Characterizing the Electrical Output of Stun Guns

A Presentation to the European Working Group on Less Lethal Weapons

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Abstract:

Less Lethal Weapons have traditionally been of the type (ie Tasers) that is used by law enforcement and military authorities. These Less Lethal Weapons are characterized by progressive improvements in design and high level manufacturing processes over the past 15 years. Additionally, the unit costs of these LLW's and peripheral costs, such as training, have been significant and the deployment has been principally to law enforcement and military authorities.

There is an emerging class of Less Lethal Weapons (Stun Guns) that is being sold to consumers for personal protection in several jurisdictions. This class of LLW does not have the same integrity of design, manufacturing or controlled distribution as Tasers. The electrical discharges from Stun Guns are highly variable and design and performance criteria are not readily publicly available.

Our goal was to measure and compare a representative sample of stun guns to inform the use and safety considerations of these less lethal weapons.

To describe the performance of stun guns, we examined and characterized the electrical output from 244 tests of 41 different models of stun guns from different manufacturers and distribution networks in 2016 and 2017. Results show high variability in electrical output and stability. Manufacturer's performance claims on product packaging are unrealistic and unproven in our tests. We have identified a significant consumer protection issue with these results.

Introduction:

There is an emerging class of Non Lethal Weapons (LLW) or Stun Guns that are being sold to consumers for personal protection in several jurisdictions. This class of LLW does not have the same integrity of design, manufacturing or controlled distribution as LLW used by police and military authorities. The electrical discharges from Stun Guns are highly variable and design and performance criteria are not readily publicly available. To the best of our knowledge there is no peer reviewed literature with respect to the electrical integrity or safety considerations of stun guns.

Method:

During the period from 2013 to 2016 we conducted examinations of several different models of stun guns which were in various states of operability due to use and abuse. We could not generalize on electrical outputs since each and every stun gun might vary significantly from another. There was no publicly available design, patent or technical specifications which might indicate expected performance.

In January 2016 we had an opportunity to test several models of stun guns fresh from the manufacturing line. Over the next 12 months we examined 41 different models directly from the post manufacturing distribution system. The stun guns had never been fired before we examined them. We have used letters to render the identity of the manufacturers of our 41 stun guns.

We built a simple test jig from brass and wood to focus the output of the stun gun to a 600 ohm resistor which is a median value for typical body resistance. We demonstrated data acquisition and handling to ensure integrity. We took several shots from new weapons and demonstrated how to capture the signal for a quality control specialist who had control of the stun guns.

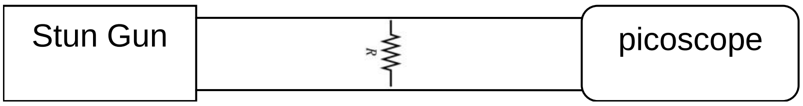

Figure 1: signal acquisition

In accordance with our Test Procedure for Conducted Energy Weapons[i], we made 3 test shots from each unit of every model into a 600 ohm load. The acquisition software was triggered to capture sufficient energy to display a consistent pulse train which was saved to file with time stamp and date. Our acquisition equipment used 12 bit quantization and a 20 MS/s sampling rate.

Electrical characteristic data was taken from one to three units of 41 different models from several different manufacturers and distributors. The data was named and saved in a standardized format for subsequent analysis. In presenting graphical data we have anonymized the model names of the stun guns we tested.

The binary data files were retrieved from the test site and stored on our secure server. The binary data files (extension *.psdata) were converted to Matlab4 files and analysed with our custom Matlab software. The Matlab analysis generated information which we presented in an html file in both tabular and graphical outputs. The table of numerical values included date, time, unit ID as well as the electrical characteristics of pulse length, pulse repetition frequency, charge per pulse, and current and a coefficient of variability. A portion of the pulse train was displayed graphically to verify consistent amplitude and pulse spacing. A single pulse was presented graphically to examine waveshape integrity, display pulse width and observe any anomalies.

