**SYNOPSIS**

The project gives an outline of the work done relating the project “Muscular Stimulator”. It also contains the details regarding the project and how it can be developed into successful commercial products. The next few pages engaged in the designing the process of PCB connection.

The main project has done by a batch of amateurs and we hope any flaws on this project will be overlooked.

**ABSTRACT**

The world is fast developing in every field. Man has attained the supremacy in this world using his brain power. The scientifical and technological developments are a result of this. Thus a better technology is developed each and every day which makes life easier and comfortable.

The days where medicines where the only ways to treat muscle sprains are gone, now people prefer more reliable ways such as external stimulations which are very low cost and do not have any side effects.

This is a circuit that stimulates that part of your body where electrodes are attached. It is useful to relieve headache and muscular pain and revive frozen muscles that impair movement. Though it provides muscle stimulation and invigoration, it’s mainly an aid in removing cellulites. Muscular stimulator is a medical device which is used to treat various muscle conditions

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1. **INTRODUCTION**

It uses electrical signal to tense and release muscles, through the employment of small electrodes on either side of muscle area. Muscular stimulator is a popular way to shake the muscles and is good when the patient has been suffering from strong injuries and is put to bed for a long time.

Muscular stimulator is the only way for these people to get their muscles strong again. It is done by stimulating some part of the body. For this purpose, an electronic device is used, little electrodes of which are out directly on the body areas that need to be stimulated. A slow tension is then put on the wires and muscle stimulation is done. The electrical low voltage Is done on smaller, involuntary muscle groups, which cannot be stimulated in other ways. The low voltage also stimulates the brain, which starts sending impulse through the involuntary muscles, is stimulating.

Muscular stimulator is useful to relieve headache and muscular pain and revive frozen muscles that impair movement. The system comprise of two units stimulator circuits and timer circuits.

Muscular stimulator is used to treat migraines and muscle pain. It is so practical and easy to use. There are few things easier to comprehend. You can find cheap battery loaded device, as well as electronic plug-in stimulators, both for no big costs. The best thing about these devices is that you can also use them to lose weight and give tonus to your muscle. This kind of stimulation is considered a safe way to keep good form.

**2. BLOCK DIAGRAM**

2.1 STIMULATOR CIRCUIT

**OSCILLATORY**

**CIRCUIT**

**INTENSITY**

**CONTROL**

**POWERDRIVE**

**CIRCUIT**

**TRANSFORMER**

**0/P**

**3 V DC**

2.2 TIMER CIRCUIT

**9 V**

**SUPPLY**

**BUZZER**

**CIRCUIT**

**TIMER**

3. BLOCK DIAGRAM DESCRIPTION

**3.1 STIMULATOR CIRCUIT**

3.1.1 OSCILLATORY CIRCUIT- It consists of IC 7555 timer connected in astable mode of operation. It generates output pulses with frequency 80Hz. This section provides the necessary voltage for intensity control circuit.

3.1.2 INTENSITY CONTROL- It consists of transistor along with a voltage divider resistive network. The variable resistor acts as an intensity control for the circuit. The output of the circuitry can be varied by choosing appropriate resistance values. Thus it acts as the intensity control section.

3.1.3 POWERDRIVE CIRCUIT- it consists of a power amplifier which provides necessary voltage to drive the transformer section.

3.1.4 TRANSFORMER –it consists of a 2V-220V step up transformer. The electrodes are connected to the secondary of the transformer, in which the stimulations are obtained.

3.1.5 SUPPLY- A 3V dc supply is given to the whole circuit.

**3.2 TIMER CIRCUIT**

3.2.1 TIMER CIRCUIT- The IC 555 timer is connected in monostable mode of operation so as to obtain output pulses.

3.2.2 BUZZER CIRCUIT- It is connected to the output of IC. The buzzer along with the LED will indicates that the delay time has been elapsed.

