MOHO UNO

Single-component seismometer

Key features

✅ Compact design
✅ Switchable gain
✅ Easyandrapid deployment
✅ Working modes: DataStreamer, Seedlink, Win2SDR, EwExport.

Applications

✅ Earthquake early warning systems
✅ Structural health monitoring (e.g. dams, industry, buildings)
✅ Shake intensity research

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1. General specifications

Performance

Analog input channels:	1 (CH1)
Input signal range:	±20 V (40 V_{pp}) Note: To connect a differential signal to the digitizer card, modify the resistive values in the input channel; see the Analog interface section for the corresponding values. The digitizer card only accepts a ground-referenced differential signal at the input.
ADC:	Delta-Sigma, 24 bits, Cirrus Logic CS5532
Sample rate:	■ 50 ■ 100 ■ 200
Resolution (effective bits):	21 @ 100 SPS
Clip level:	±8,388,608 counts @ 24 Bits
Adjustable gain:	Yes
Selectable gain:	2, 4, 8, 16, 32, 64
Selectable digital filters:	■ Low-pass filter ■ High-pass filter ■ Inverse filter
Polarity correction:	Yes
Sensor included: (check the order information)	■ RGI-4.5Hz (Racotech), or ■ L-28LB (Sercel)
Sensor compatibility:	All geophones All active sensors (with ±5 V, ±10 V, or ±20 V referenced to ground) Notel: Before connecting the sensor, check the compatibility with the digitizer board + Raspberry Pi Zero W in the Analog interface section.

Single Board Computer (SBC)

SBC full compatibility:

- Raspberry Pi Zero 2W
- Raspberry Pi Zero W
- Raspberry Pi Zero along with one of the following configurations:
  - OTG Cable (micro USB) + USB Wi-Fi stick
  - Micro USB to RJ45 converter + Ethernet cable

SBC compatibility:

- Raspberry Pi 4 model B
- Raspberry Pi 3 (model B+, B, and A+)
- Raspberry Pi 1 (model B+ and A+)

SD card support: MicroSD 8 GB (included) for operating system and data storage

Communications

Timing: NTP (Network Timing Protocol, default)

Data transmission:

- TCP
- UDP

Connectivity:

- 802.11 b/g/n LAN wireless (Wi-Fi 4)
- Ethernet 10/100 BaseT (on request)

Software

Operating System: Linux BBshark 5.10.63+ (based on Raspberry Pi OS)

Software:

- Earthworm
- WindSDR

Continuous seismic data: miniSEED format

Web-interface (HTML):

- Network and system settings
- Helicorder and waveform plot generator
- System status and logs.

System Requirements:

- Windows
- Linux
- Mac OS

Physical

Dimensions:	■ 142.0x134.1x55.0 mm
Weight:	■ 410 g (with RGI-4.5Hz) ■ 470 g (with L-28LB)
Enclosure rating:	IP65, standard 3D printed enclosure
Enclosure material:	PLA Plastic (polylactic acid)
Environment[1]:	Operating temperature, 0°C to +45 °C

Power

Input power:	■ 12 V/2.1 A DC via wall plug AC-DC power adapter supply ■ 5 V via GPIO header ■ 1.752 W power consumption (run-time, 5 V × 350 mA)

[1] Limited by the PLA case, the Raspberry Pi, the digitizer board and the geophone themself can go from -20°C to +70°C)

1.1. Recommended operating conditions

Minimum and maximum specifications apply from T_A = –20°C to +70°C. Typical specifications are at T_A = 25°C.

PARAMETER		MIN	NOM	MAX	UNITS
Input power supply					
V_{A+}	Power supply voltage:	4.75	5.0	5.25	V
Analog input (note 1, note 2)					
V_{IN}	Differential input voltage, eq. (1):	-0.3		V_{A+}+0.3	V
V_{CM}+V_{AINx}	Common-mode + Signal on AIN1+ or AIN1-:	0.7		V_{A+}-1.7	V
	Absolute input voltage (+IN, -IN):	See the Analog interface pinout section			

