# Team Project: Developing and testing a CES device simulator[1]

Due Sun Dec 5th at 11:59pm

Team work submitted individually on Brightspace as a tar or zip file named teamX.tar or teamX.zip, where X is your team number. **Mandatory demos** will be **individual** the week of Dec 6th. The scheduling details will be announced the week before and the demo times will be arranged between you and your assigned TA. You are encouraged to check your progress on a weekly basis with myself and the TAs. Do not wait until the last minute.

The goal of this project is to develop and test a simulator for embedded software used in Cranial Electrical Stimulation (CES) devices similar to the Alpha-Stim and OasisPro products described below.

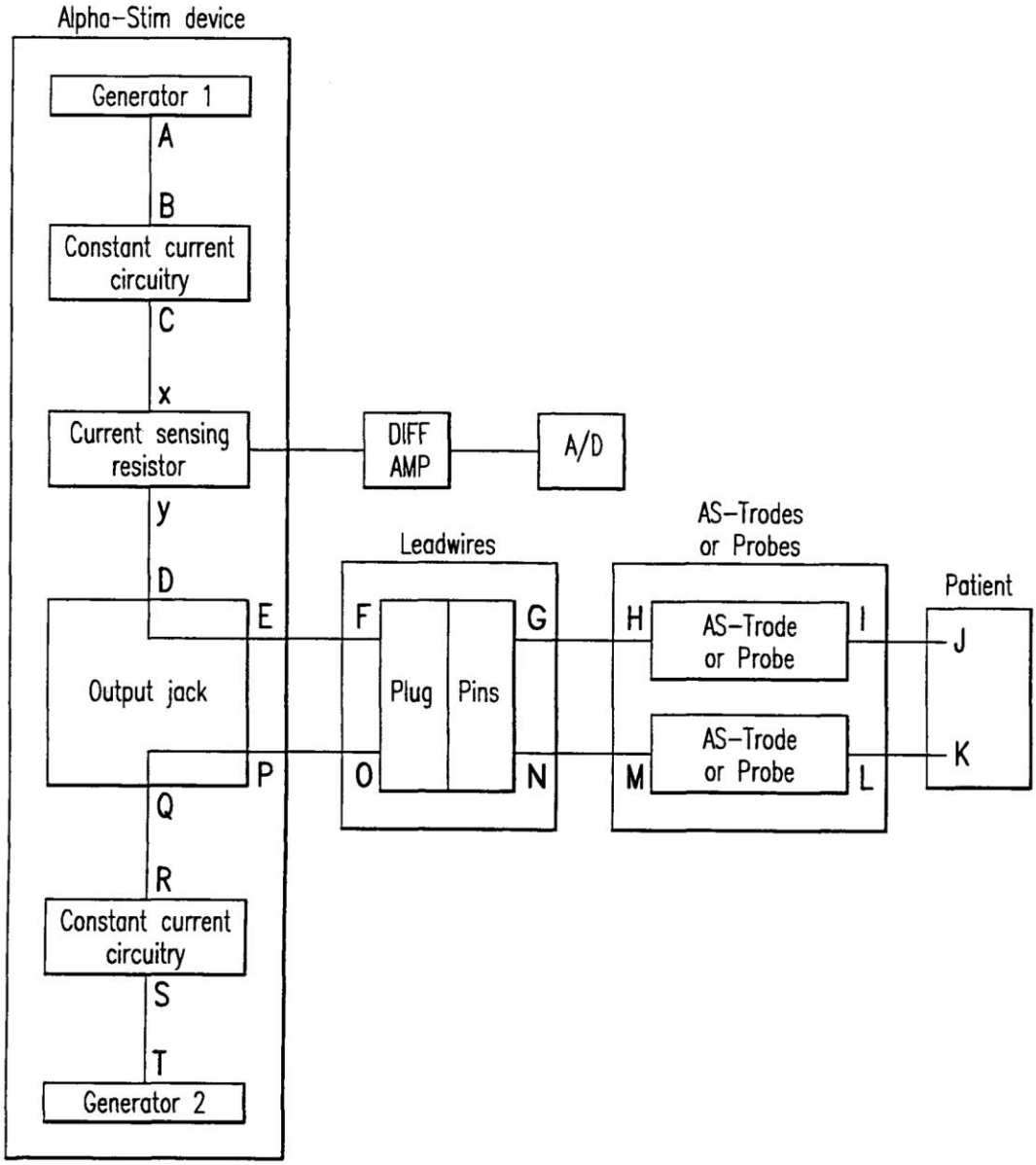
A CES device is a non-invasive neuro-stimulation medical device that delivers microcurrent via an electrode through the earlobes to stimulate the brain for the purpose of therapeutic intervention. The implementation and testing are to be in C++ using the Qt framework on the COMP3004-F21 VM which has the Qt Creator IDE installed.


