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DESIGN AND IMPLEMENTATION OF OUTPUT CURRENT SOURCE CIRCUIT FOR NEUROMUSCULAR FES DEVICE

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ABSTRACT

Spinal Cord Injury (SCI) causes a great discomfort and misery to human life. Loss of communication between the brain and the muscles is the main reason of such misery and discomfort. Functional electrical stimulator (FES) device is typically used to restore the muscle function by producing stimuli in the form of current through electrodes which are strapped on the patient's skin. The FES device mainly consists of a digital controller, a Digital to Analog Converter (DAC), an interface circuitry and electrodes. The digital controller (Microcontroller/ FPGA) processes the stimulus parameters to generate arbitrary stimulus pulse. The DAC converts the digital output data from the controller into an analogue signal before it is transferred to the interface circuit. Constant Voltage Source (CVS) and Constant Current Source (CCS) are the two main types of interface circuits. However, the CCS is preferred over the CVS due to safety and easy maintenance. For the CCS, an output current source circuit is required to amplify and transfer the generated current from the DAC to the electrodes. In the simulation circuit, the DAC0800 was used while the Digilent PmodR2R DAC was used for hardware measurement. A few types of CCS output source circuits were focused in this project such as Monophasic, Howland current pump and Improved Howland output source. Proteus Design Suite software was used to design and simulate the output source circuits. The, hardware circuitries were developed and connected to an FPGA board for output current generation and measurement purpose. Several output currents were measured across three ranges of resistive output loads (500, 1k and 2k ohm). In the simulation, it was found that lower resistive load produces higher output current. Improved Howland circuit generated output current in the range of 7 – 15mA. Howland charge pump circuit generated output current in the range of 5 -15mA. The monophasic circuit produced output current around 4 – 11mA. In the hardware measurement, the monophasic output current source circuit generated output current in the range of 21 – 26mA while the improved Howland output circuit generated output current around 1mA only. The Howland charge pump circuit was observed and could not produce any output current at all during the hardware measurement. Additionally, the designed CCS circuits were also used to validate the digital controller (FPGA) functionality in generating a few arbitrary stimulation waveforms.

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