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Design and implementation of a physical therapy device

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Abstract
People use devices in the field of physical therapy to relieve pain or rehabilitate the injured organ, as scientific developments have led to the discovery of the microcontroller, which helps in building less expensive, easier to use and more useful devices, using the Arduino card is the best way to design and implement a practical device that works in physical therapy. Since all physical therapy devices are similar in action, I have proposed designing a device that works on two principles: a vibrating motor and air temperature, which are useful in physical therapy. In this paper, a DC motor has been used to generate soft and gentle vibrations to treat the area to be treated, so that they are not practically annoying to the patient, and are also useful for activating blood vessels, in addition to stimulating cells to restore their normal working condition, through the method of this paper. The work here is done to generate waves of vibrations that are increasing according to measurements specific to the work in order to carry out the stimulation. The experiment was conducted on 50 patients, and some characteristics were studied, including the process of turning the oscillation motor on and off, in addition to a survey of patients' satisfaction in terms of whether the device bothered them or not. Finally, a device was obtained that works according to two principles of physical therapy: the oscillating motor and the temperature affecting the body. This device has been successfully worked.
Keywords*: Physical therapy, Arduino card, Arduino shields, DC Motor, vibration DC motor.*

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I. Introduction

Physiotherapy is a branch of medicine that aims to restore motor function and improve patients' quality of life through non-surgical techniques. One of its most important tools is physiotherapy equipment. These devices are based on precise scientific principles and are used in a variety of conditions, such as sports injuries, back pain, paralysis, and post-surgical rehabilitation. The importance of physical therapy lies in accelerating the recovery process, reducing the need for painkillers and surgery, improving motor performance, and preventing the aggravation of injuries[1].

A physical therapy device is a medical device used to deliver physical therapy through various techniques, such as heat, cold, electricity, ultrasound, or mechanical movements. This device is operated by a physical therapist after diagnosing the patient's condition. Physical therapy equipment is used in many medical conditions, such as sports injuries, neck and back pain, paraplegia or complete paralysis, strokes, and post-operative rehabilitation[2,3].

Physical therapy devices vary depending on the technique used and the medical condition. The most prominent of these are:

1. Transcutaneous electrical stimulation (TENS): This device uses mild electrical pulses to relieve pain and stimulate muscles. It is effective in cases of chronic pain and muscle spasms.
2. Ultrasound therapy: This device uses high-frequency sound waves to increase blood flow and accelerate healing. It is used for tendon and soft tissue injuries.
3. Low-intensity laser therapy (LLLT): This device promotes tissue healing and reduces inflammation. It is useful in cases of arthritis and chronic wounds.
4. Heat and cold therapy devices: Such as heating pads and cooling devices. These are used to relieve muscle spasms and reduce swelling.
5. Exercise and resistance equipment: Such as stationary bikes, treadmills, and resistance systems. These are used to strengthen muscles and improve balance after injuries or strokes[4].

1. Arduino System

Arduino is an open-source platform or microprocessor used to build electronic projects ranging from simple ones like a thermometer to complex ones like robots, 3D printers, internet applications, and much more[5,6].

Arduino's open source nature means you can view and modify the engineering designs and source codes for each of the various Arduino boards to suit your needs. You can also freely develop the Arduino C programming language and view their source codes. All of these features and software are completely free, unlike some development environments, such as Micro C, which require you to purchase an expensive license, sometimes costing thousands of dollars, to use them. The main goal of creating the Arduino platform is to provide an easy-to-use platform to help people with no prior background in electronics and programming. The Arduino platform consists of two main parts: the hardware and the software. The hardware part consists of the Arduino board and its associated electronic components and other hardware components, while the software part consists of the Arduino development environment (Arduino IDE), which represents the environment for writing program code in the Arduino language and uploading it to Arduino boards to control the hardware[7,8,9].

There are several types of Arduino boards that differ from each other in terms of the number of inputs and outputs, which determine the number of devices that can be controlled, such as:(Arduino UNO, Arduino Mega, Arduino Nano, Arduino Mini, Arduino Lilypad, Dermulive Arduino), the most popular type is the Arduino UNO, as in figure (1)[10].

The Arduino board contains a number of shields that help the board to ensure that the devices connected to it work properly. These shields differ in terms of the method of connection and the nature of their work. A number of them have been used here, such as: MP-32764 sensor as in figure (2), Relay as in figure (3)[11,12].

Figure (1): Arduino UNO

Figure (2): MP-32764 sensor

Figure (3): the relay

2. Motors

One of the types of motors is the DC motor, and among its types is the vibration motor. The vibration motor generates an oscillation, and depending on the size and type of the vibration motor as in figure (4) , this oscillation may help in many tasks, including the process of sensing the situation to be sensed, or as in this paper, it works to stimulate the blood stream and the cells located next to it or touching it to make a light tremor that helps to activate these cells or the movement of blood in vessels[13,14].

