

# Design of Microcontroller-Based Electroacupuncture Stimulators

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**Abstract:** *The use of an electroacupuncture stimulator allows an injection cannula to be located without the cooperation of the patient. Regional anaesthesia thus becomes safer because the basic condition "no paraesthesia, no anaesthesia" becomes irrelevant. Electroacupuncture has been a developing field in parallel with various medical applications. Among possible pathological conditions, electroacupuncture therapy has found application in areas such as pain management, cancer symptoms, musculoskeletal system, neurology, obstetrics, gastrointestinal cardiovascular and surgical anaesthesia. Although research in this direction is intense, the problems and questions in the scientific study of the electroacupuncture method in medical applications remain unanswered. The article discusses the design problems of electroacupuncture stimulators, the design of the stimulator based on the 16F877 microcontroller, and the circuit selection. Finally, the author made an offer.*

**Keywords**—acupuncture, electroacupuncture stimulator, electroacupuncture stimulator, design

## 1. INTRODUCTION

Acupuncture is an ancient practice of medicine. It originated over 2,500 years ago. The procedure of acupuncture has been used to treat and relieve symptoms of a wide range of diseases and conditions. Acupuncture has been used throughout the world unlike other forms of alternative and traditional therapies that have been confined to their national or cultural context. Acupuncture has developed since the 1970s.

There are some known explanations of the effect of acupuncture:

a. Augmentation theory - Acupuncture raises the level of triglycerides, certain hormones, prostaglandins, leukocytes, gamma globulins, opsonins, and antibodies. (immunostimulating effect)

b. Endorphin theory - Acupuncture stimulates the production of endorphins (especially the enkephalins, and dynorphins) (analgesia)

c. Neurotransmitter theory - Acupuncture can influence on the production and secretion of several neurotransmitters (serotonin, noradrenaline) (depression and emotional diseases, the decreased level of serotonin may lead to weight loss)

d. Circulatory/vasomotoric theory - acupuncture liberating vasodilator substances (especially histamin). (oedemas, neuropathy and post traumatic regenerative conditions)

e. Gate control theory - by acupuncture stimulated somatosensory A-delta fibres on the level on interneurons of spine lock the thinner viscerosensory C fibers transmitting the incoming pain information, by which they prevent its spreading into higher level center and prevent the perceiving of pain (anesthesia, analgesy, Diffuse Noxious Inhibiting Control, -le Bars, 2003)

Acupuncture can be considered as a treatment method for many diseases since non-traditional medicine is also involved in the nervous system and nerve control centers. Electroacupuncture is a method of irritating acupuncture points with electrical currents using electrical stimulation. There are some limitations and challenges in clinical practice and research areas of electroacupuncture, as the results obtained are more dependent on the professional level of the user. This affects the confidence level of the research results and makes it difficult to interpret the results. To overcome these problems, there is a need to develop a wearable and programmable electroacupuncture stimulator via smart mobile devices. The stimulator has gained the ability to be remotely controlled via a smart mobile device. Thus, it was possible to adjust the output voltage and frequency without contact. In terms of modernity, in the design of electroacupuncture devices, it is necessary to look at the stimulants controlled by a smart phone and developed with a Bluetooth connection.

## 2. ELECTROACUPUNCTURE METHOD

Acupuncture is a method used to heal pathological conditions by irritating certain points in the nerve channels, lymph channels or nerve control centers in the body. Stimulation can be done with different methodologies and due to the advantages of using electrical current and stimuli, interest in electroacupuncture has emerged more than others. Electroacupuncture has been a developing field in parallel with various medical applications. Among possible pathological conditions, electroacupuncture therapy has found application in areas such as pain management, cancer symptoms, musculoskeletal system, neurology, obstetrics, gastrointestinal cardiovascular and surgical anaesthesia. Although research in this direction is intense, the problems and questions in the scientific study of the electroacupuncture method in medical applications remain unanswered.

One of the problems encountered in electroacupuncture research is that acupuncture methods and stimulation parameters vary depending on therapeutic experience,

personal preference, and individual pain sensitivity threshold. In addition, commercially available electroacupuncture stimulants are large in size and require the patient to remain relatively still during treatment. This can cause undesirable stress reactions in animals or cause the animal to be sedated with drugs. Both of these provisions completely change the physiological state of the patient and as a result have the potential to significantly affect the results of the experimental process. From the point of view of therapists and scientists, electroacupuncture instruments are not designed to conduct modern experiments using computational techniques from smart mobile devices or computers. There is a need to design devices that offer opportunities for both therapists and scientists to overcome these problems.