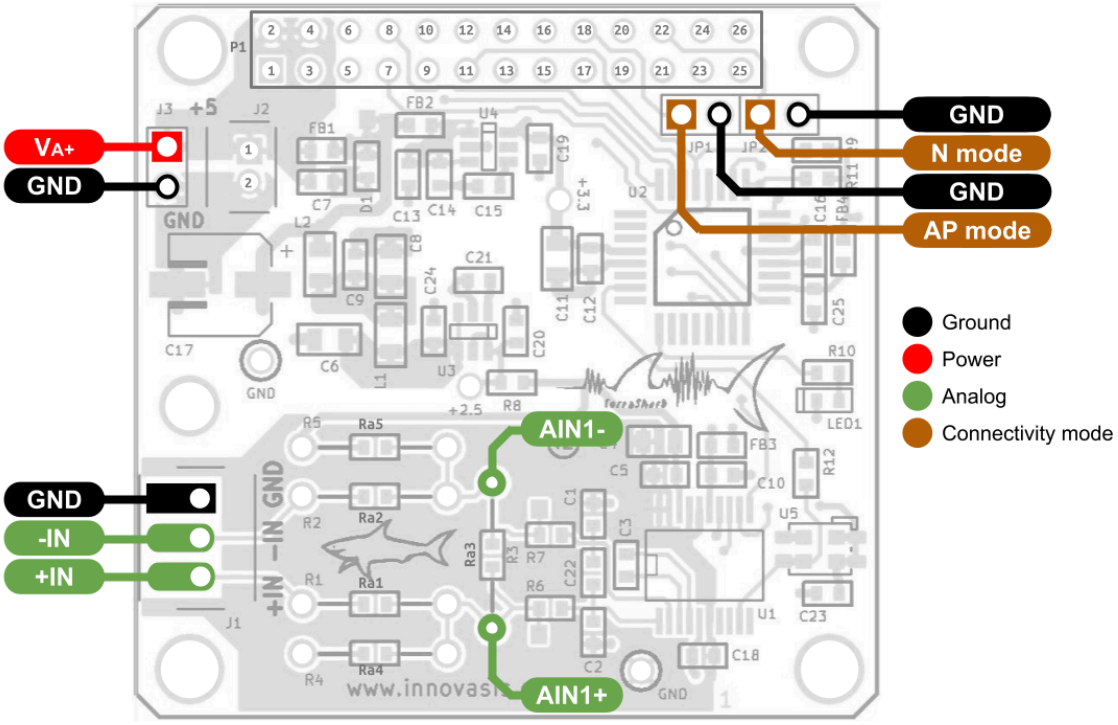
Notes:
1. For accurate measurements, in the gain ranges from 2 to 64, the input signals AIN+ and AIN- (voltages in R3 and Ra3, Fig. 1) must remain between the given voltages values (MIN and MAX).
2. Voltage on the BIS-M1DAQ analog inputs

The differential input voltage is denoted by V_{IN}, and it is calculated using eq. (1):

$$V_{IN} = V_{AIN+} - V_{AIN-} \quad (1)$$

The common-mode voltage is calculated using eq. (2):