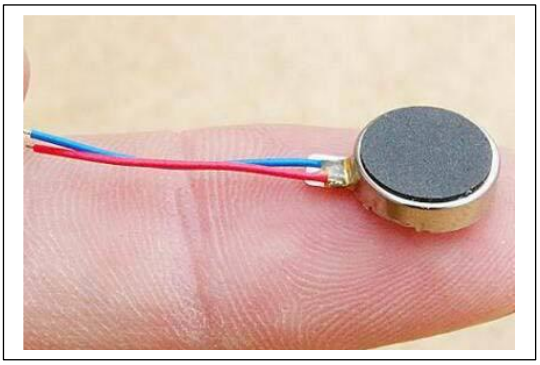

Figure (4): vibration DC motor

II. Material and Method

The device consists of the following materials (Arduino board , MP- 32764 (temperature-controlled microcontroller), thermal conductor + fan, DC motor (oscillating), relays, personal computer (PC) , breadboard, connecting wires, hose, metal + insulating material chassis and rubber belt, DC power supply).
The figure (5 and 6) represents a detailed diagram of the device components.

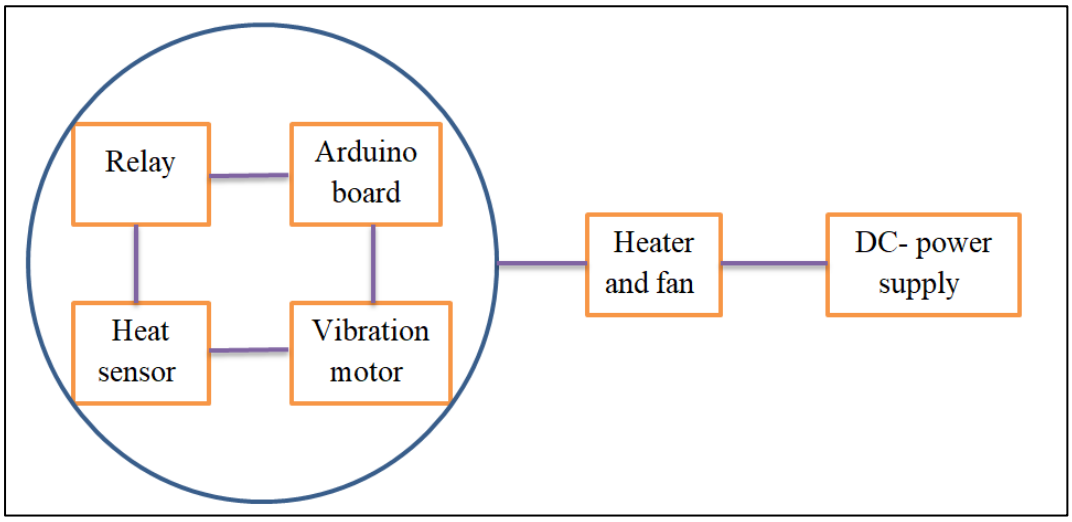

Figure (5): Diagram of the device components

The device was worked on and connected practically in the lab as follows:

- First programming the microprocessor board (Arduino) on a personal computer.
- Then programming the self-regulating temperature regulator board (MP- 32764).
- Then connect the metal frame together and secure its components (microprocessor, controller, and relay) securely and connect the oscillator with connecting wires.
- Connect the thermostat and fan to the hose to transmit heat and direct it to the patient's skin. We then cover the metal frame with insulating material.
- Now connect the microcontroller to a direct current (DC) source and supply a voltage of 9 amps to power the device.
- The device is then wrapped with an elastic belt around the part of the human body to be treated, whether the elbow, shoulder, knee, neck, etc.
- Closely monitor the temperature and the device's on-off time for the safety and comfort of the patient.

