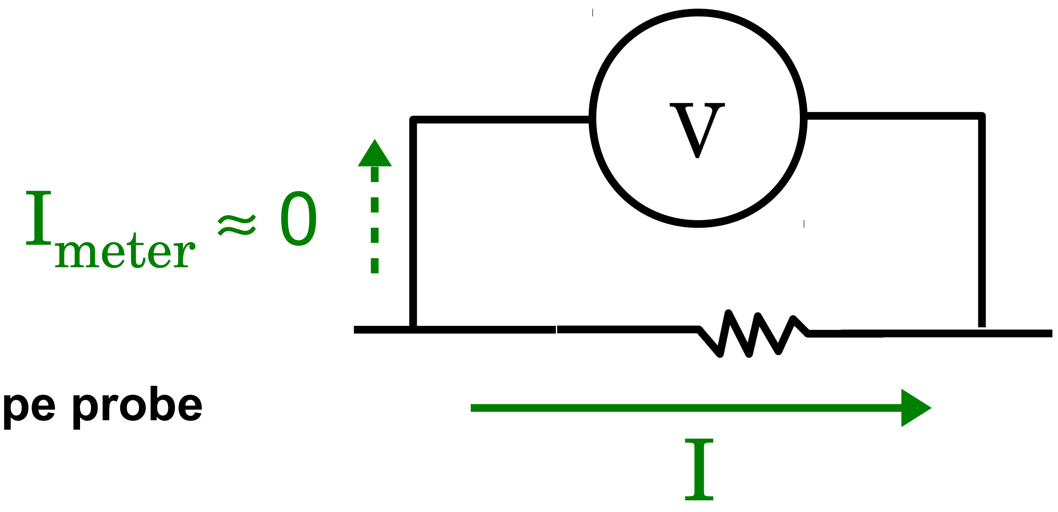
Lab 2: AC Circuits and Oscilloscope

Ideal meters

VOLTMETER:



EXAMPLE: 10X oscilloscope probe

Ideal meters

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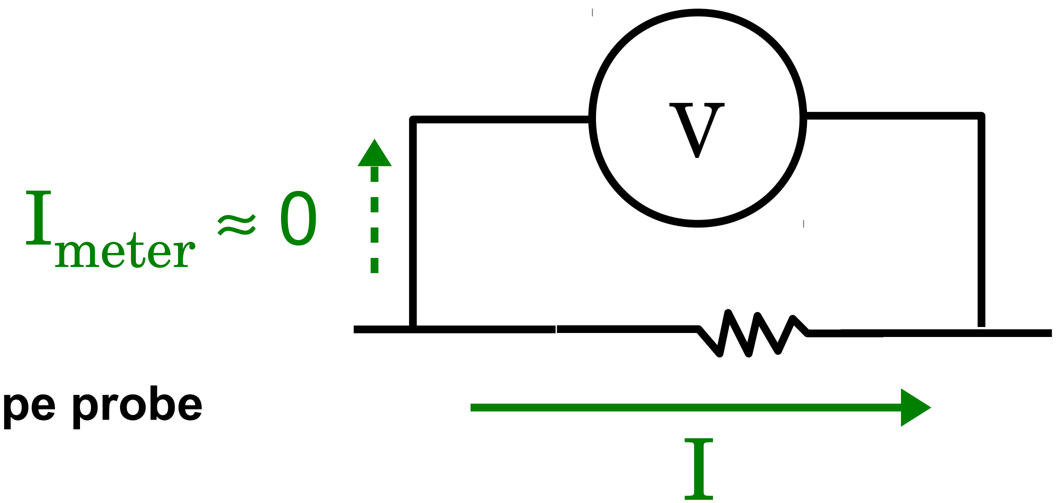

EXAMPLE: 10X oscilloscope probe

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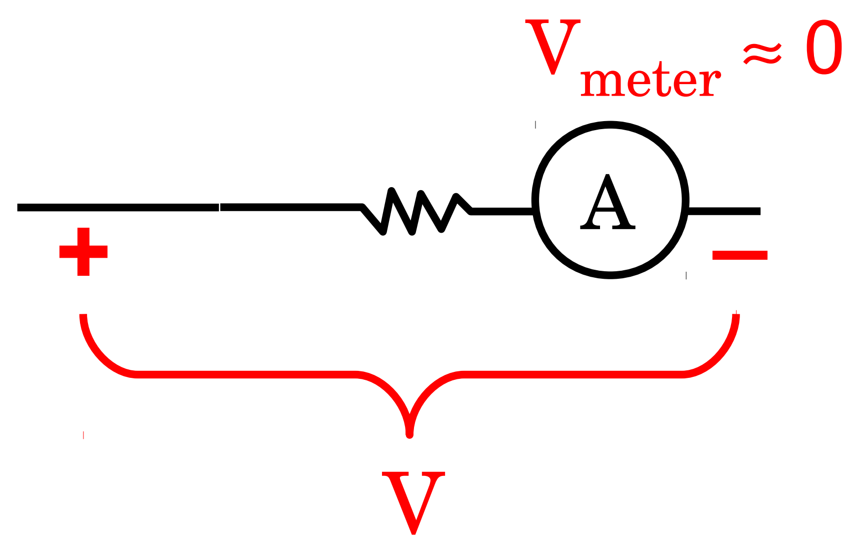
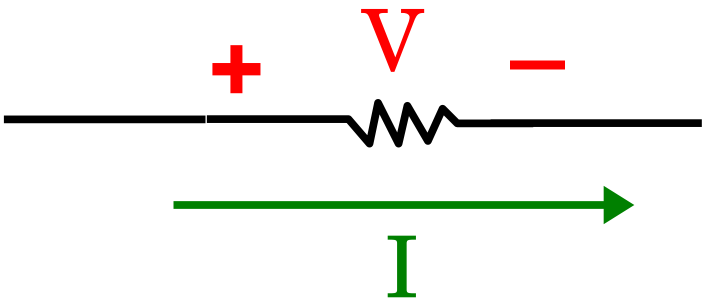
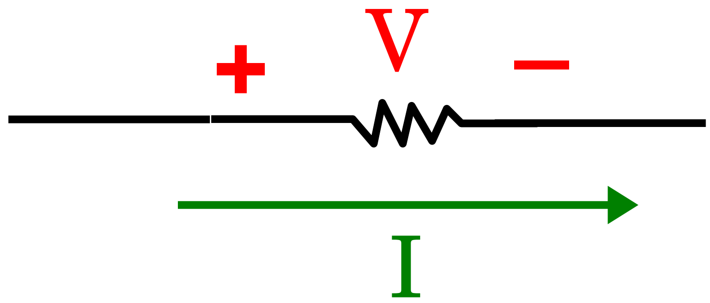


Power Dissipation

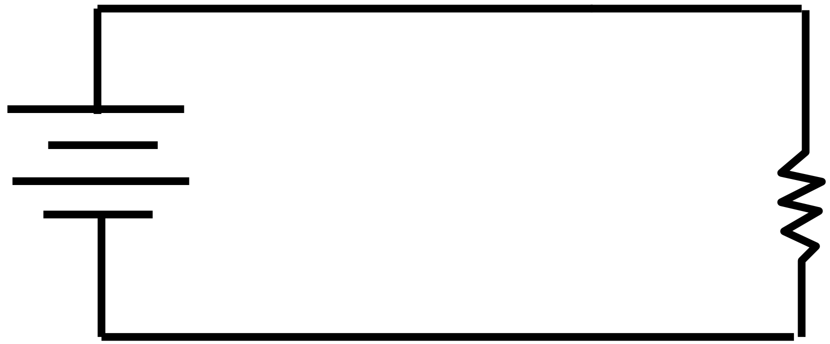


Power Dissipation

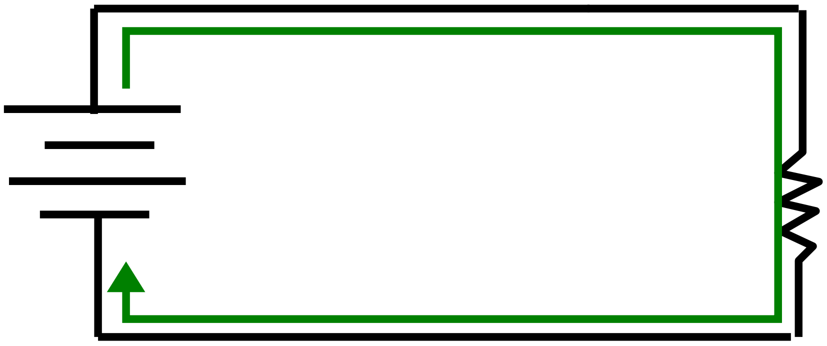


$$\text{Power dissipated} = \frac{V^2}{R} = I^2 R$$

AC (alternating current) circuits



AC (alternating current) circuits



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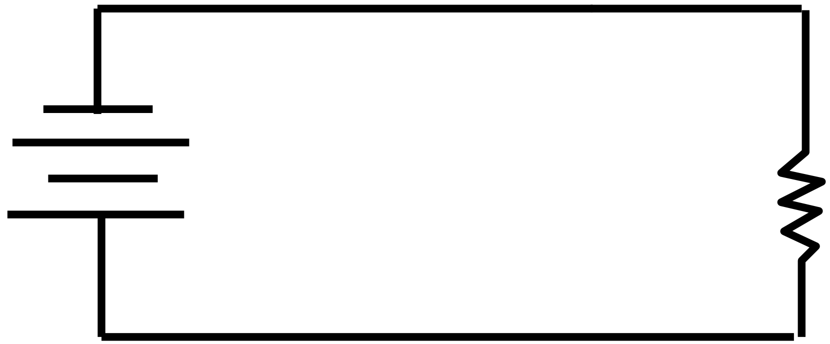

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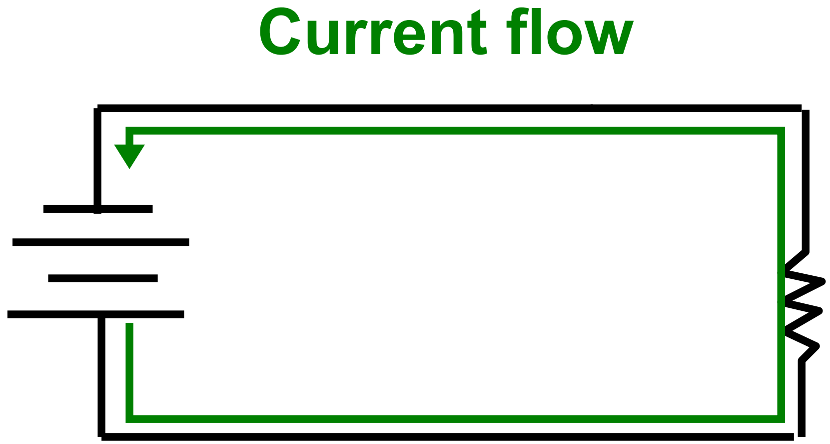
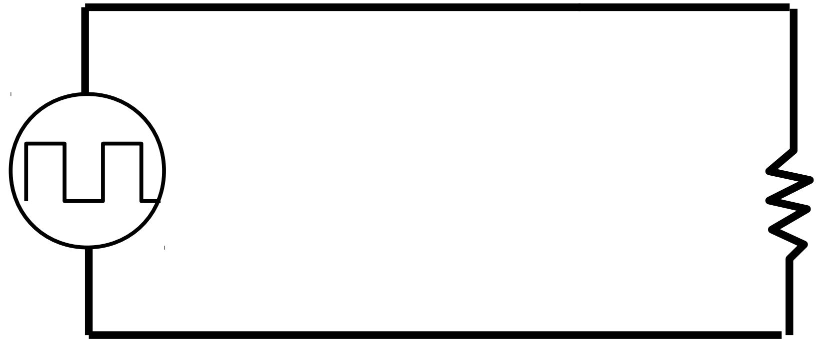
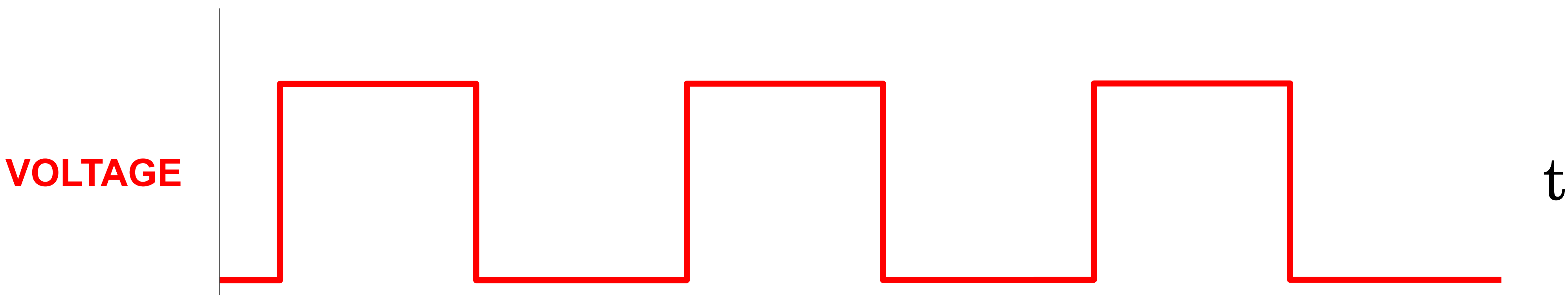
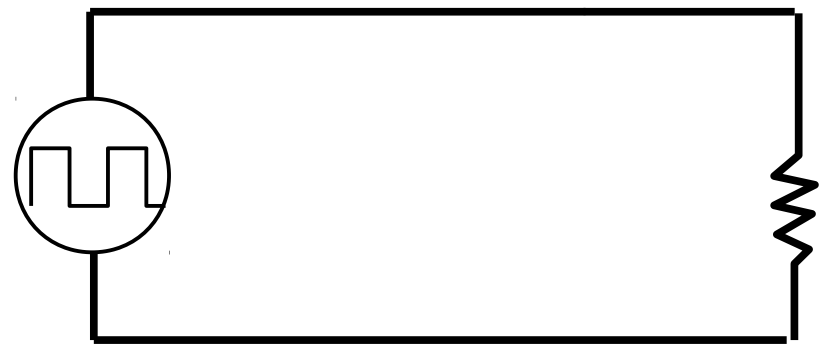


