Towards a portable, memory-efficient Test System for Conducted Energy Weapons

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Index

- Introduction on Taser X26.
- Problem we want to solve.
- Solution for the problem.
- How the Taser X26 works.
- The electrical specifications of the Taser X26.
- Biomedical effects.
- Design of the Taser X26 performance text system.
- Results.
- Conclusion .

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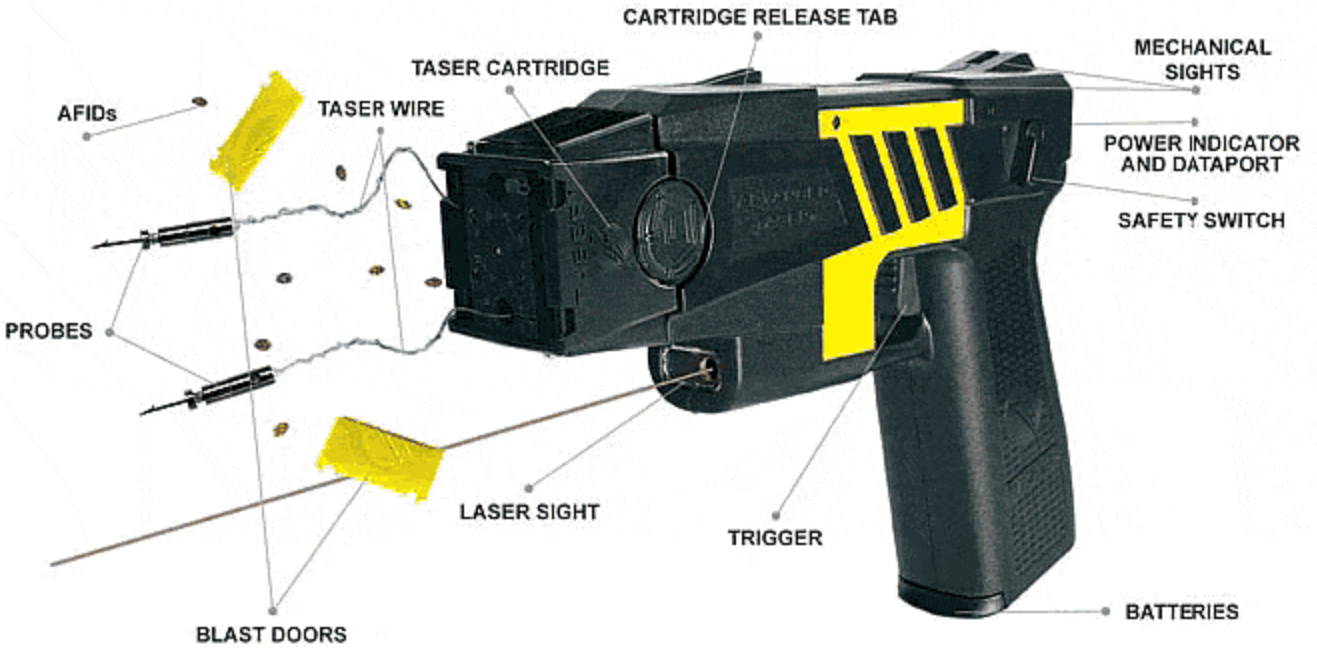
Introduction on Taser X26



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- Conducted Energy Weapons (CEWs) use electrical stimulation to cause **neuromuscular incapacitation**.
- The most common CEW in use with police forces is the **Taser X26**.

Problem we want to solve!

- Since CEW use has been associated with some **high profile deaths**, there is considerable controversy over their safety, effectiveness and associated usage policy.
- Until very recently in Canada, there **was no benchmark or regular testing** of these weapons for conformance with performance specifications.

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Solution

- Government, industry and academia have collaborated to create and distribute a **Canadian Test Protocol** and **a Canadian Performance Test System (PTS)** for all CEW's.
- The protocol incorporates **safety standards** for the CEW’s.

