



Special Edition

NCASIT 2023, 29<sup>th</sup> April 2023

Department of Computer Engineering,

St. Vincent Pallotti College of Engineering & Technology, Nagpur,

## SOLAR POWERED AUTOMATICALLY CONTROLLED PHYSIOTHERAPY MACHINE

Bhushan Thakre

Dept. of Electrical Engineering

St. Vincent Pallotti College of Engineering and  
Technology

Nagpur, India [thakarebhushan786@gmail.com](mailto:thakarebhushan786@gmail.com)

Ayush Atalkar

Dept. of Electrical Engineering

St. Vincent Pallotti College of Engineering and  
Technology

Nagpur, India [atalkarayush44@gmail.com](mailto:atalkarayush44@gmail.com)

Prof. Shradha Banode

Dept. of Electrical Engineering

St. Vincent Pallotti College of Engineering and

### ABSTRACT

The aim of this project is to design and fabricate a Continuous Passive Motion (CPM) machine that possesses greater versatility and affordability compared to commercially available alternatives. Utilizing CPM as a treatment option following joint surgery aids in promoting tissue regeneration, increasing range of motion (ROM), and reducing the risk of contracture formation. Evidence suggests that this method yields better results than traditional approaches. The use of contemporary devices has seen a surge in advanced mechanical, electrical, and computer systems, aimed at various applications ranging from industrial to research domains. In particular, Continuous passive motion (CPM), an often-prescribed postoperative treatment technique for aiding joint surgery recovery processes, is being widely used. Studies have shown that CPM can reduce hospital stays time and the need for analgesics while also accelerating the healing processes.

### I. INTRODUCTION

Modern devices are being used in advanced mechanical, electrical, and computer systems for various applications, and to assist in research. Continuous passive motion (CPM) is a widely used postoperative treatment method that is designed to

Technology Nagpur, India

[sbanode@stvincentngp.edu.in](mailto:sbanode@stvincentngp.edu.in)

Abhilasha Kamble

Dept. of Electrical Engineering

St. Vincent Pallotti College of Engineering and  
Technology

Nagpur, India [abhilashakam03@gmail.com](mailto:abhilashakam03@gmail.com)

Tanushree Chakre

Dept. of Electrical Engineering

St. Vincent Pallotti College of Engineering and  
Technology

Nagpur, India [tanushreeshakre20@gmail.com](mailto:tanushreeshakre20@gmail.com)

aid recovery after joint surgery or injury. In the present work, we have designed and developed a project of a low-cost knee CPM machine with the energy conservation point of view and with the advanced heating and cooling effect which was not in old CPM Machine. The cost of the machine has been reduced by 70%, without compromising the functionality and accuracy of the machine. The patient's pain level has been abridged. Scientific studies have determined that patients who have troubled achieving the normal range of motion can be benefited by the use of CPM Machine and the recovery is accelerated.

In most patients after extensive joint surgery, attempts at joint motion cause pain and as a result, the patient fails to move the joint. This allows tissue around the joint to become stiff and scar tissue is formed. This results in limited range of motion of the joint and often may take months of physical therapy to recover that motion. Passive range of motion means, the joint is moved without use of the patient's muscles. Also pain is decreased, ROM is maintained.

A knee surgery has come a long way in the past fifty years. However, orthopaedic surgeons are always looking into ways to improve their results. One persistent problem following joint surgery is stiffness of the joint.



**Special Edition**

NCASIT 2023, 29<sup>th</sup> April 2023

Department of Computer Engineering,

St. Vincent Pallotti College of Engineering & Technology, Nagpur,

The lofty cost of machine is a big concern for its use in the rehabilitation centres in India. “Low cost Knee Physiotherapy Machine” will be the aim of our project.

## II. LITERATURE REVIEW

Total joint replacement is the removal and replacement of a damaged joint. For example, knee replacement surgery involves replacing the diseased or damaged joint surfaces of the knee (or ends of the bones) with metal and plastic components which together are shaped to allow continuous motion of the knee. In the last decades, total knee replacement (TKR) surgery procedures have continued to increase, with the most pronounced rate among younger patients.

Generally, the average age of individuals undergoing TKR has declined. The underlying reason for this trend could be a combination of changes in medical practices as well as increased prevalence of an individual's obesity. There is also a significant correlation between GDP and health expenditures with the utilization of the TKR. Not only have the number of operations increased, but also the total cost charges for the procedure have also increased resulting in a significant economic impact on the overall healthcare system. In Thailand, a similar trend has been found. According to data from some national funds (i.e. Government Welfare fund, National Health Security Fund and Social Security Fund), the total number of knee replacements have continually increased from 2006 to 2010. The increased lifetime direct costs in the case of TKR procedures can be offset by societal savings from reduced indirect costs (i.e. increased employment and earnings, fewer missed workdays and lower disability payments) and eventually the total net benefit. Nonetheless, to achieve such offset, effective recovery to gain full functional status after surgery is crucial. After surgery, the orthopaedic surgeons or therapists usually discuss the option of an exercise program pertinent to each individual patient. According to our interview with the head therapist in the orthopaedic department at

