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Mechanism of Electronic Delay Device for Detonator

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ABSTRACT: SCB is a low energy and small size initiator device with very small firing delay. A Semiconductor Bridge (SCB) can initiate unintentionally by Electro-Static Discharge (ESD) and high power RF. Detonators are compact devices that are designed to safely initiate and control the performance of larger explosive charges for blasting. Electronic detonators are being used that eliminate almost every drawback of the earlier inventions. In this project miniature programmable Electronic detonator is designed which is factory settable. The Electro explosive device(EED) used in the detonator is Semiconductor bridge(SCB) due to its excellent properties such as high safety, low ignition energy, fast ignition time, small size and low cost which is indigenously made by ARDE. The designed system consists of a microcontroller based setter for entering detonator number and passwords, and the detonator comprising of microcontroller based delay, boost convertor, firing circuit with Semiconductor Bridge and electro static discharge(ESD) and Radio Frequency(RF) interference protection circuitry for reliability and safety against unintended firing. The boost convertor will boost the input 3volts to 30 volts. To achieve miniaturization we have designed the firing and delay circuit for the detonator with PCB of size 6mm*40mm. The system will be secured with two passwords to avoid unauthorized .use and ensure better safety and reliability and system should work at distance of 2km 5km range using RF communication.

KEYWORDS: Microcontroller, detonator, delay, pyrotechnic delay.

I. INTRODUCTION

A detonator is a gadget which gives enactment vitality to the unstable charge to start synthetic response. A material is said to explode or blast when a mechanical stun wave with appropriate sufficiency engenders through it starting a synthetic response in the material. A detonator is a gadget which gives actuation vitality to the hazardous charge to start synthetic response. Detonators can be artificially, mechanically, or electrically started. The two regular sorts of detonators are electrical detonators (otherwise called impacting tops) and percussion detonators. Percussion detonators contain grating coarseness and essential high touchy in a fixed holder that is actuated by a terminating pin. The effect power of the terminating pin is adequate to start the ballistic succession that is then transmitted to the reception unit. The explosives and mining industry is quickly receiving innovation in all structures so as to enhance execution. Worldwide rivalry and expanding client requests are constraining administrators to search out and receive these advances so as to deliver their item all the more monetarily and all the more proficiently. Today, dangerous industry is utilizing the freshest explosives, gear, outlines, and estimation instruments with an end goal to guarantee that each pound of explosives is being used to its fullest potential. An EED with dangerous yield can be utilized to start an unstable train. The hazardous yield of an EED is moderately little. It must be expanded utilizing other vivacious materials as a part of the touchy train with diminishing stun affectability and expanding volumetric vitality content. In this manner, a little electrical information sign can start a dangerous occasion that moves huge amounts of rock. Starting explosives are intended to securely actuate bigger unstable charges at a controlled time and in a pre-decided succession. Starting explosives can be extensively grouped into electric and non-electric sorts. In an electric framework, a gadget that can produce or store electrical vitality transmits that vitality to the starting explosives through

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a circuit of protected conduits. Impact arrangements can be controlled by method for electric planning frameworks however defer timing is typically accomplished through pyrotechnic deferral components fused inside detonators. Non-electric starting frameworks use receptive chemicals to store and transmit vitality by controlled smoldering, explosion, or stun waves. Numerous detonators essential touchy is a blend called azidestphynate aluminum (ASA) compound. This piece is framed from lead azide, lead styphnate and aluminum and is squeezed into spot over the base charge, for the most part tri nitro toluene (TNT) or tetryl in military detonators and pentaerythritol tetra nitrate (PETN) in business detonators. In a general sense, the deferral detonators must present a pre-decided time delay amongst start and ensuing explosion of the associated hazardous charge. In the blink of an eye, the most utilized postponement detonators make utilization of pyrotechnic deferral component with changed lengths, containing in its inside, blend of solids equipped for blazing at a characterized speed for getting delay time. A pyrotechnic deferral component is an independent pyrotechnic gadget comprising of an initiator, a postponement segment and a yield charge, gathered into a uniquely composed dormant lodging. Delay time prerequisite differs from couple of milliseconds (ms) to a few seconds. The application ranges from a basic hand tossed explosive to a propelled canister dispatched strategic rocket. The fundamental impediment connected with pyrotechnic postponement is the exactness that lies between $\pm 4\%$ of mean worth over a scope of military working temperatures. An endeavor was made to enhance the precision of postponement for improving an adequacy of explosion. A decent achievement has been accomplished by creating microcontroller based electronic postponement gadget with an exactness of $\pm 1\%$. Security, time reproducibility, and ignition exchange are viewed as critical parameters to be met. These programmable electronic deferral gadgets yield are created to detonator to enhance the exactness of timing in explosion. Detonators with electronic postponement gadgets are along these lines a key device in setting up control of the impacting because of their accuracy delay and resulting capacity to guarantee successive terminating. A radio frequency (RF) signal refers to a wireless electromagnetic signal used as a form of communication, if one is discussing wireless electronics. Radio waves are a form of electromagnetic radiation with identified radio frequencies that range from 3Hz to 300 GHz. Frequency refers to the rate of oscillation (of the radio waves.) RF propagation occurs at the speed of light and does not need a medium like air in order to travel. RF waves occur naturally from sun flares, lightning, and from stars in space that radiate RF waves as they age. Humankind communicates with artificially created radio waves that oscillate at various chosen frequencies. RF communication is used in many industries including television broadcasting, radar systems, computer and mobile platform networks, remote control, remote metering/monitoring, and many more.

