



AN AUTOMATIC TREADMILL SPEED CONTROL WITH HEART RATE

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Abstract— Treadmill is an exercise machine for walking or running while staying in the same place. The proposed system presents a method to control the treadmill speed automatically with respect to the person's heart rate. This is mainly useful for the rehabilitation/secondary prevention program of the heart patients. Heart disease is one of the leading causes of death in the present scenario of the world. Antecedents of cardiovascular disease or heart disease should begin in the early life, making primary prevention efforts necessary from childhood. Thus, it has increased the emphasis on preventing atherosclerosis by modifying the risk factors, for example by healthy eating and regular exercise. Running also reduces obesity which is one of the causes of the heart disorders. The heart rate may vary while exercising, according to the medical condition of the patient. Since the exercising of the body causes adverse effect on the heart rate, it is important to control the speed of the treadmill to reduce the stress on the person. The different ranges of the possible heart rates are set in the system. The Electrocardiograph of the desired heart rate is set. The selection of a particular range is done with the multipoint switches. The voltage and speed is set differently according to the input heart rate range. A Permanent magnet DC motor is used for controlling the treadmill. The voltage given to the motor is regulated by a MOSFET according to the pulse width modulated output. Heart rate variation causes the variation in the Pulse width modulated output which regulates the on-off time of the MOSFET, and it regulates the amount of the voltage given to drive the motor. Hence the voltage variation in the motor input causes the regulation of the speed of the motor. A 230 v AC supply is filtered and rectified for the working of the motor. Pulsated DC produced by the MOSFET enables the smooth control over the voltage. Simulation of the proposed system is done in MATLAB software. Model based simulation is used for showing the execution of the proposed. Speed, heart beat and voltage variations are the parameters represented.

Index Terms— Heart rate monitoring, PWM, Microcontroller, MOSFET, Motor speed control.

I. INTRODUCTION

The innovations in different fields like sport training, rehabilitation centers and medical diagnosis lay emphasis on the automated exercise systems. Exercising have revealed their importance in the rehabilitation administered to the patients who went through Cardiac Catheterization or Bypass surgery to gradually build strength into their hearts. Since the Heart Rate can be effectively used as a measure of the exercise intensity, a precise and individual exercise prescription can be expressed in terms of a specific Heart Rate reference profile; precisely controlling the Heart Rate during exercises becomes crucial. Treadmill is an exercise machine for walking or running while staying in the same place. Treadmill machine provides a moving platform with a wide conveyor belt driven by an electric motor or a flywheel. The belt moves to the rear requiring the user to walk or run at a speed matching with that of the belt. The rate at which the belt moves is the rate of the running or walking. Thus the speed of the running may be controlled and measured. IJTET©2015 Health care technology is going through the most sophisticated era of the world. With

reference to the cases studied so far in this field, we can say that prevention and rehabilitation of the heart disease is very important in the present scenario. Exercising in the treadmill is very effective because running is a world approved fitness exercise. Running gives exercise to all the muscles as well as heart muscles. Running also reduces obesity which is one of the causes of the heart disorders [3]. It is also important for patients who went through Cardiac Catheterization or Bypass surgery to gradually build strength into their hearts through exercise. This build up needs to be done in a careful manner since too much exercise may damage the recovering heart [5]. Various experiments have been done in the similar pattern for controlling heart rate with ergometer and wheel chair [7]. One of the parameters to control in this process is the heart rate. The proposed system allows the user to set a maximum heart rate he or she can achieve based on the recommendations of a cardiologist. The heart rate of the patient is continuously monitored and fed to a controller while the patient runs on the treadmill machine. If the heart rate is lower than the maximum value, the speed of the motor will automatically increase and vice versa. The proposed system controls the treadmill speed



automatically with respect to the patient’s heart rate. Patients run on a treadmill machine while their Electrocardiogram is monitored through various techniques. Since over exercising of the body may cause adverse effect, it is important to control the speed of the treadmill to reduce the stress on the person. The heart rate is sensed and is passed to the controller [12]. Pulse Width Modulated output is used for controlling the speed of the motor. If the heart rate falls in a particular range the treadmill will be working accordingly. Hence the motor speed increases and decreases according to the heart rate. A simple DC motor is used for controlling the treadmill. Heart disease is the leading cause of deaths worldwide, though, since the 1970s, cardiovascular mortality rates have declined in many of the high income countries. At the same time, cardiovascular deaths and diseases have increased at a faster rate in the low and middle income countries. Antecedents of cardiovascular disease should begin in the early life, making primary prevention efforts necessary from childhood [4]. Thus, it has increased the emphasis on preventing atherosclerosis by modifying the risk factors, for example by healthy eating and regular exercise.

1.1 Heart Risk Factors

There are a number of risk factors for heart diseases including age, sugar consumption, family history, lack of physical activity and psychological factors. Some factors are immutable. But there are also many risk factors which can be modified by lifestyle change, social change, drug treatment and other preventive measures. The causes of cardiovascular disease are diverse but atherosclerosis and hypertension are the most common. In addition with that, with aging there occur a number of physiological and morphological changes that may also affect the cardiovascular functions [14].

