

EAS 4803/8803 - Obs Seismology

Lec#5: Seismometers and Seismic Networks

• Dr. Zhigang Peng, Spring 2019

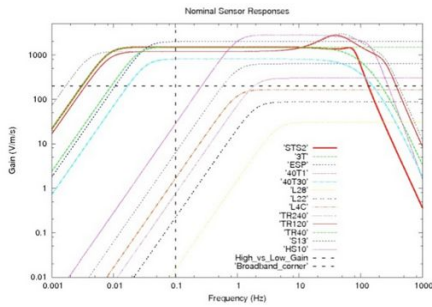


Figure 6.6-1: Diagram of a vertical seismograph.

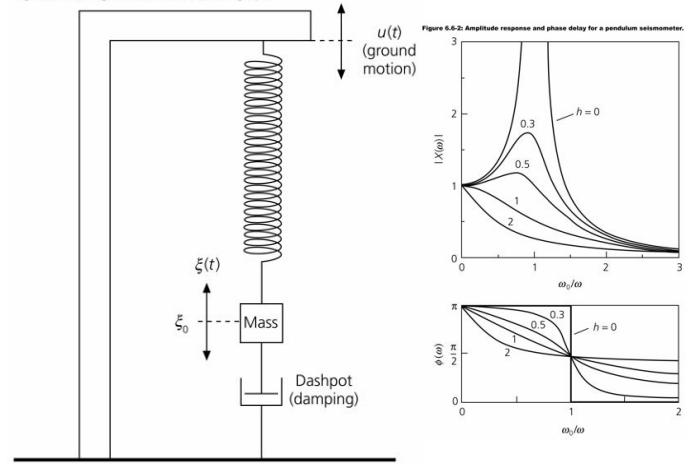
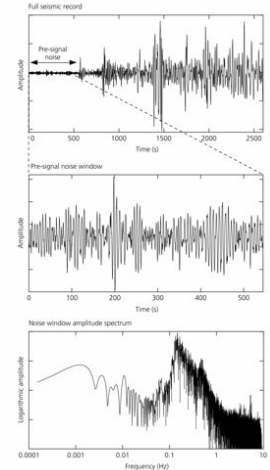


Figure 6.6-3: Demonstration of seismic noise on a broadband seismogram.



1. A microseism is defined as a faint earth tremor caused by natural phenomena, such as winds and ocean waves. (from wikipedia)
2. Thus a microseism is a small and long-continuing oscillation of the ground.
3. The term is most commonly used to refer to the dominant background seismic noise signal on Earth, which arises from wave action in the oceans, i.e. the low-frequency part of the Ambient Vibrations.

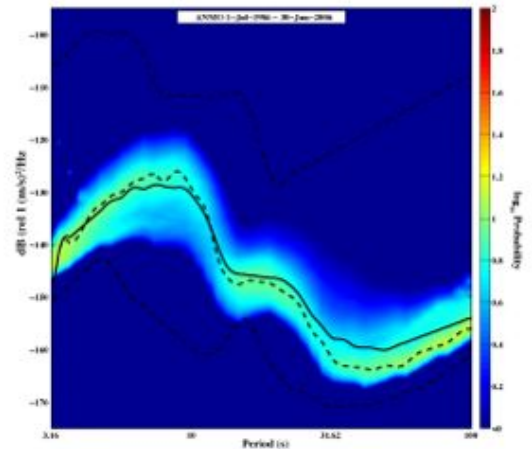


Figure 6.6-4: Examples of seismoscope recordings.

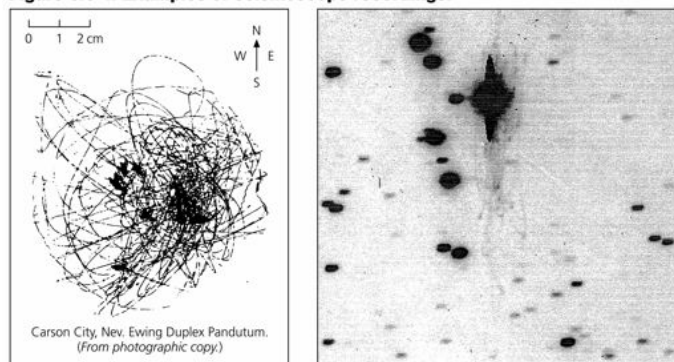


Figure 6.6-5: Illustration of an electromagnetic seismograph.