II. ELECTRONIC DELAY DETONATOR DESIGN

The mining and explosives industry is quickly receiving innovation in all structures with a specific end goal to enhance execution. Impacting is typically an initial phase in any mining procedure [1]. Initiator is a term that is utilized as a part of the touchy business to portray any gadget that might be utilized to begin an explosion in hazardous. The gadgets that start high dangerous are called detonators. Various types of postponement detonators are accessible [4]. At first concoction detonator came into picture which utilized a train of chemicals for producing delay before impacting. The postponement produced questionable, incorrect and created uncontrolled impacting and pulverization. In addition these detonators did not have any element for keeping away from unapproved use. Next best in class was the stun tube delay [3] detonator. Be that as it may, the gathering was excessively perplexing and immoderate so it was not utilized regularly. The following kind of detonator was the electric postponement detonator. In this deferral was produced utilizing electric sign. This framework is profoundly helpless to stray streams, AC-DC voltages, electrostatic release subsequently not solid. Diverse sorts and outlines, all use put away electrical vitality inside the detonator as a method for giving the planning deferral and start vitality. These days electronic detonators are being utilized that wipe out practically every downside of the prior innovations. Under the electronic detonator different ideas have been utilized for better execution. Diverse parts for deferral era were utilized, as RC segment based postponement era, CR based deferral era has likewise advanced through numerous stages. Microcontroller based deferral era [1] is an adaptable approach to program the postponement in research facility. These modified chips are then utilized on field. At first 40 pin microcontrollers were utilized with the end goal of postponement era. The size and power impediments prompted the utilization of littler microcontrollers. The associating join between the terminating of a warhead and an electronic melding sensor is the electrical started unstable gadget. Distinctive sorts of Electro [5] unstable gadgets (EED"s) are hot

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scaffold wires, blasting extension wire, slight metal film span, stun tube, Semiconductor Bridge. Hot-span wire initiator [3] has a few inconveniences, for example, it requires high vitality for its working; it has reaction on the request of many milliseconds, exceedingly ESD delicate. In this paper the electronic detonator is composed utilizing SCB. SCB is indigenously made by ARDE. We have utilized SCB because of its brilliant properties, for example, high wellbeing, low ignition vitality, quick ignition time and little size. In the proposed plan the size is scaled down and dependability and security is expanded. Figure no.2 demonstrates the proposed changes in the electronic detonator outline.

