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A VLSI BASED MEDULLA SPINALIS USING ANALOG COMPARATOR

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ABSTRACT

Spinal cord injury results loss of mobility causes a dramatic increase in the physical effort required to perform daily tasks and severely affects an individual's quality of life. A neural prosthesis for restoring locomotion must simultaneously control multiple joints in the lower extremities to ensure proper force production and limb movement. Neural pathways can be artificially activated through the use of electrical stimulation. For individuals with a spinal cord injury, intraspinal micro stimulation, using electrical currents on the order of 125 A, can produce muscle contractions and joint torques in the lower extremities suitable for restoring walking. Low power circuit designs are mostly required for microchip to avoid performance degradations and accurate signal generation. Here we proposed Analog Comparator in mixed signal circuit by enabling push pull capacitance activation that reduces switching activity of analog components.

INTRODUCTION

1.1 SPINAL CORD INJURY

occur at any level of the spinal cord and can be classified as *complete injury*, a total loss of sensation and muscle function, or *incomplete*, meaning some nervous signals are able to travel past the injured area of the cord. Depending on the location and severity of damage along the spinal cord, the symptoms can vary widely, from pain or numbness to paralysis to incontinence[1]

The prognosis also ranges widely, from full recovery in rare cases to permanent tetraplegia (also called quadriplegia) in injuries at the level of the neck, and paraplegia in lower injuries. Complications that can occur in the short and long term after injury include muscle atrophy, pressure sores, infections, and respiratory problems[2].

In the majority of cases the damage results from physical trauma such as car accidents, falls, or sports injuries, but it can also result from no traumatic causes such as infection, insufficient blood flow, and tumors[3]. Efforts to prevent SCI include individual measures such as using safety equipment, societal measures such

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as safety regulations in sports and traffic, and improvements to equipment. Known since ancient times to be a catastrophic injury and long believed to be untreatable, SCI has seen great improvements in its care since the middle of the 20th century. [4]

Treatment of spinal cord injuries starts with stabilizing the spine and controlling inflammation to prevent further damage. Other interventions needed can vary widely depending on the location and extent of the injury, from bed rest to surgery. In many cases, spinal cord injuries require substantial, long-term physical and occupational therapy in rehabilitation, especially if they interfere with activities of daily living. Research into new treatments for spinal cord injuries includes stem cell implantation, engineered materials for tissue support, and wearable robotic exoskeletons [5].

PROPOSED MODEL

4.1 Introduction

The resulting loss of mobility causes a dramatic increase in the physical effort required to perform daily tasks and severely affects an individual's quality of life. A neural prosthesis for restoring locomotion must simultaneously control multiple joints in the lower extremities to ensure proper force production and limb movement. The two main approaches, exoskeleton systems and functional electrical stimulation (FES), have had varying levels of success with functional improvement dependent on the severity of the injury. For example, an individual with an incomplete SCI may have limited neural communication to their lower limbs and may benefit from an assistive FES device which augments the existing function. An individual with a complete SCI will have minimal-to-no neural communication and requires a device such as a walking exoskeleton to provide trunk support and motor control .When electrically stimulating muscles, the distance the individual can walk is directly correlated to the fatigability of the target muscles and the muscle's ability to produce controlled force. If the muscles fatigue quickly, the individual would need to rest after walking short distances until the muscles recover.

By targeting fatigue resistant muscle fibers, walking movements and forces can be produced over longer durations before the individual must rest and recover. ISMS is one solution for activating muscles in such a manner, as the elicited movements tend to be fatigue resistant since the slow-twitch fibers are recruited first in a biofidelic manner . ISMS electrically activate neural pathways in the spinal cord to produce forces and movements adequate for walking. Micro wires (m diameter) are inserted into the ventral horn of the spinal cord, which electrically activate lower limb muscles with low stimulation currents (A). Other peripheral nerve stimulation methods require much greater stimulation amplitudes.

To activate quadriceps muscles require up to 220 mA. Intramuscular stimulation (IMS) activates motor neurons which innervate the target muscles, where 20–50 mA stimulation amplitudes can produce walking forces and movements. This is comparable to the stimulation involved in intracortical micro stimulation. This low ISMS current amplitude is advantageous for designing a low power, integrated

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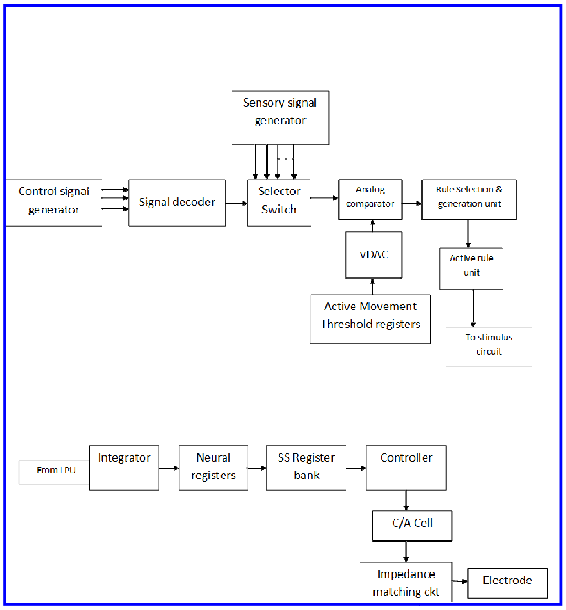
system to produce and control walking movements. A suitable control strategy is also required to coordinate these Multi-joint movements. Previous work utilized IF-THEN rules in a state-space control strategy to produce over-ground walking a cat model of SCI.



