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MICRO ELECTRONIC MECHANICAL SYSTEM SENSOR BASED WHEELCHAIR CONTROLLER FOR THE DISABLED

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Abstract

The use of powered wheelchairs with high navigational intelligence is one of the great steps towards the integration of severely physically disabled and mentally handicapped people. Driving a wheelchair in domestic environments is a difficult task even for a normal person and becomes even more difficult for people with arms or hands impairment. Tetra pelagic people are completely unable to operate a joystick unless they use the tongue, which is obviously a very tedious task. Simultaneously blind and paraplegic people deal with a very uneasy situation which couples two problems: locomotion and localization. The Rob Chair system is being developed to overcome the problems described above, allowing the end-user to just perform safe movements and accomplish some daily life important tasks.3 Axis Acceleration Sensor (ADXL335) from Analog devices is used for gesture recognition. It is a first generation sensor. User could get acceleration value of X, Y, and Z axis. And it is widely used in shock, slope, and moving detection. Output sensitivity could be select by simply set voltage level on few pins. The output of the sensor is in analog mode. A prototype chair is implemented with a small chair and 60 RPM motors are used to move the chair. A free-wheel is arranged to change the chair direction according to user's requirement. This is an interesting robot that can be controlled by hand gestures. This can be moved forward and reverse direction using geared motors of 60 RPM. Also this wheel chair can take sharp turnings towards left and right directions. This project uses LPC2148 as its controller.

ARM7TDMI is an advanced version of microprocessors and forms the heart of the system. The LPC2148 are based on a 16/32 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, together with 128/512 kilobytes of embedded high speed flash memory. The project can be extended by controlling the speed of the DC motor by using PWM technique. A pulse width modulator (PWM) is a device that may be used as an efficient DC motor speed controller. One additional advantage of pulse width modulation is that the pulses reach the full supply voltage and will produce more torque in a motor by being able to overcome the internal motor resistances more easily With a wide range of serial communications interfaces, they are also very well suited for communication gateways, protocol converters and embedded soft modems as well as many other general-purpose applications. In this wheelchair controller 3 Axis accelerometer chip, RF Module, LPC2148 Microcontroller, DC Geared motors are used. In this project, L293D H-Bridge is used to drive the geared DC motor. The RF modules used here are STT-315 MHz Transmitter, STR-315 MHz Receiver, RF Encoder and RF Decoder. This project uses 12V (Lead Acid Battery). This project uses two power supplies, one is regulated 5V for modules and other one is 3.3V for LPC2148. 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the AC output of secondary of 230/12V step down transformer.

***Key Words:** KMEMS sensor, RPM, ARM&TDMI LPC2148 controller, DC Motor*

1. Introduction

The rapid growth and advancement of modern technology has led to innovative solutions to health and disability problems afflicting people. Some of these inventions have mitigated human pain and suffering significantly. One among these that has made a great impact on the lifestyles of disabled and handicapped people is the motorized wheelchair. There are many kinds of motorized wheelchairs available for example; wheelchairs that utilize analogue joysticks, touch activated switches, sip and puff switches, chin-controlled switches and tongue touch pad switches.

The proposed work concentrates and focuses on the implementation of a wireless hand gesture controlled motorized wheelchair. The advantage of this Micro Electro Mechanical System (MEMS) based controller provides is the increase in reliability being not dependent on mechanical devices like joysticks and switches which are subject to wear and tear. The degradation in performance over time could be annoying to the disabled wheelchair user. MEMS based sensors can operate with little loss in precision and accuracy for many years thereby enhancing user's satisfaction levels. The motorized wheelchair controlled by MEMS based sensor increases the independence and mobility of the disabled in performing their daily activities.

A wheelchair is a wheeled mobile device in which the user sits. The device is propelled manually by automated systems. Wheelchairs are used by people for whom walking is difficult or impossible due to illness, injury or disability. The first recognizable wheelchair was used by King Philips I of Spain in 1595 and was fitted with wheels, armrests and footrests. A drawing of the King dated 1595 shows him in a chair with wheels, armrests and footrests. However, it was not self-propelled. The modern wheelchair began to take shape in the late 19^{th} century to early 20^{th} century with the advent of push rims for self-propulsion in 1881. In 1900 the wooden spoked wheels were replaced by wire spoked wheels. The first motorized wheelchair was invented in 1918.

A clinical survey indicates that 9-10% of severely disabled patients have difficulties in using powered wheelchair in spite of being trained in handling and operating the wheelchair. This indicates that they lack motor skill and strength to operate sophisticated wheelchair functions. It is therefore necessary to make available, leveraging the advanced technological advances in MEMS based sensors, a user friendly and easy to operate motorized wheelchair controller. This implementation is to demonstrate the operation of a motorized wheelchair that can travel at a maximum speed of 30meters/min and turning radius 0.7meters.

Existing motorized wheelchairs

There are many types of commercially available controllers for powered wheelchairs such as joystick, push-button, head-array and sip-and-puff controllers. All of these controllers are widely used among wheelchair users with different types of injuries. The main issue with majority of these controllers, except sip-and-puff, is that the patient is assumed to have reliable mobility in their bodies.

Figure 1: Common Commercially available Controllers

An early unmodified battery powered wheelchair with a joystick control is shown in fig1.2. The controller is interfaced to a motor controller. The user selects the desired speed and direction using joystick and the controller drives the motors based on the signal received from the joystick.

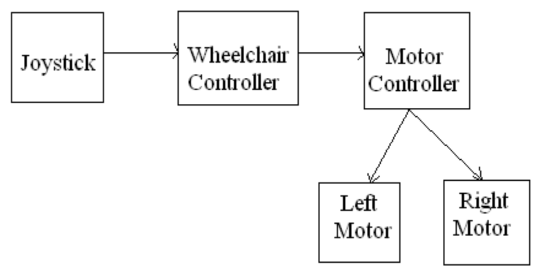


Figure 2: Electric power wheelchair control system

MEMS Sensor based wheelchair controller

With the advancements of microprocessors, significant innovation has occurred in power wheelchair control interfaces, as well as many other areas related to control of assistive technology. In spite of today's sophisticated control interfaces, persons with severe and/or multiple disabilities may yet find it prohibitively difficult to smoothly steer a power wheelchair in typical residential, institutional, or office settings in which maneuvering space is limited maximize the flexibility afforded by the microcontroller making it user friendly and easy to learn with little training.

