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# System Design for Active Tremor Stabilization

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***Abstract*—** *Parkinson's disease, also known as tremors is one of the leading disability that is prevailing globally. Many people are affected by this disease. Generally, men are 1.5times more prone to suffer from tremors than women. According to scientists, this disease is partially curable by medications and also by complementary support therapies. But these have not resulted to be efficient in controlling tremors. Therefore scientists have developed many models to control the effects of tremors. Based on the previous studies, it was found that many inventions have been done to reduce the effects of vibrations but had few limitations. So, this paper exhibits the system that attains low cost and efficient device by using classic PID controller. This PID controller is tuned in such a way that it gives in best optimum result. The system design is done in Simulink software. This simulation study can be further used to develop a device.*

***Keywords*—** *Parkinson's disease [PD], Mechanisms, Simulink, Design.*

## I. Introduction

Parkinson's tremor is a nervous disorder in the brain which affects the movement of the body parts. It is progressive as well as a chronic disease which means, symptoms grow worse with time and it remains for a longer period of time. PD is a common neurodegenerative disorder after Alzheimer's and is estimated that over 10million people are affected because of it.[1]When the nerve cells die or get damaged due to any injury or chemical imbalance, patients start noticing minor problems like tremors, stiffness in limbs or body parts, sudden impaired balance, experiencing problems in talking, walking, writing or completing other simpler tasks. The figure below shows the effects of tremor on a person's writing.

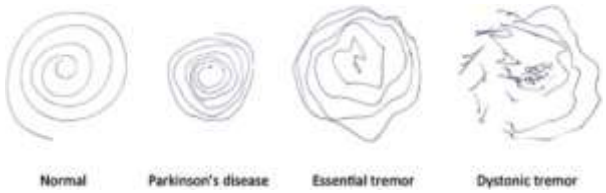


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Figure1: Archimedes spirals drawn by normal person, and patients suffering from Parkinson's disease, essential tremor and dystonic tremor respectively. [2]

The original cause of PD is unknown till date but some doctors claim that few of these can be hereditary and remaining cases are sporadic. So, it is concluded that this can result from either hierarchically or exposure to unknown environmental factors that can trigger the disease [3].

Tremors adversely affect the quality life of patients making them less interactive with the society and worsening their financial condition. This disease prevails from every 41 people per 1, 00,000 to 1,900 people per 1, 00,000. It is generally seen in people who are 80 and above. 4% of the people in 1900 people are able to get diagnosed before the age of 50 [4].

The frequency of these tremors ranges from 3Hz to 12Hz and are also classified based on frequency variations. Basic tremor types are as follows.

TABLE1: classification of tremors based on frequency and characteristics.

| **S.NO** | **Type of the tremor** | **Range of frequency** | **Activation condition** | | |
|---|---|---|---|---|---|
| | | | **Rest** | **Posture** | **Kinetic** |
| 1 | Parkinson | 3-7Hz | more | less | Less |
| 2 | Essential | 4-12Hz | - | more | Less |
| 3 | Cerebellar | 3-5Hz | - | Less | more |
| 4 | dystonic | 4-7Hz | - | more | more |

- **Resting tremor** is seen when the part affected is at rest but is held against gravity.
- **Postural tremor** is observed in patients whose limbs are voluntary maintained against gravity or in patients who extend their arms towards front.
- **Kinetic tremor** occurs in both resting and non-resting movements [5].

Symptoms in most of the cases are observed in hand and head. This illness is difficult to diagnose in initial stages and can be identified when it becomes worse with time. It is also said that, thinking related problems can also occur to the patients suffering from this disease. The most commonly used medicine is L-DOPA (levodopa). Since excessive usage of drugs might affect the body and cause side effects, therefore scientists started developing devices that can help to reduce this effect. [6]

Based on the previous analysis done, it is found out that the main motto of every anti-tremor device is to reduce the effects of vibrations and get the position of the hand as per the requirement. Figure2 shows a generalised block diagram of any device that is been invented till date.