$$V_{CM} = \frac{V_{AIN+} + V_{AIN-}}{2} \quad (2)$$



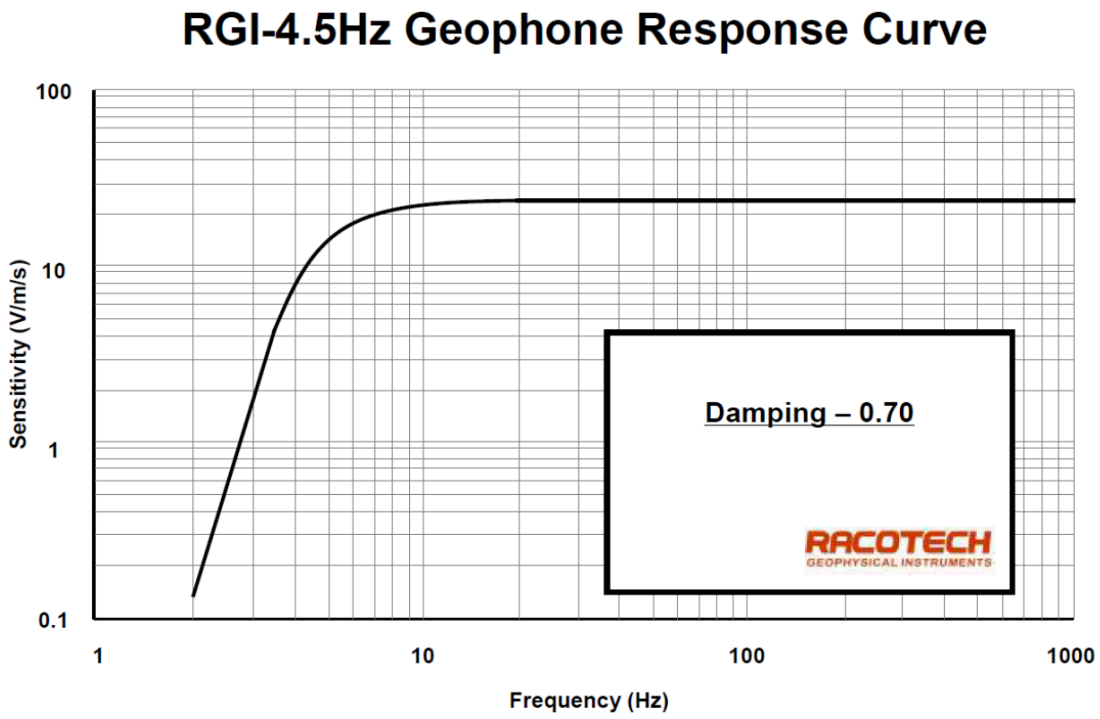
1.2. Typical characteristics

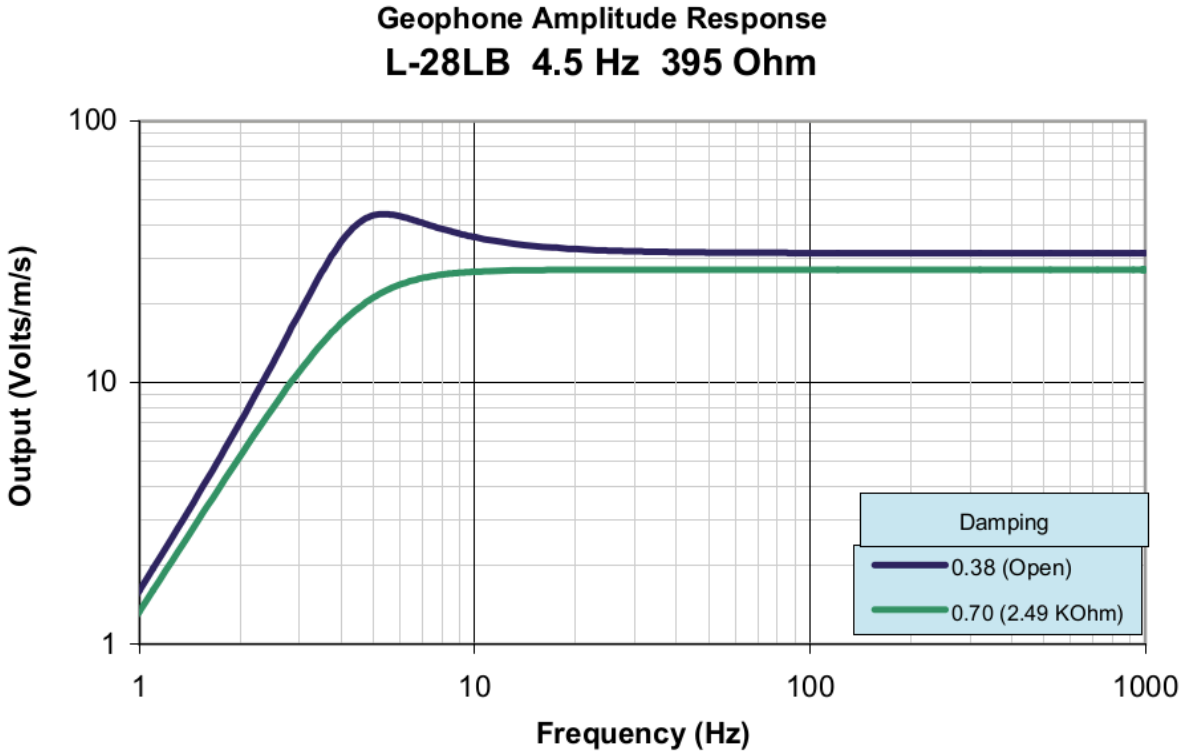
PARAMETER		MIN	NOM	MAX	UNITS
Power supply					
V_D	ADC digital power supply:		3.3		V
Voltage reference					
V_{REF}	Reference voltage:	2.498	2.5	2.502	V
	Output voltage temperature drift:		2.0	8	ppm/°C
	V_{REF} long-term stability (1000 hours T_A=25°C):		40		ppm
Internal clock source					
f_{CLK}	Internal frequency clock:		4.9152		MHz
f_{stab}	Internal frequency clock stability:	-20		20	ppm
DC	Duty cycle:	45		55	%

