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DETONATOR TESTING SOFTWARE

VLADIMIR DRINCEVIC
Metropolitan University, Vlatacom Institute, Belgrade, vladimir.drincevic@vlatacom.com

PROF. DR DRAGAN DOMAZET
Metropolitan University, Belgrade, dragan.domazet@metropolitan.ac.rs

NIKOLA LATINOVIC
Vlatacom Institute, Belgrade, nikola.latinovic@vlatacom.com

Abstract: *Trend in the modern military technology is usage of electric explosive devices. In domain of aerial bombs, modern fuzes use electric igniting devices, electric detonator devices and pyrotechnic components controlled by electronics. For safe and secure usage, these components must also be tested according to applicable military standards and these tests are of high interest. Due caps high sensitivity, all tests must be done with great care using very precise equipment.*

This paper presents method of detonator testing using specially designed software. Special attention is given to Maximum No-Fire Current, Minimum All-Fire Current and Stray Voltage tests.

The software manages the test hardware, which is cheap and it consists of commercially available components. Those components can be easily changed in the hardware itself, thus providing a great opportunity to vary parameters and restrictions for caps testing.

Detonator testing software provides great advantages over classical testing methods primarily in terms of data acquisition speed and in terms of test price. Considering that's possible to use the software even with changes in hardware, which enables very fast and cheap modification of test parameters, this software can become an indispensable part of the equipment when testing the caps according to the requirements of military standards.

Keywords: *Detonator; Testing software; Electronics; Pyrotechnic, EED.*

1. INTRODUCTION

In aerial bomb fuzes, any explosive, if used correctly, applied in no matter how small quantity, can produce useful mechanical effect. For proper initiation the explosive needs some form of external stimuli [1]: mechanical force, heat energy or an electrical signal. In this paper the focus is on initiation via electrical signal.

When we talk about detonator, we are talking about electro-explosive devices or EED, as are known in the literature. EEDs must be determined before using any device that contains them and this is to be done with the help of suitable sensitivity tests as explained in [2]. Sensitivity testing must be made only by properly employed techniques in order to get accurate estimates of EED reliability and safety. Improperly applied, sensitivity testing can produce misleading data which may compromise mission success or result in rejection of reliable units [3].

For reliability determination of EEDs, their stimulus level is determined by suitable sensitivity tests. Published papers gives frequently used sensitivity test methods: Bruceton Method, Langlie Test, Neyer's Method, AD Optimal Method. Common to all tests is that they require experiments with high testing cost and numerous statistical calculations. To reduce the manual error and the lengthy calculations which are consuming huge amount of time, user-friendly menu driven software has been developed. Software will process the entire experimental data, perform tedious and complicated statistical calculations, and give the optimal results in a few seconds.

Testing of EEDs involves the determination of various properties of the different energetic materials that are used in commercial, mining, and in military applications. It is highly desirable to measure the required conditions for several reasons, including: Safety in storage, Safety in handling, Safety in use.

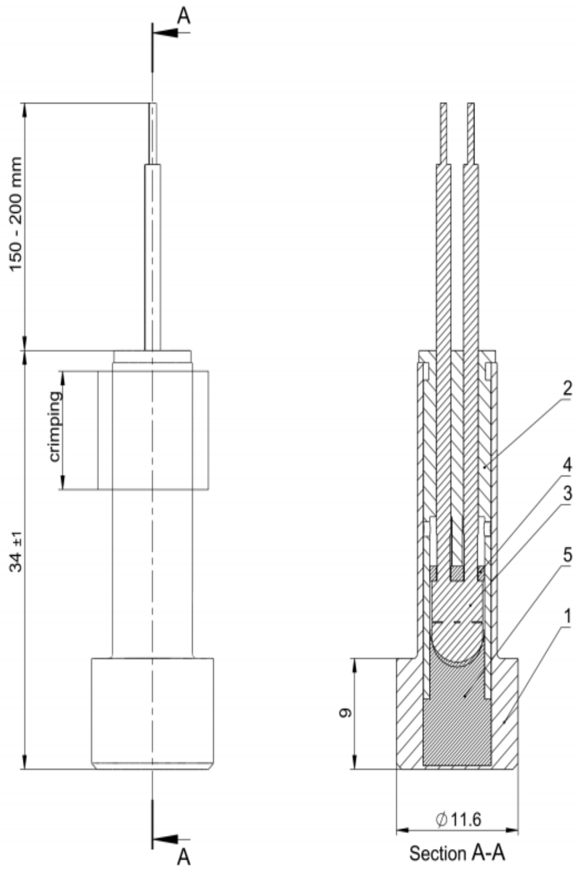
EEDs give consistent and repeatable performance and therefore are extensively used in aerial bomb fuzes.