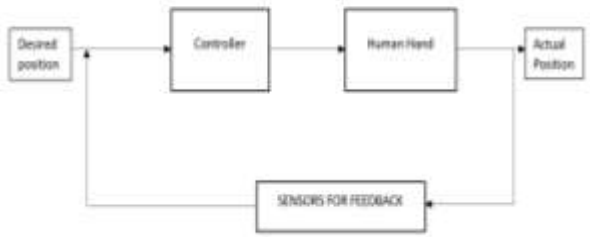


Figure 2: Generalised block diagram of Anti-Tremor Device.

## II. System Design

From the previous study, it can be concluded that despite many developments, the patients are finding difficulties in wearing the devices due to many factors like the weight of the device, range of the frequency-controlled, amplitude factors and actuators used [7-15]. To have an efficient system with actuators and higher frequencies to be controlled, a system design is developed with a simple class PID controller for tuning purposes which gives signals to the actuators that in turn control the vibrations of the hand. The proposed system design is as shown in the figure3.

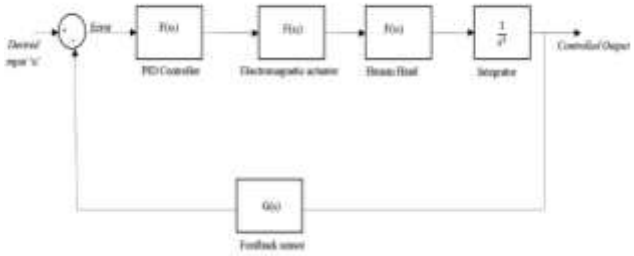

Figure 3: Proposed system design

The proposed model aims at reducing the effects of hand tremors that are caused by Parkinson's disease. Based on the previous study, a 4 degree of freedom model is used to depict the palm of the human hand. To note the association among the force and motion of the hand tremor, a human hand is used. The tremor is observed in human hand due to the damage of the nerves in the brain which disturbs the functioning when no external force applied at hand. Therefore, an opposing force should be applied at hand that can induce the vibration. Therefore a mechanical model, mass-spring-damper system is used as palm model as shown in figure 4.[16]

Here, in the four degrees of freedom, the masses $m_4$, $m_3$, $m_2$ and $m_1$ represent the mass exerted by the muscle, the tissue of the hand, dermis and epidermis respectively. The elements $k_1$ to $k_4$ and $c_1$ to $c_4$ are used to represent the properties at the 4 degrees of freedom. The basic equation of motion of the model is expressed as [17]

$$F = a\ddot{q} + b\dot{q} + cq$$

1)

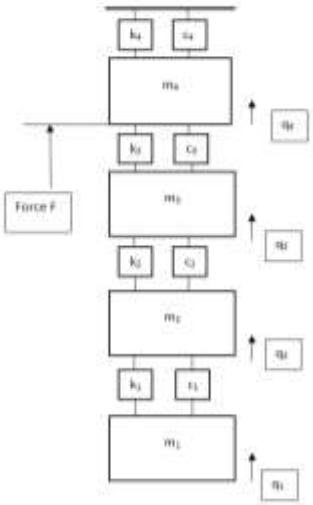


Figure 4: model of the palm

Where m, k and c stand for mass, stiffness element and damping force. The $q, \dot{q}, \ddot{q}$ and $F$ represent the parameters of displacement, velocity, acceleration and force respectively.

## III. Transfer Function of Actuator

In this study, an electromagnet is an actuator in suppressing hand tremors because it has the following advantages:

- An electromagnet doesn't need any external power supply to generate electrical power.
- It can produce either AC or DC power.

An electromagnet, there are two types.