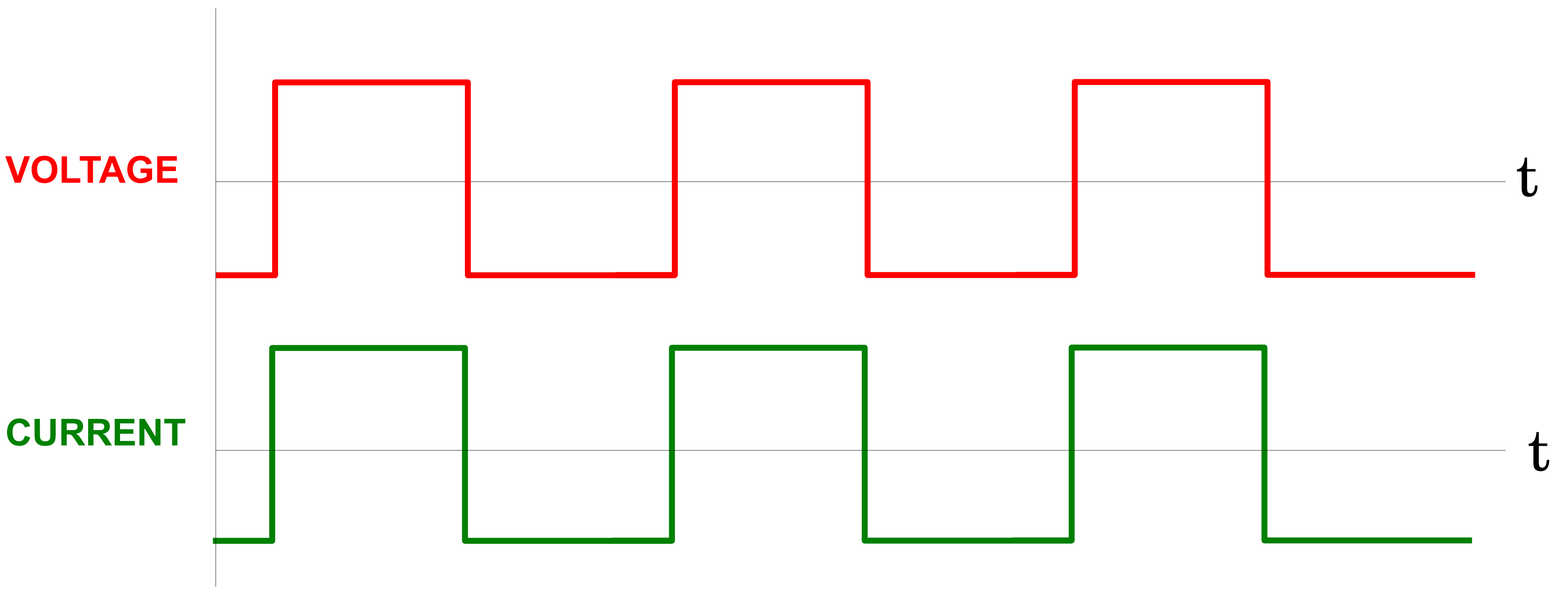
Square wave source



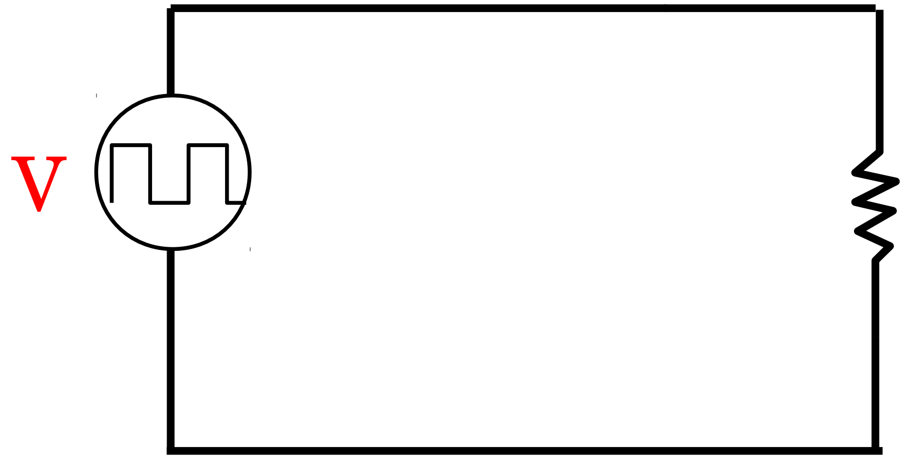


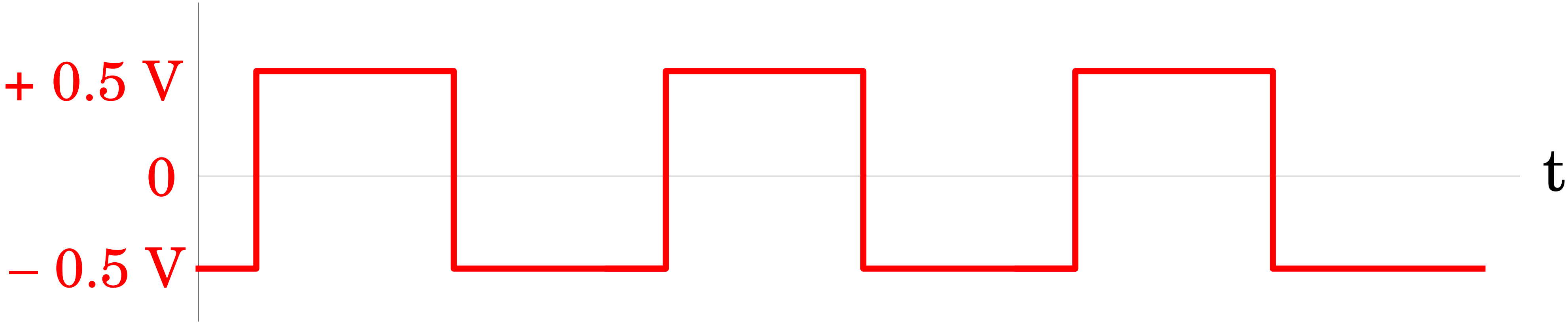
Square wave source



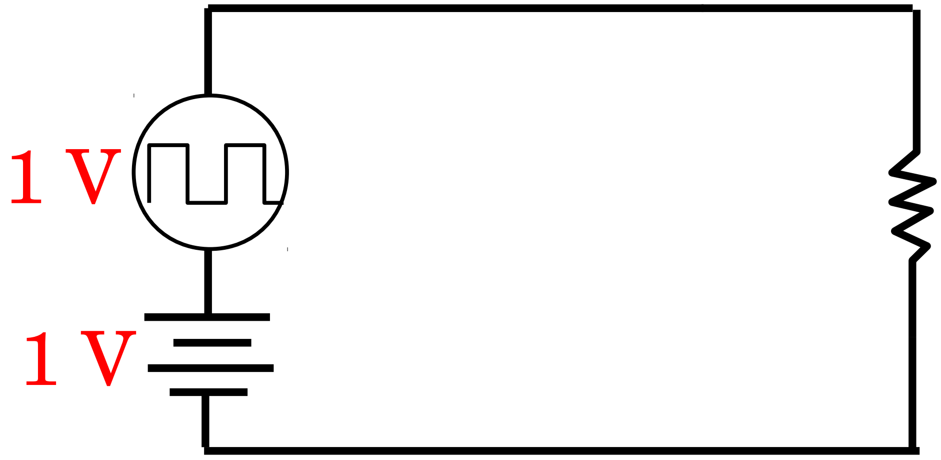


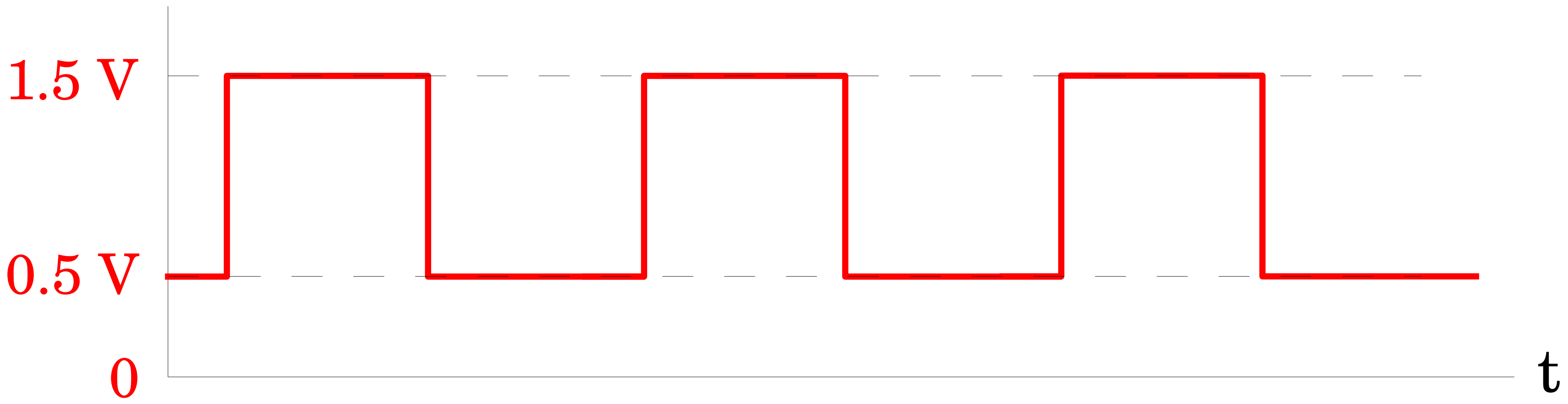
Square wave source +





Square wave source + voltage offset





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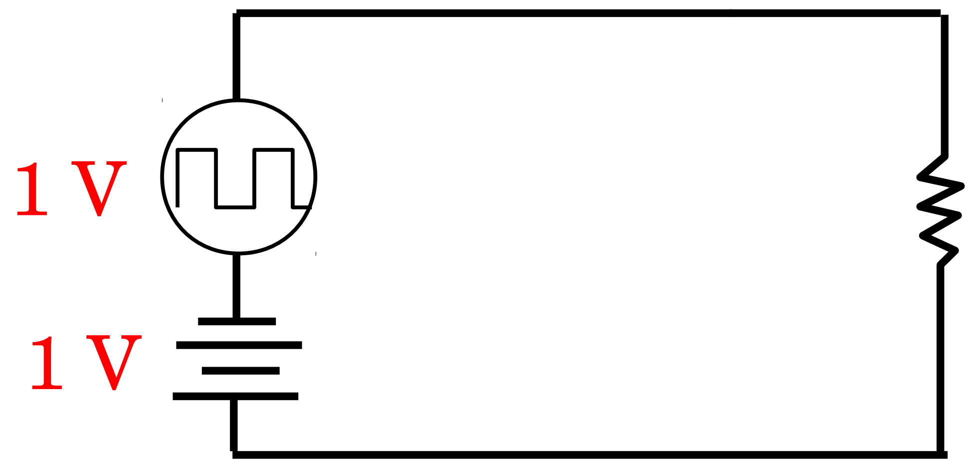

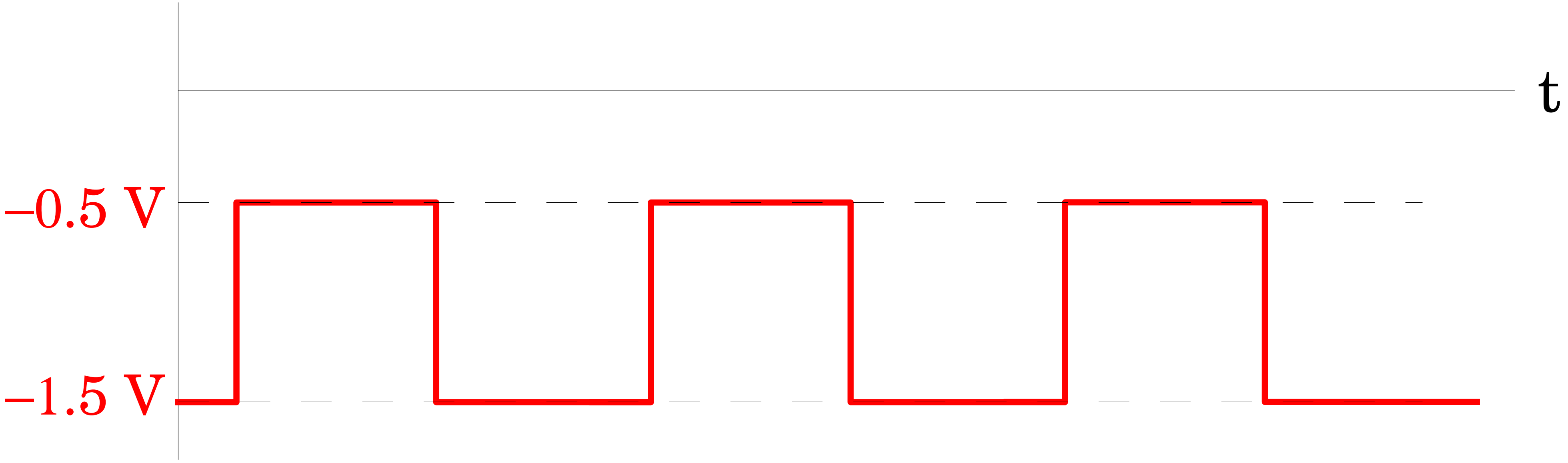

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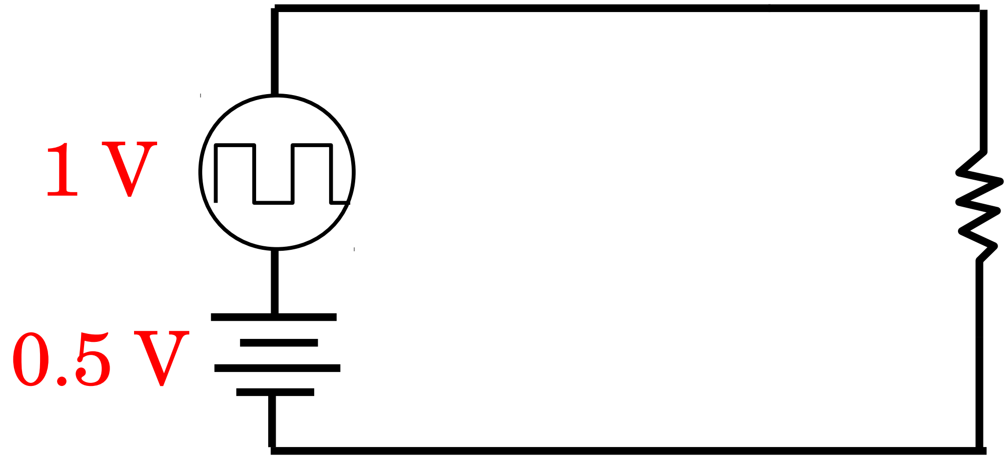
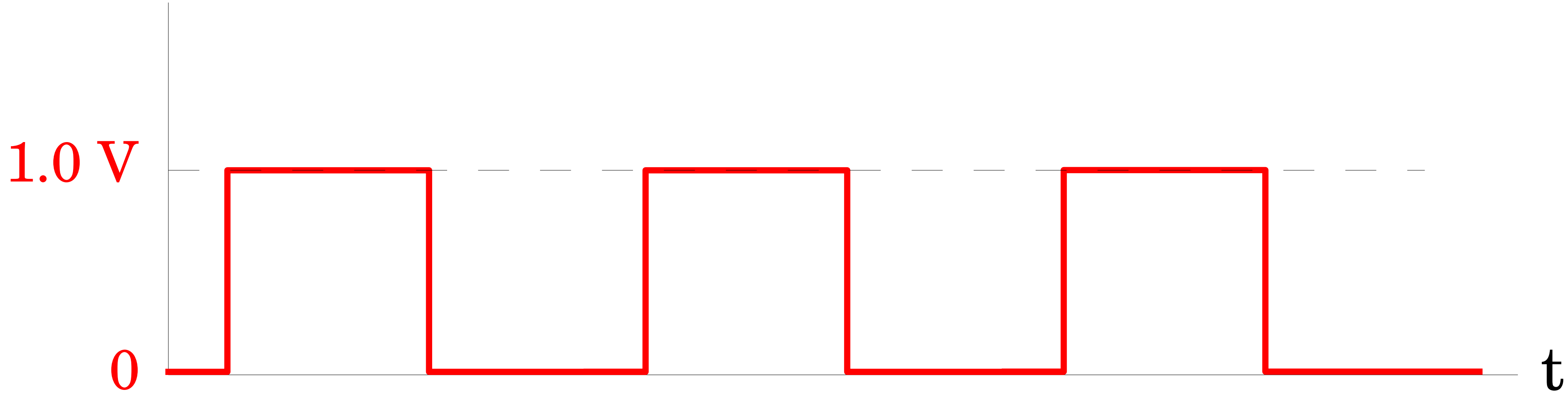
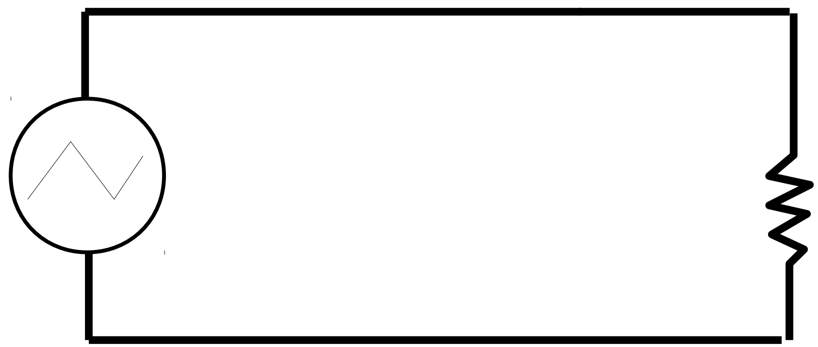
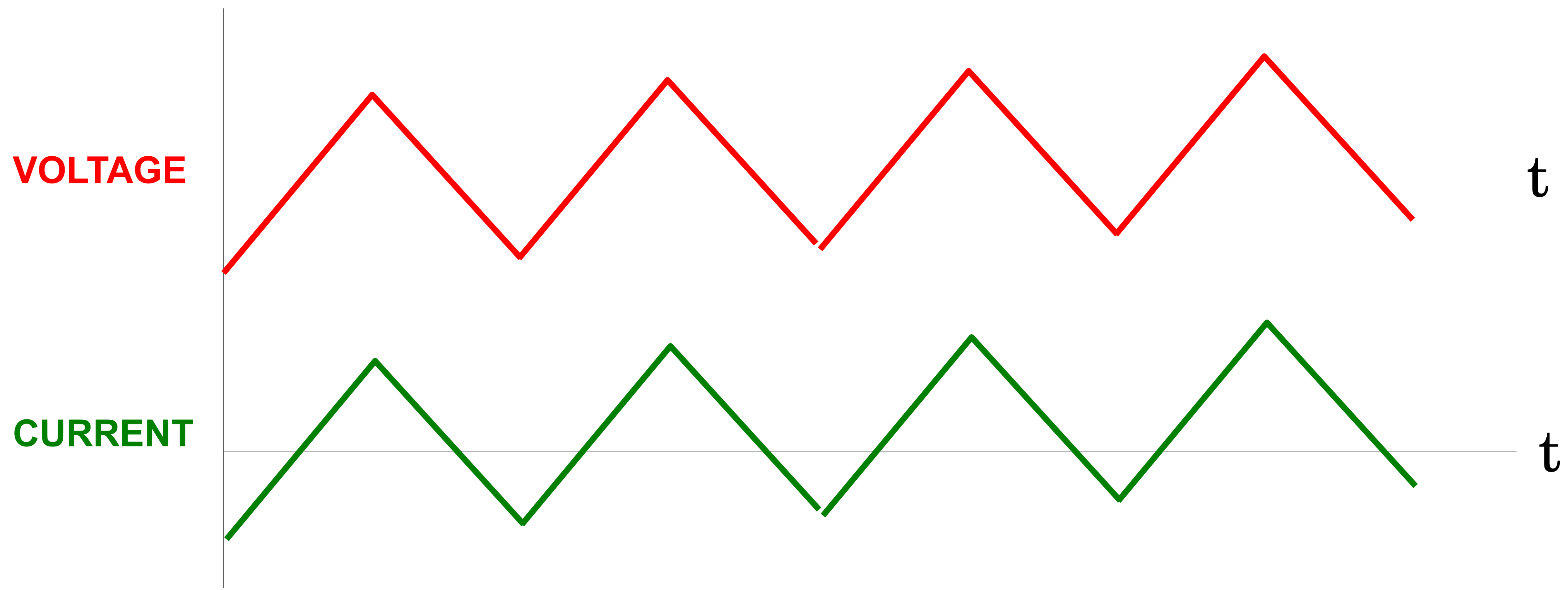