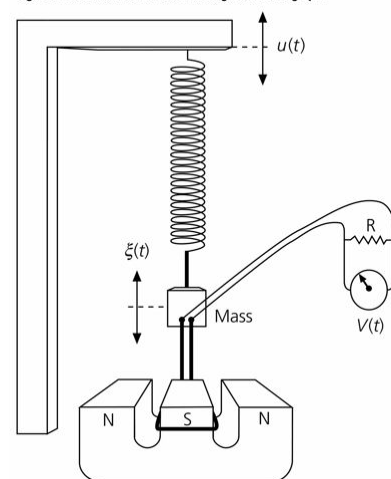


Figure 6.6-6: Coupling of the transducer of an electromagnetic seismograph to a galvanometer.

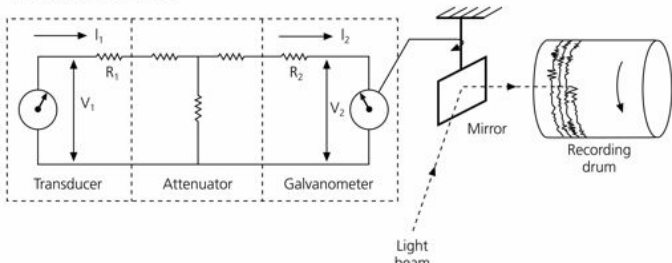


Figure 6.6-7: Responses of the components of an electromagnetic seismograph.

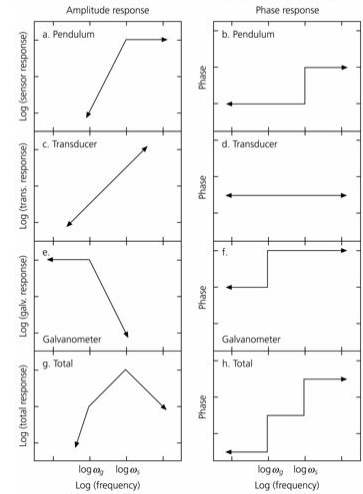


Figure 6.6-8: Instrument responses for several types of seismometers.

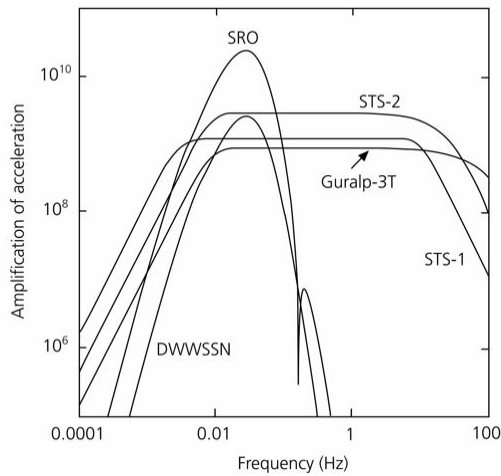
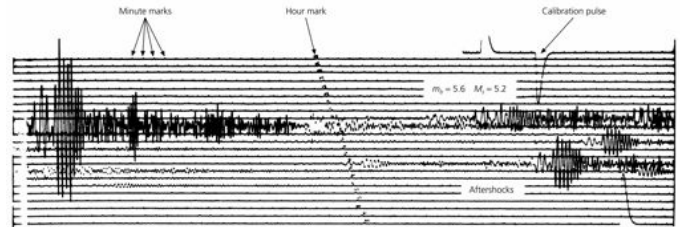
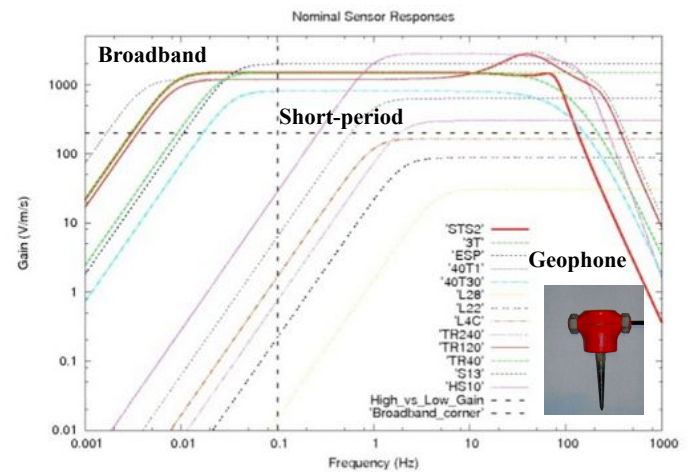


Figure 6.6-9: Sample WWSSN long-period vertical-component seismogram for one day.



