Wearable Robust Controller for Tremor Suppression and Heartbeat Sensing with Wireless Technique

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***Abstract* – The rhythmical and unintentional oscillatory movement of a body part is called tremor. Tremor is a musculoskeletal level involuntary vibration and one of the most frequent movement disorders. Instead of medication or surgery or drug consumption to use this orthotic devices have been under exploration as noninvasive tremor suppression. Assess and attenuating the tremor motion without impeding the patient's intentional motion is the challenge in musculoskeletal tremor suppression. In this project the robust tremor suppression algorithm was derived for patient with pathological tremor in the upper limbs. At first the tremor frequency range is calculated by using a high-pass filter. Then by applying back stepping method the correct amount of torque is estimated to impel the output of the estimator toward zero. This is equivalent to an assessment of the tremor torque and shown that the orthotic device control system is stable. A human arm joint stimulator, efficient of emulating tremor motion of a human arm joint was used to appraise the proposed suppression algorithm. The device is designed as wearable and personal equipment using wireless communication. Heartbeat and tremor is continuously monitored with help of sensor. Sensor output is given to controller which is used to control the valve with help of driver circuit for controlling tremor action and heartbeat is monitored. Non return valve is used to arrest the air pressure in the valve. The above functions are monitored. SMS to the physician and relatives using GSM modem automatically if the heartbeat is high and tremor is not controlled by maximum times of suppression.**

***Keywords* – Accelerometer sensor, Heart beat sensor, Pressure cup, Non-linear robust control, GSM, Tremor suppression.**

I. INTRODUCTION

Tremor is an involuntary movement disorder for the human body parts and also can occur without any intentional thought from the patient. The tremor syndrome has more effective cause when it reaches a chronic stage. Normally the daily human activities are also comes under the tremor but, the continuous uncontrollable involuntary activities of the patient body parts is called as acute tremor. Acute pathological tremor can significantly affect the daily activities. Tremor syndromes are having two types based on its severe. The types are Parkinson tremor (PT) and essential (ET). Parkinson tremor is a rest tremor that mostly affects fingers, wrist, leg and pronation-supination of the forearm. Action tremor develops during the action of voluntary contraction of muscle. Essential tremor is an active tremor that mostly affects the spinal cord. ET primarily affects the hand motion, though it can affect the head, face, trunk and spinal region through it can affects the brain and completely hold the brain action for certain time. This may make the patient to falling coma stage. As per the studies tremor frequency is very small which lies between 3-15HZ. 10-12HZ is the action tremor frequency range. Basically action tremor also having two types as essential and physiological tremor. In normal clinical feature the essential tremor is typically relieved by small amounts of alcohol. Physiological tremor is aggravated by caffeine. Both Postural and kinetic types is the most common form pathological tremor, it is a neurological movement disorder causing involuntary oscillations in body parts. This work approaches a light weight, wearable tremor suppression orthotic device using a pressure-cup method for the basis of sphygmomanometer technique. Using this method we can easily estimate and extract the tremor data with the help of accelerometer sensor and controlled by using pressure-cup method. At present treatment technologies for this severe pathological tremor are deep brain stimulation, drug prescription, neurosurgeries, medication, relaxation techniques, functional electrical stimulation, lesioning surgery and gamma-knife radio surgery. But, few people cannot accept these kinds of treatments because which is giving only a temporary relief from the tremor. Both the medication and neurological procedures can have a stern side effects as like as ataxia, confusion, hallucinations, muscle paralysis, speech holdup multiple sclerosis and even stroke while the tremor onset point. Approximately 5-10% of patients are Parkinson's disease cases.

In this project approaches the wearable type of tremor suppressed action by the way of using pressure-cup technique. Here level convertor plays a good role to control the action of force to giving pressure-cup and its inflation-deflation actions. This project consist the heartbeat sensor part which is useful to analyzing whether the heartbeat is normal or not and it is working under the principle of piezoelectric. And also having accelerometer sensor which working under the principle of MEMS. And this wearable orthotic device is the noninvasive type which is one of the main challenging for the present invasive treatment techniques for tremor. In this project can also having additional features such as heartbeat sensing and

wireless technique by using GSM module. After all the process of tremor assessment and suppression the result can be SMS to the relation and also the physician at the same time analyzing whether the tremor suppressed or uncontrollable.