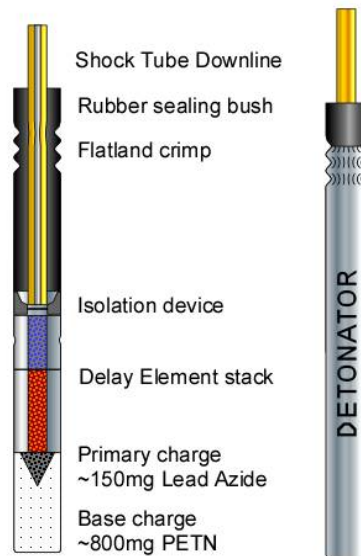


Fig 01 Electronic Detonator Design

III. LITERATURE SURVEY

1. Plain Detonator

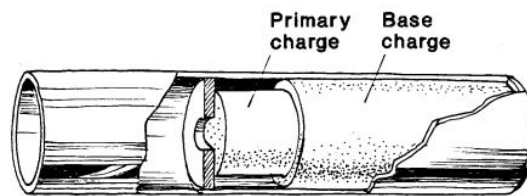


Fig 02 Plain detonator

Plain detonators may be used with safety fuse and slotted connectors / plastic igniter cord as a non-electric initiation system

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2. Chemical detonator

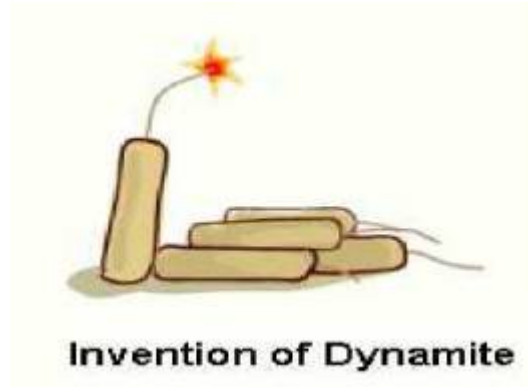


Fig 03 Chemical detonator

The chemical detonator employed a train of chemicals for generating delay before blasting. The delay generated was unreliable, inaccurate and caused uncontrolled blasting and destruction. Chemical detonators are thin metal or paper cylindrical shells, open on one end for the insertion of safety fuse, which contain various types of primary and secondary explosives.

3. Shock tube detonator



Fig 04 Shock tube detonator

- (1. Next state of the art was the shock tube delay [3] detonator. It used piezoelectric assembly to convert mechanical vibration into oscillator based delay generation, timer chip based delay generation and microcontroller based delay generation. Microcontroller signal that was further used for delay generation but the assembly was too complex and costly so it was not used frequently.
- (2. It used piezoelectric assembly to convert mechanical vibration into electrical signal that was further used for delay generation but the assembly was too complex and costly so it was not used frequently.

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4. Electric Detonator

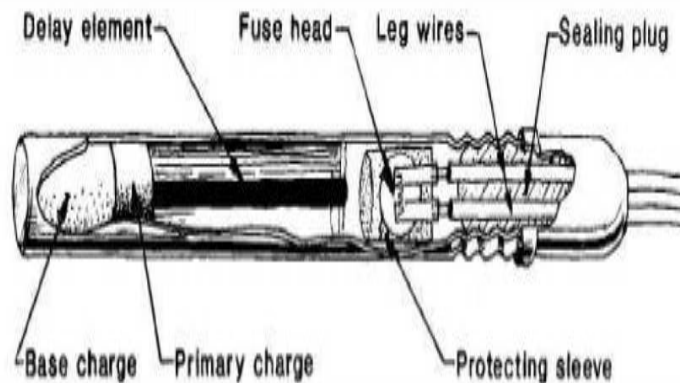


Fig 05 Electric detonator

Electrical detonators are similar to non-electrical detonators except they are initiated by the application of electrical current through electrical wires. The current causes a bridge wire or match elements to heat/function thereby, causing the ignition charge to explode which in turn, causes a chain reaction to cause the base charge to be initiated. The wires are secured into the detonator by a closure plug, crimped into the shell, which seals the explosive from moisture. In addition to sensitivity from heat, shock and crushing, these products are subject to extraneous electricity due to the presence of electrical wire. Figure shows the delay electric detonator. The delay electric detonator is same as instantaneous electric detonator, except for inclusion of delay powder train. Delay time based on length and composition of delay powder. Half second delay during early 1900s. It was further improvised to get a delay of millisecond during 1943.