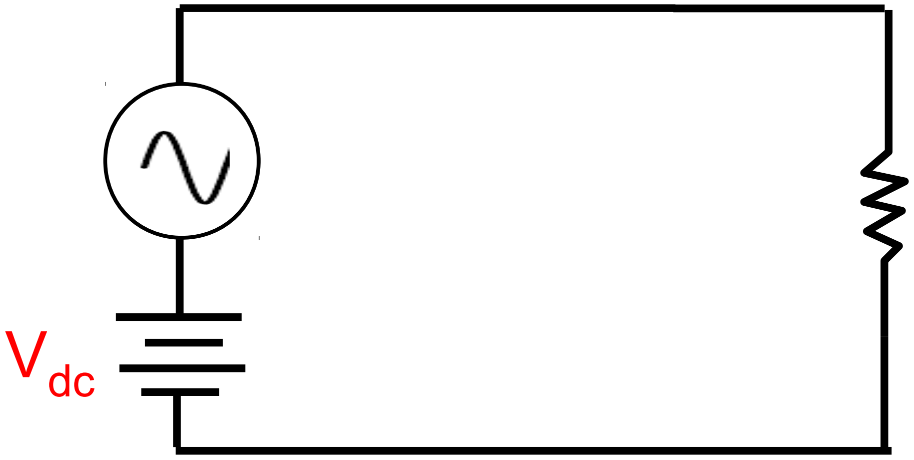


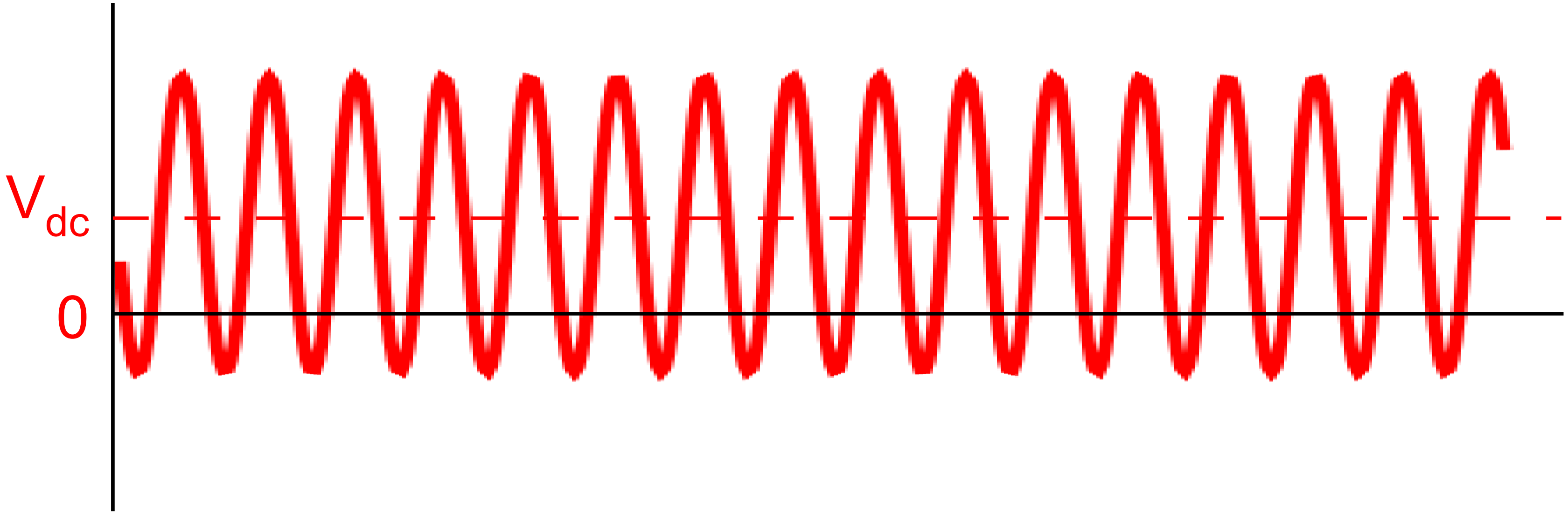
Triangle wave source



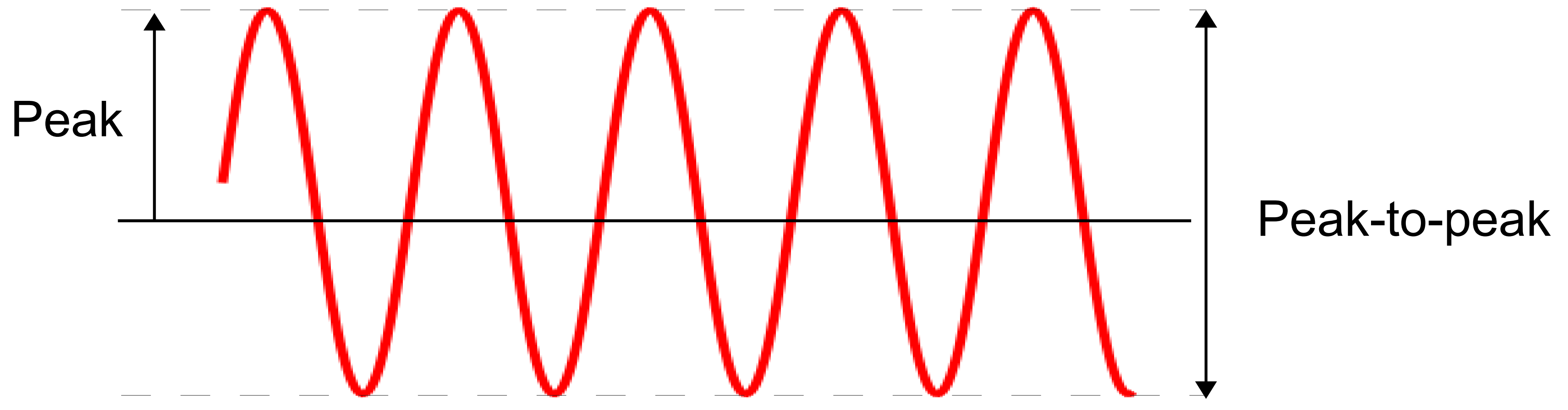


Sinusoidal wave source + dc offset



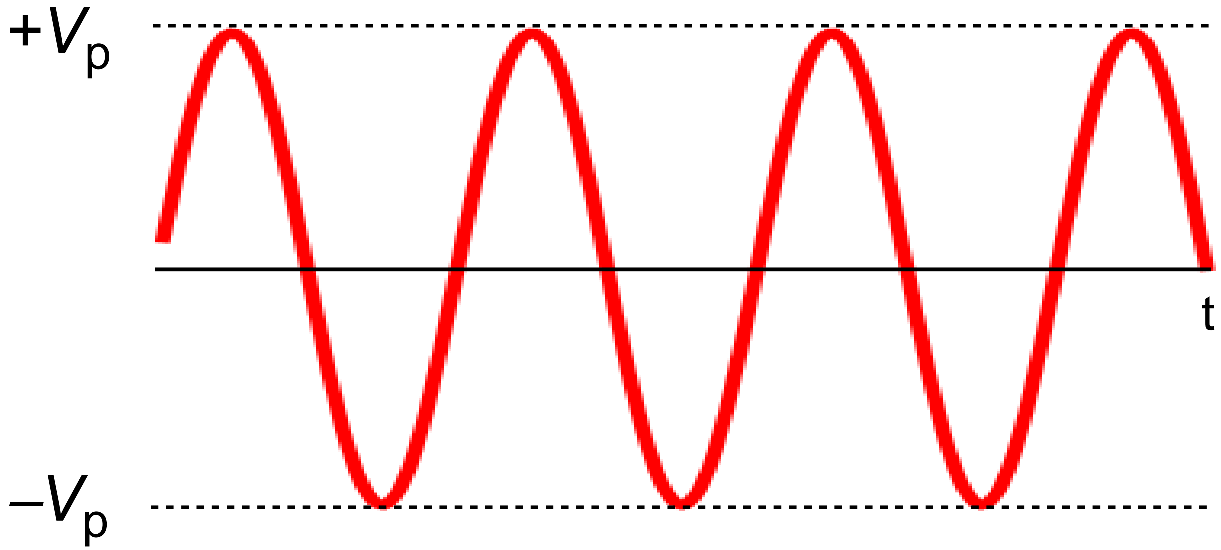


Characterizing an AC wave

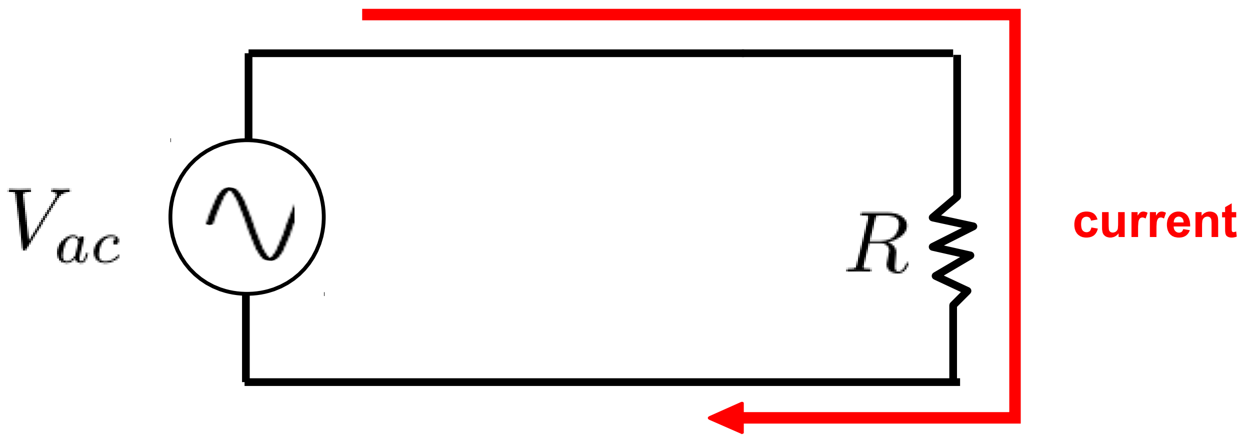


The average voltage of a pure sine wave is identically zero.

$$V(t) = V_p \sin(\omega t)$$



We know that an AC voltage can deliver plenty of power to a load



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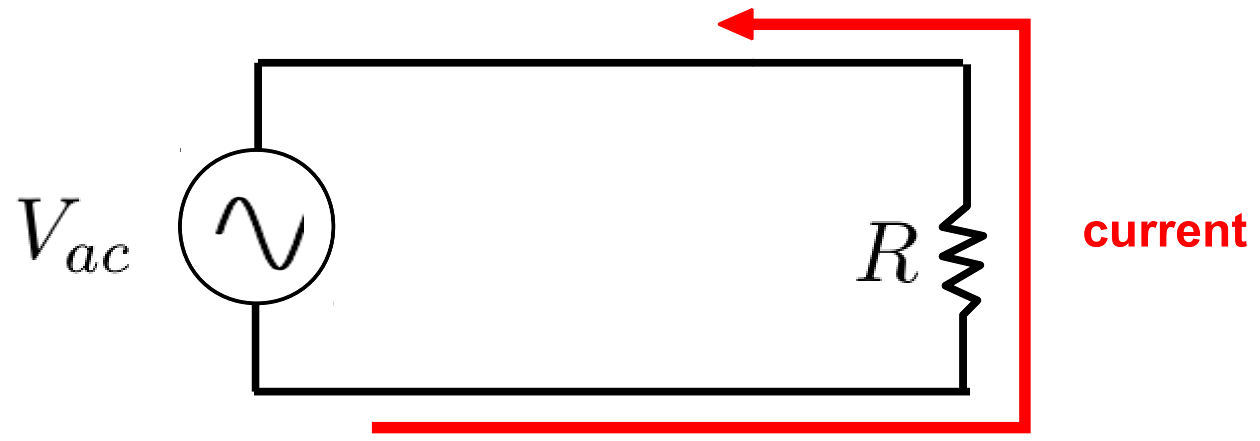

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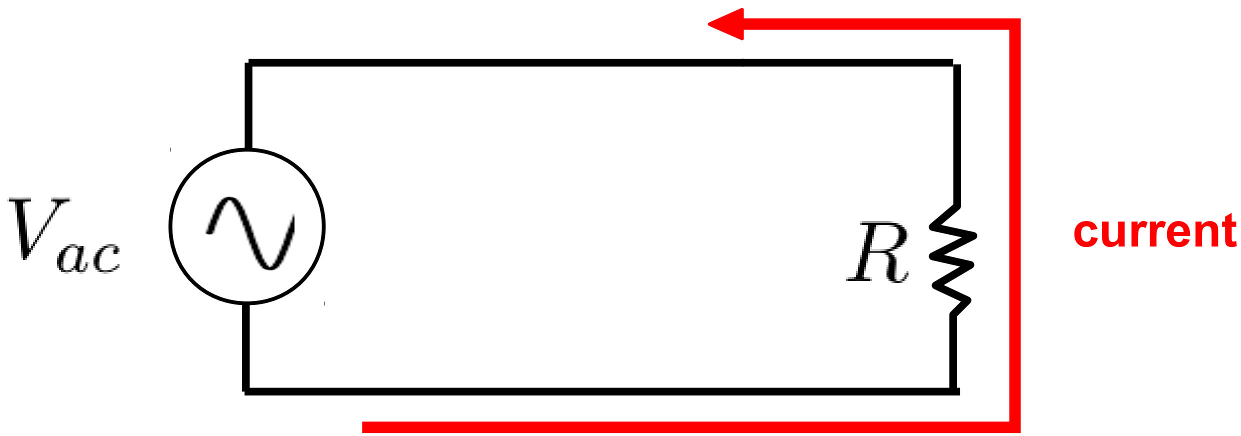
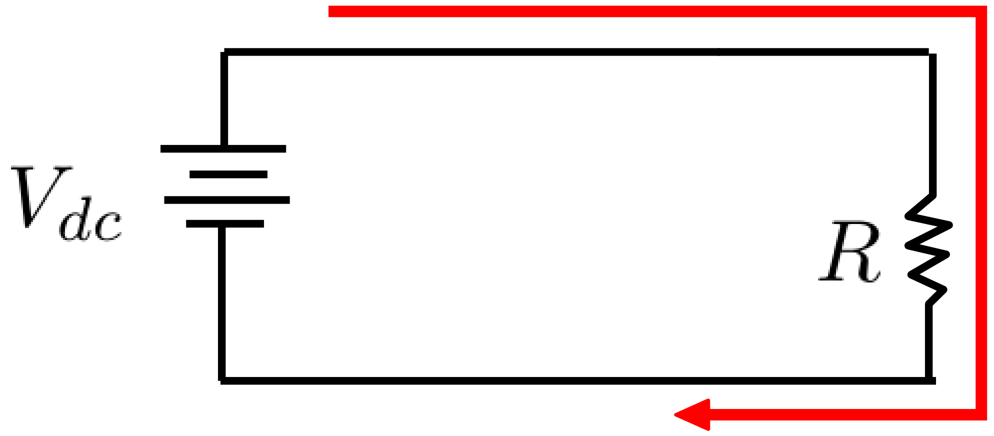


How do we calculate this power if the average voltage and current is zero?