3.2.3 SUPPLY-- A 9v battery is connected which provides the necessary voltage to make the IC turn on.

*4.* **COMPONENTS REQUIRED**

|  |  |  |
| --- | --- | --- |
| COMPONENTS | SPECIFICATIONS | QUANTITY |
| **STIMULATOR CIRCUIT** | | |
| TIMER IC | IC 7555 | 1 |
| RESISTOR | 180K, 1.8K, 2.2 K, 4.7K POT,100Ω | 1each |
| CAPACITORS | 100 nF, 0.01µF | 1each |
| TRANSISTORS | BC 327 | 2 |
| TRANSFORMER | 12V-220V,160mA | 1 |
| DIODE | 1N4001 | 1 |
| LED | - | 1 |
| BATTERY | 3V | 1 |
| **TIMER CIRCUIT** | | |
| TIMER IC | IC NE555 | 1 |
| RESISTORS | 33K,10K,1M | 1 each |
| CAPACITORS | 220µF,0.47µF,0.01µF | 1 each |
| LED,BUZZER | - | 1 |
| BATTERY | 9V | 1 |

*5.***555 TIMER**

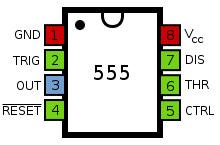
The **555 Timer IC** is an [integrated circuit](http://en.wikipedia.org/wiki/Integrated_circuit) implementing a variety of [timer](http://en.wikipedia.org/wiki/Timer) and [multivibrator](http://en.wikipedia.org/wiki/Multivibrator) applications. Depending on the manufacturer, the standard 555 package includes over 20 [transistors](http://en.wikipedia.org/wiki/Transistor), 2 [diodes](http://en.wikipedia.org/wiki/Diode) and 15 [resistors](http://en.wikipedia.org/wiki/Resistor) on a silicon chip installed in an 8-pin mini dual-in-line package ([DIP-8](http://en.wikipedia.org/wiki/DIP-8)).Variants available include the 556 (a 14-pin DIP combining two 555s on one chip), and the 558 (a 16-pin DIP combining four slightly modified 555s .Ultra-low power versions of the 555 are also available, such as the 7555 and TLC555.The 7555 requires slightly different wiring using fewer external components and less power.



The 555 has three operating modes:

* [Monostable](http://en.wikipedia.org/wiki/Monostable) mode: in this mode, the 555 functions as a "one-shot". Applications include timers, missing pulse detection, bouncefree switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) etc
* [Astable](http://en.wikipedia.org/wiki/Astable) - free running mode: the 555 can operate as an [oscillator](http://en.wikipedia.org/wiki/Oscillator). Uses include [LED](http://en.wikipedia.org/wiki/LED) and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, [pulse position modulation](http://en.wikipedia.org/wiki/Pulse_position_modulation), etc.
* [Bistable](http://en.wikipedia.org/wiki/Bistable) mode or [Schmitt trigger](http://en.wikipedia.org/wiki/Schmitt_trigger): the 555 can operate as a [flip-flop](http://en.wikipedia.org/wiki/Flip-flop_(electronics)), if the DIS pin is not connected and no capacitor is used. Uses include bouncefree latched switches, etc.

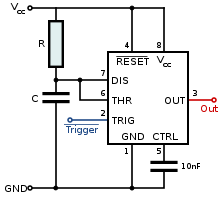
**PIN OUT DIAGRAM**

[](http://en.wikipedia.org/wiki/File:555_Pinout.svg)

The connection of the pins is as follows:

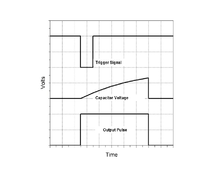
|  |  |  |
| --- | --- | --- |
| **Pin** | **Name** | **Purpose** |
| 1 | GND | Ground, low level (0 V) |
| 2 | TRIG | OUT rises, and interval starts, when this input falls below 1/3 *V*CC. |
| 3 | OUT | This output is driven to [+*V*CC](http://en.wikipedia.org/wiki/Vcc) or GND. |
| 4 | RESET | A timing interval may be interrupted by driving this input to GND. |
| 5 | CTRL | "Control" access to the internal voltage divider (by default, 2/3 *V*CC). |
| 6 | THR | The interval ends when the voltage at THR is greater than at CTRL. |
| 7 | DIS | [Open collector](http://en.wikipedia.org/wiki/Open_collector) output; may discharge a capacitor between intervals. |
| 8 | *V*+, *V*CC | Positive supply voltage is usually between 3 and 15 V. |