1.1. Caps used for testing

Caps tested by the software are mostly used in aerial bomb fuzes. Models used are M-79 and ED-P2.

Many other caps can also be tasted by the software, like other detonators ED-DD, ED-P1 and M-84.

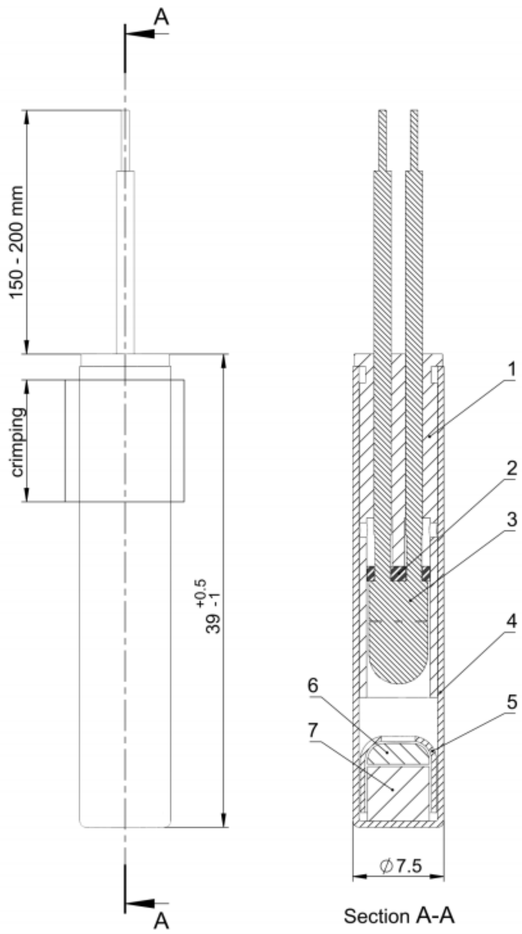
Figure 1 shows drawing of M-79 detonator with its elements and explosive filling quantity.



Pos.	Name, Description	Material	Qty
1	Aluminum housing	3.2315	1
2	ESD Protective rubber	P/N F300 esdpV	1
3	Bridge wire	NiCr thickness 30 μm	1
4	Silicon plate 1.2mm 70 shore	Silicon VMQ70	1
5	Black Powder No.7 class	340±10mg	1

Figure 1. M-79 detonator drawing

Figure 2 shows drawing of ED-P2 detonator with its elements and explosive filling quantities.



Pos.	Name, Description	Material	Qty
1	ESD Protective rubber	3.2315	1
2	Silicon plate 1.2mm 70 shore	Silicon VMQ70	1
3	Bridge wire	NiCr thickness 30 μm	1
4	Tube 7.5 mm diameter	AlMg2	1
5	Aluminum cup	AlMg2	1
6	Detonating charge 2 DLA	2DLA (40±5mg)	1
7	Primary charge PETN	PETN (100±5mg)	1

Figure 2. ED-P2 detonator drawing

2. METHODOLOGY

2.1. Tests of interest

Maximum No-Fire Current is the term for the maximum current that may be applied for a specified time period without firing the initiator or pyrotechnic device.

Minimum All-Fire Current is the minimum current that will always fire the initiator or pyrotechnic device.

Stray Voltage test determines whether the initiator or pyrotechnic device is capable of withstanding the effects of a stray voltage environment without firing.

2.2. Hardware

Hardware is implemented via 8-bit Arduino microcontroller [5], power supply LT3092 [6] and transistor switching logic for charging and discharging of 440μF capacitor (see block diagram on Figure 3).