II. PROPOSED SYSTEM AND SIMULATION

The system designed in the proposed system improves the design specifications. It is important for patients who went through Cardiac Catheterization or Bypass surgery to gradually build strength into their hearts through exercise. This build up needs to be done in a careful manner since too much exercise may damage the recovering heart. One of the parameters to control in this process is the heart rate [9]. Heart diseases cause many variations in the heart rate. The analysis of the heart rate thus helps to indicate the type of heart disease as well as to determine the health condition of the patient. Electrocardiography is a transthoracic interpretation of the electrical activity of the heart over a period of time. The recording produced by this non-invasive

procedure is termed an electrocardiogram. The ECG device detects and amplifies the tiny IJTET©2015

electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. The heart rate detector detects the heart rate of the person running on the treadmill. Respiration of the patient is also monitored. Change in the heart rate causes variation in the respiration rate of the patient. Abrupt increase in the heart rate causes to increase the respiration rate rapidly. Temperature sensor is also indicated to improve the efficiency in the analysis of the medical condition of the patient. The maximum heart rate is inputted to the system. When the measured heart rate moves beyond the threshold level, then the microprocessor controls the speed of the treadmill by regulating the heart rate. A keypad is included for inputting the maximum heart rate. Microcontroller regulates the speed of the motor by comparing the set of the inputs. The calculated heart rate is displayed in a LCD display. The heart rate variation is used for the PWM technique. The PWM output regulates the speed controller for regulating the speed of the treadmill. Separate motor driver circuit is connected with the microcontroller for regulating the speed of the treadmill. A simple DC motor is used for the working of the treadmill. Separate power is given to the motor.

2.1 Block Diagram

The proposed method can be illustrated with a block diagram which is shown in Figure.1. ECG is a signal which is very difficult to detect as well as to process. Smoothing and the noise removal of the signals is done in between which is not included in the block.

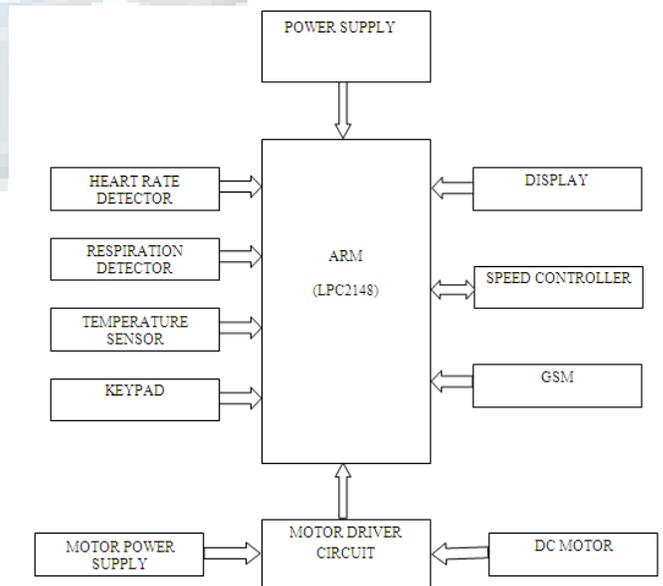


Fig.1 Block diagram



The rectification of the signal is also necessary because the motor selected for the proposed method is PMDC motor. The separate motor drive circuit is shown in Figure.2.

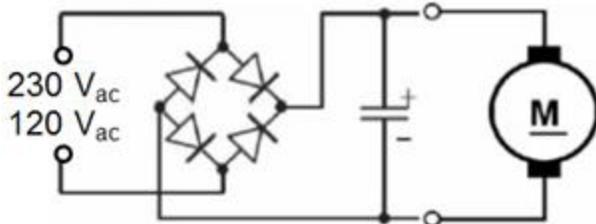


Fig.2 Motor Drive Circuit

III. RESULTS AND DISCUSSIONS

A simple method to control the speed of the treadmill with heart rate is implemented. Heart rate varies with the various actions and mechanisms in the body. Hence different ECG waveforms are generated and their number of occurrence of the peak values within a particular interval of time varies. According to this heart rate the pulse width modulated output varies and hence the motor speed. The input is the heart rate of the person running and the output is the change in the speed. Patients who are not admitted in the hospital can take use of the graphical data transmission technique for analysis and interpretation. The data's since transmitted in the graphical format, the accurate measurement and analysis can be done. When the heart rate of the patient is increased beyond the set threshold value, then the speed of the motor of the treadmill will get automatically reduced. When the heart rate of the patient goes very down of the threshold value, then the speed of the motor of the treadmill gets automatically increased. The variation is used in the PWM technique for controlling the motor with the help of the change of the set and the calculated heart rate. With the reference of the temperature and respiration, the control of the motor is done with maximum efficiency and the analysis is easier for indicating the present medical condition of the patient. The simulation of the proposed method is done with simulation software MATLAB. The drive system is simulated to predict the performance of the system before its real time implementation. The investigation of the working of the motor with the heart rate is carried out by using the simulation. The heart rate is given as input and the outputs are voltage and the speed of the motor. The simulation model includes different blocks such as ECG generator, amplifier, DC motor, MOSFET and PWM module.

