Product Design Specification (PDS)

Multichannel Brain Tissue Stimulator Project – April 27, 2006
Team Members - Roles

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Function
In order to stimulate neurons in a more realistic manner, a controller device is needed to independently control current on 16 electrodes in a multiple-electrode array. The device must use parallel logic from a computer to control the current. The device must be isolated from electrical noise so the measurements are accurate.

Client Requirements

- The device should take a signal from a 16-bit analog to digital converter using a 25-pin parallel connection.
- As the parallel logic data bits are turned on and off, current on the corresponding electrode should be turned on and off. There should be very small lag time.
- The device must be isolated; electrical noise (60 Hz) must be minimized.
- There should be an independent gain adjustment for each channel; the current available on each channel should be adjustable between 0.1 to 10 mA.
- When the data bit is turned on, the corresponding electrode should get a square pulse of current with a very fast rise time. When the data bit is turned off, the current should stop almost immediately.
- The square pulse should have a time length of 25 to 200 microseconds, controlled with the computer.
- The impedance of the electrodes is between 0.2 and 1.2 MOhms on each channel. The top end of this impedance range has been decreased significantly due to a technique known as "electrode activation." This technique is described in detail in the body of this report.

Design Requirements

1. **Physical and Operational Characteristics**
    - **a.** *Performance requirements:* See client requirements.
    - **b.** *Safety*: As with any device using electricity, the risk of electrical shock is always present. However, in our case this risk is especially great because we will be working with very high voltages and supplying direct current to electrodes. The finished prototype

needs to be fully enclosed to prevent accidental shock, and the connection to the electrodes should be secure. The device should use several fuses to ensure that electrocution does not occur. Additionally, care needs to be taken during the design and testing stages of the project, to prevent electrical shock before safety features are in place.

- **c.** *Accuracy and Reliability*: Each of the 16 channels must be capable of consistently producing the current desired by the operator. The operator may choose from a series of current options which vary by 0.1 mA increments from 0.1 mA to 1 mA. Therefore, the device should supply a current that is accurate to within 0.01mA of the set current.
- **d.** *Life in Service:* Although the device is unlikely to be used in such a manner, each channel must be able to produce a steady current for several hours at a time. In addition, the device must be able to withstand daily use for a minimum of 10 years.
- **e.** *Shelf Life:* If stored in a dry, clean area of a moderate temperature, the device may be stored for many years without causing damage. If batteries are used as a power source, they should be removed before storage for long periods of time and replaced when the device is returned to operation.
- **f.** *Operating Environment:* The device will not be subjected to very strenuous conditions. It will be kept in a dry, room temperature, laboratory setting and will not often be moved from one place to another. It should be kept clean and as dust free as possible to avoid interference with the circuitry. Only the electrode will be subjected to fluids and organic material and therefore may need to be replaced periodically.
- **g.** *Ergonomics:* The device should be designed such that it is as easy as possible to operate. Any dials and buttons should be clearly labeled in a font that is easy to read and should require minimal force to adjust.
- **h.** *Size:* The prototype should be easily contained in a laboratory setting. The voltage supply component of the design is enclosed in a steel case. The gating and current supply circuitry will be enclosed in metal enclosure that can be mounted in a standard-sized test equipment rack.
- **i.** *Weight:* Because the device will be installed in a laboratory, weight is not a big issue. It should not be prohibitively heavy so as to make the rack that it is mounted on unstable, but great care need not be taken to design a light-weight prototype.
- **j.** *Materials:* The materials used in the device will mostly be electrical components. The voltage supply and isolation circuitry will be housed in a steel enclosure to prevent capacitive coupling between the high levels of AC voltage within and the sensitive laboratory equipment in the rest of the lab.

k. *Aesthetics, Appearance, and Finish:* While the appearance of the device is relatively unimportant, it would be preferable to have the finish of the prototype match similar finishes on other devices used in the lab for aesthetics.

2. Production Characteristics

- **a.** *Quantity:* A single prototype is expected. If this prototype is effective, more devices may be constructed.
- **b.** *Target Product Cost:* No set ceiling for project cost was set. It is probable that the net cost will be relatively low compared to commercially-available multielectrode stimulator devices.

3. Miscellaneous

- **a.** *Standards and Specifications:* As the research is preformed in vitro minimal guidelines and restrictions apply. However, because samples are obtained using sacrificed rodents animal research ethics and restrictions apply. Federal Restrictions:

  Very general guides:
  - USDA-Animal Welfare Act
  - U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training

  More specific guidelines:
  - National Research Council publishes the Guide for the Care and Use of Laboratory Animals
  - AAALAC (American Association for Accreditation of Laboratory Animal Care) accredits institutional compliance with the Guide

- **b.** *Customer:* The customer had some specific requests that are also common similar commercially available stimulus generators:
  - i. The device should take standard TTL signals from a 25DIN connection as the signal input.
  - ii. Current should be in an “On” or “Off” position with a very small rise time (~10 μs).
  - iii. Stimulus must have all 60Hz noise removed. It was suggested to do this by separating the supply voltage from a land line voltage via batteries or DC/DC converters. Additionally, no additional electrical noise should be introduced into the system or the surrounding lab because of the prototype.
  - iv. Independent current amplitude control (exact current range has yet to be determined)
  - v. The length of the square pulse should be able to hold 25-200 μs, controlled by a software program on an Apple computer in the lab.
- **c.** *Patient-related Concerns:* This stimulus generator will be used specifically on rodent neural tissue segments *in vitro*. As a result

typical safety and comfort concerns are most likely negligible. However, the generator should be designed with the user in mind in that, their will likely be researchers and expensive equipment (microscopes, computers, etc.) in proximity of the generator and electrodes. Care should be taken to prevent shock to these researchers and equipment.

d. *Competition:* There are various commercial variations capable of creating the stimulus our client requires. However, all commercial variations are capable of much more then a simple “on”, “off’ pulse and this increases their cost significantly. In addition many commercial products are designed to operate *in vivo* which requires additional circuit control to prevent electro-metal plating. Commercial stimulus generators also are usually capable of recording in addition to stimulating. The excessive amount of hardware and capabilities leads to a cost that places most stimulus generators out of reach for the common research laboratories. Two stimulus generators can be found:

http://www.a-msystems.com/physiology/Instruments/Model3600/default.aspx

http://www.alascience.com/products/mcs_stg2000.html