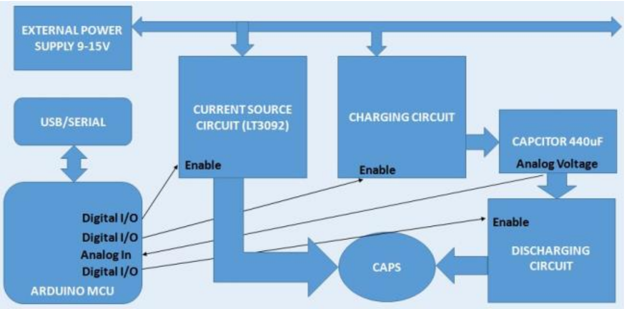


Figure 3. Block diagram

All these blocks are controlled from a microcontroller through digital input/output ports that receives commands via a graphical user interface from a PC. Also, on Analog Digital converter of microcontroller is connected circuit for measuring the voltage on the capacitor.

Following tests are enabled: Stray Voltage, Minimum All Fire Current and Maximum No Fire Current.

The Arduino microcontroller unit MCU is powered from a PC via a USB connection. The power supply for the current source, charging and discharging of capacitor is supplied externally and it should be in range of 9-15V DC. Arduino MCU is connected to a PC via a USB cable.

2.3. Software

The software is written in the LabView [7] programming environment using the Arduino MCU library. User interface with clarification of the commands can be seen on Figure 4.

For Stray Voltage test we set the duration of one and zero (x times 50 ms) and the duration of the test itself (in seconds) – by standard [4] it is 1000 s, namely 2000 impulse, where one lasts 300 ms and zero 200 ms, so we write in the boxes with following order 1000, 6, 4. The one corresponds to a direct current value of 100 mA.

For Maximum No-Fire Current the duration of the test is set – by standard [4] it is 5 min (300s). Current of 100 mA is released continuously in the detonator, after the end of the test, the indicator that the test is finished is activated and the power source is automatically turned off.

After entering the appropriate values for the tests, we activate and deactivate the specific test using the commands.

For Minimum All-Fire Current test, it is necessary to first define the voltage value of the capacitor based on the calculated minimum energy necessary to trigger the cap.

$$\frac{1}{2}CU^2 \tag{1}$$

In Equation (1) C stands for capacitance in Farads and U stands for potential difference or Voltage in Volts.

After determination of minimum activation energy, activate the capacitor charging circuit, and after indication that the capacitor is charged to the desired value, deactivate the capacitor charging circuit and activate the capacitor discharge circuit.

Moreover, within Graphical User Interface GUI, the user is enabled to follow the movement of the voltage value on the capacitor at any time through the graph.