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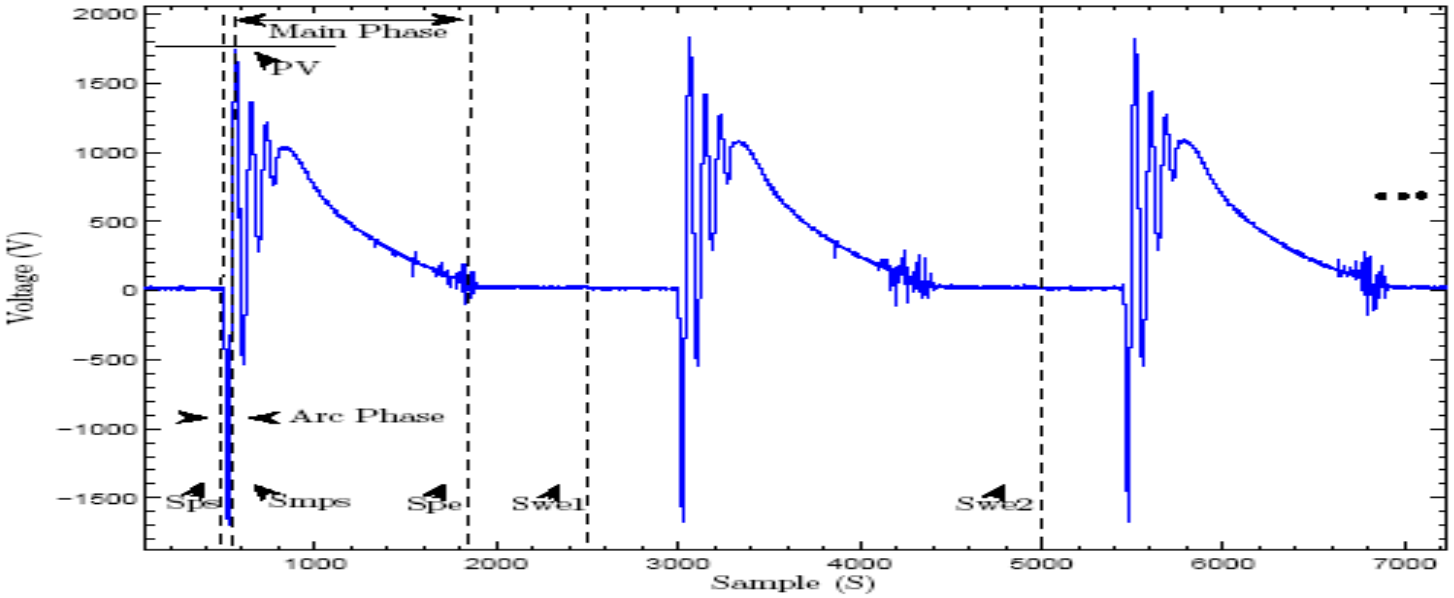
How it works



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Taser X26 fires a sequence of pulses (pulse train) at a typical rate of **20 pulses per second.**

There are two phases for a single pulse of Taser X26:

Arc phase and **Main phase.**

How it works

- A single pulse of Taser X26 is produced by **charging and discharging three capacitors** with three different time constants, producing **three different frequencies** in the output waveform.

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The Electrical Specifications of the Taser X26

- **Six electrical parameters** have been agreed to be measured for **taser performance monitoring**:

1) **Peak Voltage (PV)** which is peak of main phase voltage on a pulse,

2) Peak Current (PC) which is peak of main phase current over a pulse,

3) Full Charge (FC) representing the integral of the absolute value of the current over the entire pulse

4) Net Charge (NC) showing the integral of the main phase current on a pulse,

5) **Pulse duration (PD)** which is the time from starting point of a waveform to end point.

6) Interpulse time (IPT) which is the time from the start time of one pulse to the start time of the next pulse.

7) Pulse repetition frequency (PRF = number of pulse-1 /Firing length time.

