Principles of the Brain's communication network

and possible applications

Jont B Allen
UIUC Urbana IL, USA

September 30, 2022

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Abstract

The goal of this presentation is multi-fold:

- Summarize some basic facts about brain science
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± to zoom in/out

Neurons:

- Properties of
- The of the neuron has

- The brain's communication network is based on
- Each neuron is typically part of a large
- The brain contains an estimated 10^{11} (100 billion)
- Personal likes of

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input
  - an output and >
  - cell body
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKS OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKS OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± to zoom in/out

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKS OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs Cajal

Overview of Human brain

▸ ANATOMY, ▸ CORTEX, ▸ FACTS Use **CTRL**± to zoom in/out

Neurons:

- Properties of ▸ NEURONS
- The ▸ ANATOMY of the neuron has
  - an input ▸ DENDRITE
  - an output ▸ SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ▸ ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large ▸ NETWORKS OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) ▸ NEURONS.
- Personal lives of ▸ Golgi vs. Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKs OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKs OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKs OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs. Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKs OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs. Cajal

Overview of Human brain

ANATOMY, CORTEX, FACTS Use **CTRL**± TO ZOOM IN/OUT

Neurons:

- Properties of NEURONS
- The ANATOMY of the neuron has
  - an input DENDRITE
  - an output SYNAPSE, and a
  - cell body.
- The brain's communication network is based on ACTION POTENTIALS **(spikes)**
- Each neuron is typically part of a large NETWORKs OF NEURONS.
- The brain contains an estimated 10^{11} (100 billion) NEURONS.
- Personal lives of Golgi vs. Cajal

Helmholtz first measures spike propagation

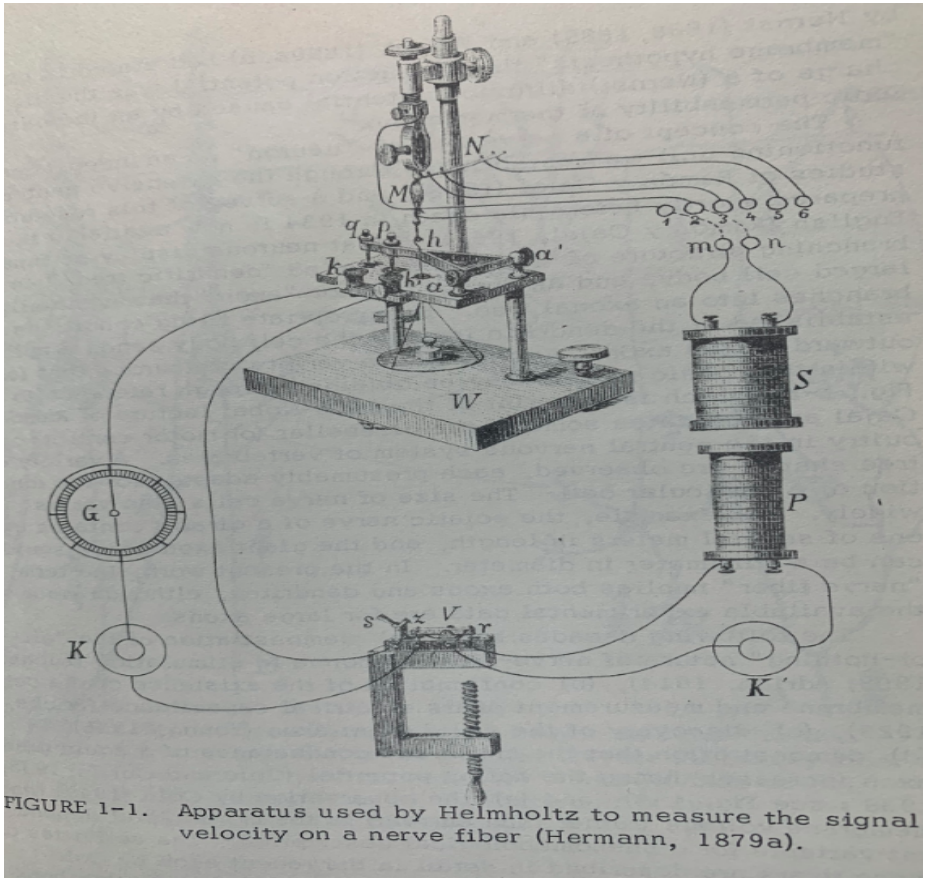


FIGURE 1-1. Apparatus used by Helmholtz to measure the signal velocity on a nerve fiber (Hermann, 1879a).

