Measurement of low energy pulses generated by stun gun

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Abstract

This article presents a reflection on the current stun guns research performed by various institutions around the world. On their basis, presented important parameters of the describing stun gun and inaccuracies associated for their accurate interpretation. The end result are research that will help provide reliable scientific information on the quality of pulses generated by stun guns, the accuracy of determining the electrical parameters, how to carry out the measurements, the impact of various external influences which may distort the measurements and results the electrical properties of the device. Based on preliminary studies described the manner of their implementation. It is new concept to approach this type of measurements and the possibility verify the quality and accuracy of test stun guns.

1. Basics

For the electrical properties, stun gun can be defined as a device generating low-voltage pulses - Conducted Energy Device (CED). Generated pulses are characterized by a specific type of low-intensity current, the voltage can reach more than 50kV. The waveforms are time-variant and have a high content of higher harmonics, with very steep slopes of the pulse. From the viewpoint of application, stun gun is defined as Conducted Energy Weapon (CEW) designed to incapacitate a person without causing damage to the body. Voltage pulses generated, influence on the nervous system of the body by applying control signals to the body, causing spasms, muscle relaxation and muscle pain. Often there are also cases that stun gun is also used to disturb or damage to other electrical device or some of their components such as memory chips.

Stun guns can be divided into two types. The first is the Taser, the patented invention and produced by one manufacturer, often used by the departments of public safety. Using compressed air, it shoots electrodes in the direction target, which are connected to high voltage generator by means of thin wires. These devices give rise to a lot of controversy, which are due to many negative consequences of their use. There are many publications and even more conflicting opinions about safety and their impact on the human body. The second type of stun gun is manual, generally available device which can be bought without a permit. There are a lot of types, models, designs and these produced by many manufacturers. The electrical specifications are inconclusive and often incorrect. In both cases, it's device for which have not yet been fully effective method of measuring their electrical parameters.

2. Electrical Parameters of the stun gun

Thinking about the parameters of electric stun guns at some point, you can ask yourself when and under what conditions the device can generate dangerous impulses threatening the organism. Effect of electrical charge on humans has been described in many publications, and all research for effects on the human body, are based mainly on simulations, simulated signals or by using a several stun guns. The second issue is opinion and verification of correct operation device and maintenance of tolerance in a given field of electrical properties in accordance with accepted safety standards. Therefore it is necessary to define the areas of test, to correctly interpret the electrical parameters characterizing the device, generated pulses and measurement methods that would allow to run tests in a correct and reproducible manner.

In the publications [1] [2] [3], accurately are characterized waveforms, generated by stun guns. In additional., are described electric parameters and their correct interpretation. The main parameter describing the quality of the generated pulses is the total value of the average current. According to the accepted norms, it should not exceed 10 mA, which is also the limit of safety for the human body and the legal limit defining the free opportunity to purchase the device and can also decide whether the device may be construed as a weapon. The most stun guns

in the specification of this parameter is not given precisely, while the information is given that the average value does not exceeds permissible limit threshold. But already changing the power source for batteries with higher charge, could make the average current value above the acceptable range.

The second important parameter is the frequency of the generated pulses. Its value is often not given, but as it turns out, is of particular importance. Waveforms of a stun gun are typically generated with a frequency of about 20 Hz, reaching into the body overlap on nerve impulses which leads to take direct control of skeletal muscle. Many organs in the human body have theirs natural frequency of a few or several hertz. In addition, very important parameter of stun guns is the ability to maintain the stability of the generated pulses, the constant frequency value in order to reduce the probability that there is no resonance with any internal organ of the body.

Another important parameter is the maximum value of output voltage electrodes. Most stun guns have two pair electrodes. The outer pair is used to transmit pulses to the load, and the internal pair serves as a safeguard against over limit the maximum voltage that may occur in the output at high loads. These voltage is in range from 50 kV to 900 kV. With such high voltages the current does not flow practically, and the same voltage has intended to guarantee high efficiency operate to get through a large resistance. But what happens exactly when stun gun is operate, this is a matter of discussion. External electrodes and load closed circuit and causes a current to flow through the body. Generated level of voltage depend than existing load on the output.

Pulses also carries charge which is the energy cannot be over than acceptable 300 mJ. In addition, there is a large group of electrical parameters, which can be used to assess the quality and accuracy of work stun gun. These include example :

- the time between pulses,
- current average value of a single pulse,
- maximal peak current at a given load,
- maximal peak voltage at a given load,
- total duration of the pulse,
- total charge transferred to the load,
- total power transferred to the load.

The above considerations leave many unanswered questions yet. Therefore, the further research will include the solution of measuring method evaluation of stun guns.

