University of Southern Queensland

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Develop a computer-based system to assess and exercise the arm movement of stroke patients.

A dissertation Submitted by

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Abstract

In 2009 it is estimated that over 60,000 Australians will suffer a stroke. One in five of them will die while more than 88%of the rest will have disabilities. The two main types of stroke that occur are name Ischaemic and Haemorrhagic stroke. Ischaemic stroke occurs because of a blockage that obstructs the flow of nutrient to the brain, this affects 80% of people. Haemorrhagic stroke is when a blood vessel in the brain burst causing the pressure inside the brain to increase and damage brain tissue.

The aim of this project is to develop and enhance a computer-based system to rehabilitation stroke patients. The reason projects such as this one is need in today's world is because of the lack of health care professional to provide the stroke patients with the rehabilitation the need to return to some normality in their lives.

This Project looks at modifying a part to the stroke rehabilitation device to provide patients with a better easier manner in which to get back into society. The overall aim of the project is to create a computer-based rehabilitation environment which would make the rehabilitation process enjoyable for the patient and also make it so that the physiotherapist has time to see more patients.

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1.0 Introduction

1.1 Introduction to the project

Stroke patients face many difficulties in their lives, both physically and mentally. Patients must go to hospitals to undergo physiotherapy to try and improve their incurred disabilities so that they will be able to function to some degree of normality. Stroke patient exercise devices are to assist physiotherapists to assess the level of damage done by the stroke, and to give the patient ways in which to improve their coordination and strength. Research and development of stroke patient exercise devices only started in recent years and no set device is used by physiotherapists to assist patients. This project will concentrate on the upper limbs, to develop a device that is both cost effective and would greatly assist physiotherapists to help stroke patients to redevelop both their coordination and strength.

1.2 Outline of Study

This project focuses on the rehabilitation of the upper limbs of a stroke patient, in order to provide strength and more importantly coordination. In order to develop a computer based system which would provide the stroke patient with the most beneficial treatment; research needs to be conducted on the issues that are faced by stroke patients who suffer paralysis of their upper limbs and the available computer based rehabilitation methods. The development of a hardware interface and a software rehabilitation environment, were created to be easy to use whilst being cost effective. The hardware needs to be easy to utilise so that the operator will require little to no training. The software also needs to be extremely user friendly so patients will be keen to continue the computer based rehabilitation process.

1.3 Need for the Project

In a study done on the patients of a Melbourne hospital, stroke unit; it was found that two weeks after a stroke, patients spend fifty percent of their time in bed, twenty-eight percent of their time in a seated position, and only thirteen percent of their time doing activities to prevent complications and improve recovery of mobility (Bernhardt et al. 2004). This small portion of time is ‘critical’ for the rehabilitation of stroke patients; and is a key factor in getting stroke patients back into the ‘highest possible level of independence’ by early rehabilitation practise. The reason for this trend in Australia can be associated with the number of practicing physiotherapists to stroke patients; this will be looked at in a later section.

The stroke patient exercise device will assist in getting patients straight into rehabilitation as little monitoring is required whilst the patient completes the required tasks. The physiotherapist will then be able to review the readings and change the program according to the results. Also it was found that some patients were able to recuperate in a home environment with the help and support of family. As the exercise device will be able to be operated in the home environment, journeys to and from the hospital or rehabilitation facility will be less tedious, as usually families must transport stroke patients in larger vehicles making them feel uncomfortable during the journey which hinders the rehabilitation process.

1.4 Computer-based Rehabilitation

Computer-based rehabilitation is still a developing field and there is no set device that is used by physiotherapists. However there are several devices that have shown promise, these devices are created by mainly university research groups, three devices that have shown promise are the Kinseological Instrument for Normal and Altered Reaching Movement, Arizona State University and Kinetic Muscles Inc developed a robotic arm, and the Therapy-Wilmington Robotic Exoskeleton. These computer based rehabilitation methods have many advantages over normal traditional methods, which are used by physiotherapists to rehabilitate stroke patients. These advantages include:

- More detailed analysis of the movements of the patients.
- Faster and more efficient exercise routines.
- Allows physiotherapist to have the ability to work with more patients.
- A Computer-based system does not have a ‘clock off time’ and can be used whenever the patient feels like exercising.
- Provides a more entertaining and rewarding exercise atmosphere for patients, which in turn will help with the motivation of the patient reaching their goals.

- After further development of computer-based devices it will be possible to get cheap and effective devices that will be operated in the home environment.

1.5 The Problem

With the shortage of medical professionals in countries such as Australia; the number of stroke patients greatly out numbers physiotherapists. Thus the time allocated by the physiotherapist with an individual patient is cut down, and so the patient is not receiving the full advantages of the rehabilitation process. Whilst the process being use by physiotherapists to help stroke patients return some kind of normality to their lives by the simple tasks of helping patients exercise their limbs is not very motivating, thus by implementing a computer- based system it would be possible to make the rehabilitation process more ‘rewarding’.

The device needs to be as simple as possible to use so that any individual will be able to correctly operate it without any in depth training sessions; this includes both the hardware connection set up and a friendly user software interface. The device will be made of lightweight material for easy transport and manoeuvrability around the rehabilitation room, and will be affordable for all patients that will require this device.

1.6 Research objectives

In order to develop such a device it was required to first understand what exactly affects a stroke patient and the issues that are faced by a stroke patients, therefore research was carried out to find information on:

- What a stroke is?
- Types of stokes.
- The effect of strokes.

Then using this information further research was done to find out more about the rehabilitation process:

- What the physiotherapist does in the rehabilitation process.
- Whether any computer- based system is used by physiotherapists during the rehabilitation process.

- Computer-based rehabilitation, any promising devices that could be used. Also advantages and disadvantages of these devices.
- Build an appropriate device interface which will allow the device to communicate with the computer.
- Research the development of a software package that would be easy to develop and use, for the device.
- Research games that would effectively and efficiently allow patients to exercise, while at the same time keeping them entertained and challenged.

Using this research methodology, a device was formulated to achieve the requirements of the rehabilitation process outlined above. It is of importance that this device would be designed to meet a user friendly environment for the stroke patients for both hardware and software.

1.7 Methodology

After the problem was defined and the research was done, an 'attack plan' was developed. The methodology was divided into three sections; the hardware, software, and finally testing. The hardware development consists of improving the current framework, and developing an interface circuit. The software developments are to program the microcontroller to receive and send data from the device to the computer and vice versa, also the development of the software package for windows.

1.7.1 Hardware Development

As part of the hardware development, the current existing frame work is analysed and also other devices on the market and possible developmental projects are also researched. This is to see where the pre-existing device could be modified and redeveloped. By using this knowledge, a better device can be design and redeveloped to enhance the quality of exercises received by the stroke patients.

At this part of the design stage, it is combining these ideas to come up with a device and interface which will allow for ease of use and assessment of patients condition. Plans and rough ideas are drawn up and these plans and ideas go through an analytical process to see whether they would be the best combination for the job at hand; or whether the idea could be developed further. The concept that would be used would have to be:

- Cheap the manufacture
- Easy to use by any individual
- Not a complex design in order to keep manufacture and assembly costs to a minimum.

Even though there are only three criteria points to build the concept to, it was not an easy task. As when the manufacture cost was low, the ease of use was comprised, and when the system was easy to use the manufacture cost was too high; thus a balance had to be found.

The final ideas are then dimensioned and parts required are checked and the final three dimensional drawing are created using Pro-Engineer Wildfire. These designs are verified and checked to see if it developments would be feasible for future development.

1.7.2 Software Development

Since the device only requires two analogue to digital converters (ADC) a PICAXE 08M is chosen. This particular microcontroller was selected because of its ease of programming, its ADC capacities and amount of programming memory. The programming language used for the PICAXE is BASIC which is an easy language to learn and utilise.

The circuit diagram for the microcontroller was drawn up and also a test circuit is also created to test if the 08M is working to its full capabilities.

A flowchart is drawn to show what the microcontroller must do and then developed into the final working code. The 08M was first tested in a test environment and the attached to the actual device. The final stage of this step is to create the Visual Basic code to take the data transmitted by the 08M and display it in a suitable and easy to read manner with the option of storing and retrieving data related to a patient.

1.7.3 Testing

The final stage of my project will be to test the device in a rehabilitation centre. After the final device has been created the device will be given to a stroke patient physiotherapist to be used. Using the feedback from the therapist the device will be modified and re-tested

1.8 Overview

Chapter 2 Literature review.

Chapter 3 Prototypes

Chapter 4 Final Hardware

Chapter 5 Final Software

Chapter 6 Testing

Chapter 7 Improvements

Chapter 8 Conclusion

1.9 Conclusion

After the research was conducted and a methodology is established, the project was started. The research data provided the guideline in which to form the methodology. However the methodology was not definite, changes were made to improve the device where possible. However changes were made only to improve the quality of exercise and to also keep costs of developing the device to a minimum. The first and most important research that was done was the information found on stroke patients, the next chapter will describe and show the effects of stroke and the other rehabilitation devices which are available.

Chapter 2 Literature Review

2.1 Introduction to Strokes

In 2009, it is estimated that over 60,000 people will suffer a stroke, and that 88 percent of these people who have suffered a stroke will live with disabilities. Most of these stroke survivors' have to live with disabilities, in most case in health care facilities as they are a burden of family and friends. Thus by understanding, what causes a stroke and its effects; it would be possible to create a framework for the project device. In other words by understanding the target of the device it is possible to understand the need for the device that is built. This chapter will give information used to develop the RAMSP device, and tailor it to the needs of the stroke patient. Also the rehabilitation methods used by physiotherapists and also other computer-based device were also looked at, to see what would best help a stroke patient and the best way to bring some sort of normality to a stroke patient's life.

2.2 Types of strokes

There are two main types of strokes that effect the brain and cause paralysis of the limb, first is Ischaemic stroke and the second is Haemorrhagic stoke. Each of these types of stroke can be extremely fatal, however as said above 88 percent of people survive. It is also true that strokes can occur in body parts other than the brain but for this study the focus is mainly on strokes that occur in the brain. (Wikipedia 2009)

2.2.1 Ischaemic Stroke

Ischaemic stroke is due to a lack of nutrient such as oxygen to a section of the brain due to blockage, thus causing damage to the brain tissue. This brain tissue ceases to function which causes the paralysis and more often than not death.(The Stroke Association 2009)

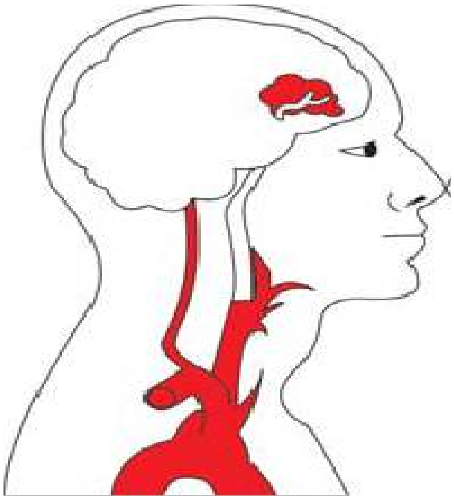


Figure 2.2 Ischaemic Stroke

There are 4 main causes for blood flow to stop flow to the brain are:

- Thrombosis – This is a blockage due to a blood clot, a gradual build up in a blood vessel within the brain; which means that the onset of a stroke is slower.

- Embolic – This is a blockage due to derby from another part of the body travelling to the brain a blocking the blood supply to the brain.

- Systemic Hypoperfusion – This is when cardiac output decreases, which cause less blood supply to parts of the body. If blood supply decreases to the brain a stroke may occur.

- Venous thrombosis - this a rarely form of stroke, which is caused by a blood clot that drains blood from the brain, which in turn starves the brain of essential nutrients.

(Wikipedia 2009)

The brain is a delicate organ and any lose or decrease of vital nutrient such as oxygen and glucose will result in the brain tissue becoming damaged. Ischaemic stroke account for 80 percent of all strokes that occur; whilst the rest are haemorrhagic.

2.2.2 Haemorrhagic Stroke

Haemorrhagic stroke is caused by blood vessel within the brain bursting and bleeding out into the brain.

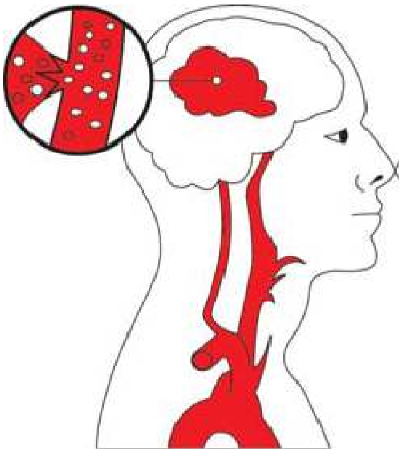


Figure 2.3 - Haemorrhagic Stroke

Figure 2.4 - Haemorrhagic Stroke. This figure shows bleeding into the brain, the dark spots.

This type of stroke usually occurs as a result of small arteries in the brain under hypertension. These arteries burst and blood accumulates within the brain. The haemorrhage in the brain causes a build up of pressure which damages the brain tissue, and also the increased pressure in the brain may stop or slow down blood flow to other parts of the brain. It was also found that direct blood on the brain tissue will cause a toxic effect and will lead to damage or death of the brain tissue.

2.3 Effects of stroke

The effects of stroke vary, as a stroke victim can suffer a partial or a full stroke. If a person suffers from a partial stroke it is possible for the individual to make a gradual recovery. However if a person suffers a full stroke, the individual is likely to be paralysed or in the worst case it many result in death. Stroke can affect the right hemisphere, left hemisphere, cerebellum, or the brain stem, and the effects are different depending on which area of the brain the stroke occurs in.

2.3.1 Right Hemisphere

The right hemisphere of the brain control the movement of the left side of the body, so if a stroke occurs in the right side of the brain the patient will be paralysed on the left side of the body. Stroke patient that suffer a stroke in the right side of the brain have trouble judging distances and perceptual abilities. As a result, patient will be unable to do task as simple as buttoning a shirt to picking up an item off a table. Perceptual ability impairment means that a stroke patient finds it difficult to tell whether an item is right way up or upside down. (Brain foundation 2009)

2.3.2 Left Hemisphere

When the left Hemisphere of the brain suffers damage due to a stroke, a patient's right side of their body will be paralysed. The left hemisphere also control the communication sector, which means that the patients speaking and writing will be greatly affected. (Brain foundation 2009)

2.3.3 Cerebellum

If a stroke occurs in the cerebellum the patients will have abnormal reflexes in the head and body, and also the patient will have issues with balance as well. Stroke patients will suffer from dizziness and nausea. (Brain foundation 2009)

2.3.4 Brain Stem

The brain stem is a vital part of the brain as it is what controls involuntary functions such as breathing, blinking, heart rate and so on; it is also the link from the brain to the rest of the body. Thus when a stroke occurs in this part of the brain the outcome is especially grave. Patients lose control of eye movement, hearing, speech, and the ability to swallow, and since the brain stem is the link from the brain to the body, patients would also have paralysis of limbs. (Brain foundation 2009)

2.3.5 What is affected?

Thus when a stroke occur an individual there is a high possibility that all or a few of the below points may affect that individual.