5. Electronic Delay detonator

Idea of electronic detonator was first discussed in the beginning of 1990s. Recognized potential to increase detonator accuracy and improve customer results. Costly technology has been used in this case. Mine site drive to increase accuracy resulted in various manufacturers beginning to develop and market versions of electronic detonator. The electronic developments make the creation of a sequential blasting machine possible. The sequential blasting machine delivers electronically adjustable timed bursts of energy to a number of lead wires, dramatically increasing the maximum number of electric detonators the blasters can connect and therefore increase the number of potential combinations. In the 1990's, the increasing miniaturization of electronic components gave birth to a new idea: using an embarked electronic clock to replace the pyrotechnical (powder) delay element that creates inaccuracy for the electric detonators. From 1990 to 2000, massive research and development movement was conducted by a large number of actors to develop pre-programmed or programmable electronic detonators. An electronic detonator has a number of advantages, e.g. higher precision, improved blasting result due to a wide range of delays, reduction of air blast / ground vibration, and safe use in extraneous electricity environments and a possibility of limiting the amount of detonators per shot. It has some disadvantages too, e.g. higher cost per detonator and the need for intensive training for users.

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V. FLOW OF THE SYSTEM

1. Receiver Circuit

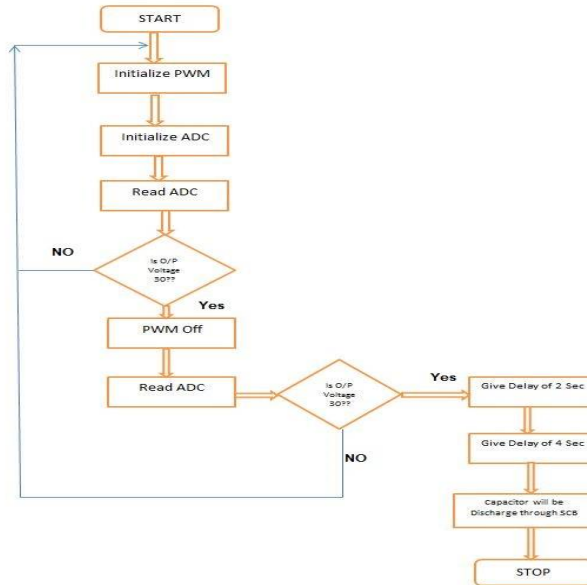


Fig 06 Receiver Circuit

2. Transmitter Circuit

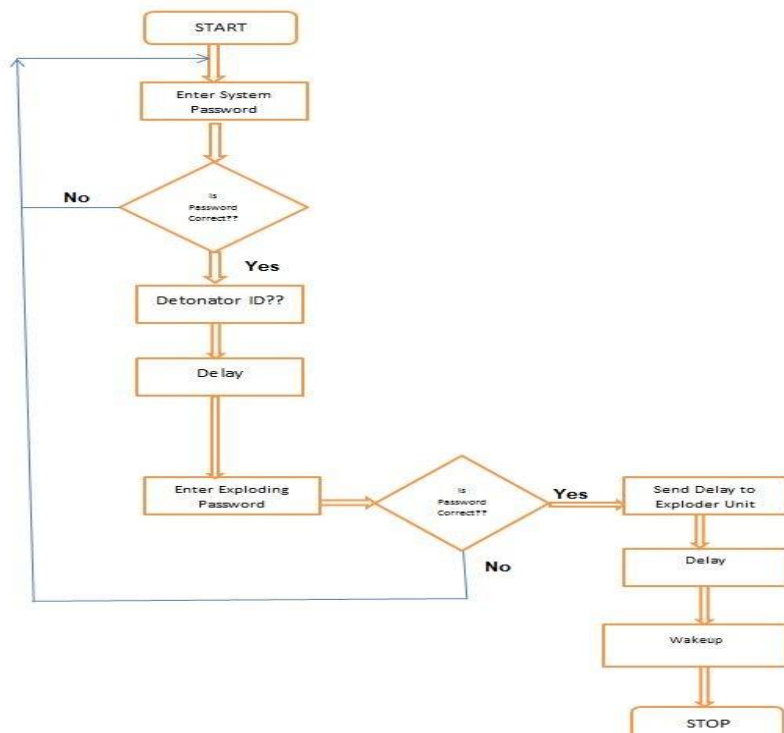


Fig 07 Transmitter Circuit

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IV. OBJECTIVE

Main aim of this invention is to reduce the size of Electronic delay detonators based on semiconductor bridges, provide programmable delay, password protection and reduced cost.

The other various objectives of this project are

1. To provide radio frequency based wireless communication within the system.
2. To operate detonators within the range of 2 km to 5 km.
3. To make system quick responsive.
4. To provide an explosive initiator unit having a security code which is unique to the user and which can be kept secret.
5. To provide explosive initiator that can be identified.
6. To minimise the area used by entire circuitry of explosive initiator to about 6mm*40mm.