The main advantage of this project is easily predict the tremor before it reaches the severe stage and suppressed it for maximum level and SMS to the physician and relation about the heart rate and tremor result with the help of GSM wireless technique. This project consist both hardware and simulation output parts. Simulation is the simple way to analyzing the project whether it is working proper or not before to start the hardware part. This is the software part of the project. Here the PROTEUS software is used to simulate the project by the help of MP Lab which is specified software.16F877A is the PIC microcontroller used in this project and the MP Lab is made only for that PIC µcontroller and its code loading process from the respective file.

This paper consist the hardware circuit designing (BLOCK DIAGRAM) and its explanation, Hardware output with image results, Program logic or code logic (FLOW CHART), Simulation output.

II. HARDWARE CIRCUITRY PART

The circuitry includes power supply system, sensor parts (Heartbeat and vibration sensors), signal conditioning unit, Analogue to Digital Convertor, PIC Microcontroller (16F877A), Level convertor, Relay driver, Inflation pump, Hand (cuff), Non return valve and output part (LCD).

The below block diagram (Fig 1) has two important sensors that will be used to acquiring the respective signals from the body. The types of sensor is heartbeat and accelerometer (piezoelectric type) used as the purpose of assess heartbeat range and also acquiring the analogue signal (tremor signal). The particular sensor outputs are given to the PIC microcontroller which has inbuilt command processing and access the relevant input. MP Lab is only used to the performance of PIC.

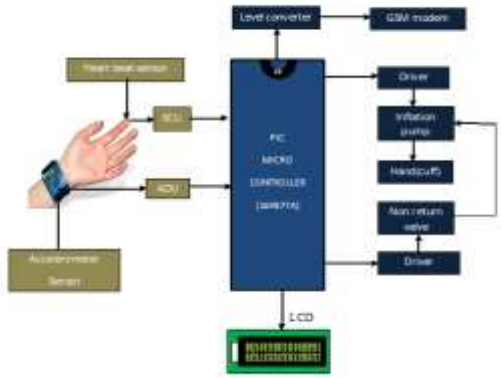

Fig 1: Block diagram of tremor analysis and suppression system

The pressure-cup part is fully controlled by the microcontroller. The interrupt is used to processing the unconditional stage of body action which means during the process of heartbeat analyzing if the tremor will occurring means the interrupt will give the preference for this tremor torque estimating process. The driver part is used to give the power supply to the inflation pump which need a 12v DC supply so the driver part is convert the 5v DC current to 12v DC current. When the tremor signal is arising the pump inflate the air bag 100 percentage and after 5seconds the pump automatically release the 50 percentage of the air from the air bag and again the respective process can performing 2 or 3 times. When the air bag is filled 100 percentage of the air non return valve has to be performed which means the air path way fully arrested for that 5seconds.

Relay is the most important part when the tremor signal is arising relay has to passing the 5V to the inflation pump for 5sec and after 5sec which is connected to the NC (no connection) pin. The relay performing randomly and control the action of pump. Relay has the magnetic switching function. The final output is displayed with the help of LCD. The above process result has to be SMS to the relation and physician with a help of GSM wireless module whether the tremor is controlled or not. Here the level convertor is used to connect the two different logic devices in a single serial model. Level convertor also called as the shifter and has two logics as TTL and CMOS. The project hardware kit (Fig 2) is given below.