**Passive Source:
naturally occurring
seismic events at depth,
or ambient background
noise**

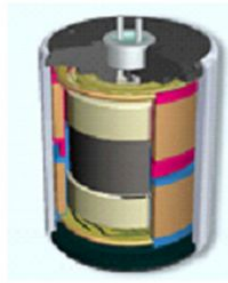
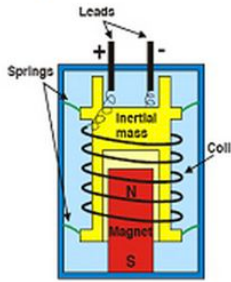
Streckeisen STS-2 Broadband Sensor
Home • Instrumentation • Sensors • Broadband.



<https://www.passcal.nmt.edu/content/instrumentation/sensors/sensor->

Geophone: a device that converts ground motion into

Geophones



Recording Differences

- Active – mostly in triggered mode (short-period of recording time), very high sampling rate (500 to 5000 sample/s), up to 10,000 units per survey
- Passive – typically in continuous mode (a few months to a few years), various sampling rate (1 to 100 sample/s), a few tens (up to hundreds) units per experiment

Traditional Active-Source Deployment



Figure 1. Seismic field technician with 20+ Kg cable. Carrying this heavy weight on rough terrain is hazardous, even with experienced personnel.

Two key sensing advancements!

R. Stewart (Univ. of Houston, 2014)

- Nodes (autonomous)
- Fibre-optics (axial)

3C geophone
Battery
Geospace Recorder

1 to 4C
GPS
No or little cabling
~ Month recording
~ Wireless download

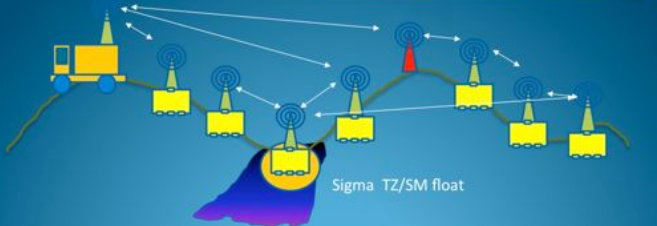
Fairfield Nodal

Current Electronic Geophone System
Current MRN Geophone System
Requirement for MRN Geophone System
USB Geophone System Performance

USB Geophone System has the lowest noise floor vs. all competing systems

iSeis Sigma: MRN configuration and deployment.

"So easy, a child could do it."



New types of sensor/recording system

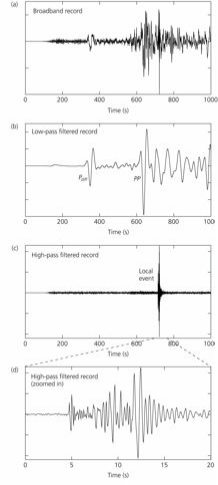


- Controller-processor
- Flash memory
- Li-ion Batteries (up to months of recording)
- GPS Receiver
- 24bit A/D Convertor
- Internal Geophone
- Spike

Typical Node specifications

<p>Seismic Data Characteristics: 3 24 bits 24 bits 0.5, 1, 2, 4 milliseconds 0 dB to 36 dB in 6 dB steps Anti-alias Filter 206.5 Hz @ 2ms (92.8% of Nyquist) Selectable - Linear Phase or Minimum Phase DC Blocking Filter 1 Hz to 60 Hz, 1 Hz increments, 6 dB/Octave, or OUT Operating Temperature Range -40°C to +60°C Operating Life 33 days continuous @ 20°C @ 2ms</p>	<p>Total Harmonic Distortion 0.0002% @ 12 dB Gain, 3 dB Full Scale Equipment Input Noise 0.25 µVrms @ 0 dB 0.2 µVrms @ 12 dB 0.1 µVrms @ 24 dB 0.1 µVrms @ 36 dB Full Scale Input Signal 2500 mV peak @ 0 dB 625 mV peak @ 12 dB 156 mV peak @ 24 dB 39 mV peak @ 36 dB Gain Accuracy: 0.50% Dynamic Range: 127 dB @ 0 dB Pre-amplifier Gain Common Mode Rejection Ratio >150 dB DC Offset < 30% of Input Noise with DC Blocking Filter IN Timing Accuracy ±10 microseconds GPS Disciplined</p>	<p>Sensor Impedance Sensor Step Response Sensor DC Resistance Sensor 3 Geophones, Orthogonal Configuration 60 Hz - 70% damped, 2 V/V (78.7 V/m/s) 5 Hz - 70% damped, 3.98 V/V (78.7 V/m/s) Battery Type: Rechargeable Li-ion Charging Temperature Range +5°C to +40°C Recharge Time: <4 hours Physical Weight: 6.2 lb (2.8 kg), including spike Dimensions: 4.6 in (11.7 cm) diameter by 6.4 in (16.3 cm) high</p>
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Figure 6.6-11: Use of filtering to enhance different frequency bands of a large seismogram.



