

# Signals: The Basics

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## Key Concepts

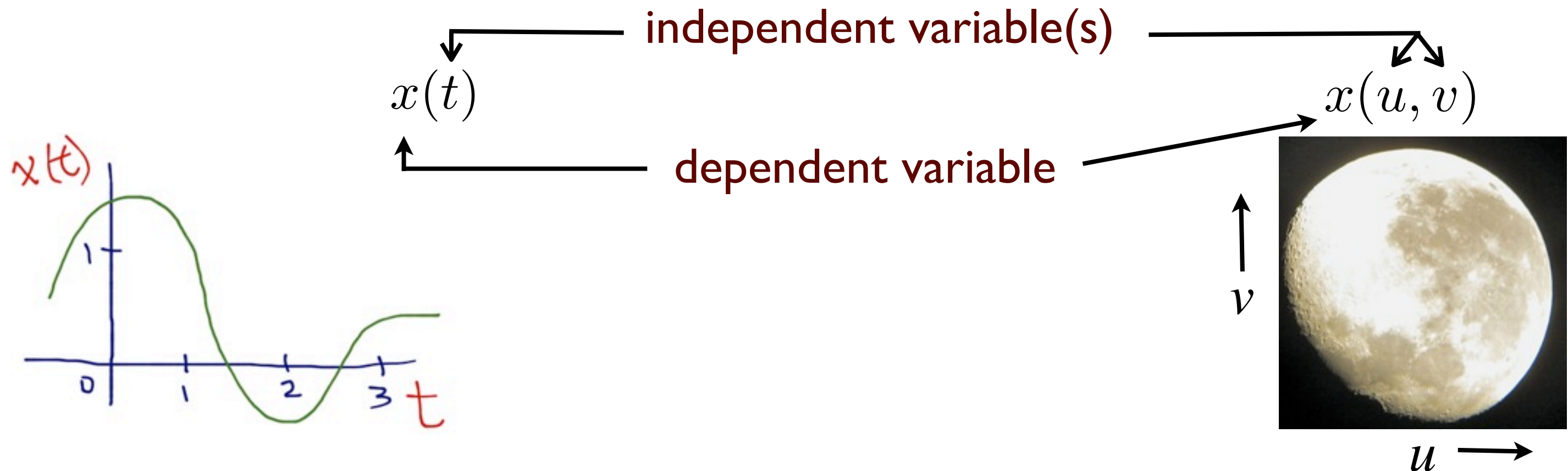
- 1) Signals are represented as functions of one or more independent variables.
  - a) In continuous- “time” signals the independent variable can take on any possible value.
  - b) In discrete- “time” signals the independent variable can only be a limited set of values, such as integers.
- 2) Discrete-time signals are often obtained by sampling continuous-time signals.

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- 3) A periodic signal repeats a pattern forever.
    - a) The period is any repetition interval.
    - b) The fundamental period is the smallest repetition interval.
    - c) the fundamental frequency is the number of fundamental periods per unit time.
  
  - 4) All signals stored in a computer must be discrete. We may connect samples with straight lines for visualization purposes.

