

# RADIAN BOREHOLE

THE TRIAXIAL, BROADBAND, DIGITAL BOREHOLE  
SEISMOMETER THAT OFFERS UNPARALLELED FLEXIBILITY



## KEY FEATURES

- > Remote, user-selectable high-pass frequency corner up to 120 s
- > Operational at any angle with hole-lock options for narrow (60 - 100 mm) or wide (100 - 140 mm) cased holes
- > Multi-instrument strings for vertical seismic profiling
- > Choose either acceleration or velocity response
- > STA/LTA and threshold triggering
- > The system can incorporate an additional analogue feed if required

## APPLICATIONS

- > Microseismic and induced seismicity monitoring
- > To complement dense surface arrays
- > Vertical seismic profiling
- > Seismic monitoring in areas of high cultural noise

The Radian Borehole system delivers advanced software communications for quick and easy instrument and data management.

# Radian Borehole

Unlike other borehole instruments, the Radian can operate at any angle, making it suitable for deployment in non-vertical boreholes. It can be deployed as a single instrument or, for vertical seismic profiling (VSP), multiple instruments can be strung together.

The Radians' triaxial, broadband, digital seismometer is housed in an ultra-slim corrosion-resistant water-proof casing constructed of SAE 316 stainless steel and fitted with a 250 Bar/25 MPa connector. Flexible hole-lock options means the instrument can be installed in either narrow, (60 mm - 100 mm) or wide (100 mm - 140 mm), cased holes.

The Radian system includes a Surface Interface Unit (SIU) that delivers data communication, timing and storage capability. The SIU records data on dual-redundant microSD cards and shares the data via Ethernet and Bluetooth connections. For deployments deeper than 100 m, a fibre optic cable and a compatible SIU is required.

GüVü, a Bluetooth App, displays waveforms, orientation, temperature and humidity data, for confident deployments.

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

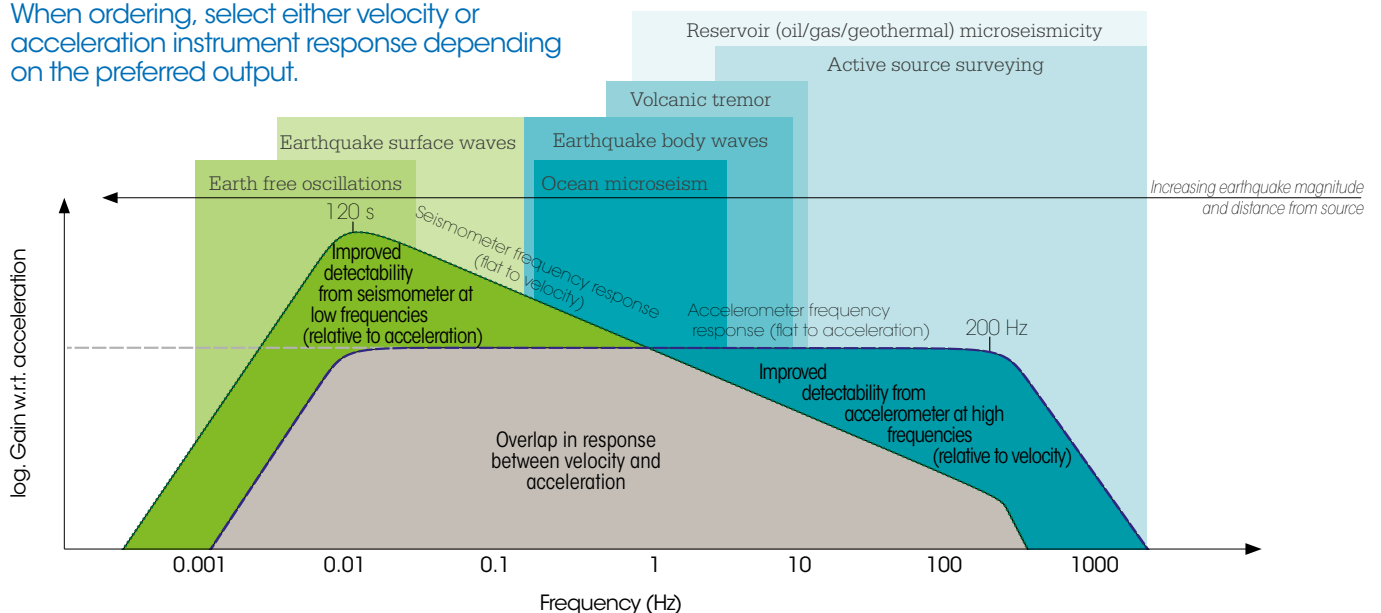
The ultra-wide frequency response between 120 s and 200 Hz makes the Radian ideal for seismic monitoring at all scales, particularly in areas of high cultural noise. For increased flexibility, the high-pass frequency corner can be remotely configured to suit the deployment environment.

