Low-Frequency Electronic Muscle Stimulator

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Here is a simple low-frequency electronic muscle stimulator used in electrotherapy (use of electrical energy for medical treatment).

Electronic muscle stimulation or electronic stimulation makes use of a small voltage that aims at the motor nerves in a human body to excite these. It basically causes contraction of muscles. The muscles rest between shocks and contract again when the shocks occur. This regular contracting and relaxing has been used to cure various vascular and musculoskeletal conditions. This method makes the movement of oxygen and nutrients to the muscles much easier. General applications of electronic muscle stimulation are to stimulate sensory and motor nerves, facilitate muscle contraction, re-educate muscles, improve circulation and prevent/stretch adhesions.

Circuit and working

Fig. 1 shows block diagram of the muscle stimulator. The power-supply block has a transformer, 230V AC mains as input, bridge rectifier and filter.

The variable-voltage block provides variable voltage to the converter block. It is built around IC LM317 and produces voltages of 1.25V to 25V with a current of 1A. This block produces the required power for upping the voltage to the required level.

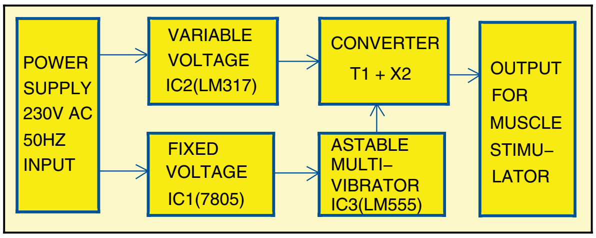

Fig. 1: Block diagram of the muscle stimulator

The fixed-voltage block provides a voltage of 5V to the astable multivibrator block.

The astable-multivibrator block is built around IC LM555 and produes low-frequency variable square wave. It provides frequency to the converter block, which produces the signal for the output block. Output from the converter is given to various points on the human body for stimulating the muscles.

Fig. 2 shows circuit diagram of the stimulator circuit. It is built around transformer X1 and a bridge rectifier comprising diodes D1 through D4, filter capacitors C1 and C2, 5V voltage regulator 7805 (IC1), adjustable regulator LM317 (IC2), timer LM555 (IC3), transformer X2 and a few discrete components.

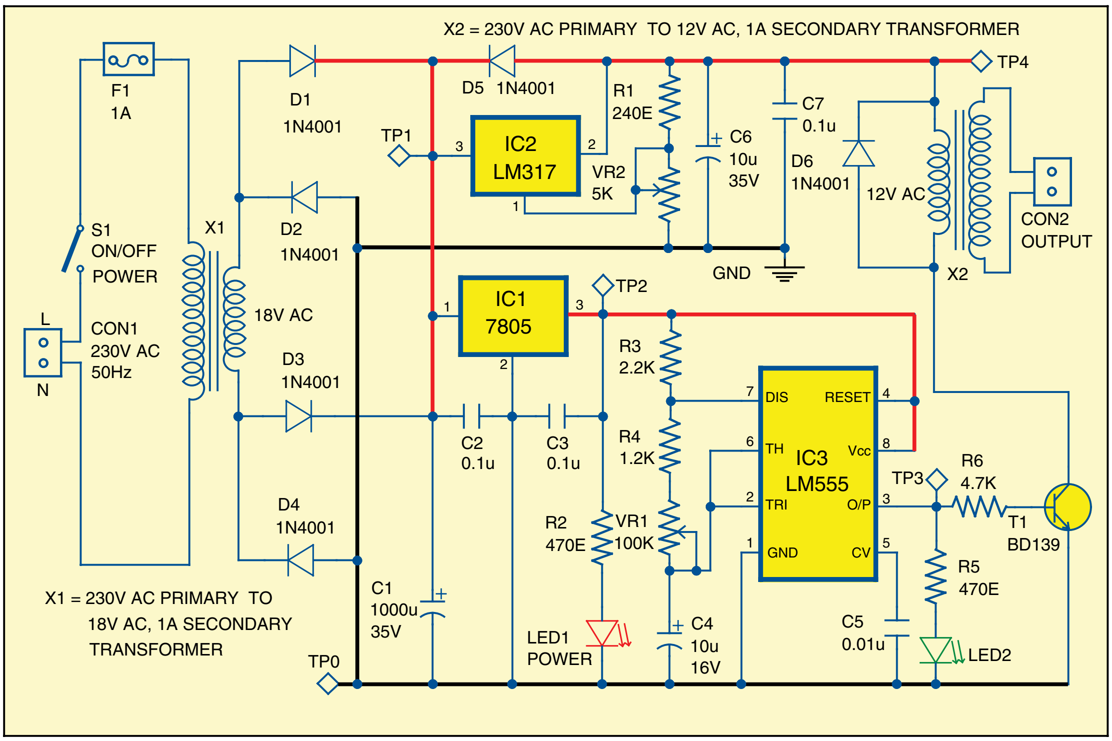

Fig. 2: Circuit diagram of the muscle stimulator

IC1 produces 5V fixed voltage to enable IC3, and IC2 produces adjustable voltage which is given to X2. LED1 indicates the presence of 5V DC.

The 555 timer is configured in astable-multivibrator mode. For stimulating muscles, low frequencies are used, ranging from 0.7Hz to 31Hz, which can be varied using potmeter VR1.