Design of the Taser PTS and experimental setup

- The developed PTS has **four distinct parts:**

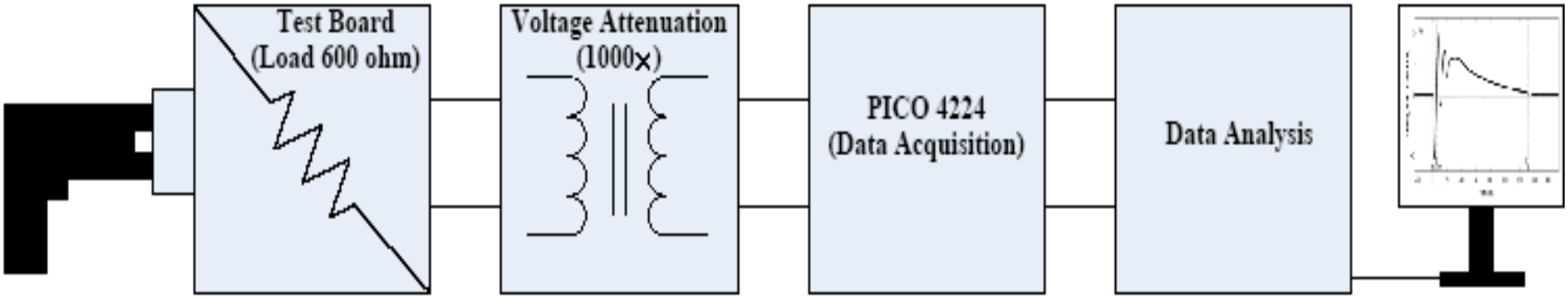
1) The energy source (Taser X-26)

2) The data acquisition block,

3) The analysis block,

4) Monitoring block.

The **sampling rate** is set up to **10 MS/s** with a resolution of **12 bits.**



Data Acquisition

- **Rapid block mode**: The taser pulse train is sampled only where the energy is delivered to the target. If the input analog voltage signal is bigger than a predefined threshold level, the signal will be sampled over a time window (250μs).

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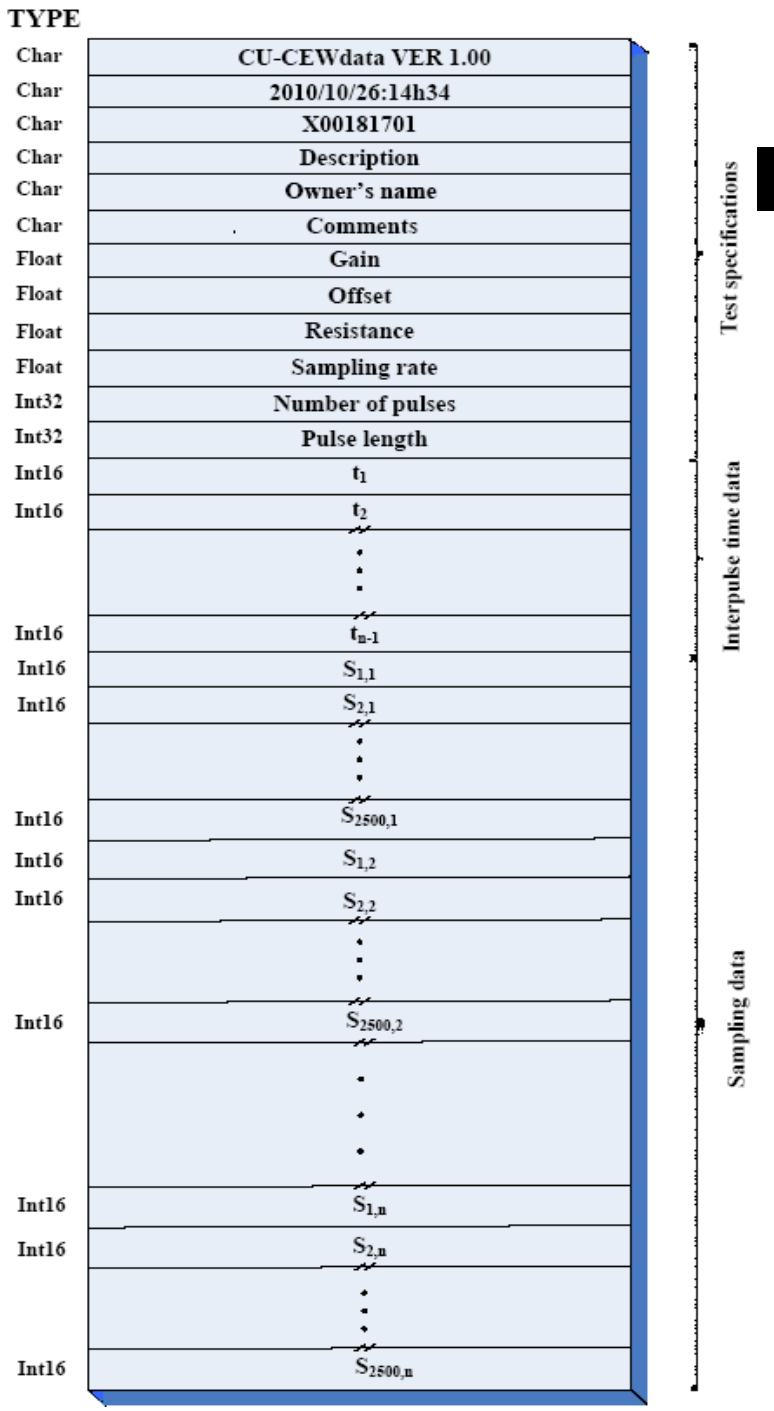
Data file format