2. Sensor specifications

Manufacturer:	**Racotech**	**Sercel**
Manufacturer product number:	RGI-4.5Hz	L-28LB
Natural frequency:	4.5±0.5 Hz	4.5±0.5 Hz
Harmonic distortion:	≤0.3% (12 Hz)	<0.2% (12 Hz @ 17.8 mm/s pk-pk)
Tilt angle for distortion specification:	Vertical	Vertical
Open circuit damping:	0.7±10%	0.38±10%
Coil resistance:	395 Ω ±5%	395 Ω ±6.5%
Sensitivity:	23.4 V/m/s ±10%	31.3 V/m/s
Moving mass:	11 g	19 g
Coil travel (Pk-Pk):	1.5 mm	4 mm
Diameter:	25.4 mm	31.8 mm
Length:	33.0 mm	38.1 mm
Weight:	87 g	141.75 g
Operating temperature:	-40 °C ~ +100 °C	-40 °C ~ +80 °C
Note:	All RGI-4.5Hz parameters are specified at +22℃	All L-28LB parameters are specified at +20℃

2.1. Sensor response curve





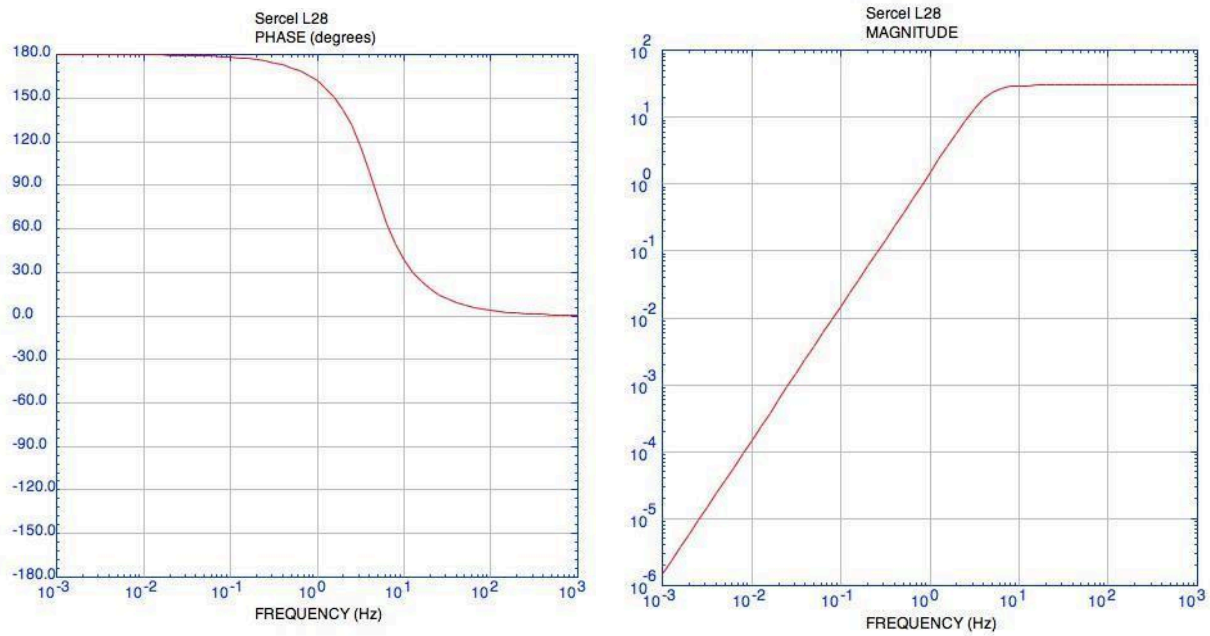


Figura 1: Curvas de respuesta en frecuencia para L-28LB[2], Sercel. Créditos: IRIS, PASCAL.

[2] Incorporated Research Institutions for Seismology (IRIS), Portable Array Seismic Studies of the Continental Lithosphere (PASSCAL) (2009). Sercel L-28-3D High Frequency Sensor, disponible en https://www.passcal.nmt.edu/content/instrumentation/sensors/high-frequency-sensors/l-28-hf-sensor (última consulta Septiembre de 2023)

3. Analog Interface

The BIS-M1DAQ has two options for sensor connection in the analog input signals: geophone and differential (ground referenced). By default, the geophone open-circuit damping (undamping) configuration is selected in the BIS-M1DAQ, see Table 1. The default configuration doesn't admit differential input voltages. The resistor values in Table 1 :

Table 1. Default resistor values (geophone design oriented).

Input voltage ranges	Resistor values										
	RT (%)	R1 (kΩ)	R4 (kΩ)	R5 (kΩ)	R2 (kΩ)	Ra1 (kΩ)	Ra4 (kΩ)	Ra5 (kΩ)	Ra2 (kΩ)	R3 (kΩ)	Ra3 (kΩ)
Factory default values	0.5	OP	OP	OP	OP	JP	100	100	JP	OP	OP

where RT is the resistor tolerance in percentage, JP is a 0 Ω jumper SMD resistor 1/16 W, and OP stands for to install nothing or leave it open. R3 and Ra3 are the damping resistor values required to achieve the damping (critical) value Q=0.7, as shown in Table 2 for some common geophone sensors.

