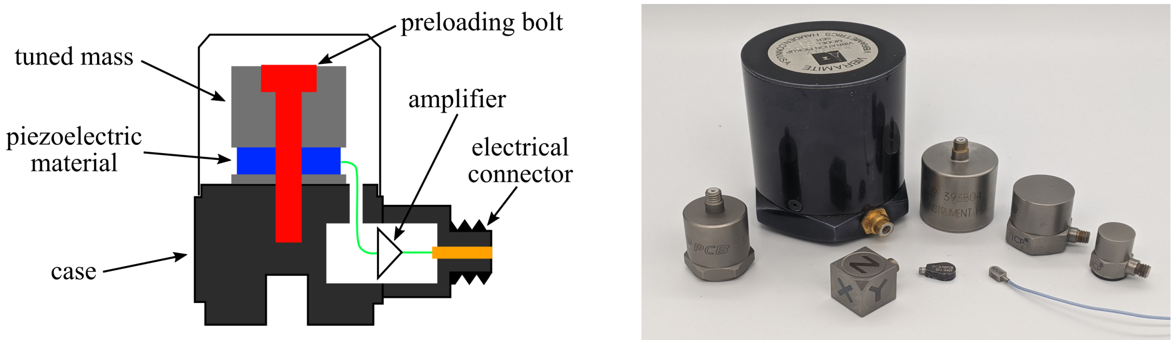
8 Experimental Vibrations

Experimental vibration testing requires the practitioner to understand the basics of testing hardware and digital signal processing.

8.1 Hardware for vibration testing



(a) (b)

Figure 8.1: Integrated Electronics Piezo-Electric (IEPE) accelerometers, showing: (a) the cross section of a typical IEPE) accelerometer with key components annotated, and; (b) selection of IEPE accelerometers for various applications.

Table 1: Parameters for various IEPE accelerometers.

parameter	accelerometers				
model number	PCB 393B31	PCB 393B04	PCB 352C67	PCB 352A21	PCB 352A92
Sensitivity($\pm$ 10 %)	10.0 V/g	1000 mV/g	100 mV/g	10 mV/g	0.25 mV/g
Measurement Range	$\pm$ 0.5 g pk	$\pm$ 5 g pk	$\pm$ 50 g pk	$\pm$ 500 g pk	$\pm$ 20 kg pk
Frequency Range($\pm$ 5 %)	0.1 to 200 Hz	0.06 to 450 Hz	0.5 to 10 kHz	1.0 to 10 kHz	1.2 to 10 kHz
Resonant Frequency	>700 Hz	>2.5 kHz	>35 kHz	>50 kHz	>100 kHz
Non-Linearity	$\leq$1%	$\leq$1%	$\leq$1%	$\leq$1%	
Transverse Sensitivity	$\leq$5%	$\leq$5%	$\leq$5%	$\leq$5 %	

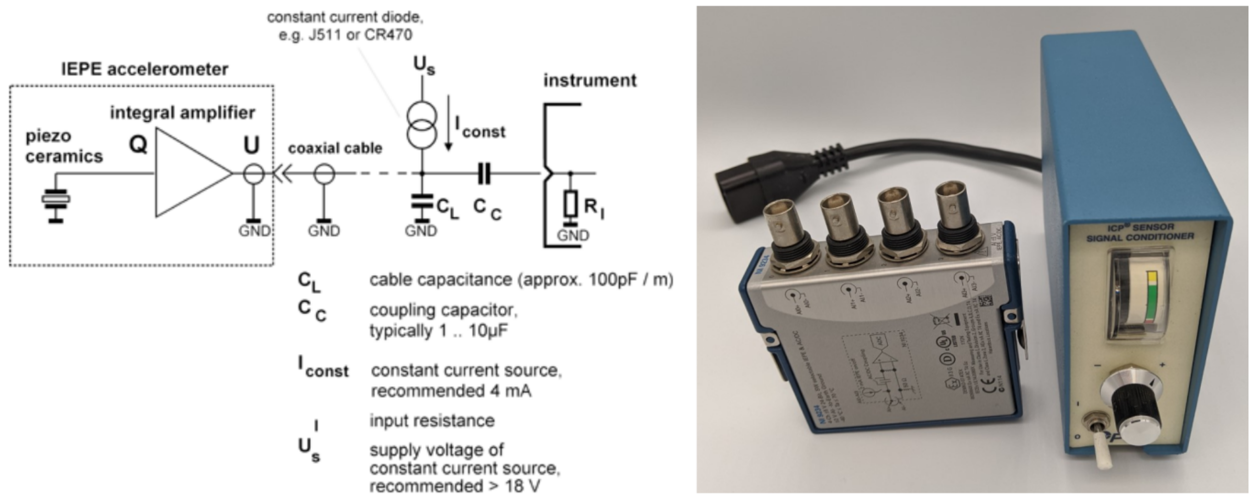


Figure 8.2: Integrated Electronics Piezo-Electric (IEPE)-based measurement system showing the: (a) simplified circuit schematic[1]; and (b) IEPE data acquisition systems in various form factors.

