REAL-TIME CONTROL OF THE EMBEDDED WAVEFORM FOR EXTERNAL DEFIBRILLATION

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Abstract-**The paper presents a method and apparatus for shaping the electrical waveform delivered by an external defibrillator based on an electrical parameter measured during delivery of the waveform. Software and hardware co-design allow embedding anyone waveform and realizing it independently from transthoracic electrical impedance changes during shock time.**

Keywords - **External defibrillation, real-time control**

I. INTRODUCTION

Despite years of intensive research, there is no suitable theory for mechanism of defibrillation that explains all the phenomena observed [1]. Moreover, there is no physiological theory that explains the mechanism of action of the bi-directional wave, nor does any theory predict the optimum amplitude and time dimensions for the second inverted wave [2].

Three key factors: (a) excitation propagation velocity, (b) refractory period, and (c) excitation path length – are sustained fibrillation. Propagation velocity is an inherent, temperature-dependent property of cardiac tissue. The refractory period can be prolonged by a strong cathodal shock applied to excited cells. An anodal shock reduces cell excitability. The excitation path length pertains to the size of the fibrillating myocardium, and both anodal and cathodal shocks can alter the path length [2].

On the one hand, an external defibrillator design is based on experimental data for optimum current waveform: strength-duration curve, delivered energy and charge, etc., and the variety of these data is obtained without taking into account transthoracic electrical impedance changes during shock time.

On the other hand, there are methods and apparatuses, which allow measuring patient electrical parameters and continual waveform shape reforming for transchest resistance dynamics. For example, it is some recent technical decisions [3-5].

The question of what current waveform should be selected as optimum, which independent from transchest resistance dynamics needs further elucidation. Two opportunities: forming anyone waveform, and providing this one independently from tranchest resistance dynamics – are needed for experiments.

The paper presents a method and apparatus for shaping the electrical waveform delivered by an external defibrillator based on an electrical parameter measured during delivery of the waveform. Software and hardware co-design allow embedding anyone waveform and realizing it independent from transthoracic electrical impedance changes during shock time.

Additional such possibilities may be useful for development a new electrotherapy methods, as electrochemotherapy for cancer treatment [6].

II. METHODOLOGY

The both method and apparatus are based on developed high voltage delivery unit [7]. Fig.1 is an illustration of it.

The power cell block (PCB) delivers of high voltage to the patient through low pass filter. PCB consists of energy storage capacitors and insulated-gate bipolar transistors under pulse-width modulation (no more than 50 kHz) with low-stress switching for efficiency [8].

Voltage sensor is measuring PCB voltage output and current sensor is measuring PCB current output. This data transfer to input of the PCB control circuit through scaling

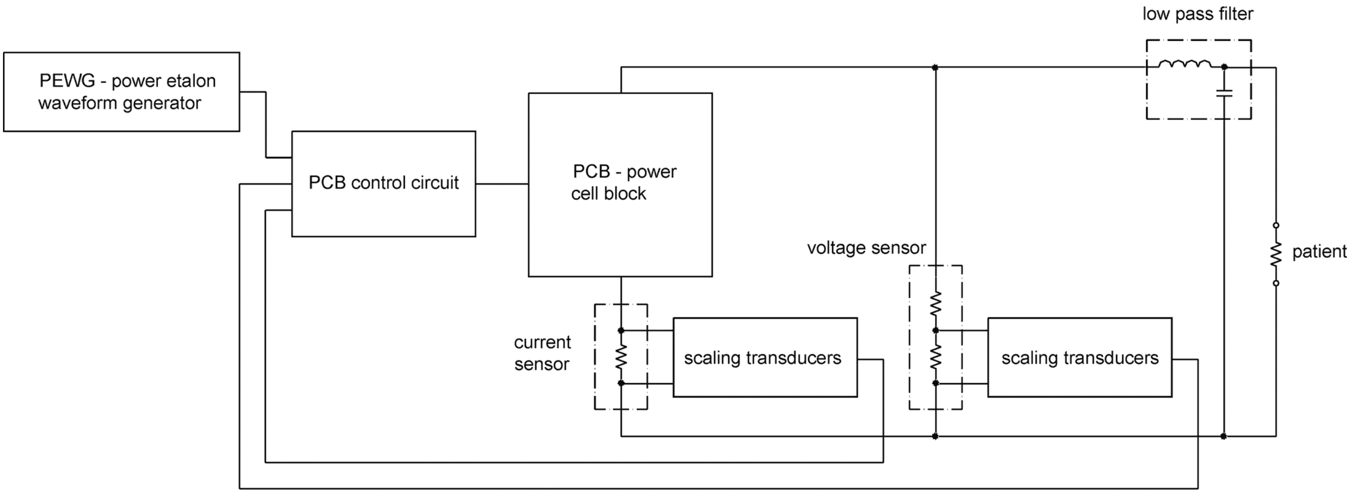

Fig.1. High voltage delivery unit.