The Alpha-Stim CES device

[1] This project has been inspired by conversations with Igor Radonjić who wrote the background material.

For purposes of this assignment you can assume a hardware layout similar to that of the Alpha-Stim presented below.

Alpha-Stim Hardware Block Diagram




For details of Alpha-Stim AID operation refer to the owner's manual on Brightspace (AS-AID-Owners-Manual.pdf).

What needs to be simulated?

1. ON/OFF switch
2. Continuous circuit check when electrodes are in contact with the skin indicated by a test circuit symbol that shows contact ON (connected) or OFF (disconnected). If skin contact is lost during treatment for less than 5 seconds treatment resumes, otherwise, treatment stops. Loss of skin contact is shown by the indicator changing from ON to OFF.
3. Three frequency options of 0.5Hz, 77Hz and 100Hz.
4. Three wave form options Alpha, Betta and Gamma.
5. 20, 40 or 60 minute countdown cycles.
6. Large timer display. Treatment starts when electrodes touch skin.
7. 0 - 500 microampere current control in 100 microampere increments (1-10).
8. 30 minute auto - off when not in use.
9. Battery charge indicator: device issues a warning at 5% charge and shuts down at 2% after issuing another warning.
10. Recording: user can choose to record a therapy and add to history of treatment. Assume only a single user. Therapy information to be recorded: Waveform, frequency, start time, duration and power level (if changed during therapy choose last selected power level).
11. Automatically and permanently disables itself should a single fault develop within the device causing the current to exceed 700 µA.

Your deliverable should include the following:

1. Readme that includes the following:
    - Team number and member names.
    - Who did what in the project.
    - File organization of the deliverables.
    - Tested scenarios: ones that work and ones that don't.
2. A use case model based on given information about CES devices using the provided videos and manuals. A use case model includes use cases and the use case diagram. Name each use case, e.g. UC1, UC2, so that it can be referred to.
3. An OO Design model using UML Class, Sequence, Activity (if applicable) and State (if applicable) diagrams. For each design diagram identify which use case or use cases it is intended to realize. Your design models should include the Qt elements you used.
4. Source files for your implementation.
5. Tests and traceability matrix from use cases to tests.

For all of the above diagrams refer to the agile modeling link on cuLearn (http://agilemodeling.com/), specifically "Artifacts -> Introduction to UML 2.x".

Background on CES Technology

Cranio-Electro Stimulation (CES) is a form of non-invasive electrotherapy proven to effectively treat conditions such as insomnia, anxiety, depression, as well as alleviate pain and improve cognition.

CES devices achieve this by delivering small electrical impulses, via small clips worn on the earlobes, through the brain to stimulate and modulate specific regions of neurons. The microcurrent is tiny, just millionths of an ampere, and so gentle that most people hardly feel it. The brain naturally produces electrical currents within this range.

There have been over 200 studies and decades of research proving the efficacy of CES, which has outperformed conventional antidepressants with no reported negative side effects.

Although there are various theories as to how exactly CES works, qEEG (quantitative electroencephalography), also known as brain mapping, suggests CES electrical waveforms modulate cells' signals to return to baseline, that is normal functioning, serving as a kind of neural reset. CSF (Cerebrospinal fluid) analysis has also shown increased levels of neurotransmitters such as serotonin and endorphins which form the basis of drug therapy in the aforementioned conditions.

CES uses pulsed alternating current (AC) waveforms of up to 5 mA within a frequency range of approximately 0.5-to-500 hz. The polarity of these electrodes is irrelevant, meaning they can be placed on either temple and still produce the stimulation results desired by the wearer.

The most popular and researched frequencies are 0.5 and 100hz. However, the frequency is secondary to the overall effect of CES, as both frequencies produce similar results.

The market leader for CES devices is the Alpha Stim AID device. It uses a preset frequency of 0.5hz.

https://www.alpha-stim.com/

Another device presented here for reference is the Oasis pro which is made by a Canadian company. It uses multiple frequencies and is programmable by the user.

https://mindalive.com/products/oasis-pro

For more information on CES, explore the listed websites:

https://mindalive.com/pages/cranio-electro-stimulation-ces

https://www.alpha-stim.com/healthcare-professionals/clinical-research/

Documentary on Alpha-Stim technology:

https://www.stress.org/thebrainelectric