### 5.1 Monostable mode

[[](http://en.wikipedia.org/wiki/File:555_Monostable.svg)](http://en.wikipedia.org/wiki/File:555_Monostable.svg)



Schematic of a 555 in monostable mode

[](http://en.wikipedia.org/wiki/File:NE555_Monotable_Waveforms_(English).png)

The relationships of the trigger signal, the voltage on C and the pulse width in monostable mode

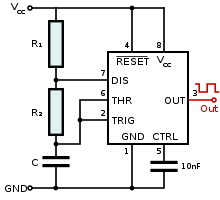
In the monostable mode, the 555 timer acts as a “one-shot” pulse generator. The pulse begins when the 555 timer receives a signal at the trigger input that falls below a third of the voltage supply. The width of the pulse is determined by the time constant of an RC network, which consists of a [capacitor](http://en.wikipedia.org/wiki/Capacitor) (C) and a [resistor](http://en.wikipedia.org/wiki/Resistor) (R). The pulse ends when the charge on the C equals 2/3 of the supply voltage. The pulse width can be lengthened or shortened to the need of the specific application by adjusting the values of R and C.

The pulse width of time *t*, which is the time it takes to charge C to 2/3 of the supply voltage, is given by

t = RC\ln(3) \approx 1.1
  RC

where t is in seconds, R is in [ohms](http://en.wikipedia.org/wiki/Ohms) and C is in [farads](http://en.wikipedia.org/wiki/Farads). See [RC circuit](http://en.wikipedia.org/wiki/RC_circuit) for an explanation of this effect.

### 5.2 Astable mode

[[](http://en.wikipedia.org/wiki/File:555_Astable_Diagram.svg)](http://en.wikipedia.org/wiki/File:555_Astable_Diagram.svg)



Standard 555 Astable Circuit

In astable mode, the '555 timer ' puts out a continuous stream of rectangular pulses having a specified frequency. Resistor R1 is connected between VCC and the discharge pin (pin 7) and another resistor (R2) is connected between the discharge pin (pin 7), and the trigger (pin 2) and threshold (pin 6) pins that share a common node. Hence the capacitor is charged through R1 and R2, and discharged only through R2, since pin 7 has low impedance to ground during output low intervals of the cycle, therefore discharging the capacitor.

In the astable mode, the frequency of the pulse stream depends on the values of R1, R2 and C:

f = \frac{1}{\ln(2) \cdot C \cdot (R_1 + 2R_2)}[[7]](http://en.wikipedia.org/wiki/555_timer_IC#cite_note-6#cite_note-6)

The high time from each pulse is given by

\mathrm{high} = \ln(2) \cdot (R_1 + R_2) \cdot C

and the low time from each pulse is given by

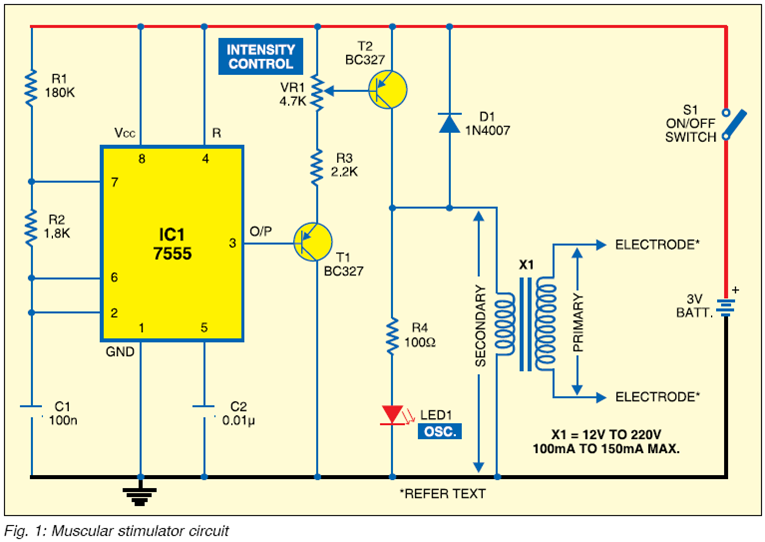
\mathrm{low} = \ln(2) \cdot R_2 \cdot C

where R1 and R2 are the values of the resistors in [ohms](http://en.wikipedia.org/wiki/Ohm) and C is the value of the capacitor in [farads](http://en.wikipedia.org/wiki/Farad).