1. Linear motion electromagnet actuator
2. Rotary motion electromagnet actuator.

To define the electromagnetic actuator in MATLAB we need to derive its transfer function. The electromagnetic field (EMF) produced is directly proportional to the flux. The particle charge '$q$' with a velocity '$v$' in the magnetic field generates the current (electric field '$E$' and magnetic flux '$B$'). Therefore, the occurrence force 'F' on the charge, can be expressed as, [18-20]

$$F = q\,(E + v * B) \quad 2)$$

When a current is produced by huge number of electrons along the wire then the total force is represented as,

$$F = i \int dl * B \quad 3)$$

Meanwhile, the Force in the equation (3) imposing on the element dl = $rd\Theta$ of one turn of the coil can be written as,

$$F = i \int rd\Theta * B \quad 4)$$

Therefore the connection among the electromagnetic force and current can be written as follows which is used as transfer function for the electromagnetic actuator,

$$F = i2\pi nrB \quad 5)$$

## IV. PID Controller

PID commonly known as Proportional integral derivative controller is a closed-loop control mechanism which is used in control systems. As we all know, the PID controller is used to calculate an error value between the input and the measuring process variable then applies difference based on proportional, integral, derivative functions. It is widely in use since the 1920s and is useful for fast response in displaying accurate and optimised automatic control in any dynamic system. It also provides stability to the system and can be tuned continuously. [21]

$$u(t) = Pe(t) + I \int_0^t e(t')dt' + D\frac{de(t)}{dt} \quad 6)$$

Here *u (t)* is the output, *e (t)* is the error and *P, I, D* are non-negative coefficients for proportional, derivate and internal functions respectively. Figure 5 depicts the controller before tuning and figure 6 shows the controller after tuning. The PID parameters are tuned using Simulink block model. After several values tested, the values of P=0.0194, I=6.642, D= 0.444 gives efficient response in suppressing the hand tremors.

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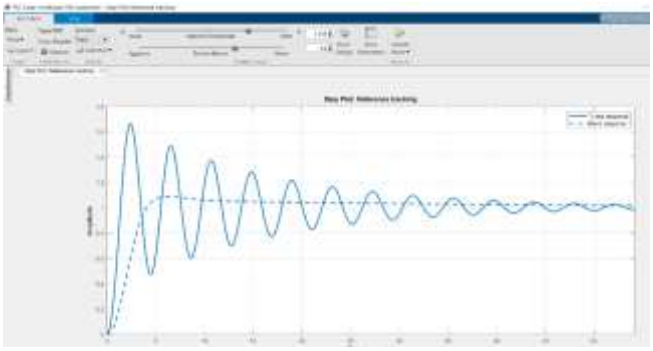

Figure 5: Controller before tuning

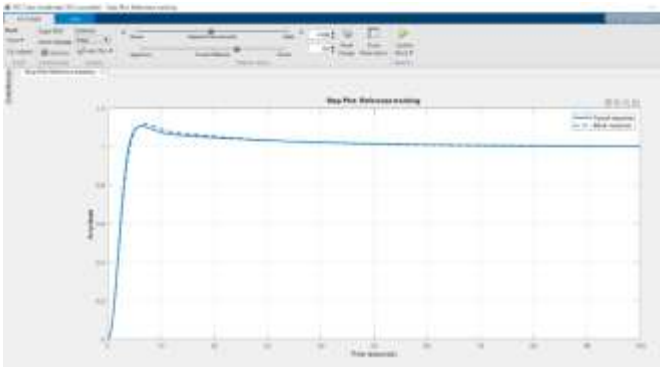

Figure 6: Controller after tuning

## V. OPTIMIZATION

The PID controller is used to optimise with the help of signal constraint block from the Simulink toolbox in the MATLAB software. Here the response signals are graphically constrained which are automatically optimised to get performance requirements. The optimization is shown in the figure 8.