Figure: *Helmholtz' system for measuring neural spike speed in 1830*

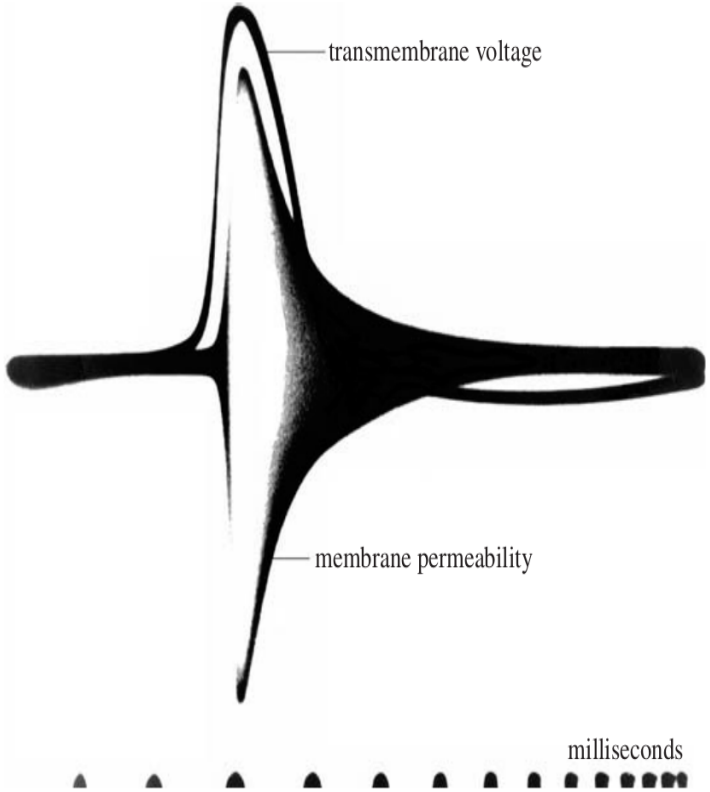
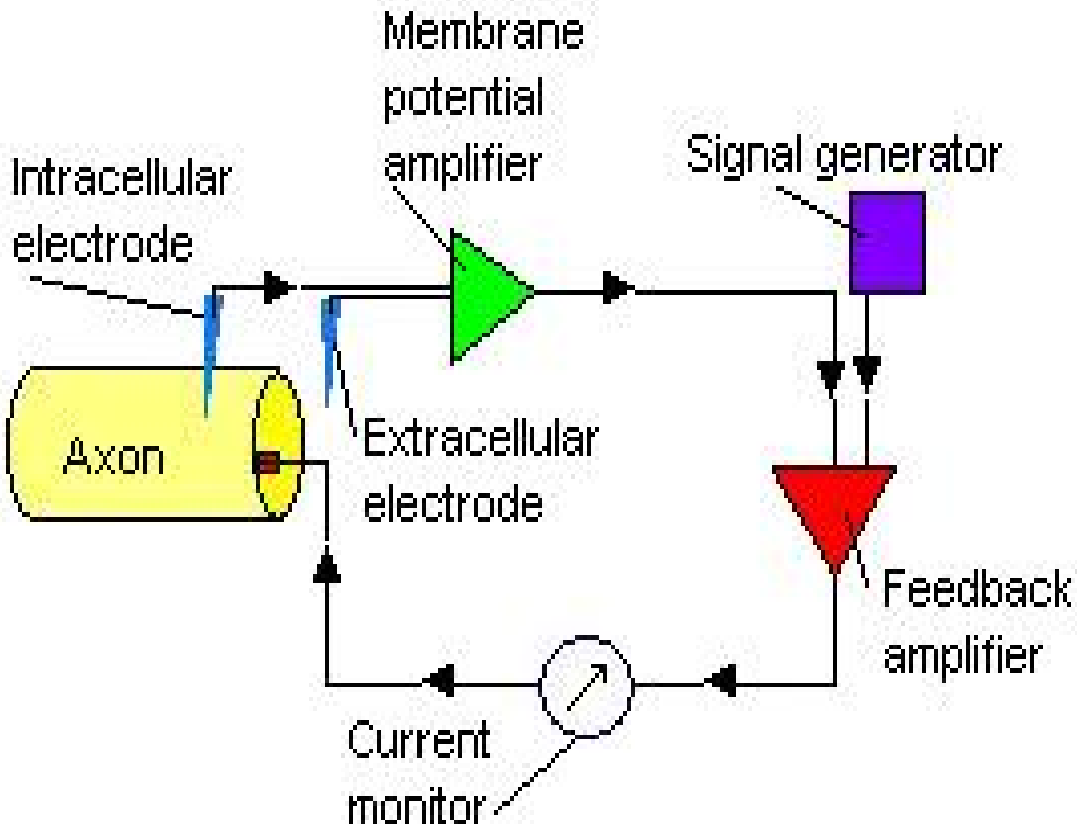