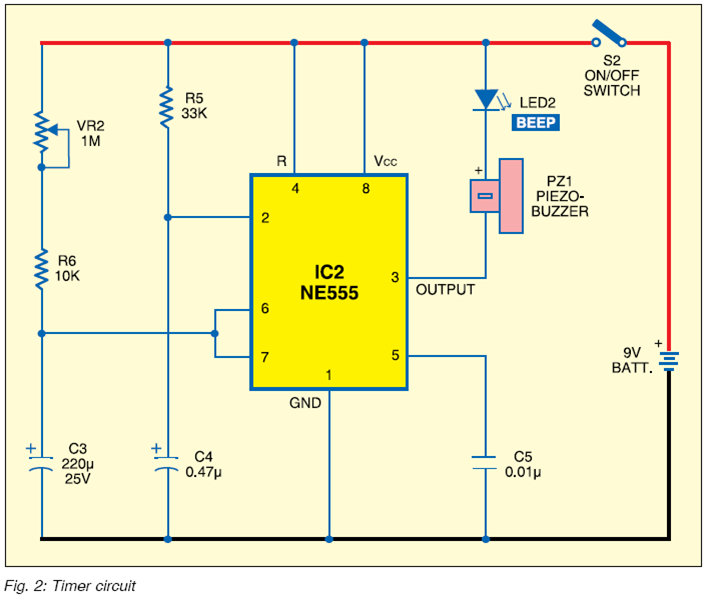
To achieve a duty cycle of less than 50% a diode can be added in parallel with R2 towards the capacitor. This bypasses R2 during the high part of the cycle so that the high interval depends only on R1 and C1.

**6. CIRCUIT DIAGRAM**

* **6.1 MUSCULAR STIMULATOR CIRCUIT**

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* **6.2 TIMER CIRCUIT**

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**7. CIRCUIT DIAGRAM DESCRIPTION**

7.1 **STIMULATOR CIRCUIT**

The stimulations are produced at this section of circuit. When switch S1 is closed, current flows and the IC 7555 will get a supply voltage of 3V battery. The IC here is wired astable multivibrator which produces continuous pulses of frequency 80Hz at the output. Thus we have output at pin no.3 which is pulses at 80Hz frequency. When the output of the timer goes low and the pnp transistor T1 turns on, thus an output current flows which causes a voltage drop across the resistor. When the voltage drop across R3 and VR1 are sufficient enough, the transistor T2 is turn on. This transistor acts as a power amplifier. The collector of transistor is connected to one end of winding of transformer X1.When the transistor T2 turns on their occurs a current flow, again causes a voltage drop across resistor R4.the transformer primary is connected across the resistor which steps up this voltage and a higher voltage is obtained at the secondary windings. The diode D1 is connected so as to protect transistor T2 against high voltage pulses generated by the transformer. Separate electrodes are connected to each ends of secondary winding of transformer X1.Using pot meter VR1 we can control the intensity of current sensing at the electrodes. The brightness level of LED1 indicates the amplitude of the pulses. The output voltage is about 60V but the output current is so small that there is no threat of electric shock. After attaching electrodes to the body flip switch S1 to activate the circuit and rotate the knob of intensity control preset VR1 very slowly until you feel a slight tingling sensation.

**7.2 TIMER CIRCUIT**

It uses IC NE555 connected in monostable mode. Initially, when switch S2 is closed, the monostable triggers and its output will go high for a particular time. This will be the quasi stable state of monostable mode whose time period can be varied by varying resistance and capacitance values. After a particular time delay the output goes low, at this point the LED get forward biased so it glows also the buzzer beeps. Thus indicating the time delay preset has been elapsed. Thus the stimulation time can be presetted by making use of the timer circuit.

**9. PCB DESIGN PROCEDURE**

**9.1 DRAWING THE CIRCUIT SCHEMATIC**

Drawing of the circuit is done through EAGLE (EASY APPLICABLE GRAPHIC LAYOUT EDITOR) Schematic capture software. It includes many libraries with thousands of component symbols. We can select the required symbols from the library and if in the schematic. After placing the component symbols, we can complete the interconnection using the wire or bus control.