Chulalongkorn hospital Bangkok, the effectiveness of the exercise is largely due to whether the correct posture is achieved during the training sessions. At the same time, from the time of pre-surgery to the recovery phase, patients were reported to have undergone difficult experiences and support from healthcare staff which resulted in negative emotions and discouragement. Hence, patients usually need the help of therapists throughout the recovery process. Compared to the demand of bone and joint cases (i.e. more than 40,000 patients had bone and joint operations or treatments in a year), shortages of physical therapists have become a consistent problem. Moreover, for some patients who use splints, high exertion force is continually required from physical therapists due to the splint weight. To ease such difficulties, the continuous passive motion (CPM) machine was introduced to the orthopaedic department at the hospital. The machine focuses mainly on range-of-motion exercise rather than resistance or functional training which requires different therapies. Unfortunately, its redundant structure and complex mechanism make the existing machine difficult to fix or to perform regular maintenance. As a result, the machine is usually left unused. On the other hand, from the patient's viewpoint, it is found that many patients preferred to undergo therapy sessions at home or in their own accommodation rather than visit the hospital. Visiting the healthcare unit on a daily basis undoubtedly requires large amounts of resources from a time and financial perspective. Hence, the situation has resulted in pressure on the medical system to provide more care on an outpatient basis. With professional competence, timeliness, and proper post-surgery care planning, the home healthcare physical therapy system (HHCPT) was shown to be a successful choice when measured against the patient recovery status. A review of over 2,400 patients from 2007 to 2011 also found no difference in terms of pain and knee function two years after surgery between patients who directly went home or those patients who utilized an inpatient rehabilitation facility. Importantly, it is still

**Special Edition**

NCASIT 2023, 29<sup>th</sup> April 2023

Department of Computer Engineering,

St. Vincent Pallotti College of Engineering & Technology, Nagpur,

important to address the patient's preparations during the discharging process. Five aspects were identified as key checkpoints to consider a patient's readiness for transferring from hospital to home including physiological and psychological experiences, coping ability, needs from the healthcare team and family support. In light of the existing needs, the aim of this research was to redesign the current machine that involved the improvement of the mechanical and electrical systems. The newly redesigned machine is scoped to address knee movement in flexion and extension directions alone. The underlying reason not to design for a more flexible machine that could be used by various joints is to avoid possible human error. Once the machine is more flexible, it will require better understanding and more attention to operate the machine appropriately whereas operating error is not acceptable in the therapy tasks. For instance, when using a machine with three possible therapy postures, there is a chance that patients recovering from a hip replacement will accidentally do the knee replacement posture, which is extremely harmful.

### III. EXISTING MACHINE

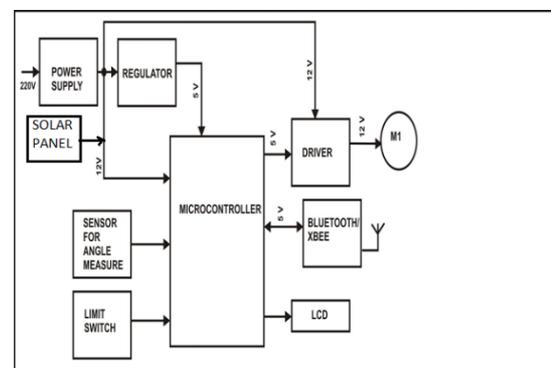
The old physiotherapy machine had to be operated manually. Its main components were microcontroller PIC16F886, sensor and DC motor. The microcontroller has less memory which does not have EEPROM with less bytes. From this survey we found that we can modify this machine into automatic operation which can operate with the help of Bluetooth by using mobile, pc, laptop, and can also provide this machine to everyone which is affordable, less in weight and can use it at home, office, which consumes less power and also saves valuable time of physiotherapist.

### IV. PROPOSED WORK

Actual innovation design consists of PIC, angle sensor, Screw drive mounted on pipe, Limit Switches, Geared Motor. The detailed design shows

an innovative product, which enables the subject, through programming, to perform sequences of precise movements of the knee at pre-determined angles. The passive motion, performed by the equipment, is for the extension/flexion of the knee from 0° to 90°.

The block diagram of automatic physiotherapy machine for leg is given below.



**Fig: Block diagram of physiotherapy machine**

Micro controller is an electronic device which can only operate on minimum voltage i.e to regulate the voltage, we used voltage regulator which supplies the power to microcontroller and microcontroller to other equipments.