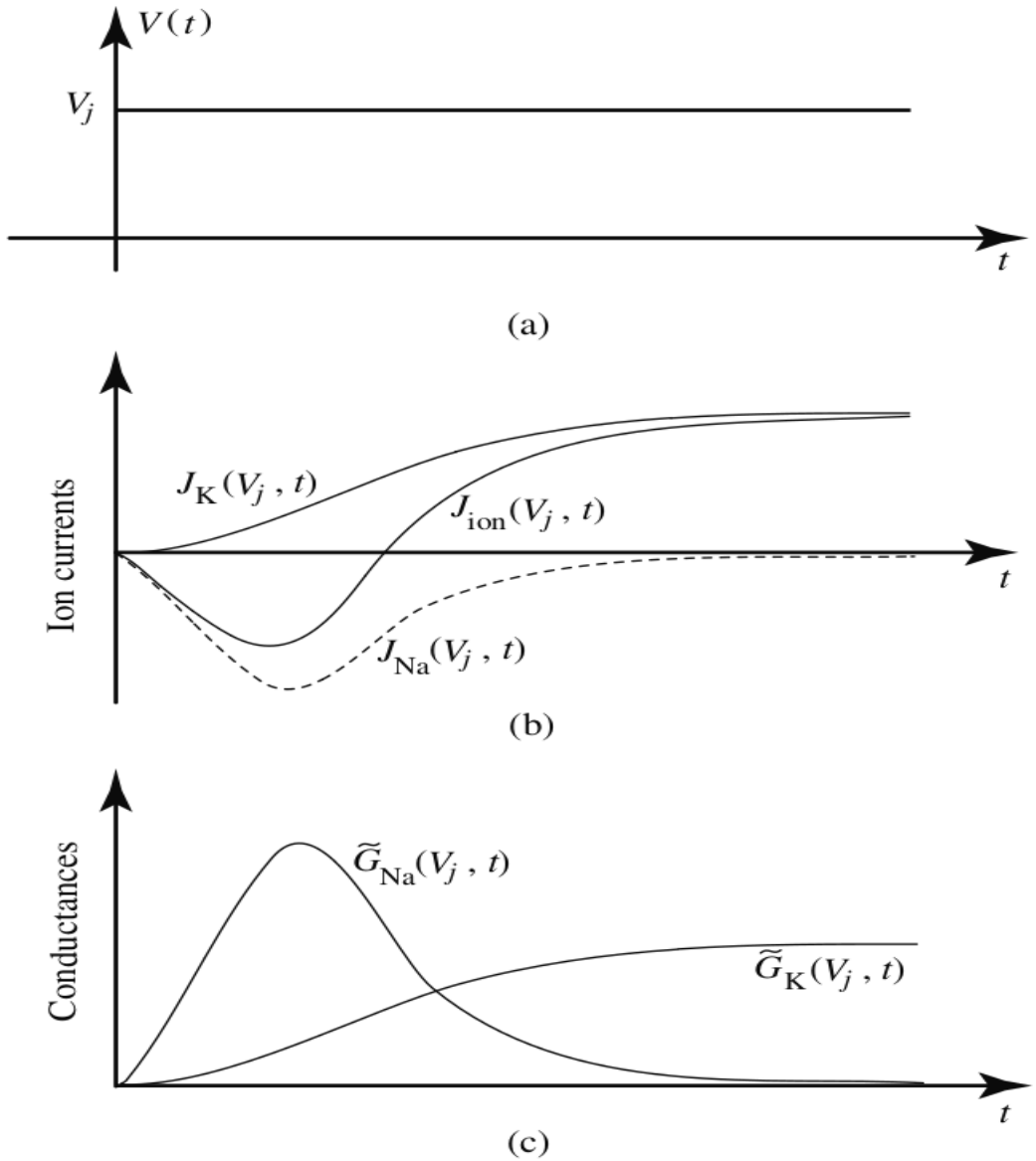
Figure 1.1. An early oscillogram of the change in membrane conductance (band) and membrane voltage (line) with time during the passage of a nerve impulse on a squid axon. (Time increases to the right, and the marks along the lower edge indicate intervals of 1 ms.) (Courtesy of K.S. Cole.)

Figure: First oscillogram of a neural spike.

