Journal of Physics Special Topics

P3_2 Stunning Weapons

J. Bettles, I. Clarke, M. Perry and N. Pilkington

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

November 10, 2011

Abstract

The non-lethal apprehension of criminals is an issue of ever increasing importance for law enforcement the world over. Existing means are primarily single use due to the need for wires to transmit the discharge to the target. The aim of this paper was to establish the viability of a wireless means of transmitting the electrical discharge of a stun gun through a process of high voltage discharge. The maximum potential range over which the necessary discharge could be projected was found to be 15cm, whilst this is low it could still have practical application.

Introduction

Non lethal electrical weapons work by introducing a high voltage low current discharge of electricity into the target. The electrical discharge interrupts the signals between the brain and spinal column causing loss of bodily function and varying degrees of incapacitating pain. Currently there are several means of transmission, an example of this is; direct contact where the device is directly applied to the target. There is also the Taser system (Taser is the brand name of a very popular stun gun) whereby conductive prongs are fired and latch onto the target. The prongs have wires that connect back to the main device; the discharge is transmitted through the wires to the target [1].

There is growing interest in the area of wireless electrical transmission. The Taser device relies upon the coiled wires and has to be rewound after each usage which limits its rate of fire; especially when dealing with multiple targets. A wireless means of ranged electroshock would allow greater flexibility to the weapon and make it more time efficient.

Theory

In order to project the electrical effect over a distance the discharge must flow through the air. Air is an insulator and as such electricity does not readily flow through it, but it can conduct if the voltage is high enough.

As an insulator the relationship between current and voltage is not linear [2]. In a conductor there is a steady rise in the current with the voltage. In an insulator however, there is no current until the voltage is sufficiently high. At this point the current will rise extremely rapidly as it conducts through the medium.

The value of the breakdown voltage is also dependent upon the pressure of the medium; the exact nature of the relationship is described by *Paschen's law* [3]. In this case a further limitation on the system is the maximum usable voltage. The voltages needed to incapacitate a human being ranges from 65-600kV [4] any greater than this could potentially kill the target.

Analysis

The range of the device is limited by the voltage required to bridge the gap, this is given by [5]:

$$V = \frac{bpd}{\ln(pd) + c}, \qquad (1)$$

where V is the breakdown voltage, p is the pressure of the medium through which the electricity is travelling, d is the distance between the source and the target, and b and c are constants determined from experiment. These constants are found to have values of b=43.6x10^6 V/(atm·m) and c=12.8 [3].

Substituting the value of atmospheric pressure, at a distance of 10m, the required voltage turns out to be 28,869kV. This value is far in excess of the previously stated acceptable limit and would easily kill a human target. In order to keep to this limit the calculation is reversed and solved for d at a voltage of 600,000V. The distance returned is 15cm.

Conclusion

The effective range of 15cm is not a suitable replacement for the traditional wired Taser weapons. A shortened range while limiting does not rule this out as an impractical device. A shorter ranged device still has a place as an immobile security measure such as a device built by the arms developer XADS (Xtreme Alternative Defence Systems) [6]. The basic principle of the weapon could also be enhanced by use of *Paschen's law*, if a gas with a lower breaking voltage was ejected into the desired path of the weapon, the effective range could be greatly enhanced.

References

[1] How does an advanced Taser work, accessed on 24/10/2011, http://www.nonlethaldefense.com/howairtawo.html#1
[2] All about circuits website, Insulator breakdown voltage, accessed on 23/10/2011, http://www.allaboutcircuits.com/vol_1/chpt_12/8.html
[3]PSES, accessed on 10/11/2011, page 24, http://ewh.ieee.org/r6/ocs/pses/0809_heresy-revc.pdf
[4] Hypertextbook, Voltage of a Stun Gun, accessed on 24/10/2011 http://hypertextbook.com/facts/2002/JonathanHamill1.shtml
[5] Global Free Energy, Breakdown voltage equation, accessed on 23/10/2011 http://www.globalfreeenergy.info/2011/02/03/breakdown-voltage-equation/
[6] XADS, Main page, accessed on 23/10/2011, http://xtremeads.com/