Scope with control specifications

The scopes of this implementation are:

1. The wheelchair system is targeted to be operated both indoor and outdoor (shaded).

2. The basic hand gesture activated functions of the wheelchair control system includes forward and backward direction movements, left and right turns.

3. This implementation is to demonstrate the operation of a motorized wheelchair that functions in the operating temperature range of 0˚ C to 50˚ C and with maximum speed of 30meters/min.
4. The MEMS based motorized wheel chair system can turn left or right when the wrist is rotated by 30°.
5. This implementation is to demonstrate the operation of a motorized wheelchair that operates with a Lead Acid Battery of 12V, 1.3 AH capacity.

Technical approach

The implementation of the MEMS sensor based wheelchair controller for the disabled is done using pulse width modulation technique (PWM) for the traction motor of the wheelchair drive. The proposed system is implemented on ARM7TDMI microcontroller. Specifically, the LPC2148 microcontroller that is used is based on a 32 bit ARM7TDMI CPU with real-time emulation and embedded trace support for its functional verification using embedded 'C' coding and simulation. The design is synthesized using Keil IDE uvision3 tools with target devices express PCB.

Thesis Outline

This thesis consists of six chapters. Chapter 1 gives the introduction of wheelchair movement control system, its background and brief history and the significance of the project, project objectives and its scopes. In Chapter 2, a detailed description of the wheelchair user command Transmitter and Receiver sections with photographs of the fabricated system are provided. Chapter 3 details the design approach undertaken and how the solution of the control problem was arrived at. It lists out the steps involved in each stage of the design.

2. MEMS SENSOR BASED WHEEL CHAIR CONTROLLER

Introduction

Micro Electro Mechanical System (MEMS) is a technology that can be defined as miniaturized mechanical and electro mechanical elements that are made using the techniques of Micro fabrication. MEMS based sensors provide an interface that can sense, process or control the surrounding environment. A powered wheelchair system is developed that can be remotely controlled using the tilt signals provided by the MEMS accelerometer. The hardware architecture of MEMS sensor based wheelchair controller system consist of two units namely user hand tilt detector unit and wheelchair traction unit.

Overview of the Wheelchair controller

The user wears an instrumented glove embedded with Accelerometer sensor for controlling the direction of the wheelchair. RF wireless communication is provided between the glove and controller which is sandwiched between the user seat and wheels. The wheelchair moves in different directions depending on the direction that the user tilts his hand (example: forward when the hand is tilted forward and so on).

Hand tilt sensor based on MEMS Accelerometer

The accelerometer which is fastened to the back of the palm of the user senses the direction the user desires to travel in. The signal output of the accelerometer is given to an Analog to Digital Converter (ADC). The output from ADC is applied to the input pins of the microcontroller.

The accelerometer output voltage is continuously compared with the reference value in the microcontroller to detect the changes in X and Y axis. A code which represents the command in which wheelchair should move is given to the 4-bit RF encoder which passes the data to RF transmitter. The transmitter sends the data to the Receiver. A block diagram of Wheelchair user hand tilt detector module is shown in Fig. 2.2.

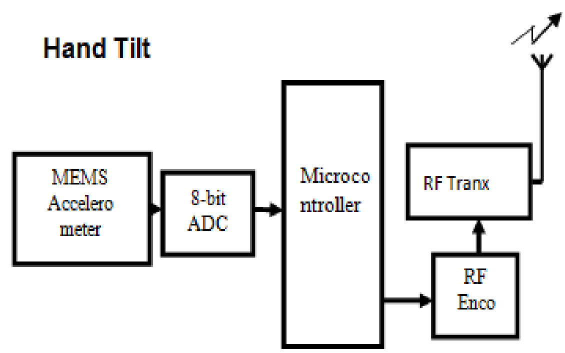


Figure 3: Wheelchair user hand tilt detector unit Block diagram

Accelerometer

The accelerometer is a small IC chip that senses the acceleration forces resulting from gravity, motion, shock or vibration. The wheelchair controller uses the 3-Axis MEMS accelerometer module ADXL335 of which the outputs from 2 axes is used to sense the orientation of the hand to which the sensor is strapped are used. The outputs are electrical analog signal voltages that are unique for each unique orientation. The analog outputs of the accelerometer are converted to digital form using Analog to Digital converter (ADC) for further processing. A photo of the MEMS based accelerometer IC chip is shown in Fig 3.

Analog to Digital converter

The Analog to Digital Converter (ADC0808) is a microprocessor compatible 8-bit converter that uses successive approximation technique for conversion. ADC0808 needs interfacing through a microcontroller to convert analog data into digital format.It has a total of eight analog input channels, among which two are used for converting the analog signals it receives corresponding to the X and Y axis orientation of the wheelchair user's hand. The two channels are selected via address lines. The outputs are interfaced to the microcontroller via latched and decoded multiplexer address inputs. Latched TTL TRI-STATE outputs are sent to Microcontroller.

Microcontroller

The microcontroller used in the transmitter unit of the Wheelchair controller is AT89S52 which is a low-power, high-performance programmable device. It has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip.

The microcontroller checks continuously the accelerometer output with the reference value along both the X and Y axes, and accordingly sends suitable signals to the RF encoder for serial transmission.

RF Encoder

The output signals of the Microcontroller are given to the Encoder. The encoder IC (HT12E) takes in parallel data and packages it into serial format making it suitable for transmission. The serial data output of the Encoder is given to the data input of the RF transmitter. The Transmitter transmits the signal in to the environment using 315MHz of frequency.

For data communication and synchronization, both the transmitter and receiver should be set to the same frequency. This implementation uses 315MHz of RF frequency.

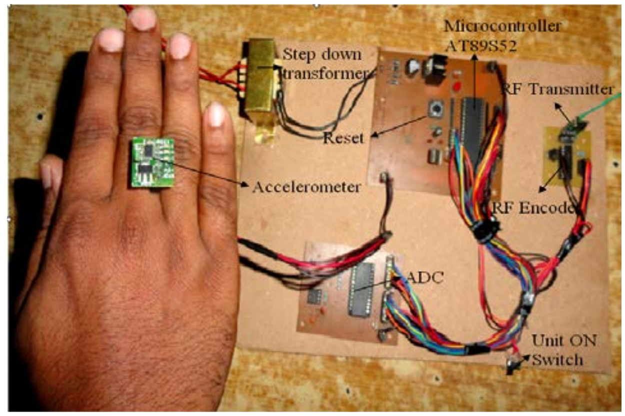


Figure 4: Wheelchair user hand tilt detector unit photo

Wheelchair traction Drive module

In the Wheelchair Traction Drive module, a decoder IC receives the signal via the RF receiver module, decodes the serial data and reproduces the original data in the parallel format. This data is given to microcontroller LPC2148 .In this, the received input is checked and accordingly the output is sent to motor driver H-Bridge IC (L293D). L293D is used to drive the motors to rotate in either forward or reverse direction. The power supply to this section is provided from a Lead Acid battery. The Wheelchair traction unit block diagram is shown in fig 2.6.

