A LOW COST INTERFERENTIAL CURRENT STIMULATOR FOR PHYSICAL THERAPY

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ABSTRACT

Modern physical electrotherapy requires of costly electronic medical equipment, most of them being out of budget for hospitals or therapy centers located in small or poor communities. This paper presents a low cost muscular electrical stimulator based on the principle of interferential currents. The device not only produces the required electrical currents that will pass through the affected area of the patient, but also features three programmable therapeutic modes, including automatic output current's amplitude and frequency scan. The proposed device is based on low cost electronic parts and an 8-bit microcontroller.

1. INTRODUCTION

Nowadays, electrical muscle stimulators are commonly used instruments in physical therapy, due to the fact that this kind of equipment has proven as highly effective. Nevertheless, as other common medical equipment, high precision and versatile stimulators are very expensive, so these devices are not commonly found in the more modest hospitals of our country. The consequences are that many needed people do not get the proper treatment for their disabilities. As an example, in Yucatan State (Mexico), only a few medical centers have the capability to offer electrical stimulation as part of their therapies, mainly due to the cost of the certified professional equipment. Trying to response to this problem, this paper presents a first approximation of the design of electrical stimulation equipment that, in spite of its low cost, could count with the characteristics of a professional instrument, according to the needs of the local geographical region. First, a brief explanation of the type of current signal is given in section 2. Section 3 explains the electronic device designed to create a pre-modulated current signal for physical therapy and its characteristics. Finally, conclusions of the work are given.

2. INTERFERENTIAL CURRENT STIMULATION

An electrical muscle stimulator (EMS) is a current signal generator that applies electrical stimulus to living creatures. The electrical signals of these generators can vary on its waveform pattern (sinusoidal, rectangular or triangular) and its frequency.

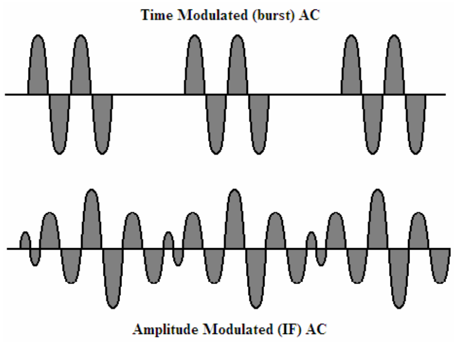

Figure 1. Common modulated AC waveforms in physical therapy.

The commonly applied frequencies ranges are from 0 or DC to 1 kHz (low frequency) and from 1 to 10 kHz (medium frequency). Also, most applications of electric current for therapeutic purposes use modulated forms of AC [1]. As seen in Figure 1, thee most common types are the time-modulated (burst) and amplitude-modulated (also called interferential current) signals. Interferential currents (IF) are commonly produced by applying two medium frequency (≈ 4 kHz) signals with four electrodes set in a crossed pattern. The combination of the two signals results in a low frequency therapeutic current [2]. The use of only two electrodes is possible applying an electronically pre-modulated signal to the skin tissue, with no practical physiological difference [3].

As the skin impedance is inversely proportional to the frequency of the stimulation, IF signals have less itching or pain effects caused by the electrical flux. This is due to the application of relative high frequency currents, with the strong physiological effects of a resulting low frequency one [2] [3].

3. STIMULATOR DEVICE DESCRIPTION

3.1 IF generator circuit

Figure 2 shows a block diagram illustrating the operation of the designed EMS. For this device, a 4 kHz frequency sine wave was chosen for the carrier frequency (CF). To create a sinusoidal wave, a common Wien Bridge oscillator [4] is used at the CF value. This is the fixed sine wave generator of Figure 2. Another oscillator, driven by a digital potentiometer is used as the modulator