Mental Affects:

- Thinking
- Feeling
- Speaking
- Understanding

Physical Affects:

- Movement - weakness or paralysis, and balance issues
- Vision
- Auditory
- Swallowing - 50% of stroke victims.
- Breathing

The affects mentioned above vary from people who have suffered strokes, a person may suffer from one or more of the affects mentioned above. People above the age of 65years are more at risk of having a stroke as can be seen in the bar chart below. Also no matter the age at which a stroke occurs, patients are at high risk of developing disabilities after having a stroke. (Brain foundation 2009)

2.4 Rehabilitation process

Rehabilitation of stroke patients takes place soon after a stroke; rehabilitation consists of occupation therapy, physical therapy, therapeutic recreation, speech therapy, psychology and vocational rehabilitation.

- Occupational therapy is to help the stroke patient perform everyday activities so that they can to some degree take care of themselves.

- Physical therapy is what my project is focused on, and this involves the regaining of motor functions, in the case of my project the build of strength and coordination in the arms.

- Therapeutic recreation is a way to improve a patient's problem solving skill.

- Speech therapy is to help the patient to with swallowing and speech.

- Finally vocational rehabilitation is to help patient's get back into their job before they had the stroke.

(Pollock & Disler 2009)

2.4.1 Effectiveness of current non-computer-base Physiotherapy

Present rehabilitation for stroke patients consist of the therapies mentioned above. Physical therapy is done completely on the stroke patient by the physiotherapist. Therapy usually involves massaging of joints and muscles to prevent stiffness. The patient will not be allowed to stay in the same position for more than 2 hours. (Rose &Capildeo 1981) Therapy is slow and usually takes months to years to see any significant improvement. As mentioned above only 13% of the patients' time in hospital is taken to do rehabilitation. (Grotta, Pettigrew, &Yatsu 1995) Patients will do a task in between therapy sessions however the therapist will be unable to see the progress the patient made towards achieving the task in between therapy sessions. This progress would allow the therapist to see how a patient approached a task and any major difficulties faced.

As the project focuses on the arms of a stroke patient more research was done into the methods in which a physiotherapist carries out treatment on the arms. For the purpose of treating limbs affected by strokes, either weakness or paralysis; physiotherapist would get the patient to move limbs along a short guided path.(Pollock & Disler 2002) As the patients' strength and coordination start to improve the movements would get longer and longer and more complex (The Stroke Association, 2009). These exercises are mainly done with the aid of common home hold items. Therapist assign patients' task such as writing their name as a method of keeping the patient exercise between therapy sessions. (Pollock & Disler 2002)

2.5 Computer based rehabilitation

Even though computer based rehabilitation is not used in a rehabilitation environment, there a several which show promise. These systems have only be developed in the recent decades and thus more research and development is required to be done before introducing the devices, to the arsenal of methods used by a physiotherapists' rehabilitation processes. Three devices that have advanced in the recent years are the Kinseological Instrument for Normal and Altered Reaching Movement, Arizona State University and Kinetic Muscles Inc developed a robotic arm, and the Therapy-Wilmington Robotic Exoskeleton. All three of the devices are based on the rehabilitation of movement and coordination of the upper limbs of patients.

2.5.1 Kinseological Instrument for Normal and Altered Reaching Movement.

The Kinseological Instrument for Normal and Altered Reaching Movement (KINARM) measure multi-joint movement from the shoulder through to the hands assessing the degree of damage do by a stroke which allows the therapist to give the patient a suitable exercise to help in recovery. However this device does not give any therapy on its own, it only assesses the amount of damage. Also the device cannot be moved very easily and so the patients have to come to the device. The KINARM is still in development. (Science Daily 2005)

Figure 2.4 - KINARM device (Science Daily 2005)

2.5.2 Arizona State University and Kinetic Muscles Inc developed a robotic arm

Arizona State University and Kinetic Muscles, Inc developed a robotic arm that allows for significant improvement in arm coordination and strength. The patient has to repeatedly perform a motor function exercise over a period of set time. The device is labour intensive and is quite expensive. (Science Daily 2005)

Figure2.5. Arizona State University and Kinetic muscles Inc, robotic arm(Science Daily)

2.5.3 Therapy-Wilmington Robotic Exoskeleton

Therapy-Wilmington Robotic Exoskeleton (T-WREX) is a device that assists people with neuromuscular disabilities. The device has 4 degree of freedom allowing for the patient to move the arm balancing the effects of gravity in three dimensions. The device has to be altered by adding mechanisms to provide the user with exercise for the arm. (Science Daily 2005)

Figure 2.6 - T-WREX with attached mechanisms for arm exercise (Science Daily 2005)

2.5.4 Computer-Based rehabilitation

All the device discussed above are still in the research and experimental stages and have not been used in practical situations.

2.6 Conclusion

Thus by looking at the different devices that have been developed and the manner in which they operate device hardware for future medication and software package can be developed. However first the issue that needs to be addressed before actually develop a final device is to create concepts and compare to the criteria which will be discussed further in chapter 3, that the device needs to fit. The focus of this project is the upper limbs of a stroke patient and so by researching and understanding the causes and effects of stroke, the project can be better tailored to assist with the rehabilitation of stroke patients.

Chapter 3 Concept Development

3.1 Introduction

After the research was conducted and a sound understanding about strokes and its effects was acquired, the initial planning and brainstorming began. Many ideas were taken into consideration, no matter how out of the ordinary it may have been. The design process was done in two parts and then in the end the parts that were the most practical and fitting into the criteria below were taken and produced.

The pre-existing device is as shown in figure 3.1, where two potentiometers located at the end and middle of the device, readings to calculate the angular movement of the device; from these movements the x and y direction can be found, which in turn are used to move the cursor on the screen. These movements on the screen are used to play the different games and do the physiotherapists assessment. This system aims at rehabilitating the coordination and strength of the shoulder and elbow regions. When the individual push the joystick upper and down the movement will be in the y direction; and when it is moved from side to side it will be data recorded in the x direction as shown in figure 3.1. Using these 2 dimensional movements the patient will be able to interactively work towards finding normality in their lives.

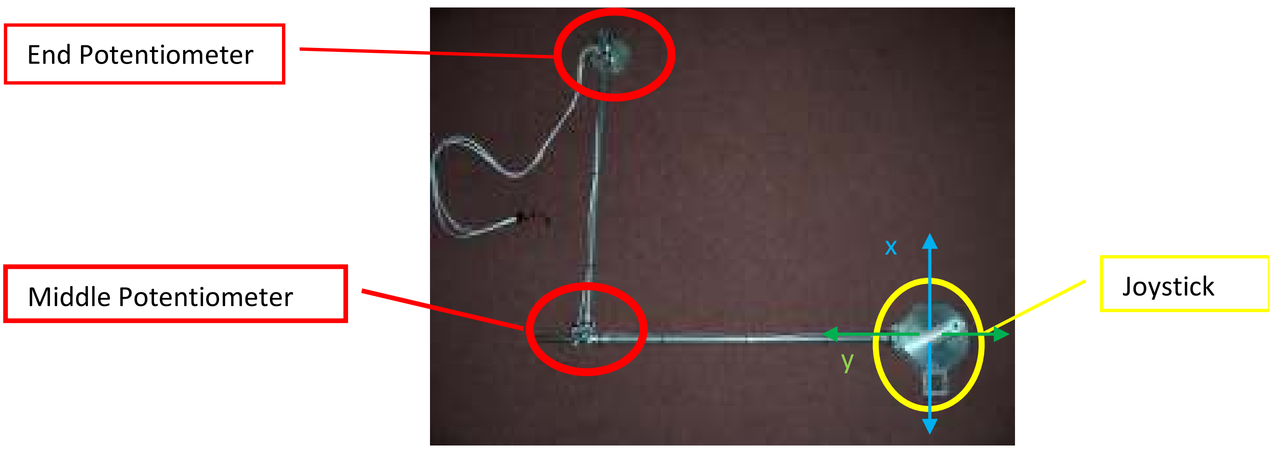


Figure 3.1 – The Pre-exist device the red circles are the location of the potentiometers

The main focus of the project was to improve the quality and effectiveness of the exercise that the device provided. Thus concepts for both hardware and the software of the device were created and evaluated. The hardware concepts were brainstormed first; how to better the system and make it more effective in the rehabilitation process. Then after the appropriate hardware solutions were found, the software aspects of the device were thought out; this took into account the programming of the windows program and also the programming of the micro-controller and its interfacing circuit. Both the hardware and software were analysed using the criteria and depending on how well the concepts fit the criteria, would give the appropriate design to be carried on into the final design stages.

There were numerous conceptual designs for the hardware and software, these concepts will be discussed and then the best structure will be selected and discussed further in the following chapter.

3.2 Criteria

There were two set of criteria, one for the hardware and the other was the software criteria. First the hardware criteria:-

- The part developed for the device must be inexpensive to create.
  - As this device is being aim toward the families of stroke patients so that they are able to take the device home and allow for the stroke patient to exercise without making the long and uncomfortable trip to the rehabilitation centres.
- Safety factor.
  - The planned development should have no dangerous parts which could harm the patient or the operator.
- Easy to use.
  - The device must be easy to set up and operate. The concept device must be simple to set up with little or no training so that it would be possible for family member and physiotherapists alike to put the device together. Also to assembly of the device must be simple as possible.
- Patient comfort.

- It should be kept in mind that the device is going to be used by stroke patient who have lost their use of their limbs and cannot move unless guided by an individual such as a family member, friend or health care worker. So the device should be easily explained, so that the instructions on how to operate the device must be kept to a minimum.

The hardware criterion was followed in the development of the future concepts that would better the device for future use.

Software criteria:-

- Inexpensive to create and obtain.
    - The actual windows program must be inexpensive to create and can be obtained by any patient, which means that the software package must be small enough to be downloaded and available in all form of removable or optical data storage. The microcontroller program also must be inexpensive and any updates must be easy to obtain.
- Ease of operating.
    - Similar to the hardware requirements, the software must being simple to use with little or no training. The operator should be able to open the program and simply start the program as if they were an expert. The program should have a help option available so if at any occasion the operator requires assistance the help menu will have the required help for any part of the program. Also physiotherapist will have a guide to be able to read the data that has been collected from each patient. The interface circuit must be fool proof so that it would be almost impossible to breakdown and simple to link to the device and computer.
- Patients' enjoyment.
    - The activities that the program provides should an enjoyable experience for the stroke patient who uses it. The activities must be challenging whilst at the same time be rewarding as well. The program will create a competitive atmosphere with the patient trying to achieve higher results than previously

achieve; thus in turn bring the patient back to exercise more and also have some fun.

The criterion serves as a guideline to try and get the best possible system to meet the needs of the patient and also the operators of the system. All the sections of the criteria were give a 1 to 5 grading scale; where 1 means that the criteria section was not met and 5 means the criteria was met. Each idea that was brainstormed was given a mark in accordance to the grading scale, and then the best score was taken and developed further. The grading was done by analysing the designs objectively by use of research data and simulation. The chapter will look at the designs comparing the pros and cons of the devise parts that were nominated to be redesigned. The software was modified section to section, and also through trial and error. The hardware sections will first be analysis and the reason why the part was chosen will be given.

3.3 Hardware

The hardware of the pre-existing device was to be modified to better the quality and the effectiveness of the exercise that is done by the stroke patient. The parts that were nominated to be modified were the:-

3.3.1 Surface of which the device operates on top of.

3.3.2 The end joint for resistance training and future development of the device.

3.3.3 The interface circuit which is the essential part that allow the device to communication with the computer.

3.3.1 Surface modification

The pre-existing device had a velvet cloth pasted on the bottom of the hand rest area as seen in figure 3.2; this was to reduce the amount of friction caused by the device as it slides along the operating surface. However it was found that this only reduce the friction to a degree and it would be possible to reduction friction further. Thus many ideas were brainstormed, from the complex to the most simple. All the structures that were thought of were investigated using the criteria and the best structure was chosen.

Figure 3.2 - The joystick where surface modifications will be done

3.3.1.1 Surface Concept 1 - Compressed air

As seen in the figure this was one of the more complex designs for the surface with least amount of friction. It would uses a similar sort of idea as a hovercraft, compressed air would be pumped in from the top of the hand rest. There will be 8 sections controls which would control the amount of air being blow out of the bottom of the hand rest. These 8 sections were to be controlled by a microcontroller, the microcontroller would check which part of the hand rest was being weighed down and blow more air through that section and less through the others, of the hand rest; thus in theory levelling out the device. This plan was halted because of the device requiring significant modifications; however this was not the main reason why this plan did not go ahead, it was because of noise of the compressed air might scar the patient and also the device could only be operated if there was access to compressed air. Another problem that would cause issue is the fact that the device will have to be restructured to be lighter weight wise which would increase costs as well as the device will be weaker; so it the patient puts too much weight on the structure it would form cracks and breaks.

3.3.1.2 Surface Concept 2 -Track and Suspension

This design used track and suspension wires, so the device would not actually touch the operating surface. The design works with two tracks on to which a wire suspension cable will be attached. The tracks are able to slide up and down as show in the figure; this was the most complex design that was created. This straight way was found to have many disadvantages; firstly, the size of the structure would make it difficult to move around. Then there is the problem of the structures complexity which would have extensive plan and have an expensive building cost. There is also the danger of patients getting the IV tube caught on the suspension wire which would cause issues. This would because the design would be too bulky and hard to fit into homes because of its size and shape.

3.3.1.3 Surface Concept 3 - Teflon and Perplex

This was thus far the simplest concept that was created; involving a perplex sheet (1 meter x 1.5 meters) and Teflon paint. The base of the hand rest would be painted with the Teflon paint and the device would rest upon the perplex sheet. Teflon or chemically known as polytetrafluoroethylene has a coefficient of friction less than 0.1 which is the second lowest of all the solid materials; with carbon compounds such as diamond being first. Thus this would create the best surface with little friction. (Wikipedia 2009) The disadvantage of this method is that the patient would have to obtain the perplex sheet, however this would be lighter than moving a table or large frames.

3.3.1.4 Chosen Surface

The surface concept were analysed using the hardware criteria and the following results were obtained:-

Concepts	Cost	Safety Factor	Ease of use	Patient comfort
Compressed air	2	2	1	1
Track and suspension	1	1	3	1
Teflon and perplex	5	5	5	5

The compressed air concept would be expensive as a result of the device having to be redesigned and modified to accommodate the new parts. Also the cost of attaining an air compressor would be costly for a patient. Safety vice this would not be an ideal concept, as the air might cause issues with dust which would cause issue for a stroke patient. Also the noise and the pressure created by the compressed air might scar stroke patients.

The track and suspension concept would be expensive to build and there might be the issue of the patient tangling themselves in the suspension cable. The device maybe easy to control as the device only has the track which would slide easily around the frame. However comfort would an issue because of the frame thus the range of movement will be limited.

The Teflon and perplex concept is the best in all of the categories, as it is the cheapest option and safest as there are no means of the patient getting their hand caught or dust issues. It is the easiest to use as there is no need for any sort of training on how to setup the device. Thus this option was selected and will be further discussed in the following chapter.

3.4.3 End Joint modification

The end joint is the fixed part of the device, which will be modified to give the stroke patient a form of resistance and also aims for future modifications of the device. The joint concepts all had similar methods of providing the aims mentioned, however the structures are different. The concepts will be described and then a grade based on the criteria will be given. All the concepts would use 2 pulleys to drive the arms of the device. The top pulley as seen in figure 3.4, is used to drive arm 1(refer to figure 3.3) and the bottom pulley would drive arm 2, both of the arm will be attached to the tops of the pulleys. The top pulley be attached in a swivel type attachment, and the bottom pulley the arm will be solidly attached, this will be discussed further in chapter 4. The pulleys used would be timing pulleys to prevent as much slippage as possible, as it is required for the patient to have a smooth and effective exercise medium. The bottom pulley would be attached to the main shaft and the top pulley would be able to move independently to the top pulley. The base and the shafts are what change from concept to concept. The figure will show the structure and the manner in which each concept works.