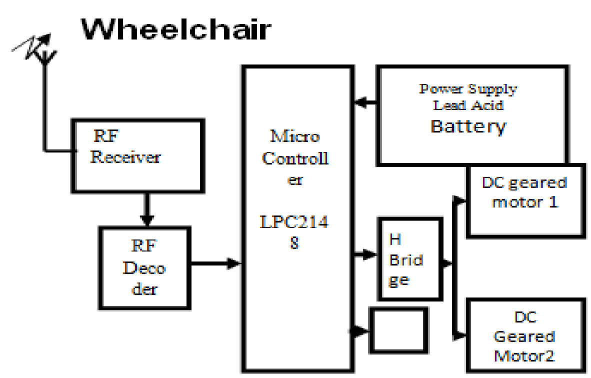


Figure 5: Block diagram of Wheelchair traction unit

RF Decoder

The decoder HT12D receives serial addresses and data from HT12E encoder that are transmitted by a carrier using an RF transmission medium. It compares the serial input data three times continuously with its local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins.

Microcontroller

The microcontroller used in the Receiver and motor control unit of the wheelchair controller is the

LPC2148 which is based on a 32-bit ARM7TDMI-CPU with real-time emulation and embedded trace support that combine with an embedded high speed flash memory ranging of 32 KB.The output data of RF Decoder is connected to LPC2148 microcontroller. The microcontroller executes the instructions according to the program and generates the appropriate PWM signals to the motor driver H-Bridge IC.

H-Bridge

As the Microcontroller ports are not powerful enough to drive DC motors directly, a motor driver IC L293D is used which is a high voltage, high current four channel driver designed to drive 2 DC motors drawing up to 600mA load current. The device is suitable for use in switching applications at frequencies up to 5 kHz.

DC Motor

The wheelchair controller utilizes two DC Motors. The motors that drive the wheelchair traction system are 12V, 60 rpm Geared DC motors which is a 25000 RPM base motor with appropriate gear reduction and capable of delivering 38Kgcm torque and power rating of 5Watts.

The DC motor generates torque directly from DC power supplied
to the motor by using internal commutation, stationa ry permanent magnets, and rotating electrical magnets. It works on the principle of Lorentz force, which states that any current carrying conductor placed within an external magnetic field experiences a torque or force known as Lorentz force. The speed of the DC motor is controlled by varying the PWM signals generated by the LPC2148.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses.

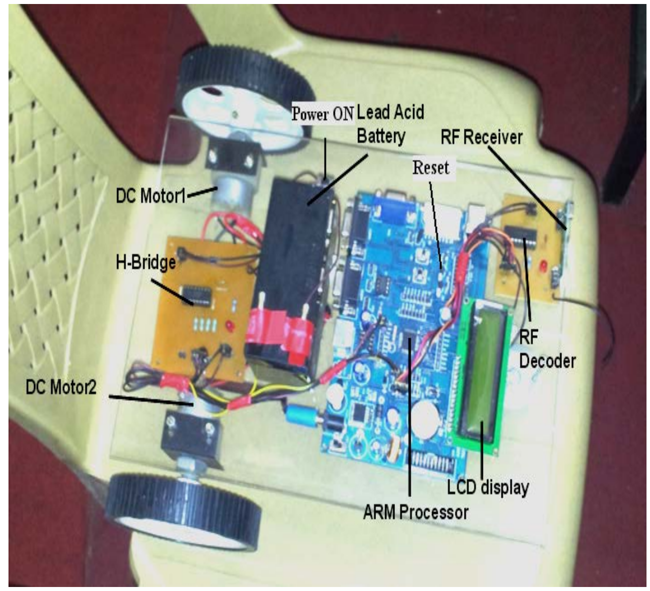


Figure 6: Wheelchair traction unit

The complete wheelchair controller hardware assembled is shown in Fig-8.

Figure 7: Wheelchair with controller assembly

Design of the Wheel Chair Controller

Introduction

This chapter presents the design and development of the wheelchair controller using MEMS Accelerometer and RF communication. The wheelchair controller requires much functionality that have to be coordinated for efficient operation. These functions are:

1. To process the data from the hand sensor.
2. Transmit the hand gesture data to the drive section of the traction.
3. The traction unit should process the received data and accordingly propel the wheelchair.
4. In addition, a visual display of the directions of the wheelchair movement must be provided.

To manage all these functionalities, two microcontrollers were selected namely AT89S52 and LPC2148.

The accelerometer is strapped to the hand of the wheelchair user that detects tilt in all three axes and generates corresponding analog output voltage signals as in Fig 3.1(a). The generated analog output is converted into 8 bit digital output which is compared with a reference voltage. In this manner the direction of motion (+x,-x, +y,-y) is detected. The data is converted to digital signals by an Analog to Digital converter (ADC) and the output from the ADC is applied to the digital input ports of the microcontroller. The microcontroller interprets the command movements and generates formatted data that is applied to an encoder. The encoder converts the command data to serial format and makes the data suitable for transmission serially.

At the receiving end in the wheelchair traction unit, the data received by the receiver is then decoded as in fig 10 and upon receiving commands from the microcontroller (AT89S52) is sent to the microcontroller (LPC2148). The data received is interpreted and corresponding direction and movement commands are sent to the H-Bridge motor drive circuit. The DC wheelchair traction motors guided by microcontroller rotate based on these commands thereby enabling the wheelchair to move either forward or reverse.

The Wheelchair user hand tilt detector

Micro Electro Mechanical System (MEMS) sensor accelerometers for sensing tilt

MEMS are small integrated devices which are fabricated on silicon substrate and can combine electrical and mechanical elements for sensing or actuating purposes. Examples of MEMS components include accelerometers, RF MEMS switches, microphones and micro-resonators.