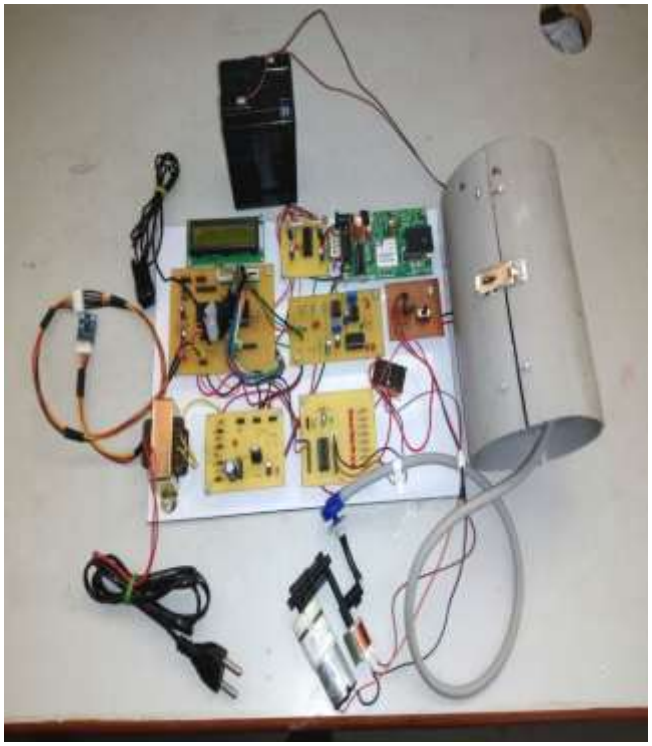

Fig 2: Tremor suppression hardware kit

All the components which are mentioned in the block diagram are fabricated and placed in a belt which is wearable. This belt may connected to the wrist or above the elbow part of hand

and then the tremor is estimated and get the tremor data then analyzing it properly and then suppressed it.

The LCD has parallel communication, 16×2 model and 32 character display. The applications are display of numeric and alphanumeric characters in dot matrix and segmental displays. When sufficient voltage is applied to the electrodes the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarizer, which would result in activating/highlighting the desired characters. The power supply should be of +5v, with maximum allowable transients of 10mv. The ground terminal of the power supply must be isolated properly so that voltage is induced in it. The module should not be removed from the live circuit. The hardware output display in LCD is in Fig 3.

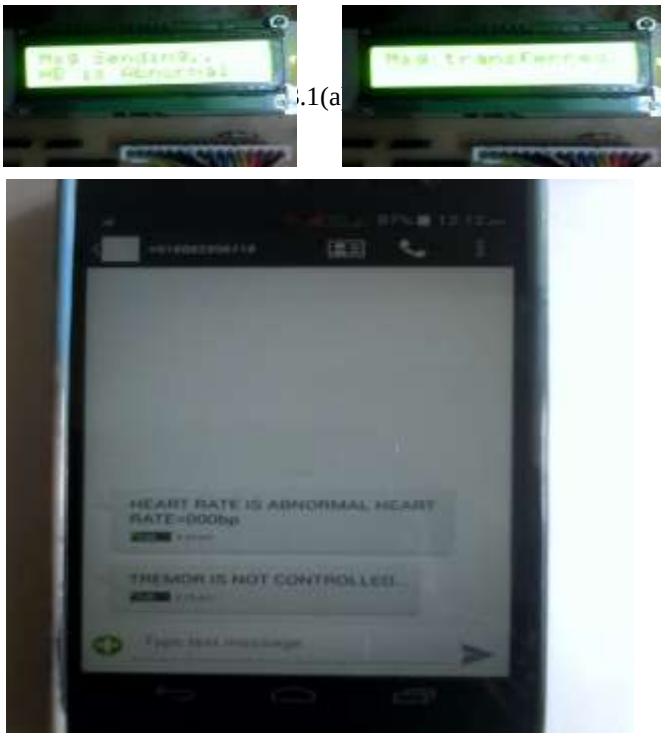

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Fig 3.3

III. SOFTWARE AND SIMULATION PART

PROTEUS software is used to performing the project which is a simulation software using engineer project designing field. The simulation and its working stages are given in Fig 4.