# Signals: The Basics

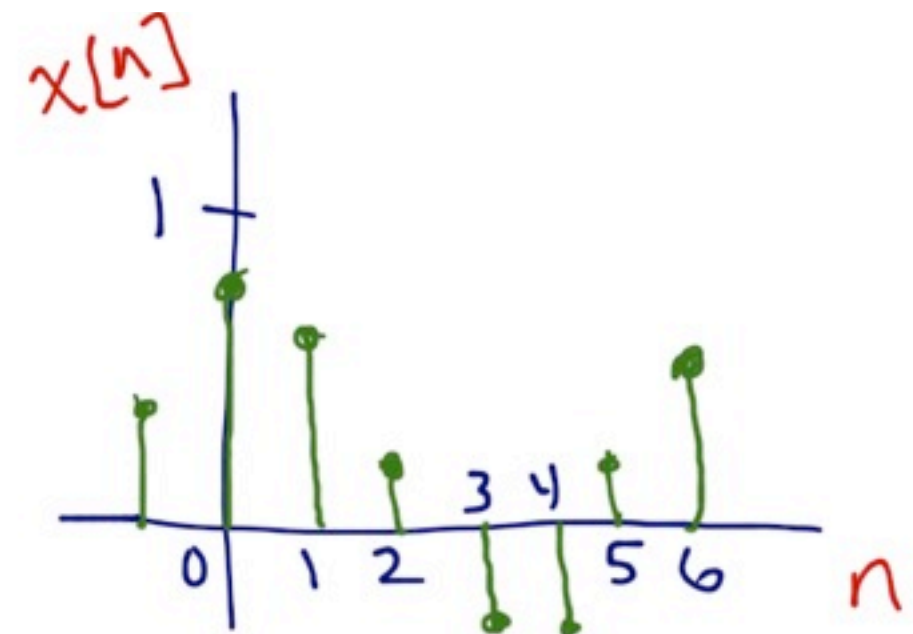
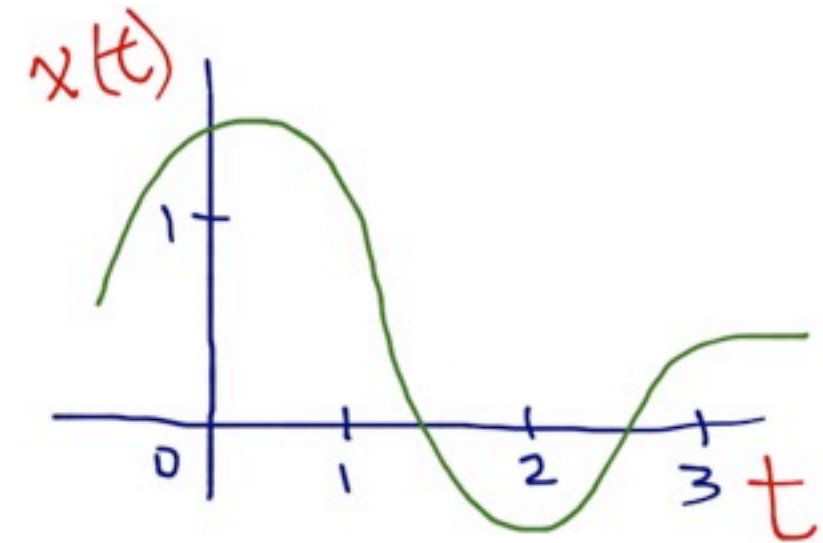
# Signals

- A “signal” describes how some physical quantity varies over time and/or space
- Mathematically: a function of one or more independent variables



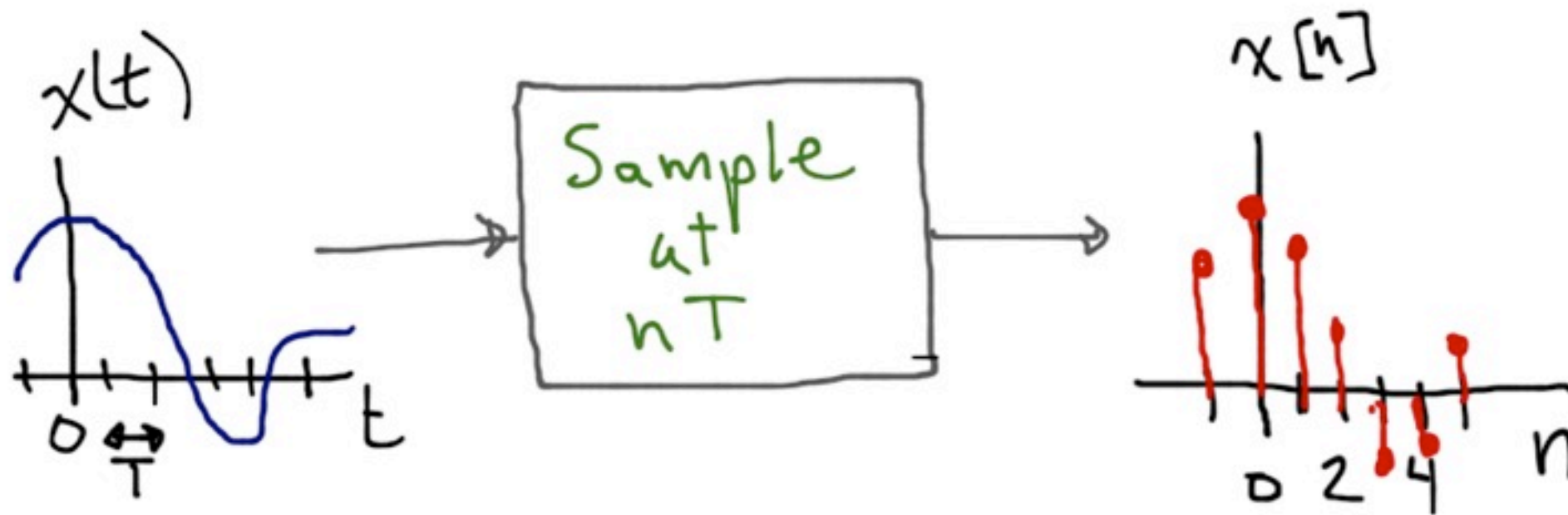
# Continuous and Discrete Independent Variables

- Continuous:  $t$  take any value
- Discrete:  $n$  limited set of values (integers)
- Notation
  - ➔  $(\bullet)$  continuous indep vbl
  - ➔  $[\bullet]$  discrete indep vbl