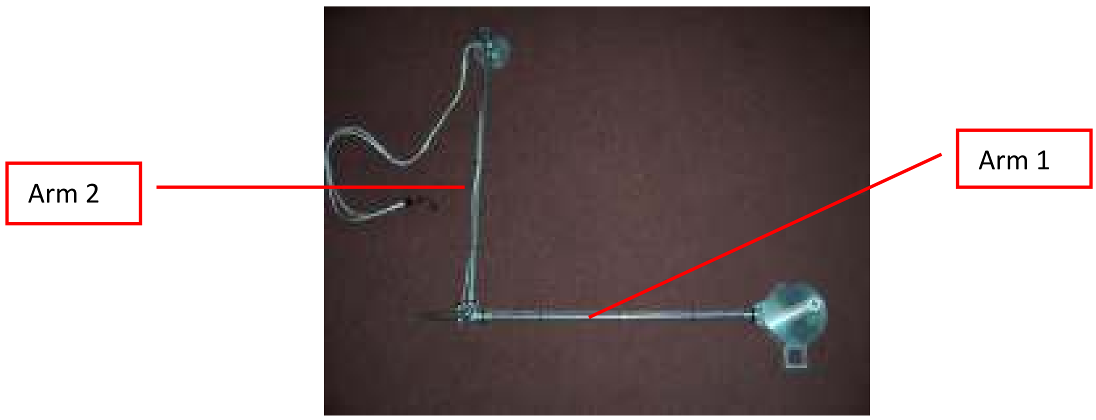


Figure 3.3 - The device showing the arm numbers

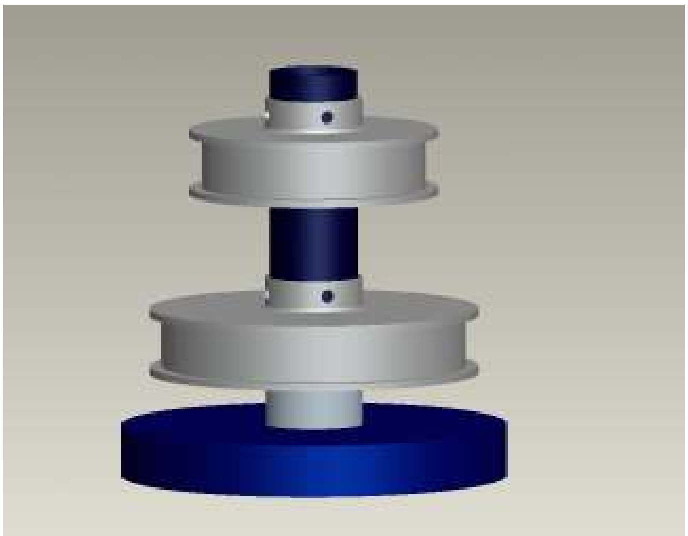


Figure 3.4 - similar structures in end joint concept 1 and 2

3.3.2.1 End joint Concept 1

In this concept design the major modifications were done to the end joint, where it is replaced by hollow shaft which is placed on a basic base section. The shaft would be machines with a small hole from the top which would allow for the potentiometer to be attached. The top pulley would be placed around 40mm from the top of the shaft with a machined place holder. This pulley would also be fitted with a ball bearing so that it would be able to move independently to the rest of the end joint. The base of this design would have 20mm extrusion on which a ball bear was tight fitted and then the shaft would be fitted over the ball bearing this was to get the shaft to move independently to the base. The issues with this design were that the actual design was extremely complex and attaching the potentiometer would be a difficult task.

3.3.2.2 End joint Concept 2

This design is similar to the design above however the base is replaced by a steadier one. The base is modified in this design to give more strength and also to provide support to the overall device. In this design however a spacer is tight fitted on to the shaft in order to stop the top pulley from sliding downward. Also in this design the base uses ball bearings on the outside of the shaft instead of on the inside. This design has the same problems as concept 1, in that it is too complicated, the shaft would make attaching the potentiometer to the base quite difficult.

3.3.2.3 End joint Concept 3

Finally the last concept used the same base as the concept above but the shaft is a solid which would make the system very strong. The spacer is removed and instead two notches are made to hold the top pulley and the second notch holds the shaft in an upright position. The shaft except for the above mentioned differences is similar in that the bottom pulley is attach directly to the shaft and the top pulley in attached using ball bears. The issue that was faced with this design was that the potentiometer was difficult to attach.

3.3.2.4 Chosen Concept

Concepts	Cost	Safety Factor	Ease of use	Patient comfort
1	3	3	1	4
2	3	3	3	4
3	2	3	4	4

All of the concepts are expensive to create as they have to be machine into shape. The end joint concept 1 is quite expensive to make because of the large amount of machining that need to be done, especial the notch that would hold the top pulley. All the concept are similar in the cost and safety categories, however concept 3 excels in both the ease of use, as the assembly of the end joint is more simpler than the other 2 concepts. Also the patients comfort would be not compromised in anyway by any of the conceptual designs. The conceptual design that was chosen was number 3 with the solid shaft instead of the hollow shaft and will be the final design that would be used to develop the end joint.

3.3.3 Interface circuit Concept

The interface circuit was one of the major parts of the project; it is the way that the device communicates with the computer and vice versa. The interface circuit has a microcontroller takes the data from the potentiometers and send this data to the computer program. There are 2 potentiometers which are the only analogue to digital connections that the system has. The button could easily be connected to any normal pin of a microcontroller. There were 3 choices of microcontroller that could be used to develop the interfacing circuit, the pros and cons of each are given in the sections below.

3.3.3.1 Interfacing circuit Concept 1

The PIXAXE 08M is a small 8-pin microcontroller, with 3 analogue to digital convert (ADC) pins which would be more than enough satisfy the requirements of the system. The 08M is a very cheap and effective microcontroller which does not require much power to be operated.

Figure 3.5- PICAXE 08M microcontroller.(PICPATCH 2009)

It is a low budget and can easily be adapted to any control system. The applications of this PICAXE range from robotics to weather a monitor, which proves how versatile this chip can be. (PICPatch, 2009)

However the issue with this microcontroller is that the printed circuit board (PCB) that is provide would not match the system that is required by the project device. Thus some additional cost will have to be taken into account in developing a PCB to match the requirements of the project device. Also the baud rate of is only 4800 bytes per second which is slower than the other microcontrollers that were being considered.

3.3.3.2 Interfacing circuit Concept 2

The Philips LPC210x ARM7 microcontroller is a low cost while being a high performance embedded processor with development board. It is able to use many programming languages such as C and C++. The program editor uploads the programs into the processor as a hex file after the program is written. The development board uses a RS232 connection to link with the computer and a 20 pin serial to link to any device. This type of system is very good for activities such as robotics. The ARM7 also has a liquid crystal display (LCD) which shows if the device is active or not.

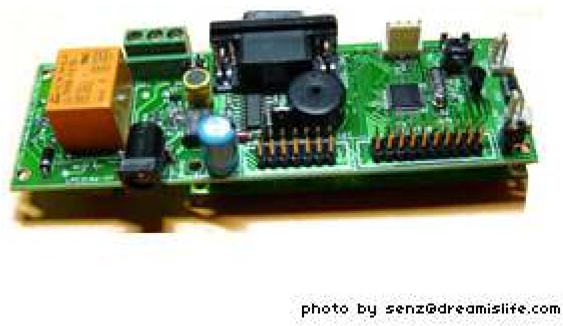


Figure 3.6 - LPC210x ARM7 Microcontroller(senz@dreamislife 2009)

3.3.3.3 Interfacing circuit Concept 3

The final microcontroller that was looked at was the PICAXE 18M, which is an 18 pin microcontroller with 5 ADC pins. It is a cheap and supports all types of projects. Its can support baud rate of 4800 bytes per second input and 9600 bytes per second output.(PICPATCH 2009)

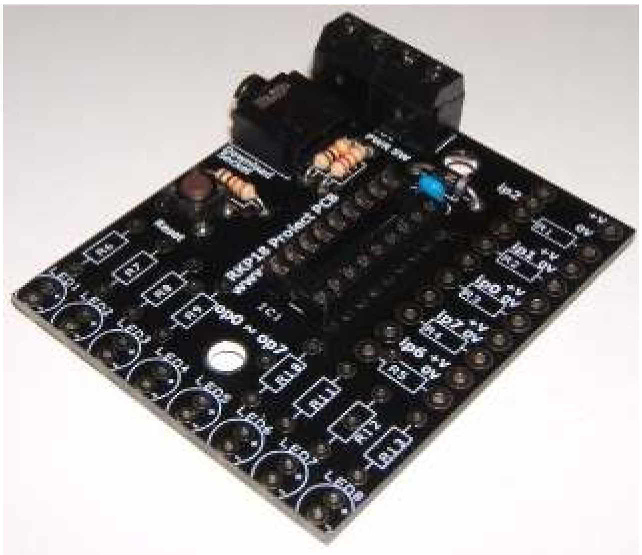


Figure 3.7 - PICAXE 18M plus development board (PICPATCH 2009)

3.3.3.4 Chosen Concept

Concepts	Cost	Ease of use
PICAXE 08M	5	5
ARM7	2	3
PICAXE 18M	4	3

The ARM7 is quite expensive when compared to the 2 PICAXE microcontrollers that were looked at. It has many functions and inputs such as buttons which would confuse most people. The instructions need to be read carefully in order to understand where the connectors plug into. The ARM7 was not chosen because it is too complex and is also quite expensive.

The PICAXE 18M has 18 pin outs which is not required for the project device. The microcontroller is more expensive than the PICAXE 08M and is more complex as well.

The interface circuit must be inexpensive and also easy and simple for any person to understand; that is why the PICAXE 08M was chosen. Since its PCB does not cater to the requirements of this project, it was possible to simply make a PCB that did, and in so do create a simple as possible which anybody would be able to understand.

3.5 Software

The software had the task of getting the data put out from the device and turning it into a visual manner of which to present data allowing the stroke patient to interact with the device in a window program providing them an enjoyable exercise environment. The main aim of the program was to provide the patient with a way to actively engaging with the device and for the physiotherapist to be able to read the data collected from each patient and be able to interpret it in a medical manner. Therefore the program will have to have a structure that would allow the exercise data that is collected by the program to be saved and retrieve on a later date by the physiotherapist and doctors. When building the program each section of code, as it was written was checked with the software criteria mentioned above. The software still had many structures which the criteria was use to see if it would be good enough, and then the criteria was again used to analysis each section of code of the selected structure, thus in theory make the program as perfect as possible.

The microcontroller programming is also very important, as the data need to be received by the windows program in a usable manner. See chapter 5.1.

3.4 Conclusion

The concepts of the hardware were mark according to the criteria and the best option that would assist the patient and their families was chosen. These options will be further discussed and a more elaborate explanation on why each was chosen will be given. For the software basic structure was explained, giving what the software would need to incorporate. Further details are given in chapter 5 with the program code given in appendix C.

Chapter 4 Hardware Design

4.1 Final Design Concepts

The conceptual designs were all analysed in the previous chapter and a final concept was chosen. To reduce the amount of friction that is caused by the movements of the device on the operating surface; a Teflon paint coat would be applied to the underside of the joystick area, and also to the middle joint where the potentiometer is located. The other approved modification was the end joint, which will be changed so that the device is able to provide the patient with resistance training that would allow the patient to build both muscle strength and also provide the patient a more challenging coordination exercise. Finally the development and the building of the interface circuit will be described and analysed. The microcontroller program will be design and development will be detailed in chapter 5. This particular chapter will take each of the final designs and run through each of them step by step and every part of the designs will discuss the reason why each particular component was selected. First the reduction of friction will be detailed.

4.2 Surface design

From the chapter 3 it was found that the Teflon paint and the perplex sheet that will be used would reduce the amount of friction caused by the device. This will assist the patient greatly as the amount of force required to move the joystick will be reduced. This will allow a more accurate analysis of the patient's condition to the physiotherapist. This concept was used because of its simplicity; as the device is aimed at possible home use, and therefore the simpler it is the better the results of the exercises will be, and the more functional it will be to the patient. The patient's families would not need an instruction booklet on how to setup the device, instead it would be a straightforward 'setup and exercise'.

4.2.1 Teflon paint

Teflon is the name given by DuPont for the chemical compound polytetrafluoroethylene (PTFE), it in mainly comprised of carbon and fluorine. As a result of the strong bond between the carbon and fluorine it is a non-reactive element; and is commonly used as a non-stick coating in frying pans and also as a lubricant.

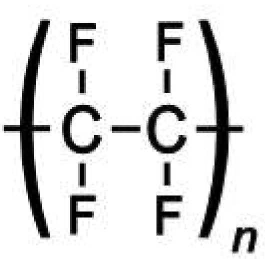


Figure 4.1 - Polytetrafluoroethylene structure

The properties of the Teflon compound when used as a lubricant are that they:-

- Reduces friction – The general range of friction coefficient is 0.05 to 0.10, this is dependent on the load applied, slide speed, and the type of coating that is applied to the part.

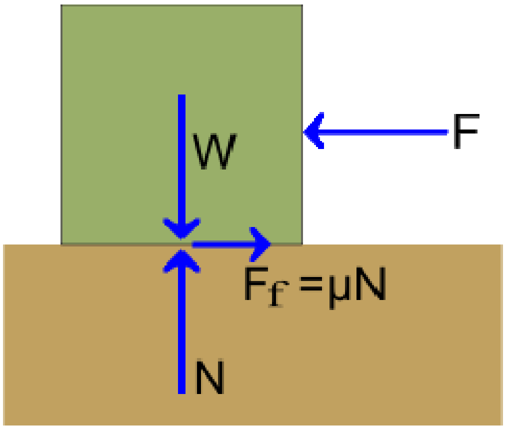


Figure 4.2 - Kinetic friction calculation

- Non-Wetting – Because of the strong carbon fluorine bond the Teflon coating is both hydrophobic and also oleophobic. This is perfect for the project device as if there are any accidents such as the if the patient vomits, then the surface will be easy to clean and will not be affected in anyway.

- Chemical Resistance – Teflon is a non-reactive with most chemicals, which mean that in a hospital environment Teflon would prove to be unaffected by medication and chemical spills.

- Temperature resistance – This compound does not lose it chemical properties unless exposed to extreme temperatures such as 260°C and -270°C.

Table - 4.1 Table of properties of Teflon from DuPont:

Property	**Value**
Density	2200 kg/m^3
Melting point	327 °C
Young's modulus	0.5 GPa
Yield strength	23 MPa
Coefficient of friction	0.05-0.10

4.2.2 Perspex sheet

Perspex is the trade name given to Poly (methyl 2-methylpropenoate), it is preferable to glass as it is easier to handle and costs a lot less. It has a good environmental resistance than any other plastic available. Perspex can also be easily cut into any shape and form which would allow the patients families to specify a size, within the designated operation range of the device, which they would want so that the device can be kept in the home.

Table – 4.2 Properties of Perspex

Properties	
Molecular Formula	$(C_5O_2H_8)_n$
Molar Mass	Varies
Density	1.19 g/cm^3
Melting Point	130–140 °C (265–285 °F)

4.3 End Joint modifications

The concept that was for the end joint modification is the solid shaft and the supporting base, which proved to be the best design because of its relative simplicity to make the parts and to assembly the whole end joint. The separate parts that make up the modified end joint will be detailed, and also the size of ball bearings and pulley will also be given.