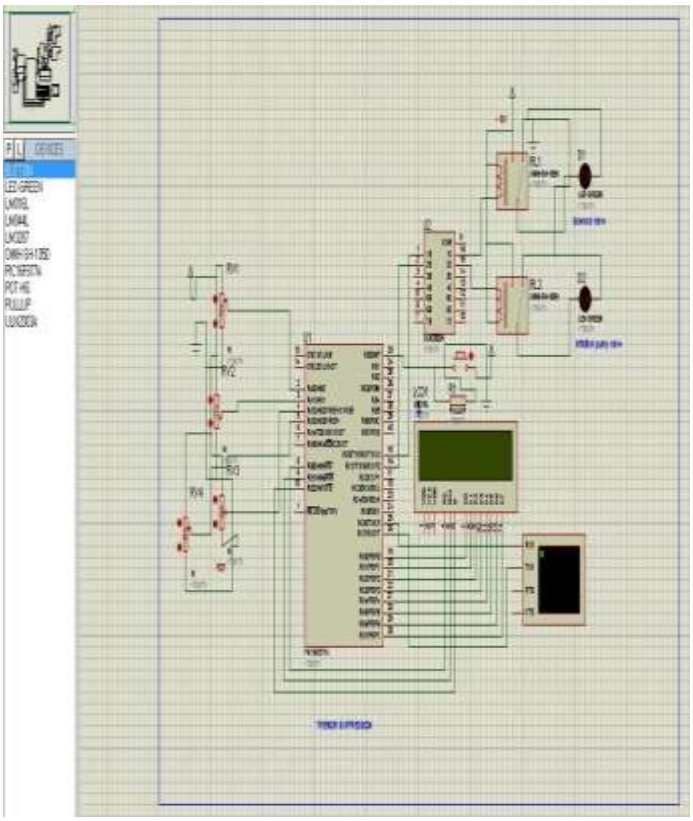
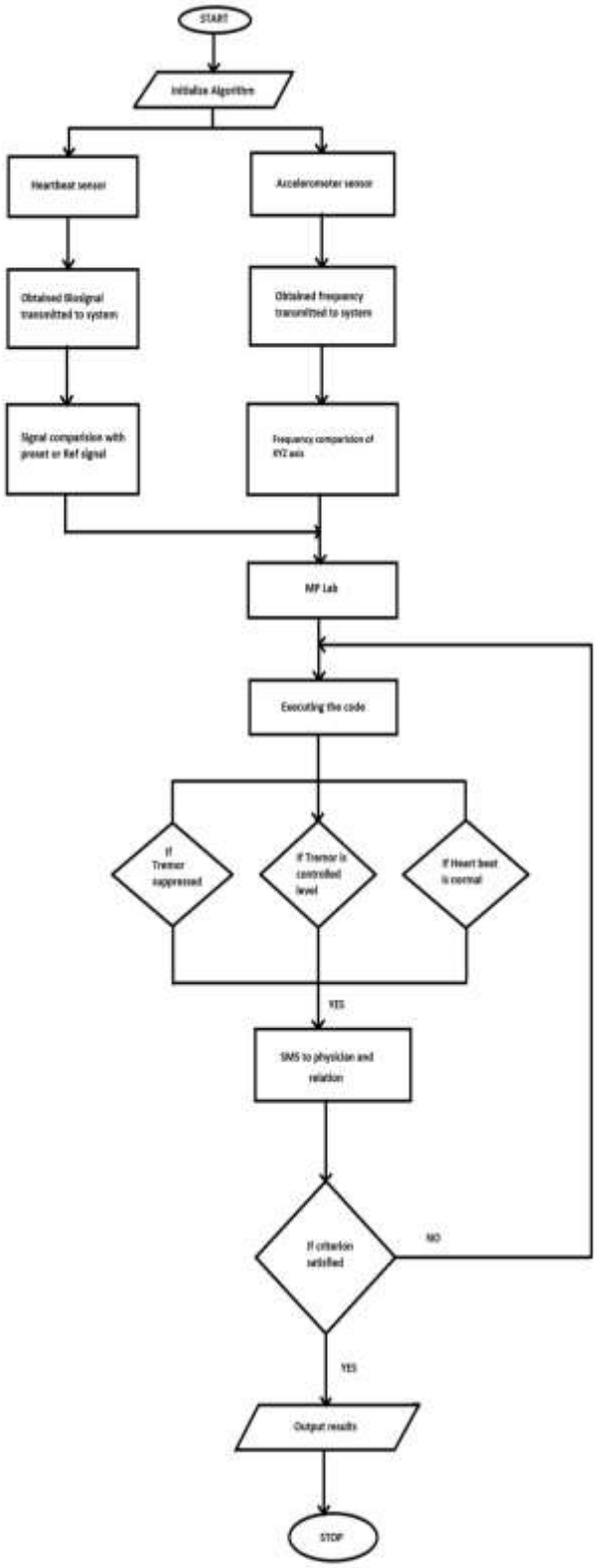