The next step is to assign to part reference. Each component has to be assigned footprint of PCB pattern name. The footprint gives the actual size, physical representation of the components on the PCB network. The component symbol and foot symbol should correspond in all respect.

**9.1.1 DESIGN RULE CHECK AND NET LIST CREATION**

After the circuit, schematic is completed with all the required information such as part reference and footprints. The design rule check can be used for checking errors in the design it will check for duplicate symbol, overlapped lines and dangling lines.

After the schematic design and file passes the DR , check a program called Electric Rule Check(ERC),which checks for wiring error, processes it. The final operation to be done before starting PCB artworks is the net list creation.

A net list creation of the components and interconnection along with other information such as footprint, track width etc. is found. A net list software or tool can take the circuit schematic as input and generate net list. The net list can be used as interconnection sources for the remaining stages.

**9.1.2 CREATING THE PCB ART WORKS**

In automatic design, the net list obtained from previous stages is used for getting the required footprint and interconnections. The software used for the PCB network design is the ORCAD layout.

**STEPS IN PCB DESIGN ARE**

Loading the net list file generated has to be loaded in to the PCB software when starting a new design. Operation being with bringing all component foot on design screen with a nest of interconnection. This interconnection indicates connection between the pins of components and connectors which helps in routing and placing.

**9.1.3 DRAWING BOARD OUTLINE AND PLACING COMPONENTS**

Depending upon the density of the components and connection, we have to design the size of the board, accordingly outline the PCB has to be drawn, saves as a barrier, to limit routing only inside the board outlines. Then the components of the footprint have to be placed to in optimum position to make the routing sample spaces referring to the schematic diagram and the nest. The software automatically recalculates the minimum interconnection distance through routing .In place , aesthetic is also a factor of consideration.

**9.1.4 ROUTING**

It is the interconnection of the components using copper track of required width. Before starting routing the following things must be done. Enabling the number of layers used and enabled in artwork depends upon the complexity of the circuit and fabrication technology available. If the board is single –sided enable only bottom as solder side layer as tracks can only on one Side of the PCB. If the double side board is required, enable bottom and component side. If the circuit is much more complex you can enable the required number of the inner layer considering the fabrication technique and cost.

**9.2 SOLDERING**

Soldering is the process of joining two or more similar or dissimilar metals by melting another metal having lower melting point.

**9.2.1 SOLDERING FLUXES:**

In order to make the surface accept the solder readily, the component terminals should be free from oxides and other obstructing films. Soldering flux cleans the oxides from the surface of the metal. Zinc chloride, Aluminium Chloride and Rosin are other commonly used fluxes**.**

**9.2.2 SOLDER:**

Solder is used for joining two or more metal at temperature below their melting point. The popularly used solders are alloy of Tin (60%) that melts at 375F and solidifies when it cools.

**9.2.3 SOLDERING IRON:**

It is used to melt the solder and apply at the joints in the circuit.

**9.2.4SOLDERING TECHNIQUES**

**SOLDERING BASIS**

A soldering joint is a junction of two metals (normally copper in the electronics industry) which are held together with a thin layer of solder between them. Soldered joint is formed by heating two metals, cleaning two surfaces, applying the molten solder and allowing the joints to cool. These steps must occur in any soldering process, although the order they follow and the method each takes may differ greatly from one soldering process to another.

**HAND SOLDERING PROCESS**

Here a soldering iron at a temperature of about 320 degree Celcius is first applied to a joint area, to both metals. A combination of solder and flux is applied as a thin wire form of solder with cores of flux.

Flux flows from solder cores on to metal surfaces. Cleans the wire and the base surface of contaminants, removing the dirt, grease and oxides, and then protects the surfaces from further contaminants.

Above 180 degree Celcius solder melts, flowing by capillary action between wire and base. A final temperature of around 215 degree Celcius ensures that a good joint can be formed. After soldering iron tip is removed, temperature of the joint should be allowed to fall slowly.

