ECE 511 MICROPROCESSORS

Professor : Dr. Jens Peter Kaps

A project report on

TONGUE DRIVE SYSTEM

using (MSP430 Launchpad)

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Table of Content

CHAPTER 1
INTRODUCTION

1.1 Introduction

Tongue Drive system (TDS) is a tongue-operated unobtrusive assistive technology, which can potentially provide people with severe disabilities with effective access and environment control. It translates user's intentions in to control commands by detecting and classifying their voluntary tongue motion utilizing a small permanent magnet, secured on the tongue, and an array of magnetic sensors mounted on a headset outside the mouth or an orthodontic brace inside. Customized interface circuitry had been developed and four control strategies to drive a powered wheel chair (PWC) using an external TDS prototype is implemented.

Persons with severe disabilities as a result of causes ranging from traumatic brain and spinal cord injuries (TBI/SCI) to amyotrophic lateral sclerosis (ALS) and stroke generally find it extremely difficult to carry out daily tasks without receiving continuous help. These individuals are completely dependent on wheeled mobility for transportation inside and out of their homes. Many of them use electrically powered wheelchairs (PWC) that are the most helpful tools allowing individuals to complete daily tasks with greater independence, and to access school, work, and community environments. Unfortunately, the default method for controlling PWCs is by operating a joystick, which requires a certain level of physical movement ability, which may not exist in people with severe disabilities.

The magnetic sensors are nothing but hall-effect sensors. A Hall Effect sensor is a transducer that varies its output voltage in response to changes in magnetic field. In its simplest form, the sensor operates as an analogue transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined.

This Project consists of a Microcontroller Units, Wheel chair and Hall Effect sensor. Wheel chair is made up of High torque Geared DC Motors, the Motors Directions can be changed through the set of instructions given from the Hall Effect sensor and the action of these Instructions is already loaded into the Microcontroller using Embedded C programming.

1.2 Project Overview:

The Tongue Drive Assistive technology for paralyzed persons using MSP430 Microcontrollers is an exclusive project that can move the wheel chair according to the instructions given by the above said microcontroller.

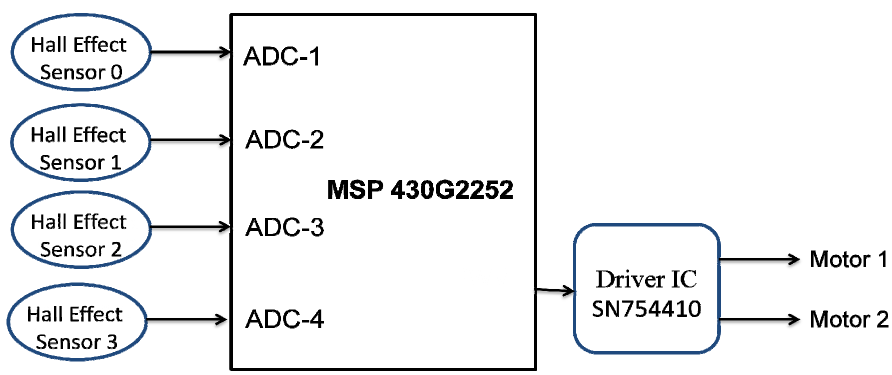
An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers.

Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result. The project consists of the hall effect sensors (A1231), msp430 microcontroller, H-Bridge driver (SN754410).

