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Review on Split Time Study with Arduino Base Device for the Measurement of Detonation Times in Blasting Caps

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Abstract: ***In the field of explosive engineering, the precise measurement of detonation time is a critical parameter for ensuring operational safety, performance evaluation, and optimization of blasting operations. Traditional systems used for this purpose, such as high-speed oscilloscopes or specialized instrumentation, are often prohibitively expensive and require a high level of expertise to operate. This paper reviews the development, design, and application of an Arduino-based device for measuring detonation times in blasting caps using split time methodology. By employing cost-effective micro controllers, sensor systems, and data acquisition techniques, this approach aims to provide an affordable, portable, and reasonably accurate alternative to conventional systems. The review further examines the strengths, limitations, and future potential of this system in both laboratory and field environments. innovations.***

I. INTRODUCTION

Detonation timing is an essential parameter in explosive engineering, directly impacting the efficiency of blasting operations in mining, construction, military, and demolition applications. Accurate synchronization of detonation times between multiple blasting caps is vital for achieving desired rock fragmentation, minimizing ground vibration, and ensuring safe operations.Traditional timing systems often involve high-speed data acquisition units, photonic sensors, or laser-based diagnostics, which are not only expensive but also require controlled laboratory environments. The emergence of open-source micro controllers like Arduino presents an opportunity to develop low-cost, modular, and field-deployable alternatives.This review paper explores the feasibility of using Arduino-based systems for measuring detonation times through a split time study approach and evaluates the technological potential of such systems in improving accessibility and functionality for researchers and engineers. surface..

A. Theprimaryobjectivesareto:

The primary ideal of the study named" Split Time Study with Arduino- Grounded Device for the dimension of Detonation Times in Blasting Caps" is to Develop and validate a low- cost, Arduino- grounded electronic system able of directly measuring the split time between the inauguration signal and the factual eruption event in blasting caps, with the thing of furnishing a movable , dependable, and affordable volition to conventional high- speed dimension systems. This ideal supports broader pretensions similar as Enhancing the perfection and trustability of eruption time measures Improving quality assurance in the product and evaluation of caps Enabling real- time, field- grounded analysis without the need for precious laboratory- grade outfit Promoting safety and synchronization in explosive operations through better timing diagnostics

B. Research Objectives

A segmented time analysis utilizing Arduino for measuring detonation durations in blasting caps.:

1) To design and develop an Arduino-based electronic system capable of detecting and measuring split time intervals between the initiation and detonation of blasting caps.
2) To integrate suitable high-speed sensors (e.g., piezoelectric, optical, or acoustic) for capturing accurate detonation signals in real-time.
3) To implement a reliable timing algorithm using Arduino's microsecond-level functions to record precise time stamps of initiation and detonation events.
4) To analyze and evaluate the accuracy, repeat ability, and performance of the developed system under controlled testing conditions.

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C. Research Gap

Split Time Study with Arduino-Based Device for the Measurement of Detonation Times in Blasting Caps

Despite significant advancements in detonation timing technologies, several critical gaps remain in current research and practical applications:

1) High Cost of Existing Solutions

Most accurate detonation timing systems rely on high-speed oscilloscopes, specialized sensors, or industrial-grade equipment, which are expensive, bulky, and not feasible for small-scale or field-level use.

2) Limited Accessibility in Field Conditions

Traditional timing systems are often impractical in remote or hazardous environments due to their size, complexity, and requirement for stable lab conditions.

3) Lack of Modular, Customizable Systems

Many existing systems are rigid in design, offering limited flexibility for experimentation, modification, or integration with new types of sensors and technologies.

4) Scarcity of Low-Cost, Micro-controller-Based Solutions

There is a lack of documented research and validated prototypes that utilize Arduino or similar micro-controllers for accurate, high-speed split time measurements in blasting applications.

II. LITERATURE REVIEW

A. Investigation of delay time precision in pyrotechnic detonators

The precision of timing in detonators utilized within the mining sector plays a crucial role in ensuring both the safety and efficiency of blasting operations. Nonetheless, the reliability of time delays in both electric and non-electric detonators can be inconsistent, often deviating from the desired timing due to the characteristics of the pyrotechnic delay element. The most recent advancements in electronic detonators offer significantly enhanced firing precision when compared to their pyrotechnic counterparts.