# Sampling

- Often we obtain a discrete-time signal  $x[n]$  by sampling a continuous-time signal  $x(t)$



$$x[n] = x(t)|_{t=nT} = x(nT)$$

## Examples

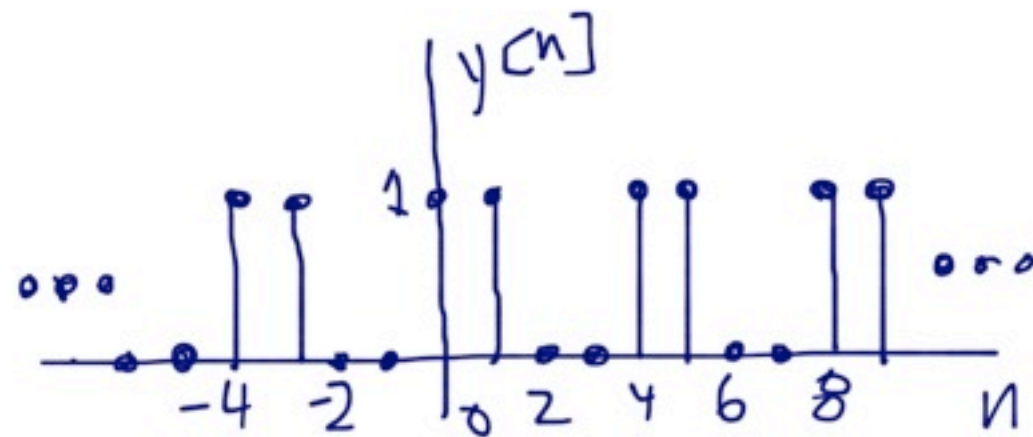
- Analog to digital converter
- Digital camera



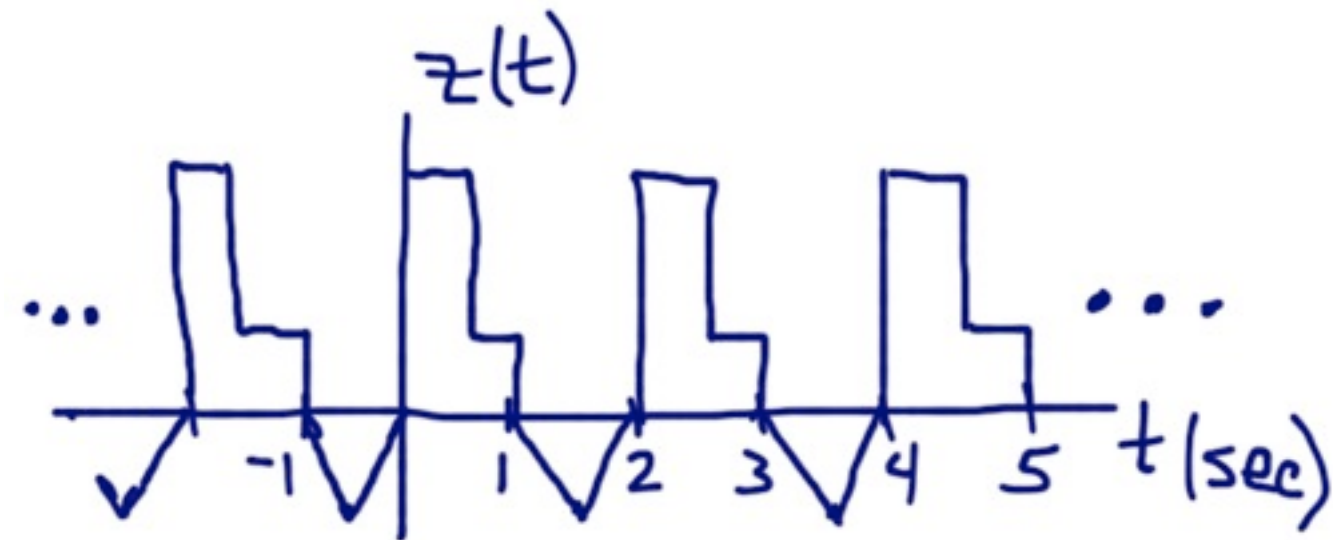
# Periodicity

- A signal that repeats a pattern is said to be periodic
- Period is the repetition interval
  - ➔ Mathematically
  - ➔ Fundamental period: smallest repetition interval