The proposed electroacupuncture stimulator is a Bluetooth module designed to be placed on the patient during the treatment process and a smart mobile device for management purposes. The advantages of the device are its small size and wearable features, the freedom of movement of the patient during the treatment process and the continuation of normal activity. These features make it possible to reduce the stress on animals, especially during animal husbandry practices. It is possible to set the voltage and frequency of the active signal with high precision through a smart mobile device. It combines data analysis methods with a smart mobile device to record patient and treatment outcome data.

The use of a electroacupuncture stimulator allows an injection cannula to be located without the cooperation of the patient. Regional anaesthesia thus becomes safer because the basic condition "no paraesthesia, no anaesthesia" becomes irrelevant. In accordance with the basic electrophysiological conditions, a stimulator should have the following properties:

- (1) adjustable constant current at resistances of 0.5-10 kOhm;
- (2) monophasic square-wave initial impulse;
- (3) impulse duration selectable (0.1 ms + 1 ms, and exactly adjustable);
- (4) impulse amplitude (0-5 mA) exactly adjusted, unequivocal scale graduation or current indicator, in particular in the range of 0.05-1.0 mA;
- (5) impulse frequency 1-2 (-3) Hz;
- (6) alarm at high impedance and check on electrical circuit;
- (7) battery test (indication of battery voltage);
- (8) unequivocal assignment of load end;
- (9) high-quality connecting cable and plug; and availability of
- (10) instructions for use with relevant parameters (tolerated variations, steady-state characteristic curves, etc.).

### 3. GENERAL APPROACH TO THE DESIGN OF THE ELECTROACUPUNCTURE STIMULATOR CIRCUIT

The block diagram of the designed device is shown in Figure 1. A 3.7 V lithium battery connected to the battery charging module was used to power the impact device. Power is mostly transferred to the Bluetooth module, boost converter circuit and microprocessor. The microprocessor uses the Bluetooth module for bidirectional information exchange to transmit stimulus-related information to the therapist's smart mobile device. The microprocessor then controls the output voltage level and stimulation frequency of the device with a high voltage switch via an amplification control circuit. The stimulator is built on a pulse generator circuit and by adding a boost converter circuit, the input power is improved and the output is controlled by a high voltage switch. The bipolar electrode connects the output of the stimulator with needles placed on acupuncture points for treatment.

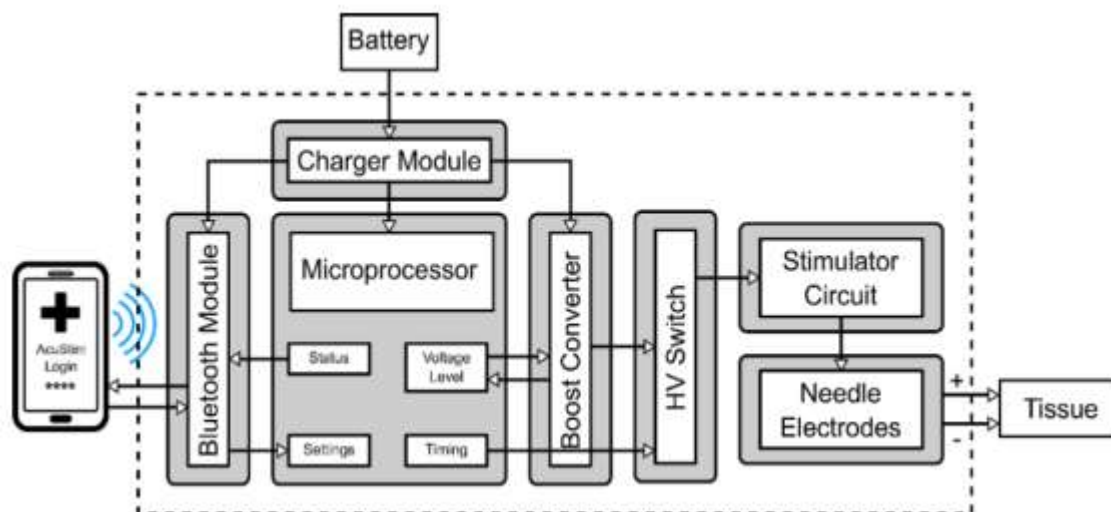


Figure 1. Block diagram of the electroacupuncture device

The output parameters of the electroacupuncture devices available in the market were analyzed and it was determined that the maximum power level used by acupuncturists was 3 V at 1 kΩ load for about 400 ms. For this reason, the maximum