CHAPTER 2
BLOCK DIAGRAM & HARDWARE COMPONENTS

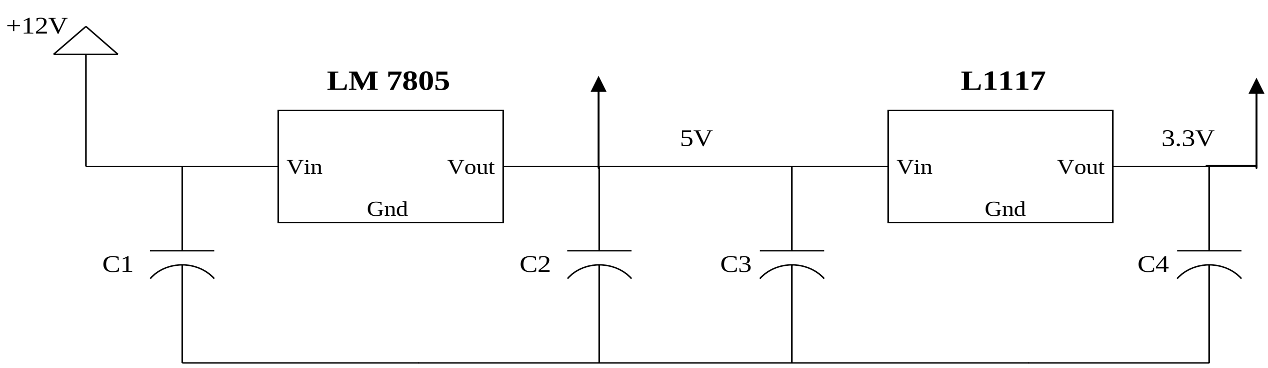
2.1 Block diagram

The overview block diagram consists of 4 hall effect sensors that can be placed as an array outside the mouth , 4 ADC channels of msp430 are used to convert the analog signals from sensor to digital values for processing. The MSP430G2252 microcontroller is the main processing unit. Based on the processing information microcontroller driver the driver IC using PWM, PWM is used to control the speed of the vehicle. The Driver IC in-turn driver the DC powered wheel chair.



2.2 Power Supply

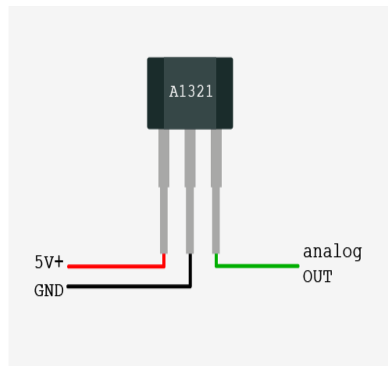
The power supply and power regulation is the main part in any project. Lack of attentions in the power supply of the board would damage all the components or may not work properly. We are using a 12V battery with 700mA of current for power supply to the motherboard. As different devices work at different voltages we have used some regulator IC and filters for regulating the power supply to each component. LM78M05 is used to regulate the power supply to 5V for all sensors and driver IC and motors, L1117 is used to regulate the power supply to 3.3V, supplied to msp430 microcontroller.



2.3 Sensors

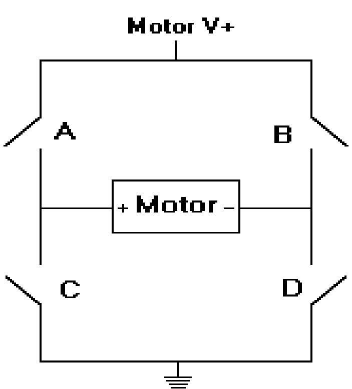
The sensor we have used in out project is a Linear Bipolar Hall effect sensor (A1321). This sensor runs at voltage of 4.5V-5.5V. This sensor can detect the north pole and south pole as well. The output of the sensor is an analog voltage value that can vary from 0-5V, that is to be read and converted to a digital value by ADC of msp430. The Hall effect sensor initially, without any magnetic field gives an output of VCC/2 i.e. if we are using 5 volts for sensor then the ideal value is 2.5V. The output value of the sensor gradually increases to 5V as north pole approaches the sensor and gradually decreases to 0V when south pole approaches. Hence detecting both north and south pole, but we in this project don't care about north and south pole just magnetic field is required in one direction.

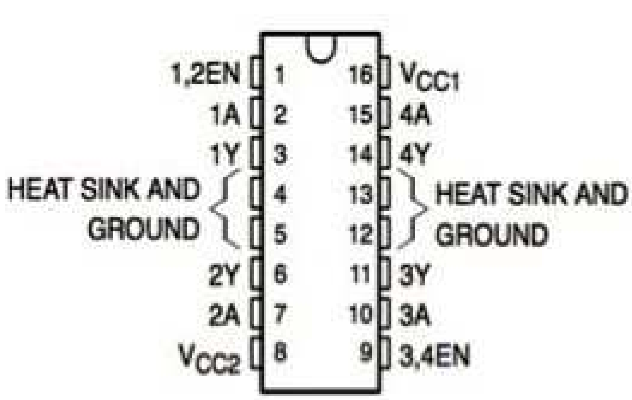
This is the image of hall-effect sensor that we have used in our project A1321. The pin connections are shown in the image red -VCC, black-GND, green-OUTPUT.