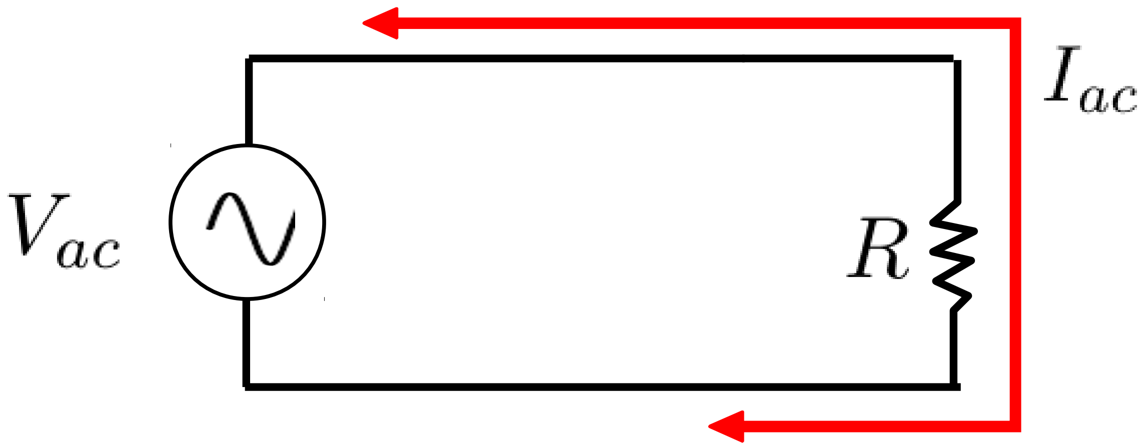
This is easy in a DC circuit: Use Ohm's Law



POWER = $\frac{V_{dc}^2}{R}$

Power dissipated in an AC circuit is time dependent:

$$P(t) = V_{ac} I_{ac} = \frac{V_{ac}^2}{R}$$



What is the energy delivered in **one period**?
Temporally integrate the power over one period:

$$\frac{1}{T}\int_0^T P(t)dt = \frac{1}{TR}\int_0^T V_p^2 \sin(\omega t)^2 dt = \frac{V_p^2}{2R}$$

AC power dissipation = $\frac{V_p^2}{2R}$

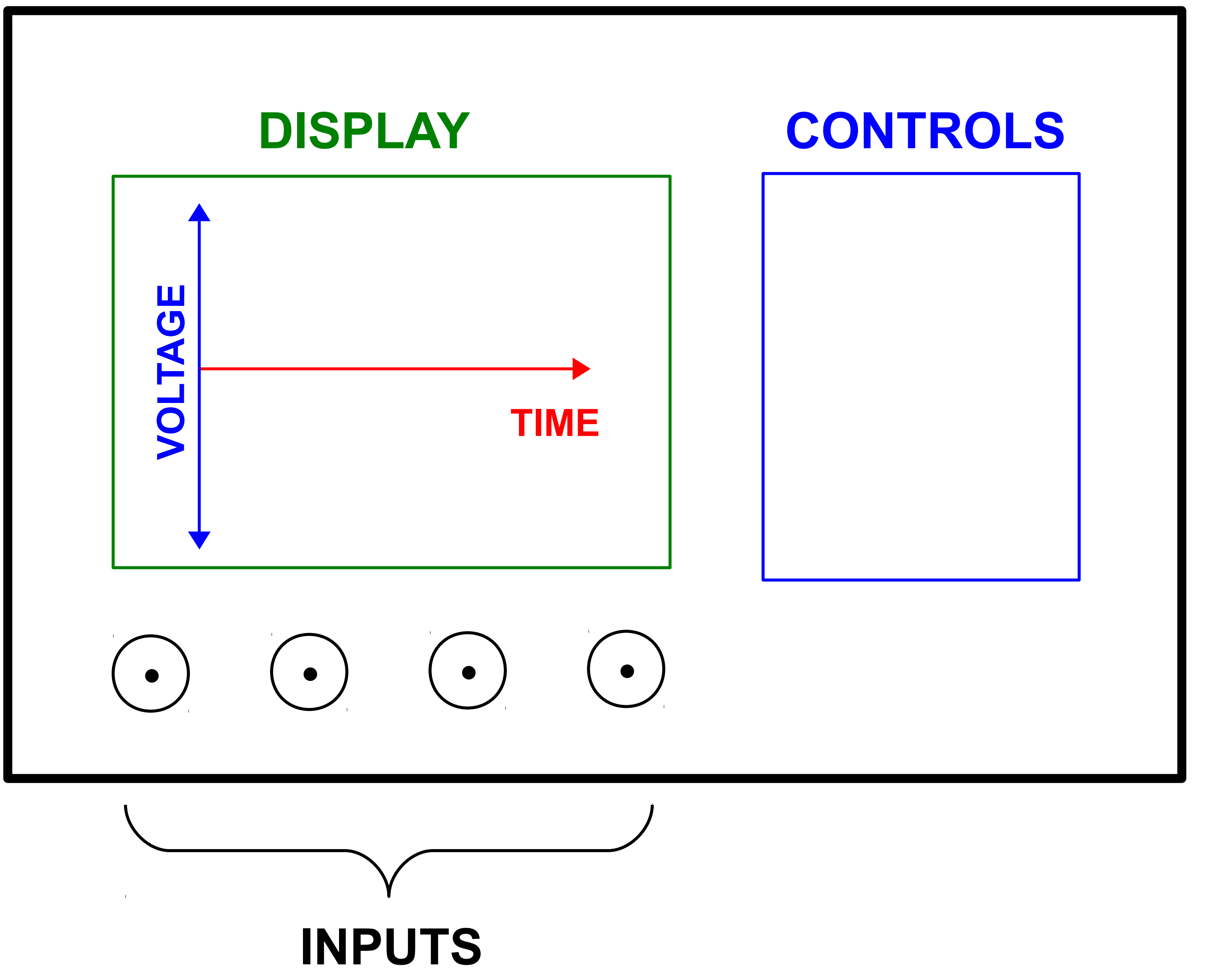
DC power dissipation = $\frac{V_{dc}^2}{R}$

AC voltage producing power dissipation equivalent $V_{RMS} = \frac{V_p}{\sqrt{2}}$

- An RMS measurement assumes a stable, periodic signal
- Characterized by a single value of voltage, current
- Measured with a multimeter or oscilloscope

The situation is often not that convenient!

OSCILLOSCOPE



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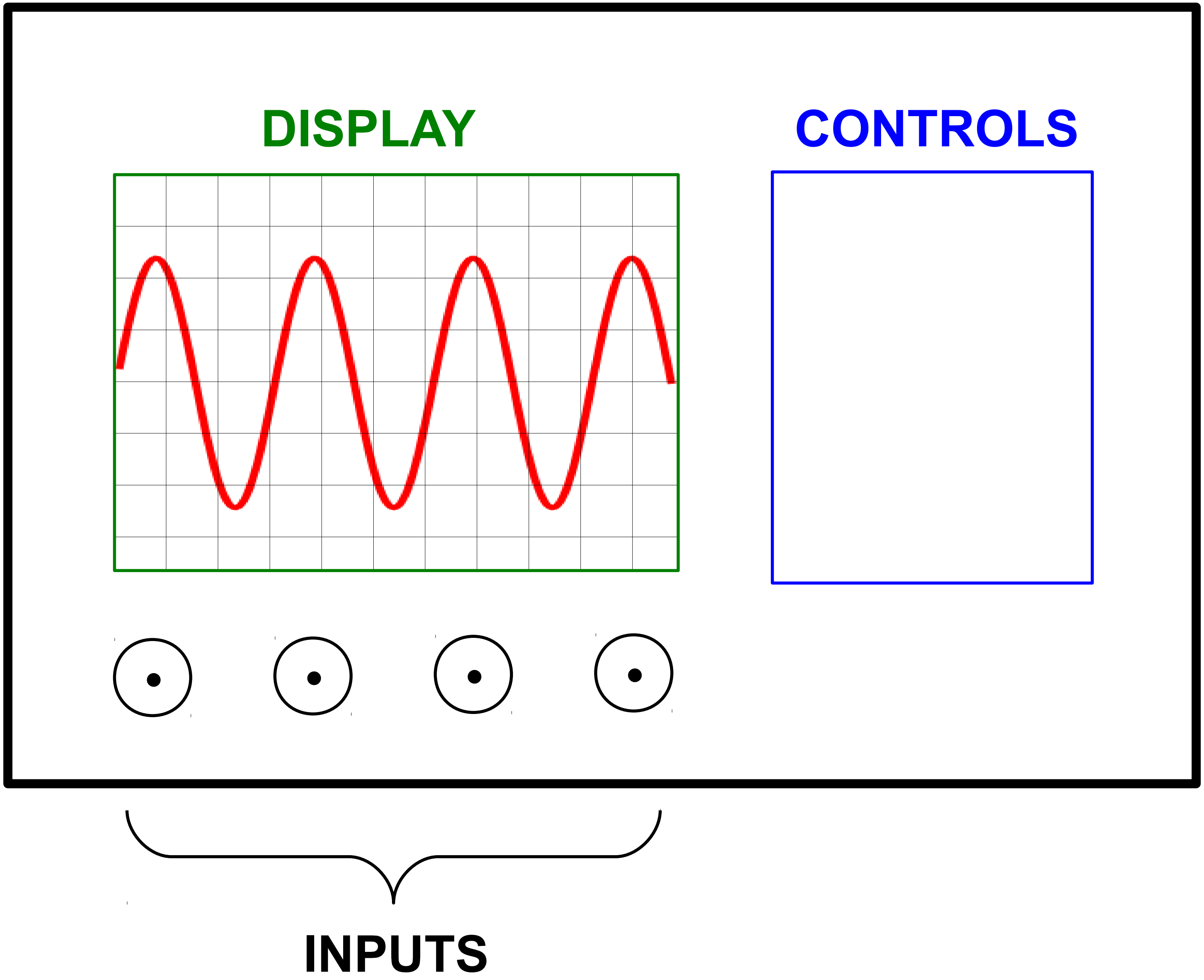
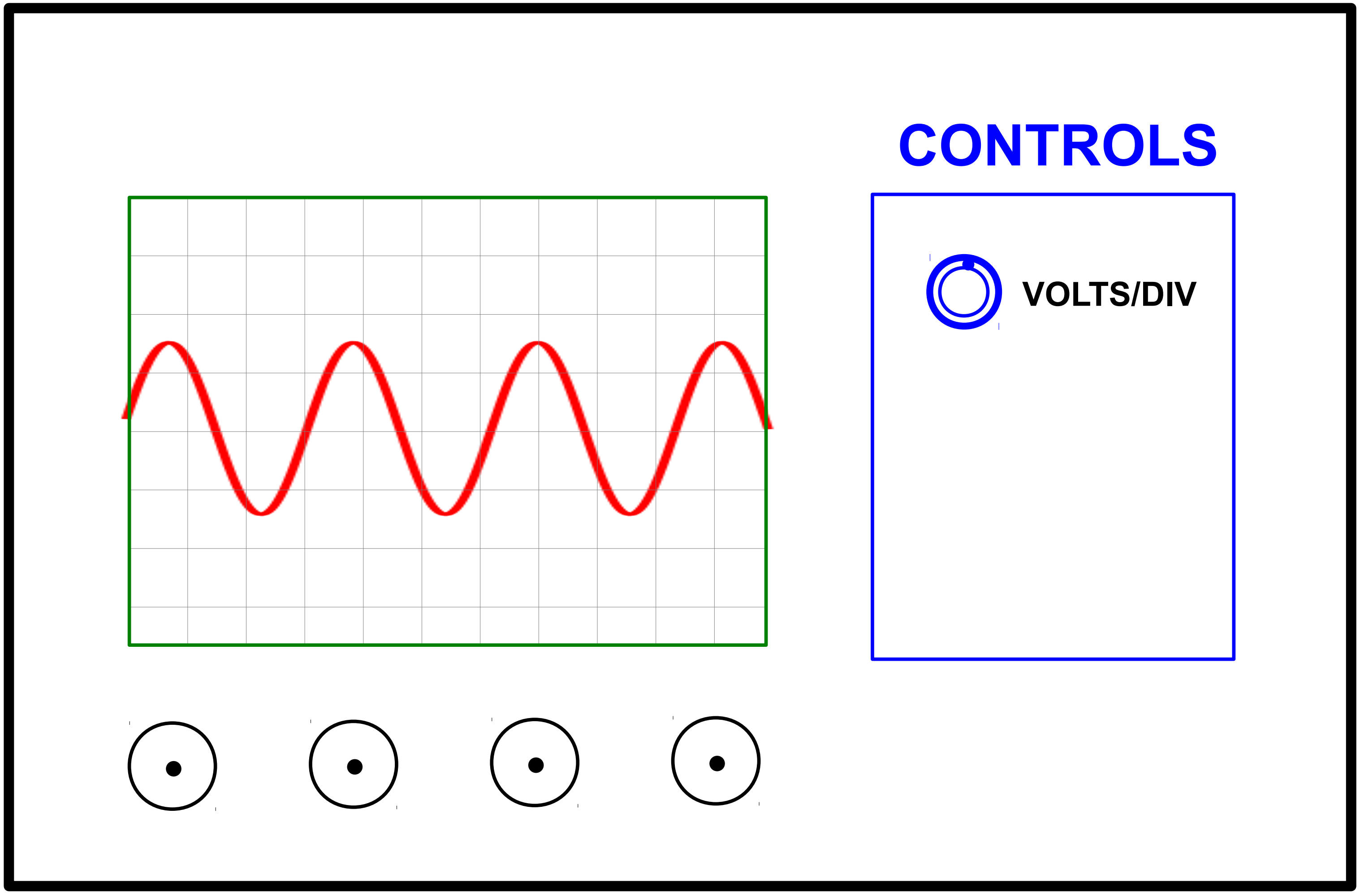


ANALOG: Cathode ray tube, swept electron beam

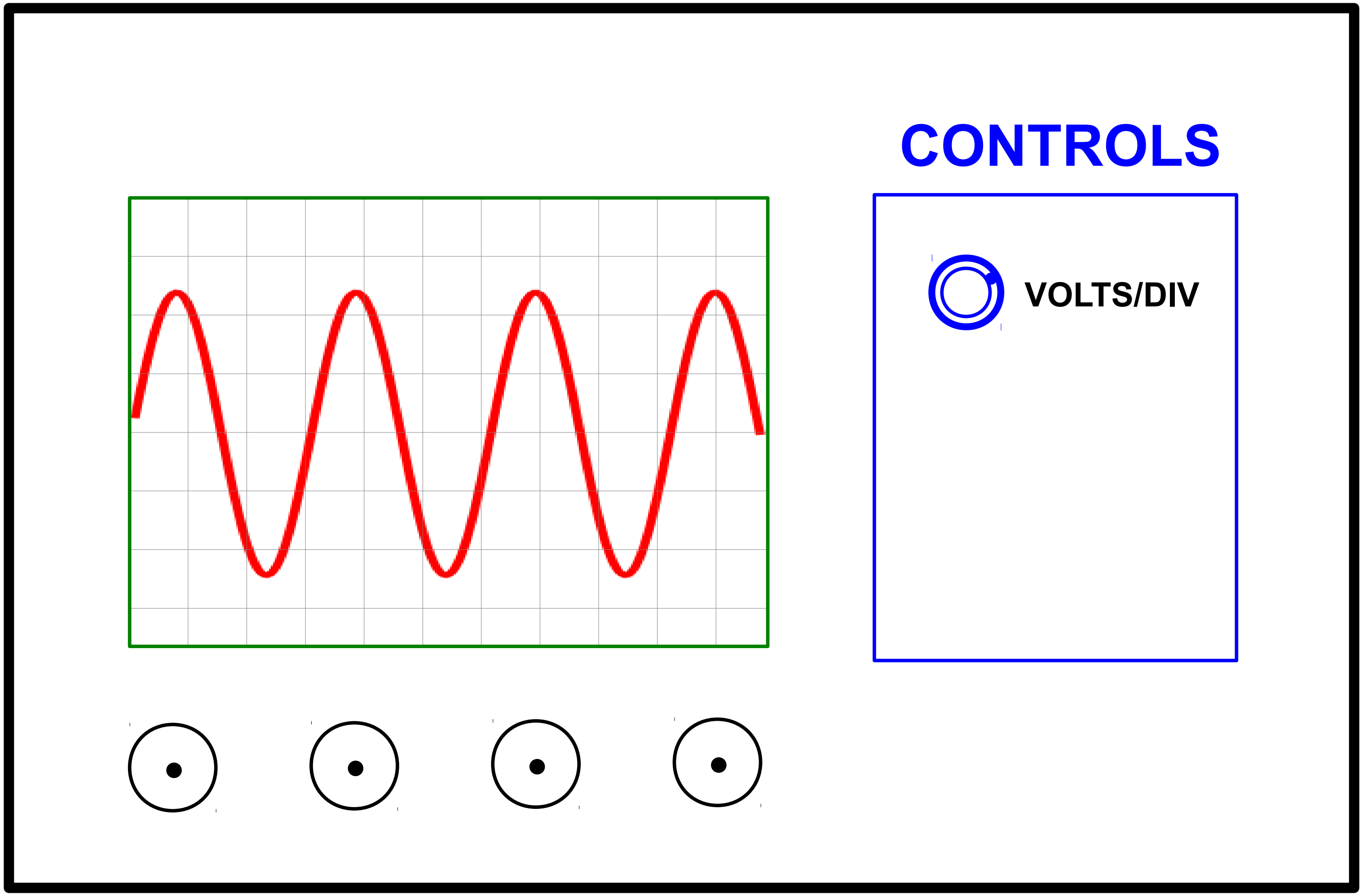
DIGITAL: A/D converter, LCD display

Although physical operation is completely different, controls are nearly identical

DISPLAY ADJUSTMENT



DISPLAY ADJUSTMENT



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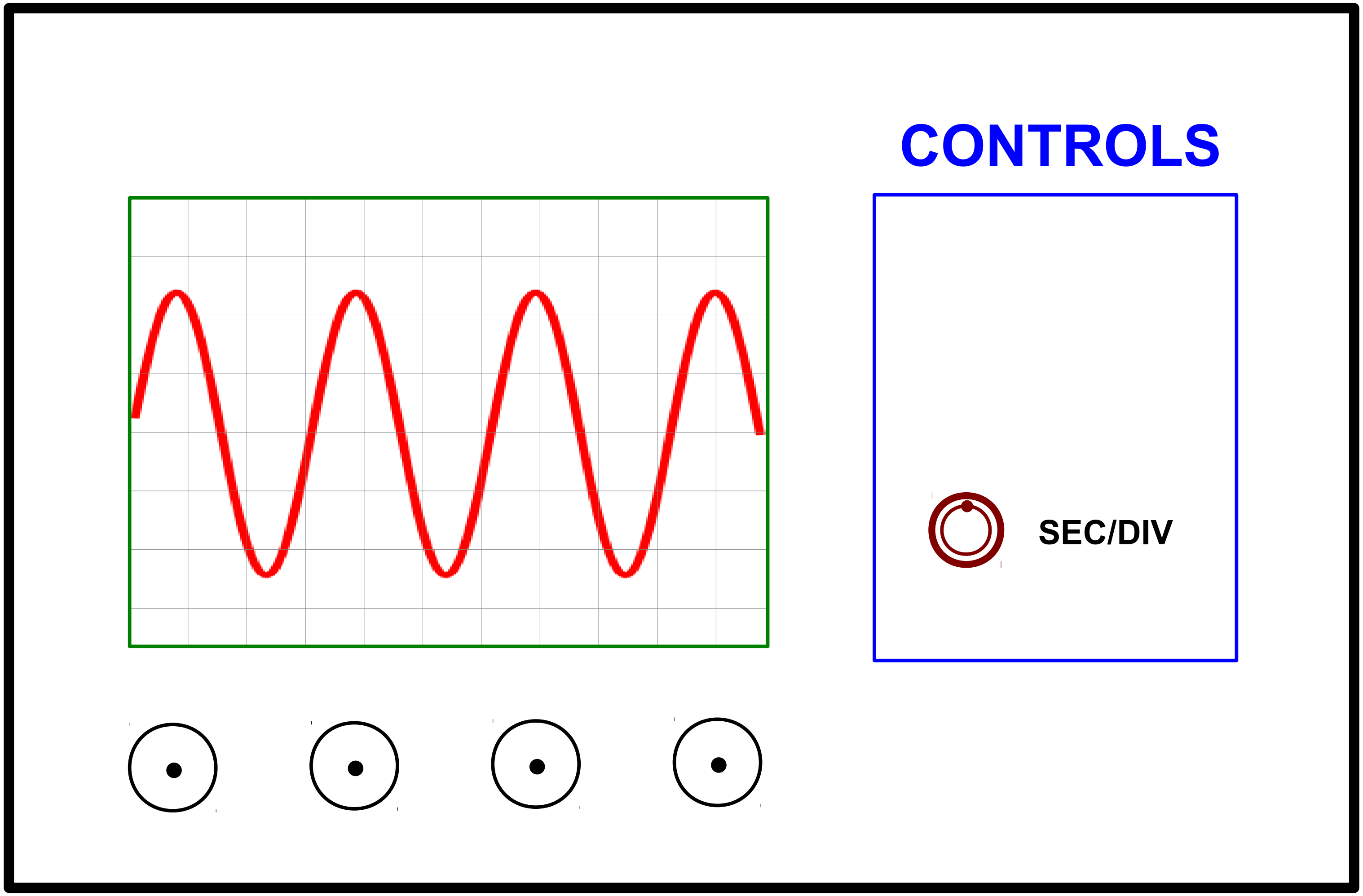