**HAND SOLDERING PROCESS BASIC REQUIREMENTS**

There are a few important points about a good soldering joint

1. The first soldering operation makes the strongest joint, subsequent heating weakens a joint.
2. Excessive dirt and grease on metal surfaces prior to the soldering reduces the flux cleaning action. Too much dirt and grease prevents a good joint altogether.
3. Thickness of solder between metals in a good joint need only be 1 micrometer. Too much solder actually weakens a joint.

**10. MERITS**

* Practical application in biomedical field.
* Low cost device hence affordable to common man.
* It relieves migraine, treatment for muscle atrophy, paralysis etc.
* Easy to implement
* Reliable
* Ease of usage
* It can be set up on a general purpose PCB

**11. DEMERITS**

* Improper use may cause skin irritation and burns
* Heart patients and pregnant women should not be used

**12. OVERVIEW OF THE TOPIC**

Muscular stimulator is a device which can be used for stimulation of muscles using electrical impulses. It is widely used in medical applications. In a broad sense it is termed as Electrical muscle stimulation {EMS}, also known as neuro-muscular electrical stimulation {NMES} or electromyostimulation, is the elicitation of muscle contraction using electrical impulses. The impulses are generated by the stimulator circuit as described and delivered through electrodes on the skin in direct proximity to the muscles to be stimulated. The impulses mimic the action potential coming from the central nervous system causing the muscles to contract. The electrodes are generally pads that adhere to the skin.

Functional electrical stimulation{FES} is also a type of NMES that uses electrical currents to activate nerves innervating extremities affected by paralysis resulting from spinal chord injury {SCI}, head injury, stroke and other neurological disorders.

**11.1 APPLICATIONS IN BIOMEDICAL FIELD**

There are several applications of muscular stimulator out of which some important one’s are explained below

* Muscle atrophy is defined as a decrease in the mass of the muscle; it can be a partial or complete wasting away of muscle. When a muscle atrophies, this leads to [muscle weakness](http://en.wikipedia.org/wiki/Muscle_weakness), since the ability to exert force is related to mass. Muscle atrophy can be opposed by the signaling pathways which induce muscle hypertrophy, or an increase in muscle size. Therefore one way in which [exercise](http://en.wikipedia.org/wiki/Exercise) induces an increase in muscle mass is to down regulate the pathways which have the opposite effect. One important rehabilitation tool for muscle atrophy includes the use of [functional electrical stimulation](http://en.wikipedia.org/wiki/Functional_electrical_stimulation) to stimulate the muscles. This has seen a large amount of success in the rehabilitation of paraplegic patients.
* Injuries to the spinal cord interfere with electrical signals between the brain and the muscles, resulting in paralysis below the level of injury. Restoration of limb function as well as regulation of organ function are the main application of FES, although FES is also used for treatment of pain, pressure, sore prevention, etc.
* Some examples of FES applications involve the use of [Neuroprostheses](file:///C:\wiki\Neuroprostheses) that allow people with [paraplegia](file:///C:\wiki\Paraplegia) to walk, stand, restore hand grasp function in people with [quadriplegia](file:///C:\wiki\Quadriplegia), or restore bowel and bladder function.
* Electrical stimulation for the purpose of helping persons with paralysis of the arms or legs mainly focuses on the neuromuscular transmission peripherally. E-stim can also be used for central nervous system stimulation to hasten awakening from coma or the vegetative state.
* FES for ambulation also shows improvements in blood flow to lower extremities and in other medical and psychological parameters including bone density.

Thus we have muscular stimulators are widely used in market in different forms. The following picture shows some commercially available electrical muscle stimulators



**13. FUTURE SCOPES**.

* The entire system can be operated on control system basis. This can be done by connecting two power MOSFETS to a microprocessor chip which makes the circuit much more simpler
* The commercially available muscular stimulators are much more small in size , thus easy to carry.
* There are possibilities that various other technologies can be integrated along.

**14. CONCLUSION**

This project is aimed at implementing a low cost muscular stimulator using IC555. It is just a miniature form of the stimulators available in markets for medical uses. The electro muscular stimulators which are widely used in shock therapies, for exercise and for relieving pain are nothing but a circuitry using 555s. The circuit we implemented can be modified further using various advanced technologies.

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