2.4 H-Bridge Driver

The H-bridge driver is used to drive the wheels of the vehicle. SN7454410 is the Bidirectional H-Bridge driver that we have used in out project. This driver can deliver a maximum current of 1Amp and Voltage of around 36V. This driver can be used for driving high voltage devices. 5 V power supply is given to this driver. The speed of the vehicle can be controlled by the PWM signals from msp430 given to the enable pins of SN754410.





The pins of driver IC 1, 9 are connected to the PWM channel of the msp430, VCC1 is the power supply to the IC VCC2 is the power supply for driven vehicle. A pins are connected to the microcontroller and y pins are connected to the DC motors or the device which is to be driven.

An H bridge is built with four switches. When the switches A and D are closed (and B and C are open) a positive voltage will be applied across the motor. By opening A and D switches and closing B and C switches, this voltage is reversed, allowing reverse operation of the motor.

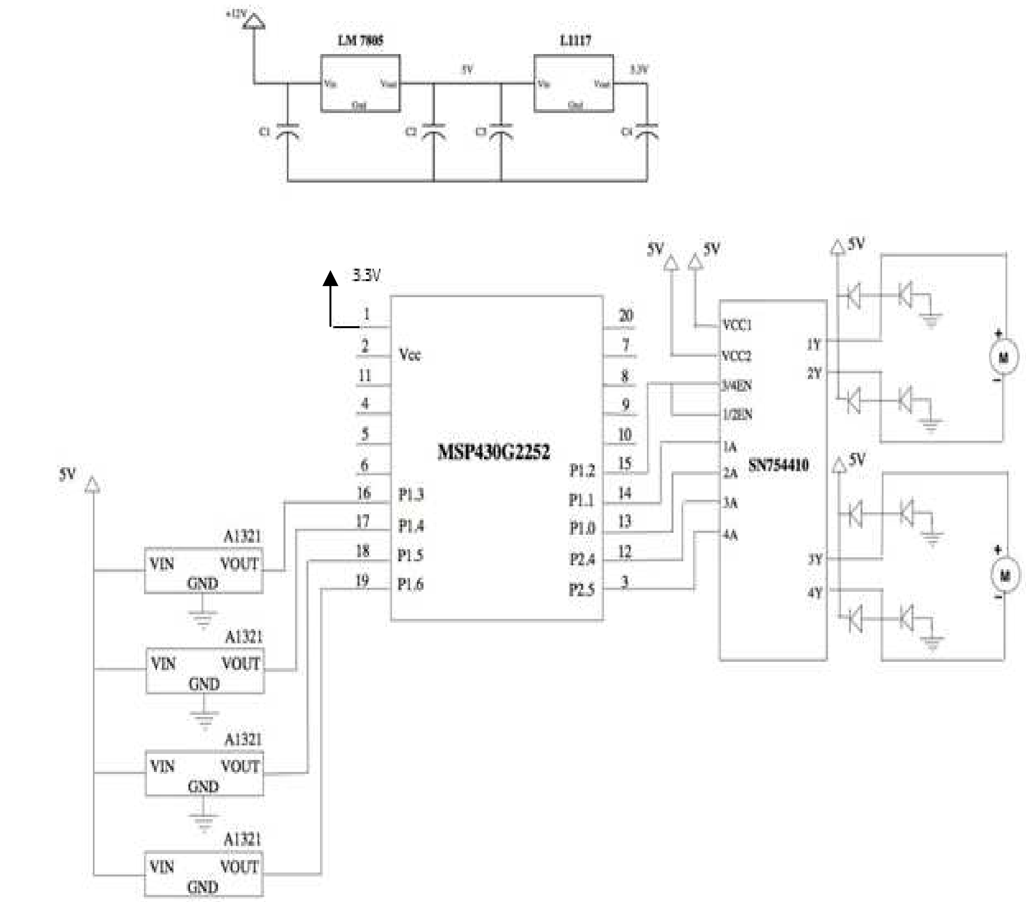
2.5 DC Motors and GearBox

We have used a 5V DC motors with a gearbox for driving the vehicle. We used 2 motors one for left and one for right so that turning might be made easy, left motor at rest and right motor in motion turns vehicle left and vice versa, for forward and backward motion both the motors are driven in same direction with same speed.

