Linear Systems and Signals

Energy-type and power-type signals

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2020

Learning objectives

The learning objectives for this section are:

- check whether a signal is energy-type, power-type, or neither

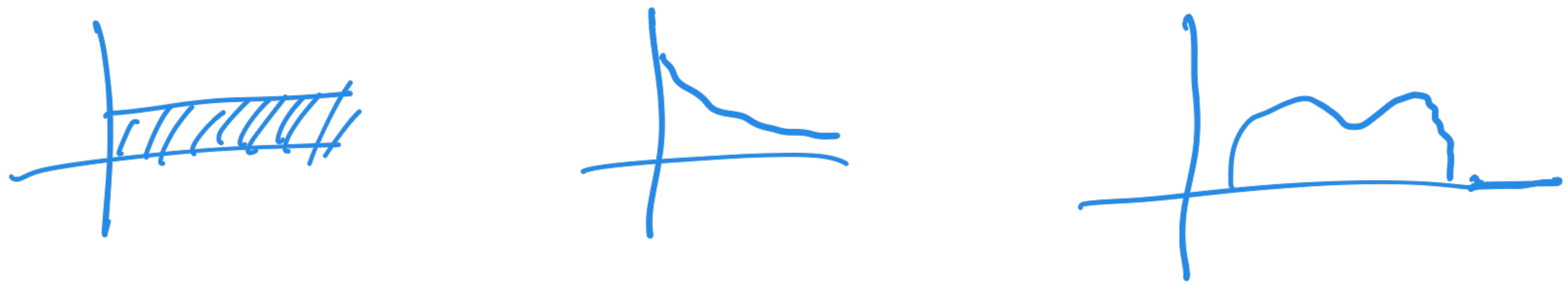
Energy-type and power-type signals

We divide signals into three types:

- Energy-type: $0 \leq \mathcal{E}_x < \infty$.
- Power-type: $0 < \mathcal{P}_x < \infty$.
- Neither energy-type nor power-type.

Given a signal, you want to be able to determine which type it is.

Energy-type

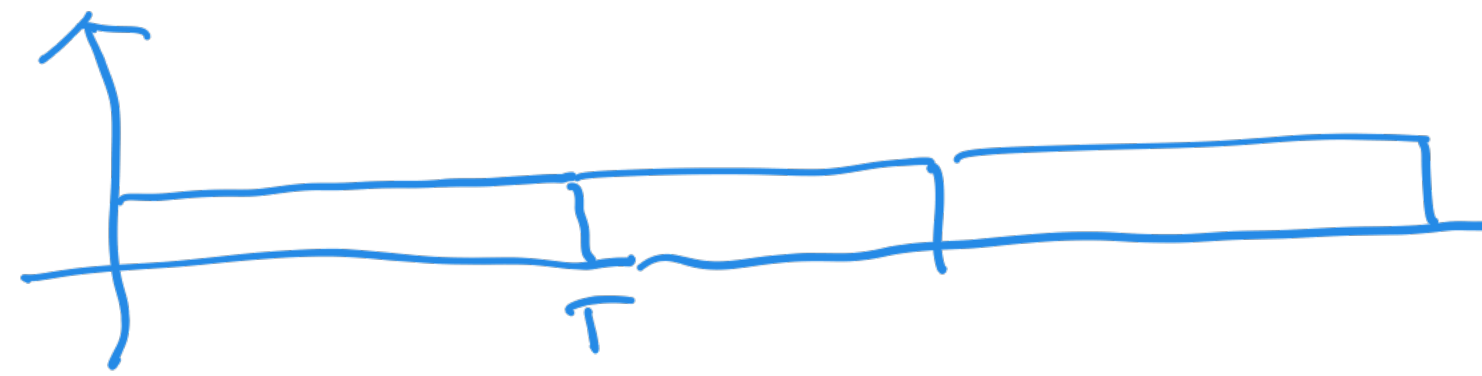


We have seen lots of energy-type signals:

- Finite-length bounded signals are energy type: suppose $x(t) = 0$ for $|t| > T$ and $|x(t)| < M$. Then $|x(t)|^2 < M^2$ and $\mathcal{E}_x < 2TM^2$.
- $e^{-3t}u(t)$ is energy-type: compute the integral.
- $u(t)$ is not energy-type: $u(t)^2 = u(t)$ and the area under the curve is infinite.

For more general signals, if you can upper bound them with a signal which you know is finite-energy, then it is energy-type.

Power-type



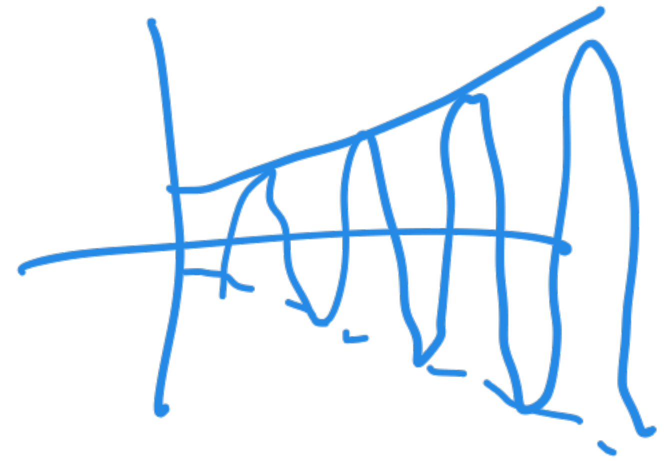
$\frac{1}{2T} T = \frac{1}{2}$

$\lim_{T \to \infty} \frac{1}{2T} T = 1/2$

We have seen some examples of power-type signals

- We saw last time that periodic signals are power-type
- $u(t)$ is not energy-type: $u(t)^2 = u(t)$ and the area under the curve is infinite. u(t) is power type.
- Nonperiodic signals which can be bounded by a power-type signal are also power-type, so $\cos(n/16 + \pi/3)$ is power-type.

Neither



Signals that "blow up" are neither energy-type nor power type. For example, look at $e^t u(t)$ or $e^t \cos(3\pi t) u(t)$. What about the signal $r(t)$?

$$\frac{1}{2T} \int_{-T}^{T} r(t)^2 dt = \frac{1}{2T} \int_{-T}^{T} t^2 dt = \frac{1}{2T} 2T^3 \to \infty. \tag{1}$$

So the ramp is neither energy-type nor power-type.

Try it yourself

Problem

Take some of the signals we have seen in class already and determine if they are energy-type, power-type, or neither.