The accelerometers are most mature MEMS based inertial sensor applications that have seen significant progress over the past decades and with advantages such as low-cost, low-power, small size, batch fabrication make MEMS accelerometers made it the ideal choice for the control of the wheelchair controller by disabled persons. Capacitive MEMS accelerometers are implemented using various surface and bulk micromachining technologies.Bulk micromachining defines structures by selectively etching inside a substrate (wafer) whereas surface micromachining creates structures on top of a substrate by using a succession of thin film deposition and selective etching. In surface micromachined devices, the thickness of the deposited layer and hence the proof mass is small, resulting in limitations on the performance of the accelerometers. While MEMS accelerometers are available in ranges up to thousands of g's, the hand strapped movement sensor of the wheelchair controller uses a three-axis model require only a few g's.

Sensing Element Design Overview

A mechanical sensing element converts the unknown quantity into displacement that is then detected and converted to an electrical signal. The simplified schematic of a fully-differential capacitive MEMS accelerometer is depicted in Fig.

The central part of accelerometer is the micromechanical proof mass M suspended from a supporting frame by mechanical springs (with effective spring constant K) and which is the main sensing element. The squeezed film damping D is imposed by surrounding air on the structure. The accelerometer has fully differential sense topology that has four sense electrodes with one common node at the proof mass. C_{S1}, C_{S2}, C_{S3} and C_{S4} are sensing capacitors between proof mass fingers and four sense electrodes.

$$C_{S1,\,2} = (C_S \pm \Delta C_S)/4$$

Where C_S is the rest capacitance and ΔC_S is capacitance variation of the sensor.

When an external acceleration a_{ext} is applied, the proof mass will move in the sensing axis with respect to the moving frame of reference (X = Y - Z), causing a change in distance between it and adjacent fixed electrodes. The displacement of the proof mass can be measured as a very small change in capacitance between it and the fixed electrodes.

cceleration due to gravity with minimum full scale range of ±3g. The device can be powered directly through the Vcc/3.3 V pin using a supply that is within the ADXL335 acceptable power supply range of 1.8 V to 3.6V and is therefore ideal for use in battery powered applications. It consumes a tiny amount of current of about 350 µA and can sustain shock survival up to 10,000g. The functional diagram of the accelerometer is shown in Fig.

As was described earlier, the accelerometer (a transducer, since it converts g's to an analog voltage signal) consists of a sensor which senses change in acceleration whenever the hand to which it is strapped tilts. It consists of two capacitive sensing cells, formed using 3 beams, where the middle beam is movable.

Capacitance is given by: C=ƐA/d
where, A is the area of the beam,
Ɛ is the dielectric constant, and
D is the distance between the beams.

When a tilt occurs in either X or Y axis, the middle beam moves changing its distance with respect to other two fixed plates. This changes the resultant capacitance of sensor. This change in capacitance is used to determine the output of the accelerometer. The IC performs signal conditioning and filters the signal, providing a high level output voltage that is ratiometric and proportional to acceleration.

The output voltage before amplification ranges from -150mV to -600mV along X-axis and output voltage change at Y-axis varies from +150mV to +600mV. After amplification, the sensor output varies from 0.1V to 2.8V. When there's no acceleration on a given axis, the output for that axis is half the supply voltage of about 1.5V. With acceleration in a positive direction along the axis, the output voltage for that axis rises. With negative acceleration along the axis, the voltage goes down. In other words, at rest the voltage is in the middle, at full forward acceleration the voltage is at its highest, at full backward acceleration the voltage is at its lowest. The sensitivity along Xout, Yout and Zout axes is 300mV/g.

The bandwidth of the device is set to 50Hz by using C_x=C_y=0.1µF. The output obtained from the accelerometer pin observed on a Digital Storage Oscilloscope (DSO) is shown in Fig. 3.6.

While analyzing the output of the accelerometer, it is observed that the output varies from 0.1V to 2.8V, when it is moved from –x to +x direction or from –y to +y direction.

Test results of Accelerometer

While changing the position of the hand in different angles, the output voltages generated by the accelerometer are recorded in the oscilloscope that is shown in Table 3.1.

Table 1: Accelerometer testing values

Accelerometer Tilt	X output(V)	Y output(V)
Initial	1.5	1.5
45° to right	1.8	1.5
90° to right	2.7	1.8
45° to left	0.9	1.4
90° to left	2.5	1.42
45° forward	1.31	0.9
90° forward	1.51	2.6
45° backward	0.5	1.35
90° backward	2.7	2.2

Converting the sensor analog output to Digital signals

The ADC0808 operates on $5V_{DC}$ using power supply that is within its acceptable range of $4.5V_{DC}$ to $6.0V_{DC}$ and uses very little current (3.0mA). The output analog signals of accelerometer are applied to an Analog to Digital Converter (ADC). The ADC needs interfacing through a microprocessor to convert analog data into digital format. The ADC pin IN0 and pin IN1 reads accelerometer's x-direction and y-direction voltages respectively.

The resolution provided by the 8 bit Model 0808 having data output lines D0-D7 is sufficient to provide digital information of the hand tilt. The ADC operates on the principle of successive approximation and has a total of eight analog input channels out of which any one can be selected using address lines A, B and C. The time it takes for conversion is approximately 100µsecs. The functional block diagram of ADC is shown in Fig.

The microcontroller functions by checking continuously the accelerometer output with the reference value along both the axes. After appending data related to whether a movement to the left or right or forward or reverse is desired, the microcontroller outputs the 4-bit data from Port 2.3 to port 2.6 pins to the RF Encoder for serial formatting as in Table 3.2 and 3.3. In this manner the microcontroller generates the code corresponding to motor movement for transmission to the Receiver section that comprises the motor traction drive circuitry.where the message has been band limited. The shape, after band limiting, depends upon the amplitude and phase characteristics of the band limiting filter.

Demodulation

Demodulation is a two-stage process which is shown in Fig 3.12 that shows the recovery of the band limited bit stream and regeneration of the binary bit stream.

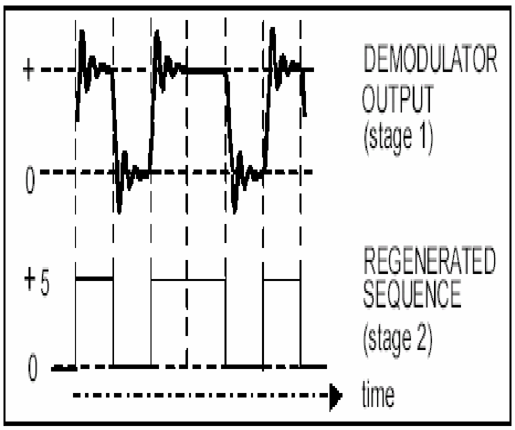


Figure 8: The two stages of the demodulation process

Among the different RF modules available, the module that incorporates Amplitude Shift Keying (ASK) based RF TX/RX pair operating at 315 MHz was chosen for the wheelchair controller. These modules interface directly to microcontrollers with the help of encoder/decoder ICs. The encoder IC takes in parallel data from the microcontroller packages it into serial format and then transmits it. At the transmitter side the 4-bit data from the AT89S52 – pins (P2.3 to P2.6) are interfaced to 4-bit encoder IC (HT12E).