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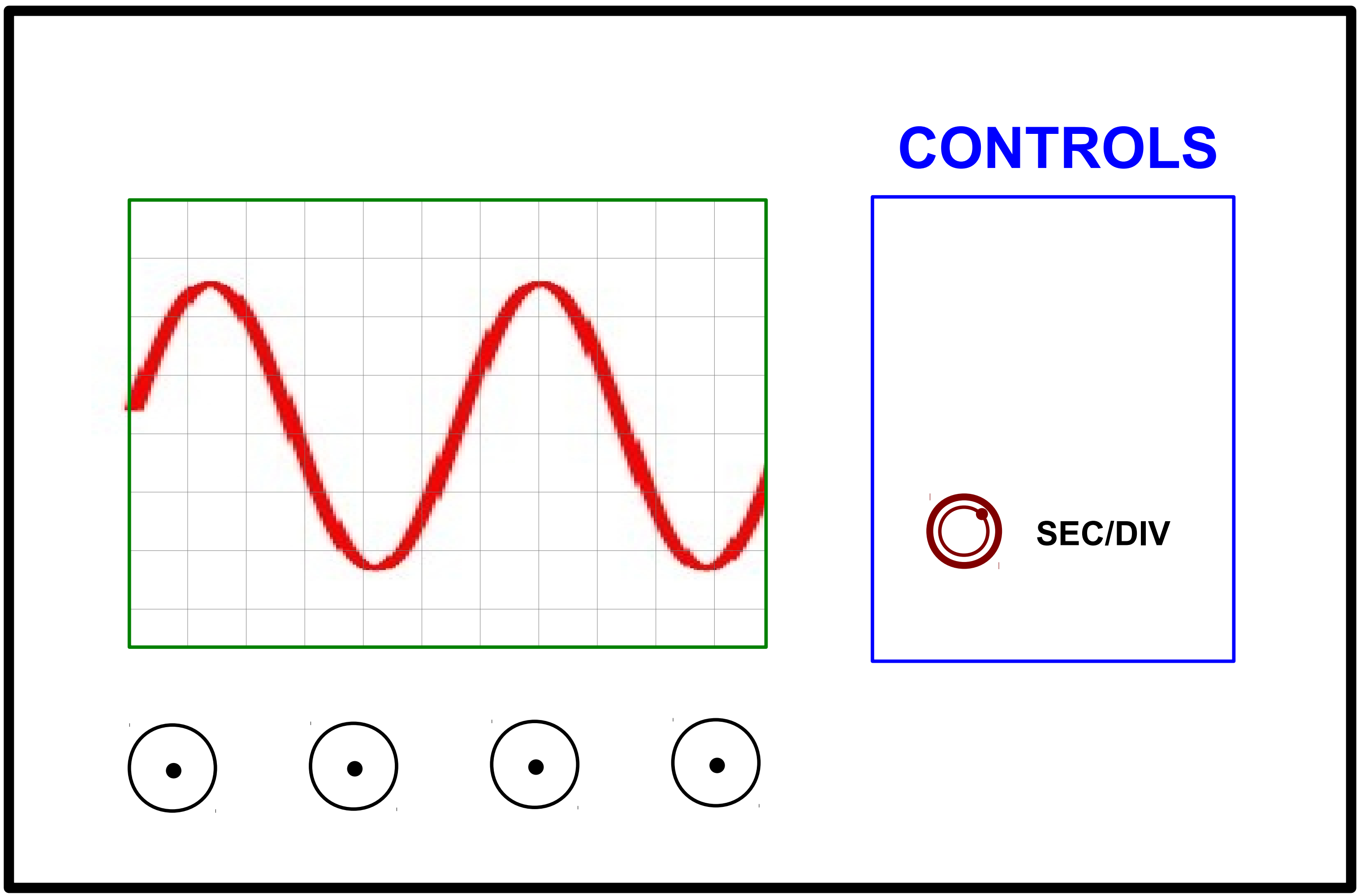
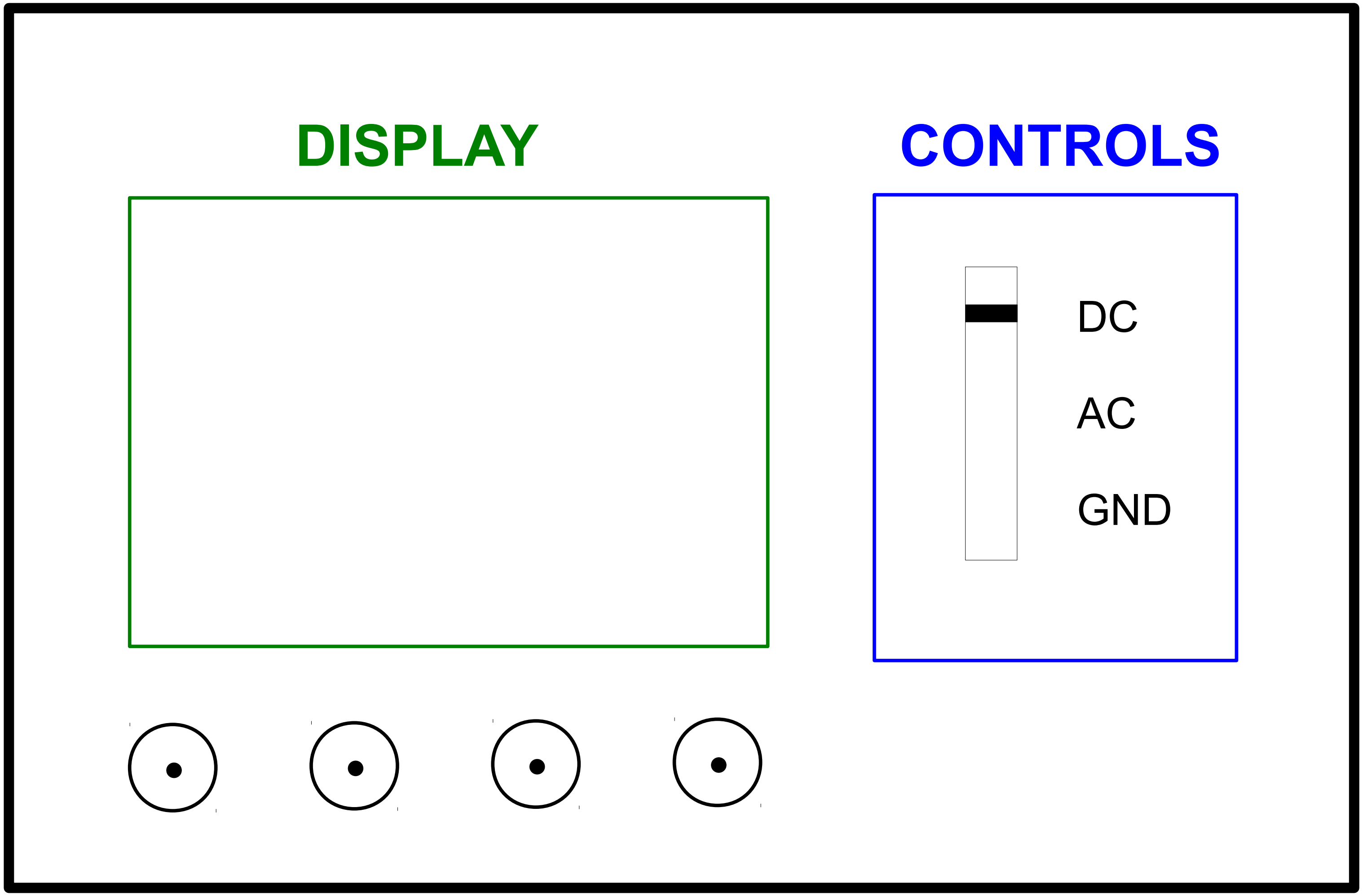
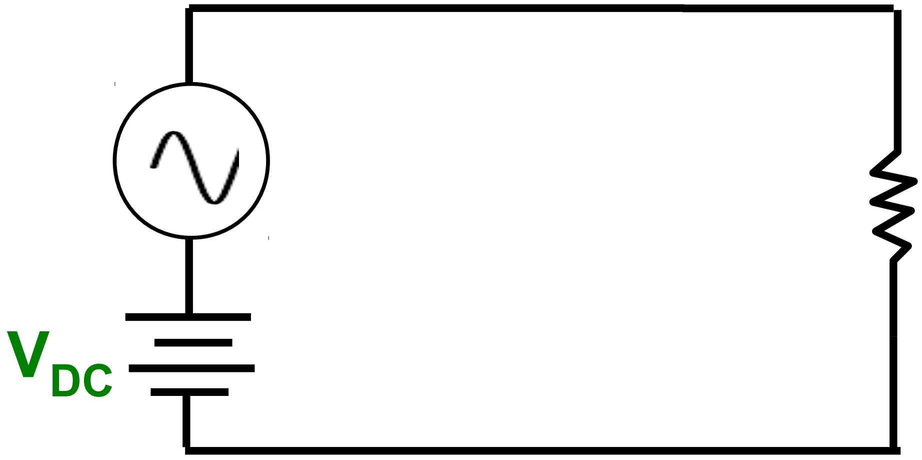
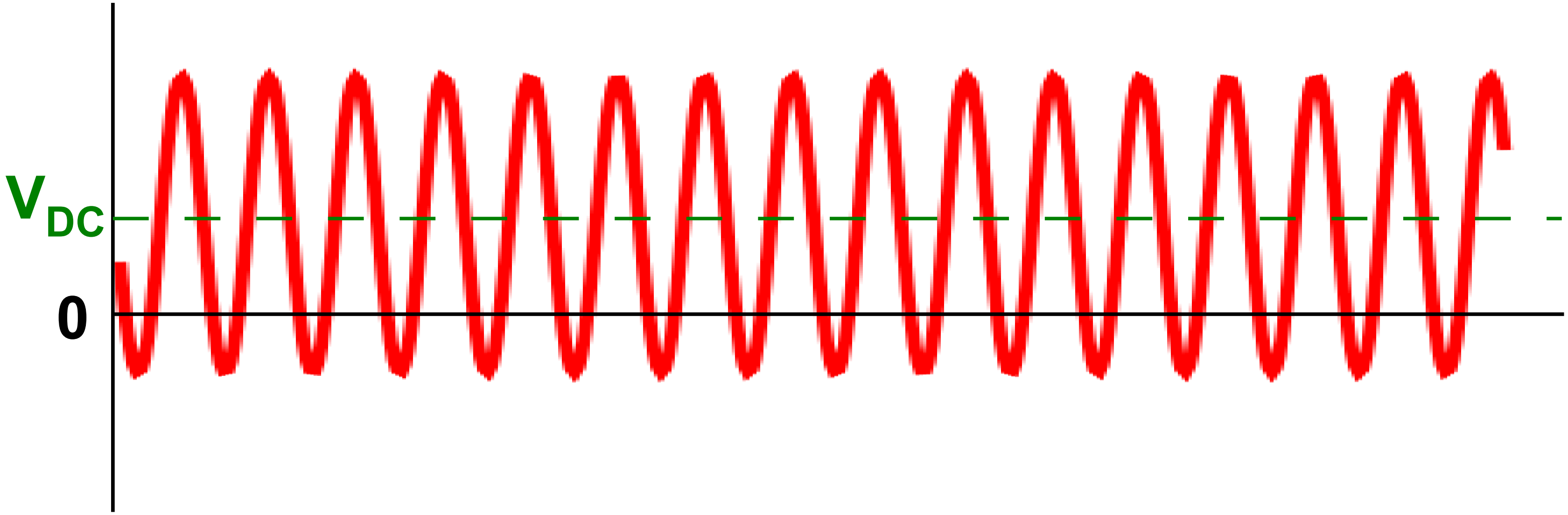