The microcontroller used is PIC microcontroller from 16F886 family. It has higher flash memory along with 24 programmable input/output pins. PIC 16F886 needed to be programmed before getting chip ,we have to save the accurate and appropriate programme in the memory of controller. Once power is fed the controller executes the code which is saved in flash memory to create response with the help of programme. In this way microcontroller controls the entire system. The equipment consists of geared motors controlled by software, which receives the data generated by other software, interprets them and sends the information through drivers to the motors that drive the axles. The computerized CPM can be applied to both upper limbs, enabling computerized control of time and for the ROM to calculate automatically the speed from the data provided by the physical therapist. The equipment structure includes an adjustable vertical rod, fixed at the lower

**Special Edition**

NCASIT 2023, 29<sup>th</sup> April 2023

Department of Computer Engineering,

St. Vincent Pallotti College of Engineering & Technology, Nagpur,

end to a support base in a cross shape. At the upper part of this rod there is an assembly attached, which is responsible for flexion/extension movements. This consists of a metal plate where they are fixed by: Screw Drive arrangement, axles, angle sensor, Geared Motor.

The motor is connected to the screw driver and platform to Movement Supporter [Ankle].

## V. MATERIALS AND METHODS

In the circuit some components are working on 12Vdc, and some on 5Vdc, hence rectifier is used to convert a 12V AC to 12V DC which is required to drive 12V motor and relays. A regulator IC 7805 of 5V is used to convert 12V to constant 5V which will be used by PIC, Angle Sensor, LCD and Bluetooth module. Capacitor C1 and C2 are used here as a filter.

After getting power supply ON, microcontroller reset the internal RAM memory for which resistance R3 and Capacitor C6 is used as a Power-ON-Reset. Further microcontroller displays all the parameters like Realtime Angle, Number of counts to be set, Maximum angle to be set, status of motor whether it is stopped/running, also shows direction arrows in upward/downward .

Once microcontroller receives a command from Bluetooth module regarding settings of parameters, it saves it into its internal EEPROM and also acknowledge by sending received data to Bluetooth application on mobile device. As soon as the start command received microcontroller gives command to relays. In our project 12V relays are used which cannot directly be driven by PIC microcontroller , hence a driver IC ULN2003 is used, which increases the level of 5V coming from microcontroller to a 12V.

In our project an accelerometer is used as an angle sensor, which gives analog voltage between 0-5V for X and Y direction. Further this analog values are read and converted to digital values with

the help of 10 bit internal ADC(Analog to Digital Converter).

Bluetooth module works on 5v and having communication range of 30mts,

SPST Relay Rly2 is used to Start/Stop the motor, whereas Rly1 and Rly3 is used to decide whether the motor run in clockwise or anti-clockwise direction.

## VI. COMPONENTS USED

- 1: PIC16F886-8 Bit Microcontroller
- 2: Regulator IC 7805
- 3: Driver IC ULN2003
- 4: Capacitors
- 5:Relays
- 6:Accelerometer ADXL 335
- 7:Bluetooth Module
- 8.Liquid crystal Display(LCD)



**Fig. PCB**





**Special Edition**

NCASIT 2023, 29<sup>th</sup> April 2023

Department of Computer Engineering,

St. Vincent Pallotti College of Engineering & Technology, Nagpur,

**VII. RESULT**

- The oscillations of leg can be adjusted. The CPM machine will bend joint according to angle settings. The physiotherapist may program the CPM machine to increase the amount that the joint is flexed over time. Oscillations may prevent scar tissue from forming. This may also prevent pain and stiffness in the knee.
- Muscles may get stronger more quickly. The CPM machine will gently exercise leg muscles to prevent them from getting weak. Tendons and ligaments, the tissue that connects to the muscles and bones, may also get stronger by using CPM. Patients may have less pain. A CPM machine will elevate leg and decrease swelling. Increased blood flow to their tissues will help them heal faster.

**VIII. CONCLUSION**

From the existing types of physiotherapy machines for leg we conclude that these machines are quite expensive and are difficult from one place to another which uses lot of power to operate the machine and also has limitations. Henceforth, we designed such a machine which is 70% less in cost with more advance features and light in weight which can give more comfort to the patient. For all these reasons we want to implement a system which is Automatic, advanced, Easy to handle and can consume low power. That's why we are designing Automatic Physiotherapy machine for leg with advanced features and reasonable in price.

**REFERENCES**

[1] K. Donald Shelbourne and Paul Nitz. Accelerated rehabilitation after anterior cruciate ligament reconstruction. Am. J. Sports Med. 18, 1990, pp.292.

[2] Nicola Phillips, Michael Benjamin, Tony Everett and Robert W. M. van Deursen. Outcome and progression measures in rehabilitation following

anterior cruciate ligament injury. Physical Therapy in Sport, 1, 2000, pp.106-118.

[3] O'Driscoll SW, Giori NJ: Continuous passive motion (CPM): Theory and principles of clinical application. J Rehab Res Dev, 37, 2000, pp. 179-188. (Pubitemid 30641246)

Microcontroller pic: It is used to control all the automatic activities which are required for the controlling of the project. Once the program is fed in Microcontroller it is used to work manually.

Limit Switches: A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

Geared Motor: It has sturdy construction with gear box built to handle stall torque produced by the motor. Drive shaft is supported from both sides with metal bushes. Motor runs smoothly from 4V to 12V and gives 30 RPM at 12V. Motor has 6mm diameter, 22mm length drive shaft with D shape for excellent coupling.

Screw Drive: It is used to lift the one part smoothly according to the command given by the Micro Controller.