The Encoder HT12E operates at 5V which is within its acceptable power supply range of 2.4V to 12V and consumes less current of 40µA for f_{osc}= 3 KHz. The encoder IC has eight address A_0 to A_7 lines and four data AD_8 to AD_{11} lines. The Transmission Enable (TE) pin of encoder is set low, the address/data lines available is transferred serially through D_{out} pin. The output from D_{out} pin is interfaced to input pin of RF Transmitter. For proper transmission, appropriate frequency f_{osce} is selected using resistor connected between OSC1 AND OSC2 from graph shown in Fig. 3.15. The input voltages measured for logic high signal varies from 4V to 5V and 0V to 1V for logic low signal.

RF Transmitter STT 315 MHZ

The Sunrom technologies STT-315 is suitable for remote control applications where low cost and longer range is required. It operates from a 1.5-12V supply which employs a SAW-stabilized oscillator, ensuring accurate frequency control. Some of the features that employed by the transmitter are low cost, 11mA current consumption at 3V, small size, 4 dBm output power at 3V.The transmitter block diagram is shown in fig 3.16.

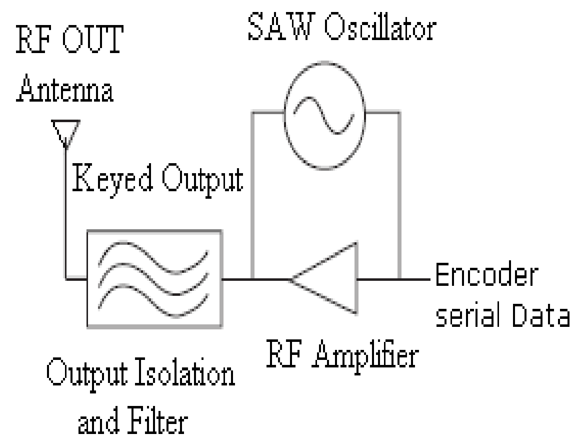


Figure 9: RF Transmitter block diagram

The transmitter is a negative resistance LC oscillator whose center frequency is controlled by a Surface Acoustic Wave (SAW) resonator. SAW resonators are fundamental frequency devices that resonate at frequencies much higher than crystals.

The STT 315MHZ transmitter employs an On-Off Keying (OOK) modulation technique which is a binary form of amplitude modulation. When a logical 0 is sent, the transmitter is off, fully suppressing the carrier and takes very less current that is, less than 1mA. When a logical 1 is transmitted, the carrier is fully on and takes high current consumption about 11mA with a 3V power supply.

As OOK transmitters draw no power when they transmit a 0, they exhibit significantly better power consumption than FSK transmitters. OOK data rate is limited by the start-up time of the oscillator. High-Q oscillators which have very stable center frequencies take longer to start-up than low-Q oscillators. The start-up time of the oscillator determines the maximum data rate that the transmitter can send. The oscillator start-up time is on the order of 40uSec, which limits the maximum data rate to 4.8 kbit/sec.

The transmitter sends the command signals for forward, Reverse, Left and Right to the wheelchair traction unit. The RF communication module was designed, tested and fabricated in consultation along with institute faculty.

Wheelchair traction drive unit

RF Receiver STR 315 MHZ

The Sunrom technologies Receiver (STR-315) is suitable for short-range remote control applications. The receiver module requires no external RF components except for the antenna. Some of the features are low cost, operates with 5V only, 3.5 mA drain current, sensitivity of -105 dBm.

The super-regenerative design exhibits exceptional sensitivity at a very low cost. The manufacturing-friendly SIP style package and low-cost make the STR-315 suitable for high volume applications.

The super-regenerative receiver uses a second lower frequency oscillation (within the same stage or by using a second oscillator stage) to provide single-device circuit gains of around one million. The Receiver block diagram is show in fig 3.17.

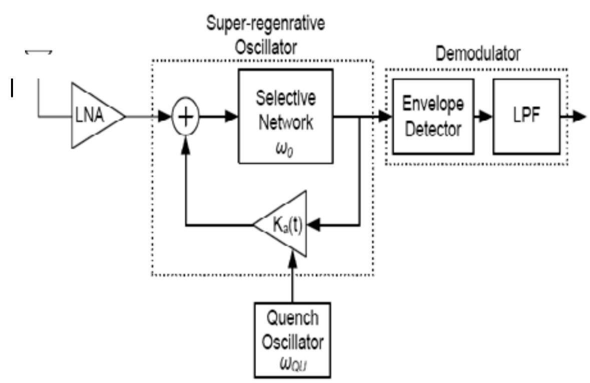


Figure 10: Receiver block diagram

This second oscillation periodically interrupts or "quenches" the main RF oscillation. Ultrasonic quench rates between 30 and 100 kHz are typical. After each quenching, RF oscillation grows exponentially, starting from the tiny energy picked-up by the antenna plus circuit noise. The amplitude reached at the end of the quench cycle (linear mode) or the time taken to reach limiting amplitude (log mode) depends on the strength of the received signal from which exponential growth started. The demodulator consists of a lowpass filter in the audio amplifier. The LPF filters the quench and RF frequencies from the output, leaving the AM modulation. This provides a crude but very effective AGC (Automatic Gain Control).

Microcontroller (LPC2148)

The data received from pins D_8 to D_{11} of the encoder is interfaced to Port P1.25 to P1.28 pins of LPC2148. The received input at the Port 1 pins is checked and accordingly the pulse width modulated (PWM) output signals are given to motor driver L293D IC. The speed of the motor can be controlled by varying the PWM signals generated by LPC2148. For the system designed, the speed for moving forward, backward, left and right is fixed.

The 16-bit Thumb mode reduces code by more than 30 %. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, In-system programming flash memory, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make this microcontroller suitable for industrial control and medical systems. The block diagram of LPC2148 Microcontroller is shown in Fig 3.20.The ARM7TDMI-S is a general purpose 32-bit microcontroller, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles.

Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory.

H-Bridge Motor Driver (L293D)

The Microcontroller ports are not powerful enough to drive DC motors directly and therefore, some kind of driver is needed.

