

Signal Classifications and Properties

<http://cnx.org/content/m2102/latest/m10057>

Continuous-Time vs. Discrete-Time

As the names suggest, this classification is determined by whether or not the time axis (x-axis) is discrete (countable) or continuous (Figure 1). A continuous-time signal will contain a value for all real numbers along the time axis. In contrast to this, a discrete-time signal³ is often created by using the sampling theorem⁴ to sample a continuous signal, so it will only have values at equally spaced intervals along the time axis.

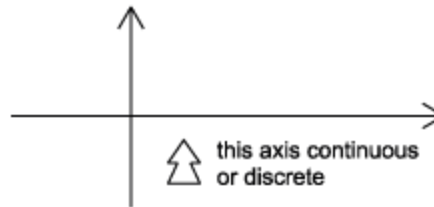


Figure 1

Analog vs. Digital

The difference between analog and digital is similar to the difference between continuous-time and discrete-time. In this case, however, the difference is with respect to the value of the function (y-axis) (Figure 2). Analog corresponds to a continuous y-axis, while digital corresponds to a discrete y-axis. An easy example of a digital signal is a binary sequence, where the values of the function can only be one or zero.

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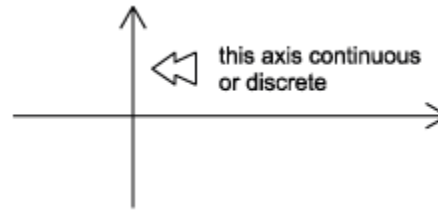


Figure 2

Periodic vs. Aperiodic

Periodic signals repeat with some period T , while aperiodic, or nonperiodic, signals do not (Figure 3). We can define a periodic function through the following mathematical expression, where t can be any number and T is a positive constant:

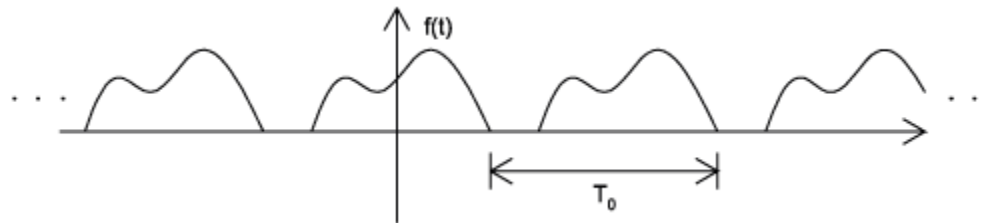
$$f(t) = f(T + t) \quad (1)$$

The fundamental period of our function, $f(t)$, is the smallest value of T that still allows (1) to be true.

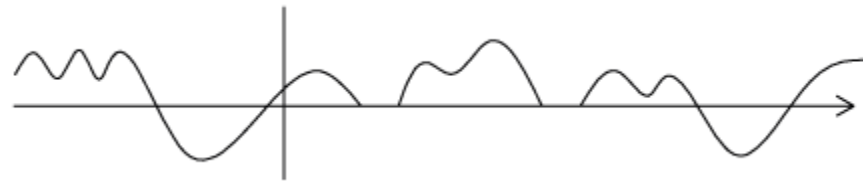
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Periodic vs. Aperiodic - devam -1



(a)



(b)

Figure 3: (a) A periodic signal with period T_0 , (b) An aperiodic signal.

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Causal vs. Anticausal vs. Noncausal

Causal signals are signals that are zero for all negative time, while anticausal are signals that are zero for all positive time. Noncausal signals are signals that have nonzero values in both positive and negative time (Figure 4).

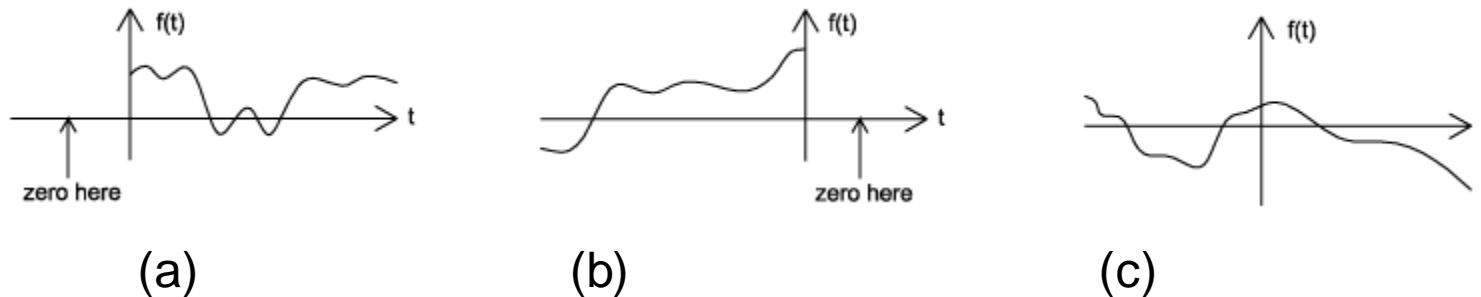


Figure 4: (a) A causal signal, (b) An anticausal signal, (c) A noncausal signal.