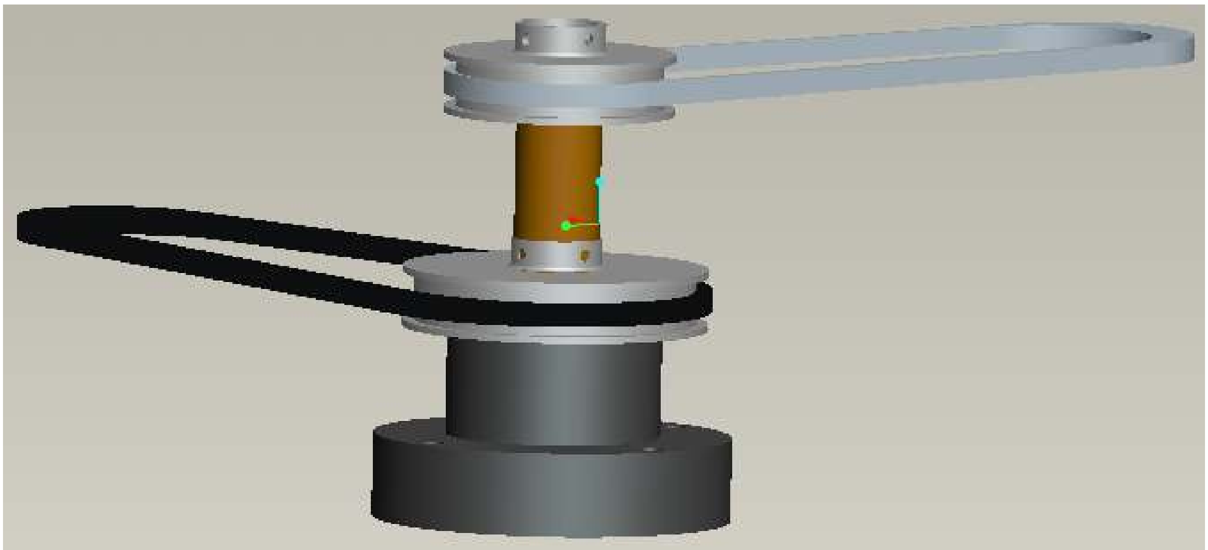


Figure 4.3 - Modified End Joint

4.3.1 Shaft

The shaft is made by machining a solid cylindrical aluminium rod of diameter 45mm, the small end seen in the figure below is the part where the top pulley will be attached with the ball bearing. The shaft gets larger after the section the top pulley is attached to, which acts as a spacer making sure that the pulley does not slide down. The second section is designed in a similar manner to the first and has a larger section which stops the second pulley from displacing. Both pulleys are attached above these larger section parts which would act as spacers.

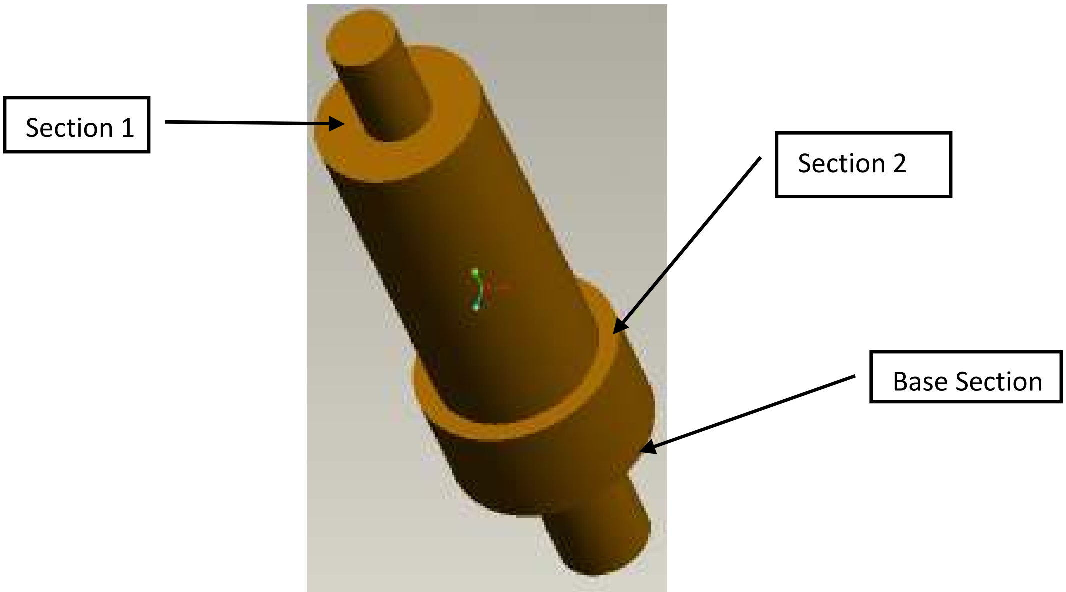


Figure 4.4 - The shaft

The base section would be fitted into the base with ball bearing to allow the shaft to rotation freely.

4.3.2 Base

The base section of the shaft will be fitted into the base with a ball bearing (refer to 4.3.3). The fitting will be done on the first outer most hole allowing the shaft to rotate with minimum friction. The end of the shaft will be a loose fit with the inner hole of the base.

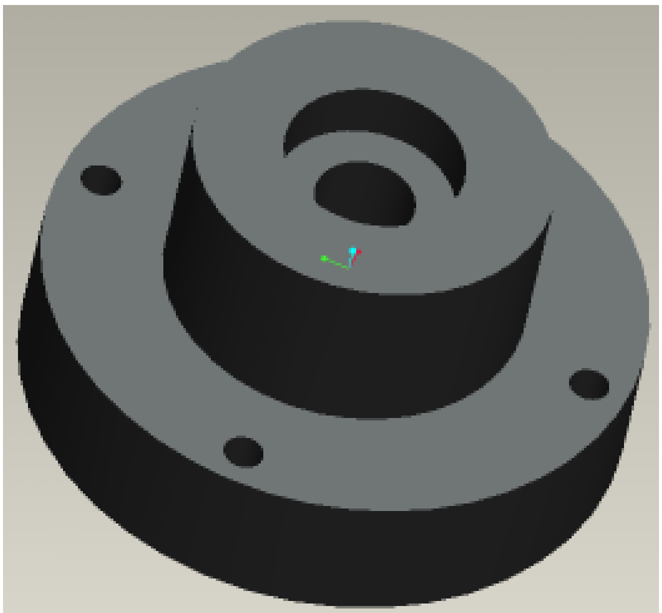


Figure 4.5 - The base of the device

4.3.3 Ball Bearings

The ball bearing will used for both the top pulley and that base section of the end joint to allow the joint to rotate freely. The reason the top pulley only gets a ball bearing is because it will control the second arm of the device and requires being independent of the rest of the end joint. The shaft will use the ball bearing to rotate so that the first arm will be able to rotate as well.

The ball bearings which were chosen were from a company called SKM which provides a variety of bearings. For the top pulley, ball bearing chosen is a cylindrical roller bearing, and a single row was opted for. This was one of the precision bearings, as the pulley operates the arm that will require a large amount of accuracy. (SKM 2009)
The second bearing that was used was the deep groove double row ball bearing, this bearing was used, since the shaft and the base would carry a lot of the force that would be exerted on the system, thus by adding a double row deep groove ball bearing these forces are manageable. (SKM 2009)

4.3.4 Pulleys

The pulleys that were used are made of aluminium unflanged timing pulleys. Timing pulleys are used to avoid too much slipping when the device is operating.

Figure 4.6 Pulley (Small part and Bearings 2009)

The pulleys are drilled to make the bore holes larger so that they would be able to fit the shaft. The top pulley is attached to arm 1 by a rod connected from the extension of the arm to the top pulley. The rod is not fully joined it is connected by one pin which allow the rod to swivel allowing for the arm to move freely without obstruction from the rest of the end joint. Arm 2 on the other hand is fixed by pinning the arm down on to the actual pulley, thus when the end joint moves the arm also moves. The potentiometer would be fixed to the timing belt and this will then be scaled to get an accurate result.

4.4 Interface Circuit

The interfacing circuit is the most important part of this project, as it allows the project device and the computer to communicate. The first task was to developing the PCB as the PIXAXE 08M development board was not adequate for the task at hand.

Figure 4.7 - PICAXE 08M kit

Thus firstly the circuit to support the microcontroller was drawn up and make on a bread board. This bread board prototype used a 5V battery power supply.

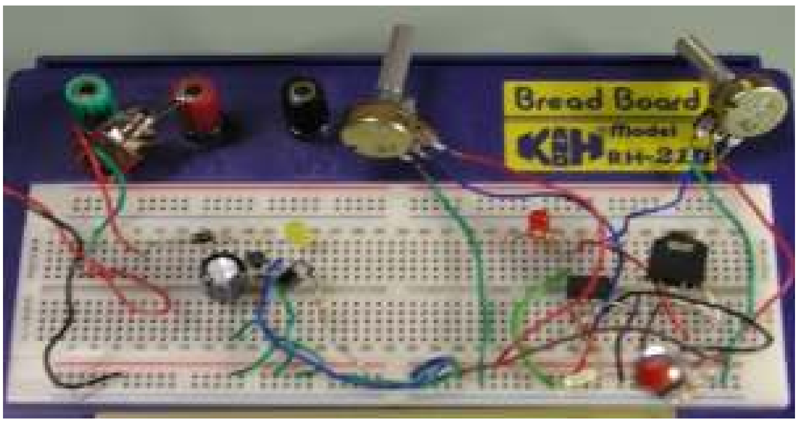


Figure 4.8 - Bread board prototype

However using a batteries to power the system would not be practical, so a power regulator circuit was incorporated into the circuit which would make sure that only 5V would go into the powering of the microcontroller.

4.4.1 Power Regulator

A 7.5V power adapter will be used with the regulator circuit to regulate the voltage to 5V using a LM7805 power regulator. LM7805 is a 3 terminal 1 amp position regulator; it uses thermal overload protection, short circuit protection, and also safe operating area protection; which makes it almost indestructible. This also makes sure that the PICAXE is also protected and will not be damages. Also for safety of the circuit a diode was put in before the regulator so that if the negative and positive power terminals were switched by accident the circuit would always be protected.

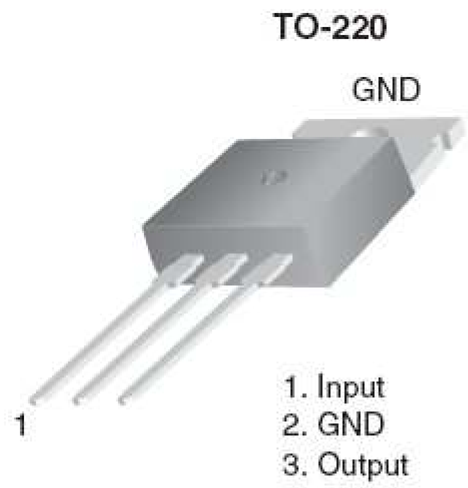


Figure 4.9 - LM7805 regulator

4.4.2 PICAXE 08M circuit

The PICAXE microcontroller was connected with a 20 pin serial get data from the device and an RS232 port to link with the computer. The 20 pin serial connects the power and ground to the potentiometers and switch on the device and also received the output from them as well.

The voltage supplied to the device was 5V regulated, with a pull up resistor on the switch the reason for this will be further explained in chapter 5.

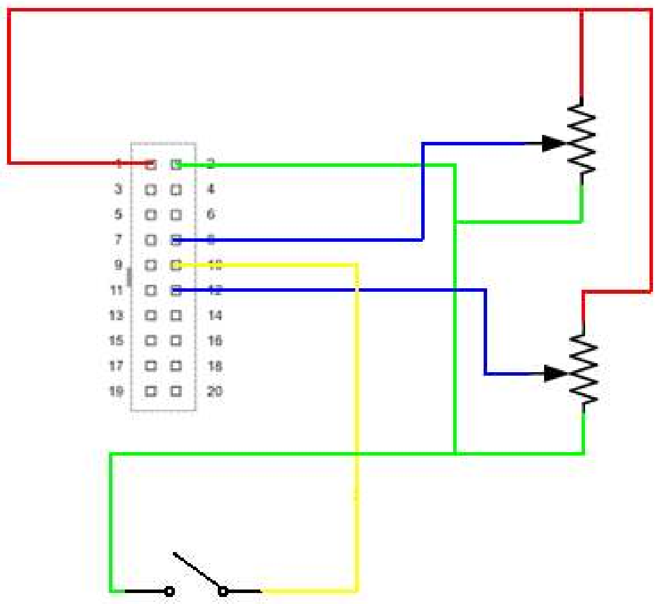


Figure 4.10 - Project Device connections to serial port

4.4.3 Printed Circuit board

The PCB was created using Altium winter 2009, which allowed for the easy construct of the PCB directly. Using the footprint function which lays the copper pads for components, nearly all the parts were found except for the RS232 port. The reason the RS232 port could not be found was because it was a unique jack type port; and so the pads had to be laid manually. The bread board circuit was directly transferred to the PCB; which was created of two parts, the regulator circuit and the PICAXE circuit.

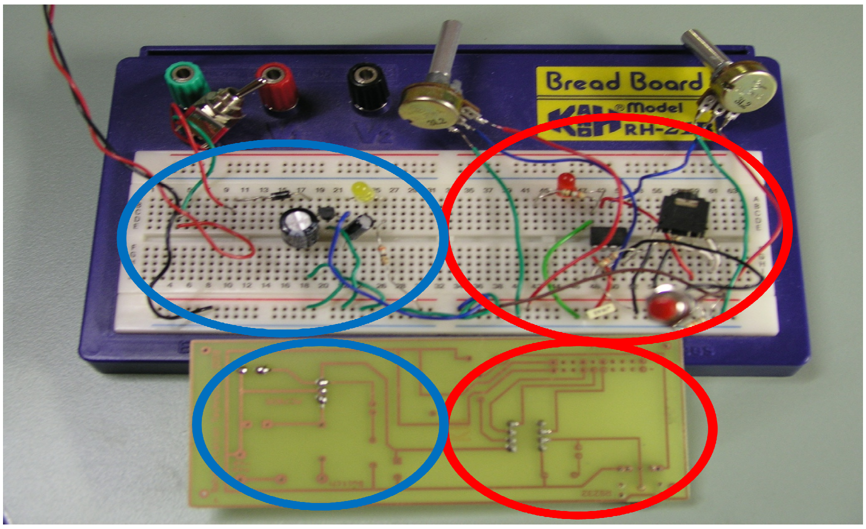


Figure 4.11 - PCB and Bread board show the 2 sections. The blue circle is the power regulator and the red circle is the PICAXE circuit.

Additional LEDs (Light emitting diodes) were added; 1 was added to indication the power supply part of the PCB was working and another was used to show when the system was active and transferring data.

4.5 Conclusion

In the project specification, the 4th aim of this project was to create a standalone system which would allow the user to interface the project device to the computer; the interface circuit does exactly this. As mention many time before the interface circuit is the most vital as without it the data collected has no means of being used to both enable the stroke patient to exercise and also for the physiotherapist to interpret the exercise data and thus evaluate the patient progress to see the levels of improvement improving.