Table 2: Motor operation

Motor Operation	A	B
Stop	Low	Low
Clockwise	Low	High
Anti Clockwise	High	Low
Stop	High	High

Working Theory of H-Bridge

The "H-Bridge" is derived from the actual shape of the switching circuit which controls the motion of the motor. It is also known as "Full Bridge". There are four switching elements in the H-Bridge.

There are four switching elements namely, "High side left", "High side right", "Low side right", "Low side left". When these switches are turned ON in pairs, the motor changes its direction accordingly. If switches High side left and Low side right are ON, the motor will rotate forward, as the current flows from the Power supply through the motor coil goes to ground.

The time that takes to start and reset the wheelchair controller system is 5secs. The steering mechanism of Wheelchair based on user hand gestures.

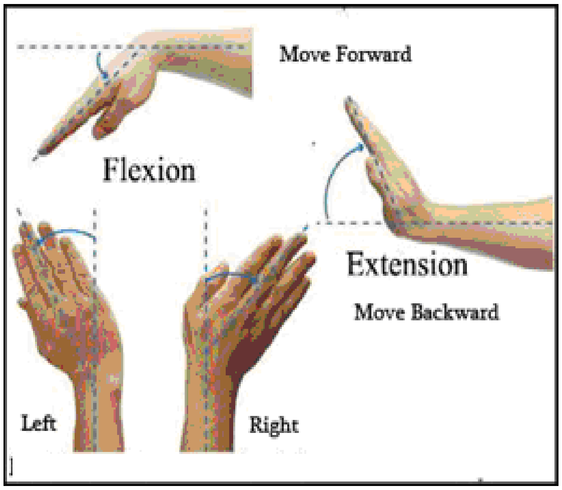


Figure 11: Wheelchair user hand gestures

A two inch Field-effect LCD module is shown in fig 3.35.The forward, reverse, left or right directions of the wheelchair movement is displayed on LCD. The control signals to the LCD are provided by the Micro controller with which it is interfaced. Port P1.16 to P1.21 of LPC2148 are connected to data pins of LCD.

WHEEL CHAIR CONTROLLER SCHEMATIC AND DESCRIPTION

Hand gesture signal module

The complete schematic diagram of the hand gesture tilt section of the wheelchair controller.

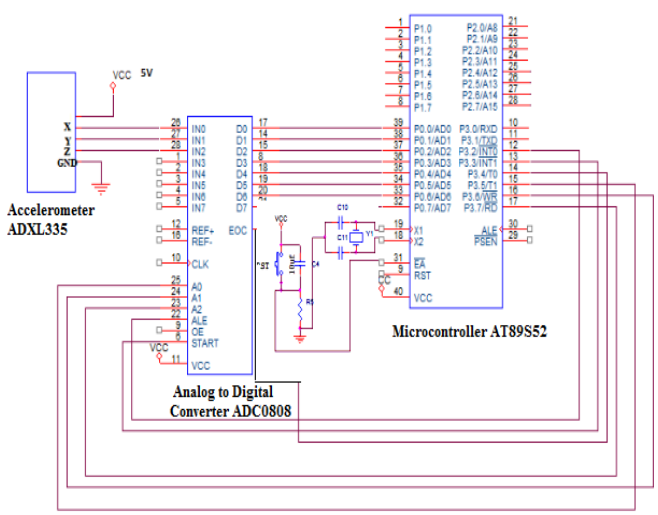


Figure 12: Accelerometer tilt sensing, A to D converter and Microcontroller Input

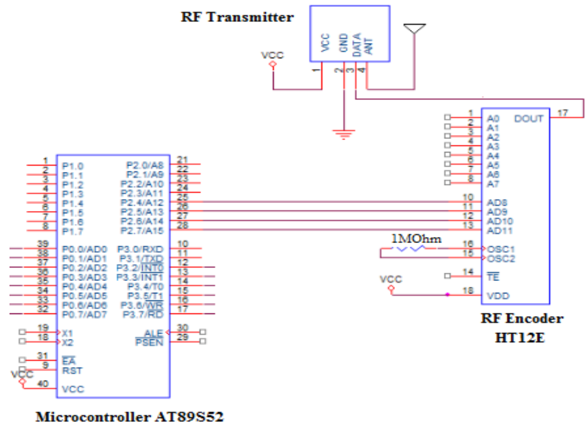


Figure 13: Microcontroller Output, Encoder and Transmitter

Hand gesture sensor

Accelerometer sensor is used for gesture recognition that can detect tilt in all three axes and accordingly generate a corresponding analog output voltage at X_{out}, Y_{out} and Z_{out} pins. Analog bandwidth can be set by changing Capacitors C2, C3, and C4. C1 at V_S is a bypass capacitor to reduce supply noise. C2, C3, and C4 at XOUT, YOUT, and ZOUT are filter capacitors to set the bandwidth to 50 Hz.

The sensor output at X_{out} and Y_{out} pin as observed ranges from 0.1V to 2.8V for different tilt of the hand. The output of accelerometer is analog in nature, to convert these analog signals into digital form, an ADC is used. The X_{out}, Y_{out} output pins are connected to Pins IN0 and IN1 of ADC0808 for digital conversion.

Hand gesture tilt module transmitter

The wheelchair system allows one way communication between transmission and reception. The receiver, upon receiving these signals, sends them to the decoder IC (HT12D) through pin2. The serial data is received at the data pin (DIN, pin14) of HT12D. The decoder then retrieves the original parallel format from the received serial data.
To send a particular signal, address bits must be same at encoder and decoder ICs. By configuring the address bits properly, a single RF transmitter can also be used to control different RF receivers of same frequency.

FLOW CHARTS AND SOFTWARE IMPLEMENTATION

Hand tilt detector module-Control flow

The program makes the microcontroller read the input and respond accordingly to the hand tilt sensing direction.