V. BLOCK DIAGRAM OF THE SYSTEM

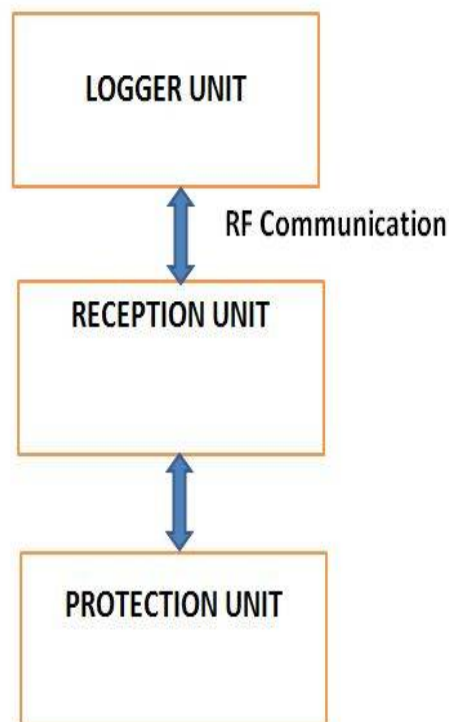


Fig 08 Block Diag of System

The proposed system consists of three parts

1. Logger Unit
2. Reception Unit
3. ESD and RF protected SCB Unit

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1. Logger Unit

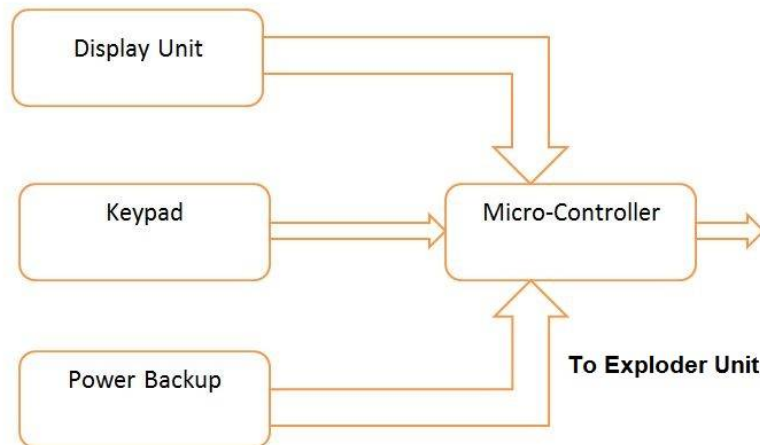


Fig 09 Block diagram for Logger Unit

The **Logger** Unit consists of LCD, Microcontroller, battery and keypad to enter the password and required delay. The Microcontroller sends commands to the delay or timer unit. The detonator ID, delay time is fed from the **Logger** Unit which is then set into the delay unit. Commands including firing and abort are also given through the **Logger** Unit. The **Logger** Unit is password protected and hence avoids an authorised access. The maximum input voltage of the system is 9-12V.

LCD

The LCD is interfaced with the 40-pin microcontroller. 16*2 LCD is used for displaying the messages like enter the password, enter detonator ID and firing password. Two level authentications is used in the system. The messages for authentication will be displayed on the LCD.

Matrix keypad 4*4

The 4*4 matrix keypad is interfaced with the 40-pin microcontroller. The keypad is used to enter the system password, the delay, detonator ID and the firing password.

Microcontroller

The 40-pin microcontroller is used for providing two level authentications to the system. At the first level the system password needs to be entered by the user. On authentication the system will provide further access to the user to enter the detonator Id and the delay. This password is known to all and is common for all the systems. This is first stage of authentication. The design has a two stage authentication. The second level of authentication is required at the time of firing of detonator unit. This password is unique for the particular initiation system. This password is only known to the manufacturer and the authentic user who has purchased the system for any commercial application. No person other than this two knows this password.