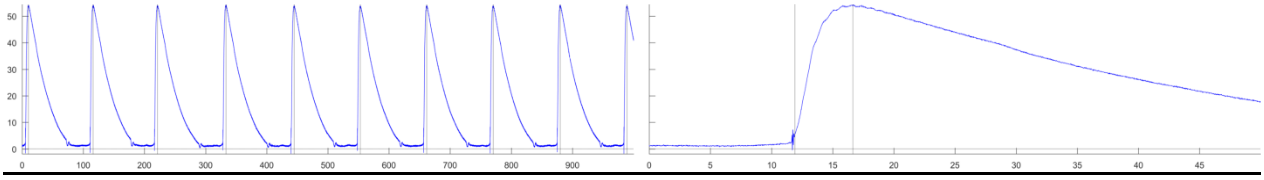

Figure 2: Model T segment of pulse train and single waveshape

Findings:

We found a concerning variability in waveshape, pulse duration, pulse repetition frequency, voltage under load (and thus current and charge). Some examples of widely varying waveshapes are illustrated in Figures 2-4.

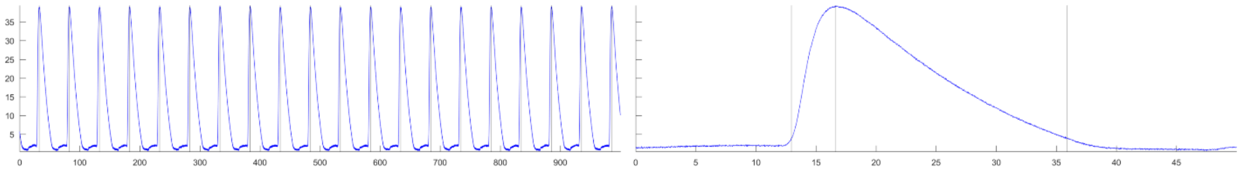

Figure 3: Model B

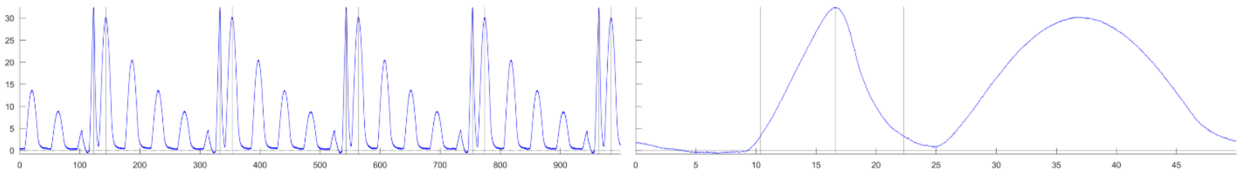

Figure 4: Model D

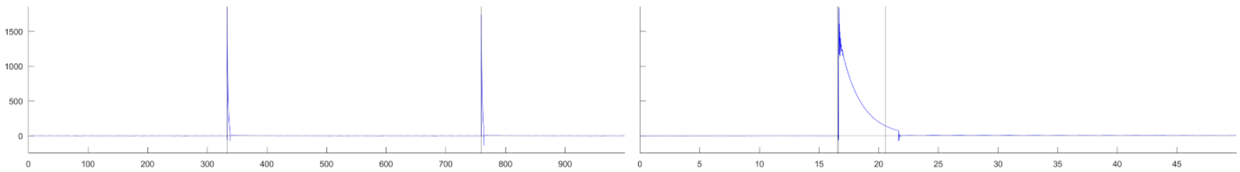

Figure 5: Model H

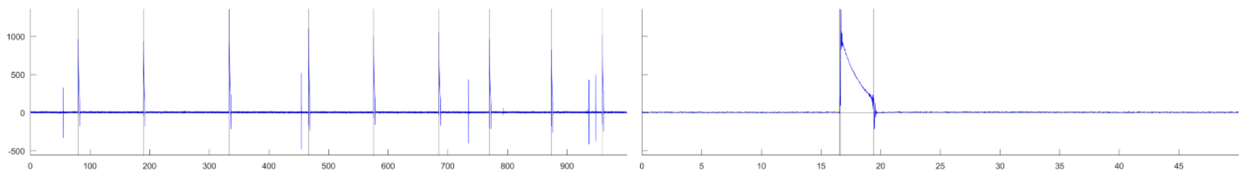

Figure 6: Model W

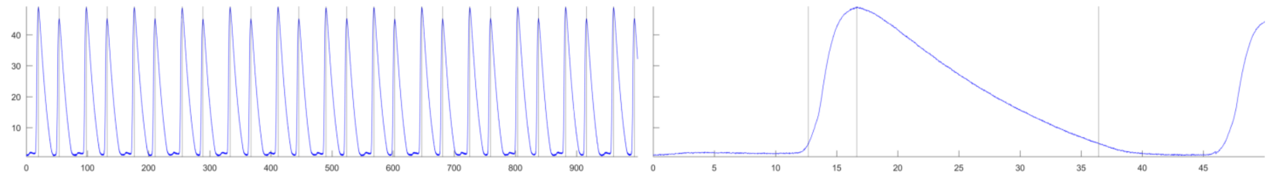

Figure 7: Model L

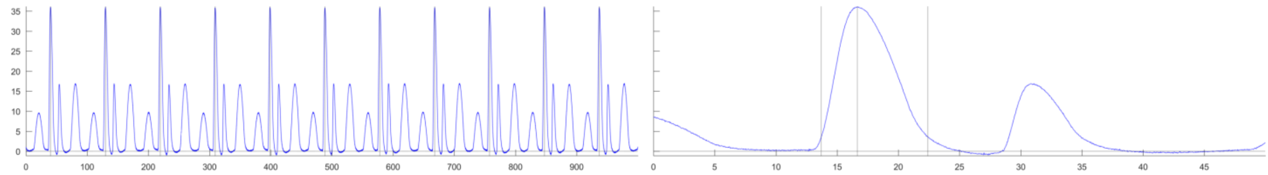

Figure 8: Model F

In comparing the electrical emission of one stun gun to another one, we focused on 4 characteristics; namely pulse time (duration in µs), pulse charge (charge per pulse in µC), pulse rate (pulse repetition frequency in kHz) and average current (in mA) over the pulse train.

Although we made observations on terminal voltage under load and wave shape integrity and we did not present these because we determined that they were less relevant to a consistent comparison between stun guns. To consider the charge delivered to the body by a stun gun, consideration must also be given to pulse rate and pulse width. For this reason, voltage by itself is not a particularly useful parameter.

In summary, we found the following minima and maxima during our tests:

Pulse time: 0.175 µs < pulse width < 36.8 µs

Pulse rate: 1.5 kHz < prf < 158.2 kHz

Charge per pulse: 0 µC < Q < 4.8 µC

Average Current: 0 mA < I < 16.9 mA

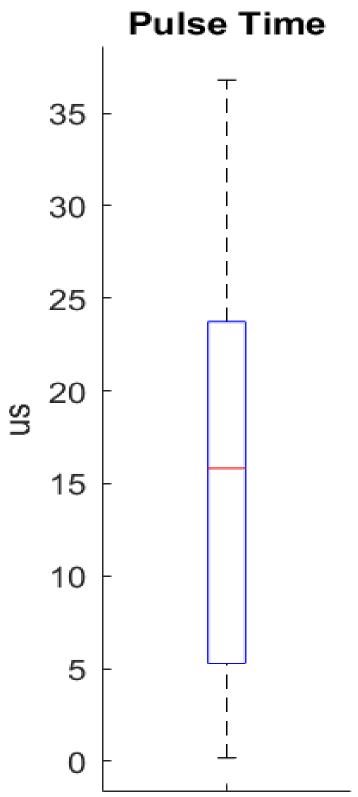

Figure 9: pulse time (duration) in us

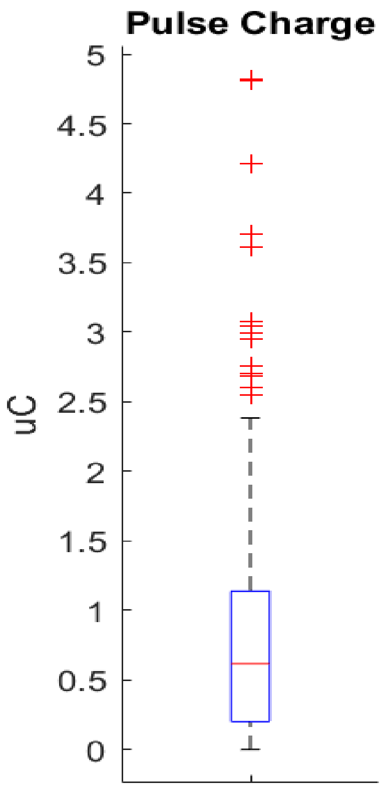

Figure 10 :pulse charge in uC

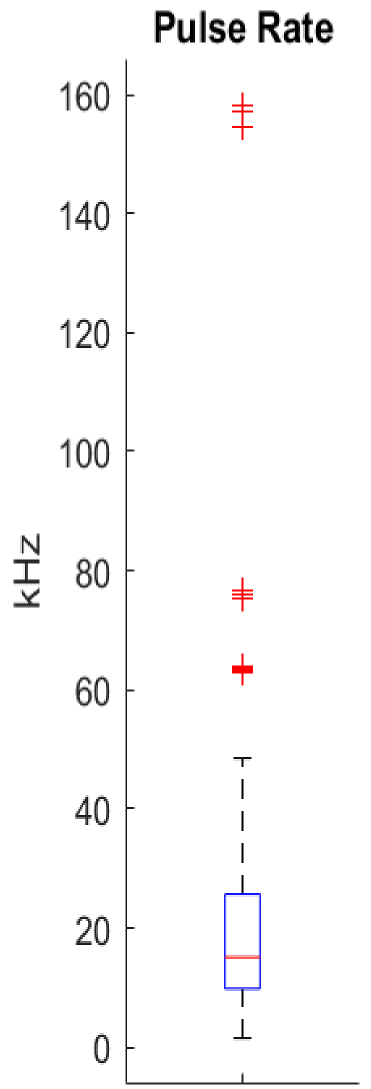

Figure 11: pulse rate in kHz

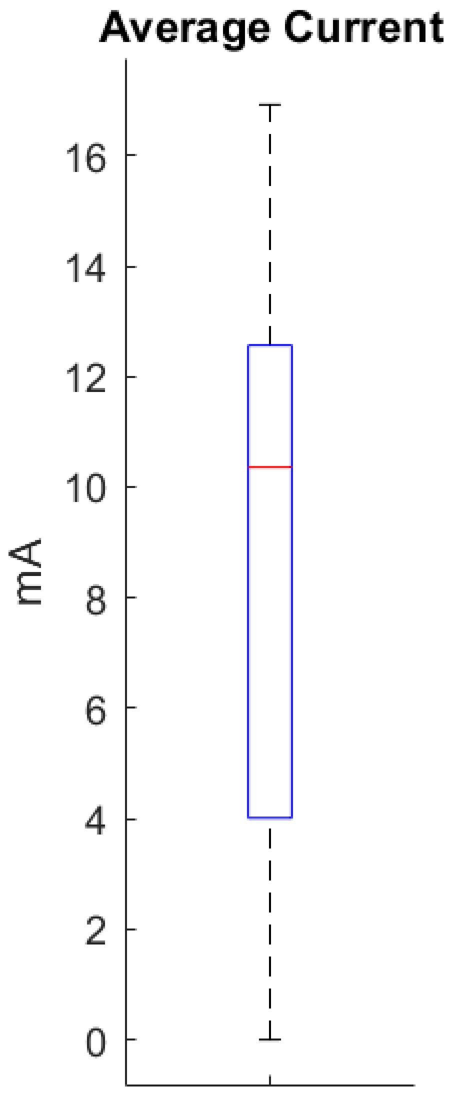