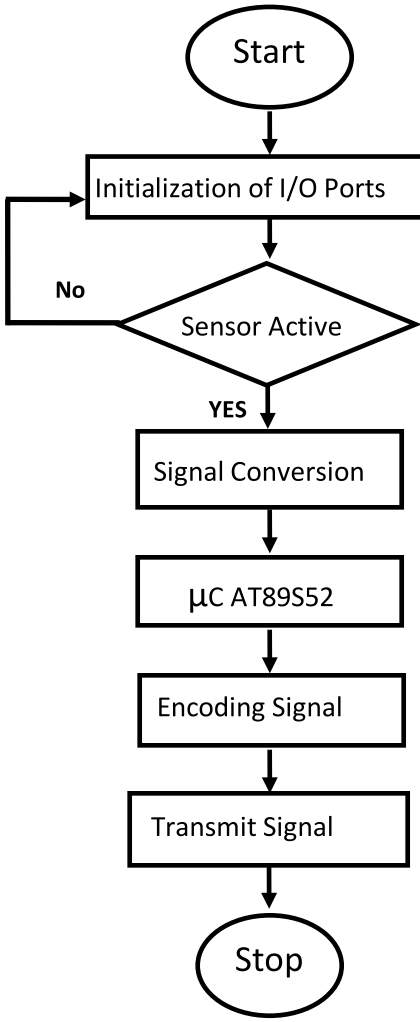


Figure 14: Wheelchair user hand tilt detector flow chart

At power ON, the I/O ports of the Microcontroller are initialized. The Accelerometer sensor status is checked whether it is active or not. When the sensor is active, it measures the acceleration forces corresponding to hand gestures. This analog acceleration signals are converted to digital signals in order for microcontroller to process it. The microcontroller produces the appropriate output signal. This signal is encoded and transmitted.

As shown in gesture control program flow chart, the unit is initialized with Reset button. The Reset button initializes the Input -Output ports and the memory of the microcontroller. The microcontroller checks the different signals of the hand tilt detector unit. Depending on the input data from the accelerometer, the microcontroller will send commands to the wheelchair traction drive unit through Encoder accordingly. For example, if the data read into the microcontroller is a forward tilt, it will send the forward Command to the wheelchair traction drive unit letting it know that the hand gesture is forward otherwise it enters in to wait state.

Wheelchair Traction Module Receiver and Motor drive -Control flow

As shown in the wheelchair traction motor drive program flowchart, the unit is initialized with the Reset buttons. The Reset button initializes the Input-Output ports and memory of the microcontroller.The microcontroller checks the different signals of the hand tilt detector unit. When a command is received from the hand gesture tilt detector unit, it will interrupt the wheelchair traction drive unit from its current process, compare it to a table of commands, and execute the proper function. For example, if the wheelchair traction drive unit receives a command to start moving forward, it will execute the function which will drive the wheelchair forward otherwise it enters into wait state.

The decoder receives data that are transmitted by encoder and interpret the first 8 bits of code as addresses and the last 4 bits as data. A signal on the DIN pin activates the oscillator which in turn decodes the incoming address and data. The decoders will then check the received address three times continuously.

Programmed instructions and Hardware module development

The program for the wheelchair controller was developed with the following software.

Windows XP

This is an Operating System (OS) on which the software applications required for the wheel chair controller was developed.

Orcad is a software tool used for electronic design automation. The software was used to create electronic prints for etching printed circuit boards and drawing schematics.

Keil µVision3

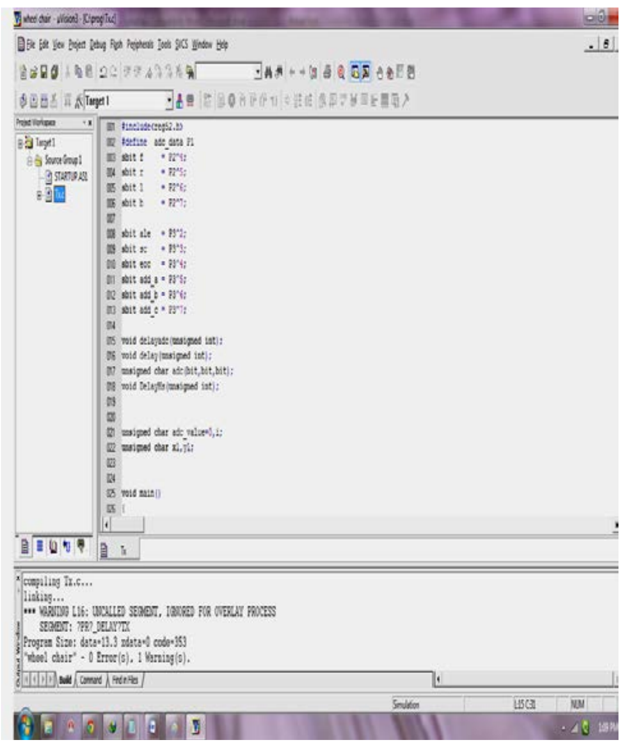
Execution procedures of Hand tilt sensor module code

Click on the Keil µvision3 Icon on Desktop, the following figure will appear.

Click on project menu from title bar, and then Click on New Project and save Project by typing suitable project name with no extension in the own folder sited in either C:\ or D:\. Click on **save** button. Select the component for the project i.e. Atmel. Click on the + Symbol beside of Atmel then select AT89S52 as shown below.

Then Click on "OK", Click "NO". Now project is ready to use. Double click on Target1, it would get another option "Source group 1", Click on file option from menu bar and select "new", now start writing program either in "C" or "ASM", for a program written in Assembly, then save it with extension ". asm" and for "C" based program save it with extension " .C". The wheelchair controller was programmed using embedded C language.

The window with default "C" files will appear. The saved file extension is selected and '**ADD**' option is selected. F7 key is pressed for compilation. If file contains no error, Control+F5 is then pressed. The new window is as follows, "OK" is clicked.



PROLOAD

Proload is software which is used to transfer the Traction motor drive module code into the AT89S52 microcontroller. Once the machine code is converted into hex code has to be loaded into the microcontroller memory in the programmer kit. Programmer kit contains a microcontroller on it other than the one which is to be programmed. This microcontroller has a program in it written in such a way that it accepts the hex file from the keil compiler and dumps this hex file into the microcontroller which is to be programmed.

Program loading process

1. Connect the programmer kit to the PC through serial cable.
2. Place the microcontroller in the GIF socket provided in the programmer kit.
3. Open Proload software in PC. Click on browse option to select the hex file to be dumped into microcontroller and then click on "Auto program" to program the microcontroller with that particular hex file.
4. The status of microcontroller can be seen in small status window in bottom of the page.
5. After completion of this process, remove the microcontroller from the programmer kit and place it in the system board.