This is the gearbox we have used for driving our vehicle. The dc motors in this gearbox can be driven by 5V supply.

2.6 Circuit Diagram

The circuit diagram is pretty simple. Power supply and then the motherboard. Sensors and driver ic acts as peripheral devices and msp430 is the CPU

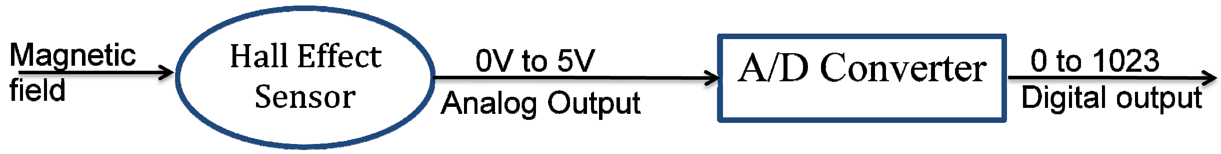


This is the circuit diagram of our project. Four sensors were used and they were connected to pins P1.3, P1.4, P1.5, P1.6 of the msp430 microcontroller. P1.2 of microcontroller generates the PWM signals that is connected to the enable pin of driver IC for speed controlling. Pins P1.1, P1.0, P2.4, P2.5 are used to control the direction of the individual motors. We have used the Darlington array of diodes for preventing back emf from DC motors. This was the major challenge that we have faced.

CHAPTER 3
SOFTWARE COMPONENTS

3.1 ADC10 (Analog to Digital converter)

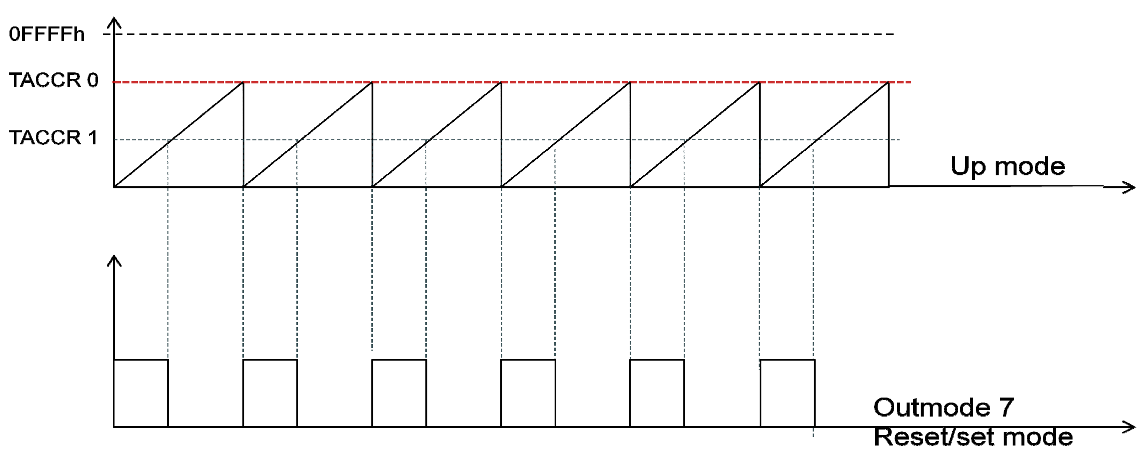
MSP430g2252 has 8 ADC channels of 10bit each, this ADC10 of the msp430 is used to convert the analog signals from the hall effect sensor into digital value. ADC10 is of 10bits hence we can get the value ranging from 0-1023 depending on the value of voltage supplied to the ADC pin. 4 ADC channels: A3, A4, A5, A6 on pins P1.3-P1.6 are used for analog input.



Analog Voltage from Sensor(V)	Corresponding Digital Value
0	0
2.5	512
5	1023

3.2 PWM (Pulse Width Modulation)

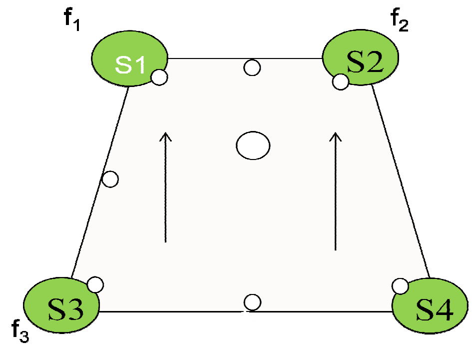
PWM is one of the complex module of our project, we have been struggling for a longer time in achieving PWM signals. A modulating technique which generates variable width pulses is used to vary the speed of the motor. The Duty cycle is varied based on the input values at P1.5 and P1.6 from sensors 3 & 4 respectively. The output is driven from P1.2 of controller to the 1,9 enable pins of H-bridge. We can change the duty cycle of the PWM by changing values in the TACCR1 register in msp430 program.