$$x(t + T_o) = x(t) \text{ for all } t$$
$$x[n + N] = x[n] \text{ for all } n$$



$$N = 4, 8, 12, \dots$$

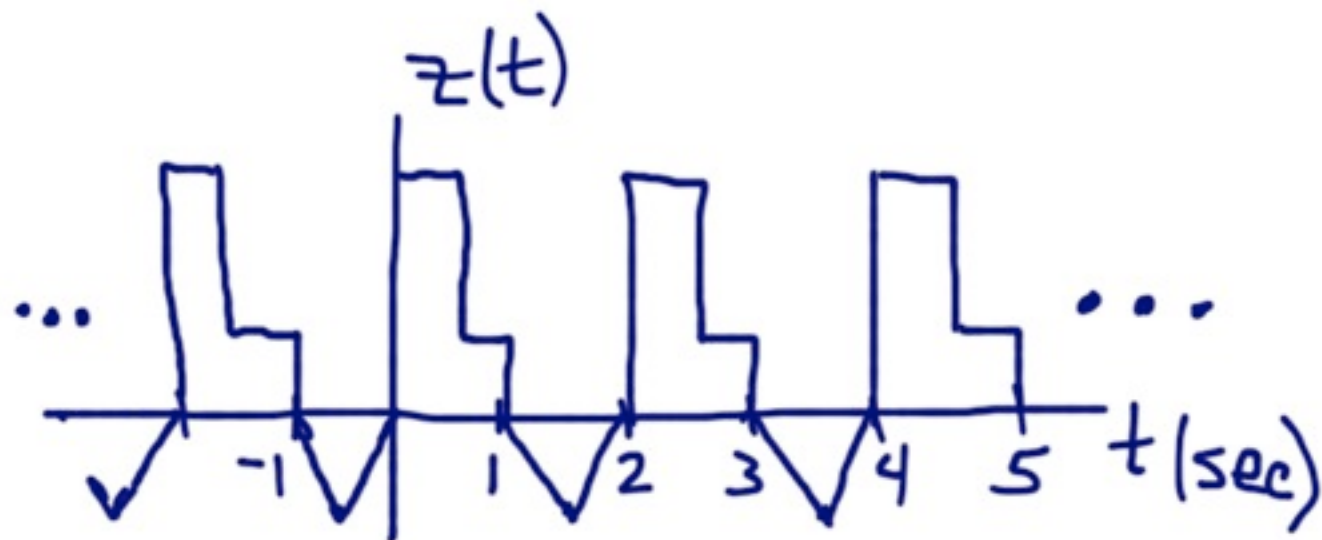


$$T_o = 2, 4, 6, \dots \text{ sec}$$

# Fundamental Frequency

- Fundamental frequency: the number of periods per unit time

$$f_o = \frac{1}{T_o} \frac{\text{period}}{\text{sec}} \text{ or Hz}$$



$$T_o = 2 \text{ sec} \rightarrow f_o = \frac{1}{2} \text{ Hz}$$