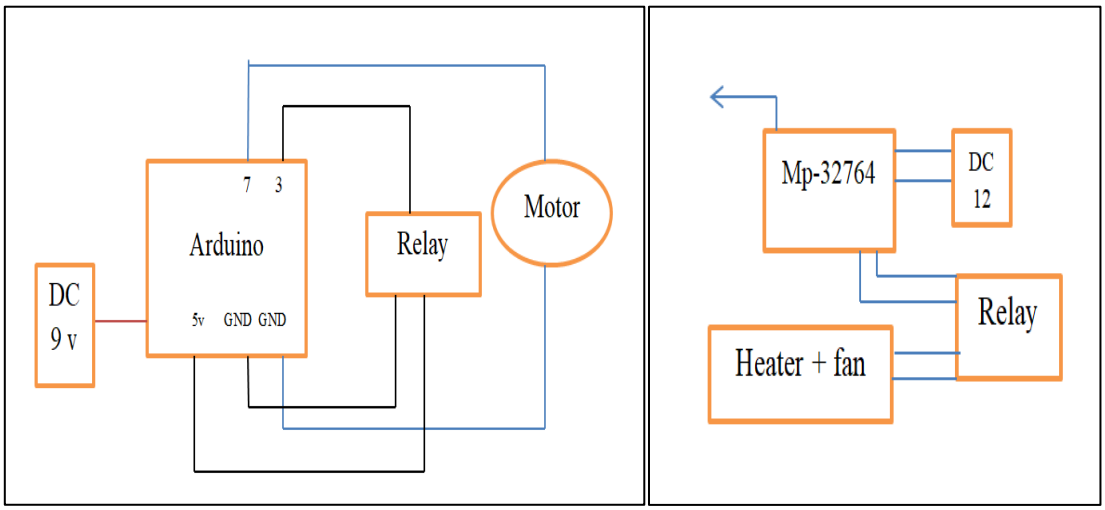

Figure (6): Diagram of the device components

3. Programming

In figure (7), Steps of programming the Arduino card using the Arduino program.

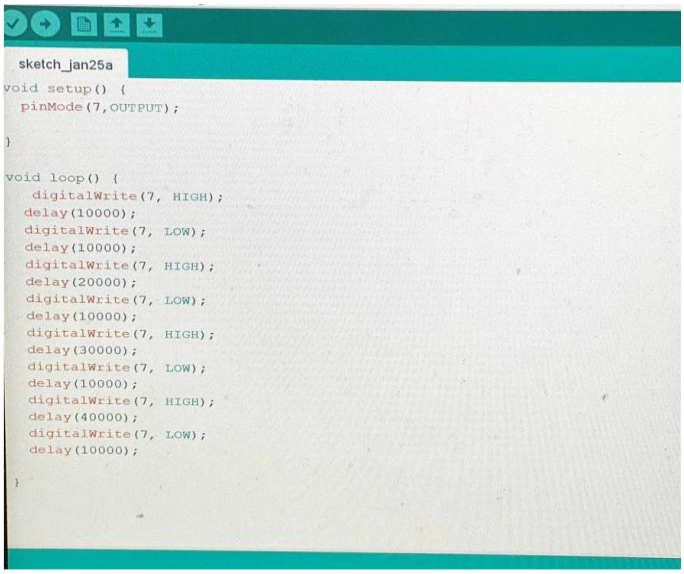

Figure (7): Steps of programming the Arduino card

Since the oscillator operates at a frequency of 11,000 cycles per minute (approximately 11,000/60 = 183.3 cycles per second), if the duration of a single treatment session is slightly more than four minutes, and we will take 280 seconds here, readings would obtained as shown in Table (1) below:

Time/sec	Frequency/circle per sec	Heat / C°	Work of motor
0	0	26.9	off
10	1833.333	28	on
20	1833.333	28.6	off
30	3666.667	30	on
40	5500	31	on
50	5500	31.4	off
60	7333.333	33.1	on
70	9166.667	34.4	on
80	11000	34.1	on
90	11000	35.6	off
100	12833.33	37.1	on
110	14666.67	37	on
120	16500	36.3	on
130	18333.33	35.8	on
140	18333.33	35.3	off
150	20166.67	35.4	on
160	20166.67	37.3	off
170	22000	36.9	on
180	23833.33	36.3	on
190	23833.33	35.8	off
200	25666.67	35.4	on
210	27500	35.8	on
220	29333.33	36.9	on
230	29333.33	37.3	off
240	31166.67	36.6	on
250	33000	37	on
260	34833.33	37.5	on
270	36666.67	37.1	on
280	36666.67	36.7	off

Table (1): shows the nature of the device's operation during a period of 280 seconds.