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transducers. The value of scaling transducers depends upon the setting defibrillation energy.

The setting power waveform stores into power etalon waveform generator (PEWG). This etalon may be anyone. Its power waveform is embedded by software technology. Besides the integral from power waveform etalon on shock time is setting defibrillation energy.

The PCB control circuit is real-time driving the process of high voltage delivery using real-time comparison of PEWG output and scaling transducers output, that is control feedback.

The high voltage delivery unit was simulated by PSpice. Than it was realized by printed-circuit board technology.

III. Results

Fig.2-5 are illustrations of simulation results for high voltage delivery to patient. The simulation model includes the skin breakdown with 100V threshold. It is example of asymmetric biphasic waveform etalon, which now is optimum for external defibrillation [2]. The both duration the first and second phases are 4 ms at the half-level amplitude maximum of each phase. The amplitude of second (inverted) phase is half of first phase, and pulse tilt is 30 %.

Fig.2-4 illustrate the voltage-time curves for 200 J delivered energy and 150, 50, 25 Ω load resistance, and Fig.5 illustrates that for 5 J, 25 Ω. The skin breakdown peak is seen in Fig.5. This simulation results correspond to the worst combination for electrical parameters of the circuit components.

The experimental results are presented in Fig.6.

IV. Conclusion

There are both a method and apparatus for shaping the electrical waveform delivered by an external defibrillator based on the PCB output measured and control feedback. Software and hardware co-design allow embedding anyone waveform and realizing it independently from transthoracic electrical impedance changes during shock time.

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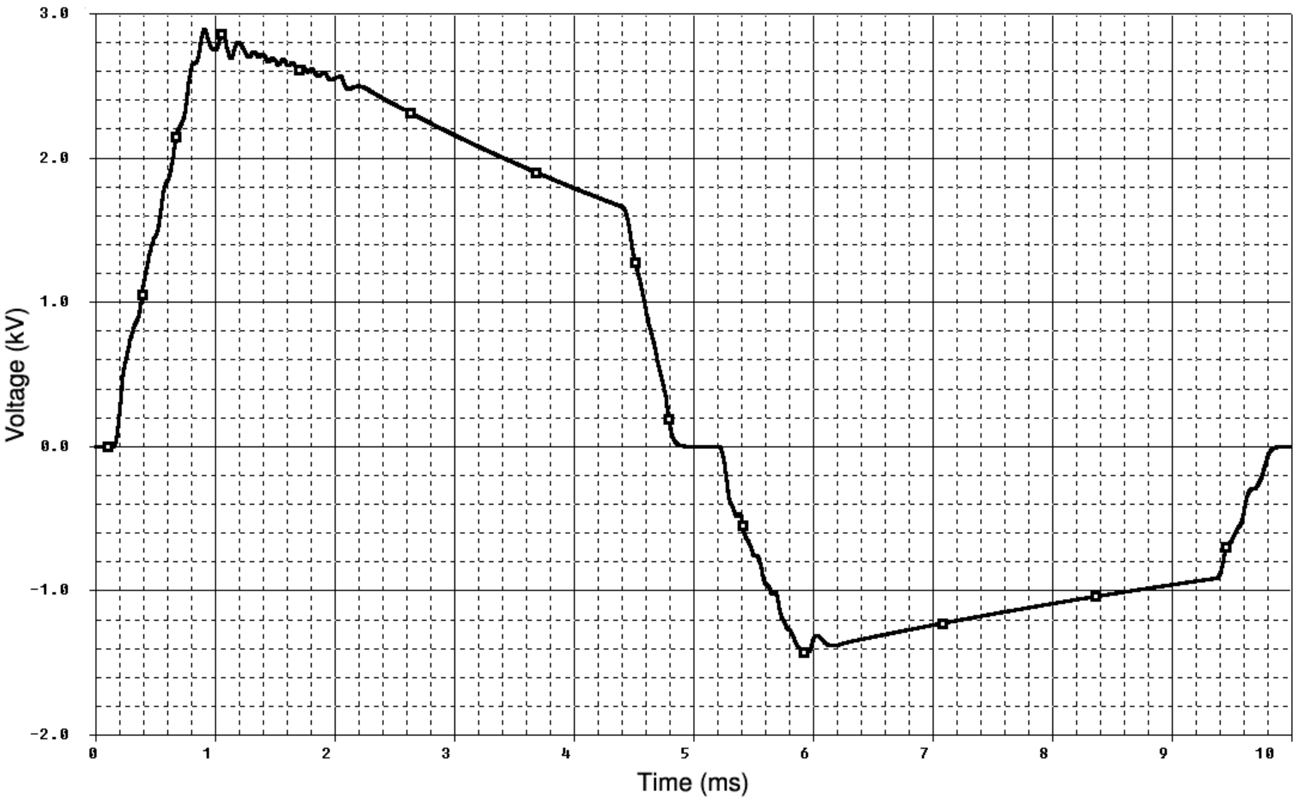