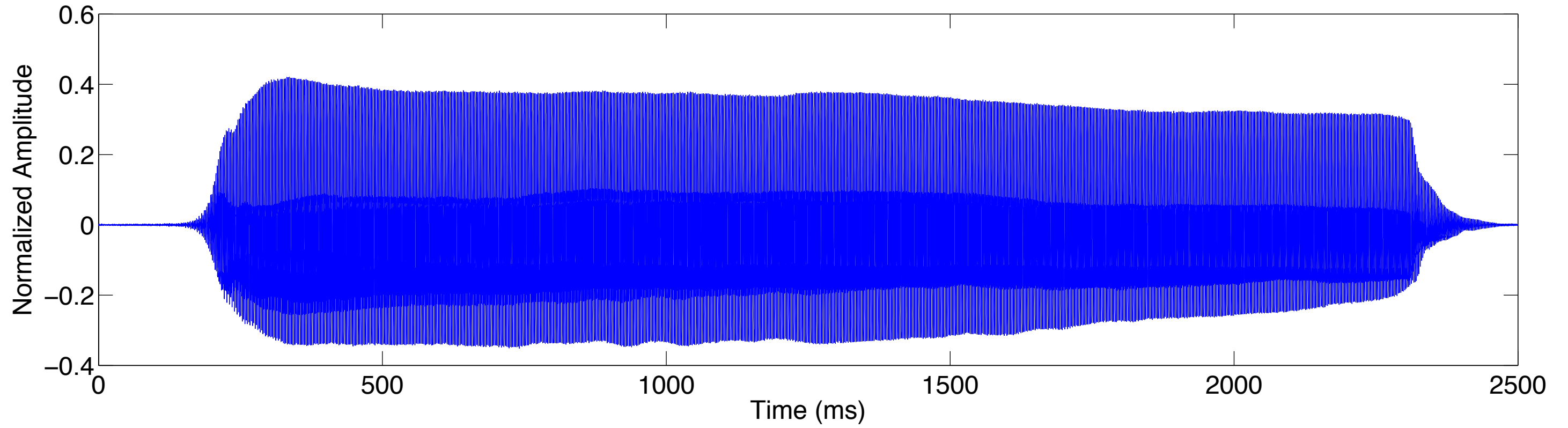
# Examples

- Saxophone
  - Note A
  - Note Db
- Speech

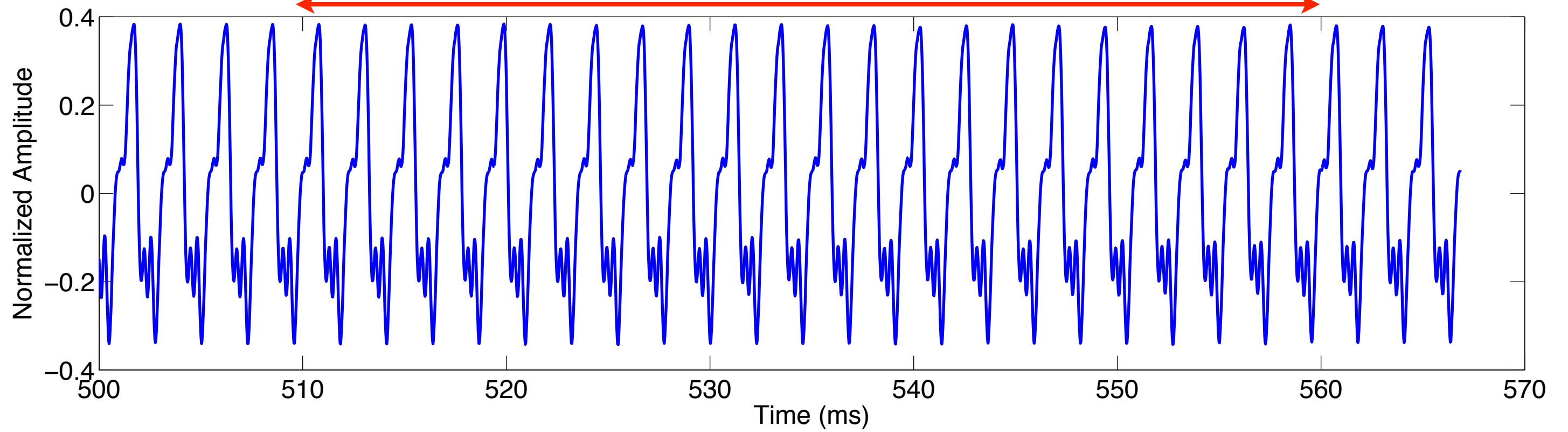
# Displaying Signals

- Signals stored in a computer must be discrete!
- Common to connect samples with straight lines
  - visual clarity with large numbers of samples
  - Use continuous time axis labels to visualize as continuous-time signal