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Even vs. Odd

An even signal is any signal f such that $f(t) = f(-t)$. Even signals can be easily spotted as they are symmetric around the vertical axis. An odd signal, on the other hand, is a signal f such that $f(t) = -f(-t)$ (Figure 5).



Figure 5: (a) An even signal , (b) An odd signal

Using the definitions of even and odd signals, we can show that any signal can be written as a combination of an even and odd signal. That is, every signal has an odd-even decomposition. To demonstrate this, we have to look no further than a single equation.

$$f(t) = 1/2 (f(t) + f(-t)) + 1/2 (f(t) - f(-t))$$

By multiplying and adding this expression out, it can be shown to be true. Also, it can be shown that $f(t) + f(-t)$ fulfills the requirement of an even function, while $f(t) - f(-t)$ fulfills the requirement of an odd function (Figure 6).

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Even vs. Odd - devam

Example 1

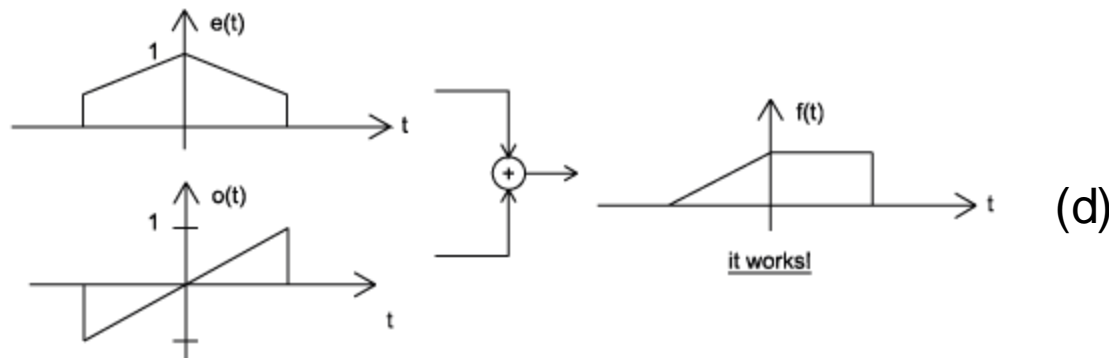
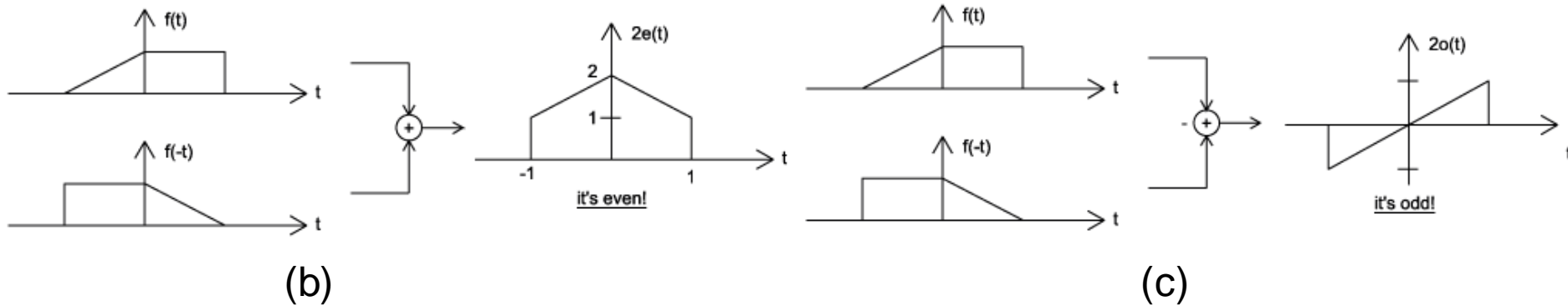
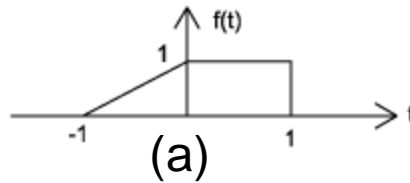


Figure 6: (a) The signal we will decompose using odd-even decomposition,
(b) Even part: $e(t) = 1/2 (f(t) + f(-t))$, (c) Odd part: $o(t) = 1/2 (f(t) - f(-t))$,
(d) Check: $e(t) + o(t) = f(t)$

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Deterministic vs. Random

A deterministic signal is a signal in which each value of the signal is fixed and can be determined by a mathematical expression, rule, or table. Because of this the future values of the signal can be calculated from past values with complete confidence. On the other hand, a random signal has a lot of uncertainty about its behavior. The future values of a random signal cannot be accurately predicted and can usually only be guessed based on the averages of sets of signals (Figure 7).