Output frequency at pin 3 of the 555 timer is used to drive transistor

Test Points

Test point	Details
TP0	0V (GND)
TP1	Around 25V
TP2	+5V
TP3	Variable frequency
TP4	Around 1.2V to 25V

PARTS LIST

Semiconductors:

IC1	- 7805, 5V voltage regulator
IC2	- LM317 adjustable voltage regulator
IC3	- LM555 timer
D1-D6	- 1N4001 rectifier diode
T1	- BD139 npn transistor
LED1, LED2	- 5mm LED

Resistors (all 1/4-watt, ±5% carbon):

R1	- 240-ohm
R2, R5	- 470-ohm
R3	- 2.2-kilo-ohm
R4	- 1.2-kilo-ohm
R6	- 4.7-kilo-ohm
VR1	- 100-kilo-ohm potmeter
VR2	- 5-kilo-ohm potmeter

Capacitors:

C1	- 1000µF, 35V electrolytic
C2, C3, C7	- 0.1µF ceramic disk
C4	- 10µF, 16V electrolytic
C5	- 0.01µF ceramic disk
C6	- 10µF, 35V electrolytic

Miscellaneous:

CON1, CON2	- 2-pin connector terminal
F1	- 1A, fuse
S1	- On/off switch
X1	- 230V AC primary to 18V AC, 1A secondary transformer
X2	- 230V AC primary to 12V AC, 1A secondary transformer
	- Probes

T1. Output at pin 3 of the 555 timer is shown by LED2.

The next major section in the circuit generates variable DC voltage. This function is done by IC LM317 (IC2). It is an adjustable regulator capable of producing 1.25V to 25V. Potmeter VR2 is used to vary the voltage at pin 2 of IC2.

The converter is centred around transformer X2. Output of IC3 is a square-wave signal given to the base of transistor T1 via resistor R6. Output from IC2 is fed to the secondary of transformer X2. Transistor T1 acts as a switching transistor. The input voltage at secondary of X2 can be varied using VR2. When IC3 oscillates, the primary of X2 produces a voltage of around 70V to 90V.

Different muscles stimulate at different levels of voltage intensity, and

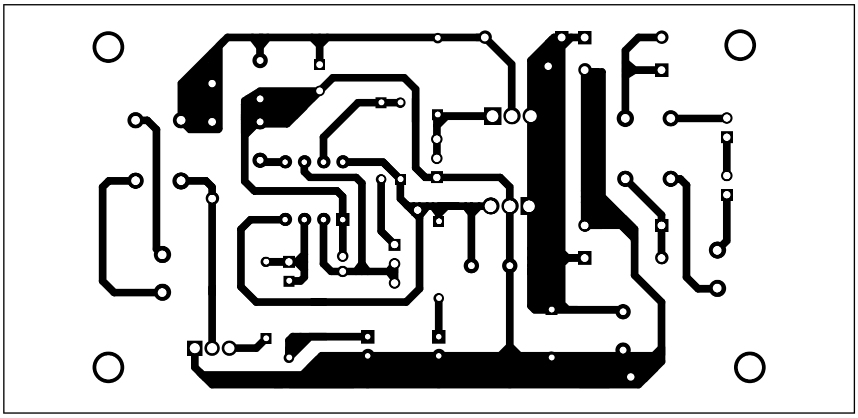

Fig. 3: Actual-size PCB of the muscle stimulator

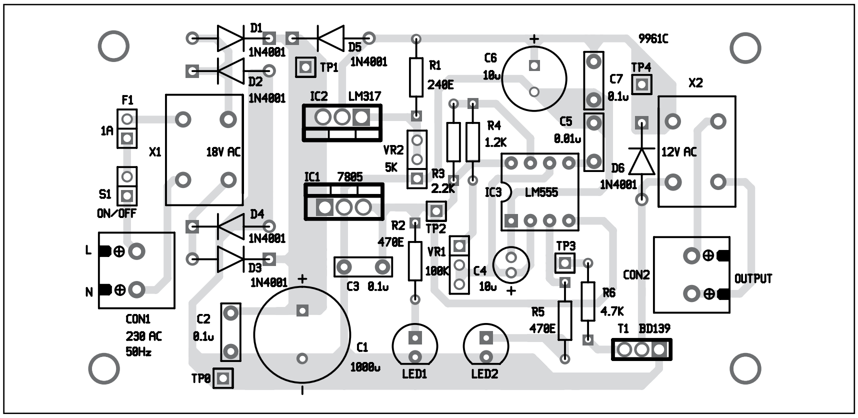

Fig. 4: Component layout of the PCB

stimulation also depends on the age of people. VR2 is labelled as intensity control. By varying VR2, different levels of intensities are obtained. VR1 is used to change the oscillation frequency of IC3.

Construction and testing

An actual-size, single-side PCB of the stimulator circuit is shown in Fig. 3 and its components layout in Fig. 4.

After assembling the circuit on the PCB, house it in a small cabinet. An old UPS cabinet can be used for housing the components and transformers. The cabinet can be fitted with fuse F1, on/off switch S1, indicator LEDs (LED1 and LED2) and variable resistors VR1 and VR2. Transistor T1 should be housed on small heat-sink. Panel mount the AC mains socket, on/off switch, fuse and output interface, as per requirement.

Verify that voltages at the test points are as shown in the test points table before using the circuit. Connector CON2 is used to measure the pulsed output voltage from X2 using an oscilloscope or a general-purpose multimeter. Set the intensity knob VR2 to minimum position and frequency knob VR1 to low. Place the probes at any two points on your body (not too far from each other). You should feel a tingling sensation which is produced by relaxation and contraction of the muscles.

Electrotherapy can also be used for improving the range of joint movement (example: frozen shoulder), treating neuromuscular dysfunction, improving strength, motor control and local blood flow, tissue repair and enhancing micro-circulation to heal wounds, under proper medical supervision. ●

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