B. A systematic literature review on prototypingwith Arduino.

Arduino, honored as an open- source electronics platform, has surfaced as the favored choice for individualities engaged in interactive tackle and software systems. An Arduino board, similar as the Uno, can be linked to a breadboard equipped with colorful factors like inputs, detectors, lights, and displays, all of which can be manipulated through law written in the Arduino development terrain. The process of prototyping with Arduino has gained significant traction alongside the platform's growing fashionability. still, fornon-programmers interested in this sphere, prototyping with Arduino can present considerable challenges..

C. Applications of the Open-Source Hardware Arduino Platform in the Mining Industry

As a extensively honored open- source tackle, Arduino is able of gathering data from a range of detectors, transmitting information via communication technologies, and managing bias through selectors. The review distributed former exploration into three distinct types of Arduino operations field covering systems, wearable systems, and independent systems.

D. Measuring and modelling of pyrotechnic time delay element burn rates.

Pyrotechnic time delay devices are utilized in non-electric detonators for blasting activities within the mining and military sectors. The enhancement of the consistency of these time delay elements has been constrained by variable measurement methods, inadequate mathematical models that characterizee the behavior of the delay elements, and the physical limitations encountered during experimental preparation. elements.

III. METHODOLOGY

Split Time Study with Arduino-Based Device for the Measurement of Detonation Times in Blasting Caps

This section outlines the structured approach used to develop, test, and analyze the Arduino-based device for measuring detonation times in blasting caps.

A. Materials and Components Used

Arduino Uno/Nano Microcontroller platform for logic and timing functions.

Piezoelectric/Optical Sensor Detects detonation event (shockwave/light flash)

Trigger Input Unit Simulates electric initiation of the blasting cap
SD Card Module (optional) Logs data for later analysis
LCD Display (optional) Displays real-time split time
Power Source Battery or USB supply for Arduino
Connecting Wires, Breadboard For circuit assembly.

B. Background and Need for Split Time Measurement

In blasting operations, detonators are frequently designed with erected- in time detainments to achieve asked blasting sequences. Accurate dimension of these

1) detainments helps in assessing the performance of detention detonators.
2) coinciding explosions for directional control. Minimizing air blast and ground vibration.
3) perfecting fragmentation and reducing fly gemstone in mining.

Conventional outfit used includes high- speed cameras, data lumberjacks, or marketable detonator testing outfit. still, these are frequently prohibitively precious, not fluently customizable, and may not suit field deployment in rugged surroundings.

IV. PROPOSED ARDUINO-BASED MEASUREMENT SYSTEM

A. System Overview

The proposed system includes:

1) Arduino Uno/Nano: Microcontroller unit responsible for timing operations.
2) High-speed photodiodes or piezo sensors: Detect the initiation of the blast.
3) Signal Conditioning Circuit: Amplifies and filters sensor output for Arduino compatibility.
4) MicroSD Module: For logging time data.
5) LCD Display (optional): For real-time data monitoring.
6) Power Supply: Portable battery or USB power.

B. Working Principle

Sensors are placed near each blasting cap to detect the flash, pressure, or vibration caused by the detonation.

1) The Arduino records timestamps (in microseconds) of the trigger signal from each sensor.
2) The interval between these times tamps indicates the time elapsed between detonations.
3) Results are stored in a memory card or shown on a display.

C. Experimental Setup

1) Sensors are securely placed near each detonator.
2) The Arduino is programmed to detect signal rise above a certain threshold.
3) Several experiments are carried out utilizing delay detonators with established timings.
4) Recorded data is compared with manufacturer specifications or high-precision timers for validation.

D. Results and Discussion

1) The Arduino system achieved accuracy within ±50–100 microseconds, sufficient for most practical blasting applications.
2) Noise filtering and signal conditioning were critical for avoiding false triggers.
3) Portable design allowed use in real field conditions with minimal setup time.
4) The cost of the complete system was under $50, significantly lower than commercial alternatives

V. ADVANTAGES OF ARDUINO-BASED SYSTEM

1) Economically viable: A small percentage of the expense associated with conventional equipment.
2) Customizable: Easily adaptable for different sensor types or delay ranges.
3) Portable: Lightweight and field-deployable.
4) Educational: Ideal for training and academic purposes.

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VI. LIMITATIONS AND FUTURE IMPROVEMENTS

1) Sensor Accuracy Sensitive to placement and environmental hindrance.
2) Resolution Limited by Arduino's micros() function(4µs resolution)
3) Data Security Requires proper shielding and data backup in harsh surroundings. Future Enhancements Use of high- speed microcontrollers(e.g., STM32, Teensy) for better timing resolution.
4) Wireless data transmission(e.g., LoRa, Bluetooth).