Chapter 5 Software Design

5.1 Software Design

The software design for this project was a long process; the saving of the data was the main priority which would allow the physiotherapist to go back and check the progress of the patient. Patient will be able to use the program and interact with the exercise that they are doing, and find that the exercise is more rewarding than normal rehabilitation processors. The program that was used to create the program for the project system was visual basic 2005, and is written in visual basic programming language. However, first this chapter will discuss the programming of the microcontroller that was used in the interface circuit.

5.2 Microcontroller Program

The PICAXE microcontroller used BASIC (Beginner's All-purpose Symbolic Instruction Code) programming language which was easy to learn and implement. The instructions for the chip was done using the PICAXE program editor, it was very direct and simple to use. The code is typed into the editor window and then simply uploaded onto the microcontroller. The editors debug tool was a great assistance in developing the microcontroller program. A test circuit was also build to test whether the data is transfer and receive data by the microcontroller pins using LEDs.

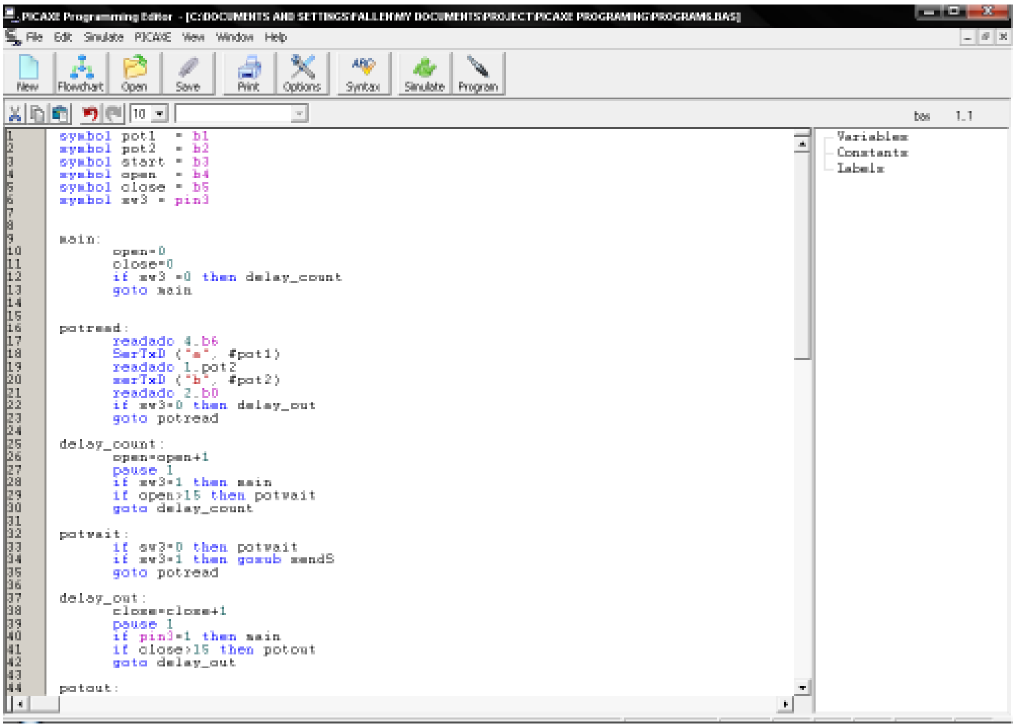


Figure 5.1 - PICAXE program editor

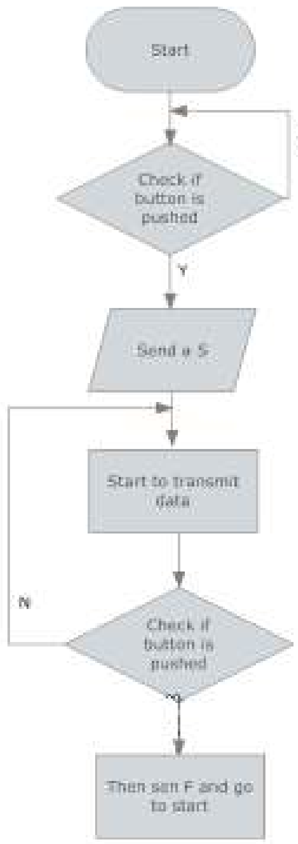
5.2.1 BASIC Programming Language

The BASIC programming language is the best for this type of programming because it is easy to use, it is a general purpose language, has advanced functions, has clear error messages, and quick response to programs. (Wikipedia 2009)

5.2.2 Program

The BASIC program developed for the microcontroller had many different sections which were combined to create the final program. The first section consisted of just a function that would read the data from the device and transfer it to the computer. However although this did work it was found that the data was received as a string of numbers making it very difficult to separate the two potentiometer results. This was solved in the second program where an identifier was put in front of each data set; these identifiers were 'pot1' and 'pot2'. The switch which the device used was a push switch which caused the issue of switch bounce. Thus to overcome this issue a debounce program was written and incorporated into the program. This consisted of a wait function after the initial button was pushed which would To try and quicken the speed at which data is read into the computer the identifiers were shorten and which meant that data was read into the windows program at a rate of

9.83ms. To make the visual basis program know exactly when to start and stop taking the data in an s for start and an f for finish was also combined into the program. The button of the device is pulled high and when the button is press will go low, therefore the program only starts when the microcontroller reads a 0 from the button. All of these functions combine to create an excellent transfer method.



5.3 Windows Program

The windows program creates the actual environment in which the stroke patient will be doing the exercises in, and also the physiotherapist will be using to evaluate the patients progress. So the program has to be both interesting to the patient and also understandable in the data that is collected to be analysed by the therapist. Also the program is designed to be use with no training, so the patients' family who purchases that system can operate the program without needing for assists from an expert. The program thus has to be simple and well structured so that the operator does not need to go looking for what they want to do.

The initial screen is a selection screen which allows the patient to start as a new patient, if the patient is not new then they will go to open patient; this would open the patients' data files and allow the patient to continue from where they left off. This will give the patient a feeling of accomplishment as the will how do the same work twice. The open patient option will mainly be used by the physiotherapists to review patient data.

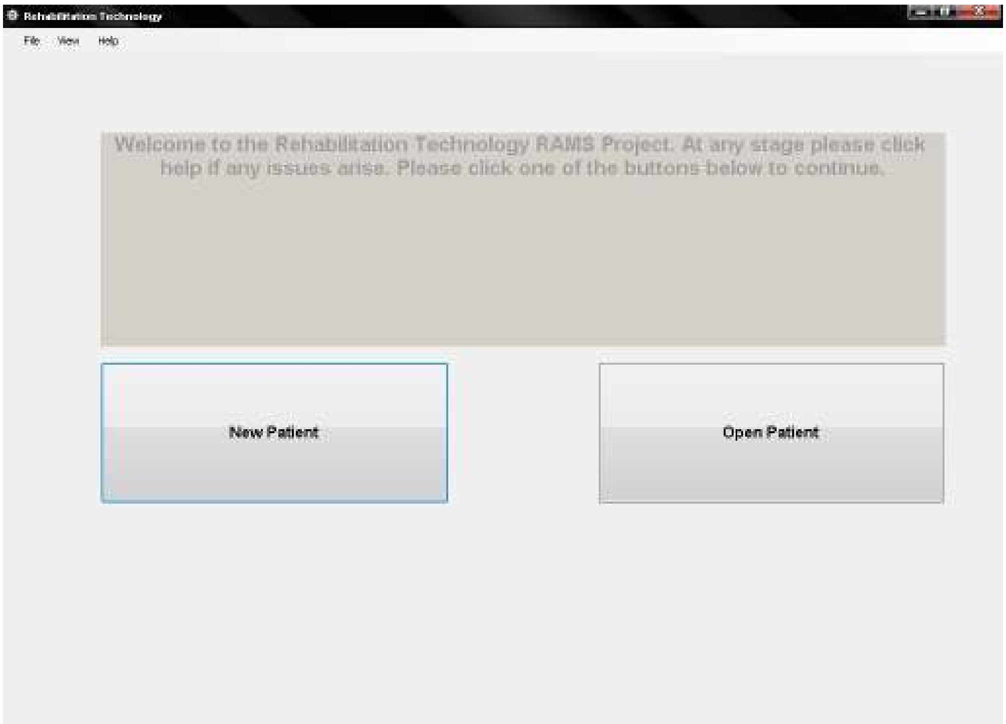


Figure 5.2 The main window

If the option of the new patient is click on the operator will be taken into a window where they will be asked to fill in the details of the patient, such as name, age, gender, the current date, and so on; there is also a comments box where the physiotherapist is able to leave note about the patient. When the save button is click this will result in the formation of a directory in the hard drive under the patients name. A sub directory will also be formed in this folder with the current date and all the patient exercise data will be stored in this sub folder.

Figure 5.3 - Data entry

Once this is done the operator will be taken to another window, where the games can be chosen and the difficulty of each game can be set. Even though there are three games, each game will give a different exercise for the arm, for example connect the dot is aim at the patient recognizing numbers and moving toward it, repeat game is the patient repeats an action such a moving up and down at a certain speed for a minute; and finally dodge is a game where the patient moves the cursor in order to move away for objects. When the level is changed this results in the small dots with a larger amount also, the repeat game the higher the level the more complex the action will become. Such as when the level is set to level 2 then the patient will have to draw diagonal lines and shapes.

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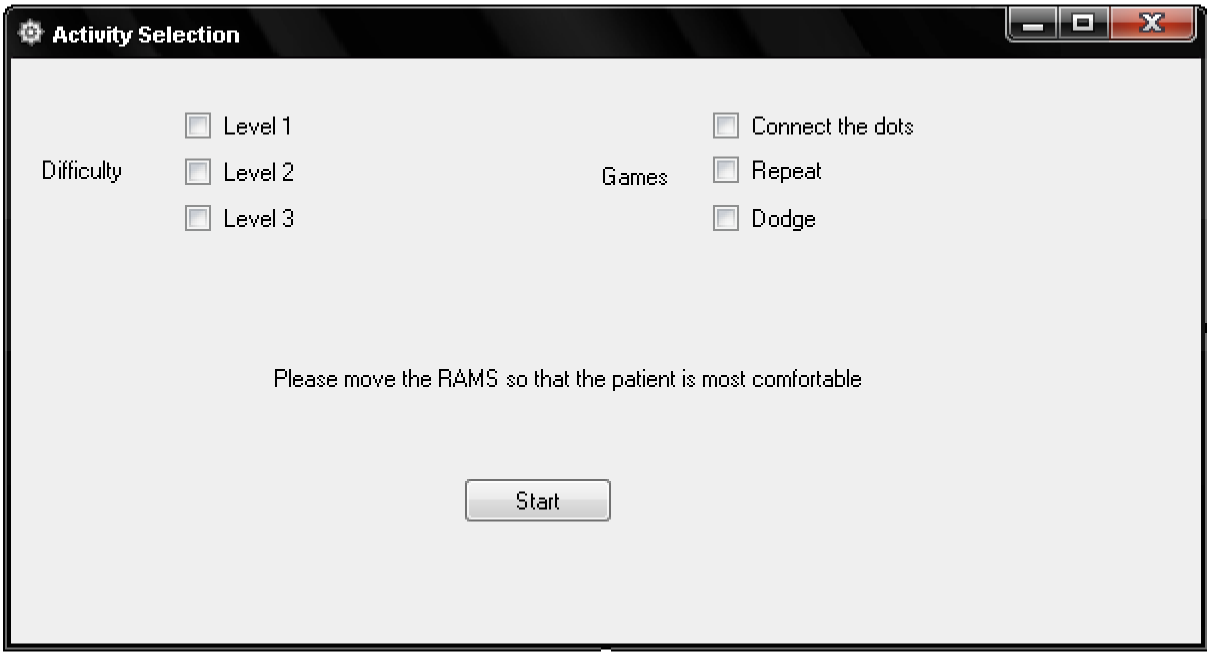

Figure 5.4 - Game selection

Then after the start button is push this will lead the patient into the actual games area where the patient place the device crosshair on a centre of the table marked by a red dot and pushing the button on the device once. This will set the coordinates to the device to zero and then the patient will start to exercise.

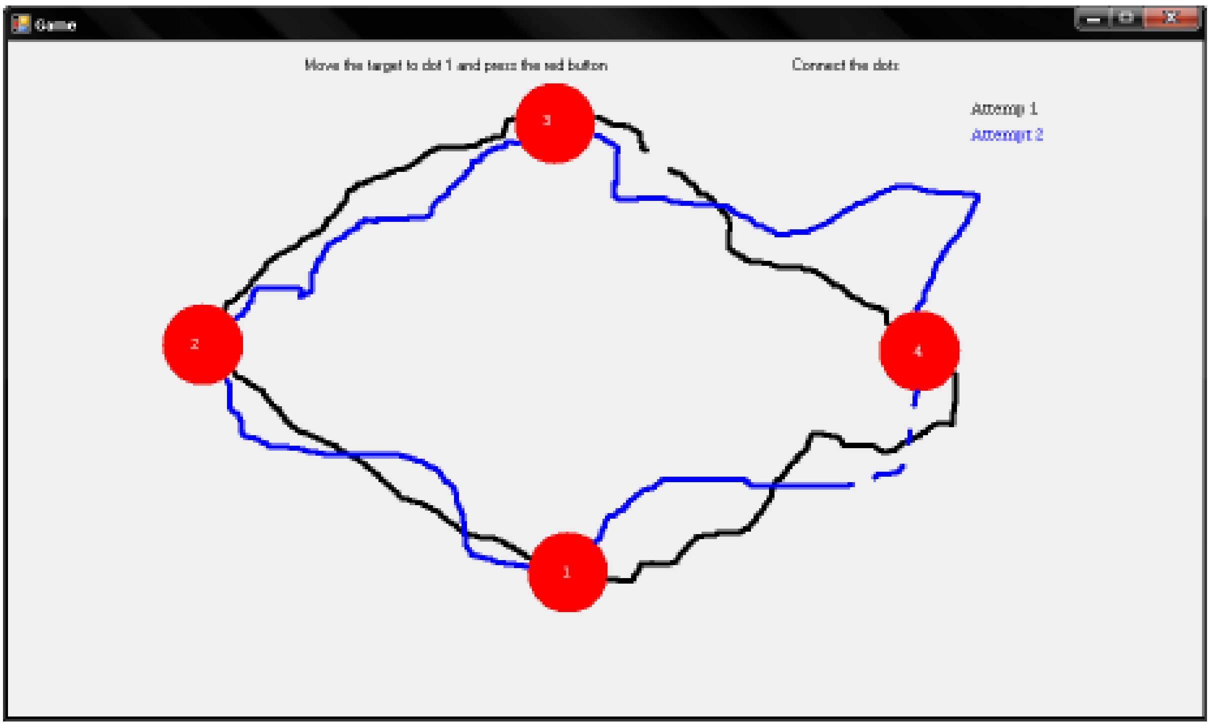

Figure 5.5 - the connect the dots game

The above is the connect the dot game on level 1 which is the easiest, it is a simple game and the patient will continue to play until the physiotherapist is happy with the progress that the patient has made and will allow the patient to move onto the next level. The data of the patient playing the game is saved and each attempt that the patient makes can be seen. Each attempt will be given separately if requested by the therapist. The way the save function works is that is records the entire set of coordinate as the patient moves the device and then save to a text file. The text file will be save in the fold s created in the new patient window of the program, along with the patient details and any other comments that the therapist many have made.