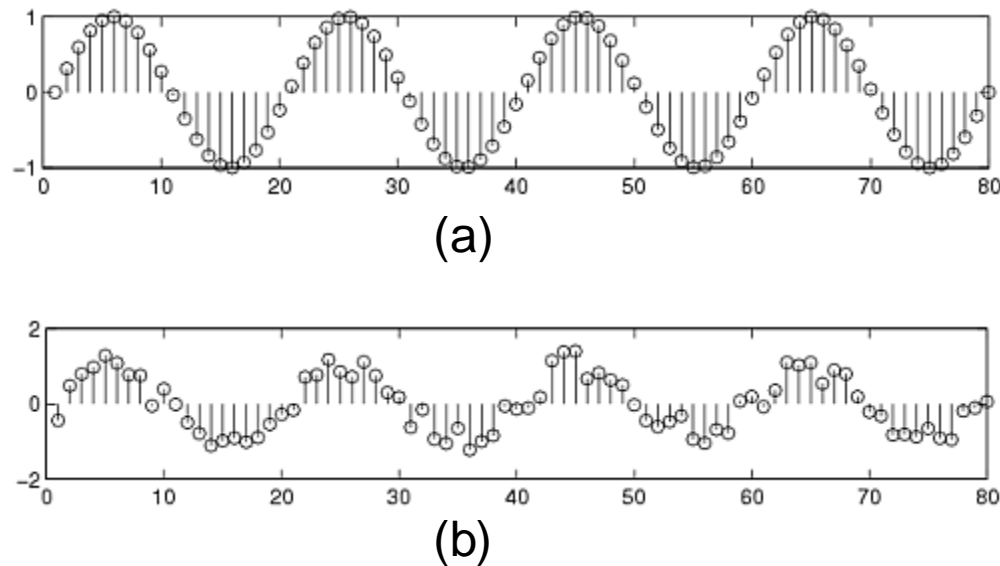


Figure 7: (a) Deterministic Signal, (b) Random Signal

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Right-Handed vs. Left-Handed

A right-handed signal and left-handed signal are those signals whose value is zero between a given variable and positive or negative infinity. Mathematically speaking, a right-handed signal is defined as any signal where $f(t) = 0$ for $t < t_1 < 1$, and a left-handed signal is defined as any signal where $f(t) = 0$ for $t > t_1 > -1$. See (Figure 8) for an example. Both figures "begin" at t_1 and then extend to positive or negative infinity with mainly nonzero values.

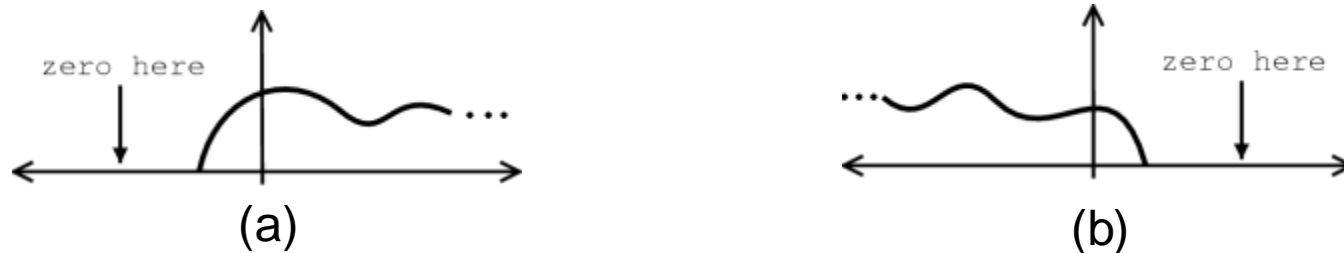


Figure 8: (a) Right-handed signal , (b) Left-handed signal

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Finite vs. Infinite Length

As the name applies, signals can be characterized as to whether they have a finite or infinite length set of values. Most finite length signals are used when dealing with discrete-time signals or a given sequence of values. Mathematically speaking, $f(t)$ is a finite-length signal if it is nonzero over a finite interval

$$t_1 < f(t) < t_2$$

where $t_1 > -\infty$ and $t_2 < \infty$. An example can be seen in Figure 9. Similarly, an infinite-length signal, $f(t)$, is defined as nonzero over all real numbers:

$$-\infty \leq f(t) \leq \infty$$

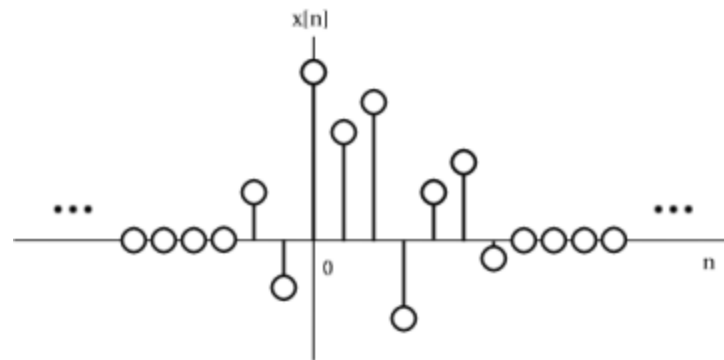


Figure 9: Finite-Length Signal. Note that it only has nonzero values on a set, finite interval.