8.2 Digital Signal Processing

Review 8.1 Harry Nyquist (February 7, 1889 ? April 4, 1976) was a Swedish physicist and electronic engineer. His parents emigrated to the U.S. in 1907. He attended the University of North Dakota starting in 1912 where he obtained a B.S. in 1914 and a M.S. in 1915, both in electrical engineering (entry to M.S. was 3 years!). Thereafter, he went to to Yale University where he received a Ph.D. in physics in 1917.

[1]"IEPE sensor connected to the input of an instrument" by JanBurg CC BY-SA 4.0

Figure 8.3: Picture of Harry Nyquist from the American Institute of Physics. Fair use, via Wikimedia Commons

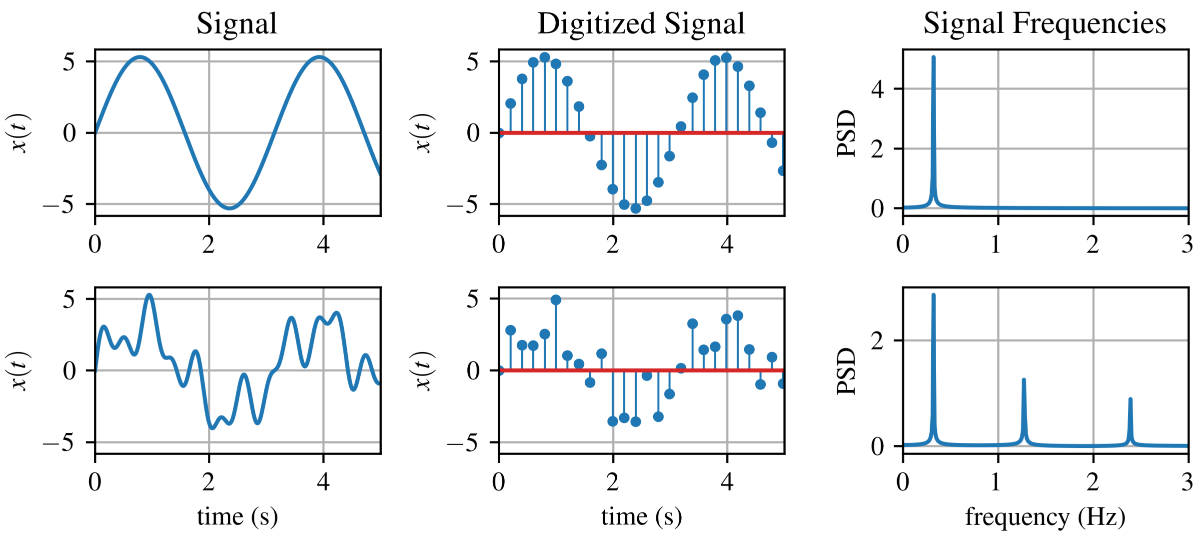


Figure 8.4: Digitization of two continuous time-series signals sampled at 5 S/s.

The Nyquist-Shannon sampling theorem is a theorem in the field of signal processing that defines the sample rate that permits a discrete sequence of samples (i.e. discrete-time) to sample a continuous-time signal of a finite bandwidth.