DC coupling, AC coupling, and Ground

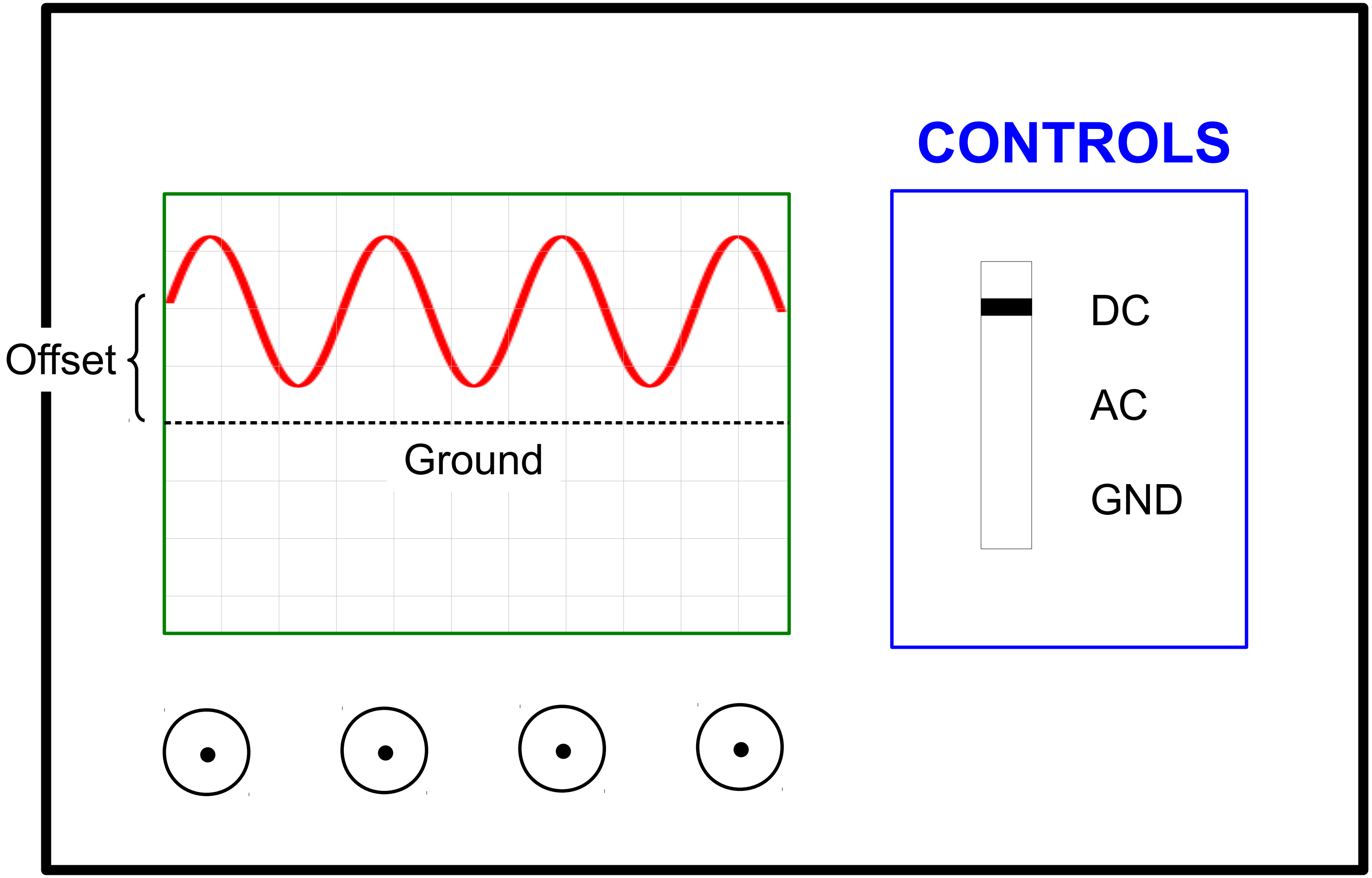


EXAMPLE: Sinusoidal wave source + DC offset

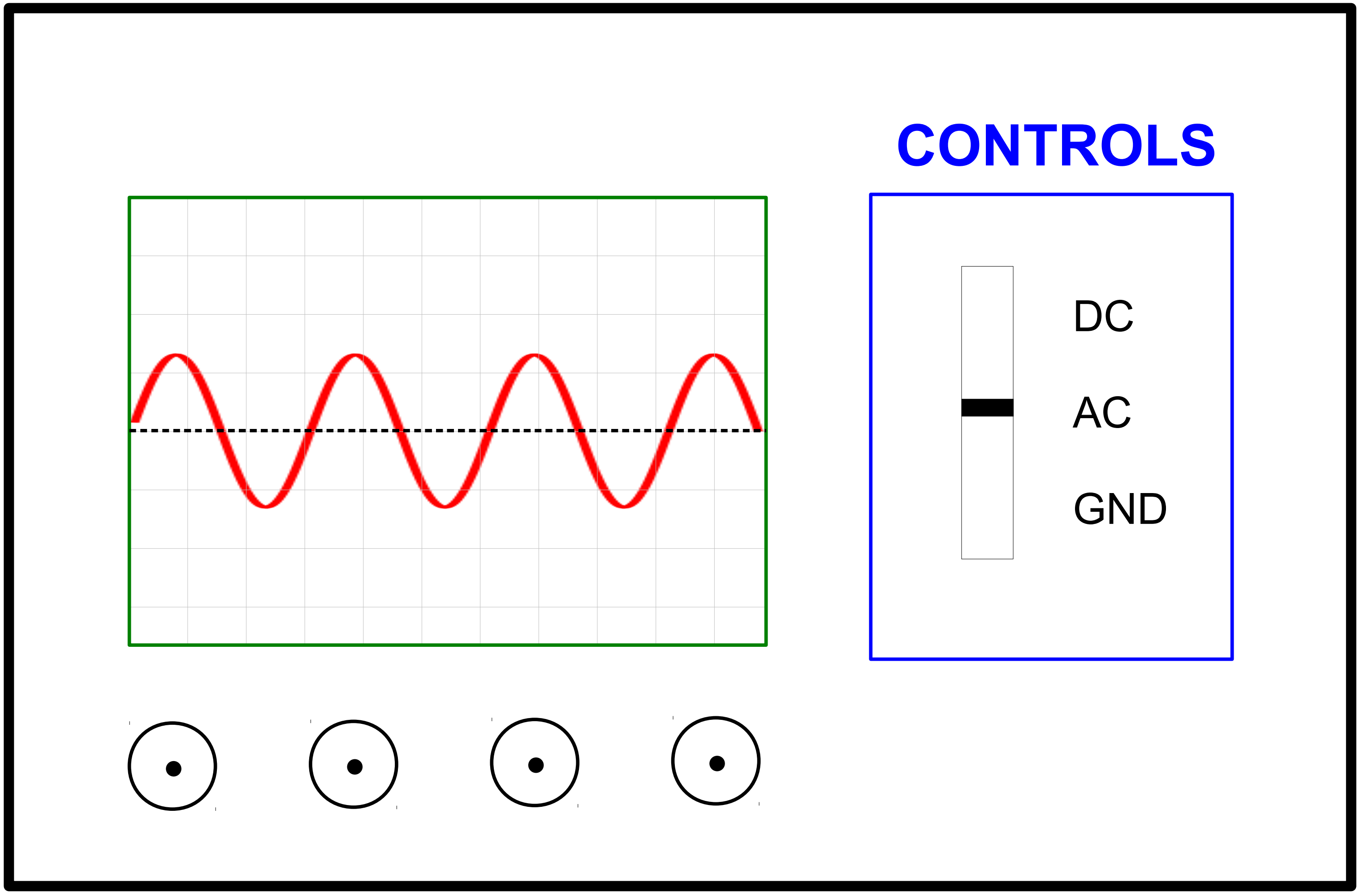




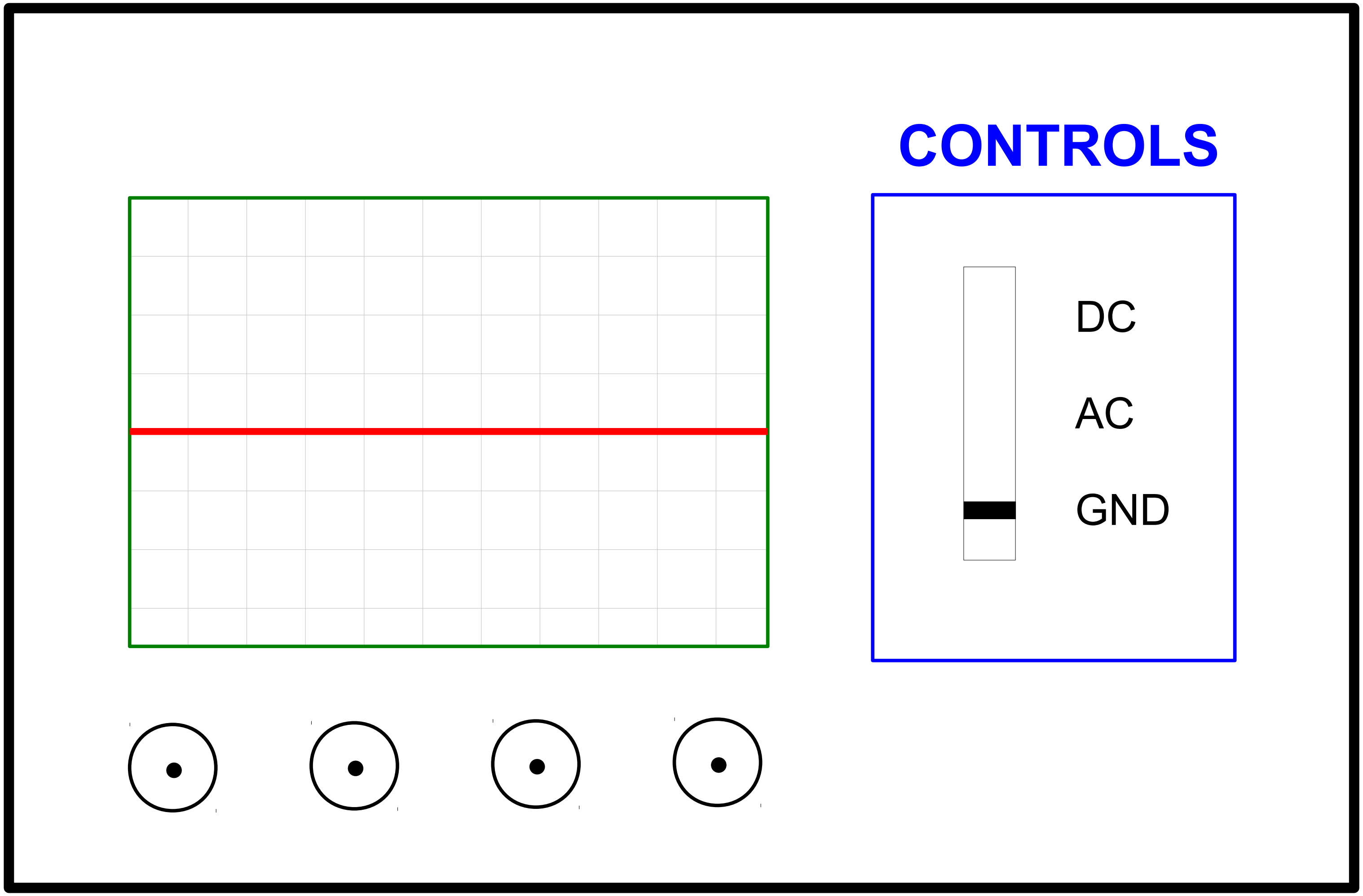
DC COUPLING



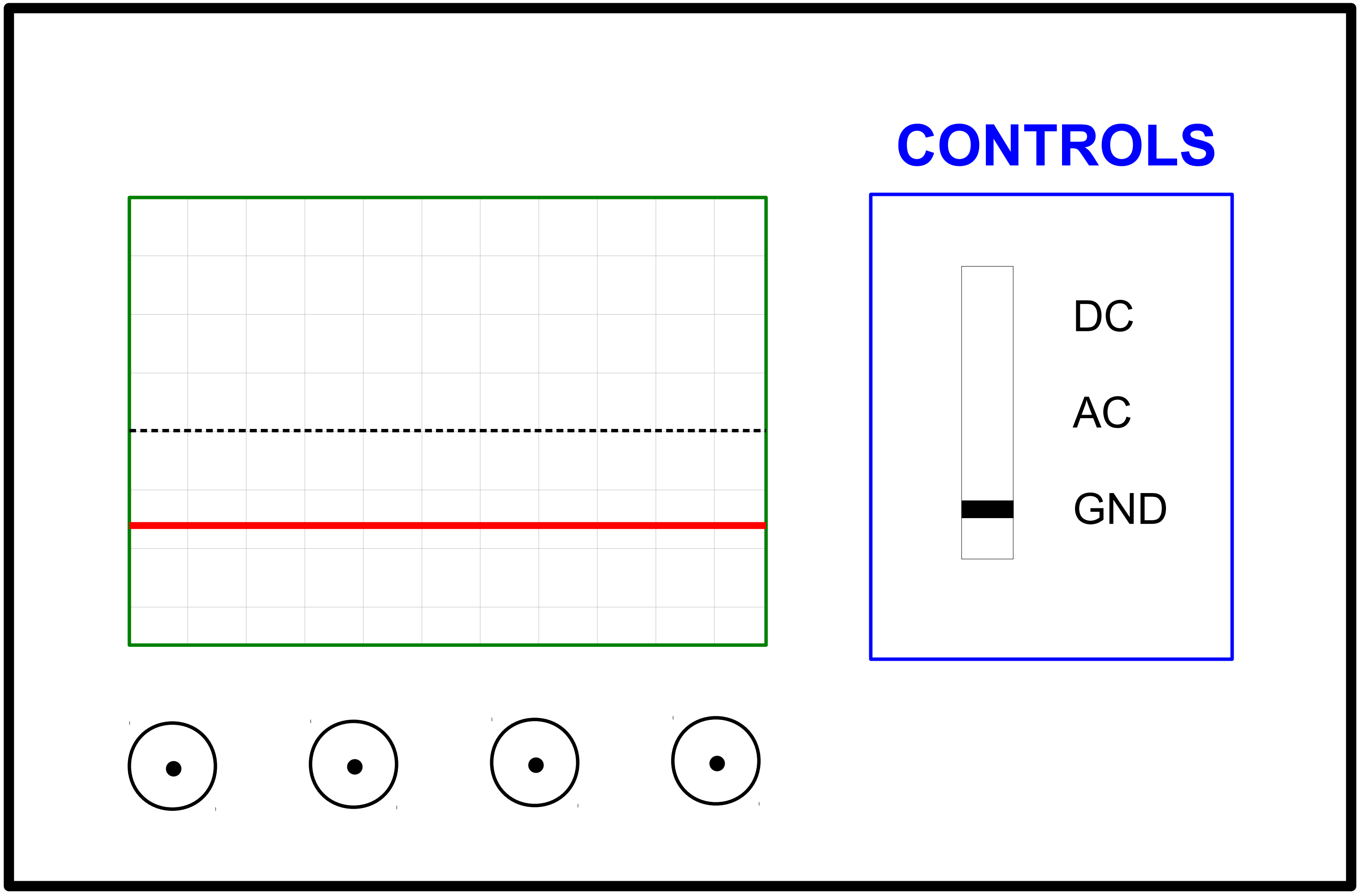
AC COUPLING



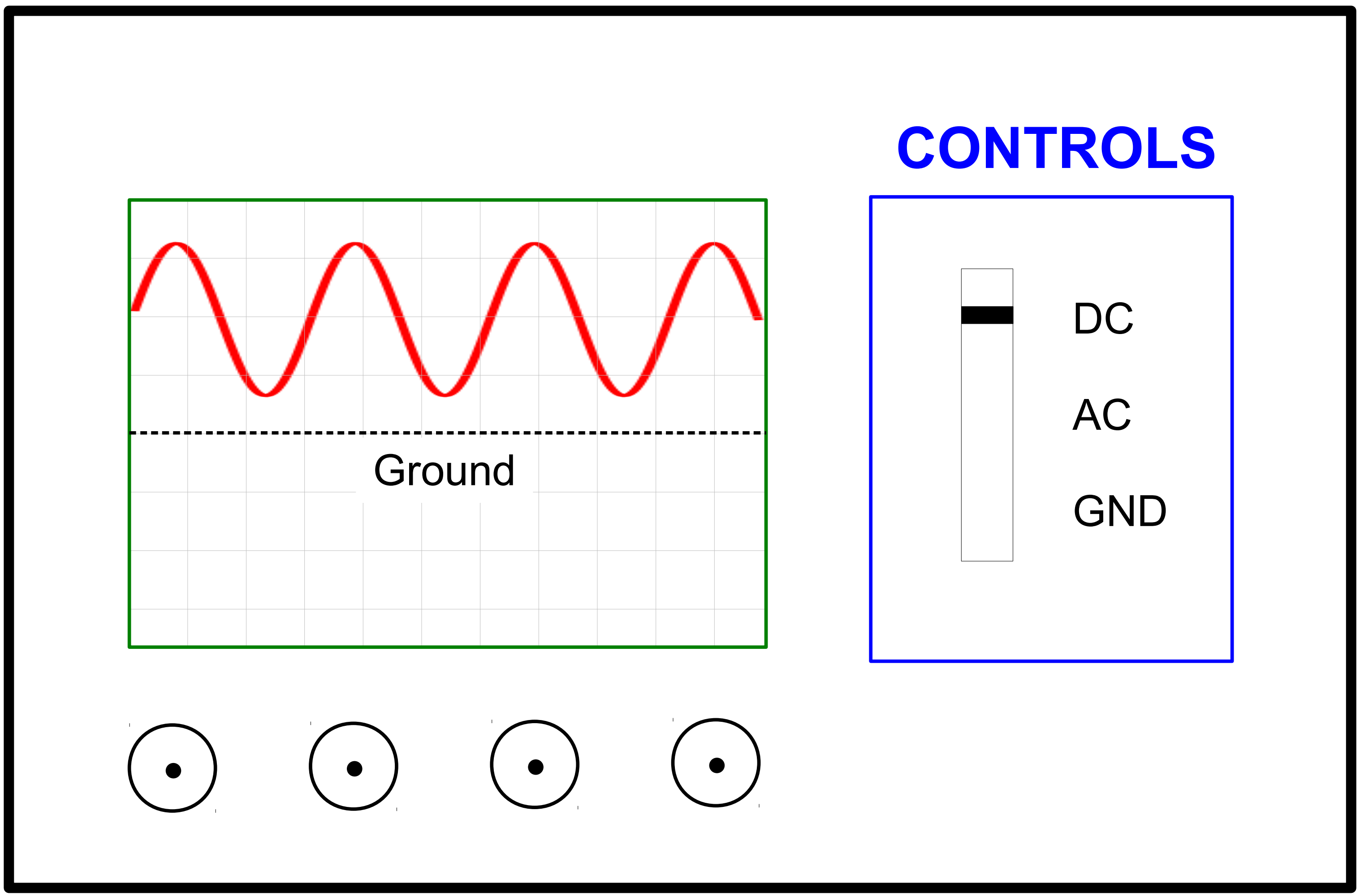
GROUND: Defines location of 0 Volts



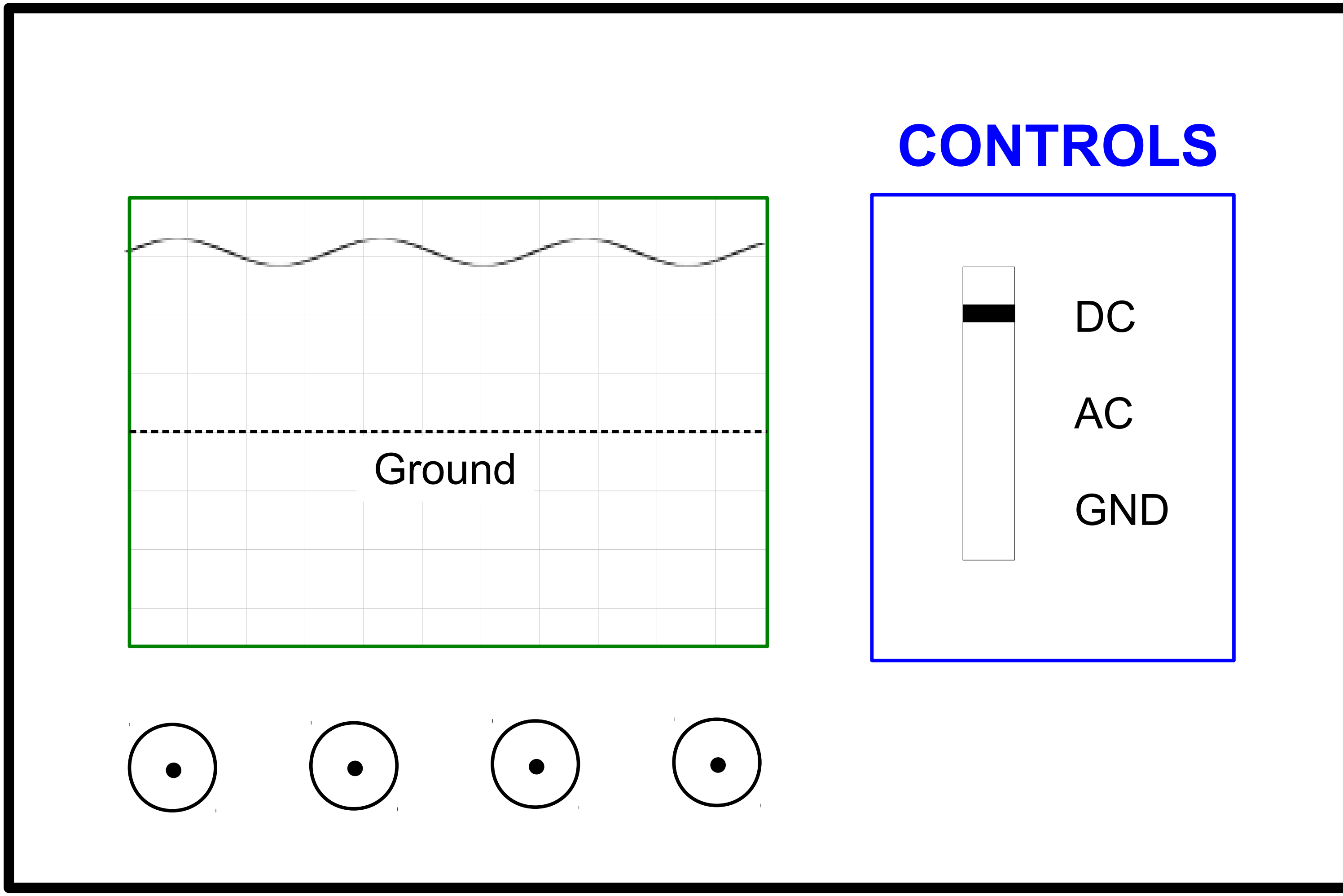
GROUND can be positioned at any convenient level