The password and delay is used for carrying out the following functionality:

1. To establish communication with detonator unit
2. To set delay for the particular detonator unit
3. To send command to the detonator unit to start the detonator unit
4. To send command to the detonator unit to detonate the detonator unit
5. To send command to the detonator unit to abort the mission

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The microcontroller on this unit will communicate with the microcontroller of detonator unit using wireless communications. The password and delay unit on detonator is basically the serial communication unit and timer unit of microcontroller of detonator unit. Received delay will be fed to detonator and trigger pulse will be sent to detonate the SCB.

2. Reception Unit

The system is composed of two parts as described below.

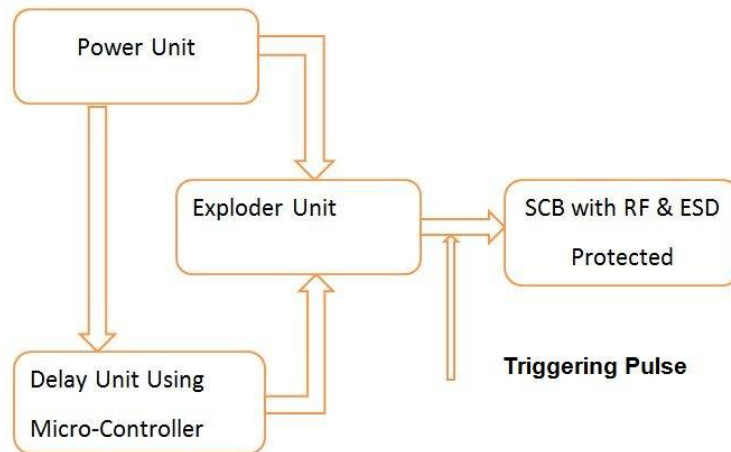


Fig 10 Delay & firing circuit

The Delay and firing unit is composed of two parts

- 1) Circuit consisting of ESD, and RF protected SCB
- 2) Circuit consisting of firing circuit, delay circuit and boost convertor.

3. ESD and RF protected SCB

SCB is a low energy and small size initiator device with very small firing delay. A

Semiconductor Bridge (SCB) can initiate unintentionally by Electro Static Discharge (ESD) and high power RF. The safety of SCB from ESD and RF is of vital importance. The SCB may fire unintentionally by human handling. There are various methods implemented to protect the SCB against ESD and RF. The protection of explosive initiators was done using Zener diode, back to back Zener diodes, TVS diodes, Schottky diodes etc that were connected along with SCB either by integrating or as a discrete components. High-level electromagnetic energy produced by Radio frequency radiation can also induce electrical currents or voltages that may cause premature activation of Electro-Explosive Devices (EEDs) and electrical arcs that may ignite flammable materials. Semiconductor bridge (SCB) initiator is a transducer. Under the effect of high electrical energy, the power transforms into thermal power. Then the doped poly-silicon layer vaporizes and generates high temperature plasma which heats the explosive. Ultimately, when the temperature reaches ignition temperature, the explosive detonates. SCB itself has a good insensitive characteristic against electrostatic inherently.

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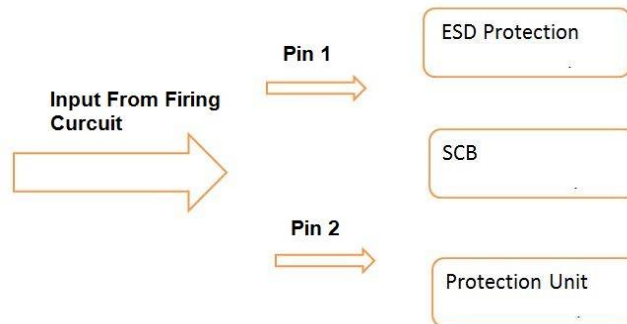


Fig 11 ESD & RF protection Circuit

Semiconductor Bridge (SCB)

Semiconductor Bridge (SCB) Igniter's are widely used as EEDs for explosive device for the initiation of explosives, propellants and advanced ammunitions. Semiconductor Bridge (SCB) is an ignition device for energetic materials using plasma explosion mechanism. Semiconductor Bridges (SCBs) are finding increased use as initiators for explosive and pyrotechnic devices. They offer advantages in reduced voltage and energy requirements coupled with excellent safety features. SCBs operate in a detonator, particularly with respect to the interaction of explosive powder and SCB. Plasma generated from SCBs is used to ignite explosives, where the heavily doped poly-silicon in contact with power gets melted and evaporated to form high pressure plasma upon introduction of large currents through the SCB. Because the typical value of bridge resistance is one ohm, the bridge is ohmic heated through the electrical current. The SCB may melt down and eventually evaporate if enough electrical energy is deposited into the bridge within a limited time.