Control signal generator:

To generate 3bit code for ankle or leg or hip movement control code. It applies input to select desired action. (000 – 111). A signal generator is an electronic device that generates repeating or non-repeating electronic signals in either the analog or the digital domain. It is generally used in designing, testing, troubleshooting, and repairing electronic or electroacoustic devices, though it often has artistic uses as well.

There are many different types of signal generators with different purposes and applications and at varying levels of expense. These types include function generators, RF and microwave signal generators, pitch generators, arbitrary waveform generators, digital pattern generators and frequency generators. In general, no device is suitable for all possible applications.

Traditionally, signal generators have been embedded hardware units, but since the age of multimedia PCs, flexible, programmable software tone generators have also been available

Signal decoder:

To generate signals with specific amplitude and frequency. In coding theory, **decoding** is the process of translating received messages into code words of a given code. There have been many common methods of mapping messages to code words. These are often used to recover messages sent over a noisy channel, such as a binary symmetric channel.

Analog switches:

Convert binary code analog voltage to trigger sensory process.

Threshold registers:

It holds predefined voltage representation for particular movement control signals

VDAC: converts digital voltage representation to analog. Its consists of cascaded capacitor networks for charging and discharging

Comparators:

A Comparator is a device that Compares decoded bit selection with predefined voltage to generate required signal.it also compares two voltages or currents and

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outputs a digital signal indicating which is larger. It has two analog input terminals.

4:16 decoder:

It generates control bits to enable or disable a particular movement. In digital electronics, a **binary decoder** is a combinational logic circuit that converts a binary integer value to an associated pattern of output bits. They are used in a wide variety of applications, including data demultiplexing, seven segment displays, and memory address decoding.

There are several types of binary decoders, but in all cases a decoder is an electronic circuit with multiple data inputs and multiple outputs that converts every unique combination of data input states into a specific combination of output states. In addition to its data inputs, some decoders also have one or more "enable" inputs. When the enable input is negated (disabled), all decoder outputs are forced to their inactive states.

Depending on its function, a binary decoder will convert binary information from n input signals to as many as 2^n unique output signals. Some decoders have less than 2^n output lines; in such cases, at least one output pattern will be repeated for different input values.

A binary decoder is usually implemented as either a stand-alone integrated circuit (IC) or as part of a more complex IC. In the latter case the decoder may be synthesized by means of a hardware description language such as VHDL or Verilog. Widely used decoders are often available in the form of standardized ICs.

Integrate and fire:

Connect front end circuit with sensory circuit to activate ff /fb stimulus. The integrate-and-fire neuron is a prime example of describing a neuron based on its membrane potential and has been studied mostly by mathematical methods. In fact, the integrate-and-fire model was one of the first neuronal models to be studied. After looking at the data from his experiment, he introduced a model of the nerve that is based on a simple capacitor circuit. Later scientists built upon his concept and used mathematical methods to analyze the action potential spike that is generated once the neuron is stimulated manually or by synaptic input from presynaptic neurons. The study of these neurons is useful in modeling phenomena in the fields of neurology, physiology, and psychology.

Stimulus register bank:

Holds and shift action sequences generated by frond end circuit.

Anode and cathode unit:

Interface stimulus signals with spinal chord

RESULTS AND DISCUSSIONS

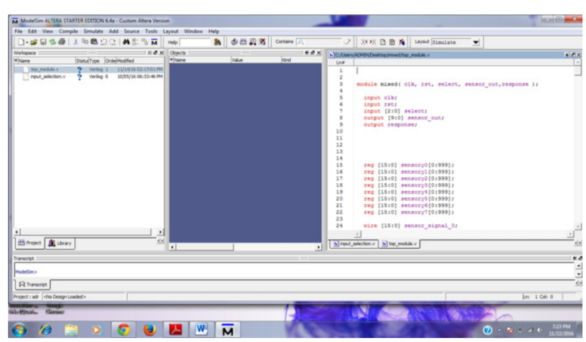

Fig 5.1 Input command window

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In this we are applying the input and we are checking for the error in it by compiling the program

