DOCUMENTATION

Parameters & Units

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All physical quantities in the codebase use the same unit system: **ms for time, mV for voltage, nF for capacitance, µS for conductance, nA for current, Hz for rates**. Time fields carry an explicit *_ms* suffix (*sim_ms*, *ref_ms_E*, *tau_gaba*); CLI flags follow the same convention (*–t-ms 600*). A Δt of 1 means 1 ms, not 1 s.

Quantities

Quantity	Unit	Typical value	Variable
Integration step	ms	0.25	*dt*, *DT_MS*
Simulation length	ms	600	*sim_ms*
Membrane time constant	ms	20 (E), 5 (I)	*tau_m_E*, *tau_m_I*
Refractory period	ms	3 (E), 1.5 (I)	*ref_ms_E*, *ref_ms_I*
AMPA decay	ms	2	*tau_ampa*
GABA decay	ms	9	*tau_gaba*
Resting / leak potential	mV	−65	*E_L*
Spike threshold	mV	−50	*V_th*
Reset potential	mV	−65	*V_reset*
AMPA reversal	mV	0	*E_e*
GABA reversal	mV	−80	*E_i*
Membrane capacitance	nF	1.0 (E), 0.5 (I)	*C_m_E*, *C_m_I*
Leak conductance	µS	0.05 (E), 0.1 (I)	*g_L_E*, *g_L_I*
External drive	µS	0.0006 (async), 0.003 (PING)	*t_e_async*, *t_e_ping*
Input current (CUBA)	nA	20 per spike	*input_scale*
CUBA weight std	nA	32	*W_STD_CUBA*
Max input rate	Hz	25	*max_rate_hz*
Population firing rate	Hz	20–80	*r_E*, *r_I*
Gamma frequency	Hz	30–80	*f_0*

COBA / PING biophysical constants

Used by COBA and PING. Values follow neuroscience conventions (cf. Dayan & Abbott, Gerstner *Neuronal Dynamics*); the E:I asymmetry in $\tau_m, C_m, g_L, \tau_{\text{ref}}$ produces the timescale separation that makes PING dynamics possible.

Parameter	E population	I population
τ_m (ms)	20	5
C_m (nF)	1.0	0.5

g_L (µS)	0.05	0.1
τ_{ref} (ms)	3	1.5
E_L (mV)	−65	−65
V_{th} (mV)	−50	−50
V_{reset} (mV)	−65	−65
E_e (mV, reversal)	0	0
E_i (mV, reversal)	−80	−80

Synapse time constants: $\tau_{\text{AMPA}} = 2$ ms (excitation), $\tau_{\text{GABA}} = 9$ ms (inhibition). These set the ceiling on PING's Δt-stability: once $\Delta t \gtrsim \tau_{\text{GABA}}$ the E→I→E loop cannot complete within one step.

Internal consistency

The chosen units are self-consistent — no conversion factors appear in the integration code. Two equations carry the whole system.

The membrane time constant is $\tau = C/g$. With C in nF and g in µS,

$$\tau_{[\text{ms}]} = \frac{C_{[\text{nF}]}}{g_{[\mu\text{S}]}}$$

so $C_m = 1$ nF and $g_L = 0.05$ µS give $\tau_m = 20$ ms directly.

The LIF voltage update is $\mathrm{d}v = (\Delta t/C)(-g_L(v - E_L) + I)$. With Δt in ms, C in nF, v, E in mV, g in µS, and I in nA,

$$\mathrm{d}v_{[\text{mV}]} = \frac{\Delta t_{[\text{ms}]}}{C_{[\text{nF}]}} \cdot I_{[\text{nA}]}$$

because ms · nA / nF = mV exactly.

Conductance-current products share the same ledger: $g(v - E)$ is µS × mV = nA, so synaptic currents fold into I alongside any direct input current without a scale factor.

Why not SI?

Pure SI (F, S, V, A, s) forces every value to a large negative exponent — $C_m = 10^{-9}$ F, $g_L = 5 \times 10^{-8}$ S, $\Delta t = 2.5 \times 10^{-4}$ s. The neuroscience convention (ms, mV, nF, µS, nA) keeps every typical value between 10^{-3} and 10^{2}, which makes numerical debugging and human intuition faster. The tradeoff is that readers have to trust the unit consistency rather than verify it by plugging into SI formulas — this page is here so that trust is auditable.