TABLE 1

HEART RATE V/S SPEED

HEART RATE	SPEED IN RPM
57	950
75	850
95	750
115	650
150	550

In order to verify the performance of the motor with heart rate, different set of inputs are given. In the proposed system, there are 5 ranges of heart rate values. The range of the heart rate is selected by inputting any one of the values- 1, 2,3,4,5 to the input selector block. A multiport switch is placed at the input section for enabling this multiple input function. The corresponding output speed is illustrated in Table 4.1. The speed is set according to the heart rate calculated by the model. The output curves are plotted from the simulation results and are shown in the below figures. The low heart rate of 57 is set for the calculation of the voltage according to the pulse width. With the increase in the voltage, speed of the motor is also increased. Voltage variation is also seen similarly in Figure 3. in which the voltage is varied from 140V which is the normal heart rate to 180V within 2 seconds.

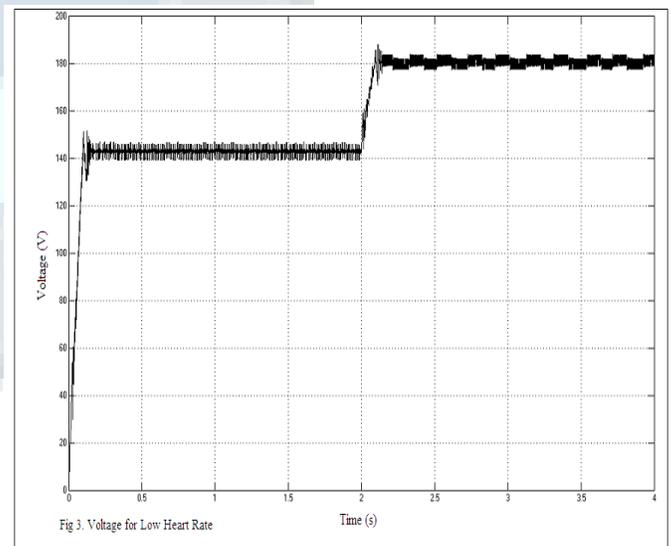
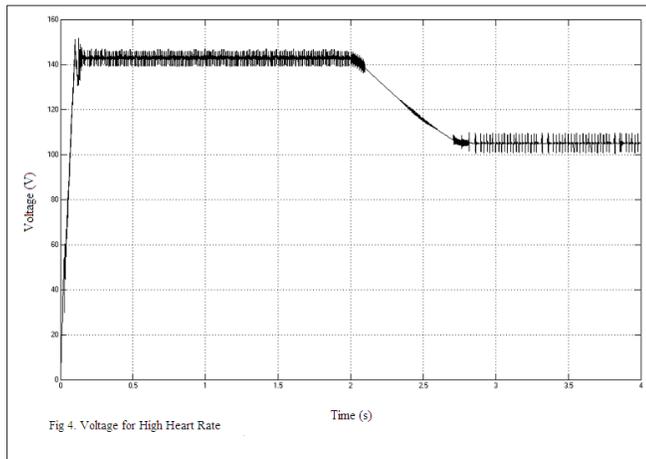


Fig 3. Voltage for Low Heart Rate

In the high heart rate, the voltage should be reduced to that particular condition. The voltage is decreased within the set time of 2 seconds. After 2 seconds, the voltage gradually decreases to the set voltage and remains constant at 100V for the calculation of the speed for reducing the speed of the motor. Speed also varies according to the voltage which is seen in Figure 4



IV.CONCLUSION

The most sophisticated techniques and development scenario is seen in the present medical field. As the heart related diseases are spreading abruptly worldwide, this approach has great importance in the developing as well as developed nations. It also provides ease for the use as well as is easier for the preventive and rehabilitation purposes. It reduces the stress on the heart of the patient, and at the same time gives exercise for the heart muscles. Medical field is one of the promising areas of technology nowadays. A lot of research programs have been launched in many countries. The increase of the heart related diseases lead the people to think about the preventive measures. The proposed method is one of the important preventive as well as rehabilitation measure. The main contributions of the proposed method are as follows:

- ✓ An effective method for the implementation of a speed control treadmill is done. The voltage of the motor is varied according to the heart rate based on the PWM method.
- ✓ It is one the simplest as well as cheapest mechanisms involved in the proposed method.
- ✓ The components involved in the method are easily available.
- ✓ A simple PMDC motor is used for its working.
- ✓ MATLAB is used for simulation for predicting the motor characteristics with the heart rate.
- ✓ It can also be used for the people in any of the age group.
- ✓ Application of the proposed is not within the limit of patients, it is also useful for the fitness maintenance of the athletes.

In Future enhancement we can be extended to use in conjunction with many other medical equipments. An advanced method with less power consumption will also be useful. Since energy is one of the most important considerations in the present scenario, the working of the treadmill with the solar energy will make noticeable changes in the fitness and the medical field.

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