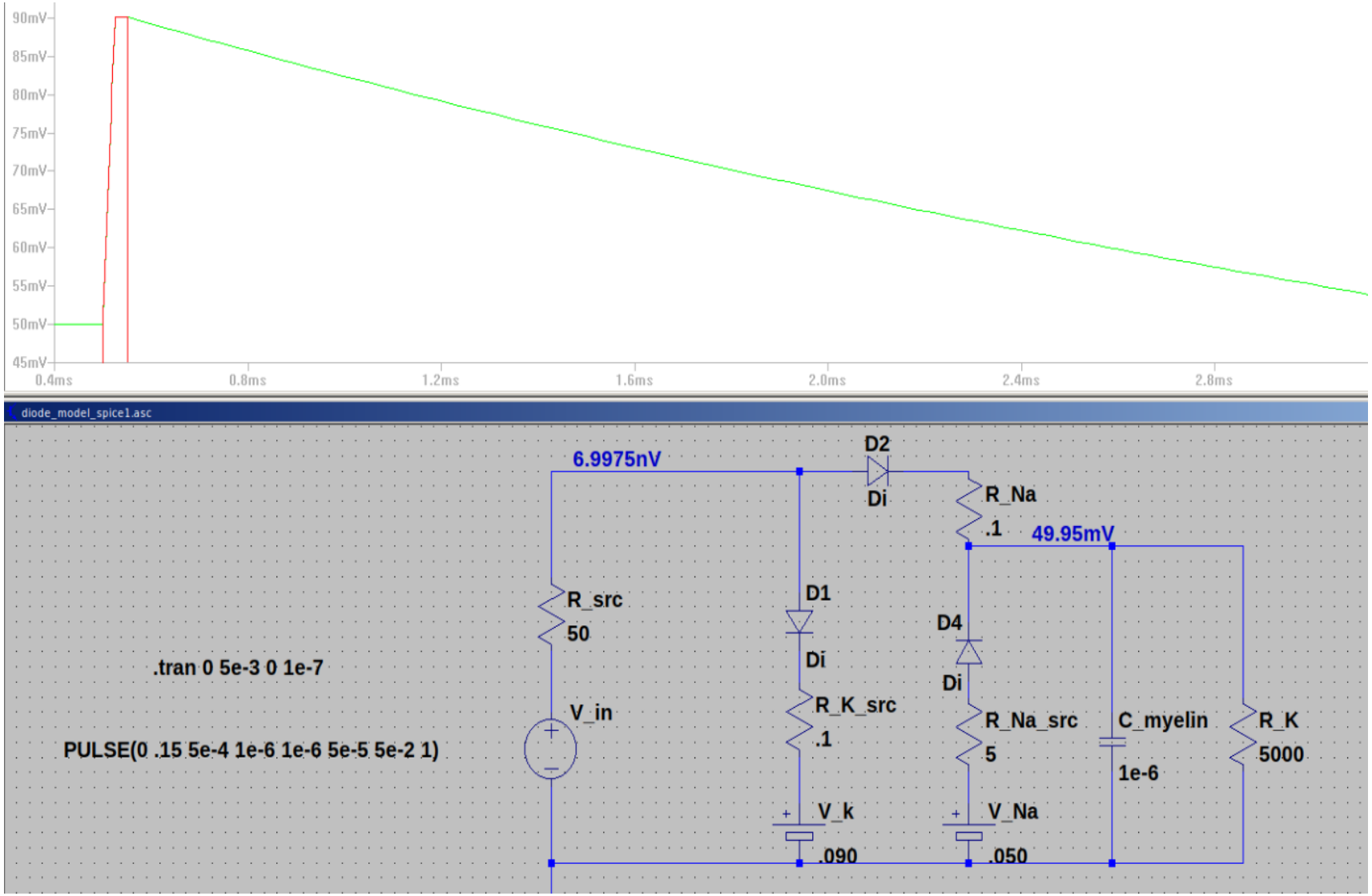
HH-50 voltage-clamp experiment on Squid nerve



HH-50 neural-clamp Results



3 Diode model of a neural spike



Conclusions

- Summary of the properties of NEURONs
- Gated channels: Na^+ K^+ Cl^-
- Neurotransmitter signaling: TYPES

Conclusions

- Summary of the properties of ▸ NEURONs
- Gated channels: ▸ Na^+ ▸ K^+ ▸ Cl^-
- Neurotransmitter signaling: ▸ TYPES

Conclusions

- Summary of the properties of ▸ NEURONs
- Gated channels: ▸ Na^+ ▸ K^+ ▸ Cl^-
- Neurotransmitter signaling: ▸ TYPES

Bibliography

Copies of my documents

https://jontalle.web.engr.illinois.edu/Public