3. The measurement methods

Precise measurement methods will determine when and under what conditions the device is only an electric toy and when it can become a dangerous weapon. However accurate definition the electrical parameters of stun gun, will better their interpretation in the field of biomedical research, but also will be a good indicator of reliability assessment.

Currently used methods of measuring waveforms with stun gun are based on the measurement technique known for high voltage. Pulses of voltages and currents are recorded using high-voltage probes, using oscilloscopes with high sampling frequency, separately. Generally, there are two methods for measuring: the open circuit (without load on the output) and the closed circuit (with load on the output). For large output voltages above 50 kV, their value is calculated using the method of spark gaps. By adding the output resistance of the electrodes simulate resistance of man. The Output waveforms are recorded as both voltages and currents. Collected samples are the basis for the calculation of individual parameters. Measurement approach is not correct. Due to the nature of the waveforms stun gun (high voltage pulses but with a very low amperage) techniques known for the high voltages where the currents measured signals are large, cannot always give correct results for the described type device. The values of current recorded are the order of milliamps and any influence of external factors may be important for final results. Therefore, it is very important to define the factors, influencing effect of measurements. However, it is impossible to do this without adequate research. Figure 1 illustrates a block diagram of the measuring system allowing both to carry out accurate measurements as well to calculate and to eliminate the influence of different factors on the results obtained.

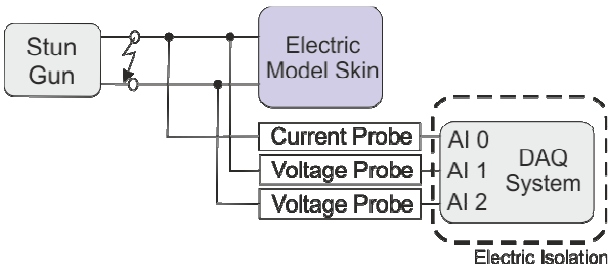

Fig.1. Block diagram for close circuit measurement

First, it is very important to use no inductive reactance to simulating the resistance of the organism. Human resistance varies depending on the damp or temperature, therefore the need for measurement was carried out for many values of resistance example in the range of 20 0Ω to several kΩ. Resistance alone does not accurately reflects human model. Therefore it can be replaced in the electrical characteristics of skin model.

It is necessary to apply good voltage and current probes, available on the market, which give distortion-free signal to the recording device. Voltage probe must have a measuring range up to

minimum 50 kV. To register waveforms as closely as possible with full information about the quality of generated voltage or current. The use of oscilloscope, unfortunately is not enough. Often the impulses generated during the use of stun gun last longer than one second. It needs a data acquisition system that allows for continuous recording and the disk, can store the samples at a frequency of at least 1 GB/s by few seconds. The proposed solution is application as data acquisition system based the PXI platform National Instruments and high-speed module analog input with up to 1 GS/s sampling and 16-bit resolution. Stored samples can be processed by means of simple algorithms to calculate electrical parameters and statistical analysis.

The measuring system gives possibility thorough analysis of the signal and verifies algorithms which were developed to accurate determination electrical parameters of device. Measurements for changes in a wide range of resistance will allow the calculation of load characteristics as a function of voltage or current and defining the efficiency of stun gun test.

4. Measuring pattern

Stun gun can be compared to a black box, which generates unknown parameters of pulses. Therefore, all measurement results obtained, cannot compare to anything. Therefore is need a model of device that will calculate influence of individual elements on the quality of the waveforms structure on the output. The actual construction of stun gun is not complicated, but the selection of appropriate parameters of the elements is no longer an easy thing.

Generally, the model of the stun gun can be divided into several functional components of the circuit design (Fig. 2). Batteries are a source of electricity, usually placed in the holder. Oscillator circuit generates pulses, which are provided to the primary winding of the transformer T1. Next pulses are processed from AC to DC voltage. Voltage multiplier is composed of rectifying diodes and high-voltage capacitor, which storage generated energy pulses. When the output capacitor voltage exceeds the threshold value, through the activation of the trigger system, it is discharged through primary winding of the transformer T2, the output voltage which is significantly elevated to the level tens of kV. Stun gun has two pairs of electrodes on the output circuit. One of them is used to close the circuit when exist contact with the object. The other serves as a test, causes an electrical arc through the air ionization. The appropriate set distance between the electrodes, ensure appropriate value impedance, thus not allowing them to cross the threshold voltage at the output.

