Circuit and Coil design for *In Vitro* Magnetic Neural Stimulation

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Magnetic Stimulation

- Advantages
  - Neural excitation without electrode implants
  - Bio-compatibility
  - Bio-resistance
- Operational Bio-toxicity
- Penetrates tissue without being attenuated because of the permeability of low frequencies

Reduce scale of the system

- Study histological effects of Magnetic stimulation
- Investigate pulse effects on nerve growth
- Selective stimulation
  - Neural tissue closer to coil
  - Reducing high power and energy required for stimulation

In Vitro System

- In Vitro studying useful for studying localized gene regulation
- Control and isolation of experimental variables
- Provide insight to contradictory information from arrays of electrical fields in magnetic stimulation experiments

Determining Requirements

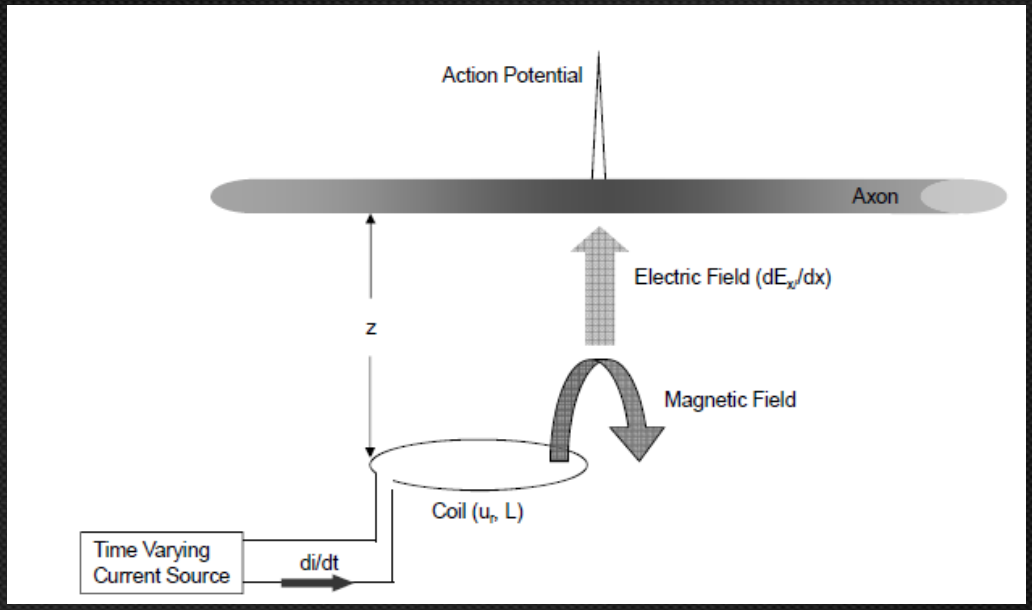
- Passive cable model

$$\lambda_m{}^2 \frac{\partial \vec{E}_x(x,t)}{\partial x} = -\lambda_m{}^2 \frac{\partial^2 V_m(x,t)}{\partial x^2} + \tau \frac{\partial V_m(x,t)}{\partial t} + V_m(x,t) \quad (1)$$

  - Used for experimental controls
- Trans-membrane voltage (Vm) is set to zero it become the Activation function

Activation Function

- Determines the initial change in Vm
- Determines the change in electric field
- Generated by coil stimulation with time varying current