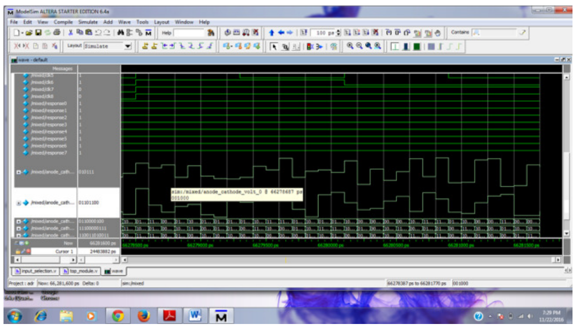

Fig 5.2 output Command window

This output command window will give the appropriate movement for each input. And this approximately select the particular movement for the given input

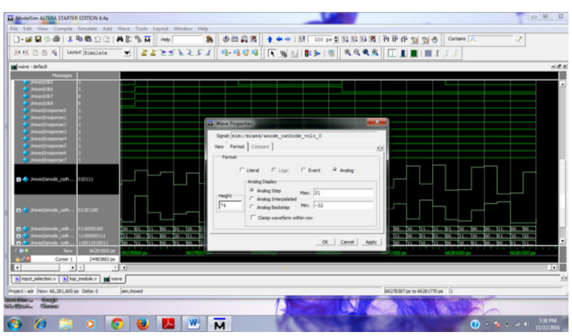

Fig 5.3 output with voltage Image

This explains the appropriate voltage for the appropriate leg movement by selecting the anode cathode voltage in which it shows the appropriate voltage for the leg movement

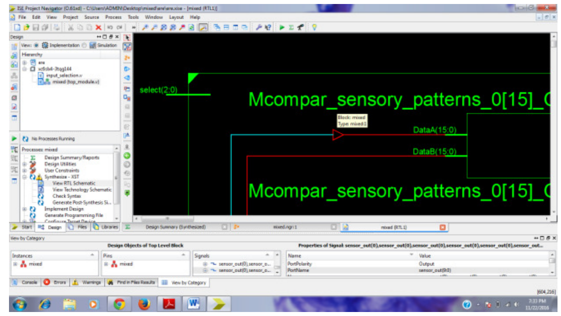

Fig5.4 Diagram of comparator sensory patterns

This is the synthesis diagram for mixed signal system. In a Xilinx we select synthesis design and in that select view RTL schematic and double click it and view the synthesis diagram.

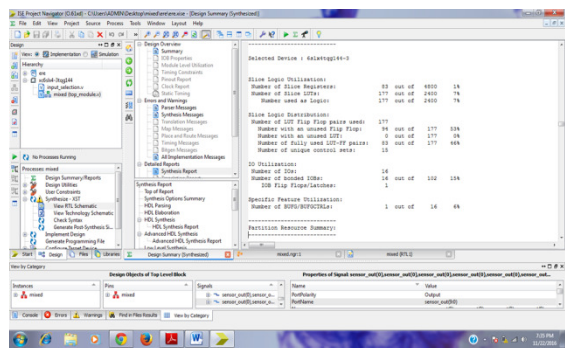

Fig 5.5Calculation of Area in Xilinx

Here we calculate the Area in Xilinx and it tells the total area occupied by the signal

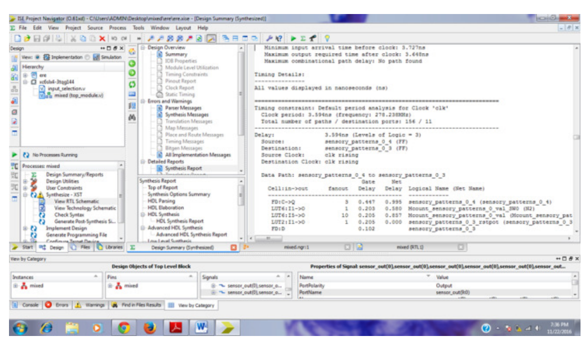

Fig 5.6 Delay calculation

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Here we are calculating the delay for each clock .It is the delay calculation for Clock 1

CONCLUSION AND FUTURE WORK

These results demonstrate how the LPU can realize state-based systems for producing temporally adapting stimulation patterns. For restoring walking, the outputs displayed in this device provide a reconfigurable platform for realizing different control strategies with the appropriate state transition rules and sensory inputs. The architecture of the LPU produces programmable current stimulation outputs in parallel while temporally modulating the Activity using external sensory signals along with an intern altiming signal. The configurability of the LPU provides the experimenter with resources to produce different walking "programs" which could potentially implement different modes of locomotion (e.g., running, walking, standing, hopping, etc.).Most existing microcontrollers or microprocessors have the ability to implement the designed control strategy; however they are limited in the number of DACs and ADCs on chip for digitizing the external analog sensors and producing current stimulation. One other limitation is that they will have to implement the stimulation output in a serial fashion by scanning from output electrode to output electrode. By using an array of integrate and fire neurons, the LPU is capable of producing the stimulation patterns in parallel and asynchronously from the control logic state machine. This allows for removing any delay times in the control logic from affecting the neural stimulation patterns In future we can implement the above system with Real time application .By doing we can reduce the power consumption, and decrease in the delay. Future work will continue to improve the control performance as well as transition the device into an implantable package for mobile use.

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