Fig.2. Voltage-time curve for 200 J delivered energy and 150 Ω load resistance.

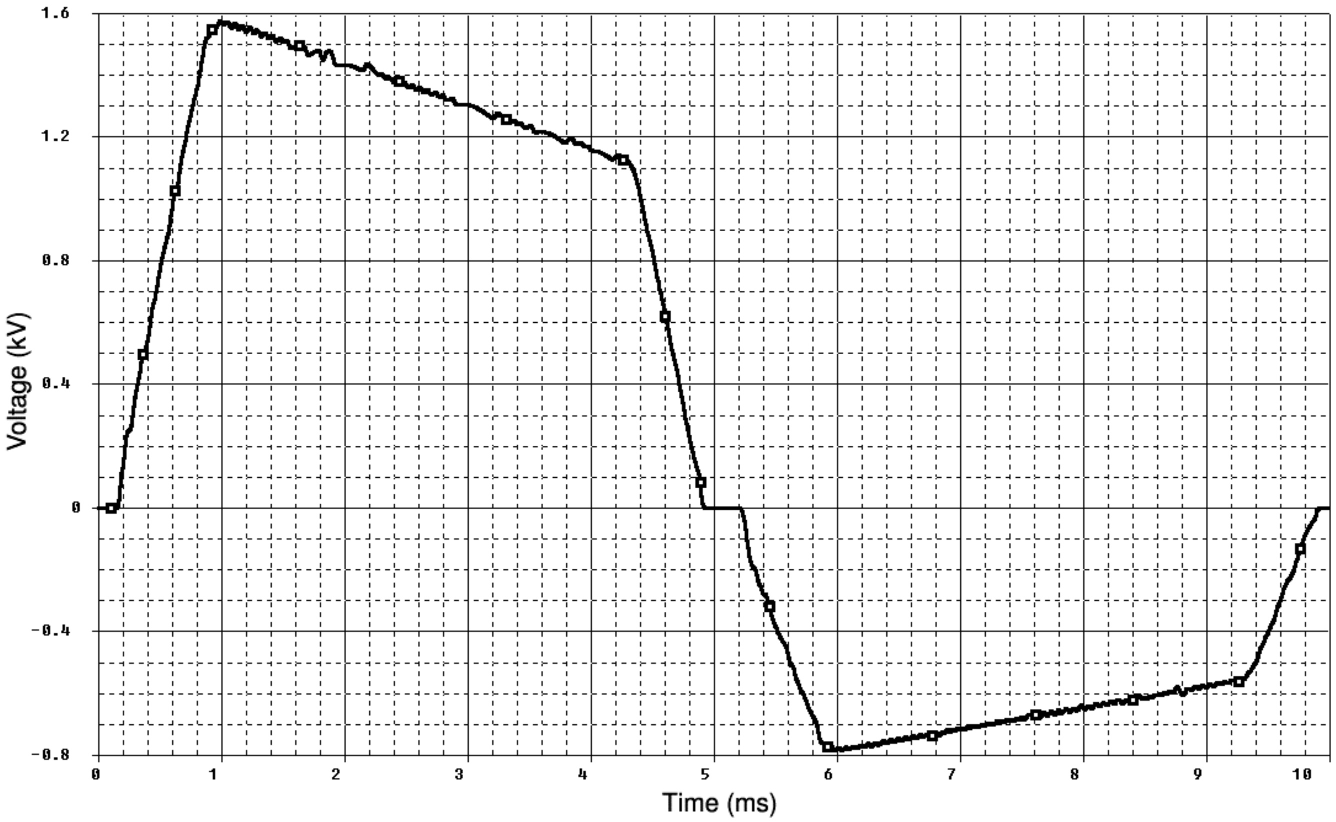

Fig.3. Voltage-time curve for 200 J delivered energy and 50 Ω load resistance.

