

1. Voltage = the neuron's internal energy level

Think of voltage as how "charged" the neuron is.

- Low voltage \rightarrow neuron is quite
- High voltage \rightarrow neuron is getting excited
- Cross threshold \rightarrow neuron fires

Voltage 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 integration like charging a battery:

- Input \rightarrow Voltage \uparrow
- More input \rightarrow Voltage $\uparrow\uparrow$
- Strong input \rightarrow Voltage $\uparrow\uparrow\uparrow$

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 \rightarrow Voltage \downarrow slowly
- With input \rightarrow Voltage \uparrow but some still \downarrow

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 \rightarrow 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 \rightarrow voltage rises
2. Subtract leak \rightarrow voltage falls a bit
3. If voltage \geq threshold \rightarrow 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 = return to baseline

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