The program uses the potentiometers and uses the resistance change as a change in angle which then is used in the program to calculate to the x and y movements of the device.

$$xposition = (length\ of\ arm \times \cos(\theta_1)) + length\ of\ arm \times \sin(\theta_1 + \theta_2)$$
$$yposition = (length\ of\ arm \times \sin\theta_1) + length\ of\ arm \times \cos(\theta_1 + \theta_2)$$

θ_1 and $\theta_2$are the degree changes of the two potentiometers. Another tool that was included in the program was the RS232 viewer, which allows the data that is being received by the program from the device to be seen directly. This tool is not meant to be used by the operators of the device, it is meant to be a programming assist, and thus it was removed from the actual program. However the part in which the RS232 viewer is called is only commented out and if the program were to break down then it is possible to re-enter this part of the code and analyse the problem. The code still function as it is what connects with the RS232 of the project device. However the operator will not be able to access it.

5.4 Two Programs Communication

The PICAXE 08M will communication with the windows program through the RS232 port or the com1port of the computer, it has a baud rate of 4800 bytes per second and an 8 data bits capacity. The chip does not have a parity bit and only a 1 stop bit. The data is received from the microcontroller and is sent to the computer once the button is pushed. First the PICAXE will send an s which means that the system is active and transferring data, then the data will be sent there will be a letter in front of the two potentiometer, the end joint potentiometer will be given an ‘a’ and the middle potentiometer will be given an ‘b’. As mentioned above the system transfers non-stop after the button is pressed, and the windows program will actually take all this data and compare it with the previous set of data and if it sees that the device is actually not moving then it will stop recording the data until the data received in different from the previous set.

5.4 Conclusion

The program allows the patient to easily interact with the program and to have a challenge and yet enjoyable workout. The program was made as simple as possible and any part of the program that may cause any confession was removed, thus only the basic program remains. As the creator of a program it is easy to say that the program is simple to use, but how is it for someone who has not seen the device. The next chapter will discuss the results of testing and further analysis.

Chapter 6 Results and Analysis

6.1 Test of simplicity

As the developer of the software it was quite easy to operate the software package and setup the device. So to see is a normal person would be able to use and setup the device, 6 people who have never seen the devices were asked to set it up and operate it to the best of the ability. The 6 people were given a brief explanation on what the device does and how it operates, this explanation was only 2 minutes long. Then individually each of them were brought into the room and asked to setup the device. It was found that 6 out of the 6 people successful setup the device and operated it. For this experiment people from 4 university student (from Engineering, business, science and art were used), and 2 school children (age 15). One student however had some issues but managed to work it out, the person was unsure about the RS232 at the back of the computer. As a final test the people were asked to setup it the minimal amount of time as possible; the results are as listed below.

Students	**Time taken to setup the system**
Art	2min 40sec
Business	3min
Science	2min 11sec
Engineering	2min 28sec
School	1min 34sec
School	2min 47sec

In timing the student; time started when the student had to setup the arm for the stroke patient and plug the device into the interface board and then to the computer and run the program. This shows that the simplicity that this project was aiming was successfully achieved. The test was carried out on young people because in most cases stroke patients live with the families and the young people are the ones who assist the stroke patient.

6.2 Testing the program

For the testing of the actual program it was not possible for the project system to be taken to the hospital without a safety certificate which says that the device is safe to be used by patient. Thus after communication with quite a few hospitals and clinic, who said they would like on a future date, it was decide to try the next best thing, which was to talk to final year student nurses. I managed to get 4 nurses to try the device and say any improvement that they feel would benefit the patient. Each nurse played each game on the level difficulty setting and found that the repeat game although not that fun would be good to the patients. It was said that the actions that are repeat over and over again will build the strength in the arm and the coordination will also slowly develop.

Figure 5.6 - Repeat game easy level

Figure 5.7 - Repeat Game middle level

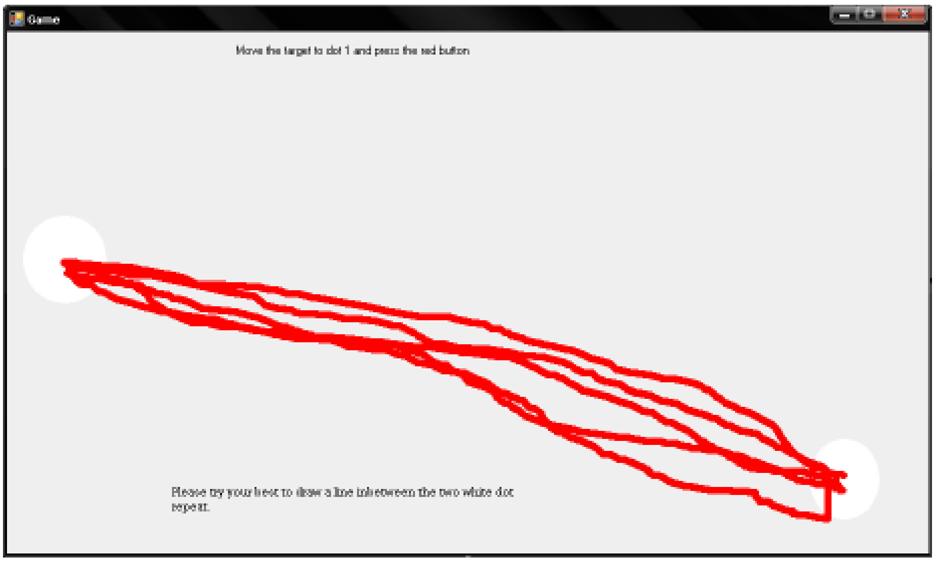

Figure 5.8 - Repeat Game on Hard level

As can be seen in the test conducted the space between the dots will increase and the patient would have to repeatedly move from dot to dot non-stop.

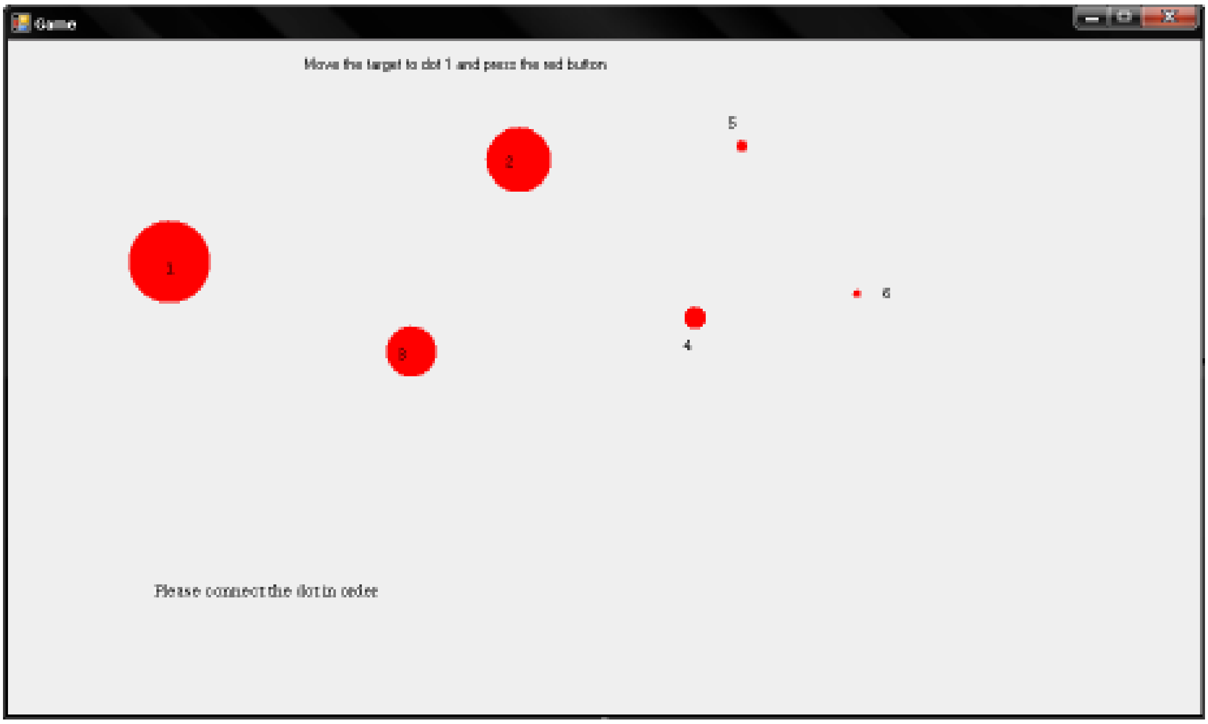

Figure 5.9 - Connect the dot hard level

This is another game that was tested by the nurse; this game is on the hardest level and aimed at coordination mostly. After try the game myself, it was actually quite difficult to get the 6th red dot. The game was created to only be used by patients who were at their final stage of recovery.

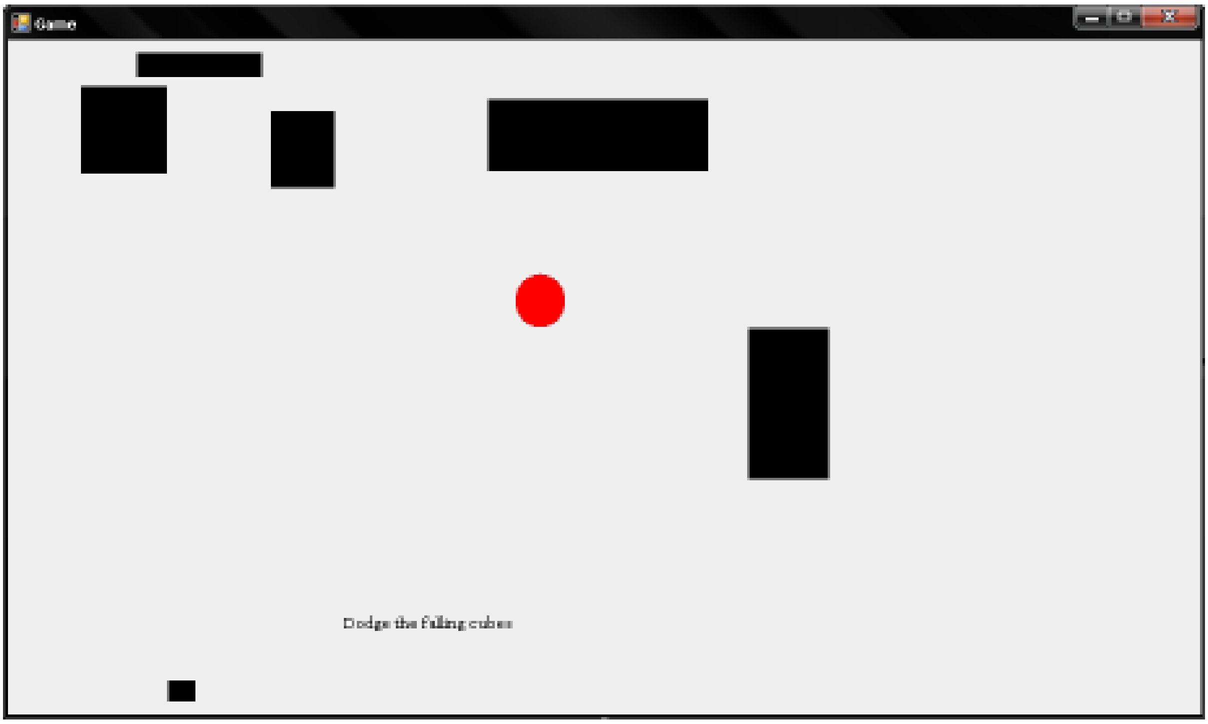

Figure 5.10 - Dodge Game

This was the final game that was created where the patient is the red dot and has to dodge the falling items. This game is aimed at coordination as well.

Most of the games are aimed at improving a stroke patient's coordination so that he or she would be able to live with some normality in the lives.

6.3 Conclusion

The result obtained from the test that were done on setting up the device and also the test with the nurse proven to be beneficial, as it showed where the device could be improved further. This will assist future development of the device and

Chapter 7 Conclusion

7.1 Introduction

Throughout the project I have learnt many different skills, programming languages, and also about the design and development. The projects aim was to develop a device which would assist stroke patient to exercise the upper limbs and bring some normality to their lives. This aim was achieve and even though I was not able to conduct tests on actual stroke patient the data collect from books and medical professionals allow to the design of the components that would give the stroke patient comfort while exercising. The ultimate aim of this project is to be used by physiotherapist in the rehabilitation process.

This chapter will look at future concepts that should be design and developed to better the exercise process of stroke patients.

7.2 Problem Review

The actual problem that was defined in the chapter 1.5 states that the project requires take pressure off of medical professionals and give stroke patients the time they require to do exercise without the physiotherapist having to wait with the patient. Thus allowing the patient to recover at a faster rate. However, I believe that the system that was developed in this project still will need to develop further and more research conducted on the stroke patient life style to be effective. The research conducted of the stroke and its effects from book is quite different to real world issues that are faced by stroke patients. I believe that an actual analysis on a stroke patient needs to be done by going to the hospital and watching the physiotherapist work with the patients would be beneficial in the process of creating and developing future systems.

7.3 Future work

There were quite a few things that I would have like to do with this project however as a result of time issues was not able to attempt. Both hardware and software requires to be better developed to ease the stroke patients mind. In this section a list of future objective will be given to make the device more acceptable to the arsenal of rehabilitation methods that are used by therapists.

7.3.1 Hardware

The hardware modification that would be suit this project are the develop of a projector to project active which the stroke patient is able to do, in so doing making the project more interactive and enjoyable. By using a projector the patient would be able to see the error that he or she may be making and try and correct themselves. At the moment the patient is unable to see the mistake that they are making and so does not know what they are doing wrong until the end of the rehabilitation session. This would also allow the games to be move interactive allow the programmer to make better, more challenging, and enjoyable game for the stroke patient. The projector would also allow the physiotherapist to be more interactive with the patient, as they would not have to sit behind a computer instead sit next to the patient and help them.

Another hardware modification is than of adding servo motor to the device to create both a training program which would show the patient what to do and also give them a form of resistance training which would help to improve the patient strength in the upper limbs. The servo motor could also be use for the assessment of the affect of a stroke on patient upper limbs. This would greatly help health care workers to assess the amount of damage that has been done to the stroke patient and then prescribe an exercise routine that best suits them, hopefully cut recovery time down.

7.3.2 Software

The software also still needs work especially after the projector and the servo motors are added to the system. The software is unable to move forward until the hardware such as the servo motor and the projector are added into the system. The software that was developed for this project mainly focused on the saving of the patients' data in an easy to recovery format. The software could be changed to be more interactive with other such system, make the exercise routine more competitive allow the patient to challenge other patient with similar conditions.

7.4 Conclusion

The research showed that computer-based rehabilitation methods are still not in use by health professionals, due to the fact the research into computer-based system have only begun in recent years. There are quite a few systems which developing and when put into practical use will be a great benefit to both the patient and the health care professional.

The system that was developed in this project was aim at home use to cut down on patients having to make the long and uncomfortable journeys to and from the rehabilitation centres. The cost of the device was kept to a minimum, so that the device would be more affordable to all families. When the final costs to building the device were added up it was around $128. There should be two systems developed, first one would be the basic model which would be a similar system to the one in my project and then there would the advanced model which would incorporate the projector and the servo motor. This advanced model will be used by hospitals to assess the patient and train him or her of the exercises that they should focus on. Then the patients' families would purchase the basic model and the patient would be able to do the exercises that the physiotherapist showed. Another advancement that could also be incorporated is the device could have internet access and send the data collected directly to the physiotherapist office, who would see the progress of the patient and send a messenger back say if the patient should done another level or a different activity.