3.3 Algorithm

The algorithm for this project is very simple. A round robin algorithm that implements polling technique, the sensor values are always read one after the other in a continuous loop. There are few threshold values set for each sensor, if the actual reading from sensor reaches the threshold value then program triggers the change of state i.e. the operations on motion and direction of vehicle.

f_1 - $S_1 > 750$ // forward
f_2 - $S_2 > 600$ // backward
f_3 - $S_3 > 700$ // speed increase
f_4 - $S_4 > 700$ // speed decrease
f_5 - $S_1 > 600$ & $S_3 > 600$ // turn left
f_6 - $S_2 > 600$ & $S_4 > 600$ // turn right



This is the actual alignment of the sensors and the permanent magnet around mouth. The image is top view of the actual alignment.

S1 & S2 front sensor
S3 & S4 back sensors

The white circle in the middle is the resting position of the tongue implanted with small permanent magnet.

We have used different flag values in the algorithm for each sensor, if a sensor is high then the flag value of the particular sensor remain high until the operation is performed, then it is again reset.

CHAPTER 4
TEAM DISTRIBUTION AND CONCLUSION

4.1 Challenges

We have faces a number of challenges in this project and also learned a number of new terms and microcontroller terminology.

- Back E.M.F produced by motors. (took a long time for rectification, had burned 2 ICs and one msp430 launchpad board)
- ADC value was read before completion of conversion.(some garbage value was compared in algorithm)
- Exact Positioning of sensors.
- Turning the vehicle Left or Right.

4.2 Conclusion

This project “Tongue Drive Assistive technology for totally paralyzed persons” is mainly intended to design to a wheel chair which can be controlled by a movement of tongue, which is very useful for handicapped and paralyzed persons. The system consists of Hall Effect sensor and a wheel chair interfaced to the controller. This device could revolutionize the field of assistive technologies by helping individuals with severe disabilities such as those with high-level spinal cord injuries return to rich, active, independent and productive lives. Also, this Hall Effect sensor can be used to control different devices basing on the movement of the tongue. For example home appliances like Fan, TV can be monitored by paralyzed person on his own. Thus this model helps severely paralyzed person in reducing his/her dependency on others.

Few features that can be added to this project as future perspective to make this project more intuitive and user-friendly

- Wireless communication.
- More sensor, Better navigation.

4.3 Team Distribution and modules

The complete project is divided in to 4 major modules

- Hardware Assembly and soldering. - **Swathi Dhanavanthri** (This module took more than few weeks)

- ADC implementation- **Vamshi Krishna Nagamalla**. (It was complicated for a beginner to implement ADC)

- PWM implementation- **Parimala Gollapudi** (Understanding PWM itself was a big task)

- Algorithm and Integration of all modules- **Anshul Naidu Routhu** (Integrating all the modules was a real tough and took more time than implementing the indivisual modules)

From this project we have learned how to design an embedded system application, based on communication with several peripheral devices connected with a CPU, we have learned how to interface several analog and digital devices to microcontroller, how to choose a controller based on requirement and efficiency. how to do a regulated power management, how to rectify the errors and hardware challenges that appear while designing the project. This project helped us in introducing ourselves to embedded system development and design.

4.4 References

- http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_28MSP-EXP430G229
- MSP430 Microcontroller Basics by John Davies (Author), John H. Davies (Author)
- http://en.wikipedia.org/wiki/TI_MSP430
- http://processors.wiki.ti.com/index.php/MSP430_LaunchPad_Learning_Community
- http://www.ti.com/tool/iar-kickstart

4.5 Parts List

- MSP430G2252 microcontroller 1qty
- A1321 Hall effect Sensors 4qty
- SN754410 H-Bridge Driver 1qty
- Dual Gear Box 1qty
- Two DC motors 2qty
- 12V Battery 1qty
- Vector Board
- Breadboard
- Few connecting wires