Examples of broadband recordings with both long-period waves and high-frequency local signals.

2002 Mw7.8 Denali Fault earthquake triggering tremor at Parkfield, CA

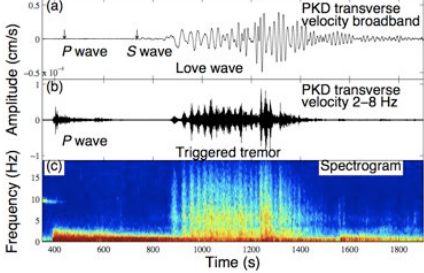


Figure 6.6-16: Station map of the Federation of Digital Broad-Band Seismographic Networks (FDSN).

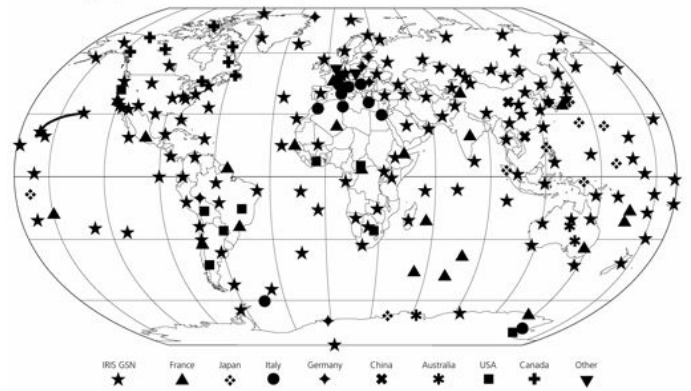
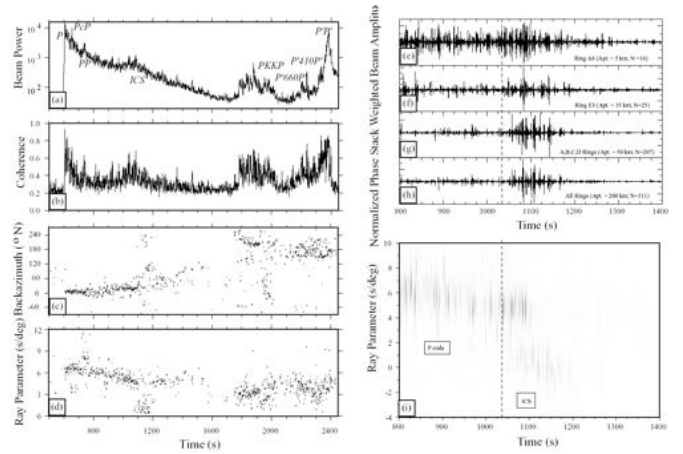
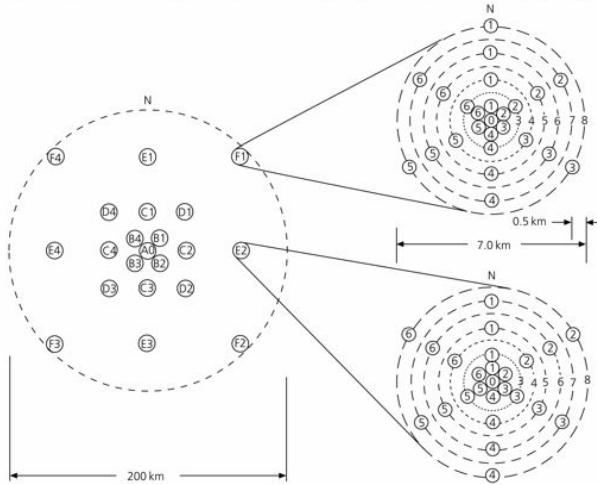
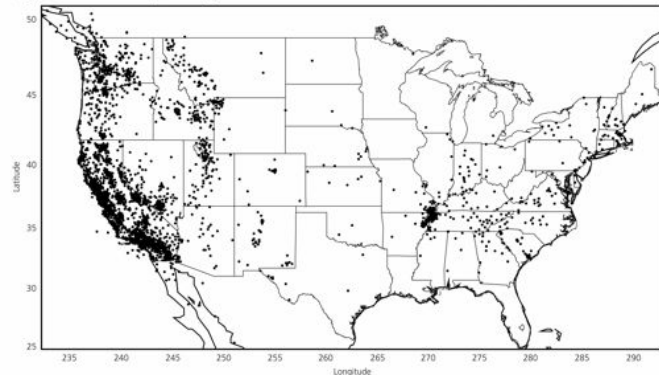


Figure 6.6-17: Station geometry of the Large Aperture Seismic Array (LASA).