The people in third world countries who suffer a stroke usual do not have enough money to get the assistance require to return to some sort of normality in their lives. Even in countries such as Sri Lanka when health services are free, the waiting list to see a physiotherapist in too long. Thus by keep the cost of the development of the device it is possible to sell it to the health services and get stroke patients the rehabilitation that they need.

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Appendix A

University of Southern Queensland
FACULTY OF ENGINEERING AND SURVEYING
ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **BUDDHI NUWAN LANKA ASSIRIYAGE**

TOPIC: Design and build a computer-based system to assess and exercise the arm movements of Stroke patients.

SUPERVISOR: Dr. Selvan Pather

SPONSORHSIP: The University of Southern Queensland

PROJECT AIM: This project aims to develop on a pre-existing frame work of a stroke excise device; improving both the hardware and software of the system.

PROGRAMME: (**Issue A, 19th March 2009**)

1. Research information about strokes and its affect on people's lifestyle and quality of life.

2. Re-design the pre-existing design to better the quality of the excise. Create prototypes.

3. Produce a user friendly software package that will allow for the easy creation of patient accounts and allow the physiotherapist to retrieve and analysis patient data with ease.

4. Develop a stand-alone system to connect the device to the computer that will be easy to work and use minimum effort to operate.

5. Produce a surface for the device to operate upon with minimum friction.

6. Research future plans for the device.

As time permits

7. Using servo motors to create resistance and also can be used as a training program for stroke patients.

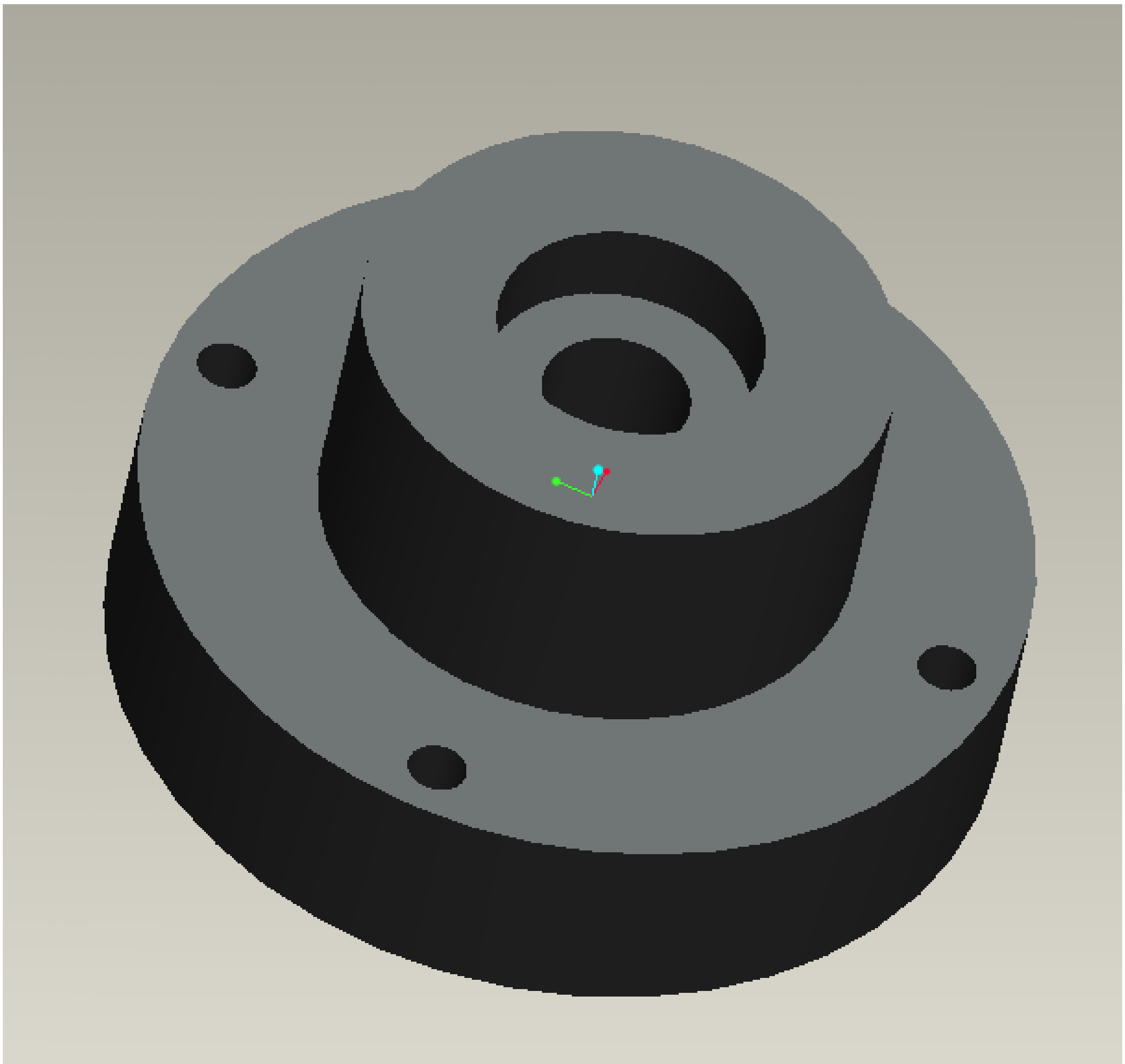
8. Develop a projection screen on the surface to display the excise activity.

AGREED (student) (supervisor)

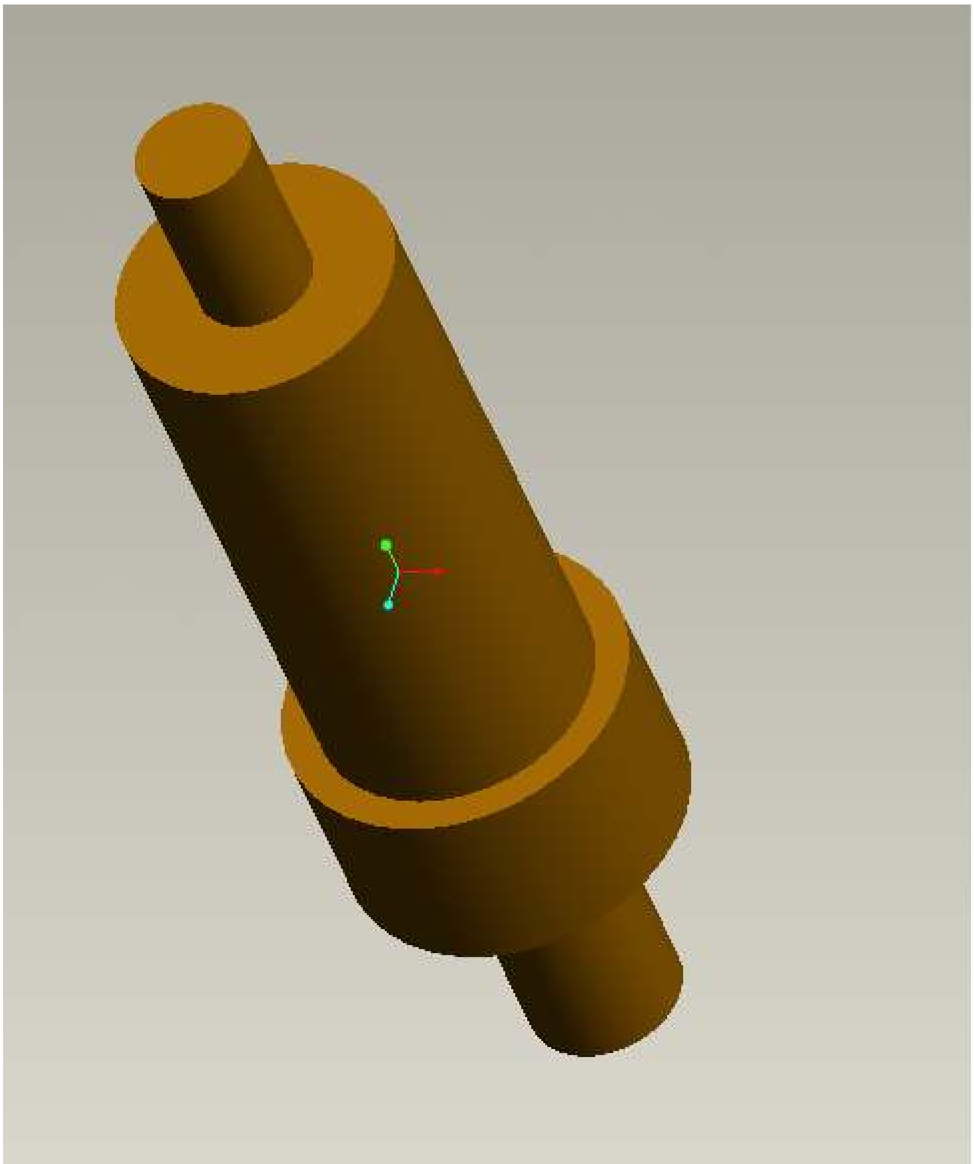
__________________________ __________________________

Date: / / 2009 Date: / / 2009

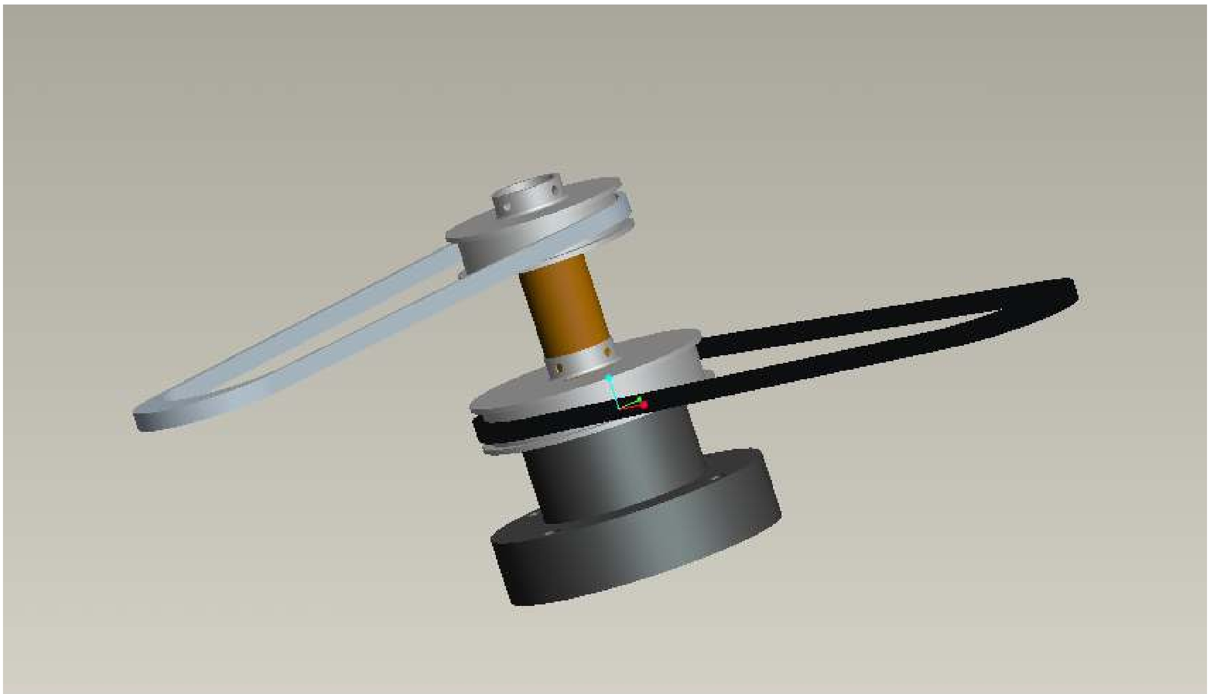
Assistant __________________________ Examiner:



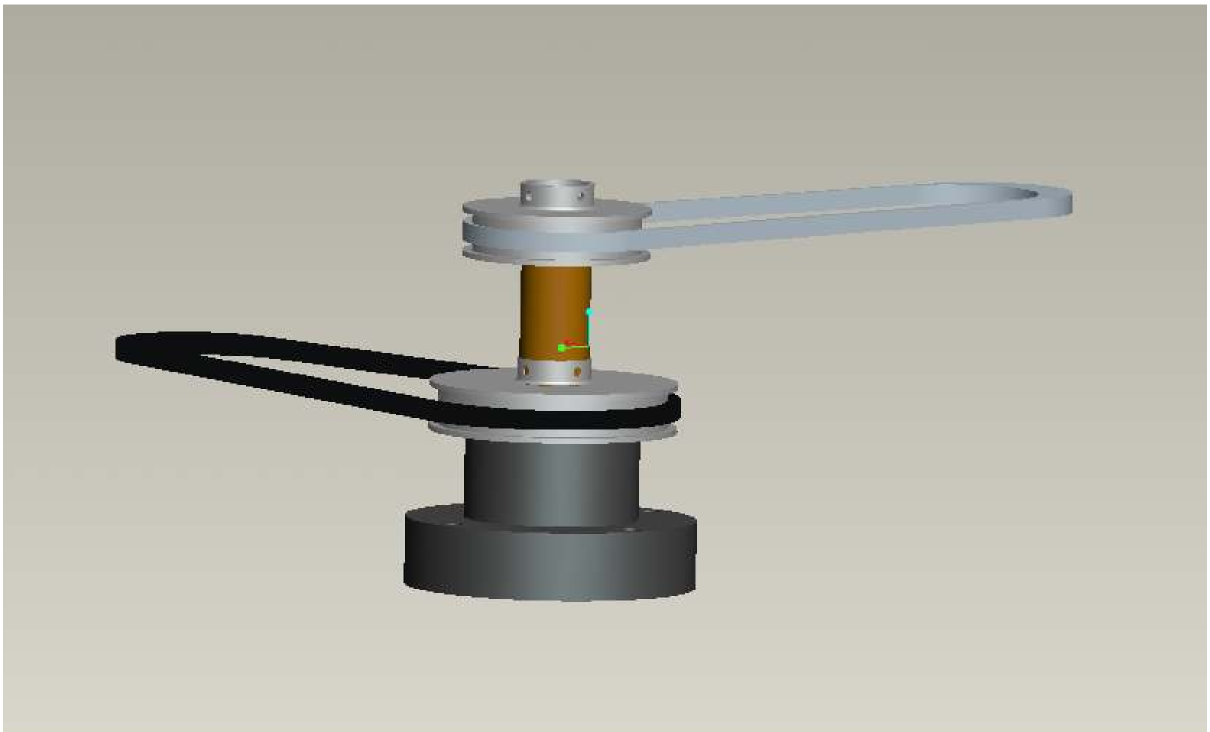
The base of the end joint.



