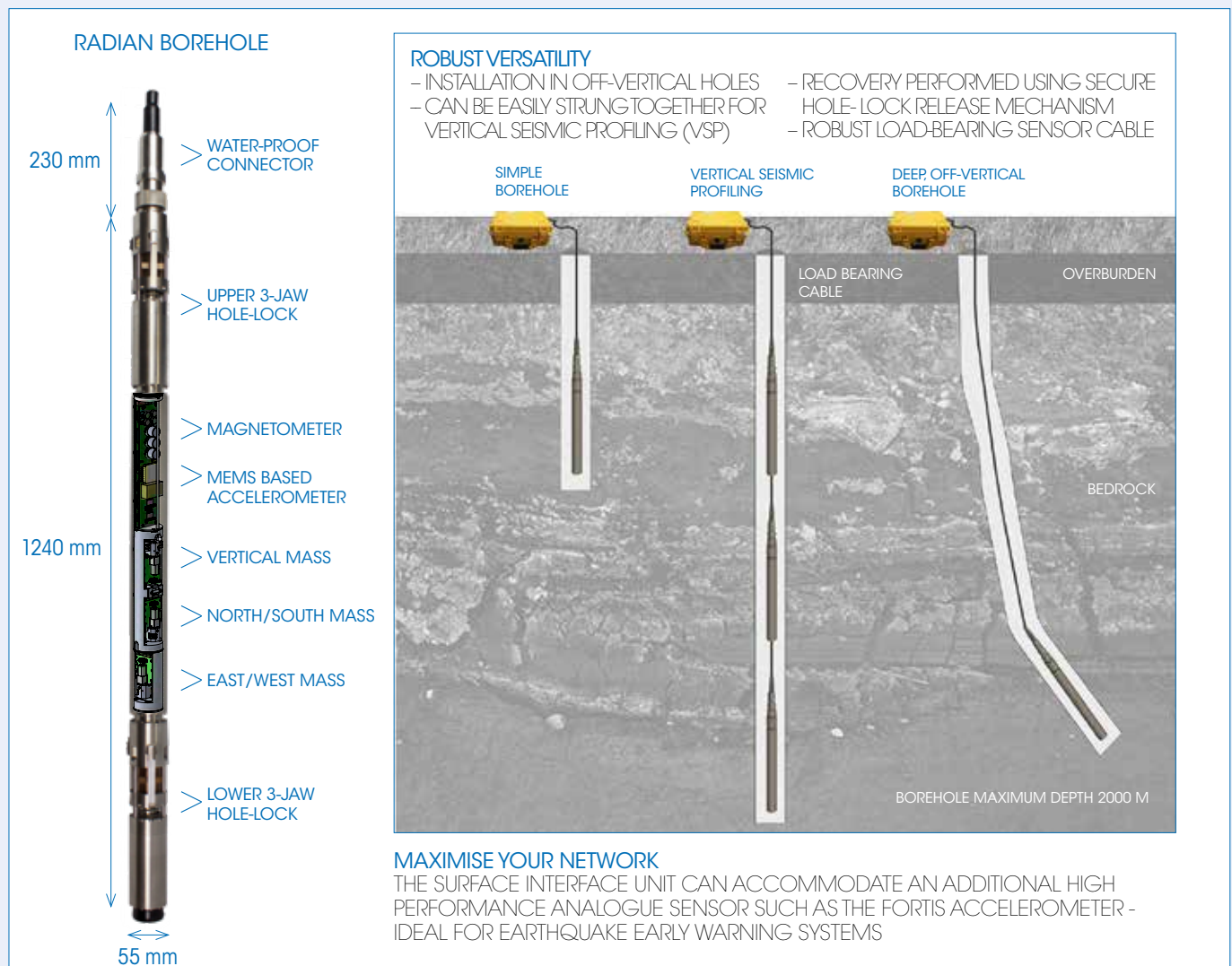
Option to accommodate an additional analogue instrument with the Minimus surface interface unit

Depths of up to 100 m suitable for temporary deployments using batteries and solar panels

Applications

- > Microseismic and induced seismicity monitoring
- > Volcanic unrest monitoring
- > Ice-quake monitoring in glaciers
- > Seismic monitoring in areas of high cultural noise
- > Strong motion monitoring caused by local events

Radian Borehole system for deployment in cased vertical or deviated boreholes



Key features

State-of-the-art seismic sensor allows full operation over a full tilt range of $\pm 180^\circ$ by automatically centring the mass

Triaxial orthogonal (ZNE) instrument with high cross-axis rejection (> 65 dB)

120 s to 200 Hz with user-selectable high-pass frequency corner from 1 s to 120 s

Select either velocity or acceleration output at time of order

Low latency outputs available (approx. 0.04 s data packets)

Industry standard retractable three-jaw motorised hole-locks for either narrow, (60 mm - 100 mm) or wide (100 mm - 140 mm) cased holes