Once the bridge material is vaporized the applied electric voltage breaks down the silicon gas generating silicon plasma. This is called as late time discharge. This plasma will eventually ignite the explosive material. The SCB works within few microseconds compared with the milliseconds response of a conventional hot-wire unit.

A semiconductor bridge comprises a substrate of non-electrically conductive material, a doped semiconductor layer on the substrate as well as first and second metal lands forming ohmic contacts on the doped semiconductor layer. An explosive charge bridges a gap between the metal lands across the doped semiconductor layer. The lands, gap, semiconductor layer and charge are dimensioned and arranged so that in response to a current equal to or in excess of a predetermined level having a duration equal to or in excess of a predetermined value being applied across the gap, plasma having sufficient energy to energize the explosives is formed in the gap.

Advantages of SCB

SCB's have following unique features, which make them superior element for incorporation in new "high tech" electro, initiated explosive devices. When a fast rising current pulse is applied on the semiconductor bridge SCB's generate hot plasma for ignition of the explosive powder pressed against the bridge. Ignition is via micro convective heat transfer process and not merely a thermal conductive heat transfer as with hot wires. Ignition energy for SCB's is one tenth to that of conventional bridge-wires metal foils. SCB function (i.e. produce a usable explosive output) a thousand times faster than bridge wires.

1. By changing the area of bridge one can greatly vary the no fire level of the device without greatly affecting the all fire energy.
2. SCB devices are explosively safe.
3. They have high no fire current.
4. SCBs are highly resistant to ESD pulse.
5. SCBs being semiconductor should not be compared with metal foils.
6. SCB cannot fail like metal foils.

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7. Current pulse required to function SCB is a unique signal preventing their accidental operation. Due to the above unique features SCB's have great benefit for several applications of ignition in pyrotechnic, propellants and explosive devices.

RF Communication Interface

Radio Frequency (RF) communications are an important smart grid enabler for functions such as volt/VAR control, reclosed control, and feeder restorations and isolation. This paper will give a basic tutorial on the types of radio frequency communications and the benefits and liabilities of each. Specific topics to be explored will be licensed verses unlicensed frequencies, distance between remote radios and base stations, and communications architectures.

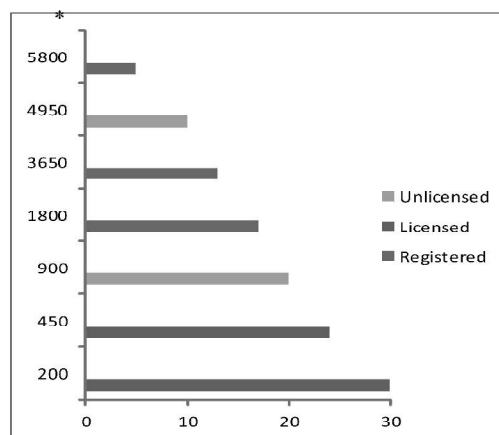


Fig 12 Frequency vs distance ratio

VI. CONCLUSION

SCB gives sheltered, dependable and low vitality method for initiators. For unstable explosions SCBs are most appropriate. Voltage supporter circuit helps the information voltage to around 30V. The Reception Unit of SCB planned in this anticipates produces a high current heartbeat for adequate time required for plasma era. The outline has measurements of 6mmx40mm for twofold sided PCB and 8mm width of the outer detonator tube. By utilizing 8-pin microcontroller as a part of the deferral and Exploding Unit of the programmable electronic postponement detonator scaling down can be accomplished. The utilization of SCB as the EED further aides in accomplishing scaling down because of its little size, makes it sheltered, dependable, ease. Since the SCB is ESD and RF ensured the unwavering quality of the detonator is expanded. The composed detonator is furnished with two level confirmations, first level is for entering the framework and second to fire that makes the detonator sheltered and dependable.

FUTURE SCOPE

The communication between anLogger Unit and timer & delay circuit is done by serial communication. Alternatively RF data and power transfer can also be used for the same. This system also can be modified by embedding concept of Internet of Things into it. By using this concept, user can be able to observe current status and other important details related to detonator while in working state.

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