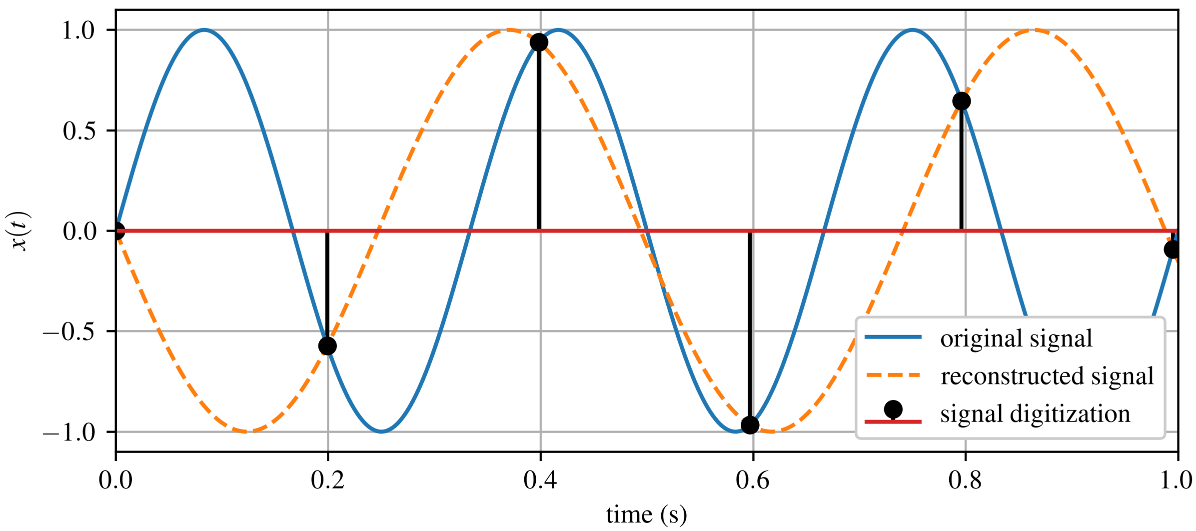


Figure 8.5: Aliasing of a 3 Hz signal that is sampled at 5 S/s.

In signal processing, aliasing is an effect that causes different signals to become indistinguishable from each other. In this way, the signals become an aliases of one another when sampled. Aliasing also accounts for the development of distortion or artifact in a reconstructed signal when compared to the original continuous signal.

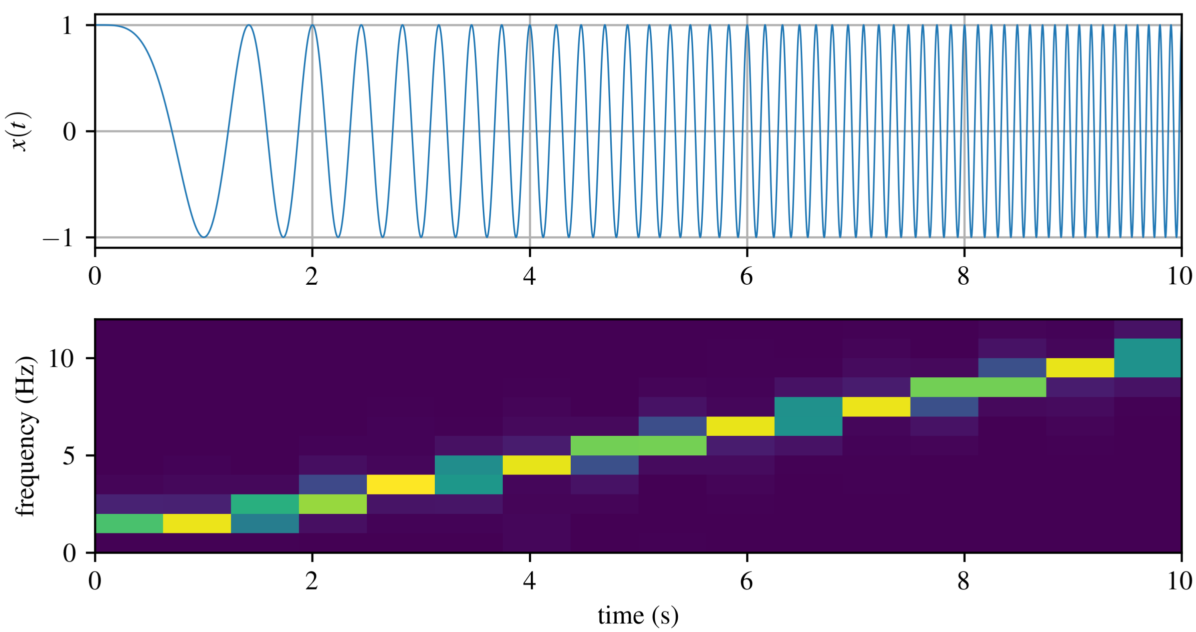


Figure 8.6: Spectrogram of a 0-10 Hz chirp signal.

Some of the key parameters in a spectrogram include:

- window
- segment length
- overlap