PERONEAL STIMULATOR WITH WIRELESS VOLUNTARY CONTROL

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Abstract: Microprocessor based, surface electrodes peroneal nerve stimulator that allows voluntary control of the stimulation has been developed. Easiness of use, minimum required maintenance and the compliance with the EC requirements were the main design goals. Radio frequency link between the crutch mounted push-button and the stimulator enables the patient to control the timing of stimulation. The use of conventional foot-switch is also possible for those patients, who are walking without crutches. Cyclic stimulation is provided for training and muscle restrengthening. To accommodate the device to individual needs, the stimulator offers seven adjustable stimulation parameters. The stimulator is small, lightweight, battery operated, energy efficient and can be worn below the knee, discretely beneath most clothing.

Key words: FES, electrical stimulator, peroneal stimulator, wireless control

INTRODUCTION

Peroneal stimulator can be used to improve the gait of the patients who suffered a stroke or spinal cord injury. The stimulation needs to be synchronized with the swing phase of the affected leg. Foot-switch located under the heel of the affected leg is traditionally used to trigger the stimulator. However, there is a group of patients, who cannot use the foot-switch, due to ankle contractures, ankle plantar flexion tone or other reasons.
Hand-switch, on the other hand, is a switch built into the handle of the crutch. It is commonly used in FES systems and can be used also for triggering the peroneal stimulator. Wire connection between the switch and the stimulator is very prone to breakage, cumbersome, as well as unaesthetic. Therefore, a wireless link to the stimulator is reasonable.

THE STIMULATOR DESIGN

This peroneal stimulator features three modes of operation depending on the trigger source. Crutch mounted hand-switch allows voluntary control over the timing of the stimulation via wireless connection to the stimulator. The use of conventional foot-switch is also possible. Cyclic stimulation is provided for training and muscle restrengthening. The stimulator offers seven adjustable stimulation parameters, which can be set on-line by a clinician via personal computer or external module. The stimulator use is simple. Single panel potentiometer is used to turn the stimulator on and to adjust the intensity of the stimulation. A miniature push-button is provided for changing the mode of operation.

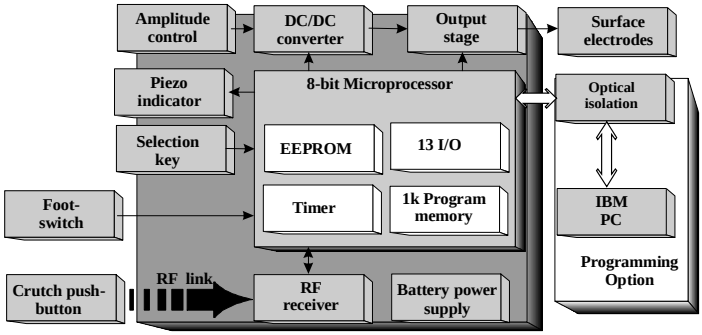

Fig. 1. Simplified block diagram of the stimulator.

Simplified block diagram of the stimulator is shown in Fig. 1. Two low-cost, lightweight, rechargeable standard AA sized Nickel Metal Hydride cells provide the power supply with the nominal voltage of 2.4 V and have sufficient capacity up to 1500 mAh.
Special attention was paid to the design of DC/DC converter, which mostly determines the overall efficiency of the device. A modified push-pull step up switching converter topology was adopted as the optimal solution in various aspects. To increase the efficiency of the converter over the entire output voltage range and minimize transient noise, a closed loop output voltage control is employed by limiting the input current to the converter. The converter was also designed for periodical switching off during the stance phase, which significantly extends the battery life. The circuit is a constant voltage generator providing biphasic output pulses of maximum amplitude of 135 V.
The telemetry system that provides reliable and interference resistant wireless control of FES has been developed previously [1]. Patient's body is used as a part of a transmitting antenna. The operating range of the system is in general limited to the patient's body, thus, in principle, no channel separation is needed. For safety reasons frequency separation and code protection is employed.

RESULTS

The prototype has been built in SMT technology (size of the housing is 85 X 45 X 22 mm) and it works according to the stated specifications. The battery-discharging period has been tested with the 50% duty cycle operation, maximum output voltage and 1kohm resistive dummy load (Frequency 25 Hz, Pulse width 250us). Under these conditions, the device is operational up to 20 hours. The maximum efficiency of the device is up to 40 %.

DISCUSSION

The new design of voluntary controlled peroneal stimulator presents another effort to achieve the performance and reliability needed to make the FES system a friendly orthotic aid. This stimulator could be used during daily activities continuously for several hours a day. Telemetry control allows trained user optimal timing of the stimulation. An important aspect is also the improved appearance, since the stimulator can be worn discretely beneath most clothing, without visible wiring.

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