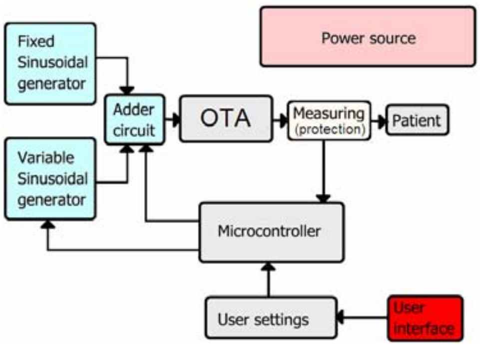

Figure 2. IFC generator block diagram

frequency (MF) generator. The use of a digital potentiometer let the microncontroller to be capable of variyng the oscillation frequency from 4 to 4.2 kHz. To obtain amplitude modulated frequency (AMF), both carrier and modulator signals are introduced into an adder circuit driven by a digital potentiometer capable to adjust gain values, obtaining an AMF from 0 to 200 Hz. After this process, the AMF is introduced into a voltage to current converter [4] calibrated so that the circuit can adjust the output current from 1 to 45 mA.

The digital control of the EMS is based on a PIC16F877 MICROCHIP® microcontroller due to its low cost and acceptable performance. Both the variable sine wave generator and adder circuits are digital controlled. The microcontroller is connected to high resolution digital potentiometers which establish the output frequency of the signal. Another function of the microcontroller is to protect the patient, cutting the output current when the measurement system detects that the output is reaching dangerous levels for the patient. A stop signal is generated by the measurement system and is instantaneously sent to the microcontroller to interrupt and cut the operation of the system as fast as possible. The maximum current that the system is supposed to apply to the patient is 45 mA. Patient is also protected with a high speed acting fuse at 50 mA in series with the output. The user interface consists in a LCD and mode selection buttons. The user introduces the data through a simple menu; the initial screen displays the three different operating modes which are described next.

3.1 Device operating modes

The device has three operating modes, providing flexibility in the physical therapy, with variations in the amplitude, frequency and duration of the applied signals. The three modes are: (1) *Fixed Frequency and Current Mode* - The user choose manually and set the current frequency (between 10 Hz and 200 Hz) and magnitude. Then the user can set the time of application. (2) *Fixed Frequency and Current Scan Mode* - In this mode the output will oscillate between the allowed minimum and maximum amplitude (1 mA – 45 mA) at a fixed frequency. The user can chose the time duration between the minimum and maximum amplitude. (3) *Fixed Current and Frequency Scan Mode* - The user sets the current amplitude and the range of frequencies (from 1 to 200 Hz) in which the signal will vary through. The user also sets the time period between these frequencies, so the current amplitude does not vary while the frequency does. With these modes, the EMS can be applied to different kind of therapies, depending of the problem indication and the recommended technique [1]. A sample of the output waveform is shown in Figure 3, while Table 1 summarizes the characteristics of the circuit.

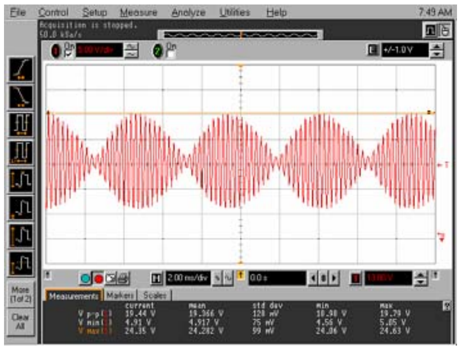

Figure 3. Output waveform of IF EMS

Table 1. System specifications

Parameter	Value
Power source	120 V (rms) / 60 Hz
Output waveform	Sinusoidal
Output Frequency	4 kHz
IFC frequency range	0 – 200 Hz
IFC range	1 – 45 mA

4. CONCLUSIONS

In this paper, a fully functional electronic interferential current EMS is presented. This device is a first approximation to reach medical equipment fully compliant with legal regulations. Nevertheless, the main feature of this circuit is its relative low cost, compared with the standard commercial equipment, resulting in an attractive alternative to hospitals limited in their budget, as is the case in many latin-american countries.

5. REFERENCES

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