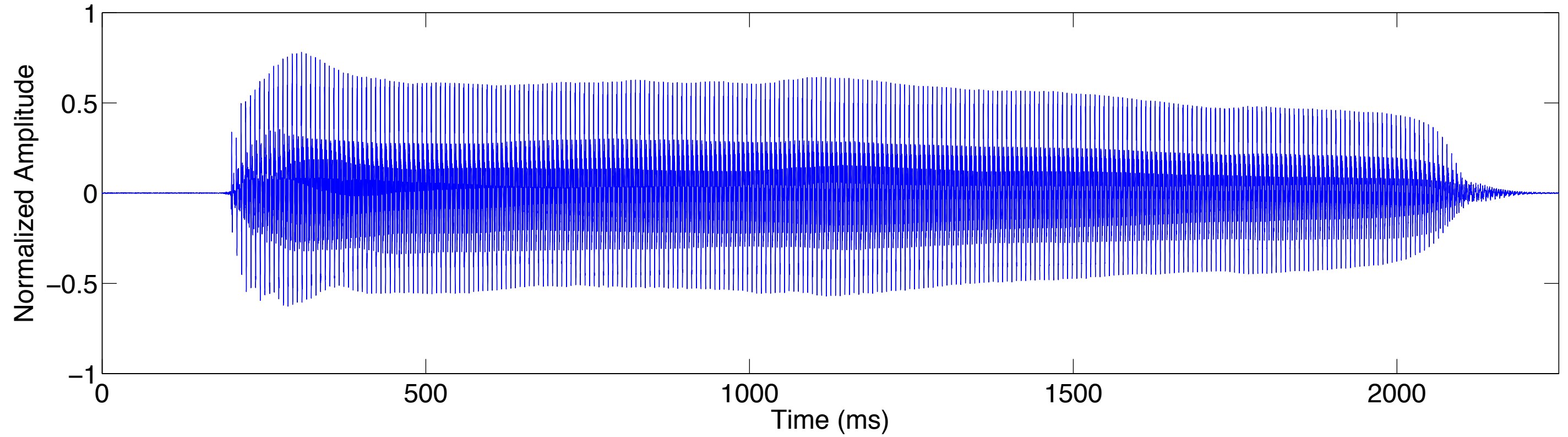
Saxophone A



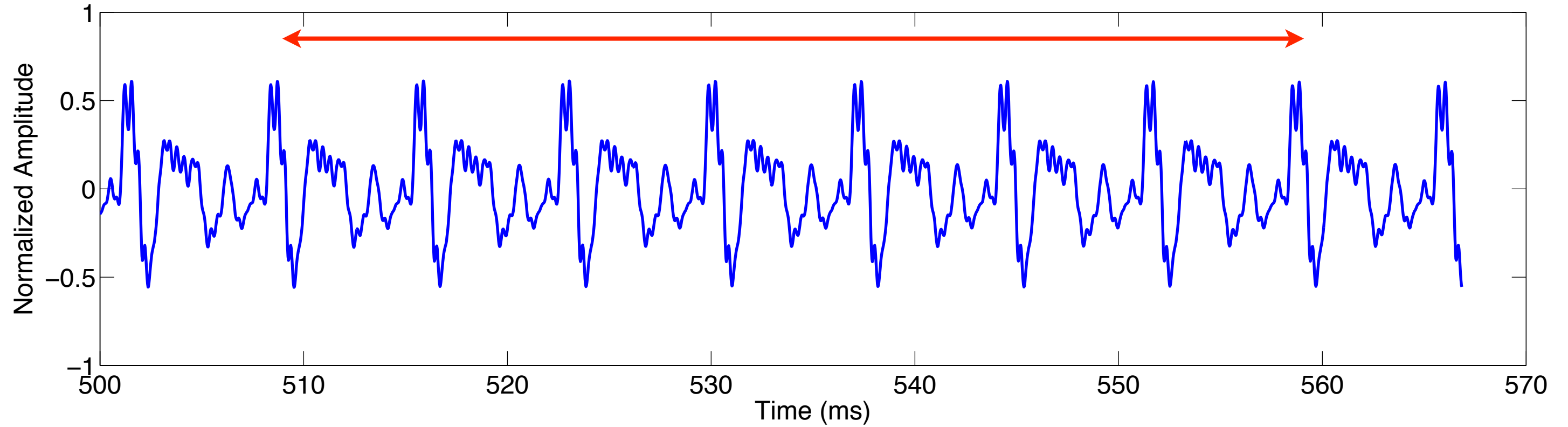
22 periods in 50 ms  $\sim$  440 per/S



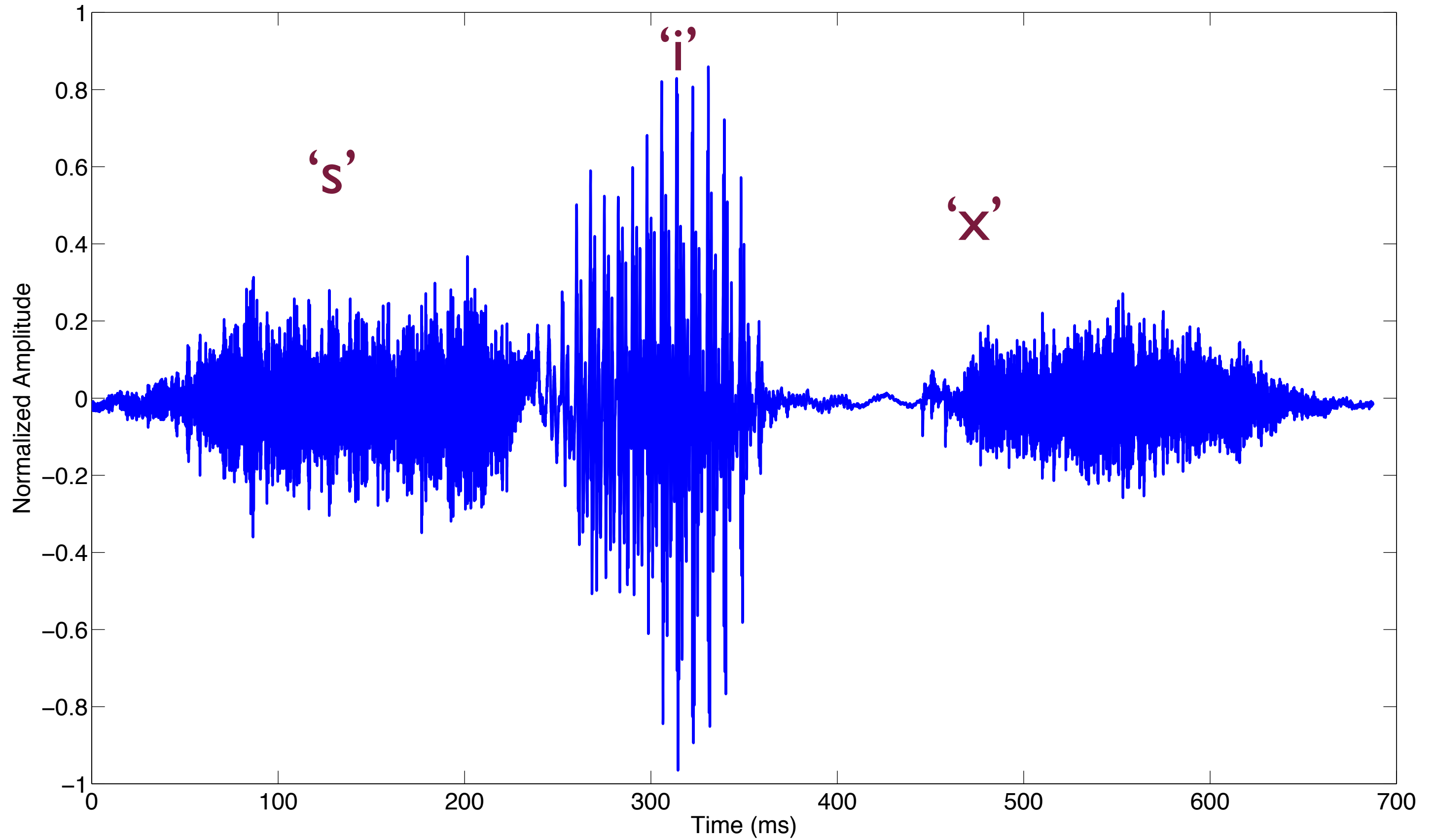