The shaft



The design for the modified end joint



FAIRCHILD SEMICONDUCTOR® www.fairchildsemi.com

MC78XX/LM78XX/MC78XXA

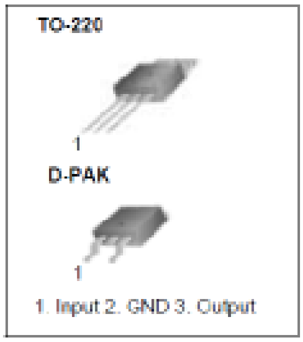
3-Terminal 1A Positive Voltage Regulator

Features

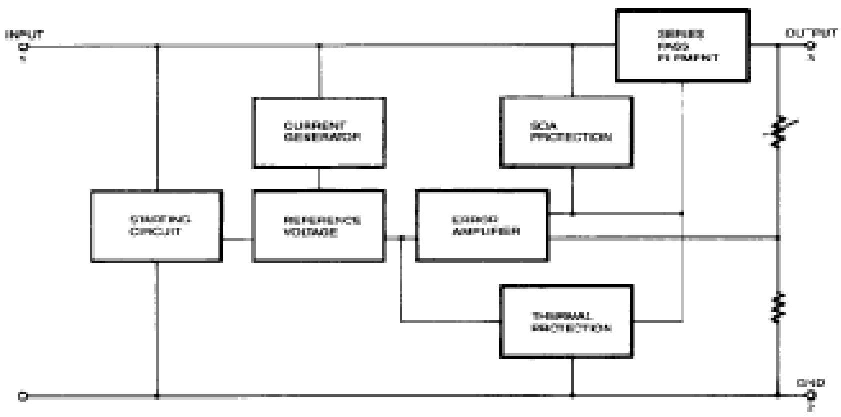
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.



Internal Block Digram



Rev. 1.0.1

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{θJC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{θJA}$	65	°C/W
Operating Temperature Range	T_{OPR}	0 ~ +125	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Electrical Characteristics (MC7805/LM7805)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I= 0.33μF, C_O= 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7805/LM7805 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		4.8	5.0	5.2	V
		5.0mA ≤ Io ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation (Note1)	Regline	T_J=+25 °C	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	
Load Regulation (Note1)	Regload	T_J=+25 °C	I_O = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	$ΔI_Q$	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	
Output Voltage Drift	$ΔV_O/ΔT$	I_O= 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A=+25 °C		-	42	-	μV/Vo
Ripple Rejection	RR	f = 120Hz V_O = 8V to 18V		62	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	15	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A =+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7806)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =11V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7806 Min.	MC7806 Typ.	MC7806 Max.	Unit
Output Voltage	V_O	T_J =+25 °C		5.75	6.0	6.25	V
		5.0mA ≤ I_O ≤ 1.0A, P_D ≤ 15W V_I = 8.0V to 21V		5.7	6.0	6.3	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 8V to 25V	-	5	120	mV
			V_I = 9V to 13V	-	1.5	60	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O =5mA to 1.5A	-	9	120	mV
			I_O =250mA to750A	-	3	60	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		-	-	0.5	mA
		V_I = 8V to 25V		-	-	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25°C		-	45	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 9V to 19V		59	75	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7808)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =14V, C_I= 0.33μF, C_O= 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7808 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		7.7	8.0	8.3	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W, V_I = 10.5V to 23V		7.6	8.0	8.4	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 10.5V to 25V	-	5.0	160	mV
			V_I = 11.5V to 17V	-	2.0	80	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5.0mA to 1.5A	-	10	160	mV
			I_O= 250mA to 750mA	-	5.0	80	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.05	0.5	mA
		V_I = 10.5A to 25V		-	0.5	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	52	-	μV/Vo
Ripple Rejection	RR	f = 120Hz, V_I= 11.5V to 21.5V		56	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:
1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7809)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =15V, C_I= 0.33μF, C_O= 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7809 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25°C		8.65	9	9.35	V
		5.0mA≤ I_O ≤1.0A, P_O ≤15W V_I= 11.5V to 24V		8.6	9	9.4	
Line Regulation (Note1)	Regline	T_J=+25°C	V_I = 11.5V to 25V	-	6	180	mV
			V_I = 12V to 17V	-	2	90	
Load Regulation (Note1)	Regload	T_J=+25°C	I_O = 5mA to 1.5A	-	12	180	mV
			I_O = 250mA to 750mA	-	4	90	
Quiescent Current	I_Q	T_J=+25°C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 11.5V to 26V		-	-	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25°C		-	58	-	μV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 13V to 23V		56	71	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25°C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25°C		-	250	-	mA
Peak Current	I_{PK}	T_J= +25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7810)

(Refer to test circuit ,0°C< T_J < 125°C, I_O = 500mA, V_I =16V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7810 Min.	Typ.	Max.	Unit
Output Voltage	VO	T_J =+25 °C		9.6	10	10.4	V
		5.0mA ≤ I_O≤1.0A, P_O ≤15W V_I = 12.5V to 25V		9.5	10	10.5	
Line Regulation (Note1)	Regline	T_J =+25°C	V_I = 12.5V to 25V	-	10	200	mV
			V_I = 13V to 25V	-	3	100	
Load Regulation (Note1)	Regload	T_J =+25°C	I_O = 5mA to 1.5A	-	12	200	mV
			I_O = 250mA to 750mA	-	4	400	
Quiescent Current	IQ	T_J =+25°C		-	5.1	8.0	mA
Quiescent Current Change	ΔIQ	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 12.5V to 29V		-	-	1.0	
Output Voltage Drift	ΔVO/ΔT	I_O = 5mA		-	-1	-	mV/°C
Output Noise Voltage	VN	f = 10Hz to 100KHz, T_A =+25 °C		-	58	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 13V to 23V		56	71	-	dB
Dropout Voltage	VDrop	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	rO	f = 1KHz		-	17	-	mΩ
Short Circuit Current	ISC	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	IPK	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7812)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =19V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7812 Min.	MC7812 Typ.	MC7812 Max.	Unit
Output Voltage	V_O	T_J =+25 °C		11.5	12	12.5	V
		5.0mA ≤ I_O≤1.0A, P_O≤15W V_I = 14.5V to 27V		11.4	12	12.6	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 14.5V to 30V	-	10	240	mV
			V_I = 16V to 22V	-	3.0	120	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	11	240	mV
			I_O = 250mA to 750mA	-	5.0	120	
Quiescent Current	I_Q	T_J =+25 °C		-	5.1	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.1	0.5	mA
		V_I = 14.5V to 30V		-	0.5	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	76	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 15V to 25V		55	71	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	18	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J = +25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7815)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =23V, C_I= 0.33μF, C_O=0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7815 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		14.4	15	15.6	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 17.5V to 30V		14.25	15	15.75	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 17.5V to 30V	-	11	300	mV
			V_I = 20V to 26V	-	3	150	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	12	300	mV
			I_O = 250mA to 750mA	-	4	150	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 17.5V to 30V		-	-	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	90	-	μV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 18.5V to 28.5V		54	70	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7818)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =27V, C_I= 0.33μF, C_O=0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7818 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		17.3	18	18.7	V
		5.0mA ≤ I_O ≤1.0A, P_O ≤15W V_I = 21V to 33V		17.1	18	18.9	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 21V to 33V	-	15	360	mV
			V_I = 24V to 30V	-	5	180	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	15	360	mV
			I_O = 250mA to 750mA	-	5.0	180	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 21V to 33V		-	-	1	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	110	-	μV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 22V to 32V		53	69	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	22	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7824)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =33V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7824 Min.	MC7824 Typ.	MC7824 Max.	Unit
Output Voltage	V_O	T_J =+25 °C		23	24	25	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 27V to 38V		22.8	24	25.25	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 27V to 38V	-	17	480	mV
			V_I = 30V to 36V	-	6	240	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	15	480	mV
			I_O = 250mA to 750mA	-	5.0	240	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.1	0.5	mA
		V_I = 27V to 38V		-	0.5	1	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1.5	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	60	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 28V to 38V		50	67	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	28	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

DATA SHEET

PicPatch 08

Data and Specifications

- The multipurpose microcontroller interface.
- Suitable for education and permanent control system applications.
- Document A000084 Rev D PicPatch™ Series Data Sheet

PIC Microcontroller Patch Board

PicPatch08 microcontroller interface circuit board adaptable to suit different applications.

FEATURES TABLE 1

- Suited for Picaxe08 and Picaxe08M 8 pin
Pic microcontroller patch board.
- Power supply options with or without
5V voltage regulator.
- Power supply socket or screw terminal option.
- Serial programming viaRS232 serial
communication network.
Serial-Out pin common to port pin 0
- Reconfigurable networks on IO pin ports.
- 10 Way Expansion port connector.

FIGURE 1. PicPatch08 Printed Circuit Board (PCB) Layout

APPLICATIONS

Suitable for general purpose type control systems with sensor inputs, output driver devices and serial
communication to a remote computer programming and monitoring station.
Ideal for electronic education to demonstrate the fundamentals of basic software programming,
electronic sensor interfacing and output driver devices such as an LED, lamp, relay, solenoid, small electric motor, Piezo beeper, magnetic beeper, etc.

FIGURE 2. Microcontroller Pin Configuration

DESCRIPTION

The PicPatch08 is a small 8 pin microcontroller circuit board that can be easily adapted and programmed for low
budget control systems and remote monitoring applications. Basic applications may include robotics, musical door bell, intruder alarm system, weather monitoring, irrigation and environmental process control.
Interfacing sensors and output control devices to the Pic Microcontroller chip is both simple and quick to
assemble. "Pic" is a trademark of Microchip Techmologies.
The PicPatch08 has provision on the circuit board for circuitry to be assembled for each microprocessor port pin
which provides the flexibility to interface and configure circuitry suitable for various sensors and output
devices.

This interface circuitry network can also utilise single inline (SIL) component sockets which will provide quick
component insertion and replacement.
Should the SIL sockets be used a soldering iron is only required initially to assemble the circuit board.
This easy interfacing provides a valuable education tool for teaching basic electronics and developing a custom
made multipurpose micro control system that can be reprogrammed for different applications.
Utilising the Picaxe 08 or Picaxe 08M microcontroller chip, which is a trade mark of Revolution Education,
their Basic Editor program provides the user with a complete microcontroller system that is very quick to learn
and simple to develop. Refer to last page for contact details.

FIGURE 3. PicPatch 08 Circuit Diagram

OPERATION

The PicPatch 08 has four INPUT / OUTPUT port pins and serial communication, Transmit "SERIAL
OUT" and Receive "SERIAL IN" port pins for communication to the Personal Computer (PC).
Port pin 0 is the same port as the Serial-Out pin, if a beeper is connected to PIN 0 a squeal sound will
be heard as information is sent from the PIC microcontroller to the PC.
The PicPatch 08 circuit diagram Figure 3 and the circuit illustrations for each port pin (See Fig. 4 to 8)
will be used as a basic guide for configuring the interface circuitry.
Refer to the Revolution Education and Basic editor program manual for details on developing
software programs suitable for the PicPatch 08.
Remember to configure the port pins according to the application examples illustrated in the manual.
Failure to do so may cause undesirable side effects or possible component damage.

COMPONENT LIST TABLE 2 Main components list

POWER SUPPLY NOTES

4.5V Battery operation: (3x AA Battery pack)

For 5V Regulated Power Packs and 4.5V Battery supplies place a wire jumper to link pins 1 & 3 of
IC2, Refer to dotted line on Figure 1.
Check capacitor C4 pin alignment is correct for (+) and (-) polarity.
Placing C4 is optional for battery operation but we recommend fitting C4 for all motor and relay
applications. For larger transient current loads in excess of 200mA, increase the capacitor value by
100uF for each 100mA increase in loading.

12V to 24Vdc Power pack or battery operation:

For supply voltage in excess of 5.5Vdc fit IC2 the 5V Voltage Regulator.
The maximum load is 50mA without a heat sink fitted and 100mA with a heat sink fitted.
If the load current on the +5V rail exceeds 50mA the regulator will get hot and may shut down to
protect itself from over heating. If the regulator exceeds 70oC fit an "L" shaped aluminium heatsink

between the regulator tab and circuit board to improve heat dissipation. Use a M3 machine screw,
spring washer and M3 nut to fix the heatsink and regulator to the circuit board.

PORT PIN CONFIGURATION

The PicPatch08 circuit board is designed specially to use the Picaxe 08 or Picaxe 08M microcontroller
chips, which is a trade mark of Revolution Education. Pic is a trade mark of Microchip Technologies
series of 8 pin Pic Microcontrollers. The Picaxe Editor Program, download from the Revolution
Education Website, has examples of how to program the microcontroller chip and various circuit
configurations that can be implemented on the PicPatch circuit board.
Information provided by KEI Ltd on projects using PicPatch08 will use this data sheet as a reference
guide to describe and illustrate how to connect each configuration of components suited to the
application.
The components on the circuit board are numbered to help identify the Pin naming associated with
each
port pin on the microcontroller. The resistors on the circuit diagram in Figure 2 use the port pin
number, however in the following circuit examples we will use the letter "n" as a substitute with the
port pin number. E.g. Rna Rnb Rnc Rnd. Refer to Figures 1, 3 and 4 to 8.
Rna – These resistors connect directly between the micro pin and the associated terminal connector
centre screw terminal. If the micro pin is configured as an input this resistor is fitted in
conjunction with a filter capacitor fitted across the micro pin to 0V. This provides filtering of
unwanted electrical noise and improves immunity from Electrostatic Discharge (ESD).
If the micro pin is configured as an output this resistor provides current limiting such as
driving an Light Emitting Diode LED, or impedance protection to guard the micro pin from
over-current from potential short circuits to neighbouring supply rails 0V,+5V,+V etc.
Rnb - When the micro pin is configured as an output to drive a Transistor these resistors, which
connect between the micro pin and middle pin of the transistor SIL socket, are used to limit the
base current to a transistor. The centre pin or base "B" pin for BC546, BC337 Transistors.
Rnc - These resistors connect directly between the micro pin and the 0V supply rail.
This position is used for a "Pull-Down" resistor or input filter capacitor position.
Rnd - These resistors connect directly between the micro and the +5Vdc supply rail.
This position is used for a "Pull-Up" resistor.
Port pins 0 and pin 3 do not have some resistors as listed, as these pins have limited functions with
some Pic microcontrollers.

The following diagrams illustrate typical port pin circuit configurations.

FIGURE 4. Port pin 1, 2 & 4 circuit diagram (Output / Input / Analogue Input)

FIGURE 5. Port pin 0 circuit diagram (Serial Out / Output / Infraout)

FIGURE 6. Port pin 3 circuit diagram (Input / Infrain)

FIGURE 7. Transistor driver circuit diagram (Pins 0,1,2,4).

FIGURE 8. LED circuit diagram (Pins 0,1,2,4).

TABLE 3. Quick Reference Electrical Specifications

Important – Do not get confused with IC1 pin number and the pin Name used in Software.

Technical Support Documentation

KEI prides itself on helping our customers the best way we can with easy access to products, applications ideas, quality information and providing well documented technical support material.

If you have any ideas on how we can improve our services to help you with product detail, product quality or you

just simply what to find out more about our products and services KEI has to offer please contact us by Email or visit our Website. Contact information:

Email info@kei.co.nz
Website www.kei.co.nz

```
symbol pot1  = b1
symbol pot2  = b2
symbol start = b3
symbol open  = b4
symbol close = b5
symbol sw3 = pin3

main:
                open=0
                close=0
                if sw3 =0 then delay_count
                goto main

potread:
                readadc 4,b6
                SerTxD ("a", #pot1)
                readadc 1,pot2
                serTxD ("b", #pot2)
                readadc 2,b0
                if sw3=0 then delay_out
                goto potread

delay_count:
                open=open+1
                pause 1
                if sw3=1 then main
                if open>15 then potwait
                goto delay_count

potwait:
                if sw3=0 then potwait
                if sw3=1 then gosub sendS
                goto potread

delay_out:
                close=close+1
                pause 1
                if pin3=1 then main
                if close>15 then potout
                goto delay_out

potout:
                if pin3=0 then potout
                if pin3=1 then gosub sendF
                goto main
```

```
sendS:
            sertxd("S")
            return

sendF:
            sertxd("F")
            return
```