The proposed taser data file format involving three different data types:

1) **Test specifications,**

2) **IPT data,**

3) **Taser sampling data.**



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Sample test results for well-performing weapon

Performance parameters	Lower limit	Your weapon			Upper limit
		1^{st} shot	2^{nd} shot	3^{rd} shot	
PRF (pps)	16.5	18.2	18.2	18.2	20
Net charge (μC)	80	102	110	104	125
Pulse duration (μs)	105	124	128	126	155
Peak voltage (V)	1400	1400	1667	1420	2520
Peak current (A)	2.3	2.3	2.8	2.4	4.2

Sample test results for out-of-tolerance weapon

Performance parameters	Lower limit	Your weapon			Upper limit
		1^{st} shot	2^{nd} shot	3^{rd} shot	
PRF (pps)	16.5	15.9*	14.8*	13.4*	20
Net charge (μC)	80	100	101	107	125
Pulse duration (μs)	105	120	118	124	155
Peak voltage (V)	1400	1708	1719	1793	2520
Peak current (A)	2.3	2.9	2.9	3	4.2

Results from testing with PicoScope

The number of tested /re-tested weapons	In tolerance		Out of tolerance	
	Number of weapons	Rate	Number of weapons	Rate
91 (on 1^{st} shot)	76	83.5	15*	16.5
15 (on 2^{nd} shot)	11	73.3	4*	26.7
4 (on 3^{rd} shot)	3	75	1*	25

- A data set in accordance with the proposed data file format was recorded from the approximately **5 second discharges** (**80-100 pulses**).
- The average size of the data set was **410 KB**

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Conclusion

- The proposed in-situ TPS for CEWs is highly **portable** and **light**, of **high resolution and high accuracy** with the capability of producing a manageable and **small data file** of several hundered **kB**.
- The new TPS uses **rapid block mode** to only sample the desired pulses delivering energy higher than the specified trigger.
- The new test system creates a **new data file format** for tasers involving all useful information about the weapon: **taser raw data, timing data, and the applied measurement specifications in the test**!

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Conclusion

- The new file format will facilitate a collection of CEW data in a standardized form across Canada allowing research on:
- 1) **how CEW's output varies during usage and over time**, 2) **out-of-tolerance modes**, and 3) **expected lifespan** of the CEW.

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