Streaming and storage of instrument response and calibration parameters dramatically simplifies data management (RESP and dataless SEED formats)

Applications

- > Microseismic and induced seismicity monitoring
- > To complement dense surface arrays
- > Vertical seismic profiling (VSP)
- > Seismic monitoring in areas of high cultural noise
- > Traffic light systems for energy extraction or storage

SPECIFICATIONS

BROADBAND SEISMOMETER SYSTEM	
Configuration / Topology	Triaxial orthogonal (ZNE)
PERFORMANCE: BROADBAND SEISMOMETER	
Maximum frequency response bandwidth	120 s (0.0083 Hz) to 200 Hz with 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)
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	$\pm 180^\circ$
Cross axis rejection	> 65 dB
Linearity	> 95 dB
Lowest spurious resonance	> 450 Hz
Centring	Automatic / can be disabled
Transfer function	Measured sensitivity, frequency response and instrument poles and zeros are stored within the instrument and accessible via web interface
ENVIRONMENTAL CHANNELS	
Sensor mass positions	Three independent sensor mass position outputs (integrator)
Orientation sensors	MEMS based accelerometer (three component); Magnetometer (three component)
Other sensors	Temperature; humidity; pressure; input voltage
INTERNAL DIGITISER	
Digital resolution/output format	24-bit
Dynamic range	> 120 dB
Anti-aliasing filter at Nyquist	> 172 dB
Sampling rates	1 to 5000 samples per second, user selectable
ENVIRONMENTAL	
Operating temperatures:	-30 to +60 °C
Humidity	0-100% relative humidity
Robustness	IP68 to 2000 m depth
PHYSICAL	
Diameter	55 mm
Radian Borehole diameter options*	Narrow borehole: 60 mm to 100 mm Wide borehole: 100 mm to 140 mm *Precise internal diameter of the borehole casing is required prior to order.
Radian Posthole case height	770 mm excluding connector
Radian Posthole weight	7.1 kg excluding connector
Radian Borehole case height	1240 mm excluding connector
Radian Borehole weight	7.5 kg excluding hole-locks and connector
Sensor enclosure/materials	SAE 316 corrosion resistant stainless steel Gold plated contacts O-ring seals throughout
Connector	250 Bar / 25 MPa water-proof connector
Sensor and load-bearing cable	Kevlar-reinforced, AC-coupled
Orientation indicator	North vertical scribe mark on side on outer casing and inside connector

Güralp Systems Limited
Midas House
Calleva Park
Aldermaston
Reading
RG7 8EA
United Kingdom

T +44 118 981 9056
F +44 118 981 9943
E sales@guralp.com

www.guralp.com

DIGITISATION AND STORAGE	
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 calibration channel
Internal environmental channels:	Humidity Temperature Supply voltage MEMS accelerometer (three component) Magnetometer (three component)
Flash memory and storage	Dual redundant 16 GB microSD cards (1 fixed, 1 hot-swappable) Option for 64 GB or 128 GB
Data recording formats	miniSEED (metadata stored in Dataless SEED format)
Configuration and control	(Ethernet) Güralp Discovery - free download, web browser interface. Free GüVu Bluetooth app (Android)
Data streaming protocols (via Ethernet)	GCF (Scream!), GDI-link ¹ and SEEDlink ¹ (¹ metadata sent in RESP, StationXML and dataless SEED file formats)

TIMING	
Timing protocols	GNSS (GPS or GLONASS, BeiDou optional) or PTP (Precision Time Protocol) timing sources
GNSS connector	14-way Lemo connector (NMEA, PPS and Debug serial)
Timing drift without GNSS	Typical drift when unsynchronised <1 ms per day

POWER	
Protection	AC-coupled differential electronics
Power input voltage range	10–36 V DC
Power consumption (at 12 V DC)	Single Radian Posthole: 2.1 W*
Power consumption (at 12 V DC)	Single Radian Borehole: 2.3 W*

**Power voltage for operation of this unit only. Connection to additional instrumentation or use of longer cables may result in a higher input voltage requirement*

MINIMUS SURFACE INTERFACE UNIT - WITH COPPER CABLE FOR DEPLOYMENTS OF UP TO 100 M DEPTH	
Dimensions	134 mm × 99 mm × 45 mm exc. connectors
Weight	674 g (without connectors)
Operating temperature	-20 to +60 °C
MINIMUS SURFACE INTERFACE UNIT - FIBRE OPTIC SYSTEM FOR DEPLOYMENTS OVER 100 M DEPTH	
Dimensions	422 mm × 323 mm × 175 mm exc. connectors
Weight	7.5 kg
Operating temperature	-20 to +60 °C

In the interests of continual improvement with respect to design, reliability, function or otherwise, all product specifications and data are subject to change without prior notice.

DAS-RAD-0001 Issue L