Table 2. Resistor values for different geophones models and manufacturers.

Sensor			Resistor values										
Manufacturer	Model No.	Q	RT (%)	R1 (kΩ)	R4 (kΩ)	R5 (kΩ)	R2 (kΩ)	Ra1 (kΩ)	Ra4 (kΩ)	Ra5 (kΩ)	Ra2 (kΩ)	R3 (kΩ)	Ra3 (kΩ)
Sercel	L4A (R_{COIL}=5.5 kΩ)	0.70	1	13.7	OP	OP	13.7	RM	5.1	5.1	RM	11.8	OP
	L4C (R_{COIL}=5.5 kΩ)	0.70	1	13.7	OP	OP	13.7	RM	5.1	5.1	RM	11.8	OP
	L-22E (R_{COIL}=510 Ω)	0.71	1	FD	FD	FD	FD	FD	100	100	FD	FD	FD
	L-22E (R_{COIL}=2.2 kΩ)	0.71	1	FD	FD	FD	FD	FD	100	100	FD	FD	FD
	L-22E (R_{COIL}=8.54 kΩ)	0.71	1	FD	FD	FD	FD	FD	100	100	FD	FD	FD
	L-28LB (R_{COIL}=395 Ω)	0.70	1	FD	FD	FD	FD	FD	5.1	5.1	FD	3.32	OP
Kinemetrics	SS-1 (Ranger)	0.70	1	16.9	OP	OP	16.9	RM	5.1	5.1	RM	11.8	OP
Geotech	S-13	0.71	1	38.3	OP	OP	38.3	RM	5.1	5.1	RM	71.5	OP
Racotech	RGI- 4.5Hz (R_{COIL}=395 Ω)	0.70	1	FD	FD	FD	FD	FD	FD	FD	FD	FD	FD

where RM stands for remove (unsolder) the part, and FD stands for factory default values, i.e. the same values as Table 1.

As mentioned before, each channel can be configured up to an input signal of ±20 V, or 40 V_{PP} (V Peak-to-Peak). This option can be used with sensors that output a ground-referenced differential signal. To measure these larger input voltage swings, a differential voltage divider must be placed on the board, as shown in Table 3.

Table 3. Acceptable values and modifications to the BIS-M1DAQ card to connect a sensor with differential output voltage.

Input voltage ranges	Resistor values										
	RT (%)	R1 (kΩ)	R4 (kΩ)	R5 (kΩ)	R2 (kΩ)	Ra1 (kΩ)	Ra4 (kΩ)	Ra5 (kΩ)	Ra2 (kΩ)	R3 (kΩ)	Ra3 (kΩ)
±20 V (16:1)	0.1	76.8	OP	OP	76.8	RM	5.1	5.1	RM	OP	OP
±10 V (8:1)	0.1	35.7	OP	OP	35.7	RM	5.1	5.1	RM	OP	OP
±5 V (4:1)	0.1	15.4	OP	OP	15.4	RM	5.1	5.1	RM	OP	OP

Important: To prevent damage to the ADC on the digitizer board, make sure to carry out the adjustments outlined in Table 3 before connecting any differential voltage signal to the BIS-M1DAQ input.

3.1. Software-selectable parameters

VARIABLE	DESCRIPTION	MIN	NOM	MAX	UNITS
Sample rate					
ChanRate	Sampling rate (Samples/s):	50	100	200	SPS
Digital filter					
LP	Low-pass filter:	0.01	15	24	Hz
HP	High-pass filter:	0.02	0.1	49	Hz
INV	Inverse filter filter:		0.5		Hz
ADC channel characteristics					
Gain	ADC channel gain (2, 4, 8, 16, 32, 64):	2	2	64	
Bits	Set the usable ADC bits:		24		Bits
DcOffset	Offset to the incoming data in ADC counts:	0	0	$(2^{Bits}/2)-1$	Counts
VARIABLE	DESCRIPTION		NOM	OPTIONS	
ADC channel characteristics					
Invert	Polarization correction of the ADC signal:		N	Y, 1	N, 0
SendToEW	Send ADC data to Earthworm ring:		Y	Y, 1	N, 0
SendToWinSDR	Send ADC data to WinSDR using the TCP Server:		Y	Y, 1	N, 0

Notes: Y=Yes, 1=Yes, N=No, 0=No