Fig 4: Simulation design in ISIS

The project working logic is given below in the form of flow chart. The flow chart explains the whole project processing steps and its procedure. The procedural way of this tremor suppression is explained in it.



The output of the simulation process is given by the mentioned Fig 5. The result of tremor suppression simulation process include the heart rate whether which is normal or not and the output of tremor whether it is suppressed or not. The output of this project having three major conditions based on these conditions only the result (SMS) will be send to the physician and relation. The conditions are,

- Tremor is suppressed and heart rate is normal
- Heart rate is normal but, tremor is not suppressed
- Heart rate is abnormal but, tremor is suppressed

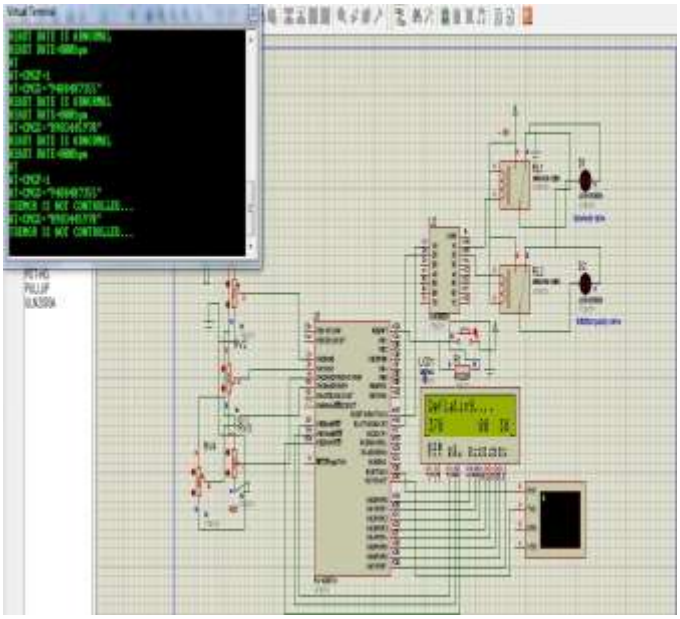


Fig 5: Simulation output in ISIS

IV DISCUSSION AND CONCLUSION

Tremor suppression via an active suppressive force as a non invasive alternative for medical treatments and surgery was studied theoretically and experimentally. In tremor suppression at musculoskeletal level, the challenge is the estimation of the muscle tremor force and application of a suppressive force that only attenuates the tremor without affecting the voluntary motion. In previous works, the suppression algorithm required an accurate model of the tremor motion. Thus the tremor was estimated using a harmonic model. Even though in the time domain tremor has a rhythmic and oscillatory behavior, it is not a simple sinusoidal motion, exhibiting significant variation in amplitude and frequency.

The tremor suppression algorithm proposed in this paper on real time estimation of the tremor motion. Instead, the main objective in the design of the controller is to suppress motion with frequencies in a board range specific to tremor motion. In order to determine the tremor frequency range, fist hand acceleration data of patients with Parkinson and essential tremor was analyzed. The fundamental frequency for both types of tremors was between 4-6HZ and the second harmonic peak was located between 8-12HZ. However, a wider range of 3-12HZ has been reported for the tremor in the literature. According in our approach we tried to design a suppression algorithm such that the closed loop wearable system has a relatively high attenuation in the frequency range of 3-12HZ.

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