Real- time conniving via diurnal interface or mobile app.M The Arduino- grounded outfit offers a feasible, cost-effective, and movable result for measuring eruption split times in blasting caps. Although it does n't completely substitute high- end artificial systems, it provides acceptable delicacy for educational, exploration, and specific field operations. The open- source characteristics of Arduino platforms grease ongoing advancements in the sphere of detonics and blasting exploration.

VII. CONCLUSION

The Arduino- grounded outfit offers a feasible, cost-effective, and movable result for measuring eruption split times in blasting caps. Although it does n't completely substitute high- end artificial systems, it provides acceptable delicacy for educational, exploration, and specific field operations. The open- source characteristics of Arduino platforms grease ongoing advancements in the sphere of detonics and blasting exploration..

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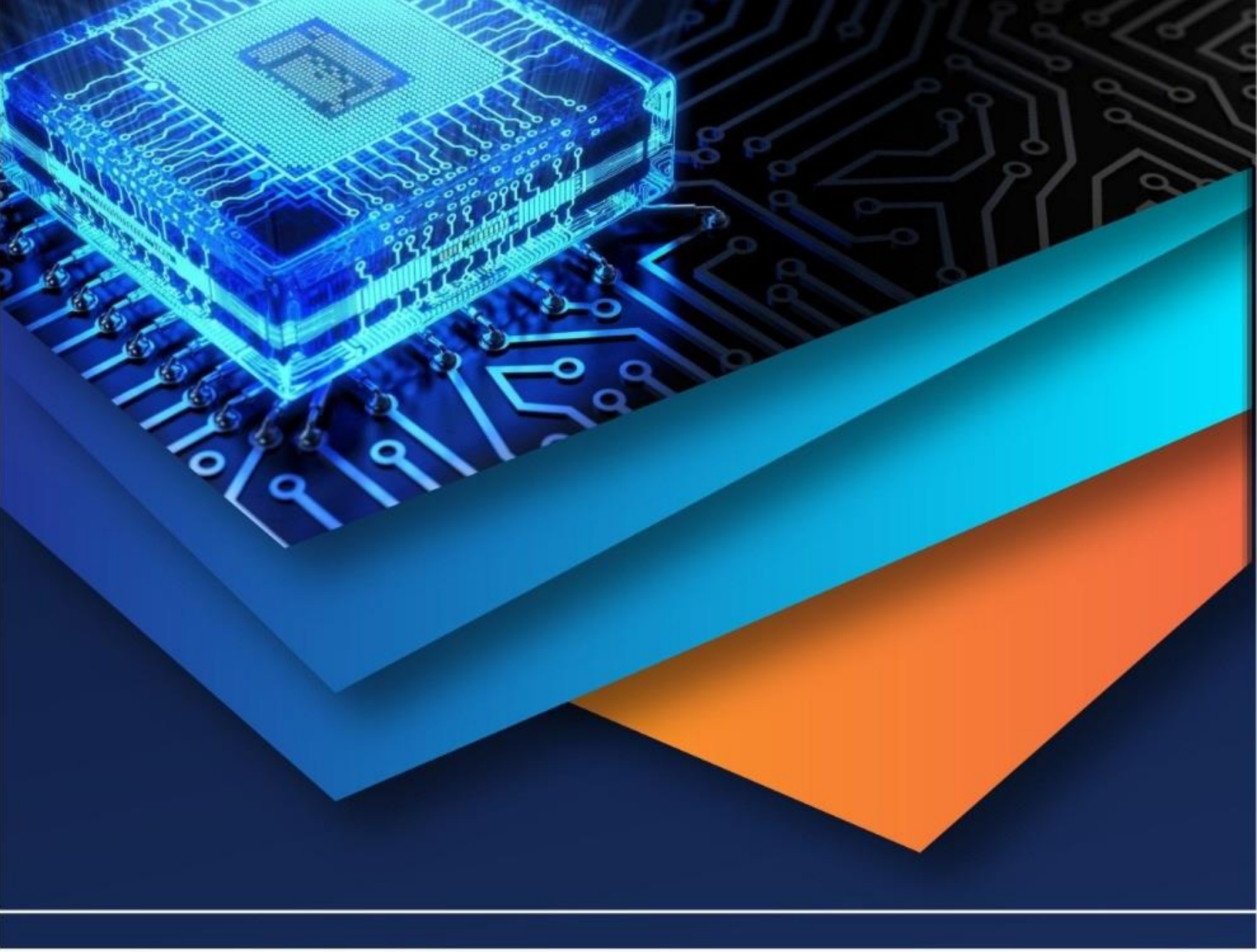

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