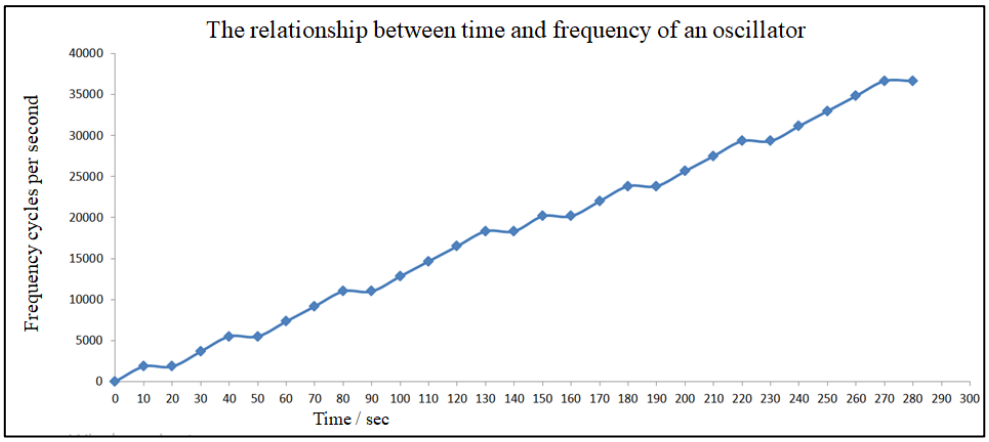

Figure (8): The relationship between time and frequency of an oscillator

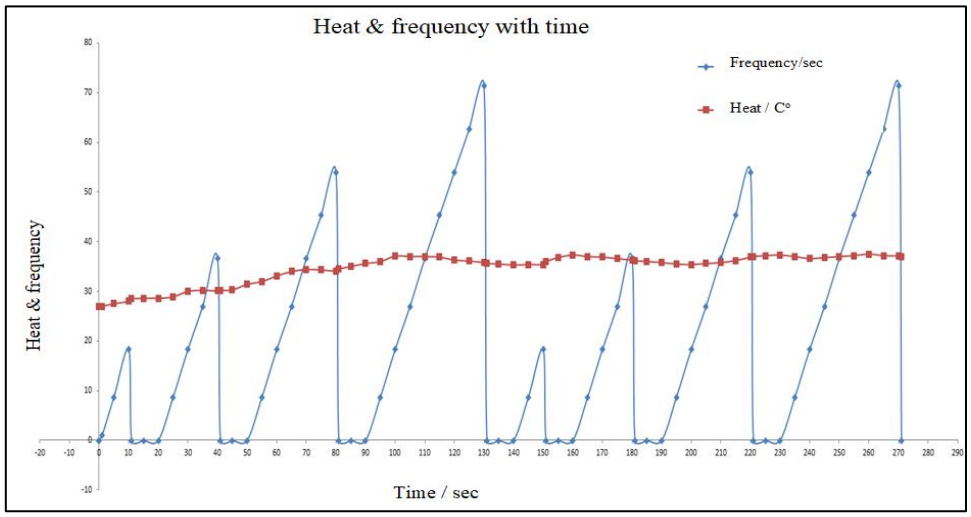

Figure (9): Heat & frequency with time

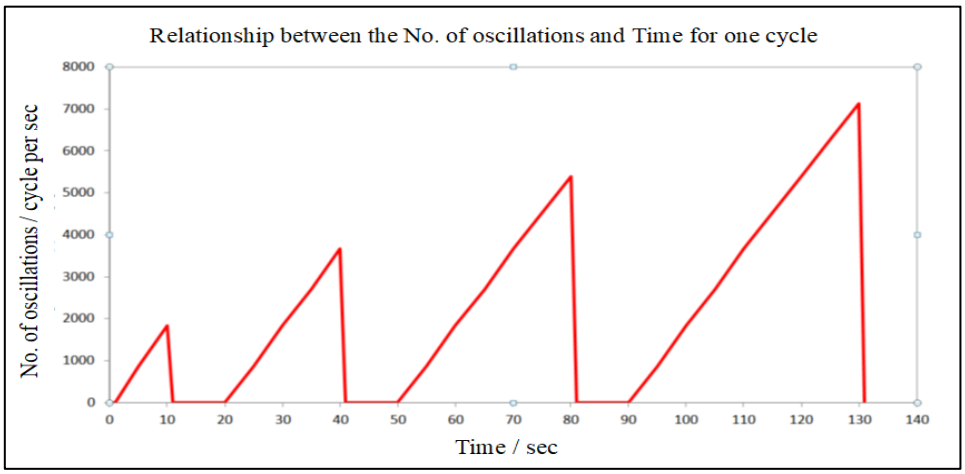

Figure (10): Relationship between the No. of oscillations and Time for one cycle

III. Results and Discussion:

Results: We tested the device on a number of patients, 50 samples. The subjects reported comfort when using the device, as the device operates with a non-irritating vibration using a soft vibration, which was better than the standard vibration device. Patients often suffer from the intensity of vibrations from standard physical therapy devices, especially those with muscle spasms.

This soft vibration works to counteract the stagnation of the tissue cells within the affected area. Since the device operates in a dual manner, the hot air mass contributed to a sense of comfort among the patients. This is due to the harmonious operation of the oscillator and the hot air mass, which does not cause skin damage or burns.

This air mass expands the diameter of the arteries for greater blood flow, which aids healing, as it provides a standard temperature for cells to divide and is suitable for coupling with low-grade cells.

IV. Conclusions:

This device is practical and can be used to treat some conditions requiring physical therapy. It differs from previous devices in that they used a fixed frequency, which causes cell stagnation. This device is the exact opposite, as it uses a non-fixed frequency that is in harmony with the applied air mass, stimulating cells in the blood. Future work will involve testing the device to confirm its effectiveness in treating fats and obesity, as cases of morbid obesity require a long period of treatment and follow-up to determine the device's effectiveness.

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