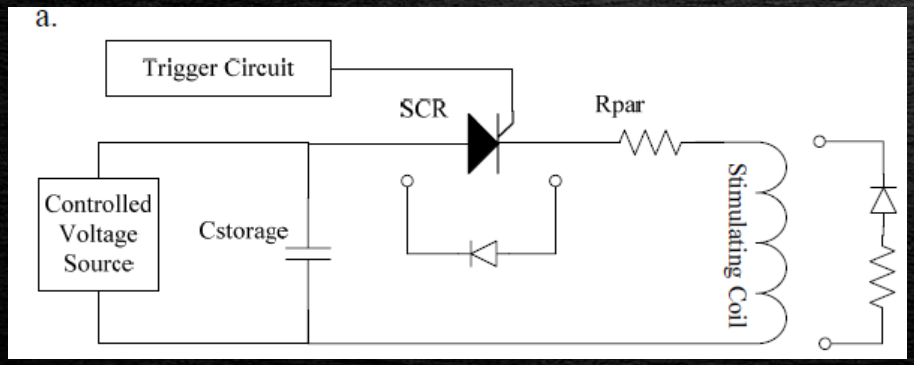


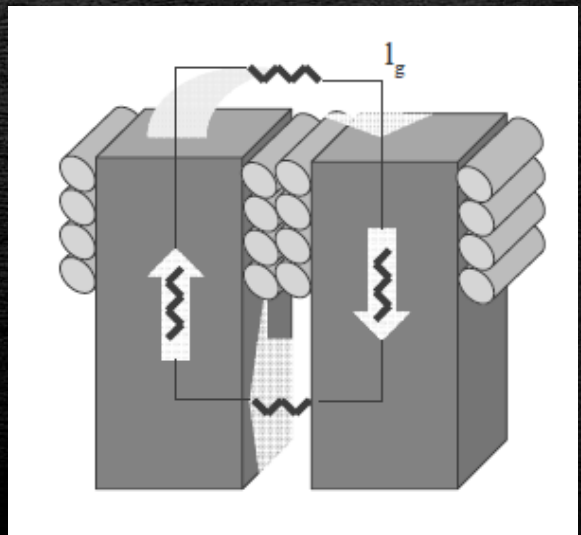
Coil

- Air core iron coils
- Can be sealed and isolated from target tissue
- Energy require and area of effect increases as coil moves further from tissue
- Inductance varies pulse width
- Spatially varying electrical fields generated from a sinusoidal pulse
  - Demonstrates waveform shape impacts strength duration response and energy requirements for stimulation

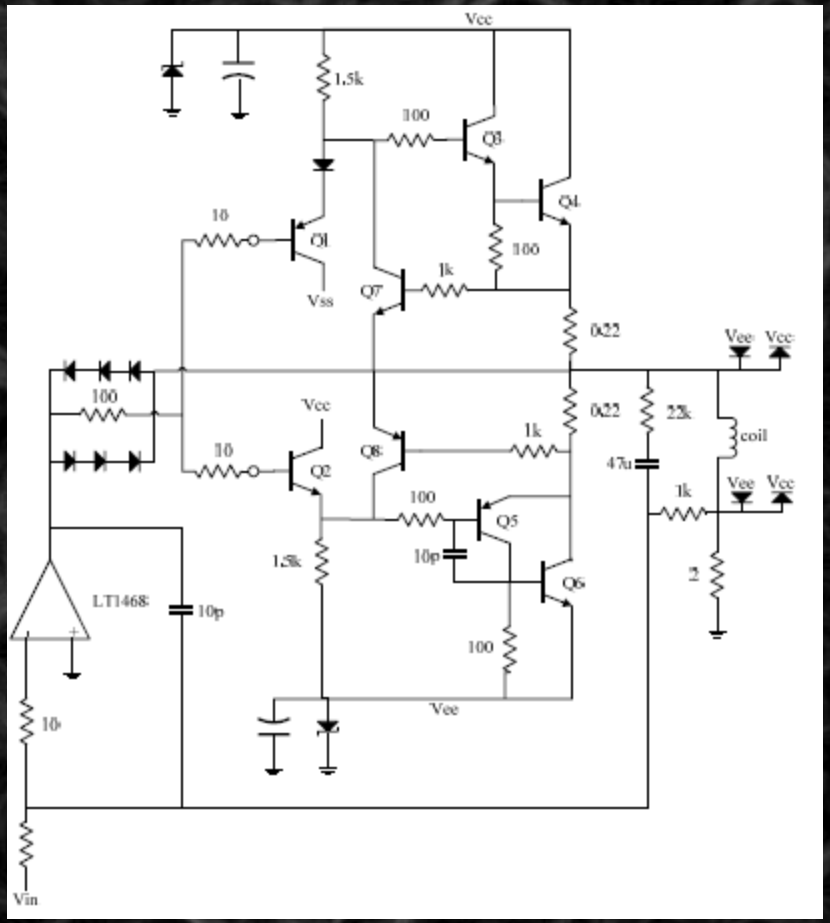
Current Ramp

- Produces a linear current ramp making a uniform magnetic field
- Created by Thyristor or Sawtooth current driver
- Pulse shape determined by capacitor and coil
- Sawtooth current driver chosen
  - Low current when flux increase





Experiment



- Testing done on unmyelinated nerves of crayfish
- Transistors control linearity of waveform
- Edge of wave form must be short
  - Prevent hyperpolarization on neural membrane

Results

- Frequency range for magnetic stimulation pulse operation at 200Hz- 1Mhz
- Passive cable model used for controlling requirements
- Coil used for stimulation
- Current ramp used to generate a uniform magnetic field

Implementation

- Brain and nerve stimulation
- Circuit can be used for magnetic cell sorting
- Scaling can be used to study brain tissue and retina