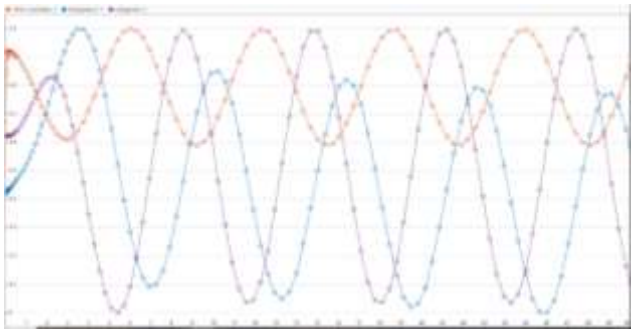

Figure 7: Time domain of the model using signal constraint block

Figure 8: Optimisation and response of PID controller

The optimisation of PID is shown in the figure where value for P,I,D are obtained as 0.0194, 6.642, 0.444 respectively. The optimisation plays a vital role in controlling and gives a good response with less effort and time.

## VI. Result and Discussions

The proposed system design is simulated to find the efficiency and effectiveness of the system in reducing the effects of tremors. The performance report is simulated using MATLAB software. These results can be used to develop an anti-tremor device. In the study, the sine wave is used as input signal and these signals are used because they represent similar properties to sinusoidal waves which are exhibited that of the human hand. To get an effective output control of human hand tremor, the value for the input signal is as follows,

- Sine wave – Amplitude [12N]; Frequency [9Hz]; Sample time [0.001]

From the figure, when the input is given as 9Hz, the output is controlled to 5Hz and similarly when the input is given as 7Hz, then output is attained to be 3.7Hz. The results can conclude that when the PID controller is used, it gives significant results in controlling the active tremors.

The blue signal in the above figure is the input and the yellow signal is achieved as an output as shown in figure 9.

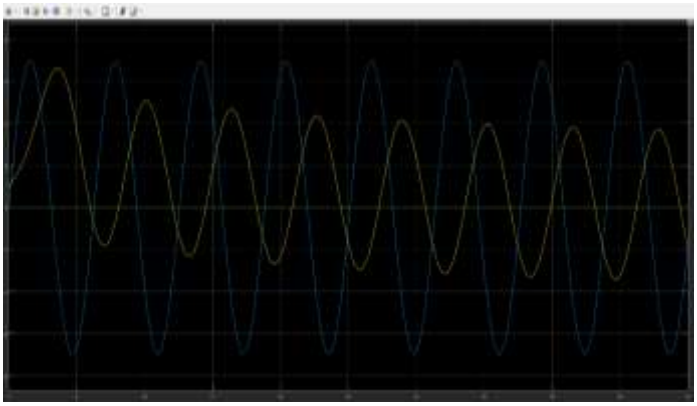

Figure 9: Input and Output signals.

In order to find out the characteristics of signals at various point, the figure shows the signal properties immediately after the PID controller and displacement of the hand after controlling. As in the figure 10, the red signal depicts the frequency tuning done by the PID controller before controlling the hand and green signal shows the displacement of the hand after controlling.

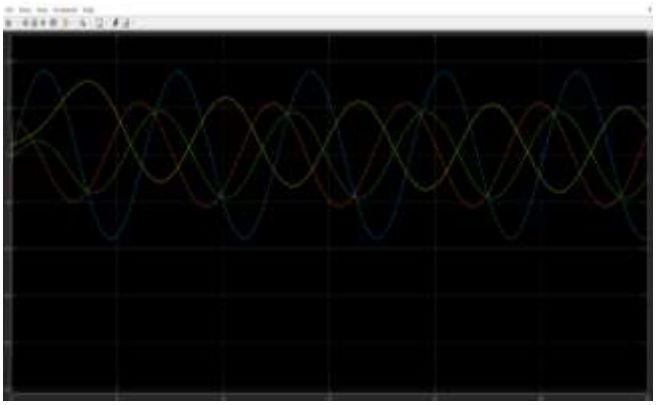

Figure 10: Frequency response of the proposed model

## VII. Conclusion

This paper gives the investigation for controlling the effects caused by the tremors. The use of the classic PID controller results in significant improvement in suppressing tremors caused by Parkinson's disease. The optimisation used in Simulink software played a vital role in developing a simple design within less time and less human effort.

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