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.

For subsurface installations where a cased hole is not practical the Radian Posthole is recommended. See the Radian Posthole datasheet for more information.

## Response selection

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



## 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

The robust Radian Borehole is a true broadband downhole seismometer capable of withstanding the harshest conditions. Easily strung together for down-hole arrays, the surface interface unit gathers data from multiple instruments.

**RADIAN BOREHOLE**

**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

**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

## 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)

Remote, user-selectable high-pass frequency corner up to 120 s

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

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)

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)

Free GüVü Bluetooth app for checking installation integrity (Android)

Dual-redundant 64 GB microSD cards (1 fixed, 1 hot-swappable)

Accurate time-base provided by either surface GNSS, Precision Time Protocol (PTP), or internal clock ( $< 1$  ms drift per day without GNSS)

## SPECIFICATIONS

### BROADBAND SEISMOMETER SYSTEM

Configuration / Topology Triaxial orthogonal (ZNE)

### PERFORMANCE: BROADBAND SEISMOMETER

Maximum frequency response bandwidth 120 s (0.0083 Hz) to 200 Hz  
Other user selectable options available within this range

Velocity or acceleration response (configurable prior to shipping)

Full-scale clip level Velocity response nominal:  $\pm 25$  mm/s (equivalent to differential output sensitivity of 2000 V/m/s)

Acceleration response nominal:  $\pm 12.5$  mm/s<sup>2</sup> (equivalent to differential output sensitivity of 200 V/m/s<sup>2</sup>)

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 / configurable

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 (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

Anti-aliasing filter at Nyquist > 172 dB

Sampling rates 1 to 5000 samples per second, user selectable

### PHYSICAL

Instrument diameter 55 mm

Borehole diameter options Narrow borehole: 60 mm to 100 mm  
Wide borehole: 100 mm to 140 mm

To determine the correct hole-lock component, the precise internal diameter of the borehole casing is required prior to order.

Case height excluding connector 1240 mm

Weight 7.5 kg without hole-locks or 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

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### ENVIRONMENTAL

Operating temperatures: -30 to +60 °C

Maximum deployment depth 2000 m

Humidity 0-100% relative humidity

Robustness IP68 to 2000 m depth

### SURFACE INTERFACE UNIT (COPPER AND FIBRE)

Dimensions 422 mm x 323 mm x 175 mm exc. connectors

Weight 7.5 kg

Operating temperature -20 to +60 °C

### DIGITISATION AND STORAGE

Additional sensor inputs Primary channels:  
Four at 24 bits. Differential input: 40 V peak-to-peak ( $\pm 20$  V). Also compatible with single-ended inputs: 20 V peak-to-peak ( $\pm 10$  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 64 GB microSD cards (1 fixed, 1 hot-swappable)

Data recording formats miniSEED (metadata is 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<sup>1</sup> and SEEDlink<sup>1</sup> (<sup>1</sup>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

### SURFACE INTERFACE UNIT FOR DEPLOYMENTS UP TO 100 M DEPTH (COPPER CABLE SYSTEM)

Full system power consumption with one Radian 8.7 W (no GNSS or Ethernet)  
9 W (with GNSS and Ethernet)

### SURFACE INTERFACE UNIT FOR DEPLOYMENTS OVER 100 M DEPTH (FIBRE OPTIC SYSTEM)

Full system power consumption with one Radian ~ 20 W with GNSS and Ethernet

Additional Radians will add approximate power consumption of 2.3 W per unit

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.

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