# Saxophone Db



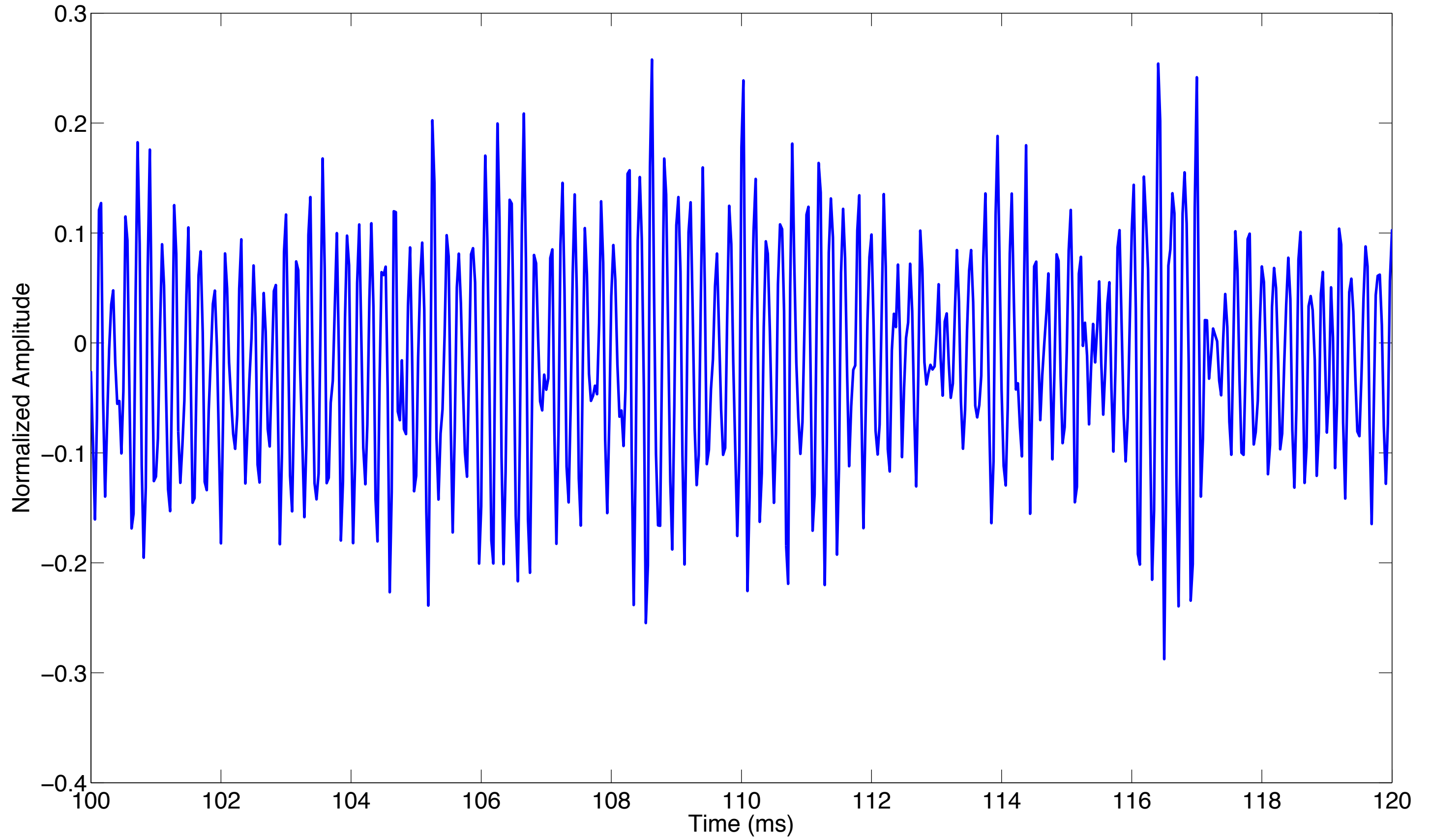
7 periods in 50 ms ~ 140 per/S



Spoken Word: Six

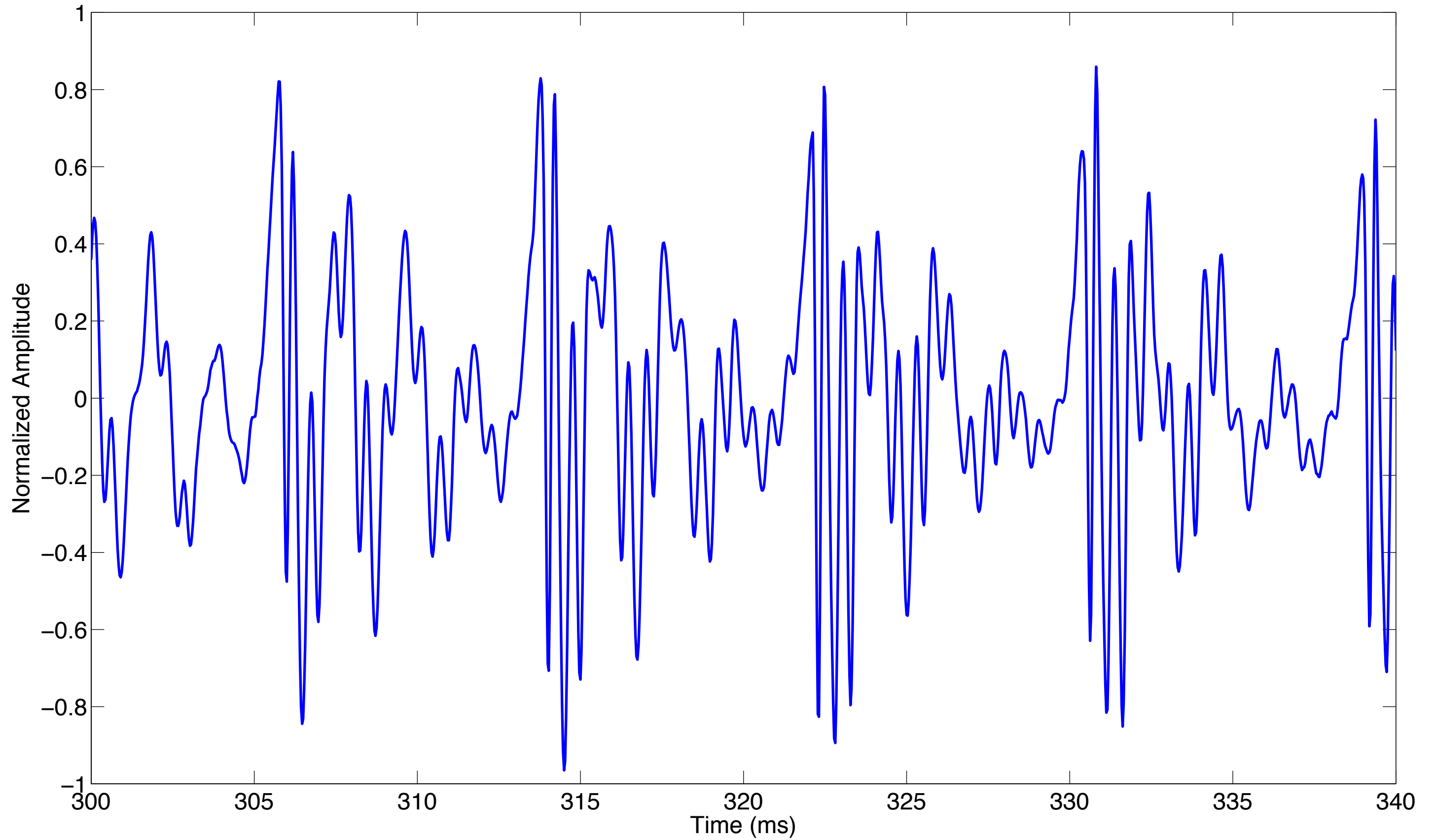


"s" sound





"i" sound



# Summary

- Treat signals as mathematical functions
- Independent variable can be continuous or discrete valued
- Periodicity – does a signal repeat – is an important property

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