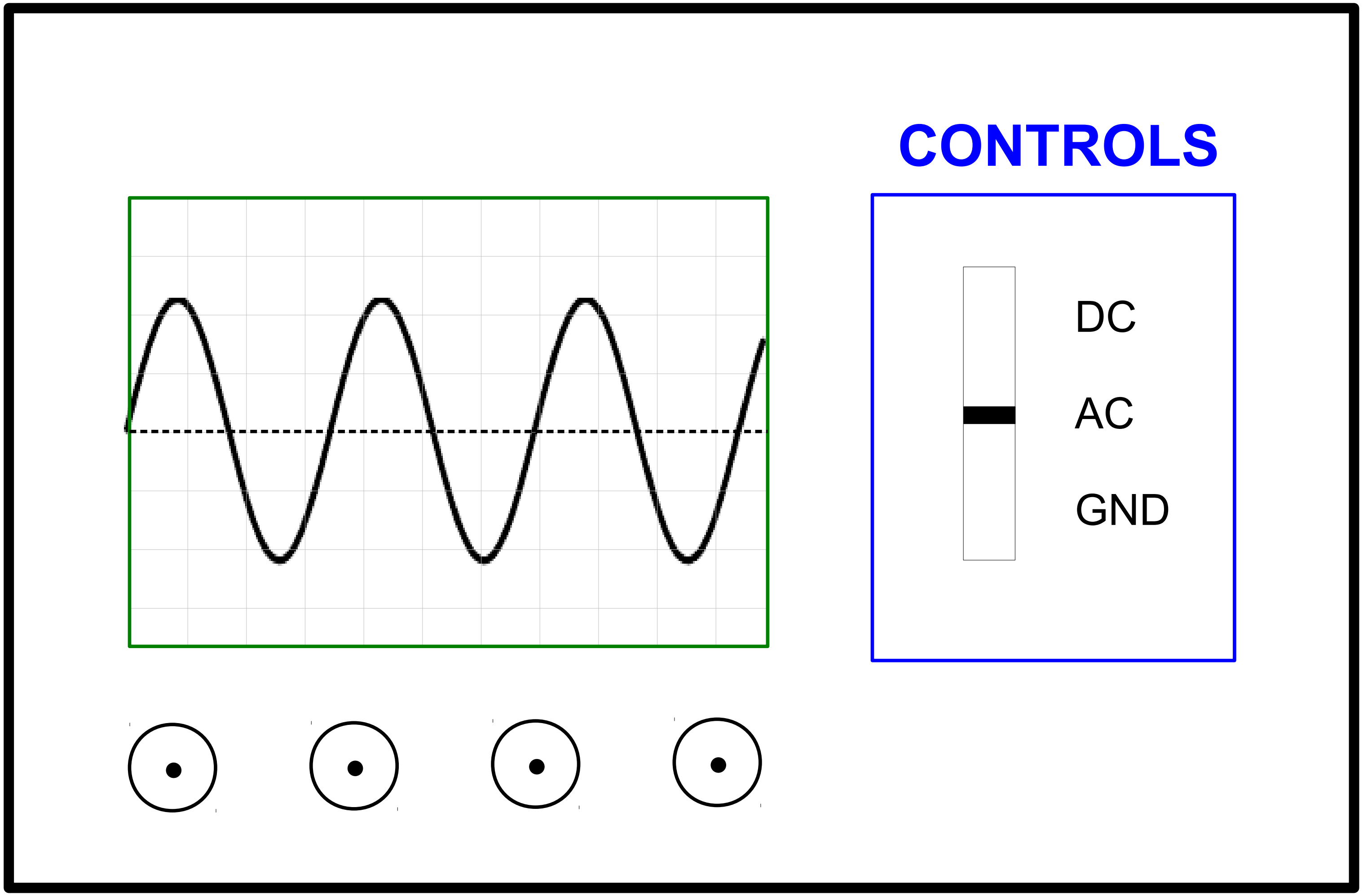
Why bother with AC coupling when DC coupling shows everything?



Often we have very weak modulation of a DC signal



AC couple and change the vertical scale



TRIGGERING

Auto: Scope gives continually updated display

Normal: User controls when the slope triggers; Level, Slope
Trigger source: Channel 1, Channel 2, etc

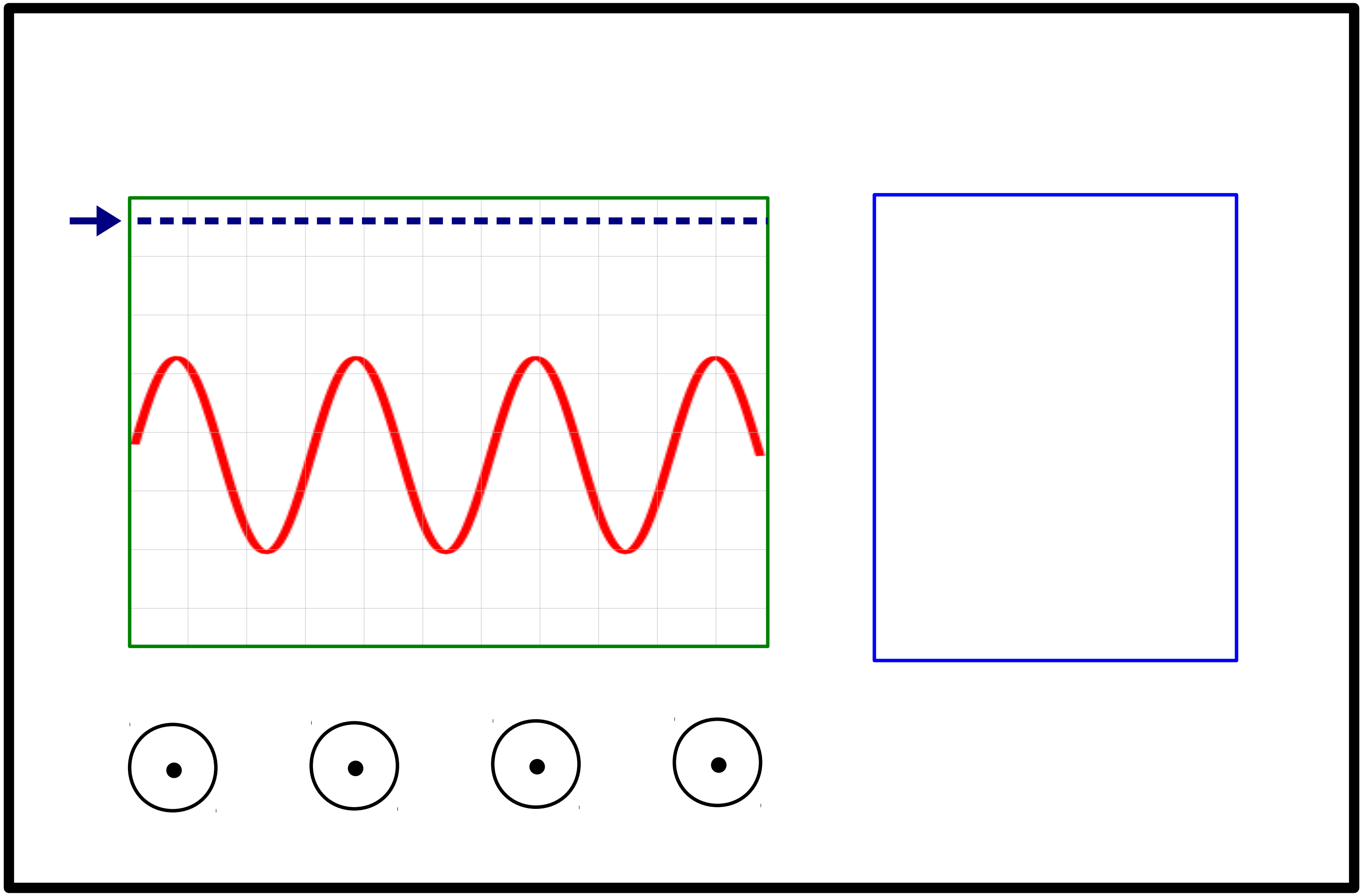
Line: Triggers on 60 Hz AC

Single event

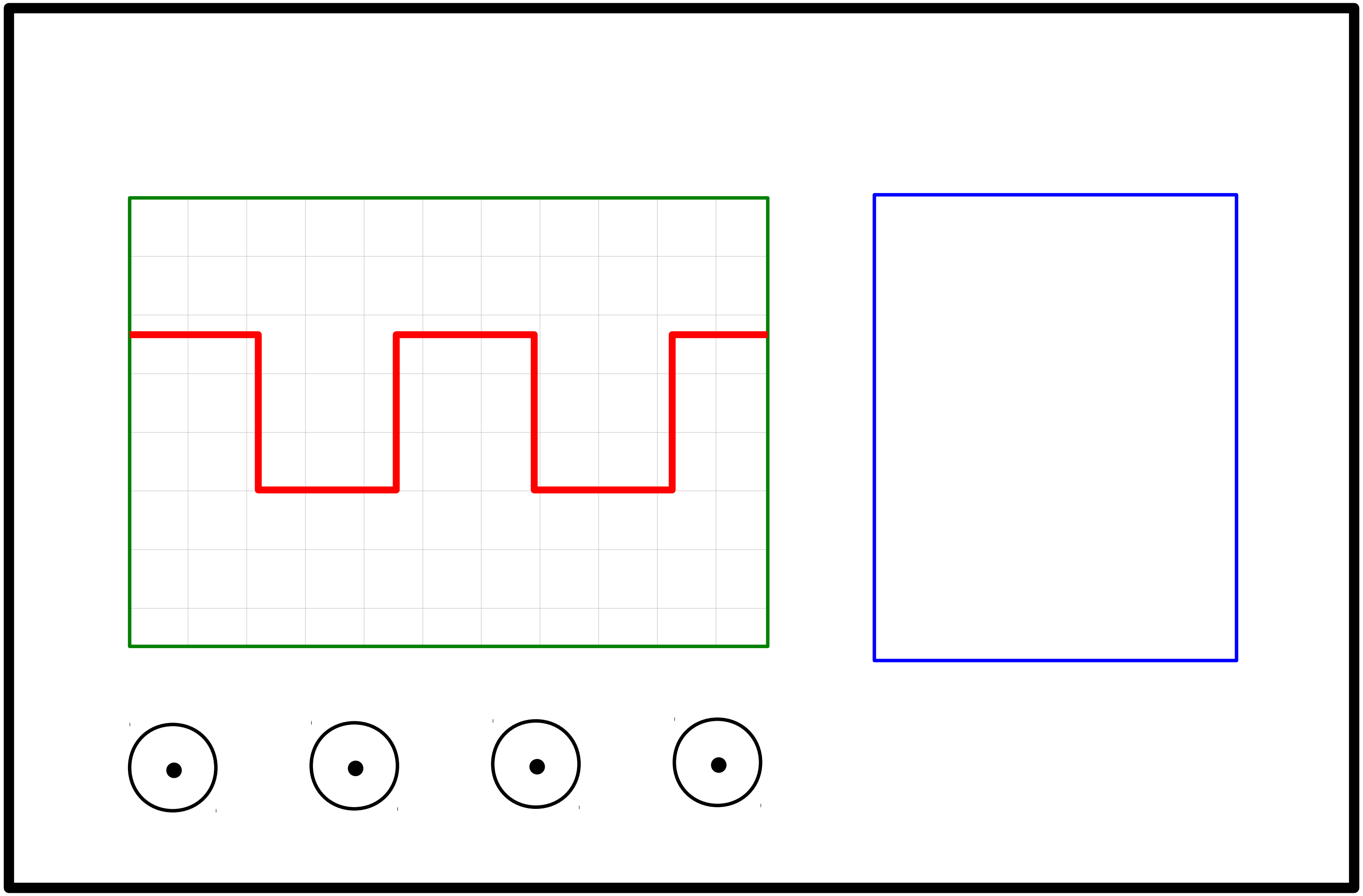
External

Use **Auto-Set** only when all else fails!