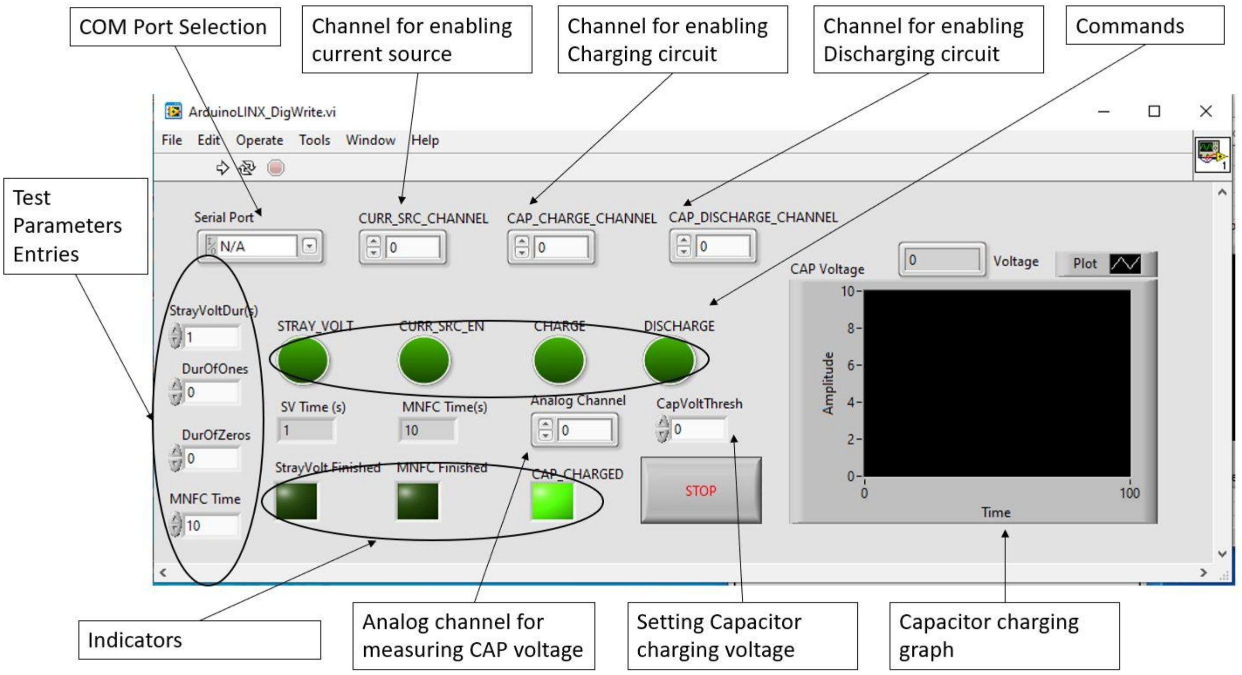


Figure 4. User interface with commands clarification

3. SOFTWARE POSSIBILITIES

Considering that test hardware consists of cheap and commercially available components, test setup can easily be adjusted to fulfill requirements of other sensitivity tests.

For calculation of Minimum All-Fire Current with Bruceton Method [9], test hardware does not need any change, the existing system can be used. This is due the fact that in the system we have the ability to define the charging voltage of the capacitor ourselves, so in software we just need to make it start from a given value and automatically raise/lower for a certain threshold that we set. To be very precise, by writing an additional software block of code and adding it to the existing one, Bruceton Method to determine Minimum All-Fire Current can be made.

There is a possibility to substitute existing microcontroller for a microcontroller with higher processing power, with support to perform even more complex mathematical operations.

Circuit diagram can be modified with addition of 1A current source. This enables execution of Bruceton Method not only by the capacitor discharge method but also by constant current test method.

4. DISCUSSION

4.1. Price

Classical testing methods, as the one shown in [8] whose no-fire current measurement schematic diagram is shown on Figure 5, requires expensive test hardware like special test chamber that can which can withstand detonator explosion.

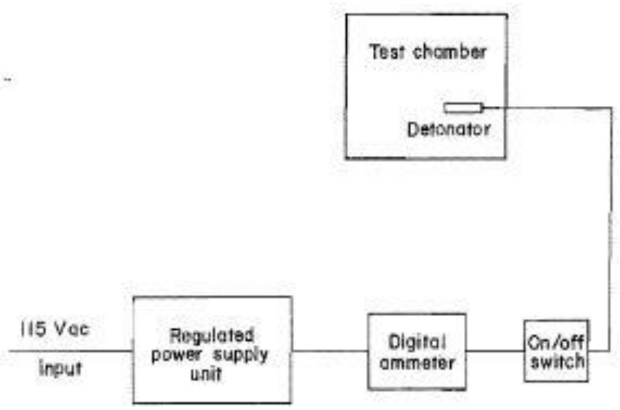


Figure 5. Schematic diagram of no fire current measurement

Presented detonator testing software manages test hardware which consists of cheap and commercially available components.

4.2. Time

Frequently used testing methods like Bruceton Method, Langlie Test or Neyer’s Method require experiments with numerous lengthy statistical calculations which can lead to manual error and certainly are consuming huge amount of time.

Presented detonator testing software will process the entire data, performs all necessary calculations, and give the optimal results in a few seconds.

4.3. Component interchangeability

Experimental setup with expensive and rigid test hardware, positioned in specially designed laboratories obviously cannot be easily moved to different location, and as such is set for specific testing without much space for variation of the test and much less for expansion of the test.

Test hardware which is managed by the detonator testing software can easily be changed, thus providing a great opportunity to vary test parameters and restrictions and even expand the scope of testing with just a minor changes/addition in software. Complete test setup can easily be moved to desired location.

5. CONCLUSION

This paper presents user-friendly detonator testing software. Tested caps are mainly used in aerial bomb fuze. The software was created for Vlatacom Institute as a part of test equipment on the project 126.

Presented software clearly provides great advantages over classical testing methods primarily in terms of data acquisition speed and in terms of test price.

It is important to note that component interchangeability and easy portability of the test setup provides possibility to vary test parameters and even expand the scope of caps testing.

With all above-mentioned advantages over classical testing methods, this software can become an indispensable part of the equipment when testing the caps according to the rigorous requirements such as those from military standards.

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APPENDIX A

Source Code