Figure 12: average current in uA

Between shots from the same model of a stun gun there were inconsistencies of amplitude and pulse repetition frequency, and thus charge delivered to the body.

Inconsistent output levels

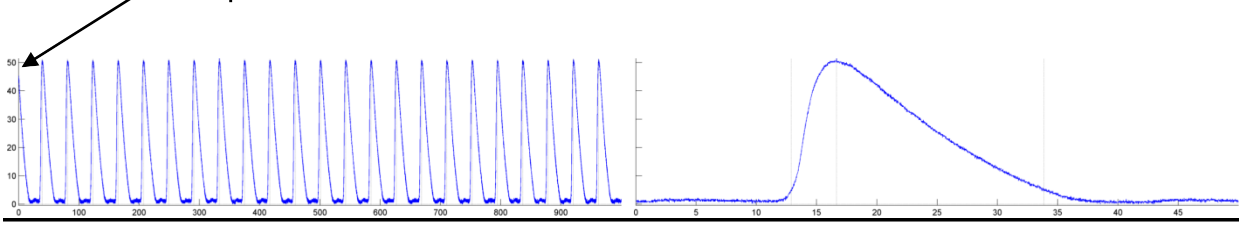

Figure 9: Model AA unit 1 test 2

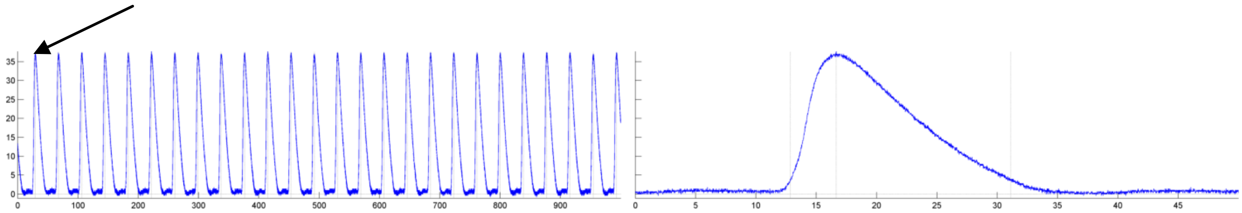

Figure 10: Model AA unit 2 test 2

Inconsistent pulse rate (frequency) and waveshape:

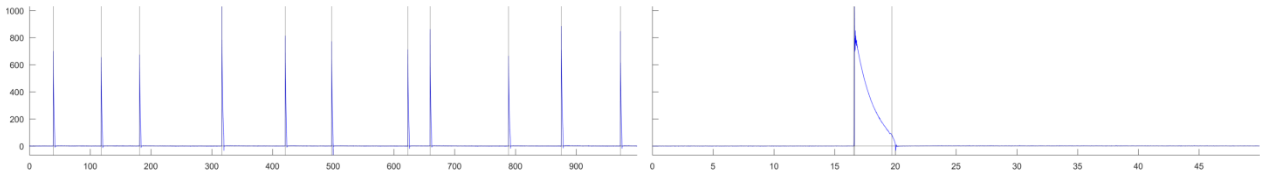

Figure 11: Model X unit 1 test 1

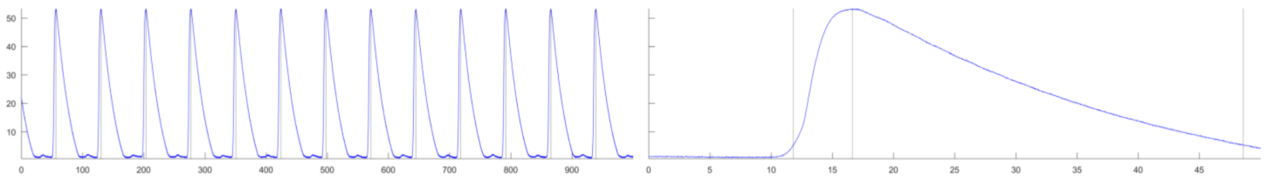

Figure 12: Model X unit 1 test 3

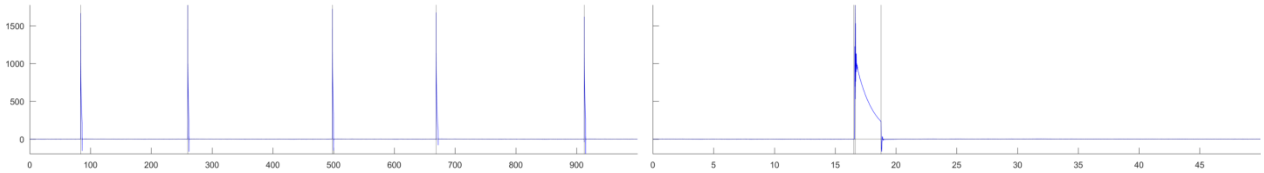

Figure 13: Model X unit 1 test 4

Results:

Testing of our sample of 41 new stun guns from different manufacturers illustrates the problem of transparency of design and the accountability that could be assured by a vigorous quality control regime. There are no publicly available design standards or performance expectations with respect to any of the stun guns that we examined. There are many more models of stun guns on the market that we did not test. There is no likelihood that the situation will differ for these models which we have not seen. Typically, manufacturers of consumer electronics will make some information available to the consumer even if it is a schematic enclosed in the packaging. At a higher level, published designs and performance expectations could lead to greater quality control in manufacturing and marketing of stun guns. Reverse engineering and scientific study are the last resorts to determine what is “inside the box” and provide guidance as to how it should operate.

Discussion:

Another issue is the unsupported claims of voltage output on packaging and promotional literature. Packaging and manufacturing claims of terminal voltage in excess of 50,000,000 V were not substantiated in any tests or theory. It is worth noting that the dielectric strength (or breakdown voltage) in air is 3×10^6 V/m. Breakdown voltage across contacts that are 2 cm apart would be 60×10^3 V. Not only are the claims of very high voltage at the terminals ignorant of the laws of physics, but they mislead the public about the effectiveness of the stun gun.

The effect of Conducted Energy Weapons used by law enforcement and military authorities is to produce Neuromuscular Incapacitation which enables a police officer to gain physical control of a subject. The design of these types of Conducted Energy

Weapons has been progressive experience over 20 years with consistent results in manufactured products.

There is no such design criteria with respect to Stun Guns that we have been able to determine. Stun Guns are designed to hurt the subject. Since pain is highly subjective and dependent on gender, age, physical build and other factors, it is not possible characterize Stun Guns on any other basis that we have done. There is varying opinion on how much charge is painful or intolerable, so we have accepted the generalization that any charge over 1 μC is very painful.

The consumerization of what has traditionally been a Conducted Energy Weapon associated with police or military use indicates a need for greater information about Stun Guns. Aside from issues of product and performance integrity, greater public understanding of the nature and electrical characteristics of Stun Guns would result in a more informed use of Stun Guns.

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[i] https://curve.carleton.ca/system/files/faculty_staff_research_publication/a96e4ba8-208d-4a80-8a21-7b485afade5/fac_staff_res_pub_pdf/aca9796a07102df3d115e154a3aabe09/cew-test-procedure-2010-ver1.1.pdf