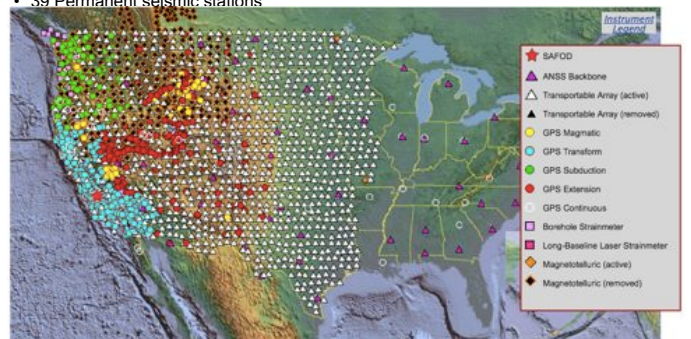
Peng et al. (JGR, 2008)

Figure 6.6-18: Map of regional network seismometers in the continental USA.



EarthScope Instrumentation

- 3.2 km borehole into the San Andreas Fault
- 875 permanent GPS stations
- 175 borehole strainmeters
- 5 laser strainmeters
- 39 Permanent seismic stations
- 400 transportable seismic stations occupying 2000 sites
- 30 magneto-telluric systems
- 100 campaign GPS stations
- 2400 campaign seismic stations



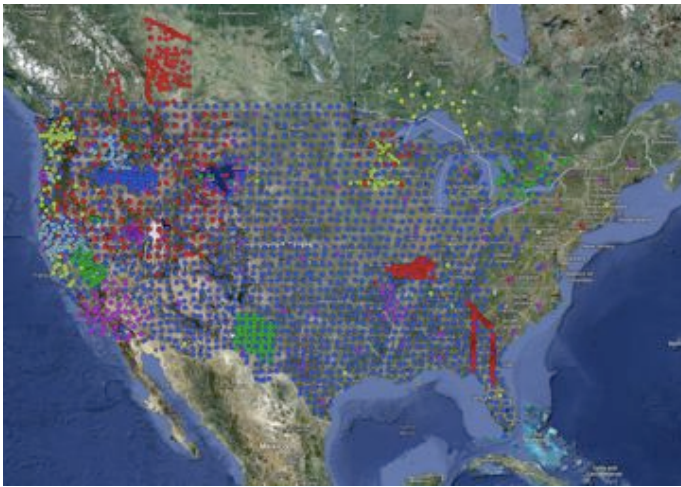


Figure 6.6-12: Diagram showing the analog-to-digital (ADC) process.

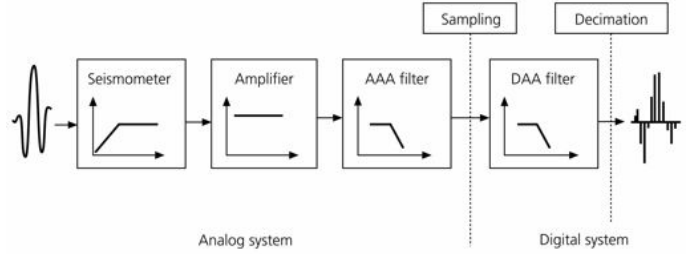


Figure 6.6-13: Example of a FIR filter and its effects on a seismogram.

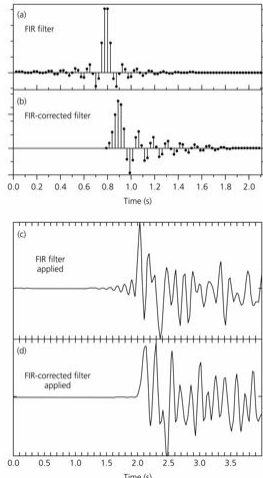


Figure 6.6-14: Relation between displacement, velocity, and acceleration in the time domain.

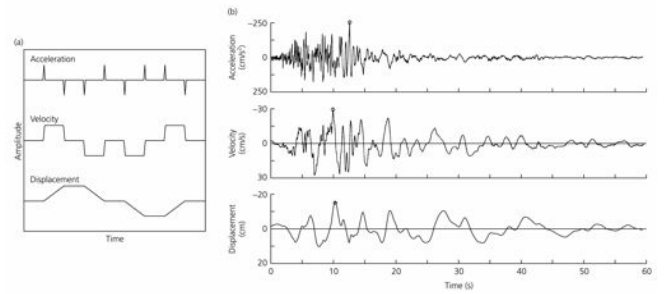


Figure 6.6-15: Relation between displacement, velocity, and acceleration in the frequency domain.

