Epileptiform activity generation by an ensemble of complete electronic FitzHugh-Nagumo oscillators connected by a sigmoid couplings

This work aims to show that the radioengineering generators able to demonstrate neural like activity can switch to the epileptiform behavior due to short time external driving if coupled using sigmoid function. The effect takes place for various number of elements. The particular coupling architecture and initial phase of external driving are of importance. The electronic circuit for modeling thalamo-cortical brain system as an ensemble of FitzHugh-Nagumo [1,2] neurons was developed and tested using SPICE emulation software.

\[ \epsilon \dot{u}_i(t) = u_i(t) - \frac{u_i^3(t)}{3} - v_i(t) + \sum_{j \neq i} k_{ij} h(u_j(t)), \]
\[ \dot{v}_i(t) = u_i(t) - b_i v_i(t) + a_i, \]
\[ h(u) = \frac{1 + \tanh(u)}{2}. \]

The scalability of the proposed technique was demonstrated for ensembles of 14, 28, and 56 elements. The dependence of length of transient processes following the driving termination on initial phase of external driving and connectivity matrix was studied. The constructed radioengineering circuits modeling thalamo-cortical system were shown to reproduce similar pathological regimes of brain activity despite different number of elements for various connectivity matrices and initial phases of driving.

This work was supported by Russian Science Foundation, grant No 21-72-00015, https://rscf.ru/project/21-72-00015/.

References