output voltage of the designed electroacupuncture device was set as 4V and the time at 1 kΩ load was 500 ms. Figure 2 shows the circuit developed for the impact device. The output level of the boost converter is controlled by the input signal (PWM

signal) from the microprocessor. The switching frequency of the high voltage switch is determined by the microprocessor.

In addition, the microprocessor controls the position of the LEDs for visual display of data.

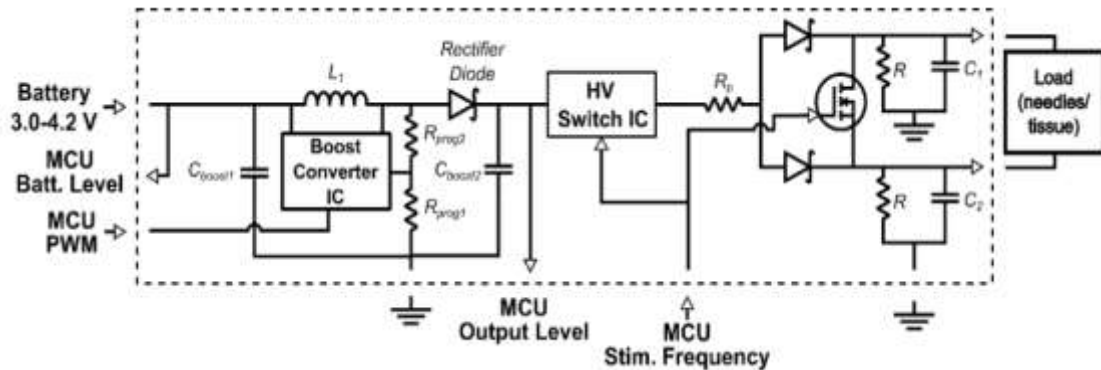


Figure 3. Boost converter, high voltage switch and pulse output circuit of the stimulator

The output voltage must be at least 3 V at a 1 kΩ load and the duration must be 500 ms. The stimulation frequency should be adjustable within a certain range, and the most commonly used frequency range is between 2 Hz and 100 Hz.

#### 4. DESIGNED ELECTROACUPUNCTURE STIMULATOR SYSTEM

The designed Electroacupuncture Stimulator system is microcontroller-based and software designed. Usually connected to the microcontroller, the input-output module consists of a two-component digital-to-analog converter (DAC) module, an LCD display module, a timer, and an amplifier block.

The microcontroller module is the main component that controls the frequency and voltage values of the main circuit of the system, selects the type of signal sent to the output, measures the frequency and voltage value, and performs all operations related to the timer module.

In addition to these basic features, there are Flash program memory up to 8Kx14 words, 368x8 byte data memory (RAM) and 256x8 byte EEPROM data memory, 14 internal/external cuts, 8 degree feed stack, Watchdog timer operation with RC generator for reliability, power saving sleep mode. Also in the initial scale there are 8-bit timer/counter Timer0 and 16-bit timer/counter Timer1; periodic register, 8-bit timer / counter with initial scale and final scale; 10-bit multi-channel ADC; synchronous serial port; There are also a number of additional features such as PWM modules.

#### 5. CONCLUSIONS

The main objective of this project is to develop a electroacupuncture device with microcontroller based application in accordance with engineering standards, and consideration of trade-offs based on economic, functionality, and manufacturability constraints.

An electroacupuncture stimulator designed to stimulate and treat the functions of the body, it is designed with a wide range of capabilities. The stimulator is based on the 16F877

microcontroller. The device has a frequency range of 2 - 10 Hz. Initially, the device will be used for stimulation in the primitive state. The next step will be to regulate the energy flow on the meridians that affect the human bioenergetic system.

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