An Application of the Inverting Integrator

Note the time average of a signal $v(t)$ over some arbitrary time T is mathematically stated as:

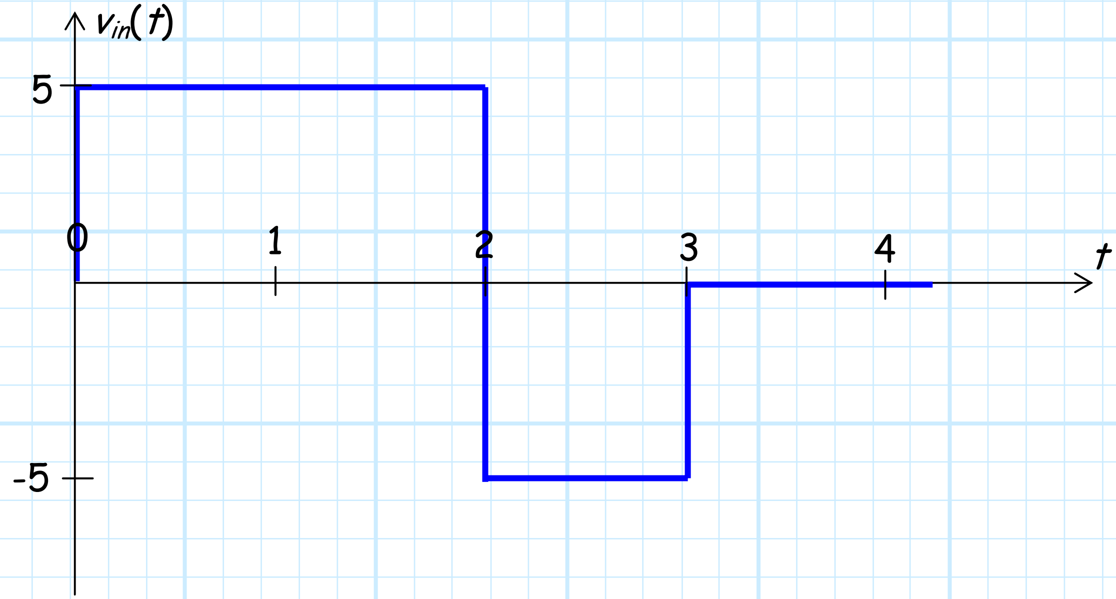
$$\text{average of } v(t) \doteq \overline{v(t)} = \frac{1}{T}\int_0^T v(t)\, dt$$

Note that this is **exactly** the form of the output of an op-amp **integrator**!

We can use the inverting integrator to determine the **time-averaged** value of some input signal $v(t)$ over some arbitrary time T.

Make sure you see this!

For **example**, say we wish to determine the time-averaged value of the input signal:



I.E.,

$$v_{in}(t) = \begin{cases} 5 & 0 < t < 2 \\ -5 & 2 < t < 3 \\ 0 & t > 3 \end{cases}$$

The **time average** of this function over a period from 0 < t < T=3 is therefore:

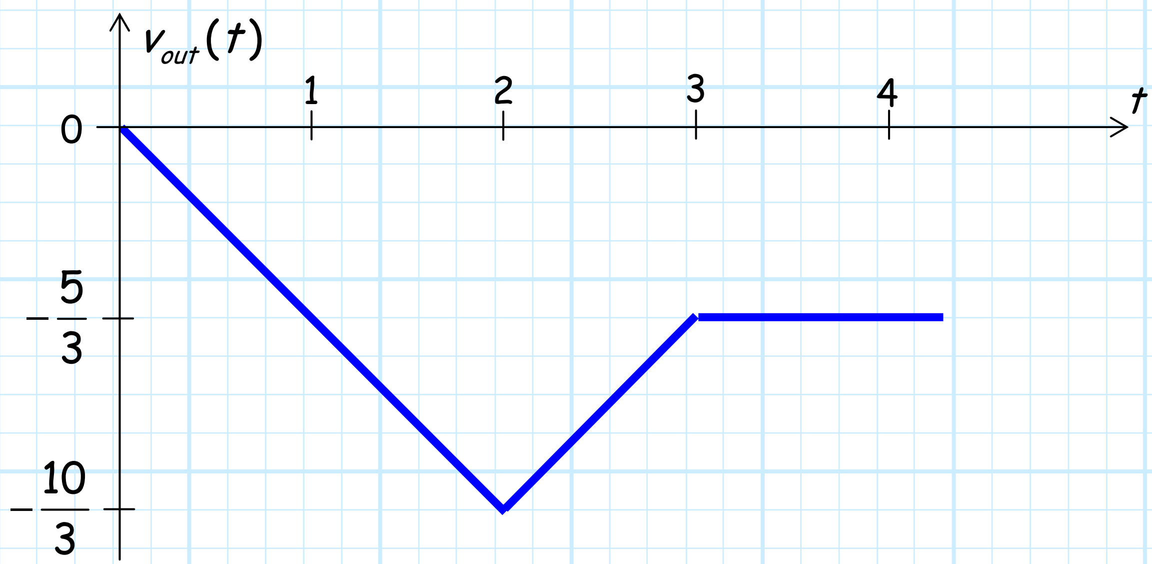
$$\overline{v_{in}(t)} = \frac{1}{3}\int_0^3 v_{in}(t)\, dt = \frac{5}{3}$$

This better make sense to you!

We could likewise determine this average using an **inverting integrator**. We select a resistor R and a capacitor C such that the product RC = 3 seconds.

The output of this integrator would be:

$$v_{out}(t) = \frac{-1}{3}\int_0^t v_{in}(t')\,dt' = \begin{cases} -\dfrac{5t}{3} & 0 < t < 2 \\ \dfrac{5t-20}{3} & 2 < t < 3 \\ -\dfrac{5}{3} & t > 3 \end{cases}$$



We must sample a the correct time!

Note that the value of the output voltage **at t =3** is:

$$v_{out}(t=3) = \frac{-1}{3}\int_0^3 v_{in}(t')\,dt' = -\frac{5}{3}$$

The **time-averaged** value (times -1)!

Thus, we can use the inverting integrator, along with a voltage sampler (e.g., A to D converter) to determine the **time-averaged** value of a function over some time period T.