

## Tutorial 7.2

Simulated a circuit for 9 cases of connection matrices 3 seconds. For each circuit, added 20 units of current pulse during 1s - 2s, and tried initial firing rate: 0 Hz and 50 Hz for each unit.

### Q1

Time Series: Both units rise during the pulse. After the pulse, activity settles to  $r_1 \approx 5$  Hz,  $r_2 \approx 15$  Hz, regardless of initial state.

Phase Plane: Two trajectories converge to a single stable fixed point, indicating mono stability.

Interpretation: The network is robust to initial condition and input perturbation. No switching or oscillation.

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### Q2

Time Series: Firing rates stay at 0 Hz the entire time. Pulse insufficient to activate.

Phase Plane stuck at the origin.

Interpretation: Thresholds too high or weights too weak. Network is non-responsive under current stimulation.

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### Q3

Time Series: Depending on initial conditions, either unit 1 or 2 saturates at 100 Hz, and the other goes to 0.

Phase Plane: Two divergent trajectories ending at different edges of the state space.

Interpretation: Strong recurrent excitation + inhibition. Shows bistability or competition.

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#### Q4

Time Series: May stay flat at 0, or rise slightly and decay, depending on pulse strength.

Phase Plane: Either both converge to origin, or one moves slightly before returning.

Interpretation: Weak recurrent structure. May reflect a soft threshold filter, with partial bistability if perturbed.

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#### Q5

Time Series: Flat for all units. High thresholds + no feedback = zero output.

Phase Plane: Stuck at (0, 0).

Interpretation: Illustrates how thresholding + weak drive prevents any activity. Oscillations only occur with large initial firing rates.

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#### Q6

Time Series: Units 1 and 2 rise and hold; unit 3 suppressed or slowly decaying.

Interpretation: System shows asymmetric convergence, with some units active and others consistently off. Not multistable in practice, but may have hidden attractors.

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#### Q7

Units activate in a sequence, one after another, each inhibiting the previous.

Interpretation: Classic sequential pattern generator. Likely implements a heteroclinic chain, where activity never truly settles.

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#### Q8

Units 1 and 2 rise and stay at high values; unit 3 inactive.

Interpretation: System has a strong attractor. Highly stable output pattern, likely independent of initial condition.

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Q9

Time Series: Some units spike or climb slowly; others jump. Can vary per initial condition.

Interpretation: The system is metastable—tiny changes can lead to different final states.  
Borderline chaotic or high-dimensional attractor surface.































