

# Voltage update logic

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2:18 PM

1. Voltage = the neuron's internal energy level  
Think of voltage as how "charged" the neuron is.
  - Low voltage → neuron is quiet
  - High voltage → neuron is getting excited
  - Cross threshold → neuron firesVoltage is always changing.

2. Integration = voltage goes UP (input adds charge)  
Whenever the neuron receives input current ( $I$ ):
  - Voltage increases
  - neuron gets more excited
  - closer to spike

Think of integrations like charging a battery:

- Input → voltage ↑
- More input → voltage ↑↑
- Strong input → voltage ↑↑↑

This is how emotional "stimulus" affects neurons.

3. Leakage = voltage goes down (natural decay)

Neurons are leaky.

They lose some voltage over time, even without input

Leak =

- voltage drops slowly
- prevents infinite charging
- makes behavior realistic
- Without input → voltage ↓ slowly
- With input → voltage ↑ but some still ↓

Leakage keeps the system stable

4. Integration + leakage happen together every  $dt$

This is the **key**

$$\text{Voltage} = \text{Voltage} + (\text{input effect} - \text{leak effect})$$

5. Threshold = point at which neuron spikes

When voltage reaches a certain level:

- neuron fires a spike
- spike is a quick electrical signal
- spike happens instantly

Think of it like:

Voltage builds... builds.. builds...

Boom → spike

This creates spike trains later

6. Reset = after spike, voltage goes back to baseline

Right after firing:

- voltage drops to a resting level
- neuron becomes quiet again
- ready for next step

This keeps spiking behaviour from being chaotic.

7. Final behaviour inside each  $dt$  step

Every millisecond ( $dt$ ), neuron checks:

1. Add input → voltage rises

2. Subtract leak → voltage falls a bit

3. If  $\text{voltage} \geq \text{threshold} \rightarrow \text{spike}$

4. Reset voltage

5. Move to next  $dt$

This loop repeats thousands of times per second.

This is exactly how the brain works.

## \* Summary

Voltage = neuron energy

Integration = input increase voltage

Leakage = voltage naturally decrease

Threshold = firing point

Reset = returns to baseline

Every  $dt \rightarrow$  update voltage based on input + leak