Basing on the above described design a block diagram has been developed (Fig.**3**). The circuit generates pulses of high voltage and low current, similar to the pulses generated by the stun gun. The initial idea was to generate a reference pulses only, which used to verify the measuring method used. However, each of the functional elements may be implemented in several ways. The solution, which was established, allows check influence many parameters internal structure circuit on the obtained output waveforms. Programmable generator provides a periodic signal generation of different shapes, and frequency modulated. This waveform is amplified to a value between 200 V – 400 V. Current value of the control block is designed to simulate varying levels of battery performance.

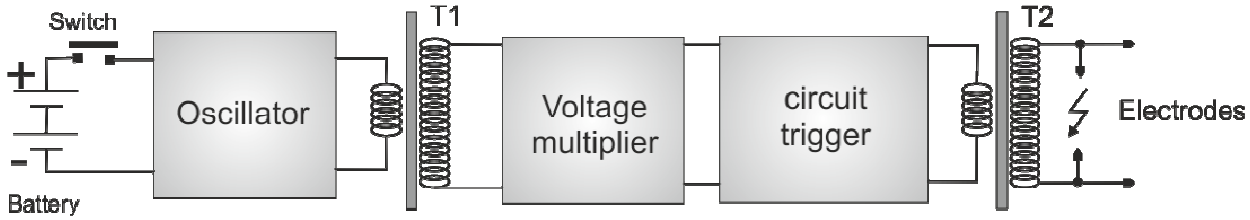

Fig.2. Functional block diagram of constructed model stun gun

Then, they are gained to the order of kVs. The first four blocks can be also replaced by high-voltage calibrator, which can be controlled with the software application. This application can define various waveforms to input of analog card. The calibrator amplifies signal to value specified by voltage range. Trigger pulses can be implemented using simple analog components such as thyristor, diak and capacitor. Different value capacities allows generated different charge of pulses on the output. The most important element is the high voltage transformer which amplifies the pulses to generate high voltages.

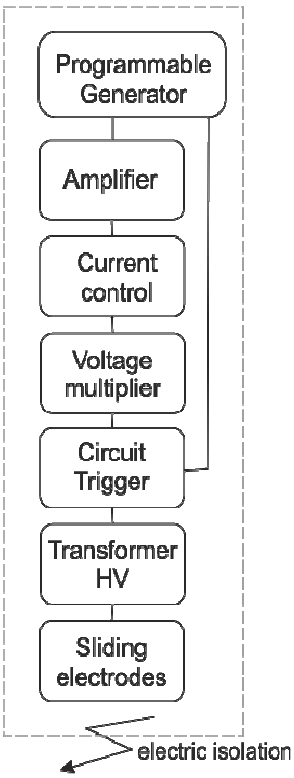

Fig.3. Block diagram for pattern model to generated high voltage pulses

Examination of stun gun characteristics and properties will be essential before performing tests. Using several different transformers it will be possible to influence of this component. The final element of the standard generator are pairs of electrodes with adjustable distance. It will enable the testing of different electrode spacing on the resulting discharge. The whole system should be properly electrically isolated. On the basis of this circuit it is possible to carry out many measurements, which in combination with the method of Figure 2, will provide impressive package of results to calculate different variables that may shape the quality of the test pulse generation device. Figure 4 presents example waveform obtained from the current course of the first version of the measuring system..

5. Results

Some stun guns commercially available may have a significant parameter deviation from the values defined by the manufacturer. Electrical parameters of individual stun gun are subject to relatively large tolerance. They have an impact on the various structural elements measuring method and also used during the tests. All research carried out in the world in the field checking and testing the stun guns have been published so far are not entirely reliable.

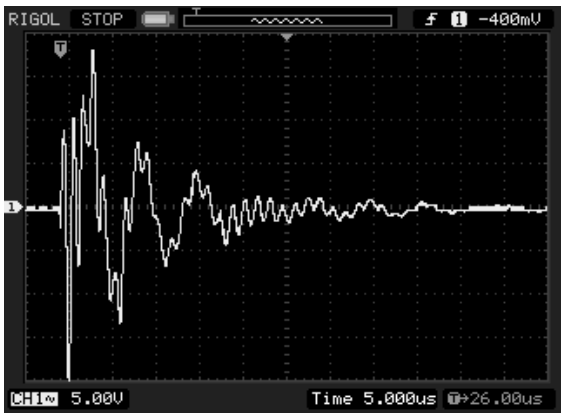

Fig.4. Example waveform on the output high voltage pulses generator

In the present embodiment, constructed circuit allows generated output waveforms, very similar to those that should generate the stun gun. Direction of further work will be to improve the accuracy of the presented concept of measuring and developing algorithms for analyzing recorded waveforms to determine the specific electrical parameters of the test a stun gun. The results which will be subjected to a confrontation with the current state of information available about stun gun, should provide interesting conclusions for further research..

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