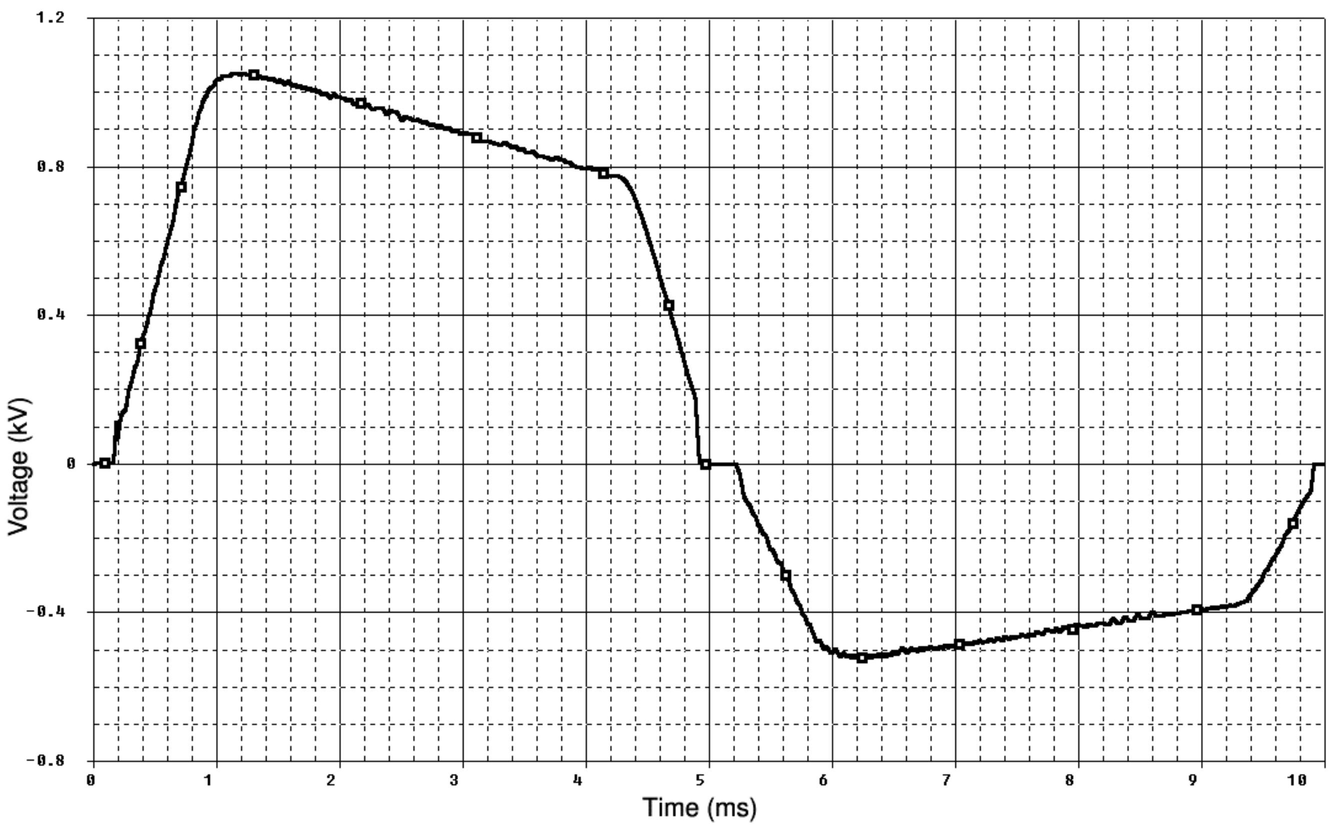

Fig.4. Voltage-time curve for 200 J delivered energy and 25 Ω load resistance.