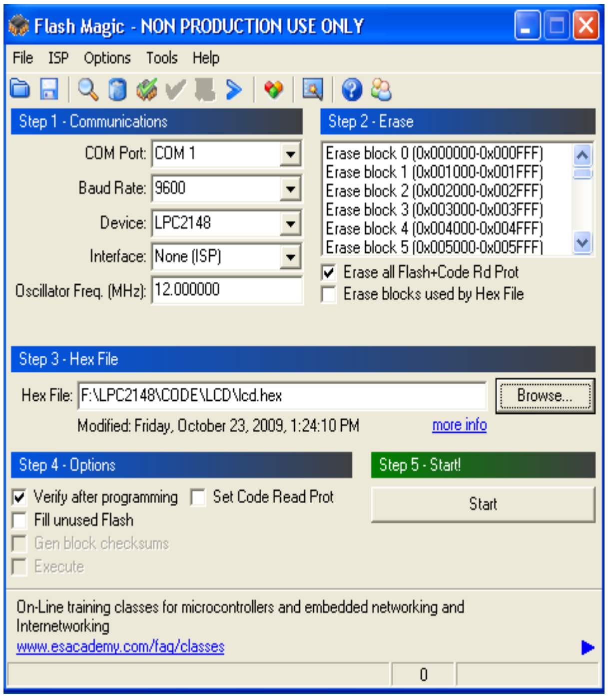
Now the system board behaves according to the program written in the microcontroller.

5.3.5 Flash Magic Software

The method to download Hex File into Flash Memory of LPC2148 microcontroller unit (MCU) in Board is to use Program Flash Magic that is connected with MCU through Serial Port of computer PC.

Procedure to Download Hex File into MCU

1. Interface RS232 Cable between RS232 Serial Port of PC and Board UART-0 (CN3).
2. Supply power into board; a red LED1 is in status ON can be seen.
3. Set jumper BR4 (INT1) in ON state.
4. Run Program Flash Magic.
5. Start setting the initial values into program as desired.
6. Select format of erasing data to be "Erase all Flash + Code Rd Prot".
7. Set Option to be **"Verify after programming"**.
8. Click "**Browse**" to select HEX File for downloading.
9. Click "**Start**", Program Flash Magic will start downloading data into MCU instantly shown in below figure.



10. When the operation of program is complete, press RESET Switch (S2) on Board and MCU will start running the downloaded program instantly.

The next chapter describes the results and conclusion of the MEMS sensor based wheelchair controller.

TESTING, RESULTS AND CONCLUSION

The wheelchair features MEMS sensor for sensing hand gesture commands to propel the wheelchair in forward, reverse, turn left and turn right directions.

The design optimizes the following considerations:

1. Operating the wheelchair in different environments both indoors and outdoors (shaded).
2. Pulse Width Modulation technique implemented in the microcontroller enables reduced power consumption.
3. Provision for expansion of inputs and outputs. For example, sensors that can detect the obstacles on the pathway can be interfaced to the microcontroller for obstacle avoidance.

Numerous tests were carried out on the wheelchair. The wheelchair was tested with 3 Kg object for 2 hours in a typical residential premise with 10ft x 10ft rooms on a plane surface. The Layout distance for one way travel through paths A and B are 12 meters and 12 meters.

When a person wears a band fixed with accelerometer and tilts his hand, the wheelchair moves in corresponding direction.

Procedure for Testing

1. Switch on the “Unit ON” switch of the wheelchair user hand tilt detector unit.
2. Press the ‘Reset’ button to initialize the Input-Output ports of the Microcontroller.
3. The user wears the band fixed with accelerometer to his hand.
4. Switch ‘on’ the “Power ON” switch of the Lead Acid Battery.
5. Press the ‘Reset’ buttons of the wheelchair motor drive traction unit.

(The time that takes to start and reset the wheelchair controller is 5 Secs).

6. When the MEMS sensor strapped to the hand was tilted in forward direction, the wheelchair was observed to move in forward direction for 6 meters and when the accelerometer was oriented parallel to ground, it stopped. When the accelerometer was oriented to the left direction, the wheelchair was observed to move in left direction for 6 meters. It was tested for the movement in backward and Right directions and then it was stopped.
7. During the normal operation of the wheelchair, the speed of the wheelchair upon plane surface was recorded as 30 meters/min. The wheelchair was operated to move on the inclination of height 0.2 meters and length 1 meter and noted that the speed was 18meters/min.
8. While jerked, it was observed that no abnormal movement of wheelchair occurred. This is due to the safety delay of 4 secs programmed between oppositely directed gesture movements.
9. In the trial phases, the software verification process was carried out and necessary modifications were made.
10. The different directions of the wheelchair movement are displayed on the LCD display.

This Table shows the different wheelchair movements based on the orientation of the hand tilt sensor and also the LCD display outputs.

Table 3: Wheelchair movement directions

Hand orientation	Left Motor	Right Motor	Wheelchair movement	LCD Output
Forward	Straight	Straight	forward	FORWARD
Left	Stop	Straight	Left	LEFT
Right	Straight	Stop	Right	RIGHT
Back	Reverse	Reverse	Backward	BACKWAR D

From the above observations it is seen that the wheelchair controller is satisfactory in operation even for people affected with high level Quadriplegia. In this case, the assist system has proven to be of a simple implementation and of low cost. The results obtained clearly demonstrate that the system is easy to handle by the patients.

3 CONCLUSIONS:

The accelerometer sensor based automated system has been presented which would be very helpful for physically challenged persons and for those who cannot move their body except their hands and fingers. The sensor is so calibrated such that it produces an analog voltage for a corresponding tilt of one's hand. The AT89S52 microcontroller is in Embedded 'C' language.

The implementation of "MEMS SENSOR BASED WHEEL CHAIR CONTROLLER FOR THE DISABLED" was achieved by integrating various features of hardware components. With careful selection and signal interface design, every module has been integrated into the controller enabling it to work optimally and with low power consumption, thereby increasing the time between charging of the battery and extending usage intervals.

The presented system can be adapted with necessary modification for military applications as remote controlled spies, where one can control its movement merely by moving the accelerometer strapped to ones hand instead of a joystick.

FUTURE SCOPE

Work is at present being carried out on the incorporation of a new interface so that the user can give commands for guidance based on eye movement. The part of the system that has already been developed is being tested with fairly satisfactorily results. This will provide an answer to the needs of people who are severely handicapped.

The wheelchair operation can be extended by controlling the wheelchair movement with the brain by using neural networks. Obstacles on the pathway can be identified and the directions of the wheelchair movement can be controlled by using ultrasonic sensors.

This implementation can also be extended by interfacing heart beat sensors to the microcontroller system of the wheelchair. A heart beat sensor can continuously monitor the wheelchair user's heart rate, and sound an alarm if the sensor detects abnormal conditions.

Another interesting topic for future work involves implementing the proposed gesture recognition system on a smart phone and personal digital assistant devices with a built-in accelerometer.

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