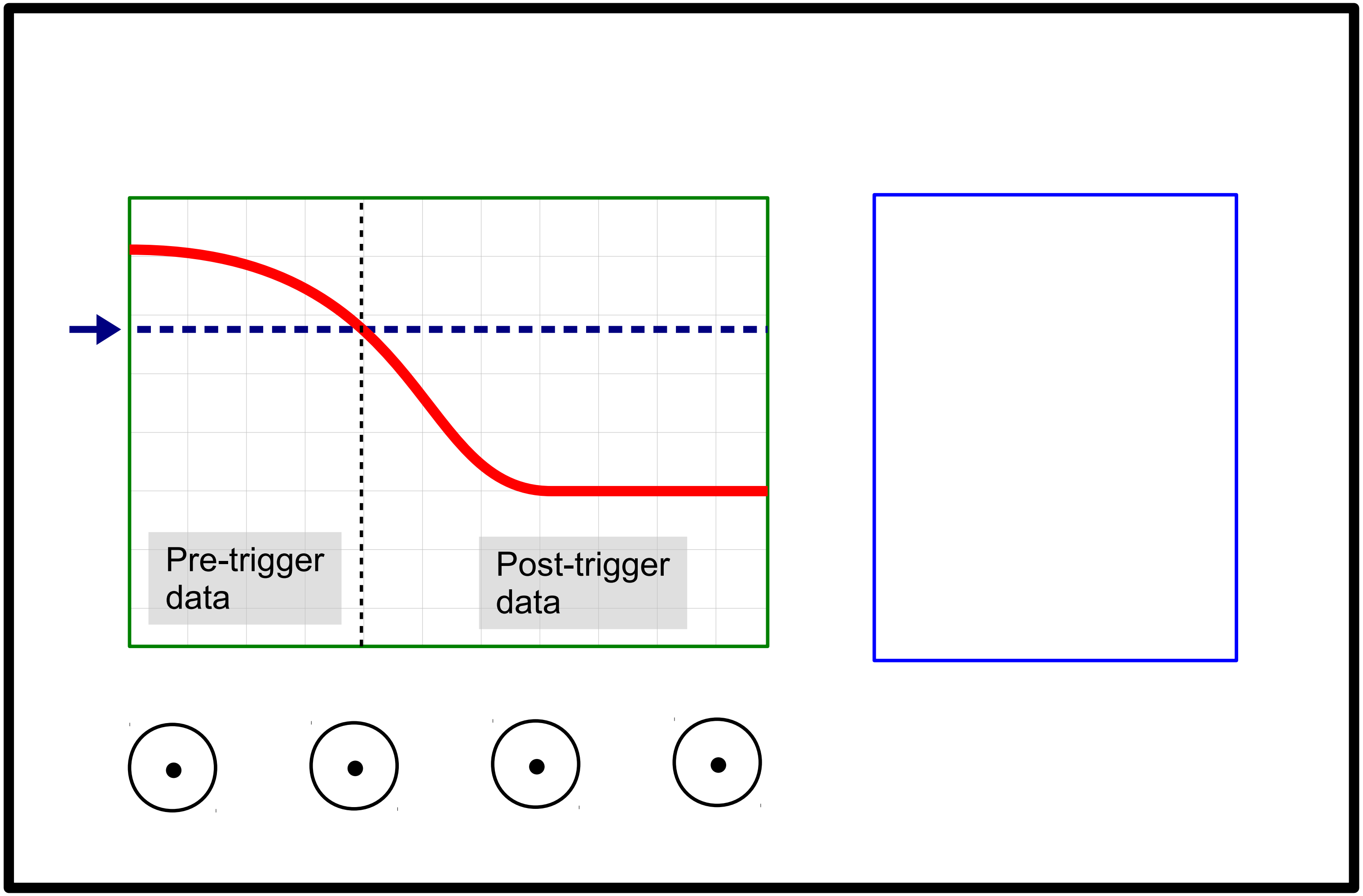
TRIGGER LEVEL



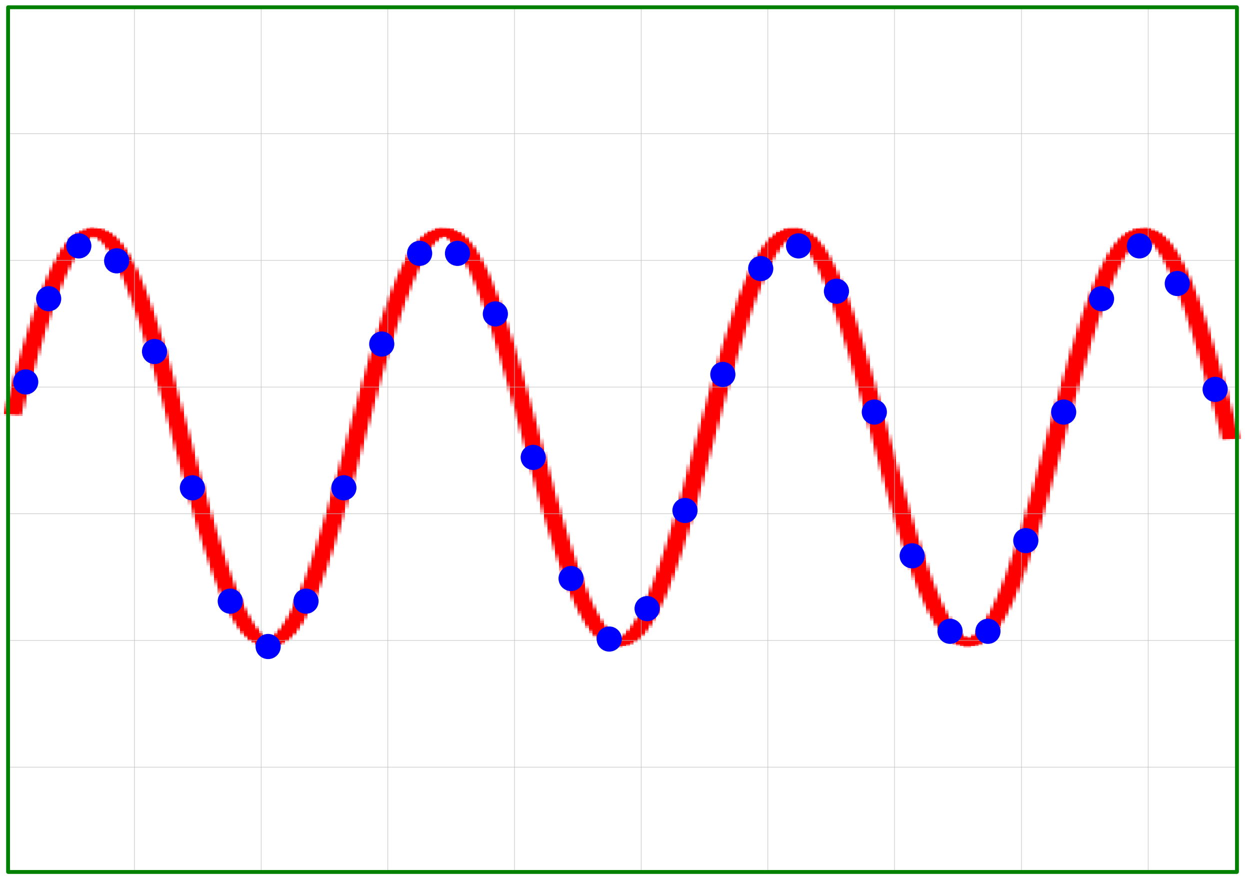
Example: Measure fall time of square wave



SOLUTION: Trigger on negative slope



SAMPLING BANDWIDTH



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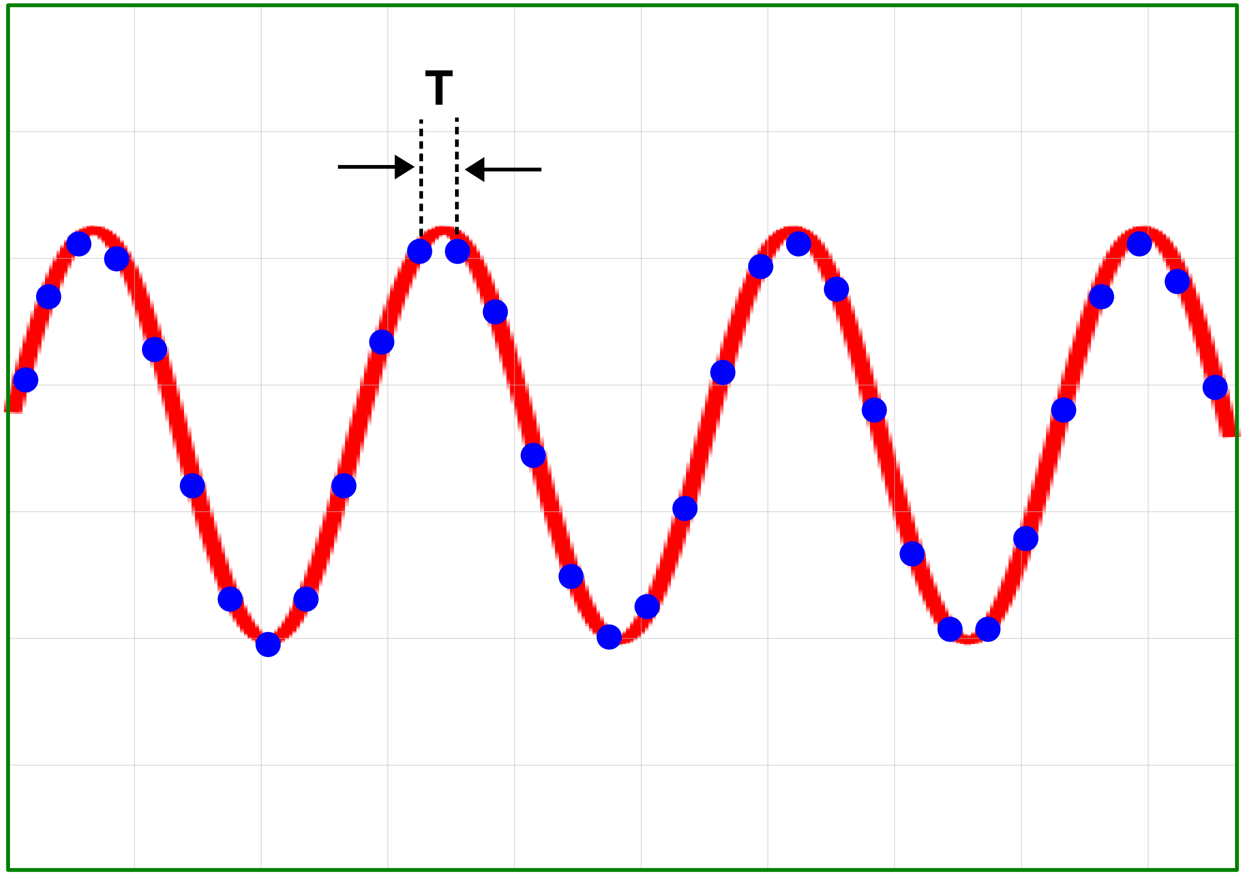

Sample spacing: **T** (sec)

Sampling bandwidth = 1 / **T** (samples/sec)

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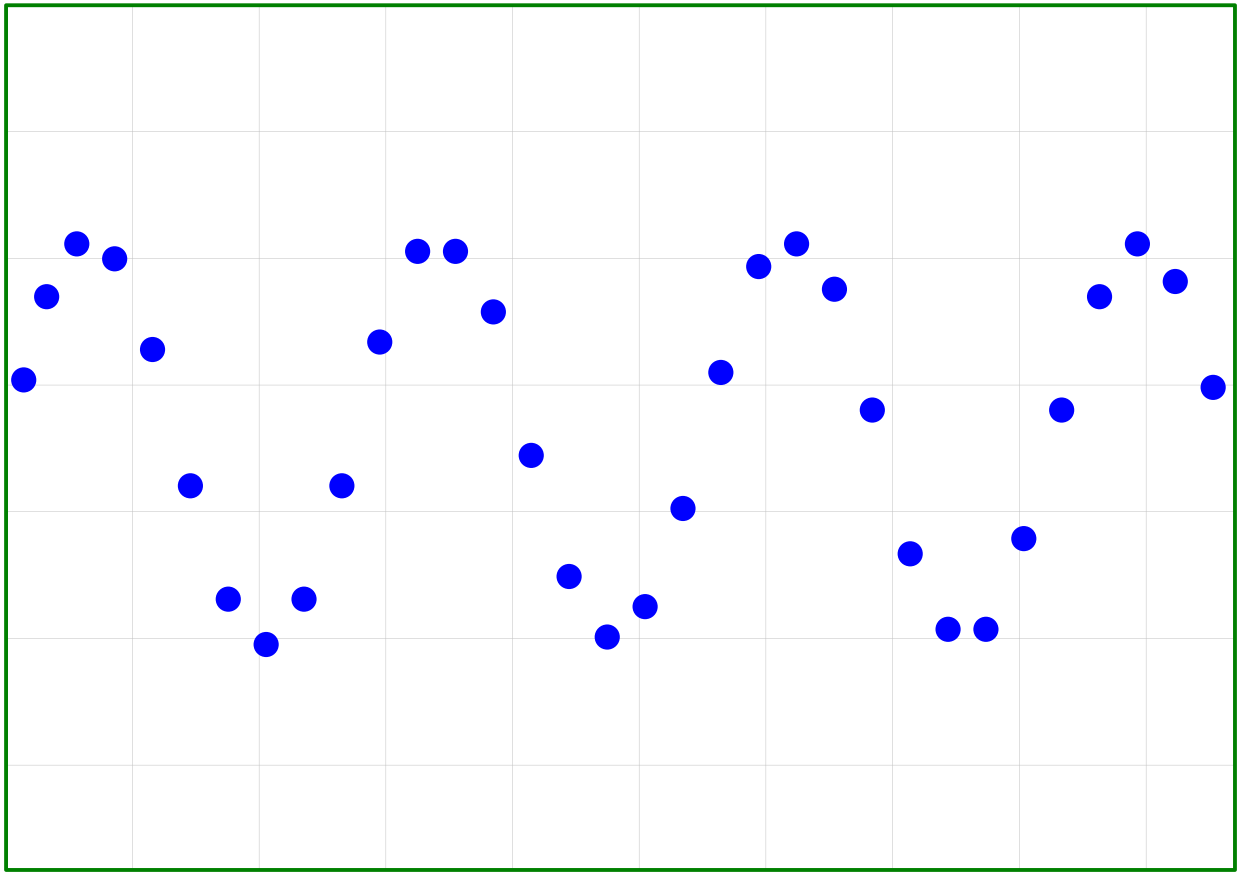

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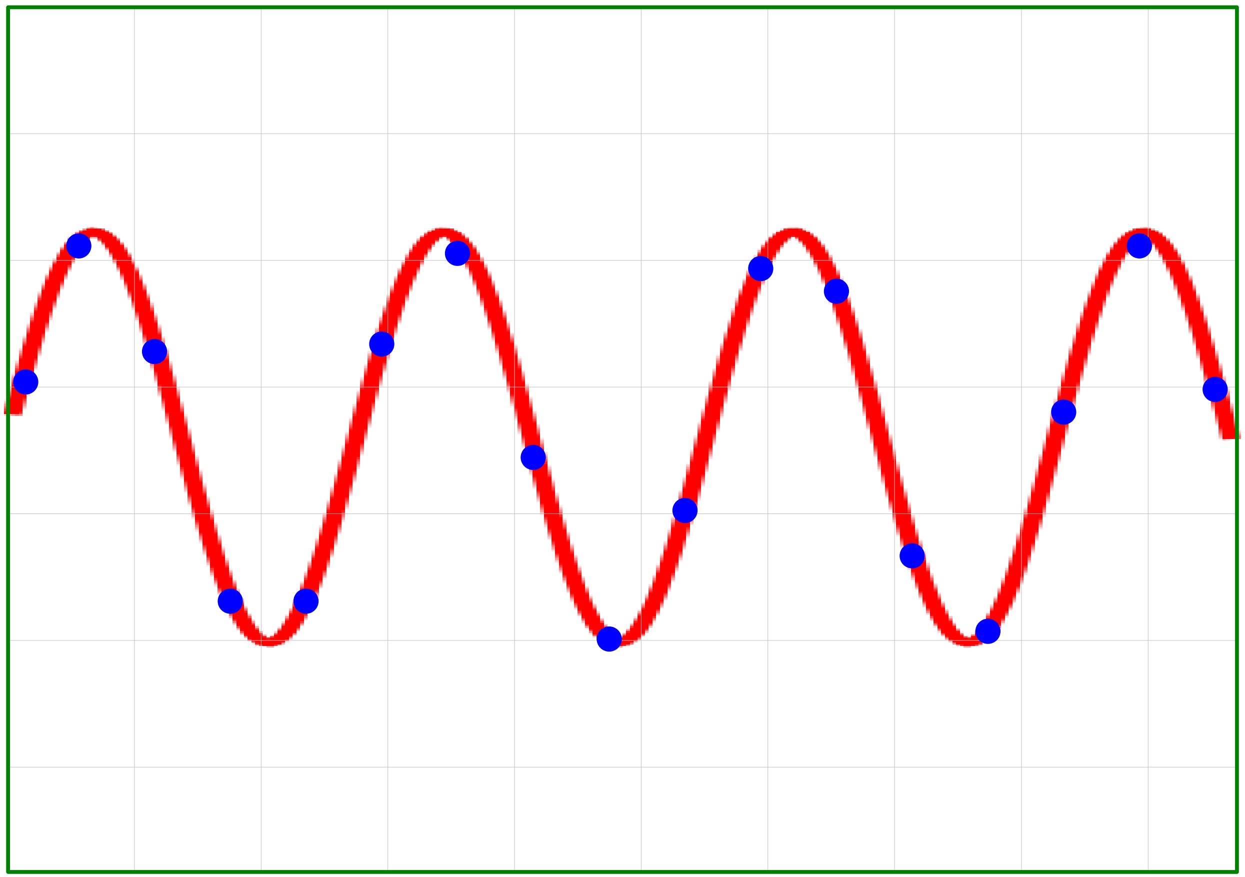
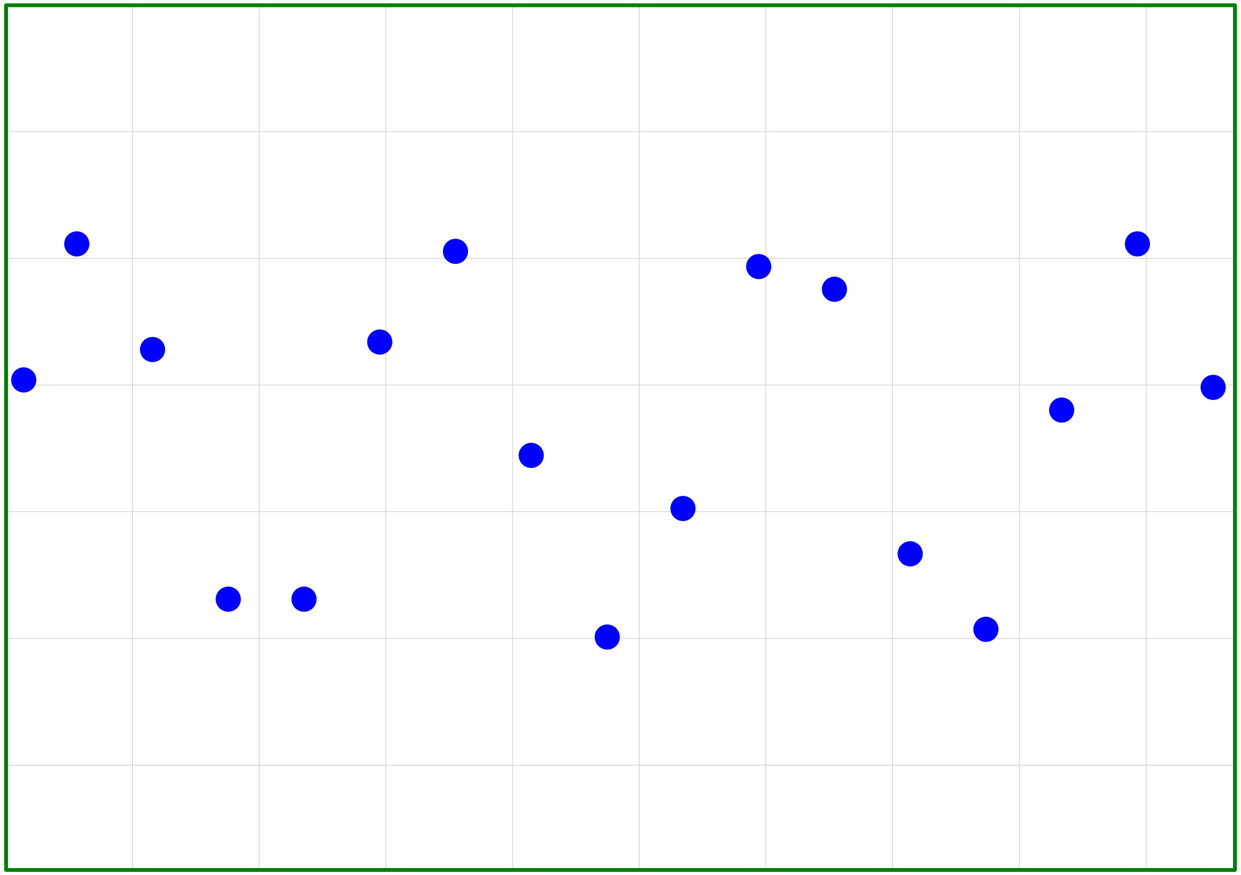


Reduce sample bandwidth 2x ⇨ Increase period 2x

SAMPLING BANDWIDTH



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