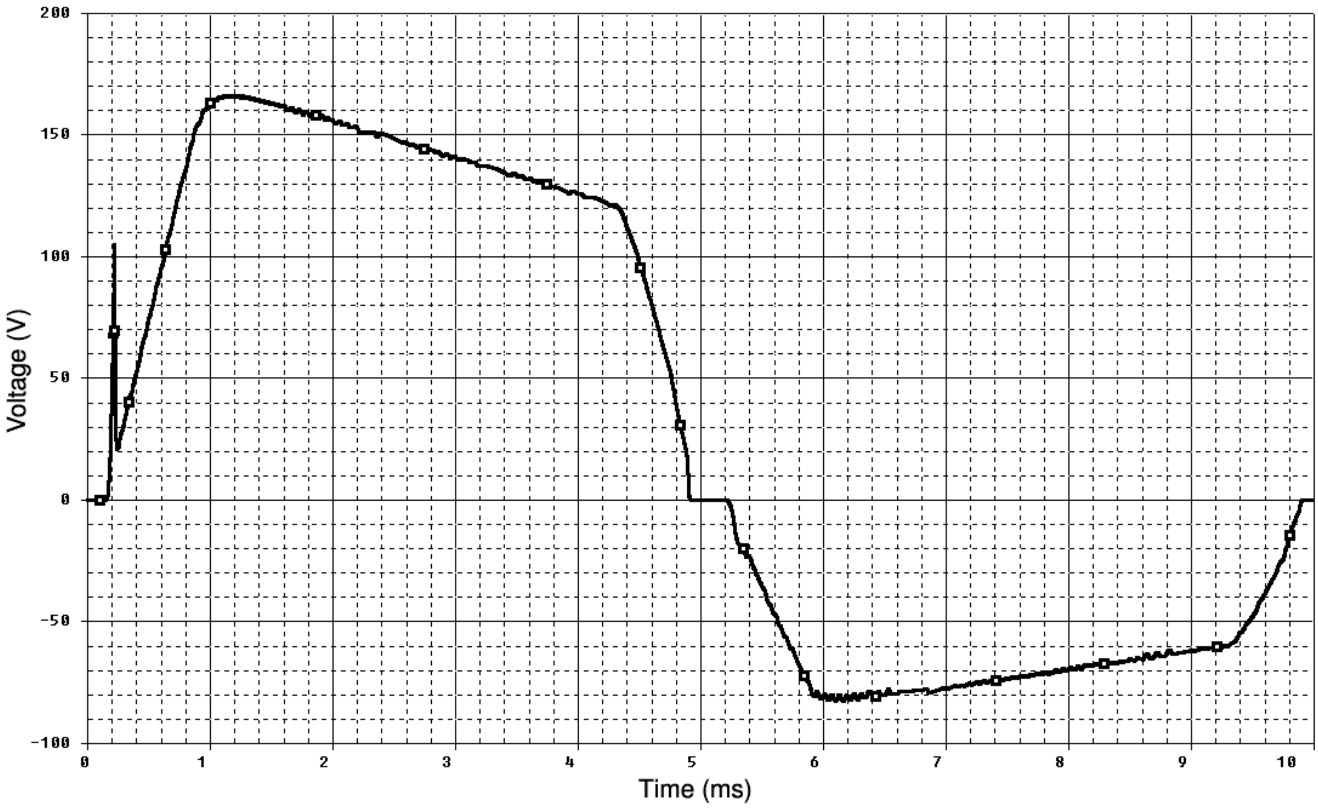

Fig.5. Voltage-time curve for 5 J delivered energy and 25 Ω load resistance.

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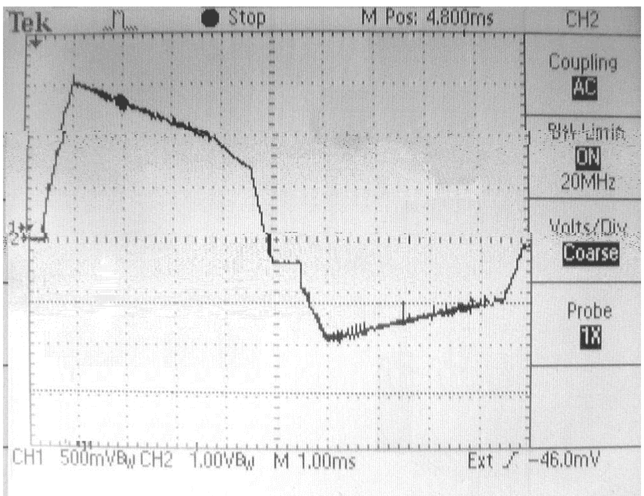

Fig.6. Experimental voltage-time curve for 200 J delivered energy and 150 Ω load resistance.